



Petex

SOFTWARE • TECHNICAL SOLUTIONS • TRAINING

Integrated Structural Geology



moveTM

PART OF THE PETEX IPM SUITE



Petex

IPM Suite - Integrated Production Modelling
& Structural Geology

RESOLVE
GAP
GAP TRANSIENT
PROSPER
MBAL
REVEAL
PVTp
OpenServer

MOVE Core
2D Kinematic Modelling
3D Kinematic Modelling
Geomechanical Modelling
Fracture Modelling
Stress Analysis
Fault Analysis
Fault Response Modelling

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CONTENTS

WHO WE ARE

Our history.....	5
Business.....	6
Financials and market position.....	6
Our people	7
Our ethics	7

WHAT WE DO

Technical Solutions.....	8
Training	10
Support.....	12

SOFTWARE

• MOVE Software Suite Overview	13
• Advantages of using MOVE	15
• Application Programming Interface (API)	16
• MOVE Core Application	18
• 2D Kinematic Modelling	20
• 3D Kinematic Modelling	22
• Fault Analysis	24
• Geomechanical Modelling	26
• Fracture Modelling	28
• Fault Response Modelling	30
• Stress Analysis.....	32
• MOVE Link for Petrel, OpenWorks & GST	34
• FieldMove and FieldMove Clino.....	35

WHO WE ARE

PE Limited (Petex) are the global standard in petroleum engineering, geological model building and structural geology tools, developing a wide range of software. We are a team of highly skilled engineering and geoscience professionals with extensive experience in petroleum engineering and structural geology software. Following the acquisition of Midland Valley, we are now established as the world leader in the field of structural geology, providing expert consultancy, training, and the **MOVE™** suite of geological software, and have a single-minded commitment to the needs of our clients.



Since Petex was founded, our strategy has focussed on delivering value to clients through end-to-end integration in modelling activities. This strategy has culminated in fully integrated physical models being used all over the world to deliver value in real time through the Digital Oil Field (**DOF**).

Integration goes beyond technology and is key to all aspects of the way we work. Our technical team draws upon the combined resources and experience of the whole of Petex, including our engineering, geology, support and technology development groups.



OUR HISTORY

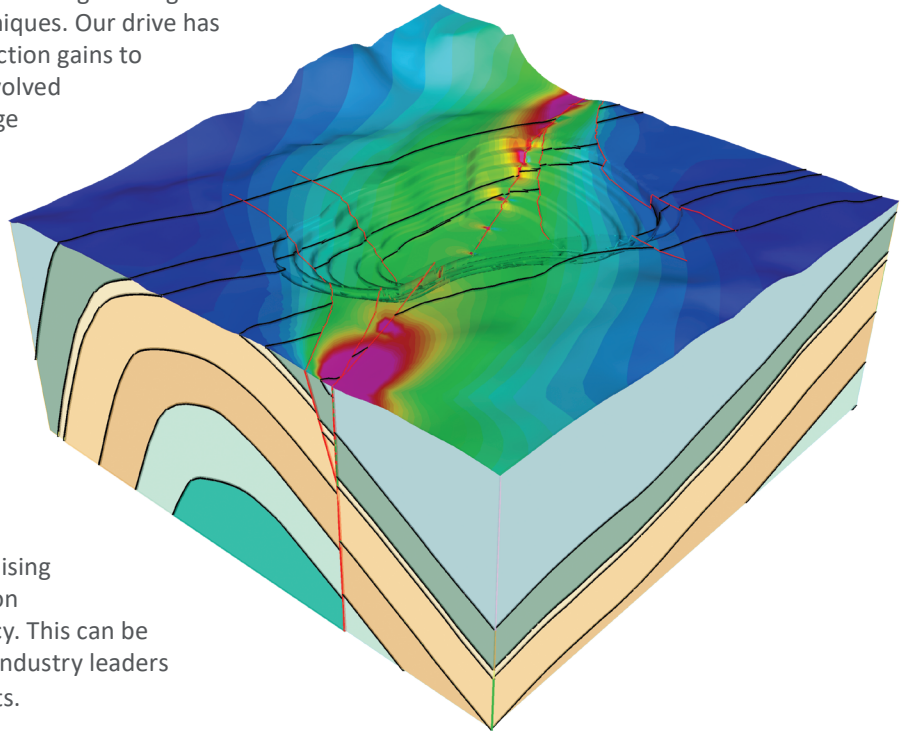
Petex started in business in 1990. All members of the team have been involved in the development of software engineering products, as well as having extensive experience in petroleum engineering and structural geology. The corporate strategy developed from this experience, and a long-term business outlook, were fundamental to the prompt success of Petex. The company's petroleum engineering software tools enable the energy industry to dynamically model their reservoirs, production and injection wells and surface pipeline networks as an integrated system.

For more than forty years, geoscientists at Midland Valley (named after an area of Scotland that lies between the Southern Uplands Fault and the Highland Boundary Fault) have used restoration and balancing techniques to understand geological evolution and extract unseen information from available data. The ground-breaking approach minimises technical uncertainty – enabling your organisation to reduce risk in a methodical and cost-effective way ensuring valid, consistent geological models. The focus of the company was to commercialise applied structural modelling and balancing in the extractive and other sub-surface industries, e.g. oil and gas exploration and production, mining and quarrying, underground storage or disposal, tunnelling and other infrastructure, etc. through the **MOVE** software suite.

In October 2017, Petex acquired Midland Valley. Petex pioneered integrated field modelling with the objectives of improving field management, production, and recovery, with their petroleum engineering **IPM** suite – fully integrated reservoir, well, surface network modelling system, and the Digital Oil Field platform (**DOF**). The next evolutionary step of integration was to incorporate geology and geophysics through **MOVE**, to begin the delivery of a seamless set of workflows from field geology to production and oil and gas field management – field discovery to late production life. Since our inception, we've moved beyond oil and gas and applied our technologies to the mining industries, geothermal, carbon capture and storage, ground modelling for offshore wind and many more – with the same integrated approach delivering value throughout.

BUSINESS

The success of our business is down to a highly-focused and – more importantly – sustained drive towards incremental and measurable steps in innovation of new engineering and structural geology modelling techniques. Our drive has brought direct, bottom-line production gains to our clients directly or indirectly involved in extractive and subsurface storage industries, for example, oil & gas, mining & quarrying, CCS, radioactive waste storage, geothermal energy, geological survey and geotechnical engineering. Key to the company's long-term business success has been our ability to guide our clients. We offer our clients constructive, holistic advice on how to best adopt our technology, enabling them to enhance their organisation; maximising not only exploration and production success but also technical efficiency. This can be evidenced by our extensive list of industry leaders who we are proud to call our clients.

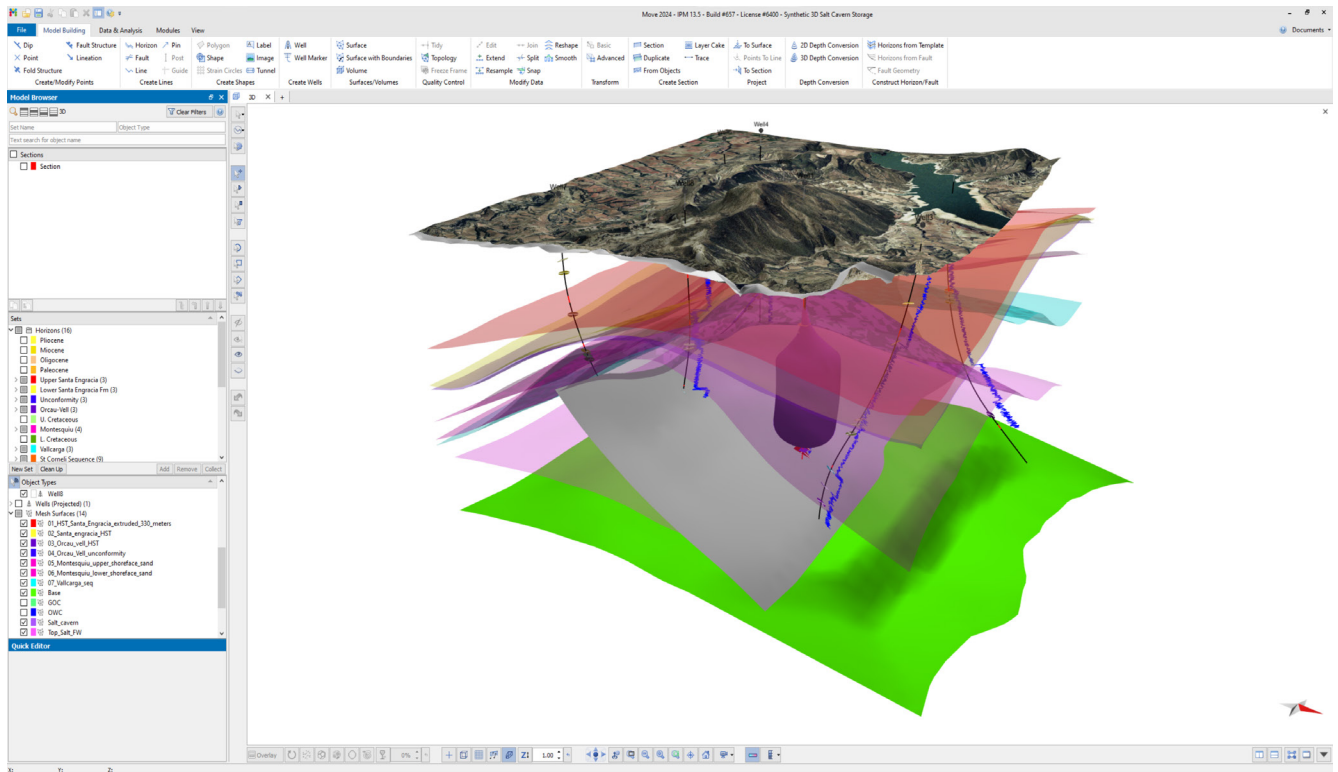


FINANCIALS AND MARKET POSITION

Since the very beginning, our financial performance has been outstanding. Petex has enjoyed a consistent increase in both turnover and profit. All of our product development is self-financed, which enables us to focus on technical innovation and quality technology, without reliance on external funding. Petex was awarded Company of the Year 2010 at the SME awards for Scotland and, in 2009, we were awarded Business of the Year for Scotland. In previous years we have won several awards for business growth, including European Business Awards “Ruban d’Honneur” in 2009 as well as the fastest growing technology companies for six of the seven years that Deloitte Fast 50 Awards were run in Scotland.

Petex has over 450 clients worldwide. In fact, more than 80% of the revenue comes from outside Europe. Our company is recognised across the international oil and gas industry as the technical market leader within its area of expertise and has been ranked number one in all technical evaluations across the industry for more than eight years.

MOVE – Integrated Structural Geology



OUR PEOPLE

One of the reasons that we are the world leader in structural geology is because our specialists and software developers are leaders in their respective fields and strive for excellence. We're lucky enough to work with a great team of creative, innovative and passionate people – from all over the world – who are key to delivering cutting-edge software, services and training. We have a team of expert geoscientists and engineers, who have a wealth of experience and knowledge between them, ready to offer insight and expertise on any project. Our dedicated software engineers are also exceptionally skilled and ensure that **MOVE** continues to be the market leader in structural geology software. And we are all dedicated to your support. Professional and efficient, we make sure all your questions are answered, assist you when you need help and make sure you can get MOVE up and running with no fuss.

OUR ETHICS

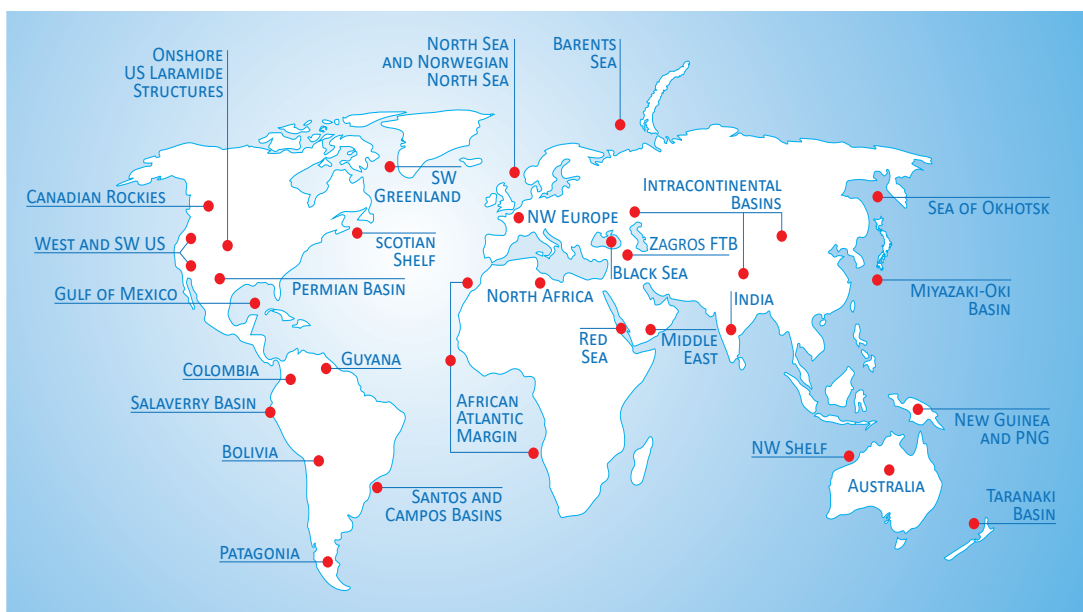
We operate a policy of inclusion and equality. Each member of our team is recruited on merit and technical ability. We expect all individuals to contribute to the decision making process and to help drive the company forward, no matter their role. We encourage communication and cooperation between all teams enabling us to perform at the highest level – both for ourselves and for our clients.

