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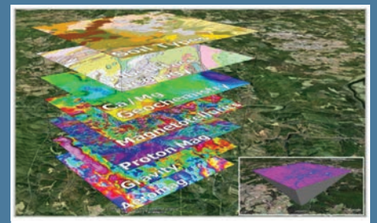
- Digital Well/Borehole Log and Cross-Section Creation
- Well/Borehole Geophysics

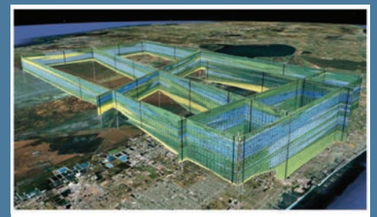
RockWare Consulting

You provide the data, we'll provide the...

Video Animations

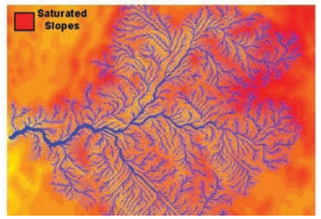


Virtual Tour Depicting Data Sets Available For Study Site as Floating Layers

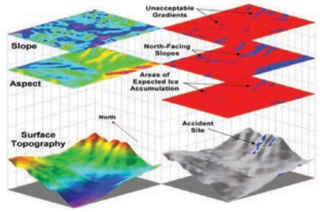


Virtual Tour Depicting Hydrostratigraphic Framework of Miami, Florida Area

Maps

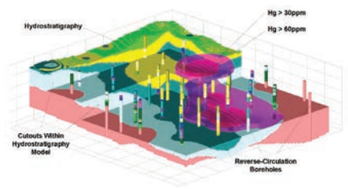


Insurance Risk – Saturated Slope Failure

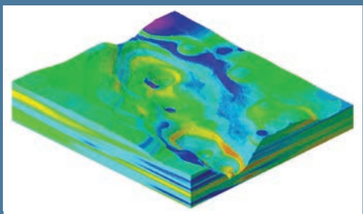


Accident Site Associated with Poor Zoning

Three-Dimensional Diagrams

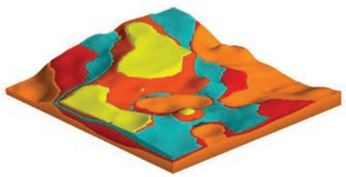


Hydrostratigraphy and Geochemistry

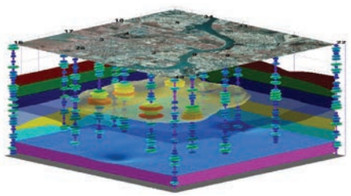


Complex, Inter-Fingered Geology Color-Coded by Hydraulic Conductivity

Volumetric Computations

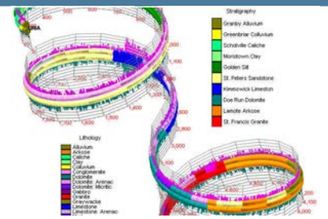


Shopping Center Site – Preparation Volumetrics

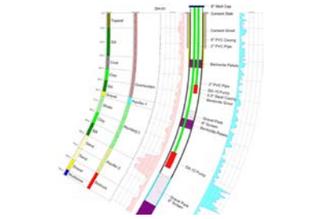


Hydrocarbon Reservoir Volumetrics

Log Digitizing

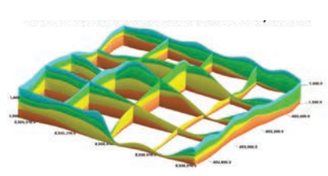


Shopping Center Site – Preparation Volumetrics

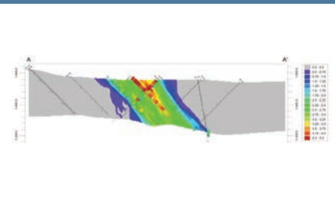


Shopping Center Site – Preparation Volumetrics

Cross-Sections



Stratigraphic Layers Beneath Litigation Site



Hydrothermally Mineralized Vein

Case Study: Using RockWorks to Identify Contiguous Zones of Favorable Hydraulic Conductivity Based on Borehole Resistivity Data

The purposes of this study are to illustrate how RockWorks may be used to show variations in short-normal resistivity within the Upper Pierre Aquifer, identify porous zones for optimal water production, demonstrate the use of grids as constraining surfaces when creating block models, delineate contiguous hydraulically-communicative zones of high resistivity, and establish resistivity cutoff values for comparison with other aquifers.

Obtaining the Raw Data: A dataset of well locations and Log ASCII Standard (LAS) files created by the Colorado Division of Water Resources (CDWR) were downloaded from the Colorado Geological Survey website at the URL listed below.

https://coloradogeologicalsurvey.org/2017/1262-water-resources-upper-pierre-aquifer

Displaying the Raw Data: The locations and associated LAS files (Figure 1) from 167 of the CDWR wells were imported into a RockWorks database. Please note that the CDWR data includes 226 wells, however this study only used the 167 wells with associated LAS files.

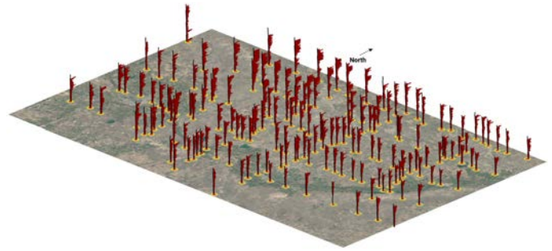


Figure 1. Well Locations & Resistivity Logs – Vertical Exaggeration – 16X

Cleaning the Data: A histogram of the initial 630,695 short-normal resistivity data point (Figure 2) showed that the outlier values needed to be truncated in order to properly evaluate the data. Accordingly, values less than 1.5 ohm-meters were discarded while values greater than 20 ohm-meters were truncated to 20 ohm-meters. As a consequence, a histogram of the data (Figure 2) exhibits an expected log-normal distribution.

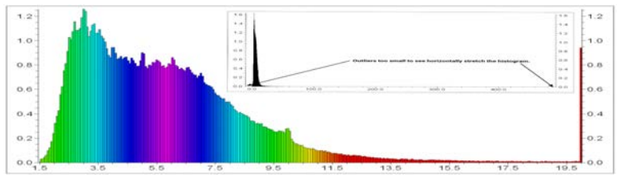


Figure 2. Distribution of Resistivity Values After Truncating Outliers

Constraining Surfaces: Grid models representing the top and base of the aquifer (Figure 3) were kriged to serve as constraining surfaces for subsequent resistivity modeling. These contacts were identified by using the interactive Stratigraphy Picker.

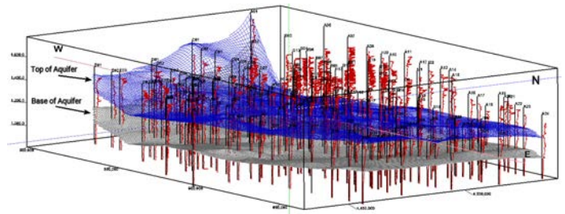


Figure 3. Constraining Surfaces Representing the Top & Base of the Upper Pierre Aquifer – Vertical Exaggeration = 40X

Creating the Resistivity Model: A horizontally-biased inverse distance weighting algorithm as constrained and "warped" by the aquifer base and top grids was used to create a block model based on the truncated resistivity values (Figure 4). The 8.8 million voxels within this model measure 1,000 x 1,000 x 2 meters (3,281 x 3,281 x 6.6 feet).

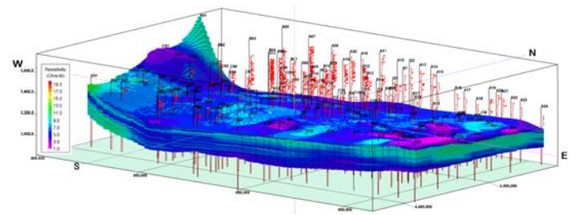


Figure 4. Resistivity Block Model – Vertical Exaggeration – 40X

Resistivity Within the Aquifer: A histogram of the resistivity model voxels (Figure 5) shows a mean value of 7 ohm-m with a standard deviation of 1.8.

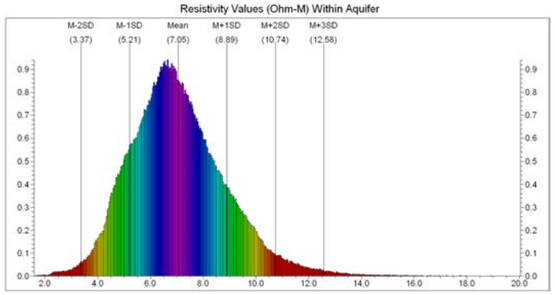


Figure 5. Histogram of Resistivity Model Node Values

Identifying Optimal Zones Within the Aquifer: In an effort to categorize porosities within the aquifer, the resistivity values were assigned colors based on the following statistical groupings;

- Yellow (Low Porosity): Resistivities less than the mean minus one standard deviation.
- Orange (Medium Porosity): Resistivities between the mean minus one standard deviation and the mean plus one standard deviation.
- Red (High Porosity): Resistivities greater than the mean plus one standard deviation.

The color-coded inferred porosities were displayed as a block diagram with cutouts to view inside the model (Figure 6) and as a fence diagram (Figure 7).

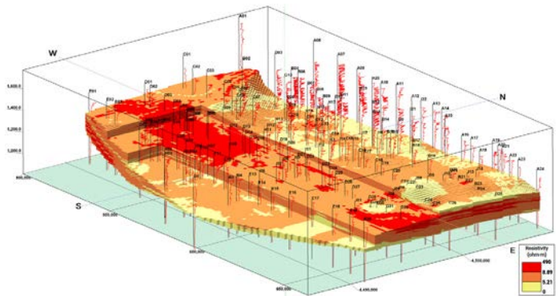


Figure 6. Cutaway Rendering of Resistivity Block Model Color-Coded by Statistical Groupings – Vertical Exaggeration = 40X

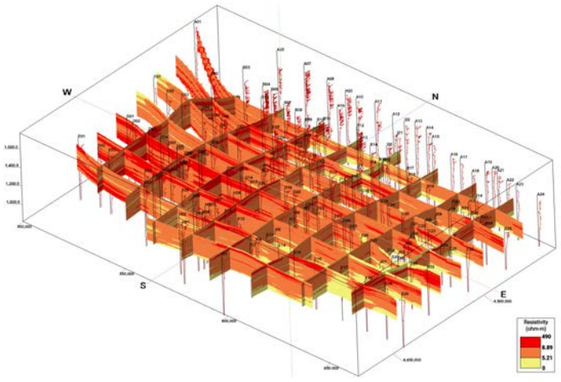


Figure 7. Fence Diagram Depicting Vertical Slices Within Resistivity Model Color-Coded by Statistical Groupings – Vertical Exaggeration = 40X

Refining the CDWR Sections: A section from the resistivity model was created to match and overlay onto the CDWR E-E' section (Figure 8).

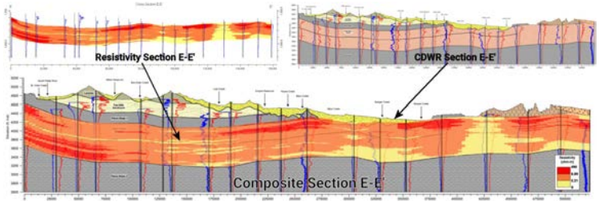


Figure 8. Resistivity Overlain on CDW Section E-E'. – Vertical Exaggeration = 40X

Creating a Grade x Thickness Aquifer Isopach: Aquifer Isopach: In order to accommodate the variations in the aquifer thickness, a Grade Thickness (GT) grid model (Figure 9) was created in which every voxel within the resistivity block model was multiplied by the voxel height and the sum of each column of voxels was calculated. This is a tool that is used within the uranium industry to qualify resource estimates by assigning proportional weighting to zones that are both thick and higher grade. In this application, the GT map shows where the aquifer is both thick and porous based on the assumption that resistivity is proportional to porosity. Note the differences between this map and the aquifer isopach. This map is intended to serve as an exploration tool when placing water wells for optimal production.

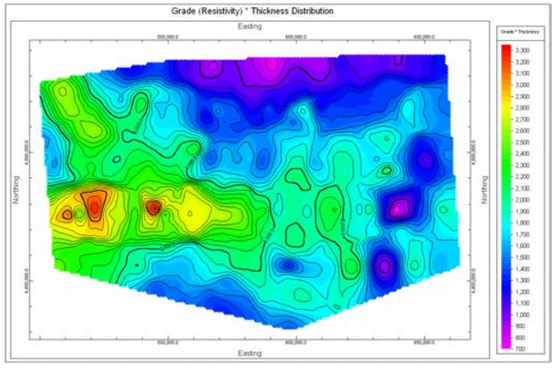


Figure 9. Resistivity * Thickness (GT) Map

Identifying Contiguous Zones: Finally, a "geobody" filter was used to identify the three largest contiguous high-resistivity (>8.9 ohm-m) zones based on the assumption that these bodies represent connected zones of optimal porosity/permeability (i.e., zones that hydraulically communicate). Although a three-dimensional diagram (Figure 10) suggests that these geobodies are connected, two-dimensional vertical slices (Figure 11) illustrate their disconnectedness.

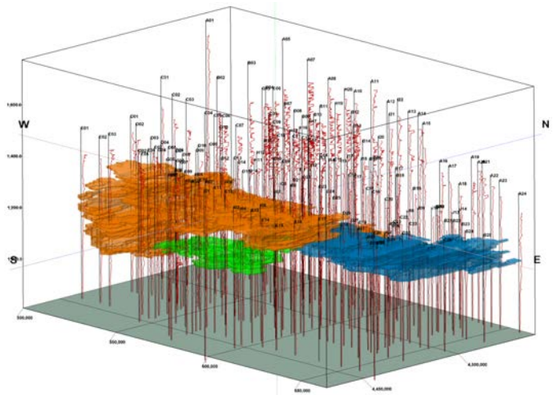


Figure 10. Three Largest Geobodies – Vertical Exaggeration = 100X

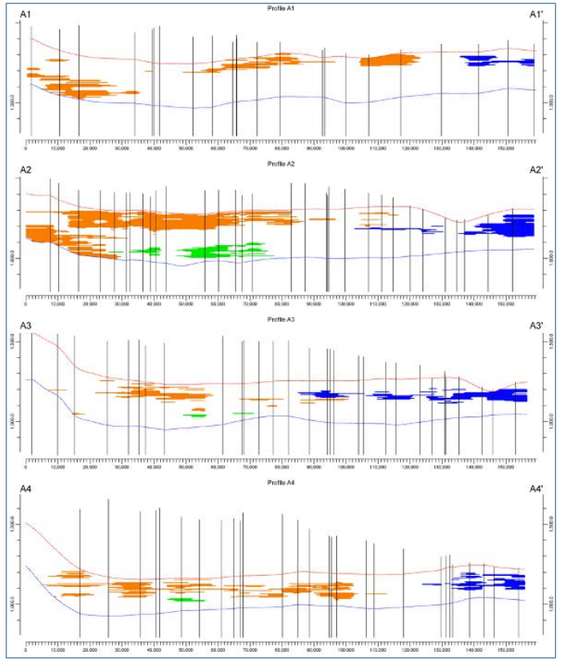


Figure 11. Cross-Sections Depicting Three Largest Geobodies – Vertical Exaggeration = 50X

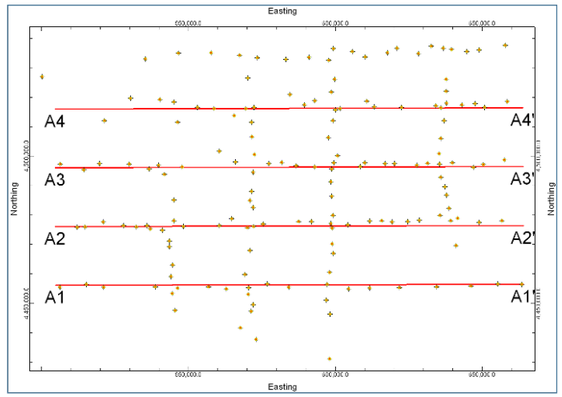


Figure 12. Cross-Section Locations

Automating the Process: All of the steps that were used to produce the models and diagram were saved within a RockWorks playlist (Figure 13).

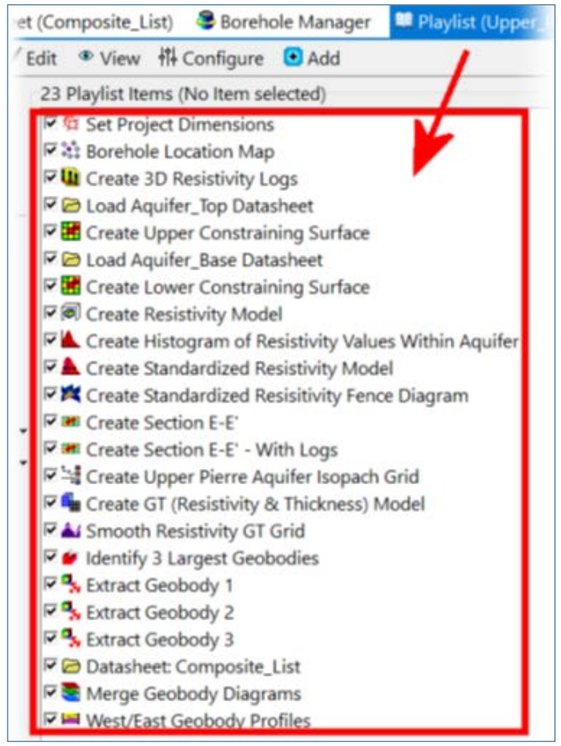


Figure 13. Playlist Used to Generate Models & Diagrams Within This Report

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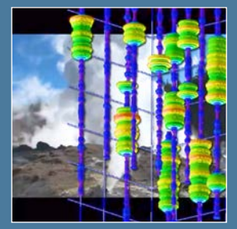
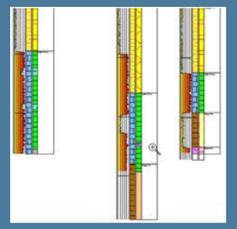
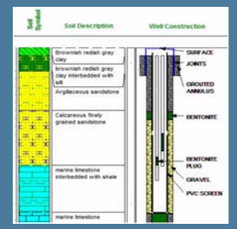


Geothermal

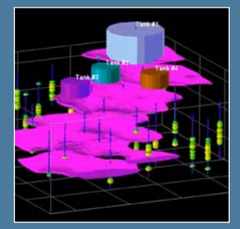


Training Videos

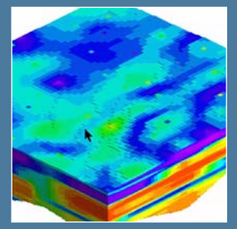
Tunneling



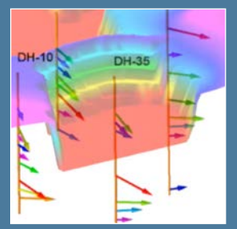
LogPlot Overview



Contaminant Plume Modeling



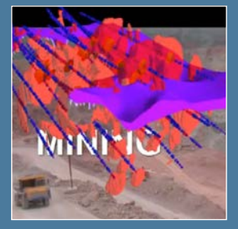
RockWorks Overview



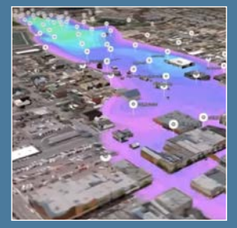
Dam Sites

Cone Penetration Testing

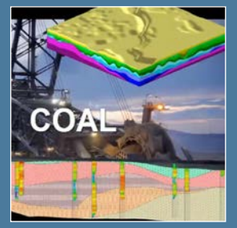
RockWorks Training Videos



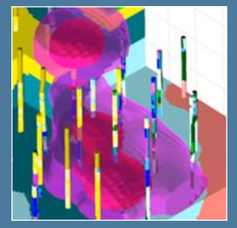
Mining



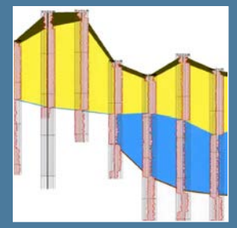
Groundwater Contamination



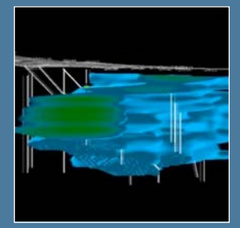
Coal Multi-Seam / Multi Attribute Modeling



Landfills



Hydrocarbon Exploration



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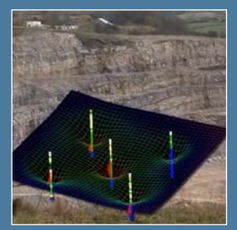
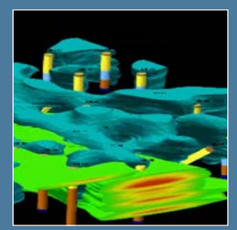
Geotechnical Soil Investigations

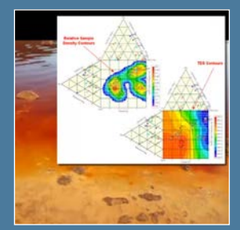
Industrial Minerals



Groundwater

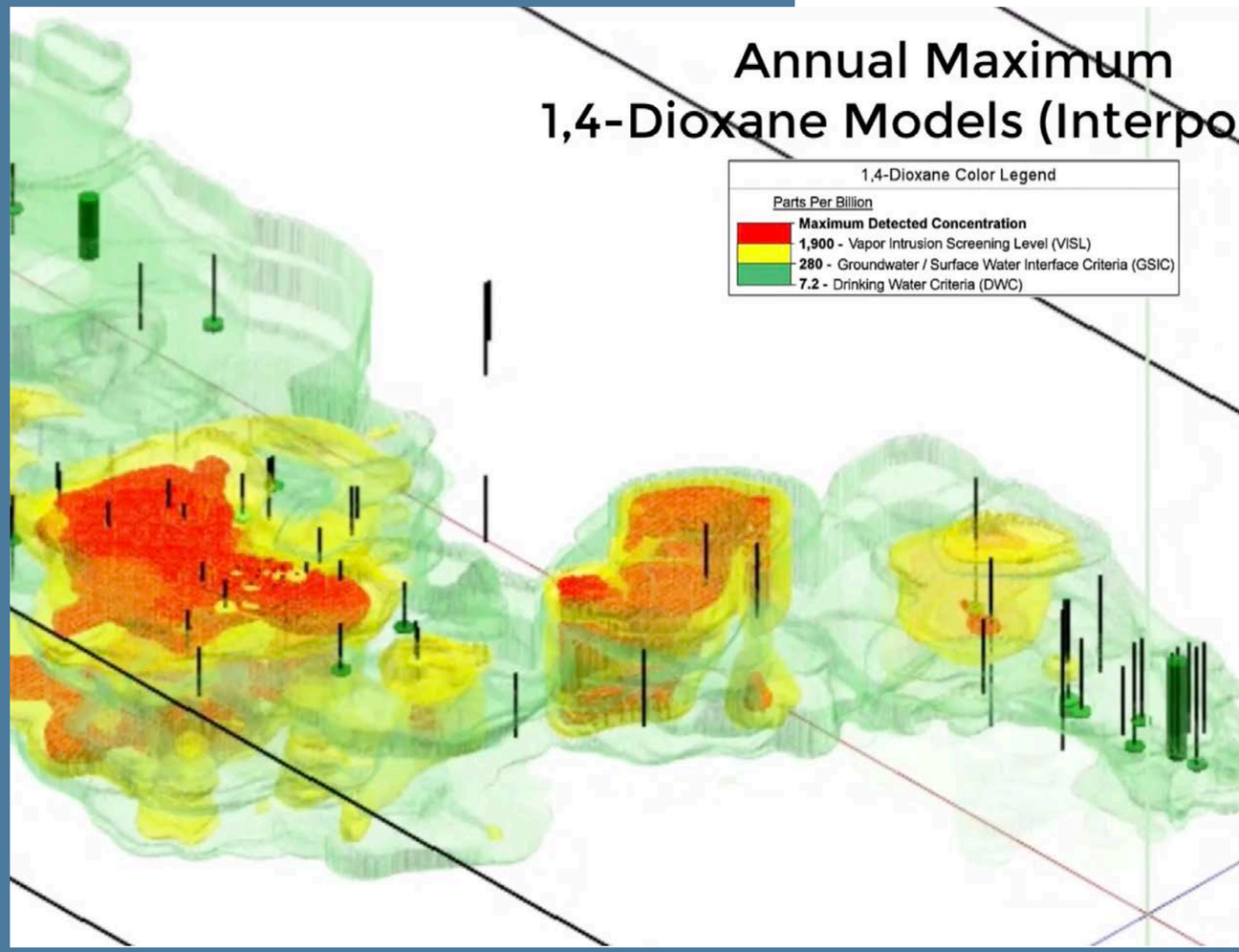


RockWorks New Features



Hydrochemistry

RockWorks®



RockWorks® is a comprehensive program that offers visualization and modeling of spatial data and subsurface data. Whether you are a petroleum engineer, environmental scientist, hydrologist, geologist or educator, RockWorks has what you need.

What's New in RockWorks®

RockWorks contains tools that will save time and money, increase profitability and provide you with a competitive edge through high-quality graphics, models and plots. See what's new!

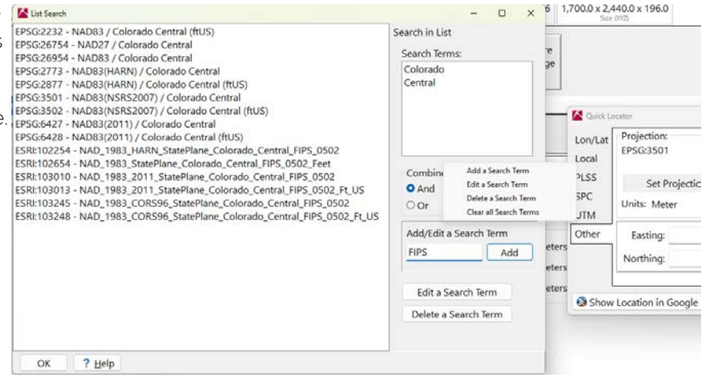
New Features

Mapping

- Improvements have been made to the *contouring and colorfill* programs, resulting in smoother and more consistent 2D and 3D contour maps.
- New *Smooth Contour* option allows contours and colorfills to be smoothed independently of the RwGrd file.
- Improved *3D Contour creation* allows contours to be floated above the 3D surface, eliminating visual conflicts with the underlying colored surface.

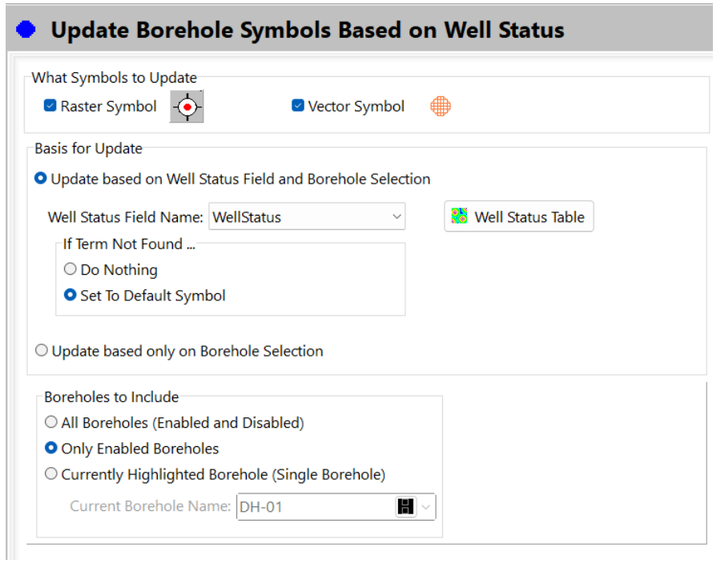
Project Dimensions and Coordinate Systems

- The Project *Coordinate System search* tool has been improved to make searching for Custom Coordinate Systems and Specific EPSG/EPRI codes easier and more complete.
- The user may now import dimensions from *Geo-referenced TIFF files* that are not GeoTIFFs.



Borehole Manager Database

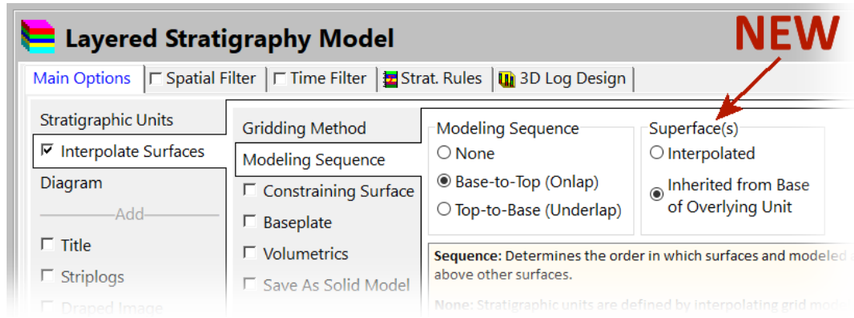
- The Borehole Manager *Edit | Update Symbols* can now update either or both *Raster and Vector* symbols.
- Project and Subsite Dimensions can now be defined based on a Polygon Table stored in the database. Options are included to round calculated borders to whole numbers and to add a perimeter.
- The *Lithology Picker*, *Stratigraphy Picker*, and *HydroStratigraphy Picker* programs now include an option for plotting a previously-created section as the background image. The programs also include a new option for plotting the picks as transparent cross-hatched patterns rather than solid-fills.



What's New Continued

Stratigraphy/Lithology

- New *HydroStratigraphy* and Hydro-Strat Type Tables have been added to the Borehole Manager Database.
- HydroStratigraphy data can now be applied to all Stratigraphic diagrams, including Layered Models, Sections/Profiles, Contour and Isopach Maps and more.
- HydroStratigraphy data is supported in the *Import and Export* menus of the Borehole Manager Database.
- HydroStratigraphy Top, Base and Thickness values can be plotted in *Borehole Location maps*.
- Improvements have been made to the plotting of 2D striplogs containing Stratigraphy data located above the top or below the base of the borehole, allowing users to more easily constrain modeling with additional data.
- *Stratigraphy interpolate surface improvements* include a new option to inherit the base of the overlying unit, which can significantly speed up modeling for projects with continuous downhole data.