TECHNICAL SOLUTIONS

It's all about reducing the uncertainty in the structural model to make better decisions. We apply restoration and balancing techniques to the geological model to reveal its geological evolution and extract unseen information from available data. Our ground-breaking approach minimises technical uncertainty – enabling your organisation to reduce risk in a methodical and cost-effective way.

Using the combined geological knowledge and experience of our team, we can benefit your organisation by solving your structural geology problems. Here's what we have to offer:

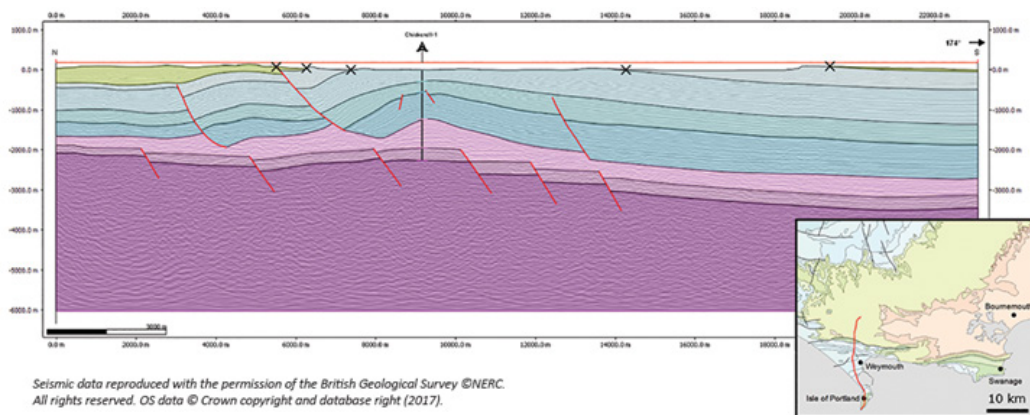
- We have passion for our field! Our 40+ years of **successful project delivery at Midland Valley and now Petex**, shows that we are the team to have on your side and you can be confident that we will strive to deliver the best results.
- We will **address your specific structural geology problems with a unique project scope**, creating an effective and efficient solution, which will get you the results that you require to make decisions and reduce structural geology related uncertainty in your projects.
- We have a **team of structural geologists** who use their combined experience to deliver every project, solving your structural geology problems and rigorously peer-reviewing all of the work delivered to you. We have worked in all tectonic settings all around the world - **salt, extension, inversion, compression, strike-slip**; we draw on our knowledge and experience of similar projects to ensure the projects we deliver for you are to the highest possible standard.



- Our team of expert structural geologists has **extensive experience in applying methods** of structural interpretation, validation and analysis, palinspastic restoration, fault seal analysis, fracture prediction and modelling, and stress analysis, which we use to address structural

problems in all the extractive and energy industries: oil & gas, mining, geothermal, geotechnical, underground storage/waste disposal, and others. We combine our unique range of expertise to address your specific structural geology problems.

- As well as delivering world-class structural geology projects, we **develop the industry-leading software (MOVE)** that we use in our projects. As the **MOVE software experts**, we have mastered all aspects of the tools allowing us to use them with maximum efficiency which means we can spend more time applying the tools to deliver your project. Our intimate **knowledge of the tools and analysis methods** means that we can develop custom-made integrated solutions for any structural modelling problem. If we develop new techniques required to achieve the project objectives, **access to the Petex development teams** means that these solutions can be implemented in the software, or deployed as workflows using our RESOLVE software, and used as part of the project. This combination allows us to deliver the work to schedule and to the highest standards. No other service provider has access to these resources.



- We have the additional benefit of being **integrated in the larger Petex organization** and we can deal with everything from a project's technical requirements to legal and contracting, ensuring that we provide a professional, reliable and efficient service from the scoping stage to project delivery.
- We also have access to **world-leading engineering teams and software**. Integration is key to success, and if your project can benefit from their input we will utilize it to deliver the best integrated solution.
- Our Edinburgh head office hosts the majority of our team but we also have part of our Technical Solutions team based in our Houston office to support and work closely with our US clients. Additionally, we carry out projects and workshops in client offices when this is the agreed best delivery.

To take the next steps then please get in touch (see below) and one of our team will then arrange a call with you to discuss your requirements further.

If you have a project that you would like to discuss then please don't hesitate to call us or email us at edinburgh@petex.com – get the experts on your side.

TRAINING

Learn from our experts and build your knowledge in the application of structural geology using **MOVE™**.

We offer training courses to suit all levels, learning styles and budgets. These include structural geology theory training using **MOVE**; Advanced **MOVE** software training; knowledge transfer workshops or support days. All of these can be delivered privately if required at a client provided venue, or from one of our Petex offices. The courses are relevant for geoscientists and engineers working in a variety of sectors and can be tailored to both individual and company requirements.

INTEGRATED STRUCTURAL GEOLOGY - MOVE STANDARD COURSE

Our Integrated Structural Geology Standard Course using **MOVE** follows a fixed course structure over five days. The course introduces basic structural geology theory and practice aimed at geologists and engineers. This course is intended for those that: (i) work with geological models in the exploration or production domain and need to become familiar with structural geology tools/analysis; (ii) attended the course already some time ago, and require a refresher, or; (iii) are in other disciplines trying to understand how structural geology is integrated into the exploration or production context. A background in structural geology is not required. The course uses practical exercises and the **MOVE** Software Suite as required. It is largely hands-on, introducing the theory and principles underlying the application of structural geology analysis in extractive industries such as oil & gas and mining.

For more information on our training courses, visit petex.com/services/training-courses

INTEGRATED STRUCTURAL GEOLOGY - ADVANCED 2D KINEMATIC MODELLING COURSE

This 5-day course is targeted at geologists that have previously attended the Standard Integrated Structural Geology Course or those who have a strong structural geology background and are familiar with the **MOVE** software. This course will provide attendees with best practise workflows for preparing and analysing 2D section interpretations. This will include conditioning and QC of interpretations, producing valid 2D geological models and, importantly, quantifying and minimizing geological uncertainties. The format of the course encourages attendees to learn through problem solving, to allow them to approach their own projects with added confidence. Some of the problems they will learn to solve include checking if their interpretation makes geological sense, testing different conceptual models and restoring interpretations through geological time. Attendees will learn how to formulate and apply advanced structural geology workflows and analyses, where key economic decisions are dependent on integration of modelling results and outcomes.

For more information on our training courses, visit petex.com/services/training-courses

KNOWLEDGE TRANSFER WORKSHOP

We can design a Knowledge Transfer Workshop specific to your needs, showing the most effective application of **MOVE** to address your specific workflow requirements. We can provide parts of our standard and advanced courses and data to achieve this and incorporate your own data into the training. Workshops can vary in length from one or two days, or up to five days or longer, and can be designed standalone or as part of a consulting project.

Generally, a Knowledge Transfer Workshop is split into two parts: the first part focuses on structural geology theory and software training in **MOVE**, and the second part focuses on client-specific structural geology techniques and workflows, using **MOVE** tutorial or prepared client data. If client data is used, and not part of a consulting project, this must be provided in advance of the workshop.

If you would like to discuss a knowledge transfer workshop, please email us at edinburgh@petex.com

PRIVATE/IN-HOUSE TRAINING

We can provide any of our training options to you at our offices, your company premises or a client-provided venue. A company private/in-house training course can include elements of any of our **MOVE** software training options outlined above, customised to suit specific requirements.

If you would like to discuss a private/in-house training, please email us at edinburgh@petex.com

TRAINING COURSE COSTS

Courses with a fixed structure delivered at our UK offices, our office in Houston or other Petex venue have prices published on our website. Where courses are tailored to your needs; costs will depend on the length, preparation required and location of training. Please contact us directly to discuss the best option for you and your organisation and to get a quote.

Email us at edinburgh@petex.com

SUPPORT

Client support is a fundamental part of what we do. All members of our team are involved in client support, whether it's on the frontline providing a rapid and technically detailed response to queries, or in making sure that our software documentation is of the very highest standard. In addition to one-on-one resolution of client support requests, we provide the **MOVE™ Knowledge Base** as a one-stop-shop for software help, explanation of underlying **MOVE** theory and self-instruction tutorials. Once a year, we host a User Group meeting, usually in Edinburgh, and invite all of our clients to attend. The meeting provides an opportunity for us to find out how our clients are using **MOVE**. It allows our clients to learn about the latest developments in the software and to submit development requests. For attending clients, requests will be discussed in open forum, increasing the likelihood of support from other clients, and considered for inclusion in our software development plans. We also have an annual Technical Meeting in Houston, and smaller meetings globally across the year.

To learn more about our user meetings, please email us at edinburgh@petex.com

MOVE KNOWLEDGE BASE

This resource contains all **MOVE** Help Pages, Tutorials, a back catalogue of **MOVE** Features and the release documentation presented in a single, offline, searchable entity, and independent of **MOVE**. The material is cross-referenced and brings together tutorial workflows with more detailed help topics including algorithm theory and recommendations for tool application and parameter values. The Knowledge Base is updated regularly and made available to our users, and allows us to continually improve our support materials.

TUTORIALS

MOVE tutorials are based on real datasets and provide users with detailed step-by-step instruction on the best practice workflows recommended by our structural geologists. They cover all functionality in the software. All 38 tutorials can be accessed from the Knowledge Base and are accompanied by example files provided via the software download link.

HELP PAGES

The Help Pages allow our users to find everything they need to know about **MOVE**. Help topics are linked with relevant tutorials to assist our users to understand best-practice workflows and how each tool is used. Help provides information on the core elements and tools of the **MOVE** software, how to navigate the user interface, explains advanced modules for more complex analysis and modelling, and provides guidelines on how to manage a project in **MOVE** and how to get the best from the software.

MOVE FEATURES

MOVE Features form part of the client support area of the website, or inside a newsletter issued by Petex. Each feature focuses on a topic or key workflow to provide our users with a deeper theoretical understanding of the software, its real-world applications and give tips and tricks to streamline workflows. Past features can be accessed from the **MOVE Knowledge Base**.

To learn more about **MOVE** support resources, please email us at edinburgh@petex.com

MOVE SOFTWARE SUITE OVERVIEW

Structural modelling and analysis software to reduce risk and uncertainty in geological models.



KINEMATIC MODULES



2D Kinematic
modelling



3D Kinematic
modelling

ADVANCED MODULES



Geomechanical
modelling



Fracture
modelling



Stress Analysis



Fault Analysis



Fault Response
modelling

DATA TRANSFER



move Link
Petrel



move Link
OpenWorks



move Link
GST

DIGITAL FIELD MAPPING



Fieldmove



Fieldmove
Clino

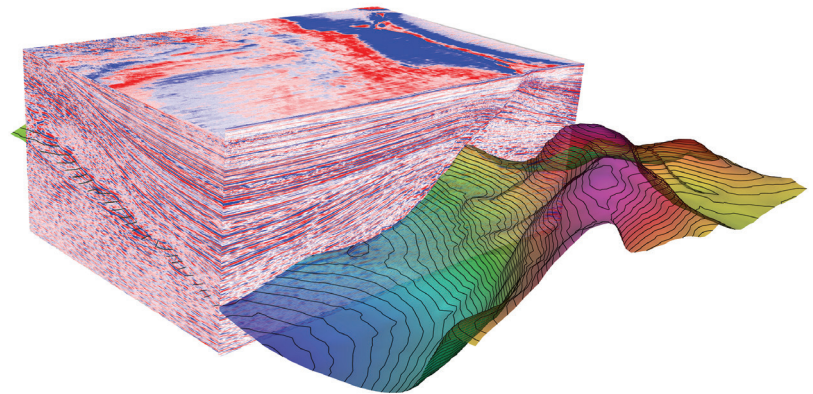
The **MOVE™** suite is the most complete structural modelling and analysis toolkit available. It provides a full digital environment for best practice structural modelling to reduce risk and uncertainty in geological models.

The **MOVE** suite provides a platform for integrating and interpreting data, cross-section construction, 3D model building, kinematic restoration and validation, geomechanical modelling, fracture modelling, fault response modelling and fault and stress analysis.