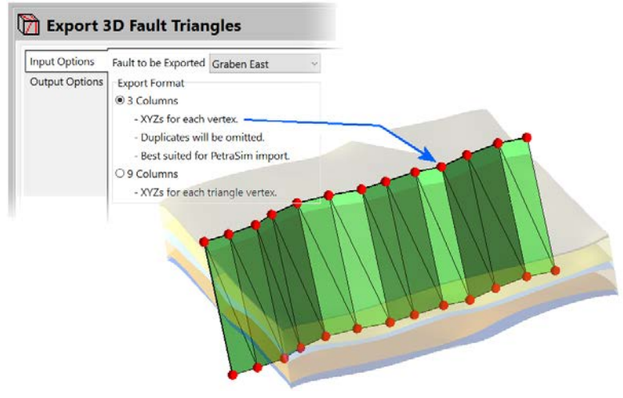


Gridding and Solid Modeling

- The time required to *smooth a grid* while accounting for faults has been significantly reduced.
- During the generation of faulted grids, the program now defaults to plotting fault intersections with the grid being created.
- The ModOps *Volume | Ore Grid* program has been improved to work more reliably with clipping polygons.
- The *Lateral Blending algorithm* has been enhanced to work with angles and warping interpolation options and is also now available for Color Modeling.
- A *new Grid | Rescaling* tool has been created to reproject grids between feet and meters.
- The Grid Export programs now include a bulk conversion option to convert multiple grids in the project folder from RwGrd files to a selected export format.
- Numerous improvements have been made to the *I-Data | GT Compositing* program.

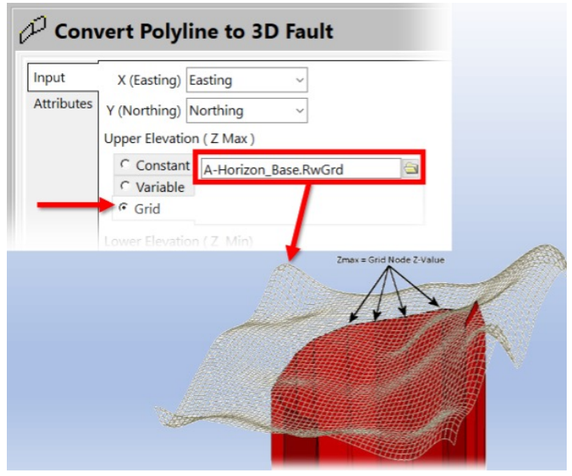
Faults

- 3D fault XYZ and DXF exports have been enhanced to *improve compatibility* with PetraSim and other 3D packages.



Faults Continued

- The new *Polyline -> Fault import* program has been significantly enhanced to create both vertical and angled 3D faults. New features include:
  - o The option to relate the top or base elevation of a fault to a constant elevation, variable elevations stored in an RwDat file, or a RwGrd file.
  - o Multiple options for fault orientation, including vertical, constant orientation, variable orientation, and conical faults.



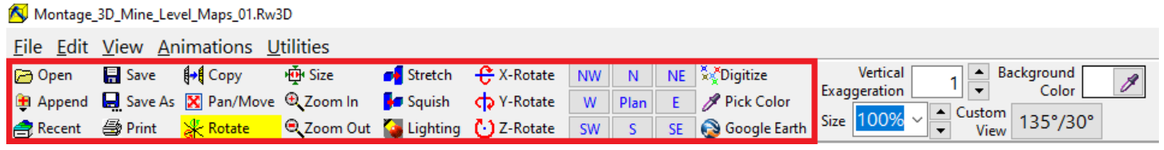
RockPlot2D

- Users can now *select multiple polygons/rectangles*, right click and modify the attributes including the border line, color fill and pattern fill.
- Rectangles can now hide/show the border line and can be filled with patterns in addition to solid colors.
- Vertex editing for lines, arrows, polylines, and polygons has been improved.
- Users can now *save the vertices* of a polyline or polygon to a Datasheet file by right clicking.

RockPlot3D

- Multiple improvements have been made to the handling of *saved Views and View | Dimensions tools*, making it easier to navigate and save composite Rw3D files containing objects of varying scales and dimensions.

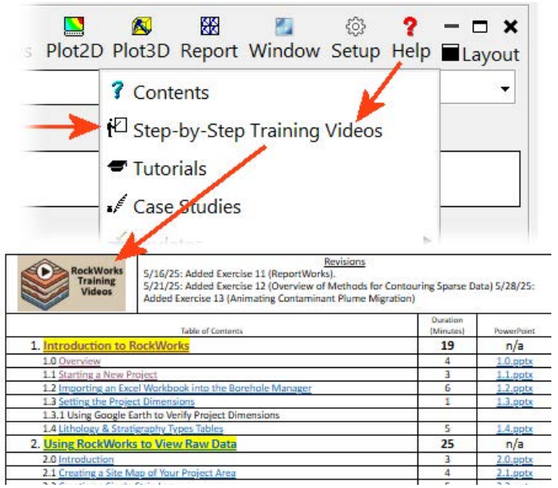
The *RockPlot3D menu panel* has been significantly improved, with many new options added.



- The *Wavefront OBJ* export has been enhanced to support larger models and models that include legends, allowing more complex models to be loaded into Sketchfab™ and other visualization packages.
- A new option to *zoom to an item or group* has been added, allowing the user to zoom to different items within larger composite Rw3D files.

Help and Documentation

- A new *Step-by-Step Training Videos* option has been added to the main Help pull-down menu.
- Multiple new help sections have been added to document new features and previously missing topics.



Interface

- The *Maximize button* behavior is now more consistent when toggling between maximized and non-maximized window states.
- RockWorks windows now properly respond to the Windows display zoom settings specified by the user.
- File names can now be specified via *drag-and-drop* into RockWorks menu dialogs used for selecting input and output files.
- Improvements to *Multi-Threading* provide a clearer and more accurate status bar display, along with overall performance improvements.
- Complex menus, such as Solid Modeling, Contouring, and Striplog Design *now load significantly faster*.

Program Automation using the Playlist

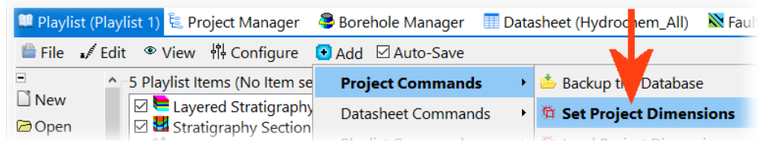
The RockWorks Playlist offers easy automation—just click a button to add a program to the current Playlist. Then, click a button to run your Playlist to create models, maps, diagrams while you have lunch. Available for Basic (5 items), Standard (5 items) and Advanced (unlimited items).

The Playlist provides:

- **A memory aid** for projects that are infrequently re-visited.
- **An audit trail** to serve as a record of what was done and all of the associated menu settings.
- **Turn-key tools** for colleagues or clients who need to use RockWorks capabilities without any downtime spent learning how to use it.
- A **template** for processing different data sets/sites using a streamlined workflow.

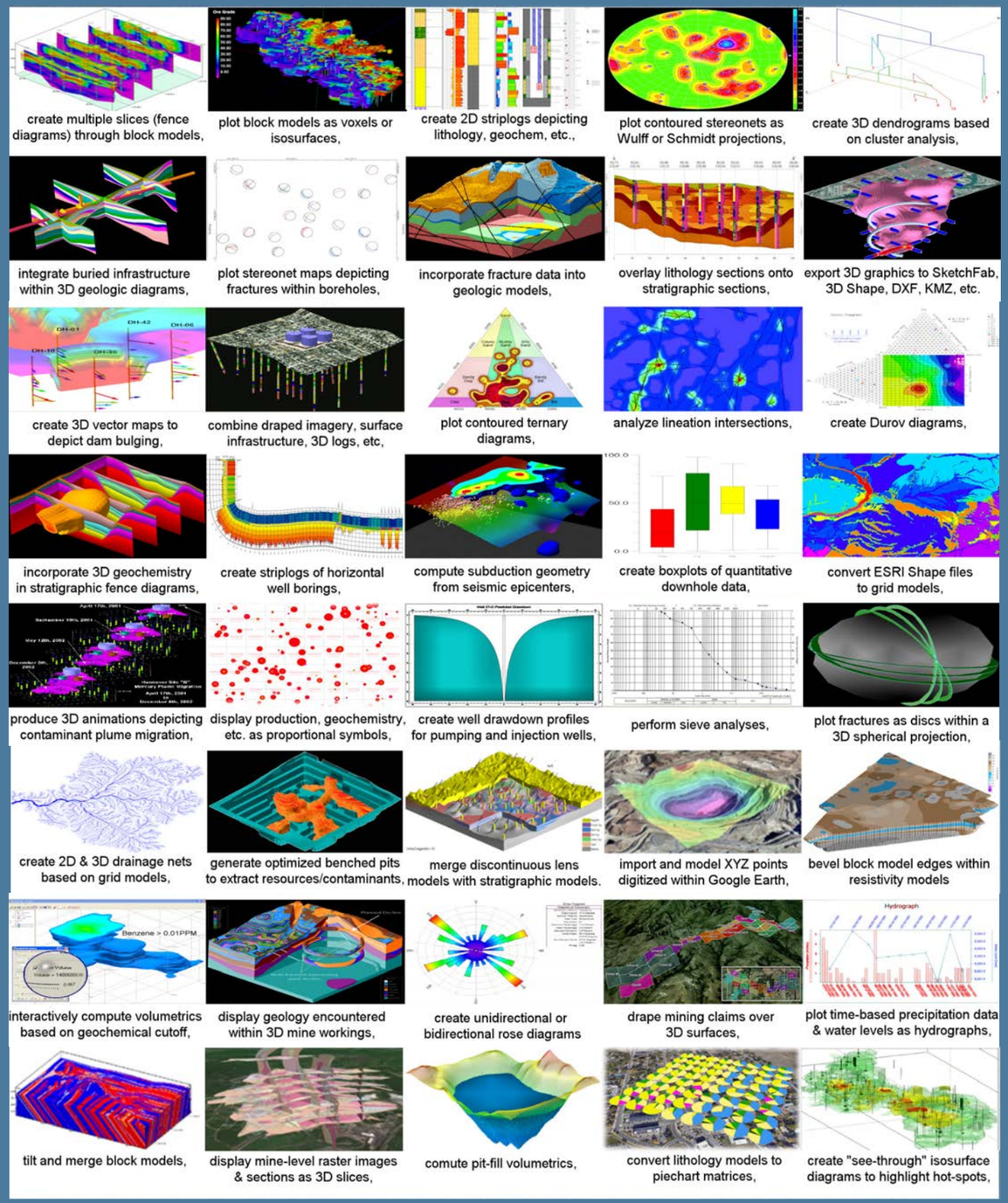
Playlist Improvements:

- Dragging the Playlist output tab now detaches it as a separate dialogue window, improving the user's workflow.
- Tools for editing playlists as text have been refined. Users are prompted to write changes back to the current playlist or save as a new one when editing in an external text editor.
- A new button lets you copy current project dimensions directly into Playlist | Dimensions fields.

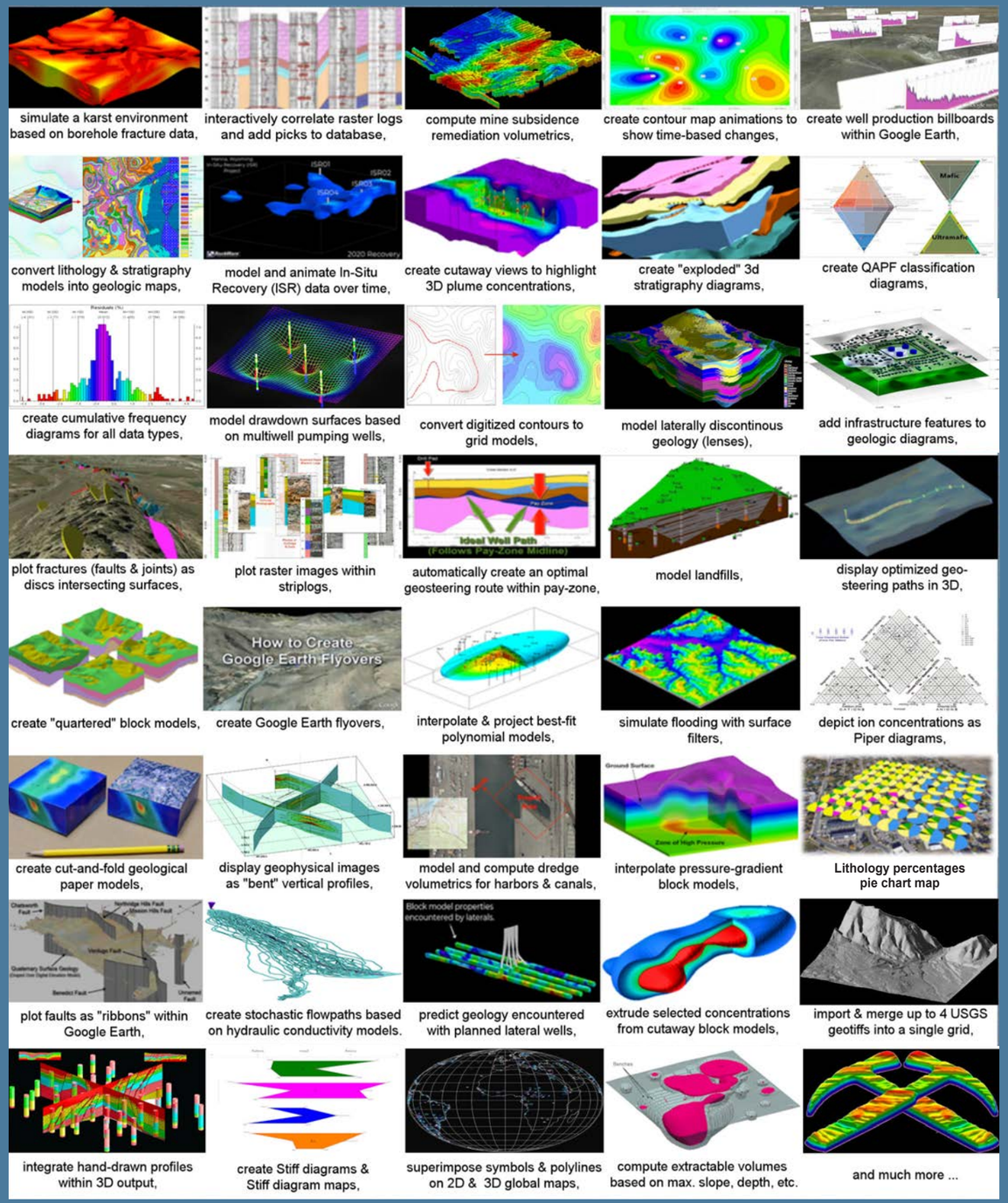


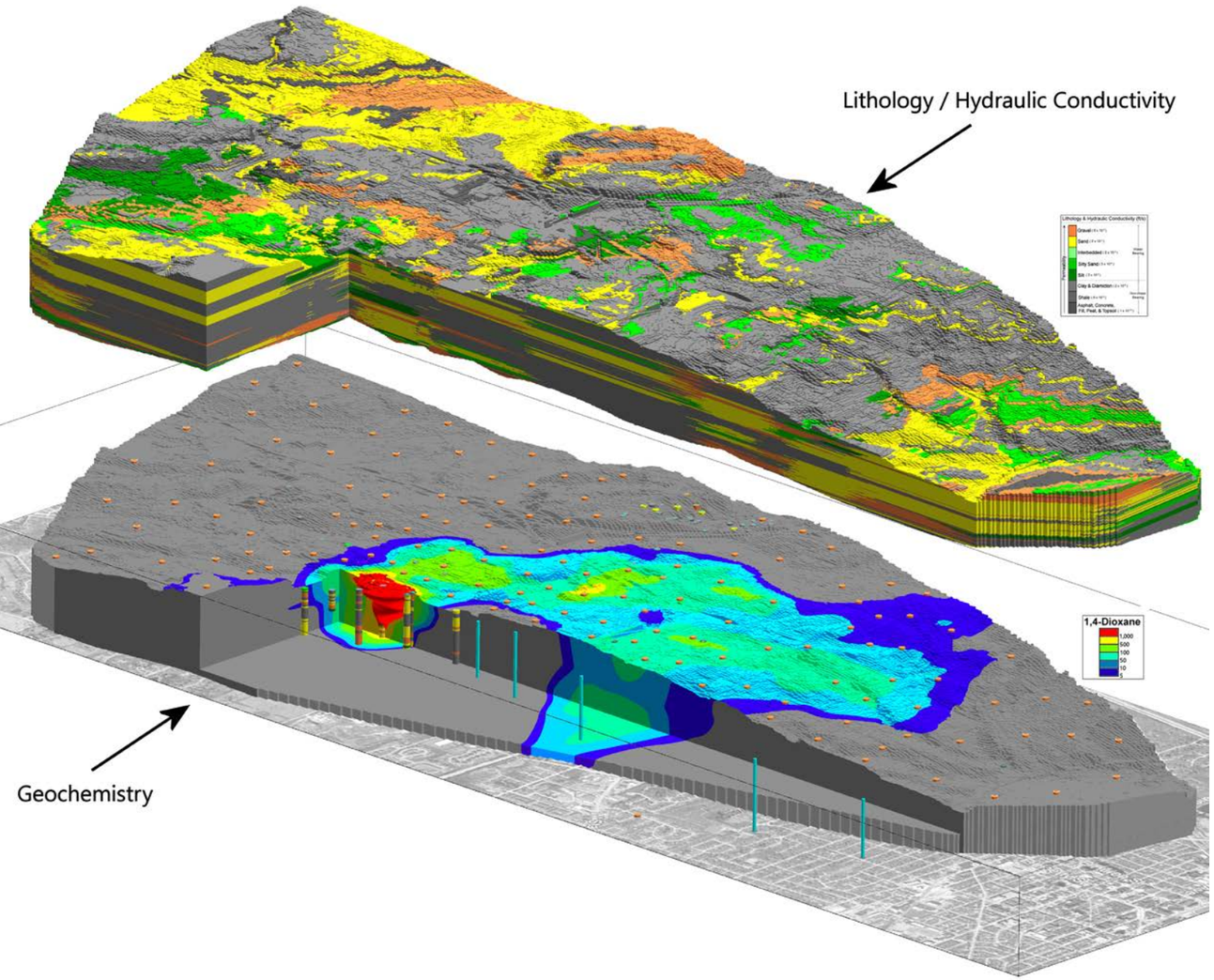
- A new "Subsite" option under Playlist | Add allows for easier switching between subsites within a playlist.

With RockWorks, you can...



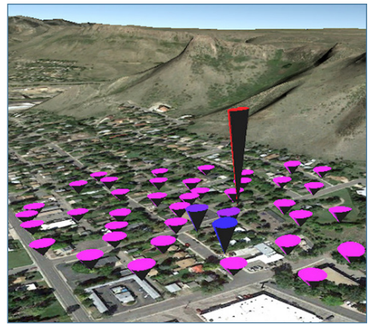
With RockWorks, you can... Continued

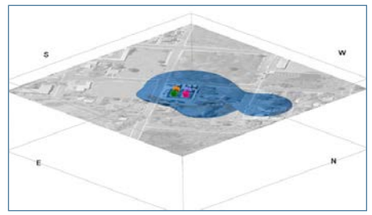


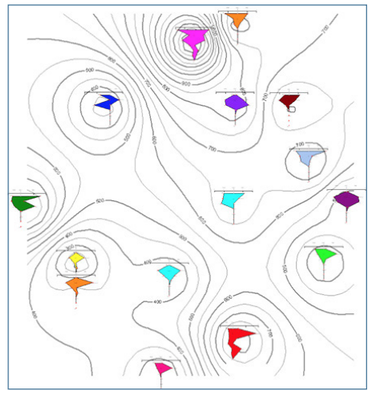


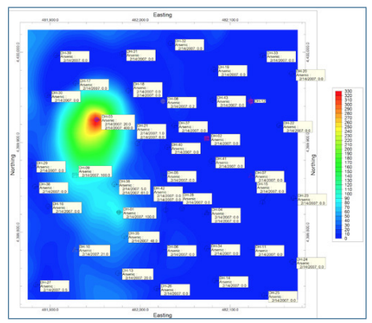
Borehole logs, cross sections, concentration maps, plume models, geology models, time-based animations, geochemistry diagrams and more. RockWorks will help the environmental professional along the path from site characterization to remediation planning and execution.

RockWorks®–Environmental









Mapping Tools

- Borehole location maps with detailed data labels
- Contaminant concentration maps with lines and color fills, custom color tables, date filters
- Plan- and surface-based slices from 3D models
- Stiff diagram maps
- Time-graph maps for user-selected analytes
- Potentiometric surface maps
- Flow maps in 2D and 3D
- Coordinate systems/conversions: lon/lat, UTM, State Plane, local, custom

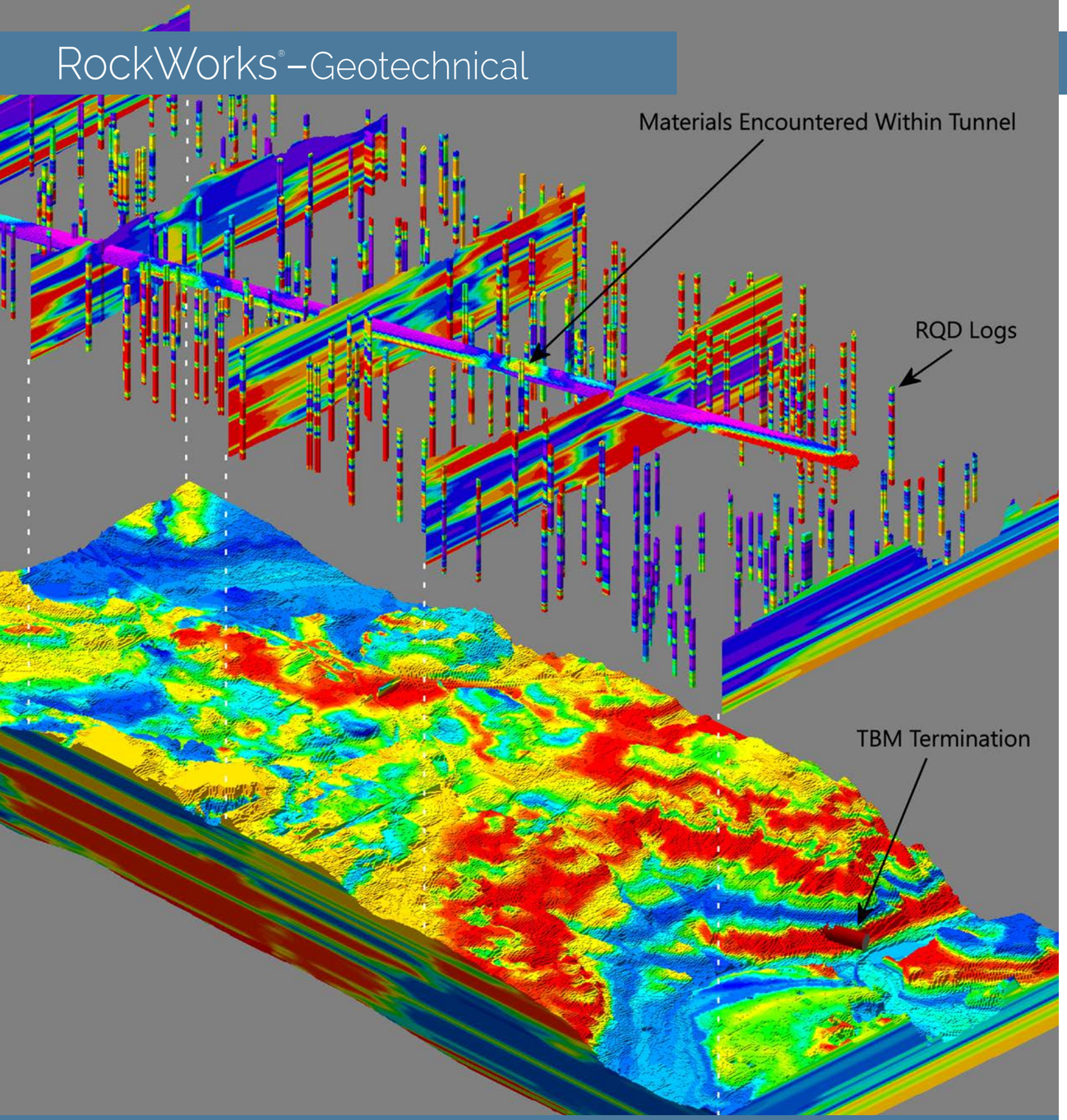
Borehole Database Tools

- Cross sections: multi-panel projected and hole to hole, with borehole logs and/or interpolated panels
- Correlations: model-based and "EZ" panels, snapping tools for hand-drawn correlations
- Borehole logs in 2D and 3D
- 3D fence diagrams
- Surface modeling of stratigraphic layers and water levels
- Plume modeling of analytical data, with display as voxel or isosurface diagrams, 2D plan and section slices
- Solid modeling of lithologic materials, geophysical and geotechnical measurements
- Volume reports of lithologic and stratigraphic models, contaminant extraction models
- Bulk data imports from Excel, text, LAS, other databases

Other Tools

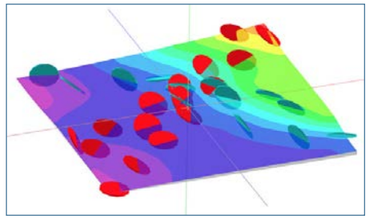
- Time-based animations
- Piper and Durov diagrams with TDS circles, Stiff diagrams for multiple samples
- Water level drawdown diagrams and surfaces
- 2D editing tools: contour lines, text, shapes, legends, images
- Composite scenes in 3D with maps, logs, surfaces, solids, panels, surface objects
- Page layout program for small to large format presentations and posters
- Exports to GIS Shapefiles, CAD DXF, raster formats, Google Earth
- Image import and rectification
- Program automation
- Google Earth output directly from data: points, cones, lines, polygons, images, flyovers

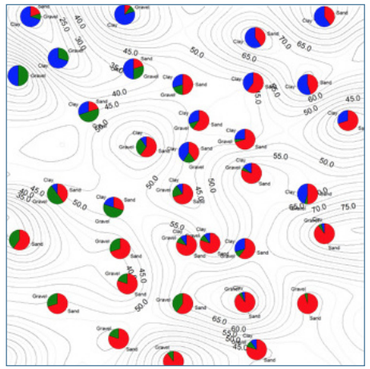
RockWorks®–Geotechnical

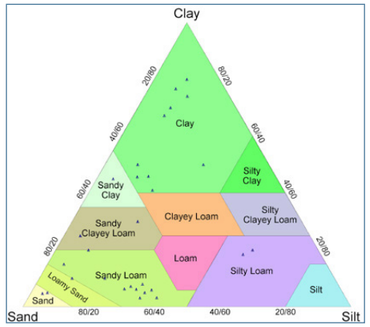


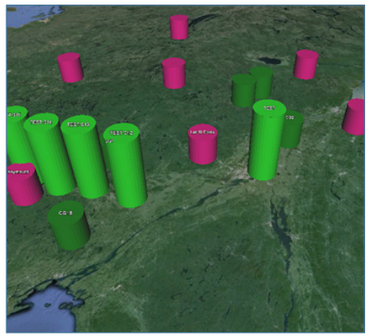
RockWorks offers geotechnical and civil engineers graphical and analytical tools for evaluating construction and excavation sites. Create borehole logs and cross sections, dozens of different types of maps, structural diagrams, geological/geotechnical/fracture/color models, volume reports and more.

RockWorks®–Geotechnical









Mapping Tools

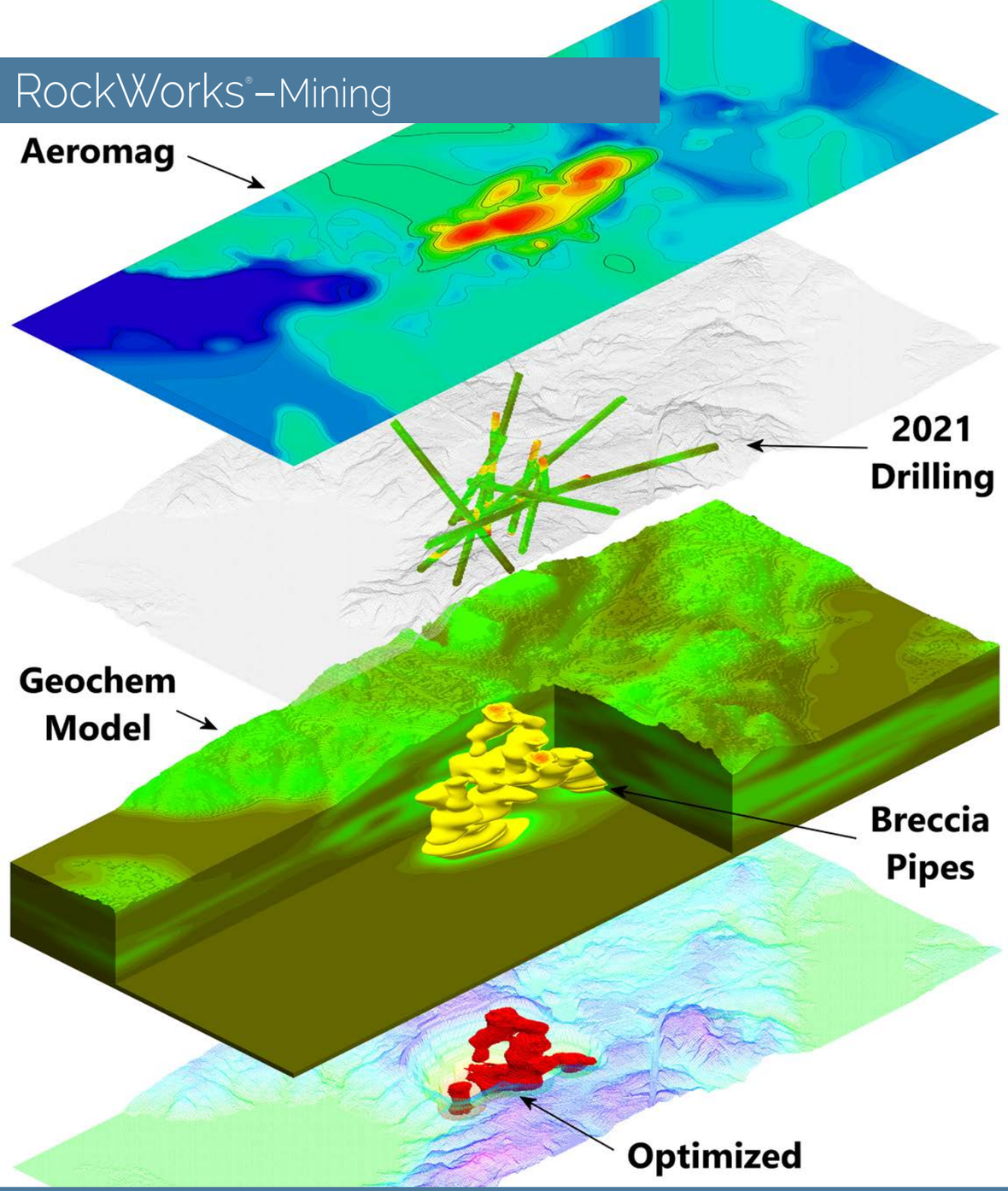
- Multiple components in piechart, spider maps
- Point maps with detailed data labels
- Topographic contour maps with lines and color fills, custom color tables
- 3D surface displays
- Strike and dip maps in 2D and 3D
- Coordinate systems/conversions: lon/lat, UTM, State Plane, local, custom