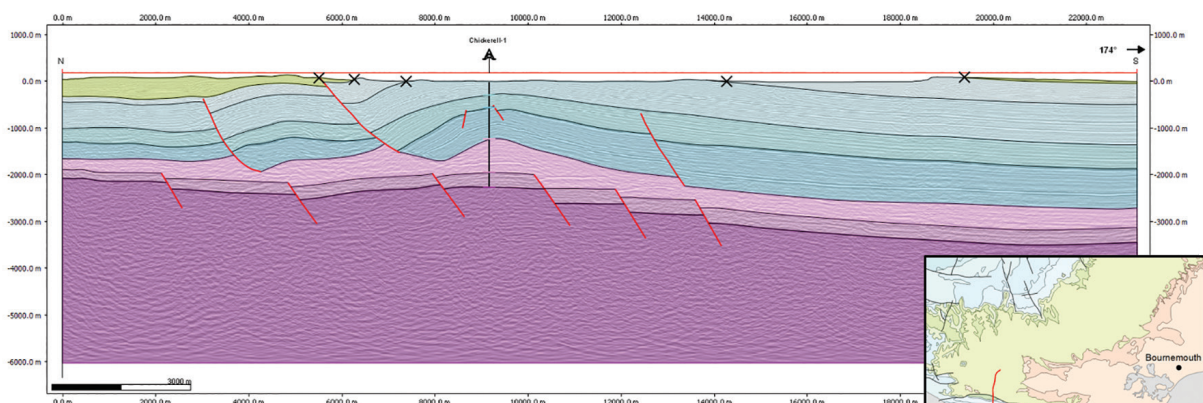
The software is designed by geoscientists working in close collaboration with software developers and enables you to create valid geological models.

MOVE reduces uncertainty by going beyond static models, which may be no more than an artist's impression. By addressing timing, development of structure, and checking geometric and evolutionary feasibility, you are three times more likely to produce the correct result.*

MOVE can be applied to any geological province or tectonic setting, including extensional, compressional, and strike-slip basins, as well as areas that have undergone inversion, erosion, thermal subsidence and salt tectonics. With the **MOVE Knowledge Base**, we offer our users access to fully integrated help and tutorials. **MOVE** is easy to use, bringing your ideas and concepts alive. The software provides you with the tools to check the geometric and evolutionary feasibility of your geological models.



Seismic data reproduced courtesy of Triezenberg, P. J., Hart, P. E., and Childs, J. R., 2016, National Archive of Marine Seismic Surveys (NAMSS): A USGS data website of marine seismic reflection data within the U.S. Exclusive Economic Zone (EEZ): U.S. Geological Survey Data Release, doi: 10.5066/F7930R7P.



Seismic data reproduced with the permission of the British Geological Survey ©NERC. All rights reserved. OS data © Crown copyright and database right (2017).

ADVANTAGES OF USING MOVE

Petex's software **MOVE™** is the industry leading software for structural geological modelling and is under continuous development for more than 30 years. It is used by geoscientists and engineers in more than 200 companies worldwide to get maximum value from their data and reduce risk and uncertainty across a variety of resource industry sectors (oil & gas, mining, CO2 storage, geothermal energy, geological surveys, geotechnical engineering, radioactive waste disposal)

- The **MOVE** suite comprises methodologies that range from model creation, structural quality-control and validation, to more advanced analysis, such as investigating reservoir compartmentalisation and fracture prediction, aiding decision making and prospect planning.
- Ensuring that the geological model is valid, reduces uncertainty in the shape and position of faults and economically significant horizons in the subsurface, for example, hydrocarbon reservoirs. The results of model validation in E & P can be used to have greater confidence in well planning, field development strategies and gross rock volume calculations, ultimately reducing costs.
- Structural evolution can be determined, to help understand how economic traps have developed through time. For example, in E & P this can be used to improve understanding of formation of hydrocarbon plays, which will inform exploration strategies.
- With a valid model and an understanding of the structural evolution, further analysis can be done on the reservoir, for example assessing fault transmissibility and secondary porosity and permeability associated with natural fractures. This information can be used to improve reservoir models and ultimately make predictions about production.
- Integration of **MOVE** with the Petex **IPM** suite gives geoscientists and engineers the ability to access more data in the production system to improve geological and production models.

USING MOVE via Petex's RESOLVE or OPENSERVR software

For **MOVE** since the 2019 release, a brand new **Application Programming Interface (API)** was developed. Integrated modelling is achieved using the API, which provides a two-way gateway for communication between **MOVE** and external applications. Modelling tasks in **MOVE** can now be automated. Doing so:

- Increases **efficiency**, and removes **subjectivity**.
- Makes analyses **documented** and **repeatable**, and **encapsulates** knowledge.

In addition to automation, connection of **MOVE** with the **RESOLVE** software (licensed separately) provides access to additional modelling tools and connections to a large network of software (Petex and non-Petex). As an example, tools such as the optimised search and sensitivity modelling tools in **RESOLVE** can be combined with structural analysis in **MOVE** to perform modelling tasks that were previously not possible.

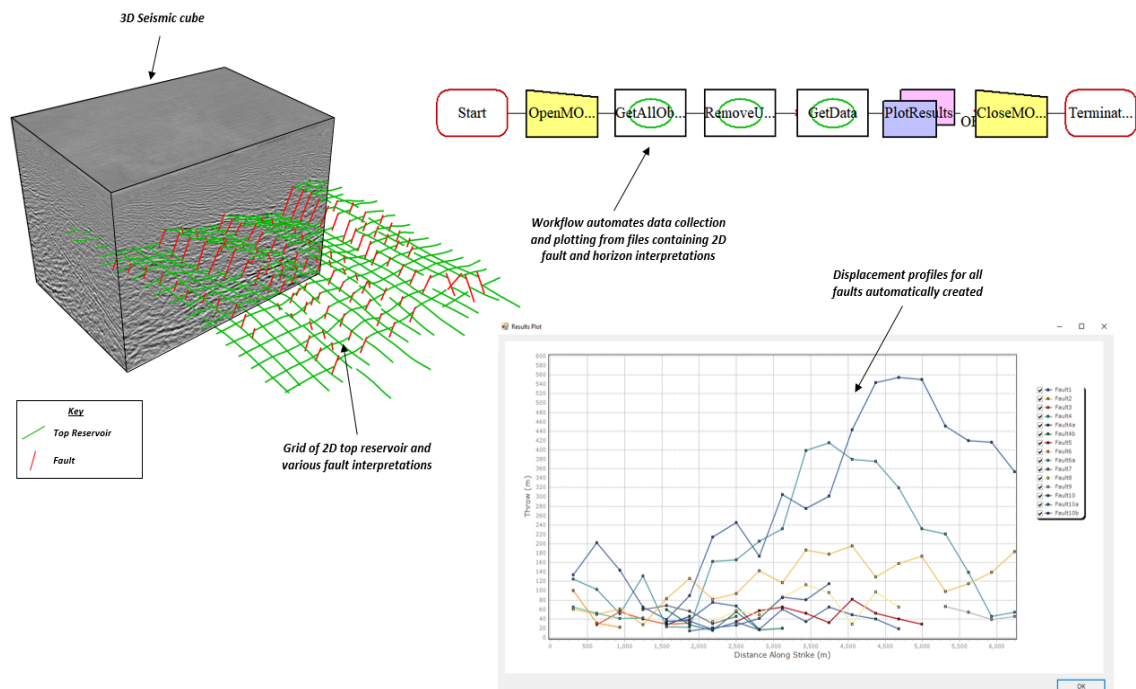
Additionally, the connection of **RESOLVE** to many other programs, such as reservoir simulators, provides a mechanism to automatically connect the outputs from structural modelling with dynamic modelling. The API continues to evolve and has been extensively updated for **MOVE 2024** release.

APPLICATION PROGRAMMING INTERFACE (API)

Use **MOVE™** as part of automated workflows and integrate **MOVE** with modelling from other disciplines (e.g. reservoir simulation).

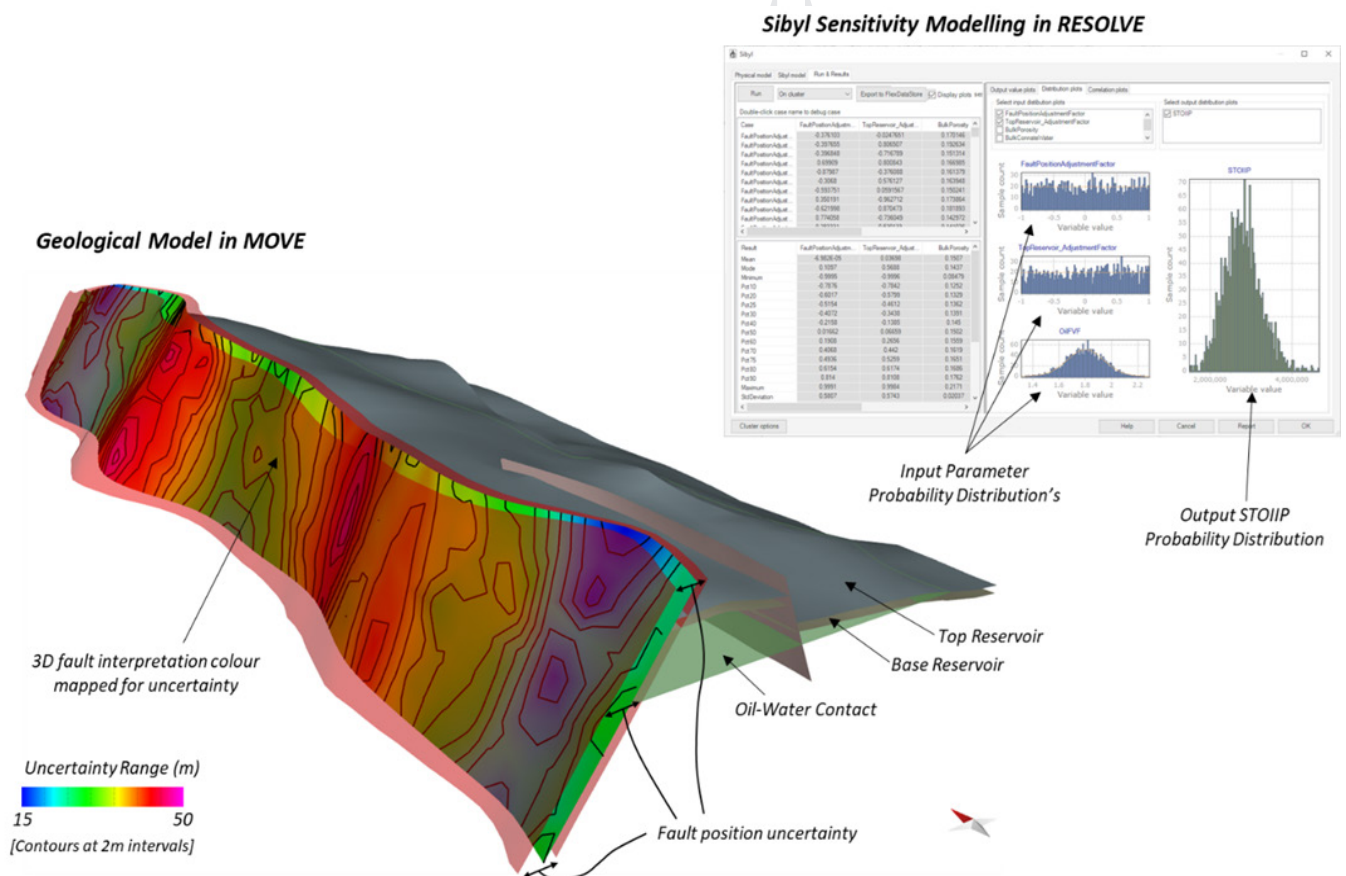
A mechanism for automating functionality in **MOVE** and communicating with Petex or third-party applications, such as Excel. The API provides a two-way-gateway for communication and data passing between **MOVE** and external applications, via the **RESOLVE** or **OpenServer** tools (both licenced separately).

- Tools in **MOVE** can be controlled and workflows orchestrated by **RESOLVE** or third party applications (via **OpenServer**).
- **RESOLVE** or third-party applications control the flow of information in **MOVE** as well as into and out of **MOVE**.
- A series of logical steps can be defined computationally to automate modelling tasks.
- The automation of operations and workflows allows standardisation to increase efficiency, make analyses documented and repeatable, reduce subjectivity, and minimise operator bias.
- Workflows can be shared within an organisation to allow others to benefit from the knowledge and expertise of structural specialists.



Automated creation of fault displacement profiles from 2D section interpretations.

- Connection of **MOVE** to **RESOLVE** provides access to a range of DataObjects, such as optimised search and sensitivity modelling tools, which expand the native capabilities of **MOVE** to allow modelling tasks to be performed that were not previously possible within **MOVE** standalone.
- Connection between **MOVE** and other modelling packages facilitates integrated modelling of systems by enabling the inclusion of structural geological modelling in the automated feedback loop for history matching of component models.
- Geoscientists now have access to any dynamic data (e.g. reservoir pressure and phase rates) that are available and can use the additional data to validate geological models and concepts.
- With every new version of **MOVE** more tools are being exposed to the API to facilitate more advanced workflows being automated via **RESOLVE**.
- The **MOVE** engine (a **RESOLVE** DataObject) allows some **MOVE** data and operations to be accessed and performed without use of the **MOVE** graphical user interface, allowing workflows orchestrated from **RESOLVE** to run even faster.