Borehole Database Tools

- Cross sections: multi-panel projected and hole to hole, with borehole logs and/or interpolated panels
- Correlations: model-based and "EZ" panels, snapping tools for hand-drawn correlations
- Borehole logs in 2D and 3D
- 3D fence diagrams
- Surface modeling of stratigraphic layers and water levels
- Solid modeling of lithologic materials, fractures, and geophysical, geotechnical, geochemical data, with display as voxel or isosurface diagrams, 2D plan and section slices
- Geology maps: plan slices from stratigraphy or lithology models
- Volume reports of lithologic, stratigraphic, excavation models
- Fracture display and modeling, stereonet maps, rose diagram maps
- Munsell colors for display in logs and interpolation into color models
- Data imports: Excel, AGS, Colog, Fugro CPT, gINT, LAS, Penetrometer, other databases

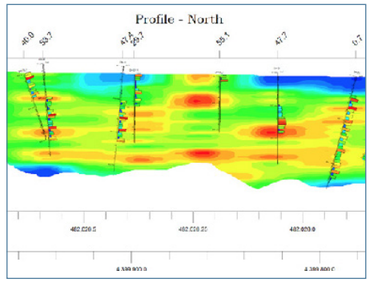
Other Tools

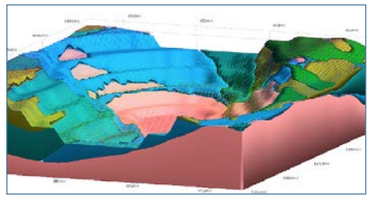
- Sieve diagrams, ternary diagrams with classification overlays
- Stereonet and rose diagrams
- Slope/aspect analysis on grid models
- Predictive tools: lithology materials from curves, interval data (porosities, strength, cohesion) from lithology
- 2D editing tools: contour lines, text, shapes, legends, images
- Composite scenes in 3D with maps, logs, surfaces, solids, panels, surface objects
- Page layout program for small to large format presentations and posters
- Exports to GIS Shapefiles, CAD DXF, raster formats, Google Earth
- Image import and rectification
- Program automation
- Google Earth output directly from data: points, cones, lines, polygons, images, flyovers

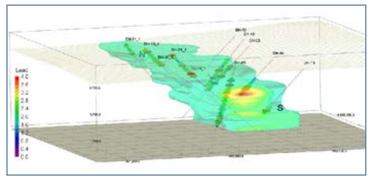


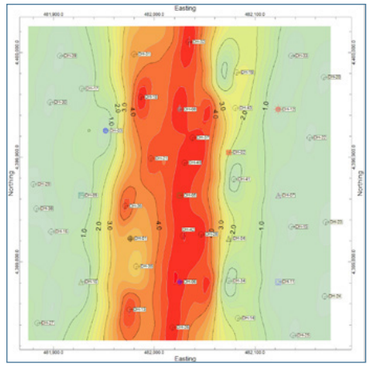
Mining professionals rely on RockWorks point and contour maps, 2D and 3D log displays, projected sections, block model interpolating and editing, detailed volume calculations, and import/export tools in both exploration and production phases of their projects.

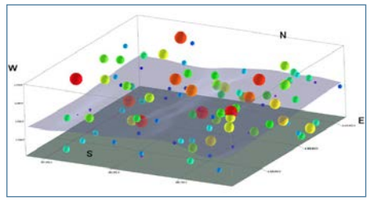
RockWorks®–Mining











Mapping Tools

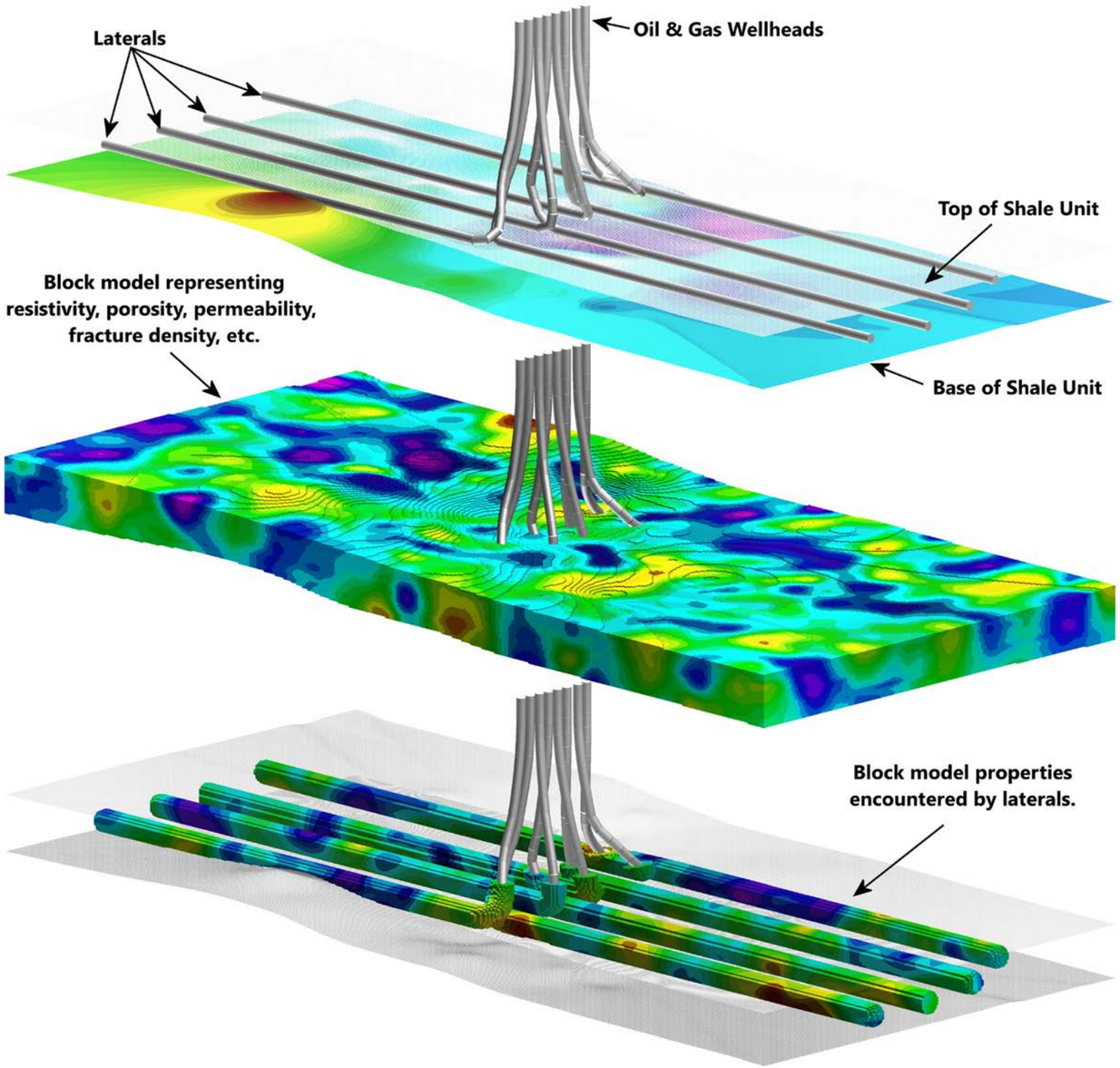
- Drillhole location maps with detailed data labels
- Assay, concentration maps with lines and color fills, custom color tables
- 3D surface displays: topographic surfaces, stratigraphic units
- 3D point maps
- Geology maps: plan or surface-based slices from block models
- Multivariate maps: pie chart, bar chart, starburst, spider maps
- Coordinate systems/conversions: lon/lat, UTM, State Plane, local, custom

Borehole Database Tools

- Projected cross sections showing drillhole orientation
- Correlation panels: stratigraphy, lithology, grade/concentration, geophysics
- Drillhole logs in 2D and 3D with lithology, stratigraphy, bargraphs/disks, curves, color intervals, text
- Block model interpolation from XYZG point or drillhole data, display as voxels, isosurfaces, fence diagrams, 2D plan and section slices
- Surface model interpolation of stratigraphic units
- Downhole fracture display and modeling—closest fracture and closest fracture intersection
- Volume reports of lithologic, stratigraphic models
- Data imports: Excel, LAS, acQuire, Newmont, other databases

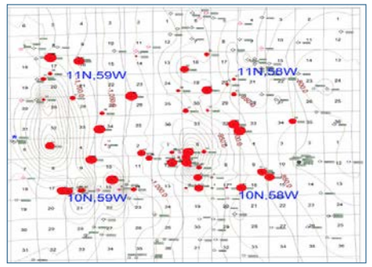
Other Tools

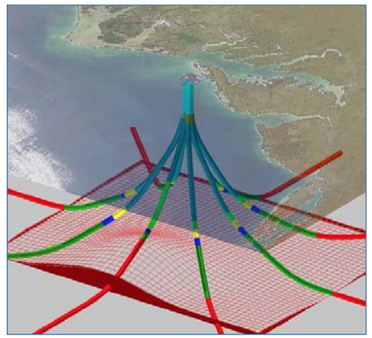
- Block model editor: 3D voxel/polyhedron editor or slice-based
- Volume calculations: grade statistics by level, extraction reports, GT calculators, floating cones model extraction tools
- Fracture display and modeling, stereonet and rose diagrams
- Ternary diagrams, frequency histograms for source data and models
- Graphic output: 2D and 3D output to RockWorks, Google Earth
- 2D editing tools: contour lines, text, shapes, legends, images
- Composite scenes in 3D with maps, drillhole logs, surfaces, blocks, panels
- Page layout program for small to large format presentations and posters
- Exports to GIS Shapefiles, CAD DXF, raster formats, Google Earth
- Image import and rectification
- Program automation

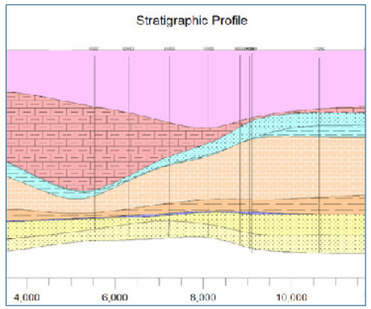


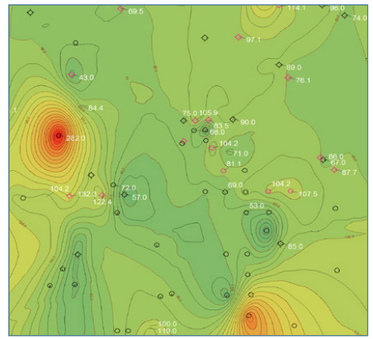
RockWorks gives the petroleum geologist the tools to get the job done:
well spotting, mapping (bubble, structure, isopach, land grid, log maps), cross sections,
stratigraphic modeling, reservoir modeling and much more.

RockWorks®–Petroleum









Mapping Tools

- Structure and isopach maps: contour maps with lines and color fills, custom color tables
- 3D surface displays
- Bubble maps of any well data (production, etc.)
- Well and lease spotting from Range, Township, Section descriptions
- Land grid and lease maps with section boundaries
- Coordinate systems/conversions: lon/lat, UTM, State Plane, local, custom
- Well location maps: customized symbols (e.g. well status), plan-view horizontal well traces
- Gridding algorithms: kriging, triangulation, inverse-distance, trend polynomial
- Grid model tools: filters, math operations, editor, imports and exports

Well Database Tools

- Cross sections: hole to hole and projected
- 3D fence diagrams
- Correlations: model-based and "EZ" panels
- Horizontal and vertical wells: 2D and 3D, flexible log layout
- Stratigraphic modeling of all/selected formations
- Solid modeling of lithologic, geophysical, geotechnical, geochemical data, with display as voxel or isosurface diagrams
- Geosteering: optimal well paths based on target formations, lateral and 3D displays
- Well database for well locations and miscellaneous well data, formation contacts, raster images, geophysical data, lithology, well construction and production
- Data imports—Excel, LAS, LogPlot, IHS, KGS, Tobin, other databases
- Stratigraphic contacts from digital elog data or raster logs

Other Tools

- Structural geology diagrams
- Graphic output: 2D and 3D output to RockWorks, Google Earth
- 2D editing tools: contour lines, text, shapes, legends, images
- Snapping tools for hand-drawn correlations
- Composite scenes in 3D with maps, logs, surfaces, solids, panels, surface objects
- Page layout program for small to large format presentations and posters
- Exports to GIS Shapefiles, CAD DXF, raster formats, Google Earth
- Image import, rectification, depth-registration
- Program automation using the Playlist feature

RockWorks® Feature Levels

RockWorks is offered with three different feature levels: Basic, Standard and Advanced that use the Borehole Manager containing a robust local database for storing and managing borehole-based data.

All three levels include the RockWorks Datasheet and the ModOps, Utilities and Graphics menus. These menus offer numerous programs for mapping XYZ data, modeling XYZG points, creating stereonets and rose diagrams, creating Piper, Stiff and Durov plots and much more.

All feature levels also include the three Graphic Output programs: RockPlot2D, RockPlot3D and ReportWorks.

RockWorks Basic

With Basic, the borehole processing tools are limited to observed data—no modeling: Borehole location maps, 2D and 3D strip logs and striplog profiles and cross sections. Simple correlation panels are offered for Stratigraphy, I-Data and P-Data in 2D section diagrams. 5 items per playlist and 3 faults.

RockWorks Standard

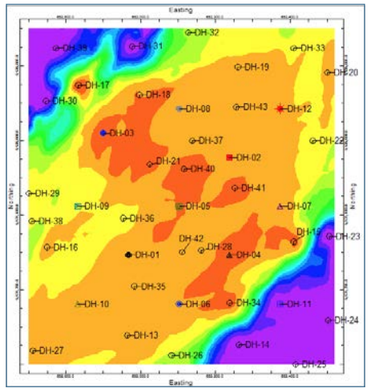
All Basic level tools, plus Borehole Manager modeling: lithology, stratigraphy, geophysical/geochemical/geotechnical, aquifers, colors, fractures. 10 items per playlist, 10 faults.

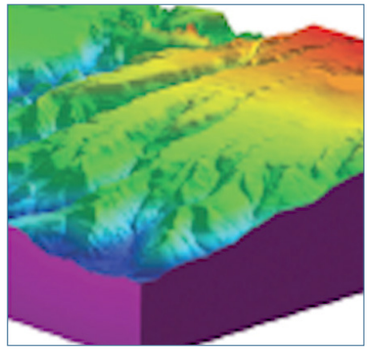
RockWorks Advanced

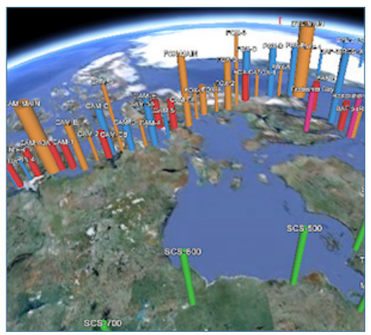
All Standard level tools, plus SQL-server database support, program automation (scripting), Borehole Manager petroleum production diagrams. Unlimited items per playlist, unlimited faults.

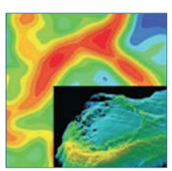
Academic

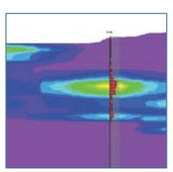
Ask us about our free college curriculum datasets, exercises, and significant academic discounts (see web site). These "canned" classes represent extended versions of the RockWorks training exercises tailored for educators. A great teaching resource.

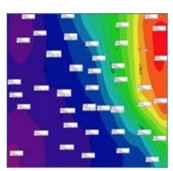


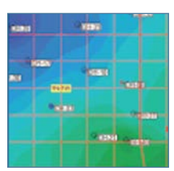


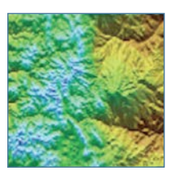


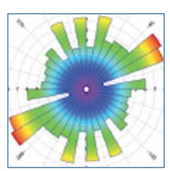












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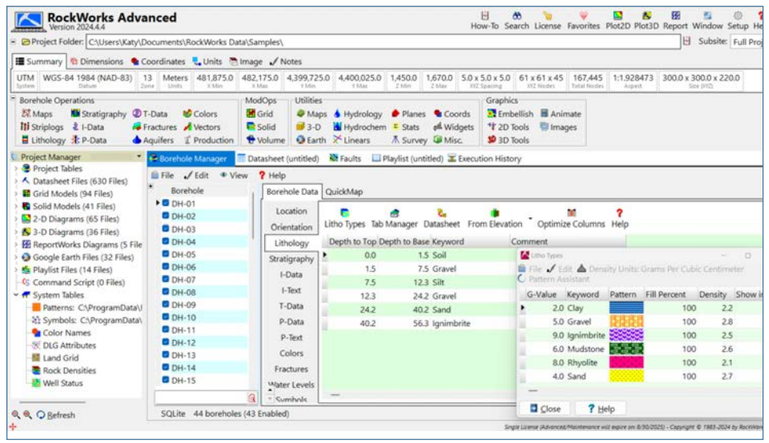
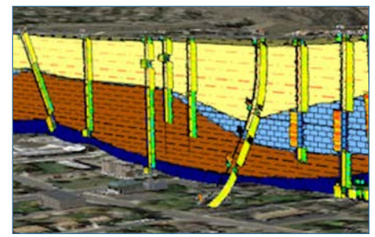
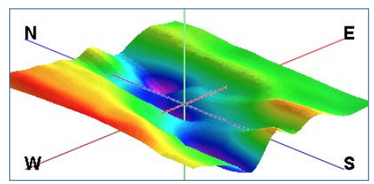
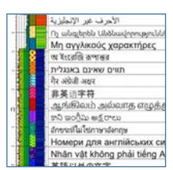
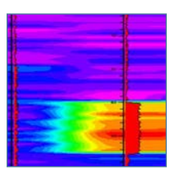
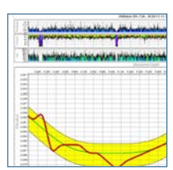


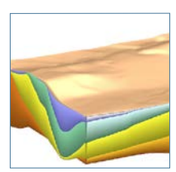


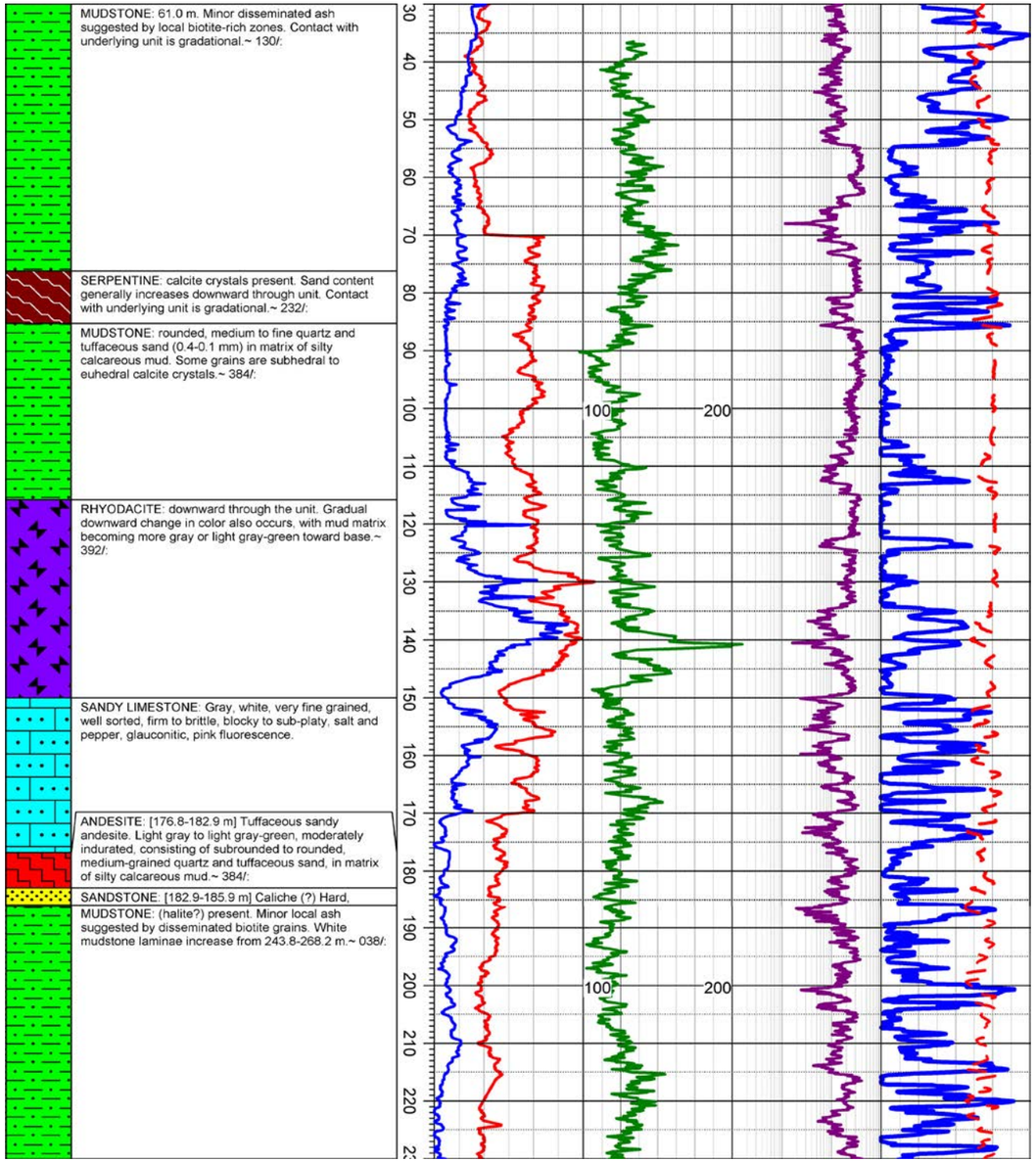








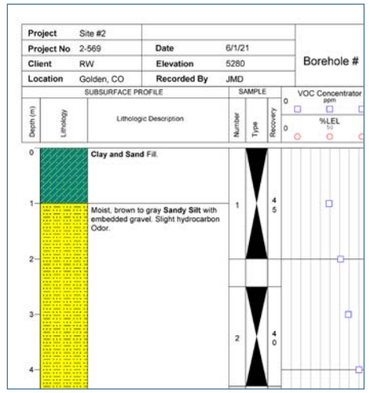


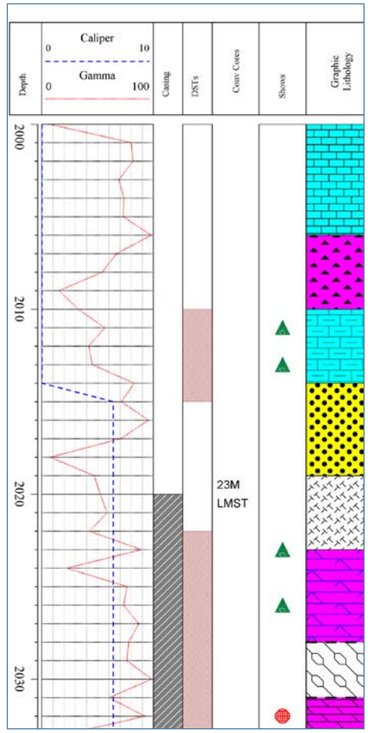


New Streamlined Interface

The LogPlot Data Editor, Log Designer and LogViewer have been Redesigned for use on Multiple Monitors and to make the creation and modification of logs easier than ever. Improvements to many of the import/export tools (PDF, Excel Multi-sheet, LAS)

LogPlot®





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The Log Designer

The Log Designer allows you to quickly design borehole and well logs and modify existing design templates.

- Easy to use, with point, click, multiple-select and alignment capabilities
- Multi-pane re-vamped design window displays headers, footers and log body
- Two header and footer designs, full page report header
- Well information linking between data file and header/footer fields
- Macros for dates, page numbers and well locations
- Header/footer images, patterns, symbols, curve and bargraph legends, notes and text
- The log body can include any number and combination of columns, including lithology patterns and descriptions, cuttings percent columns, single and cross-plot curves, bargraphs, interval and point-based text, tadpoles, fracture traces (NEW), well construction, raster images, fillbars, water levels and other symbols and scale bars

The Data Editor

Type, copy/paste and or import your log data into the Data Editor.

- Tabbed data sheets with a flexible layout, for easy data entry
- Data sheets added on the fly, or automatically updated from the log design
- Double-click access to RockWorks borehole records, data can now be extracted from and written directly to the RockWorks database
- Data import from LAS, Excel, DBF, AGS and text
- Data export to LAS, Excel and RockWorks
- Data types: lithology/stratigraphy, interbeds, cuttings percentages, curves, interval and point-based data and text, general comments, header/footer text and notes, symbols, fillbars, downhole survey, tadpoles, fractures and well construction
- Easy linking of keywords ("sandstone") to graphic patterns and colors

The Log Viewer

- Create paginated or continuous logs
- Compile and display multiple logs at once
- Quickly re-display logs at any scale and adjust header/footer settings
- Use your mouse to view depth/elevation at any point on the log
- Graphic export options include PDF, HTML (for display online), BMP, JPG, TIFF and PNG
- Print your log, export an image of a single page or export all pages in a single image

New Features in LogPlot

Log Design Template

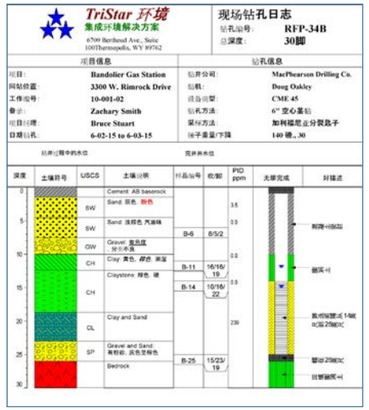
- A Total Depth comment can now be displayed below the last Lithology Description using a macro in the Log Designer where the # character is replaced by the Total Depth. This will only be displayed if there is a blank space between the last lithology description and the footer or base of the page.
- The Column Legend now has an option for a third title line.
- Many improvements have been made to the alignment tools in the Log Designer and Zoom Mode.
- Snapping is now enabled when Log Body and Header/Footer items are resized.
- The Lithology pattern column now includes the option to use a Munsell Color entered in the Data Editor as the background fill color.

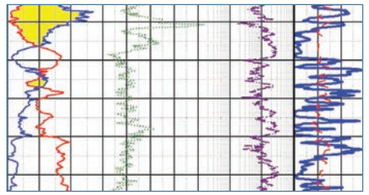
Log Data Files

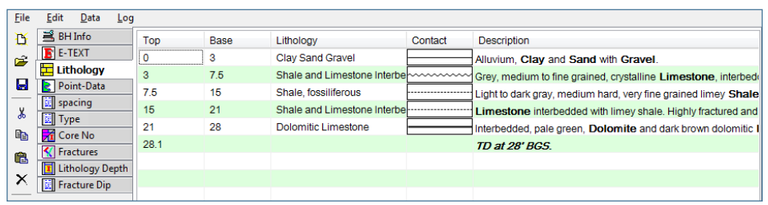
- The Edit-Text Name column can now be resized within the LogPlot data editor.
- The Data Editor now includes a new Munsell Color field in the Lithology tab. Users can type the Munsell Color codes directly into the datasheet or choose from a list of pre-defined colors.

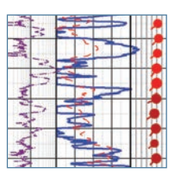
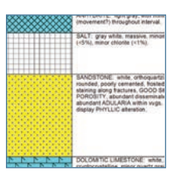
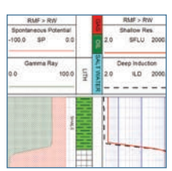
User Interface

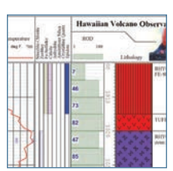
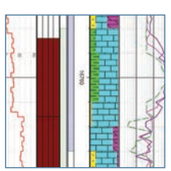
- A *CLOSE* command has been added to the command line batch processing to terminate the program upon completion.
- A new multi-page/file PDF tool allows the user to export PDFs for all opened LogView tabs.