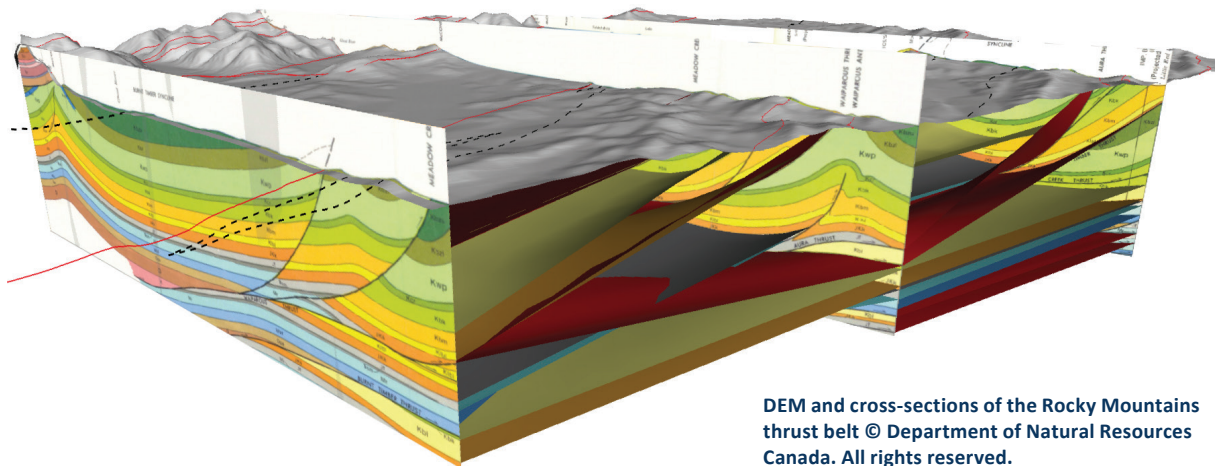


Use of the Sibyl sensitivity analysis tool to assess how uncertainty in the interpretation of structural features impacts volumetric calculations.



MOVE CORE APPLICATION

Fully integrated 2D and 3D model building and analysis.



DEM and cross-sections of the Rocky Mountains thrust belt © Department of Natural Resources Canada. All rights reserved.

MOVE™ is the core application of the **MOVE** suite and all other modules require it to run. It provides a powerful stand-alone environment for data loading and integration, cross-section construction and 3D model building, and forms the base for our specialist structural modules including 2D and 3D Kinematic Modelling, Geomechanical Modelling, Fracture Modelling and Fault Response Modelling, as well as Fault Analysis and Stress Analysis.

The **MOVE** application provides a platform which integrates geo-referenced 2D and 3D views, allowing over 100 different data formats to be combined. The integrated views can be used to construct geologically valid cross-sections and 3D models using manual and automated tools.

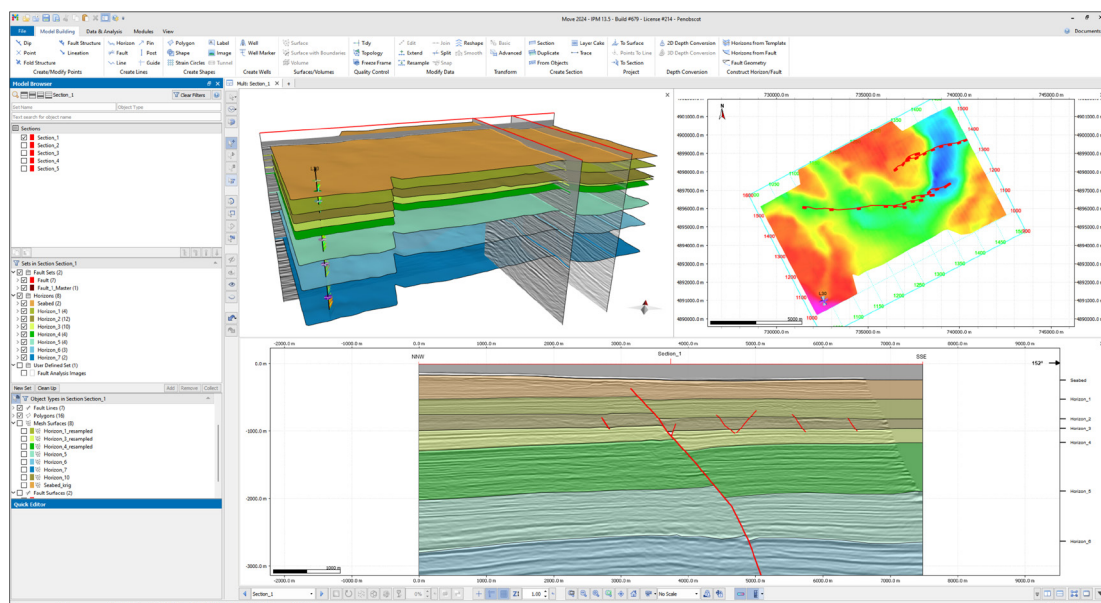
The 2D/3D space provides a best practice environment to develop models, which can then be directly tested and validated using the kinematic modules. Orientation plots, cross plots, stereonet, rose diagrams and object property tables can then be used to thoroughly investigate and analyse the model and construction process. **MOVE** is used by geoscientists and engineers with the intention of getting maximum value from their data, in any tectonic regime and across a variety of resource industry sectors.

- Multiple data imports and exports including Seismic, GIS, OBJ, GOCAD and ASCII
- Seamlessly integrated 2D and 3D model building
- Create 3D grids as input for reservoir simulation
- Cross-section construction
- Attribute and Object Attribute analysis
- Section, Map, 3D, and Google Map views of data
- Logical attribute and spatial query tool
- GIS Vector data live-stage connection
- 3D PDF export of 3D models and 2D animations
- Advanced volume and surface creation
- 3D model conditioning while preserving structural integrity
- Specialised track and marker tools for well data analysis



- Import and integrate a wide variety of data types including: digital field data, digital elevation models, seismic data, well and borehole data, geological maps, point clouds and point data, volume data, annotated field images, scanned cross-sections, grav/mag and remotely sensed data, voxet, ASCII, GIS shape and DXF files.
- Navigate the Model Browser quickly and efficiently using the Model Browser search bar.
- Quickly create shaded 2D maps and sections and 3D models in fully geo-referenced space, using automated and manual digitization tools.
- Create 3D surfaces, shapes and volumes and honour input data points and faults for surface creation using ordinary kriging.
- Maintain surface boundaries when resampling.
- Pick or part-select geocellular volumes/3D grids, create regions based on selection and extract faults.
- Photogrammetry support including the projection and draping of photographic outcrop images on an existing mesh.
- Create and slice 2D sections at any angle and orientation with controllable display of 3D object intersections in the Section View.
- Interrogate data and attributes comprehensively with the Query tool, supporting a wide range of queries to explore and analyse data relationships.
- Copy and paste images from the Windows clipboard straight into the Views.
- Project data onto sections and surfaces or manually transform objects.
- Create 2D sections from surface data, integrating overturned dip data for complex structural modelling.
- Condition and check your model and systematically improve its integrity.
- Full attribute analysis with multiple graphical plots including Surface Curvature Analysis Technique (SCAT).
- Update your model in real-time using the Reshape tool to rapidly modify surfaces, whilst maintaining structural geometry.
- Display and analyse well and borehole data efficiently with the Well Track and Well Marker analysers.
- Visualize your data and model with advanced tools, including animation, lighting, section navigation and the ability to save camera views.
- Create and export MBTiles from **MOVE** for use in our digital mapping software, FieldMove and FieldMove Clino.
- Export your data in a variety of formats for further analysis and modelling, including 3D PDF and 2D and 3D SEG-Y.
- Create 3D structural grids that honour faults as input for reservoir simulation.

Use the **MOVE** Core application as your platform for the advanced structural modules: 2D Kinematic Modelling, 3D Kinematic Modelling, Geomechanical Modelling, Fracture Modelling, Fault Response Modelling, Fault Analysis and Stress Analysis, and for links to third-party products: **MOVE** Link for Petrel*, **MOVE** Link for OpenWorks and **MOVE** Link for GST.

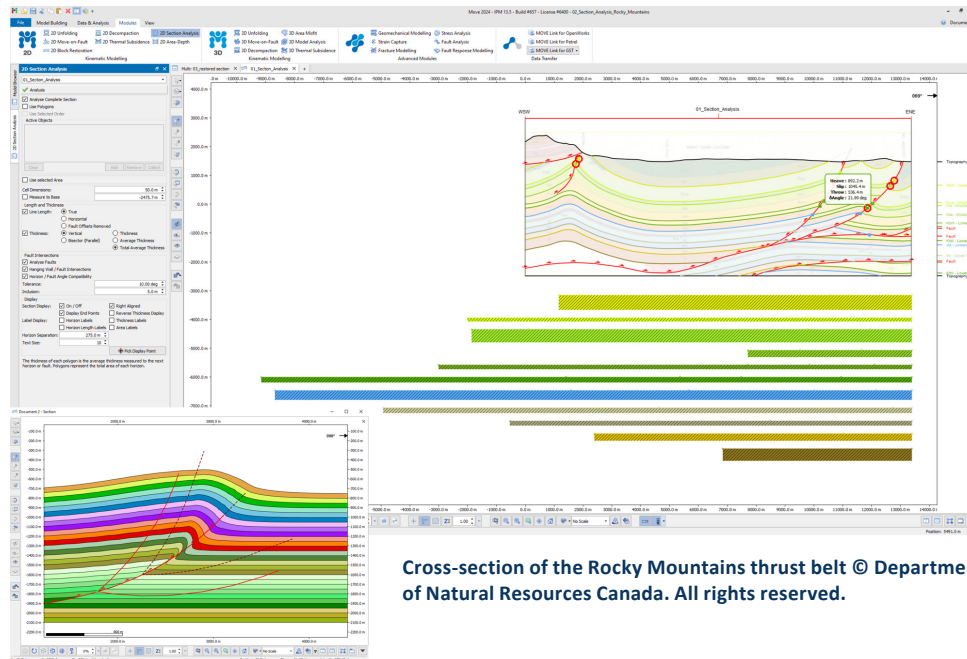


3D model at Penobscot of the Sable sub-basin, offshore Nova Scotia © Department of Natural Resources Canada. All rights reserved.



2D KINEMATIC MODELLING

World-leading forward and reverse modelling tools for validating your interpretation and reducing uncertainty in your geological model.



Cross-section of the Rocky Mountains thrust belt © Department of Natural Resources Canada. All rights reserved.

Our 2D Kinematic Modelling module provides a comprehensive range of tools to build, balance, restore and analyse cross-sections at a local and regional scale. The impact of geological time on the structures present in a model can be accounted for in any decisions.

Kinematic algorithms are used to forward model, restore and remove deformation on geological cross-sections. The tools allow the un-deformed state to be defined while staying true to line length and area balancing principles.

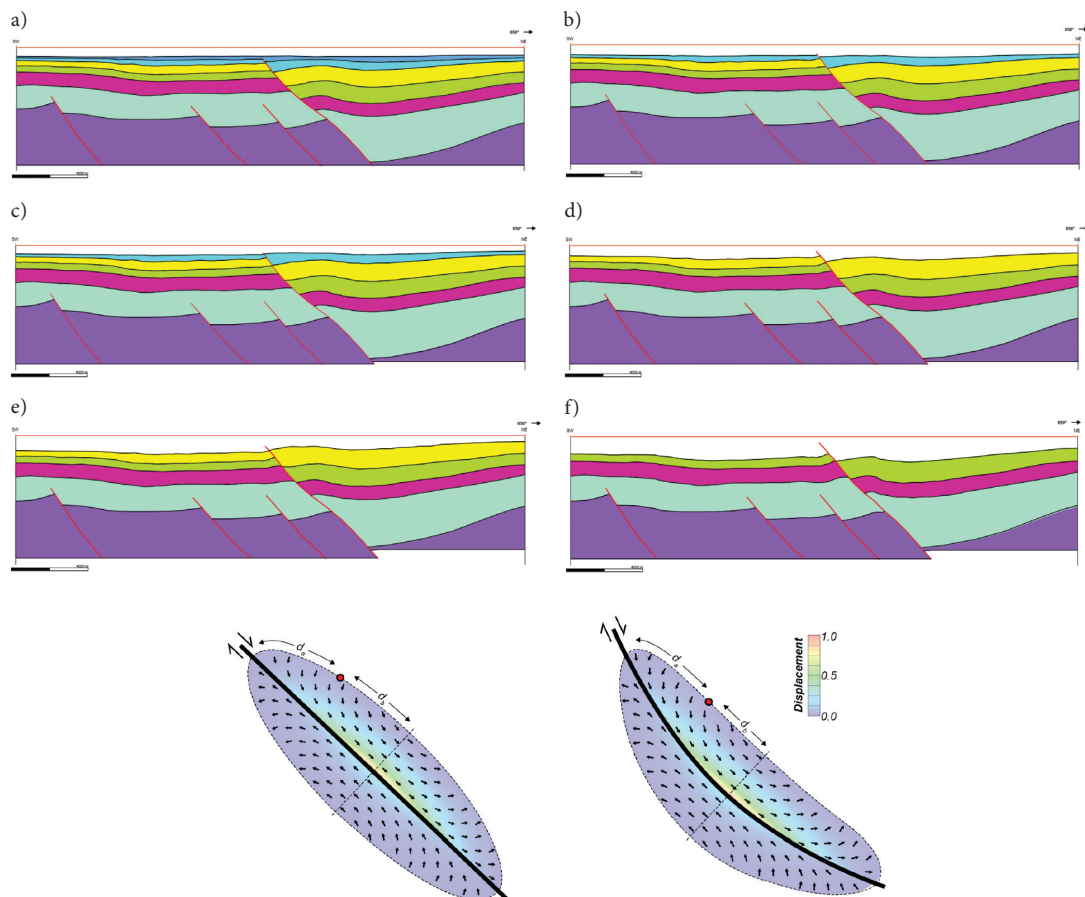
Tools in the 2D Kinematic Modelling module can be used to interactively determine deformation rates, check the geometric and evolutionary feasibility of your model, highlight areas of geological uncertainty and constrain the evolution.