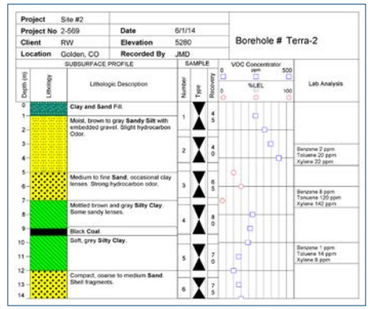


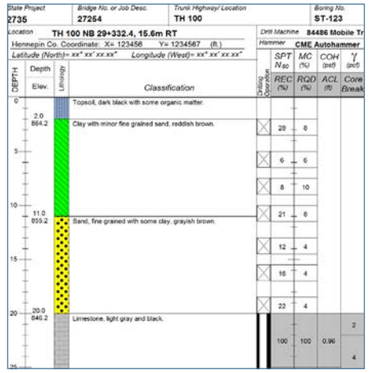


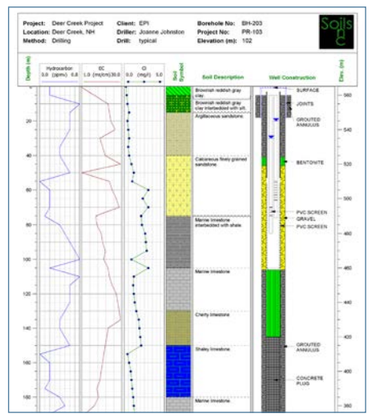






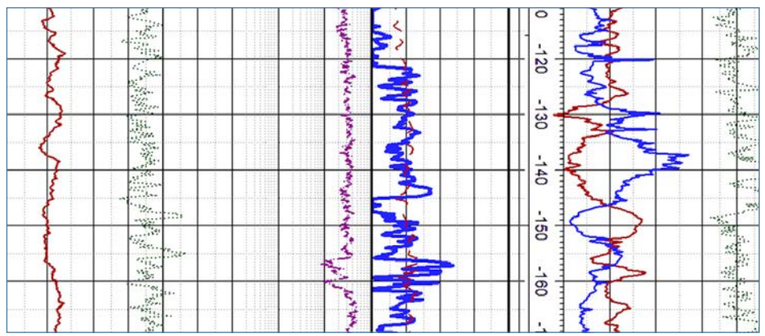


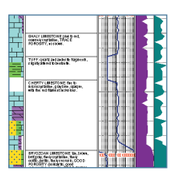
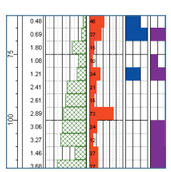
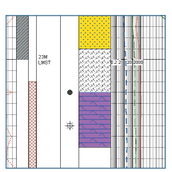
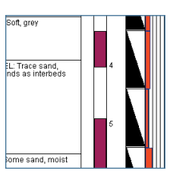
Environmental

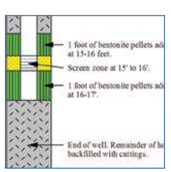
- Soil and rock type symbols and descriptions
- Sample symbols, names, descriptions and data
- VOC data collected from MIP or other sampling devices
- OVA/PID data
- Borehole geophysics
- Detailed well construction diagrams, including nested wells
- Water level data
- Water and soil contamination information
- Blow counts, RQC and other geotechnical parameters

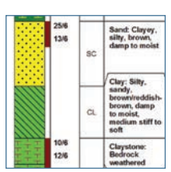
Oil & Gas

- Well/borehole geophysics
- Gas curves
- Drilling rate, RPM and Weight on Bit
- Lithologic Cuttings data
- Formation tops and descriptions
- Casing and perforation diagrams
- Drill Stem Test intervals
- Fossils
- Core data, including intervals and fractures
- Pay zones and show intervals







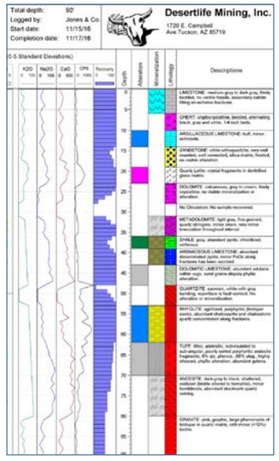
LogPlot® Continued

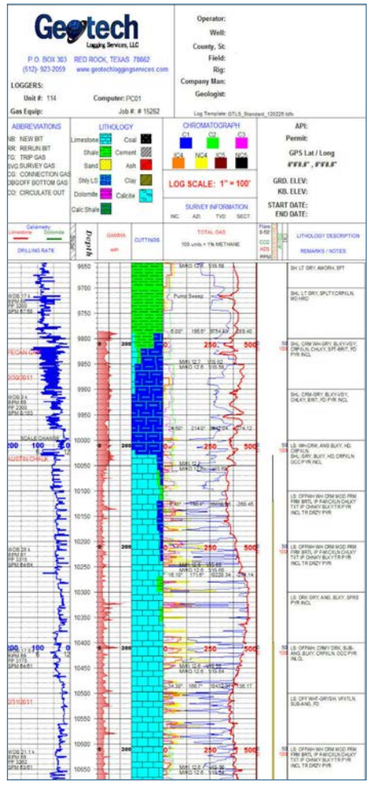
Mining

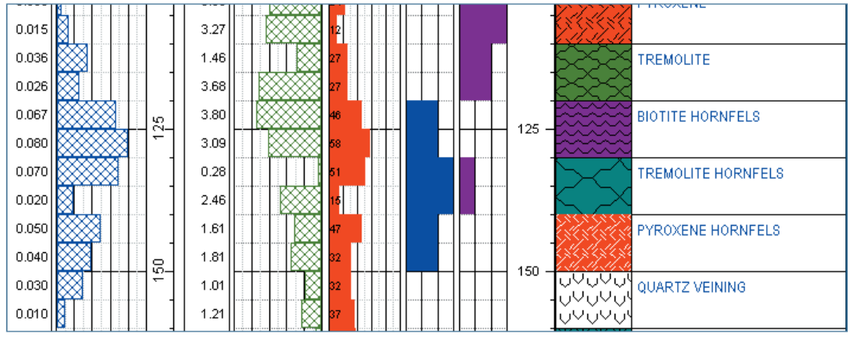
- Soil and rock type symbols and descriptions
- Core symbols and data, including Recovery and RQD
- Assay results
- Munsell Color Codes
- Fracture spacing, filling and orientation
- Alteration, mineralization and oxidation values
- Casing and well construction
- Water level data

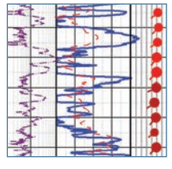
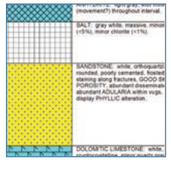
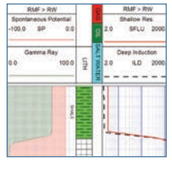
Geotechnical

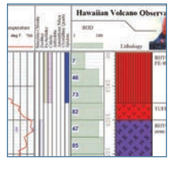
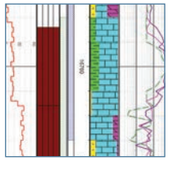
- Soil and rock type symbols and descriptions
- Blow counts, RQD and other geotechnical parameters
- Core symbols and data, including Recovery and RQD
- Fracture information, including spacing, orientation and aperture
- Sample symbols, names, descriptions and data
- Borehole geophysics
- Atterburg Limits
- Grain Size and sieve analysis results
- Water level data
- Water and soil contamination information
- CPT data, plotted as curves or colored intervals



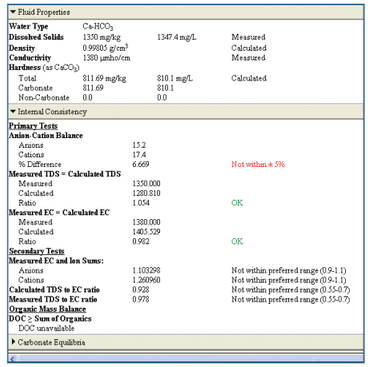


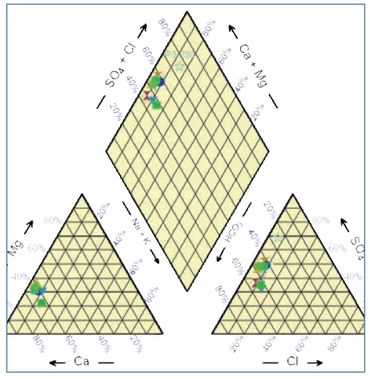


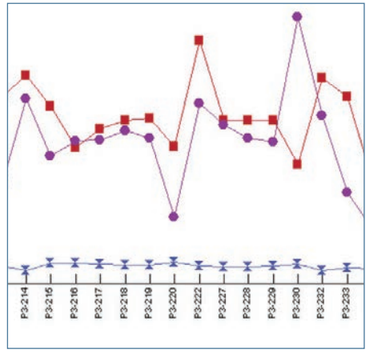




AqQA™







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Still storing your water analysis in Excel®? AqQA was created with water engineers and aqueous geochemists in mind—or for that matter, anyone who keeps water chemistry data in a spreadsheet. Analyzing your water testing data is as easy as 1, 2, 3 with AqQA:

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2) Click on the "Data Analysis" tab to check water testing data for internal consistency, and view other calculated water properties
3) Use the "New Graph" tab to create publication quality graphics—includes Piper diagram, Stiff diagram and nine other plot types

AqQA features

- Six tests for water data consistency according to AWWA 1030-E Standard Methods
- 11 plot types: Series, Time Series, Cross Plot, Ternary, Stiff, Piper diagram, Durov, Schoeller, Ion Balance, Pie Chart and Radial Plot
- Calculates carbonate equilibria, TDS, density, conductivity, hardness and more
- Flags violations of water quality standards
- Check replicates and standards
- 200 pre-defined analyte types—inorganic, organic, biological assay, radioactivity, isotopes—or define your own

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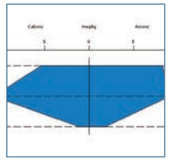
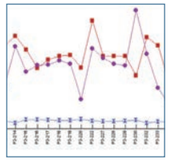
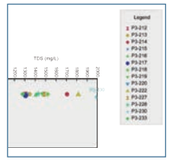
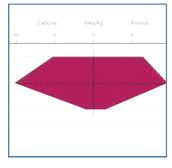
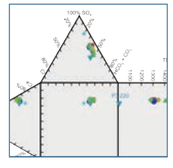
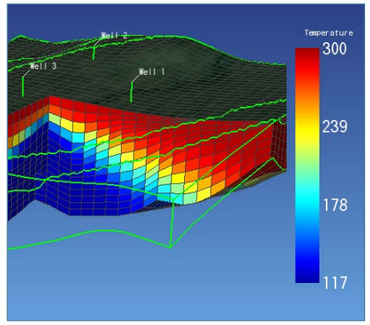
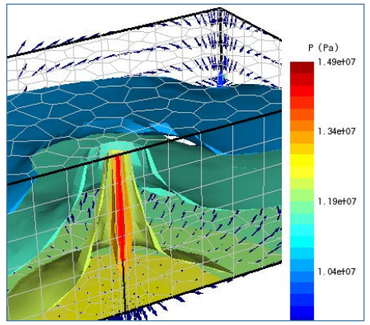
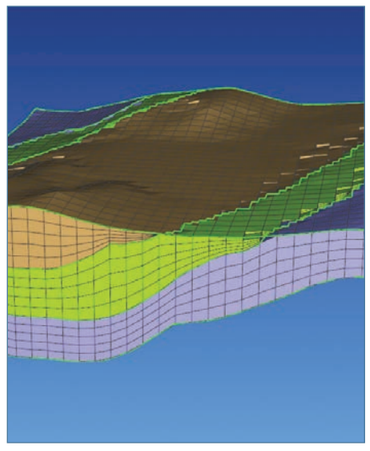
- Convert units with a mouse click—no more keying in mole weights
- Use common spreadsheet tools such as copy, paste, transpose, sort and many others
- Compare replicate analyses and check standards
- Mix samples
- Flag exceedances of regulatory limits
- Check for internal consistency against AWWA standards
- Calculate fluid properties such as water type, TDS, hardness, conductivity and carbonate speciation
- Calculate calcite saturation and CO_2 fugacity
- Quickly create Piper, Stiff, Ternary, Durov and seven other plot types









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Solve Challenging Subsurface Flow Problems with PetraSim

PetraSim is the graphical interface for the TOUGH family of simulators. Developed at Lawrence Berkeley National Laboratory, TOUGH2 and its derivatives are recognized for their broad range of subsurface simulation capabilities, including heat and multi-phase flow and reactive transport. PetraSim helps you access the power of TOUGH2 in an integrated 3D environment that includes mesh generation, parameter definition, execution and display of results. Save valuable time and increase model reliability with PetraSim.

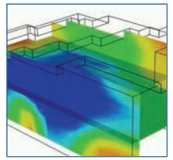
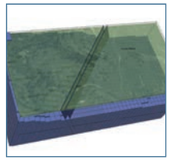
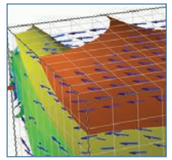
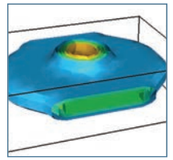
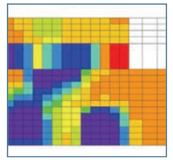
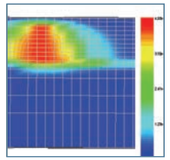
Interfaces

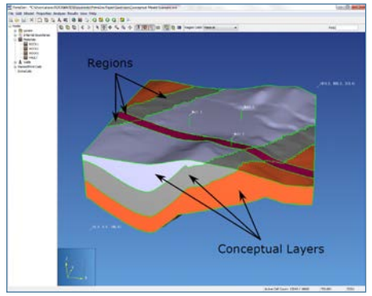
- **TOUGH* (versions 2, 3 and 4)**– for multi-phase fluid and heat flow in porous and fractured media
- **T2VOC**– for 3-phase flow of water, air and a volatile organic compound
- **TMVOC**– for 3-phase flow of water, gas and a multicomponent mixture of volatile organic compounds
- **TOUGHREACT***– for coupled modeling of subsurface multiphase fluid and heat flow, solute transport and chemical reactions

*Use of TOUGH v3 and v4, as well as TOUGHREACT v2 or v3.32/4.13, requires purchase of the corresponding simulator from Lawrence Berkeley National Laboratory, separate from the PetraSim interface. Support for TOUGH4 will be provided following its public release.

Applications for PetraSim and the simulators it supports include:

- Coupled process modeling (thermal, hydrologic, chemical, mechanical, biological)
- Carbon sequestration and hydrocarbon recovery
- Performance assessment of nuclear waste repositories
- Geothermal reservoir studies
- Vadose zone hydrology
- Fate and transport of volatile organic compounds



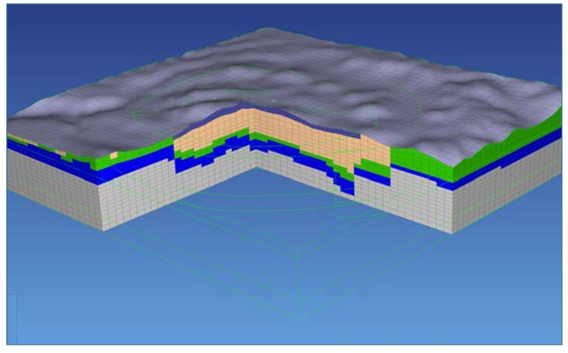
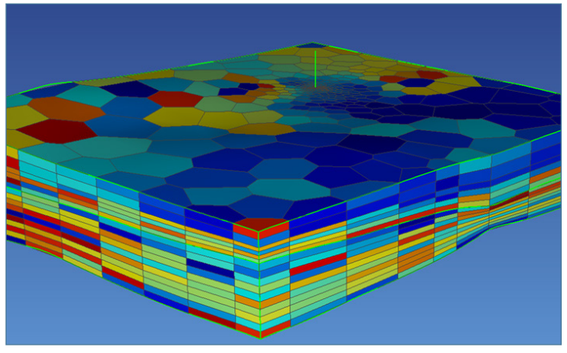
PetraSim Features

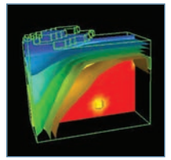
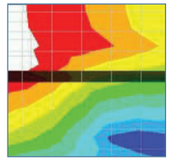
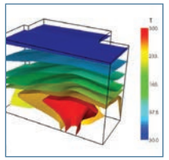
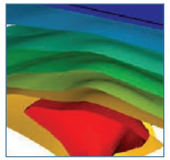
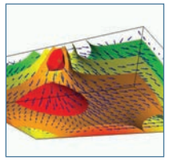
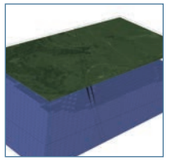
3D Conceptual Model Creation

- Define LAYERS and REGIONS as high level geometric entities
- Layers can be broken up into regions using INTERNAL BOUNDARIES, which are surfaces or planes that typically intersect many layers
- Use Layer and Regions to define material properties and physical and chemical initial conditions and spacing of cells in the Z direction
- Create wells to represent well completions through multiple adjacent cells.
- Flow in or out of the model can be evenly apportioned across the cells that intersect the completion interval evenly, or based on thickness and permeability

Mesh Generation and Editing

- Import material types or other cell parameters based on ASCII files exported from geomodelling packages.
- Create rectangular, polygonal and simple radial meshes
- Vary the spacing of rectangular meshes in the X and Y directions using a spacing factor or a list of cell dimensions
- Define the dimensions of polygonal meshes based on maximum area and refinement areas around wells or other user-define refinement points
- Create meshes with flat cell layers, or warp cell layers to match conceptual model layer boundaries
- Create non-geometric "Extra" cells to represent special boundary conditions
- Use numerous interactive cell selection tool to assign cell-based properties, including sinks/sources, material type, permeability, porosity, cell volume, print properties and TOUGHREACT zones
- Cell selection tools include layers, regions, statistics regions, intersection with well lines or internal boundaries, material type, sinks/source, print or fixed state cells, and cell layers, columns, rows or vertical columns

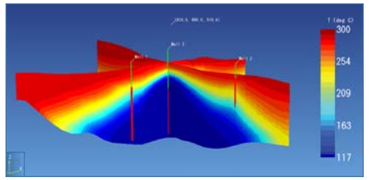



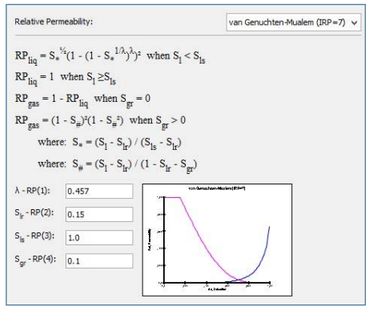







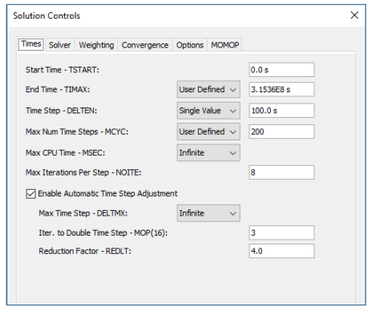
PetraSim Features continued

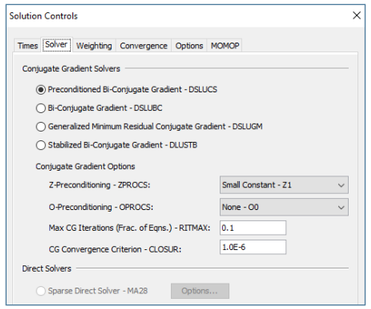
Intuitive Simulation Input

- Define material types/properties, simulation options and solver settings through an intuitive interface
- Dynamic previews of most Relative Permeability and Capillary Pressure curves
- Use a hierarchical system to establish global, layer-based or cell-based initial conditions
- Supports manual entry of new TOUGH3 blocks including the OUTPU and MOMOP tools
- Easily restart model by loading a SAVE or INCON files as cell-based initial conditions
- Link to a TOUGHREACT thermodynamic database to create water chemistry and mineral zones



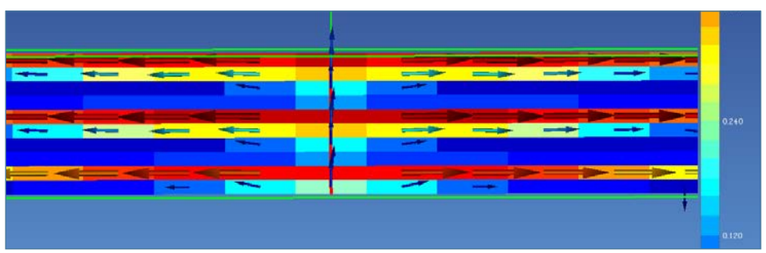


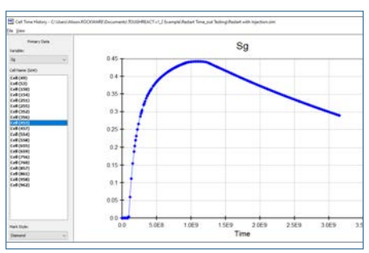


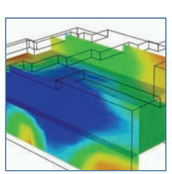


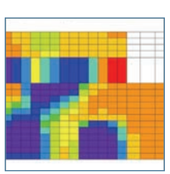
Integrated Result Visualization

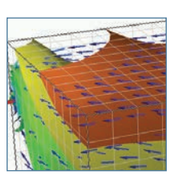
- View 3D model results as isosurfaces, cell plots, slices and vectors
- 2D plots include cell-history plots, well plots and connection plots
- Create line-plots along wells or user-defined traces
- Export data as CSV files for visualization in Excel, TecPlot or other programs

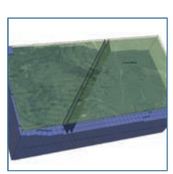


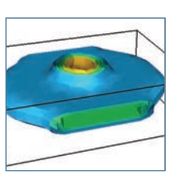


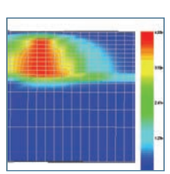






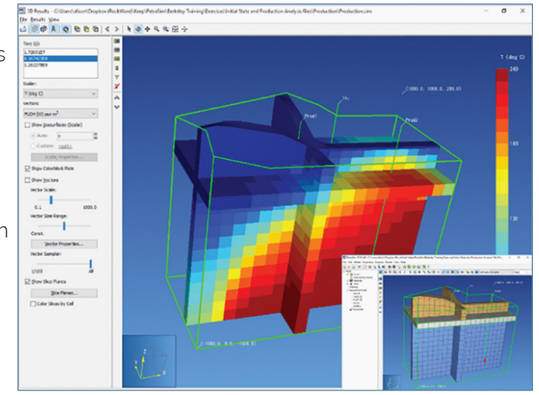


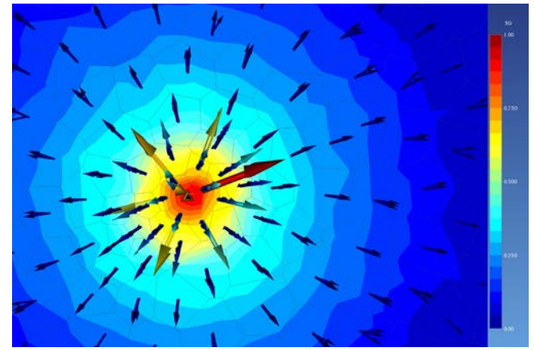




With PetraSim you can:

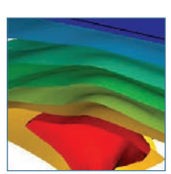
- Create complex flow, reactive transport and heat transfer models
- Dramatically reduce TOUGH2 model creation time
- Eliminate TOUGH2 input errors
- Use the intuitive toolbar for step-by-step guidance
- Select from the many fluid property options for your model
- Use enhanced TOUGH2 simulators available only with PetraSim
- Import well data in batch ASCII files
- Interactively create and edit 3D and axisymmetric grids
- Import rotated XYZ layer geometry and define conforming grids, or import Petrel/Eclipse grids
- Define irregular model boundaries and grids using Voronoi tessellation
- View graphs of relative permeability and capillary pressure functions
- Use dialogs to define solution and output controls
- Seamlessly run TOUGH simulators using the executables integrated into PetraSim
- Graphically monitor the solution progress
- Display 3D iso-surfaces, 3D block plots and vertical and horizontal slices
- Create time history plots of individual cell results, connections and wells
- Use line plots to display results along any 3D line or well trace
- Export result data in comma separated variable format

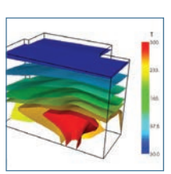


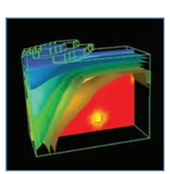


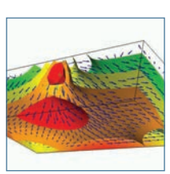
Fluid Properties Modules

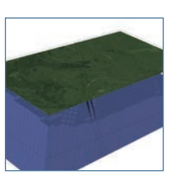
Fluid Property Module	Module Description	Simulator
EOS1	Two Phase Water	TOUGH and TOUGHREACT
EOS2	Water and CO2	TOUGH and TOUGHREACT
EOS3 and EOS4	Water and Air	TOUGH and TOUGHREACT
EOS5	Water and Hydrogen	TOUGH
EOS7	Water, Brine and Air	TOUGH
EOS7R	Water, Brine, Air and Radionuclides	TOUGH
EOS8	Water, Air, "Dead" Oil	TOUGH
EOS9	Saturated/Unsaturated Flow	TOUGH and TOUGHREACT
EWASG	Water, NaCl, Non-Condensible Gas	TOUGH
ECO2N	Water, CO2 and NaCl	TOUGH and TOUGHREACT
ECO2M	Water, CO2, and NaCl, including super- and sub-critical conditions, and phase change between liquid and gaseous CO2	TOUGH (V2.1/V3 only)
EOS7C	CO2 or Nitrogen in natural gas (methane) reservoirs	TOUGH (V2.1/V3 only)
T2VOC	Water, Air, and Volatile Organic Compound	T2VOC
TMVOC	Water, Air, and up to 19 Volatile Organic Compounds	TMVOC

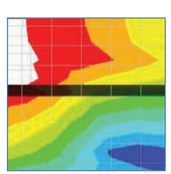












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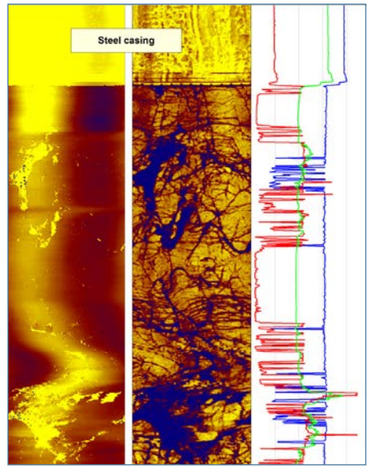
WellCAD is a PC-based composite log package, which combines comprehensive graphic editing mechanisms and data processing tools. Combining technically excellent display, editing and analysis capabilities for well data, WellCAD has become the standard log composite software in the Mining, Oil and Gas and Geotechnical industries and is used in a wide range of applications.

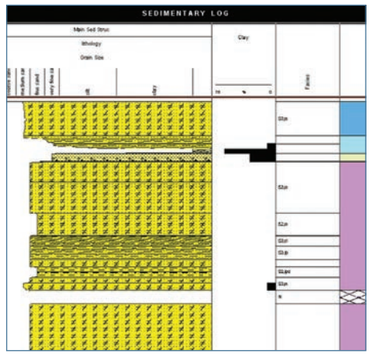
Features

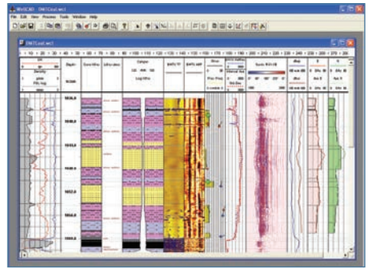
- **Import/Export** – ASCII, CSV, TXT, LAS, BMP, JPG, TIF, GIF, plus many more industry specific formats
- **Data Presentation** – 2D and 3D borehole display of images, curves, intervals, points, lithology, stratigraphy, text, symbols, stacking patterns, biostratigraphy, engineering details and more
- **Depth Management** – Multiple depth management (time, depth, TVD) plus an advanced depth matching tool
- **Editing** – Slice, shift, merge, resample, and filter curves with results displayed alongside the original data
- **Computations** – Formula parser (curve calculator with multiple discriminators)

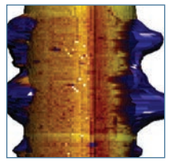
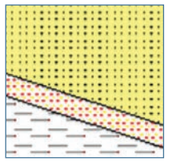
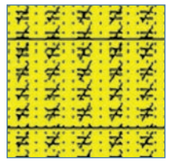
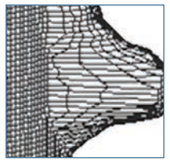
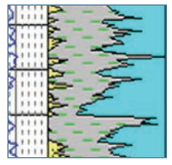
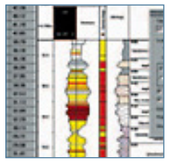
Optional Modules

- **Image & Structure Interpretation Module** – Borehole Image and Structure/ Breakout Analysis
- **CoreCAD** – Interactive digital core description
- **Full Wave Processing Module** – Sonic Data Processing and Velocity Analysis
- **LIS/DLIS Module** – Import LIS/DLIS data
- **Deviation Module** – 3D well path visualization
- **Multiwell Module** – Borehole and correlated cross-sections
- **ODBC Connector Module** – Load and save data from/to ODBC compatible databases
- **Automation Module** – Automate your workflow using COM components
- **Casing Integrity Module** – Process multi-finger caliper and ultrasonic televiewer data
- **NMR Data Processing Module** – Derive total porosity, fluid volumes, and permeability from T2 distribution data







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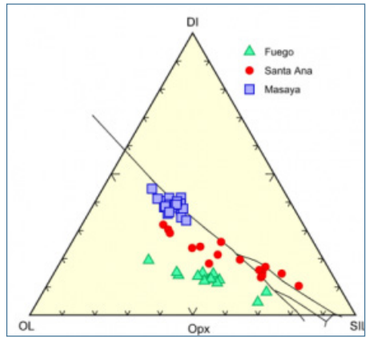

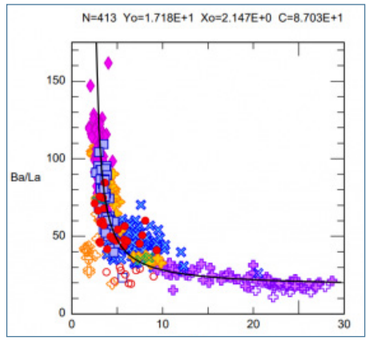

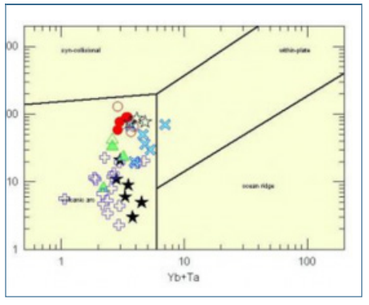

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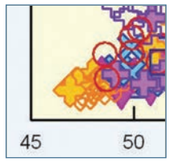
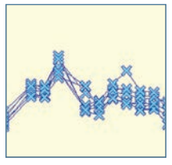
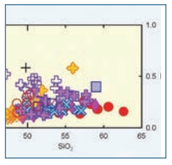
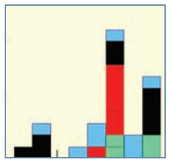
Here are a few of Igpet's Features

- Discrimination diagrams for rock types and tectonic settings
- Publication quality output for transfer to draw programs
- Simple data format with easy transfer of data to/from Excel
- Igpet draws most types of petrologic diagrams, including Harker, Fenner, triangular and log plots. Spider diagrams include REE element ratio plots, Wood, Thompson, Sun and McDonough etc.
- CIPW norms within Igpet; fractional crystallization and magma mixing calculations in Mixing.exe
- Simple X-Y plots that allow Melt modeling, AFC modeling, hyperbolic mixing, linear regression
- Mixing, Melting and AFC modeling of multiple elements and isotope ratios simultaneously using the element suite in popular spider-diagrams — this is where Igpet gets powerful!

Available for PC or Mac users.

- The latest versions of the Mac OS including Ventura, Catalina and Sonoma are supported.
- Igpet for Windows is compiled simultaneously from the source code using XoJo which improves graphics output and eases installation.



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