Analyse present-day structure and validate your section through geological time. Evolve models backwards and forwards and assess the timing of critical geological events such as trap formation, juxtaposition and basin evolution.

- Comprehensive suite of 2D kinematic algorithms
- Interactive tools to help quickly generate balanced sections
- Restore, forward model and analyse sections
- Apply to any tectonic setting including salt
- Improved Area-Depth and layer-parallel strain calculations
- Fault and horizon construction
- Decompaction
- Depth conversion
- Thermal Subsidence
- Displacement analysis and testing of fault validity

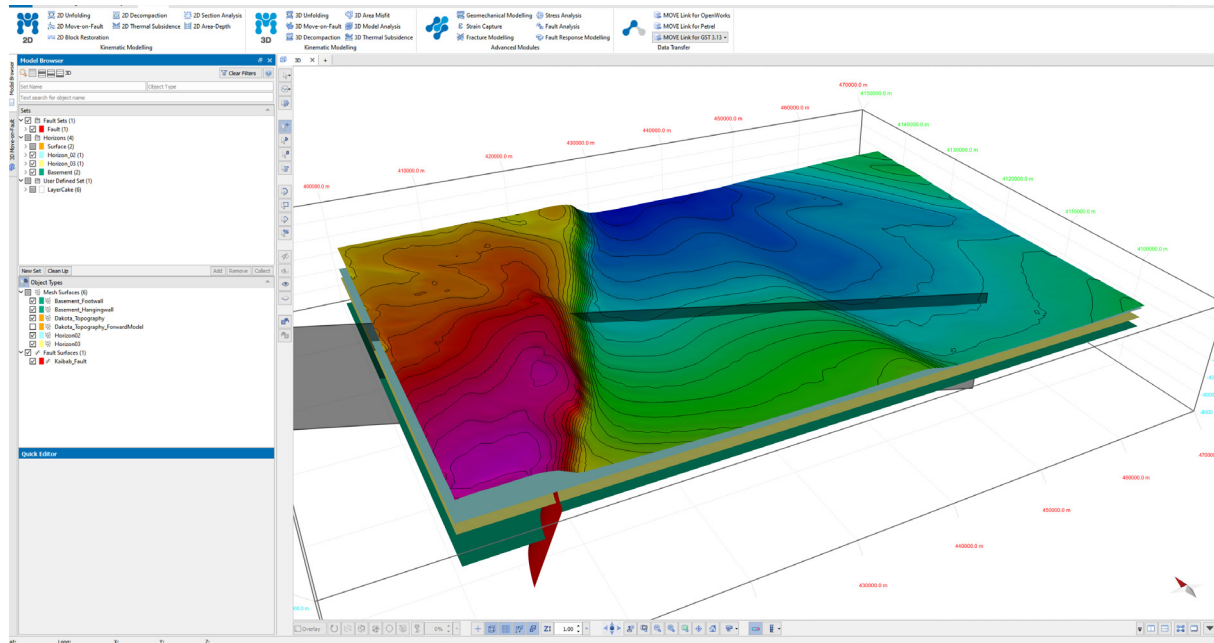


- Use kinematic algorithms for both restoration and forward modelling including:
 - Block Restoration
 - Flexural Slip Unfolding
 - Simple Shear Unfolding
 - Simple Shear Move-on-Fault
 - Trishear (planar and non-planar faults)
 - Move-on-Fault
 - Fault Parallel Flow Move-on-Fault
 - Fault Bend Folding Move-on-Fault
 - Elliptical Fault Flow Move-on-Fault
- Include sedimentation, erosion and salt movement to perform complete sequential halokinetic restorations in the most complex structural settings.
- Carry seismic data and images through the restoration.
- Backstripping techniques: isostasy, decompaction and thermal subsidence. Auto-population and synchronisation of tools for quicker workflows.
- Improved depth conversion tool to account for large velocity changes in faulted sections and quickly set a constant water velocity for submarine environments.
- Interactively define displacement, shear angle, regional level, propagation angle, trishear angle, pin position, unfolding template, sediment erosion and deposition when forward modelling.
- Preview kinematic calculations for quick sensitivity testing of input parameters when carrying out forward modelling and restorations.
- Develop realistic and structurally valid fault trajectories and depths to detachment.
- Fault-horizon angle compatibility test to identify and quickly remedy interpretational inconsistencies.



3D KINEMATIC MODELLING

World-leading 3D forward and reverse modelling tools to help validate your model, and reduce uncertainty.



Discover the geological history of your modelled scenario to reveal unseen structures and changing geometries with our 3D Kinematic Modelling module. This module uses leading edge kinematic algorithms to validate and restore 3D geological models. Complex geological structures can be restored to identify alternative scenarios in areas of high structural uncertainty.

The tools in the 3D Kinematic Modelling module can be applied to any geological setting, including extensional, compressional and strike-slip basins, as well as areas that have undergone inversion, thermal subsidence and salt tectonics.

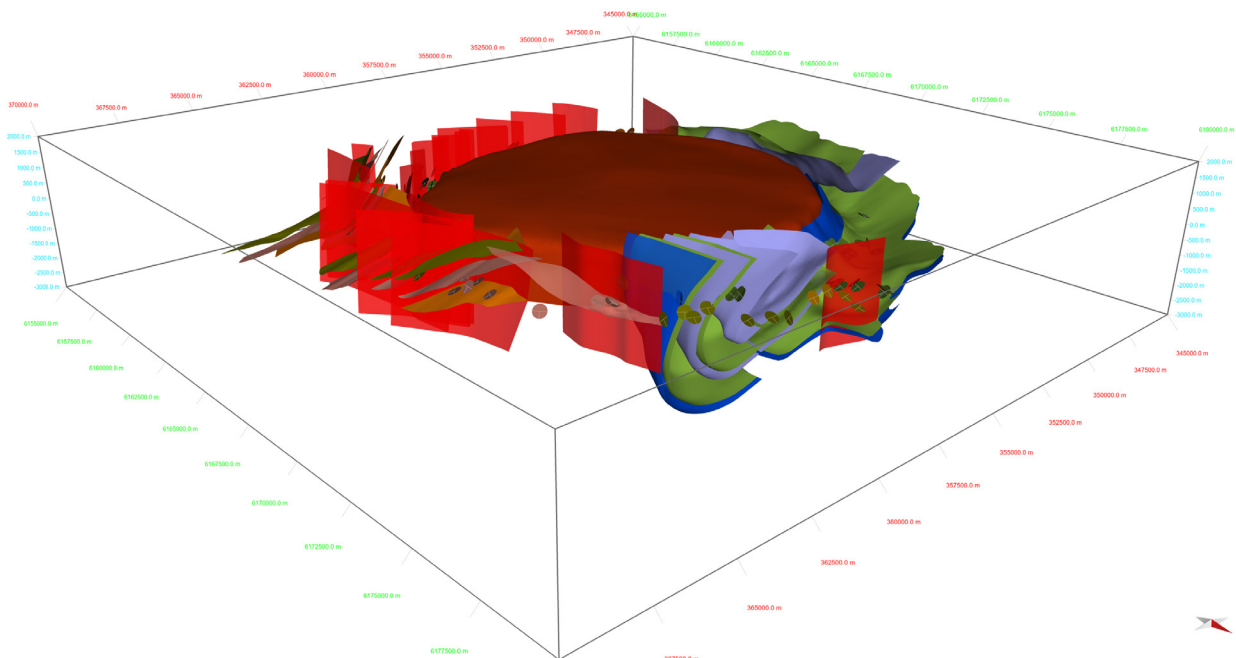
Forward and reverse model through time in 3D, whilst adhering to line length, area and volume balancing principles. The module will help you construct realistic geological models, which can then be used as the basis for further analysis.

3D Kinematic Modelling analysis allows the timing of critical geological events such as trap formation to be determined; accurate reservoir geometries and volumes to be constrained; palaeo-surfaces to be reconstructed; and areas of instability and enhanced permeability to be identified ahead of drilling.

- Comprehensive suite of 3D kinematic algorithms
- Model real-world scenarios
- Enhance structural understanding
- Predict unseen structures and reduce uncertainty
- Supports Lagrangian and Eulerian strain calculations, with Finite or Infinitesimal strain output.
- 3D Depth conversion
- Account for mechanical compaction, isostasy and thermal subsidence



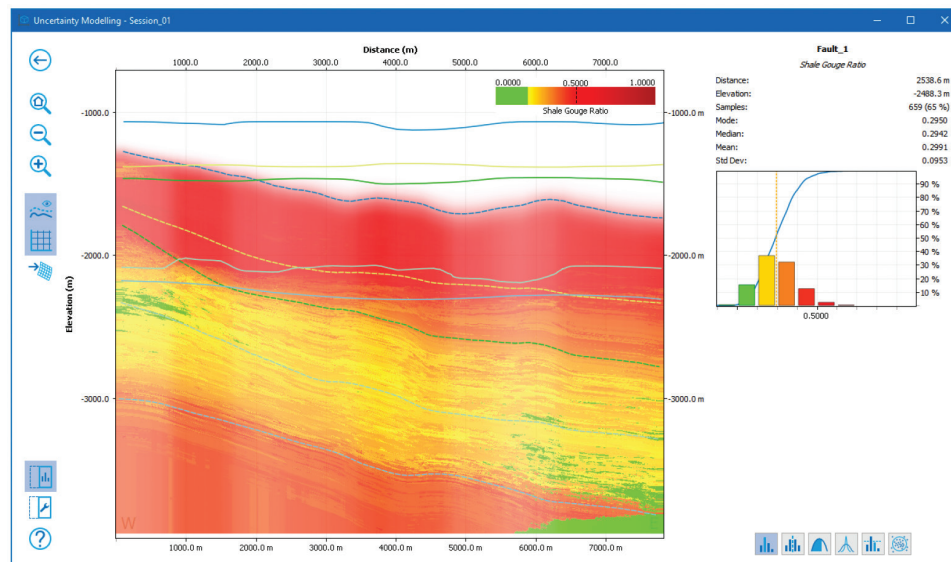
- Work in 3D plus geological time. Evolve models backwards and forwards through time and assess the timing of key geological events.
- Model fault movement using 3D kinematic Move-on-Fault algorithms, with freedom to vary parameters along strike:
 - Simple Shear: model penetrative deformation throughout the hanging wall of extensional faults.
 - Fault Parallel Flow: model hanging wall deformation by discrete movement between beds in fold-thrust belts.
 - Trishear: model deformation associated with a propagating fault tip.
- Restore and forward model folding with Simple Shear and Flexural Slip Unfolding algorithms.
- Flexibly model fault displacement with the option for constant or variable slip (asymmetric or symmetric) along the fault plane.
- Take into account mechanical compaction, isostatic and thermal subsidence effects to investigate basin architecture through time.
- Perform Jigsaw-fit restorations to assess the geometric validity of geological interpretations. Measure horizon areas and volumes in 3D models using the 3D Model Analysis tool, which allows for quick validation of 3D models. Use this to estimate reservoir volumes, sweet spots and optimise oil and mineral extraction.
- Calculate strain for areas and volumes and save strain attributes for further analysis. This essential output can then be used with our Fracture Modelling module to produce a discrete fracture model (DFN) and assess fracture porosity and permeability.
- Quickly check area and volume balance within 3D models, calculating horizon areas and volumes using the Model Analysis tool.





FAULT ANALYSIS

Quantitative analysis of fault throw, juxtaposition and seal through geological time.



A tool for rapid evaluation of throw distribution, across-fault juxtaposition and fault sealing capacity in 3D. Combined with statistical analysis of fault displacement and scaling relationships, the tool provides powerful validation of geological interpretations.

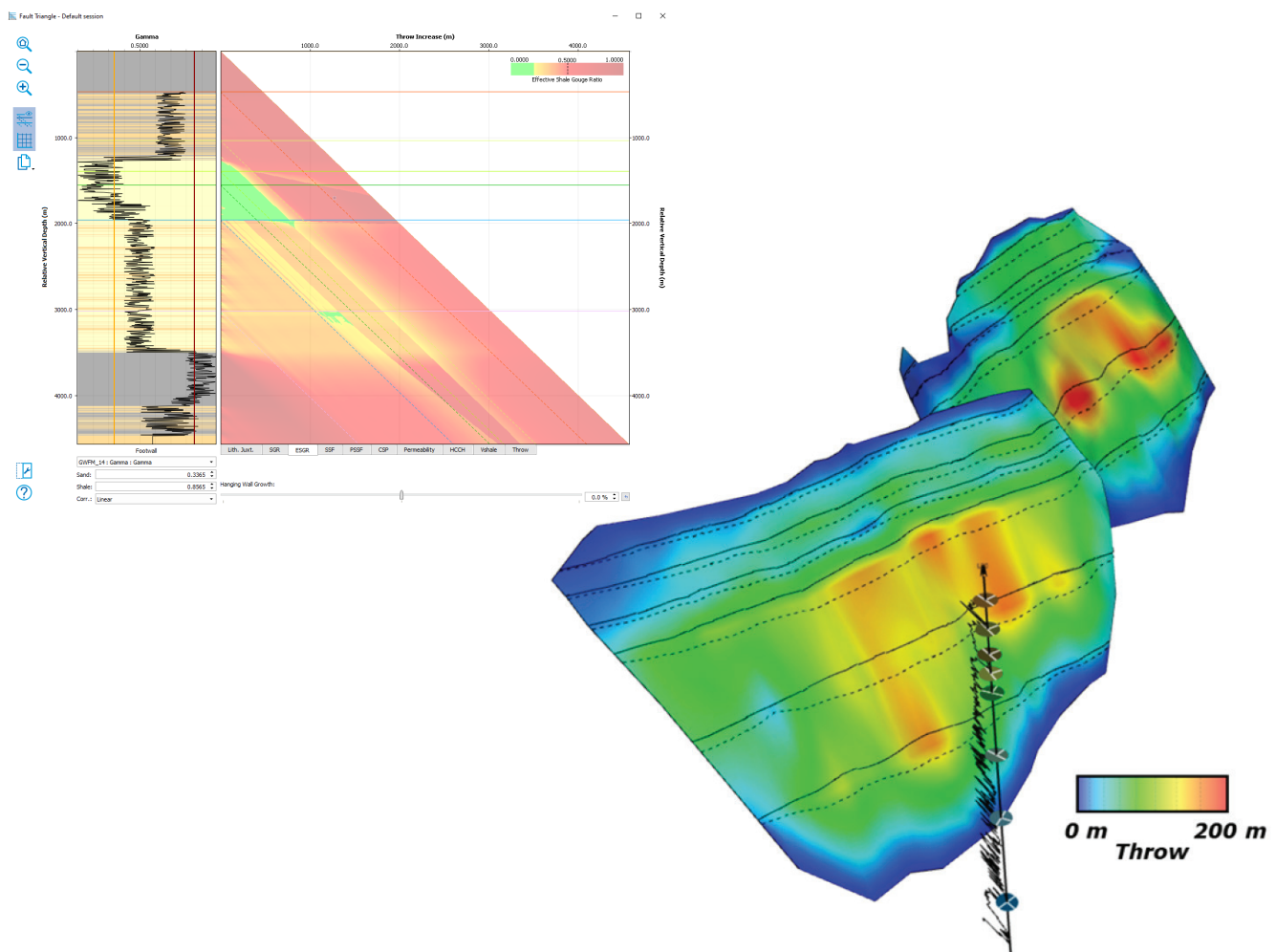
Uniquely, the module can be integrated with restoration workflows using **MOVE™**'s 3D Kinematic Modelling and Stress Analysis modules to provide a complete temporal fault displacement and seal investigation. This workflow delivers key information on potential baffles or conduits to flow at the time of hydrocarbon generation and migration. The sealing potential of faults and joints encountered in a wide range of mineral and ore systems can also be investigated using this approach.

Furthermore, the tool includes functionality to perform quick-look restorations allowing temporal variations in fault displacement and sealing capacity to be rapidly assessed. This can be crucial in identifying former migration pathways, charged compartments and potential charge risks that may not be apparent in the present-day configuration.

- Complete temporal fault displacement and seal analysis.
- Visualize throw, juxtaposition and shale gouge ratio on fault surfaces.
- Statistical analysis of fault scaling properties.
- Quantify the potential impact of uncertainties in your input data.
- Use well logs or Vshale/sand fraction volumes to define lithologies.
- Save analysis setup in sessions to reopen at another time.



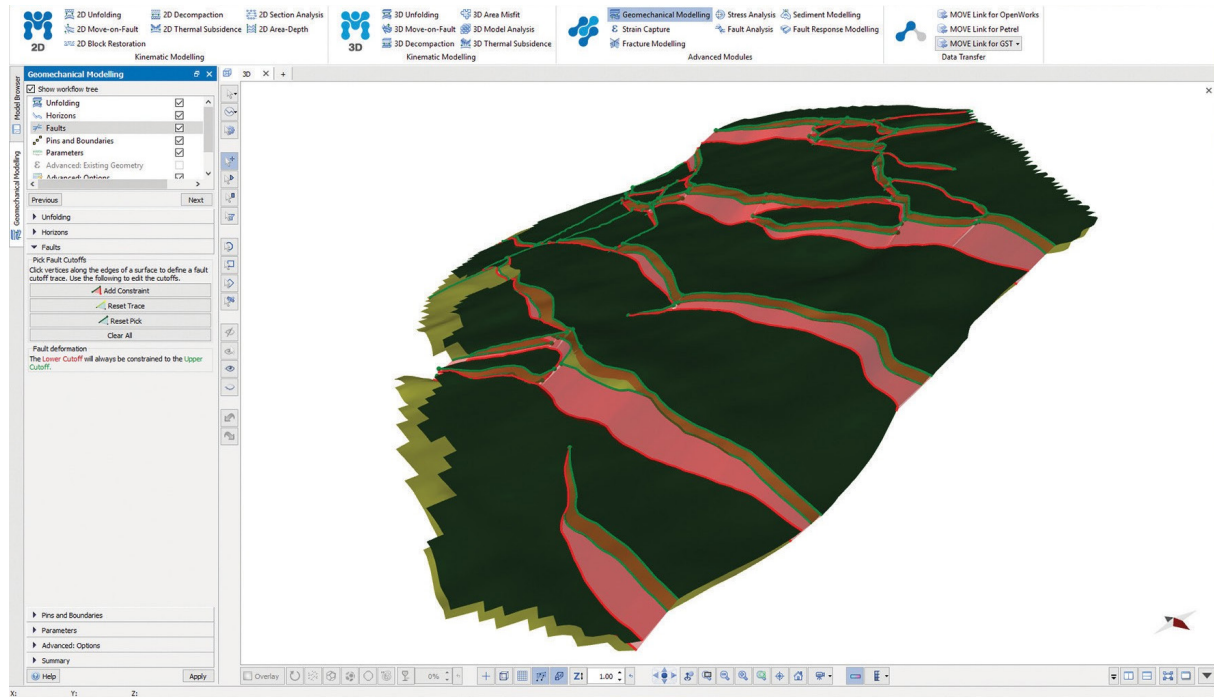
- Create hanging wall and footwall fault cut-offs highlighting interpretation inconsistencies and allowing subsequent analysis.
- Visualise 2D strike projections (throw profiles) for multiple faults.
- Define lithologies and Vshale from well logs or volumes to create juxtaposition diagrams and plot shale gouge ratio in 3D.
- Visualize throw, juxtaposition, shale gouge ratio and a host of additional seal proxies on fault surfaces.
- Calculate a broad range of seal proxies including: shale gouge ratio, shale smear factor, clay smear potential, permeability and hydrocarbon column height.
- Statistically analyse fault scaling properties, including throw/length and cumulative frequency to QC interpretations and improve understanding of the fault populations under investigation.
- Calculate heave polygons for all faults and horizons in a model.
- Create instantaneous fault-growth curves to review fault movement histories.
- Restore model to analyses palaeo-juxtaposition and fault sealing.
- Create triangle diagrams that account for across-fault thickness variations, or using two wells.
- Quantify the potential impact of uncertainties in your input data by rapidly running multiple model iterations to stochastically quantify risk based on input uncertainty.
- Interrogate distributions of possible outcomes, and visualize aggregate statistics, distribution percentiles and probabilities of specific outcomes across a fault surface.
- Complete rapid temporal fault displacement and seal analysis.





GEOMECHANICAL MODELLING

Physics-based restoration of surfaces and volumes using elastic rock properties.



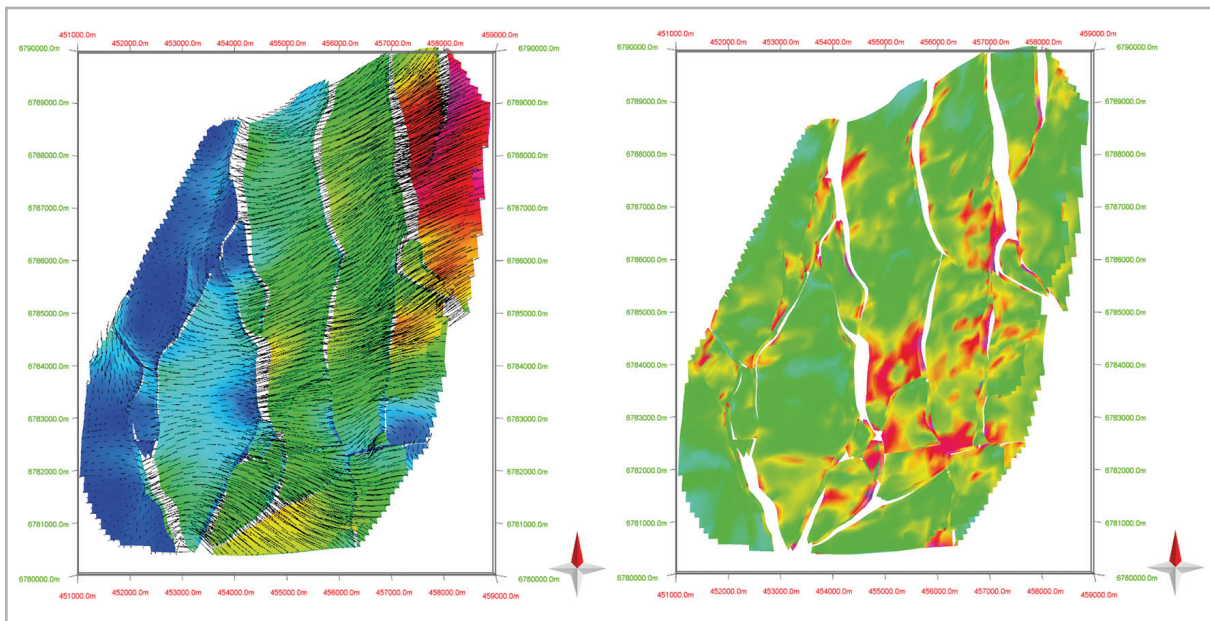
Our Geomechanical Modelling module uses elastic mechanical properties and physical laws of motion (Mass-Spring methodology, e.g. Wang et al. 2006) to mimic 3D rock deformation. Rapid modelling based on different geological assumptions can be done by running and saving multiple restoration scenarios with different mechanical properties, pin and fault displacement parameters.

The Mass-Spring algorithm calculates the forces on point masses assigned to surface or volume vertices (connected by simulated springs). These forces govern the point mass trajectories during restoration and simulate physical behaviour of the surfaces or volumes associated with heterogeneous strain. This differs from the approach used in **MOVE™** 3D Kinematic Modelling, where geometric rules govern point trajectories.

- Physics-based 3D rock deformation modelling
- Save scenarios
- Rapid run times
- Strain capture
- Multiple outputs for Fracture Modelling



- Use a flexible workflow to conduct the restoration.
- Model rock deformation using Young's Modulus and Poisson's Ratio.
- Define fault displacement cut-offs to close fault gaps on the selected surface.
- Apply boundary conditions: projection to target, restore fault displacements, change area/volume.
- Control how quickly the restoration converges on a solution, and is deemed to be complete.
- Use the strain magnitude captured during modelling as an input for Fracture Modelling.

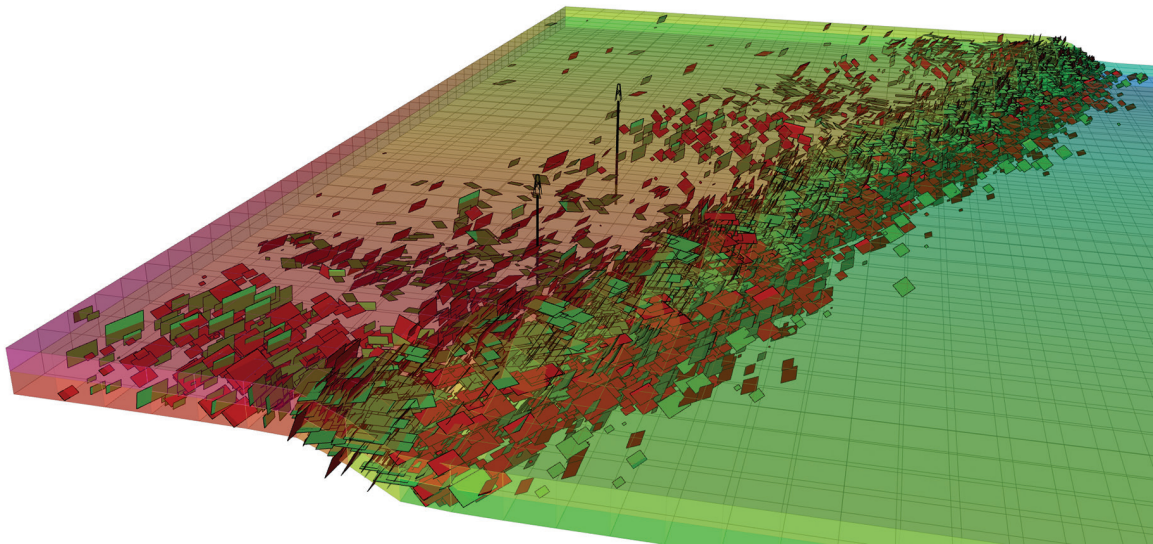


Wang, Y., Xiong, Y., And Xu, K., 2006, A mass-spring model for surface mesh deformation based on shape matching: proceedings of ACM Graphite 2006, pp. 376-380, Kuala Lumpur.



FRACTURE MODELLING

A tool for creating Discrete Fracture Network (DFN) models from an input geocellular volume and for calculating properties for reservoir simulation.



The Fracture Modelling module generates Discrete Fracture Network (DFN) models from an input geocellular volume. The workflow-driven approach guides users through the fracture modelling process, is easy to use, and facilitates rapid development of multiple fracture models. Combination with other **MOVE™** modules (e.g. 3D Kinematic Modelling, Fault Response Modelling) provides a unique capability to build and test geologically valid fracture systems.

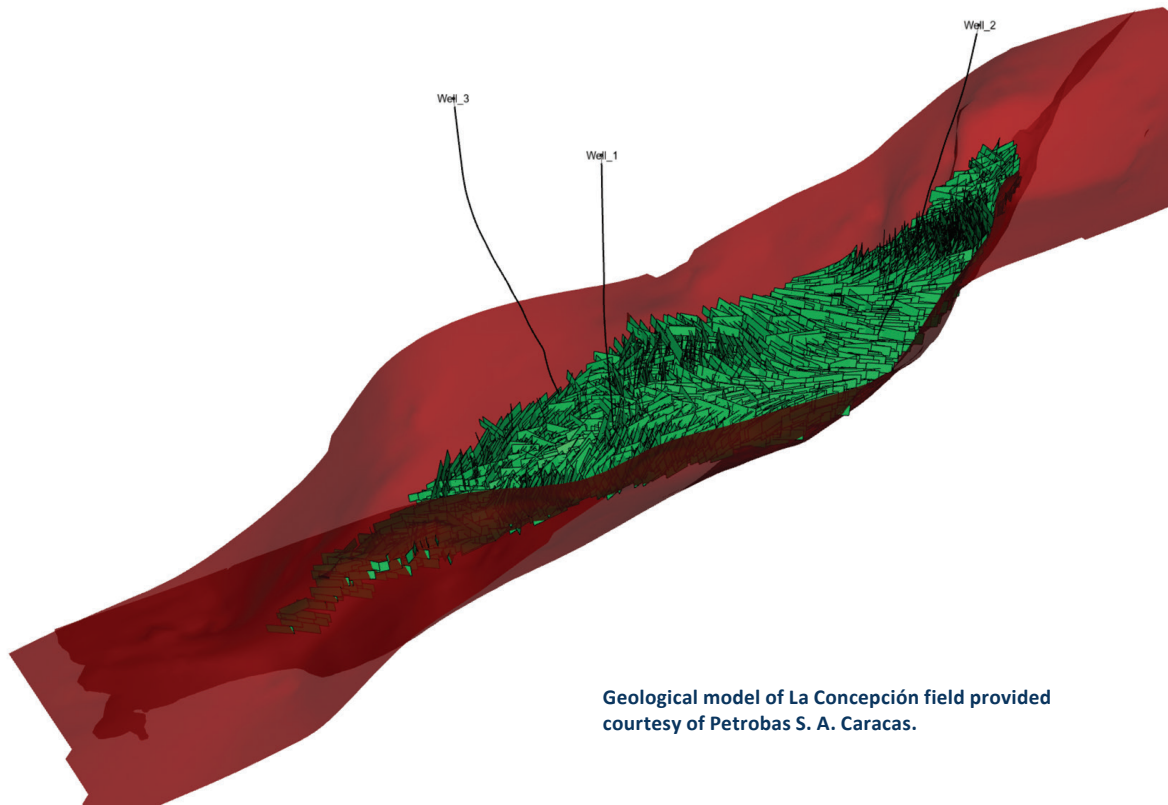
The tool uses a volume-based approach to create fractures on a cell-by-cell basis with input parameters defined for each cell of the volume. Input parameters are the size (length and aspect ratio), size distribution, orientation (dip and dip azimuth), density, and aperture of fractures. Fractures are discrete rectangular elements and multiple fracture sets can be created simultaneously. After creation of a DFN, the connectivity of fractures in the network can be calculated as well as fracture-related flow properties for each cell, including secondary porosity, secondary permeability, sigma, and fracture intensity.

- Creation of 3D Discrete Fracture Network (DFN) models comprising multiple fracture sets.
- Versatile modelling from a range of input properties.
- Connectivity analysis of DFN models.
- Calculation of volume-based, flow related properties of the fracture network such as secondary porosity and secondary permeability tensors.

Combining the Fracture Modelling module with other advanced modules, such as the 3D kinematic modelling, Strain Capture, and Stress Analysis modules allows integrated fracture modelling workflows to be performed. As an example, strain calculated using the 3D Kinematic Modelling module, Geomechanical Modelling module or Fault Response Modelling module can be used to define input properties (intensity and orientation) for fracture modelling. The mechanical stability of the DFN model can then be calculated using the Stress Analysis module.



- Generate DFN models from a range of input parameters, including:
 - Purely statistical DFN models created from no input properties.
 - DFN models created from properties in each cell of the input volume (e.g. strain).
 - Hybrid DFN models combining statistical and property-based methods.
- Save Fracture Modelling sessions so that previous sessions can be quickly revisited.
- Preview results before running a full simulation allowing for computationally expensive simulations to be identified.
- Calculate fracture connectivity and secondary parameters such as porosity and permeability.
- Filtering of fracture sets for easy visual interrogation of results.
- Save results as discrete fracture objects, either as sets or as individual fractures.

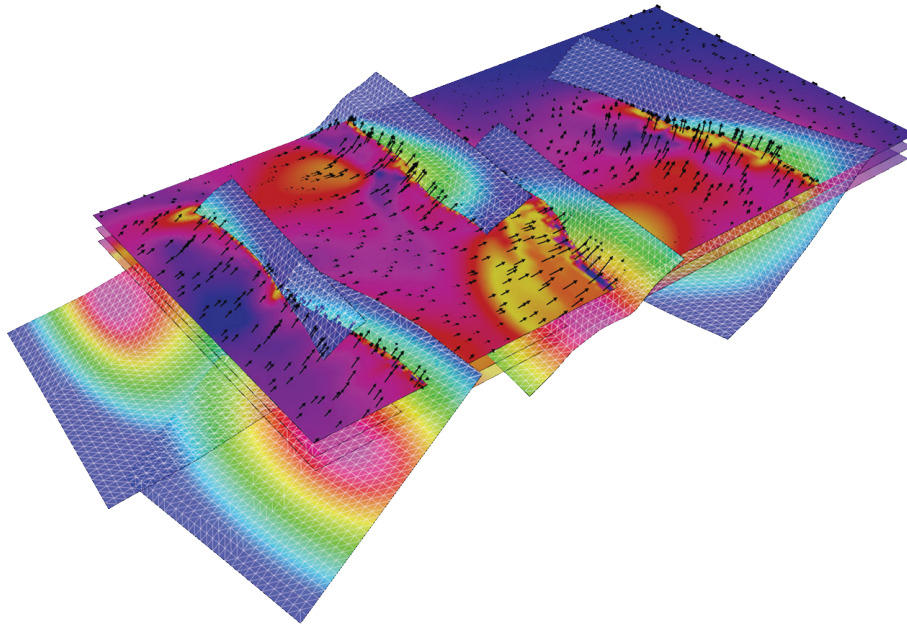


Geological model of La Concepción field provided courtesy of Petrobas S. A. Caracas.



FAULT RESPONSE MODELLING

Boundary element modelling to simulate displacement on faults, and geomechanical analysis of surrounding fracture systems.



The Fault Response Modelling module is a highly versatile tool that can be used to validate your interpretation, identify highly fractured zones and realistically model stress perturbations around faults and other discontinuities.

The module considers mechanical properties to reproduce fault-related deformation and provides a quantitative assessment of the surrounding fracture system. Faulting is simulated using a boundary element method with triangular elastic dislocations. This approach allows complex faulting scenarios to be quickly tested and evaluated.

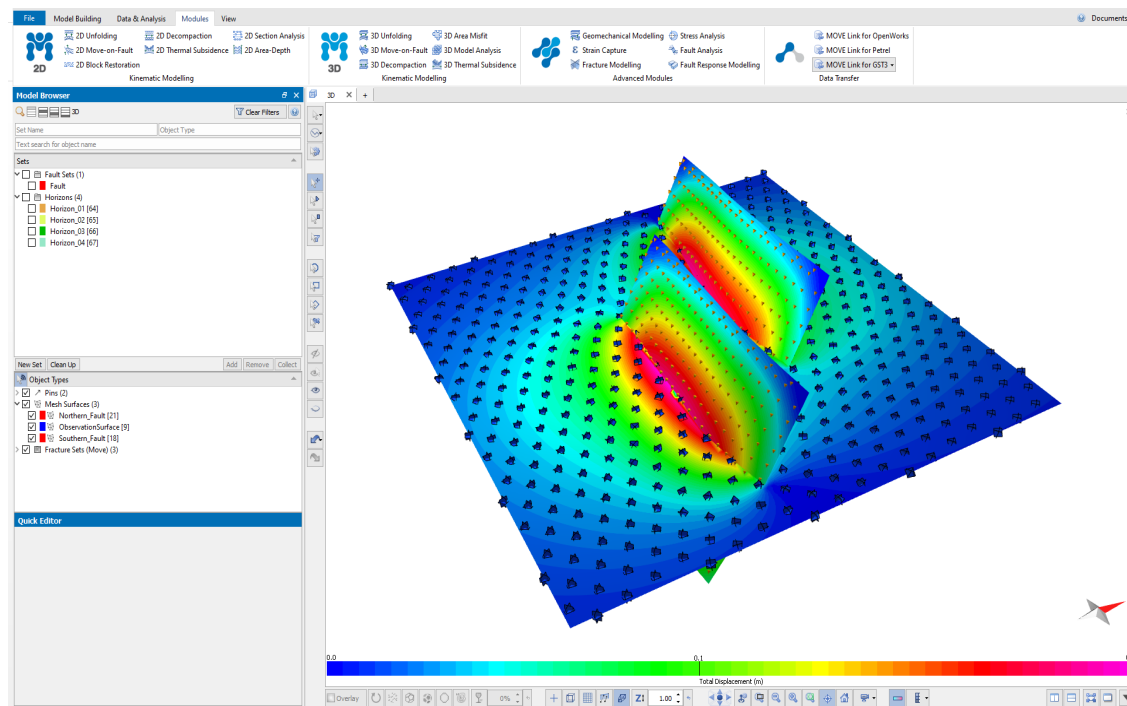
Results of Fault Response Modelling simulations can be used to predict near fault fractures which has direct applications for many sectors including hydrocarbons, mining and geothermal.

Fractured reservoir potential can be evaluated, and the risks associated with drilling near faults can be better understood. Areas near faults, which may have acted as conduits for upwelling mineralizing fluids, can be assessed and the results used for exploration and development of a wide range of mineral deposits, for example Carlin-type deposits.

- Calculate the displacement on faults from a regional stress field
- Compute and visualize displacement, strain and stress induced by faulting
- Predict spatial distributions of sub-seismic fault and fracture systems
- Assess the reactivation potential of faults and fractures



- Ability to model a wide range of scenarios: displacement on faults can be individually defined or calculated from a user-defined regional stress field, with the ability to model strike-slip or dip-slip movement, as well as to account for an opening/closing component of displacement.
- Complex geometries of faults and other discontinuities can be modelled, including enclosed bodies like salt diapirs and igneous intrusions.
- The inclusion of Slip Zone Modelling (Jeyakumaran 1992) using an iterative or direct solver allows the user to model realistic slip profiles and strain transfer between faults.
- Displacement, strain and stress are calculated at observation points in the surrounding rock volume with defined elastic and mechanical properties. These properties can either be constant or vary through the surrounding rock mass.
- Relationships between shear and normal stress can provide information about fracture intensity, mode of failure and reactivation potential.
- Shear and normal stress components can be calculated for fault and fracture systems.
- Optimal fracture orientations can be derived by using the shear and normal stress components to identify the fractures with highest Coulomb Stress.
- Fracture sets can be filtered based on fracture stability and Coulomb Stress failure, allowing the fractures exceeding the failure criteria to be easily visualized.
- Different fracture sets can be generated and compared to the orientations of real fractures using Angular Misfit.
- Pressure perturbations around reservoirs can be simulated by calculating the displacement induced by pressure acting on a triangulated surface. The Boundary Element Modelling approach provides rapid results, and the ability to model multiple scenarios quickly.
- Monte Carlo Stress Inversion: an iterative-statistical approach to reduce uncertainty when calculating principal stress orientations and ratios from earthquake or microseismic data.

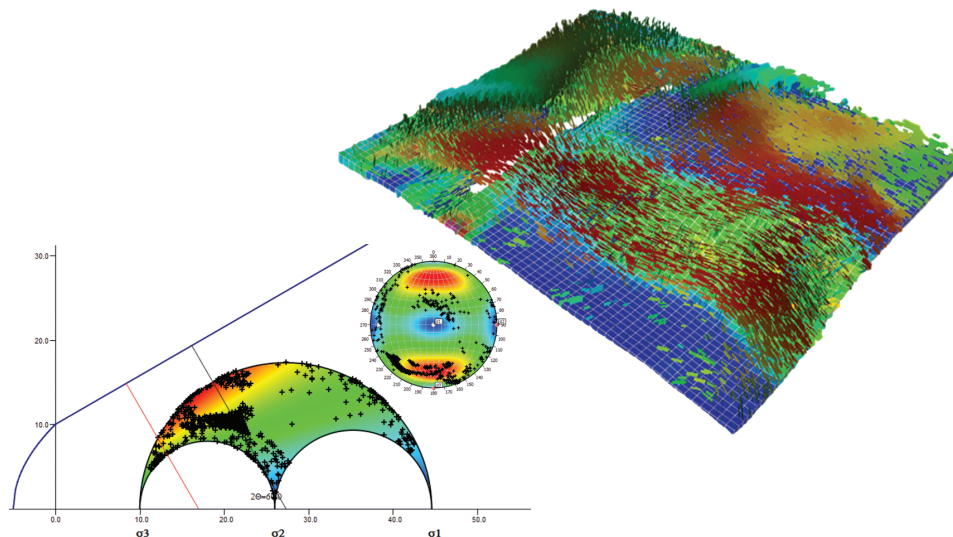


Jeyakumaran, M, Rudnicki, J.W, Keer, L.M., 1992, Modeling slip zones with triangular dislocation elements; Bulletin of the Seismological Society of America, Vol 82, no. 5, p.2153-2169.



STRESS ANALYSIS

A tool for quickly evaluating the geomechanical response of geological structures to stress field scenarios, such as present day or paleo-stress. Additionally, a tool for inverting stress fields from lineation data and loading micro-seismicity data for integration with other data in MOVE™.



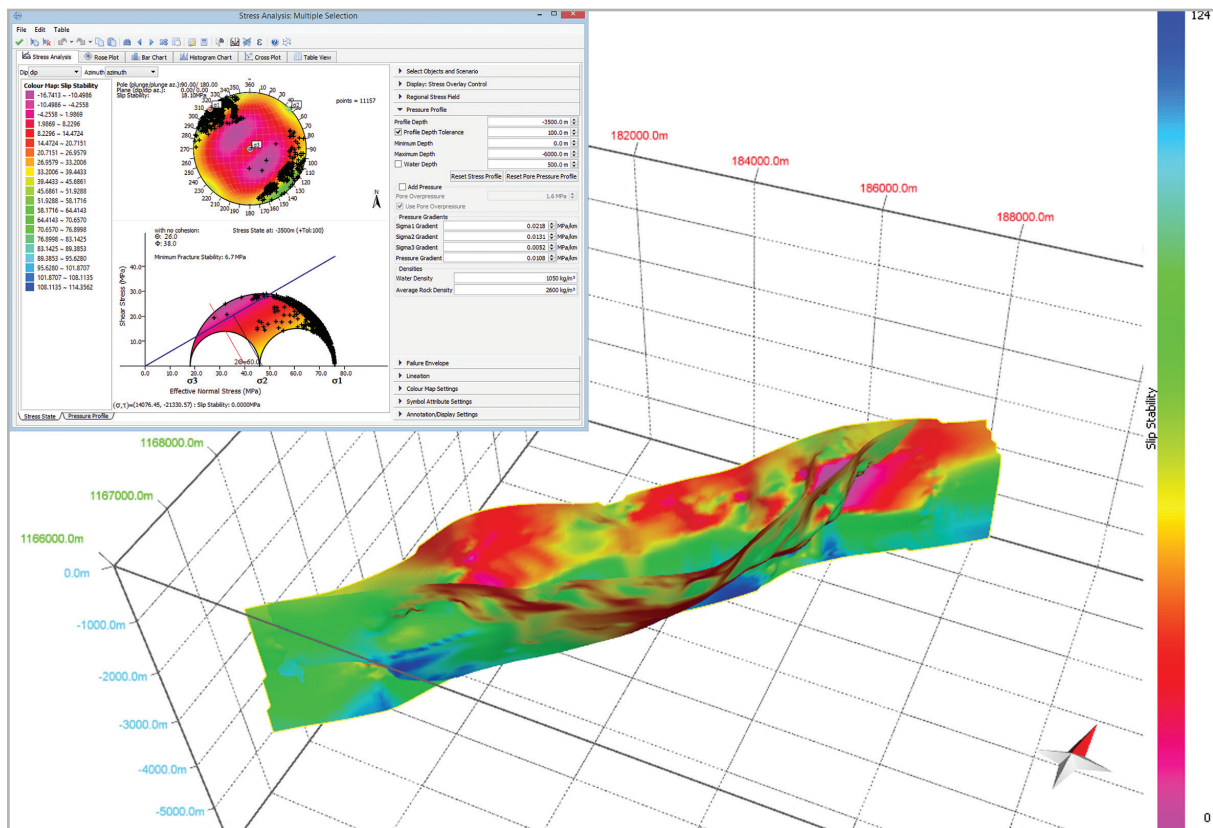
The Stress Analysis module is a tool for assessing the geomechanical response of geological structures (e.g. faults and fractures) to an applied stress field. The orientation and magnitudes of the principal stress axes are easily defined in the tool, either manually in the toolbox or interactively in the stereonet. Stress magnitudes can be set as linearly increasing with depth or variable, using a pressure profile. Stress field scenarios can be saved to objects, allowing for quick scenario testing..

Once a stress field is defined, the effect of the stress field can be rapidly visualised and evaluated, both graphically and in 3D. Filtering of the results can be used to identify areas of greatest mechanical instability, which might indicate sweet-spots or reveal potential migration pathways or spill points. The tool has many applications in the hydrocarbon, mining, geothermal, CO₂ storage, and engineering sectors.

- Visualisation of geological features (planes and lineations) on a stereonet and Mohr diagram.
- Definition of a tri-axial stress system ($\sigma_1 > \sigma_2 > \sigma_3$), with depth-dependent stress magnitude and pore pressure.
- Calculation of mechanical stability parameters (e.g. slip tendency and fracture stability) of features under any applied stress.
- Colour and visualise the mechanical stability of features in 3D.



- Freedom to define any stress regime scenario and a Mohr-Coulomb failure envelope suitable for the material being investigated.
- Visual display of shear and normal stress values when moving the cursor over the stereonet plot.
- Colour mapping of the stereonet plot and Mohr diagram for each stress attribute allowing easy assessment of likely unstable orientations.
- Compute and save stress-related attributes for slip tendency, dilation tendency, fracture stability, slip stability, retention capacity and leakage factor of planes and lines.
- Inversion of fault kinematic indicators (slickenlines) to derive a regional stress state.
- Moment tensor decomposition from earthquakes and focal mechanism display (beachballs).



Geological model of La Concepción field provided courtesy of Petrobras S. A. Caracas.



MOVE LINK FOR PETREL*

MOVE™ Link for Petrel provides a means for Petrel users to share data with Petex's structural modelling and analysis software suite **MOVE**.

- Achieve fast, direct transfer of data from Petrel to **MOVE** and back again
- Once data is in **MOVE**, it is possible to perform the full range of restoration, validation, balancing and advanced structural modelling workflows.
- The Petrel Input and Models panes are replicated inside **MOVE** to allow easy and fast selection of objects to be transferred.
- Interactively add and remove data objects from the session, even if the connection between **MOVE** and Petrel is closed.
- Automatically detects changes to geometry and attributes and allows these to be saved back to Petrel.
- Provides support for 3D grids, horizon surfaces, fault surfaces, point set, triangle mesh, fault sticks, fault and horizon interpretation, structured surface objects, fracture sets and attributes, 2D/3D seismic data and wells including markers and logs.
- Ability to transfer complete 3D grids with functionality to extract horizon and fault surfaces.
- Fault sticks can be extracted from 3D grids and well logs can be excluded when transferring wells so that trajectory and marker information may be transferred faster.
- Contents of Petrel Interpretation Windows can be transferred as **MOVE** Sections.
- Updated to support latest versions.

* Mark of SLB

MOVE LINK FOR OPENWORKS

The **MOVE** Link for OpenWorks lets **MOVE** users import their data directly from a Landmark OpenWorks R5000 data store.

Once in **MOVE**, it is possible to perform the full range of restoration, validation, balancing and advanced structural modelling operations.

There is support for multiple OpenWorks data object types including seismic data and faults plus horizon extraction.

- Validate your models without the need to export ASCII using the **MOVE** Link for OpenWorks.
- Achieve fast, direct transfer of data from R5000 to **MOVE**.
- Interactively add and remove data objects from the session.
- Pull a subset of objects from R5000 via a **MOVE** standard tree view.
- Supports geometry and attributes.
- Provides support for data types including faults, grid surfaces, horizon 2D data, horizon 3D data, 2D/3D seismic data and well tracks.
- Provides a detailed OpenWorks model description and attributes output.

MOVE LINK FOR GST

Share project data across your organisation using the **MOVE** Link for GST (Geosciences in Space and Time).

The **MOVE** Link for GST provides a direct, two-way link to Giga Info Systems (giga-infosystems.com) and the GST Database solution. This allows you to share the results of **MOVE**'s full range of restoration, validation, balancing and advanced structural modelling workflows across your organisation and via GST's web-portal. Multiple users can view, edit and query data held within GST directly from the **MOVE** desktop.

- Support for GST 2 and GST 3.
- Fast retrieval of features based on spatial locations, geometry type and schema.
- Supports point, line, polygon, mesh, and GST Block Models.
- Compatibility with Regular 3D Grids.
- Features retrieved from GST are fully integrated with standard **MOVE** tools.
- Automatic filtering of connections streamlines the loading of features.
- Edits can be saved back to GST storage or kept within **MOVE**.
- Auto Match speeds up matching attributes for upload.
- Using full or partial locking, multiple users can make and save changes at the same time.
- Changes to GST features made by other users can be applied to update existing **MOVE** documents with a single click.
- Data is held securely within corporate database systems and can be shared with other **MOVE** users or via GST Desktop and Web Interface.
- Updated to support latest versions.



DIGITAL FIELD MAPPING

Collect data in the field ten times faster than using traditional methods with our two applications for field geologists.



FIELDMOVE CLINO

FieldMOVE Clino (Clino) is a **free** digital compass-clinometer app for gathering geological data on your smartphone. The app allows you to use your phone as a traditional hand-held bearing compass, as well as a digital compass-clinometer for measuring and collecting georeferenced orientations of planar and linear features in the field. You can also capture and store geo-referenced text notes and photographs within the app.

Clino been designed and optimised for compact iPhone and Android smartphone devices.

Summary of features:

- Digital compass clinometer using device internal sensors to quickly measure the orientation of planar and linear features in the field, which are then recorded and georeferenced.
- User defined list of rock units or stratigraphy.
- Digital notebook and camera within the app allowing geo-referenced text notes, photographs and screenshots to be captured and stored.
- Geo-referenced basemaps in MBTile or GeoTIFF format can be imported and stored on the device for use where mobile data is not available, or use online map services.
- Automatic positioning using the GPS in your device or manual over-ride.
- Use Bluetooth GPS (iOS tested).
- Easy editing of data and projects.
- Expanded library of symbols for planar and linear data.
- Data can be plotted on stereonets in the App, allowing users to analyse and plan based on field observations and measurements.
- Draw contacts, faults and outcrop polygons on your chosen basemap (iOS only).
- Export your data as **MOVE™** (.mve) or CSV files to load into other applications such as **MOVE**.
- Export your data as KML (.kmz) for integration with Google Earth or FieldMove (.fm.zip) to share or load into another FieldMOVE or Clino device.

FIELDMOVE

FieldMOVE is a free map-based app for digital field mapping and geological data capture. The app is presented in a map-centric format for use on larger touchscreen tablets. You can use the drawing tools, which include a virtual cursor, for precision drawing to add georeferenced geological boundaries, fault traces and other linework to your basemap. It is also possible to create simple polygons to show the extent and distribution of rock types and other geological features.

FieldMOVE is designed for Apple and Android tablets and has the following features in addition to those of Clino:

- Virtual mouse for creation of detailed linework.
- Interactive editing of linework and the ability to sketch on captured photographs.
- Ideal for devices with screens larger than 7".
- Layering of map images with adjustable transparency.
- Map-centric workspace.
- Supports Mapbox™ online maps and can cache this extensive online map service to work offline in the field.

A more in-depth user guide and brochure is available on our website: www.petex.com/products/move-suite/digital-field-mapping

FieldMOVE and FieldMOVE clino are available to download from the following app stores:



3000 Cathedral Sq.
Cathedral Hill,
Guildford,
Surrey,
GU2 7YB, UK

Tel: (44) 131 474 7030

Fax: (44) 131 474 7031

Email: edinburgh@petex.com

www.petex.com



Petex
