# BasinMod® Overview

Model the volume of hydrocarbon generation and expulsion through time for multiple wells. Both conventional and unconventional resource plays can be modelled. A wide range of other values are modeled including maturity, porosity, permeability, pressure and temperature, all of which can be used to further analyze the petroleum system.

Burial History:

- Model complex stratigraphy, including unconformities
- Select from several calculation methods for compaction, porosity, and permeability
- Model porosity by mechanical, fluid flow, or chemical compaction
- Mix lithology or mineral components to create an unlimited number of custom lithologies
- Model changes in formation thickness due to salt or shale movement (diapirs).

Diagenesis and Pressure:

- Calculate pore fluid pressure to predict the timing and/or depth of abnormal pressure regions as well as subsequent fracturing
- Enhance porosity reduction by means of quartz cementation in sand and smectite-illite conversion in shales.

MAP OF GAS GENERATED VOLUME FOR ROCK UNIT
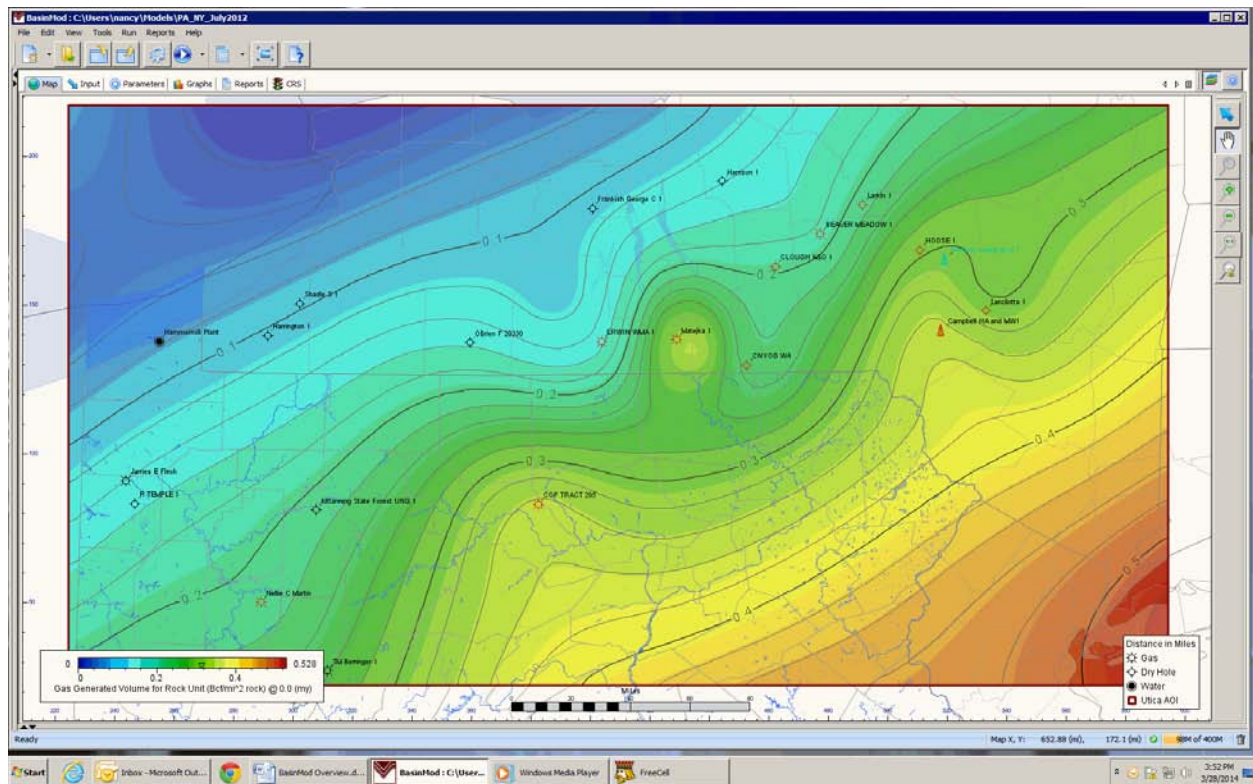
Thermal History:

- Model thermal maturation and predict timing of hydrocarbon generation/expulsion
- Model basement heat flow, radiogenic heat flow, and rifting heat flow
- Vary surface temperature and heat flow through time.

Logs:

- Drag and drop logs in LAS format
- Display logs adjacent to stratigraphy column for formation top editing
- Pick porosity points from a porosity log for use in calibration.

Source Rock Organic Richness:
- Determine Total Organic Carbon (TOC) from logs of resistivity and porosity
- Calculate Initial TOC

Maturity:
- Use several maturity indicators for calibration, such as %Ro, TMAX, TAI, and CAI.

**Kinetic modelling of hydrocarbon generation:**
- Model one component of oil and gas using simple LLNL kinetics or organofacies kinetics (Pepper and Corvi, 1995).
- Model multiple components of oil, gas, and residue using compositional kerogens
- Access a library of kerogens compiled from literature including multiple variants of Types I, II, and III.

Erosion:
- Estimate the amount of surface erosion using a sonic travel time log.

Output:
- Spatially display any calculated or measured value using a variety of color and contour options
- Display shapefiles of cultural or hydrographic data
- Display radar plots which compare several calculated values against an ideal case
- Generate standard and continuous color burial history plots
- Plot any calculated value versus time or depth
- Plot any calculated value or measured data against any value or data
- Generate log-log cross-plots
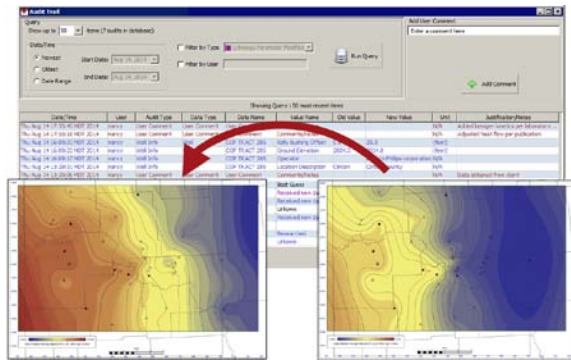- Display geochemical logs of pyrolysis data.
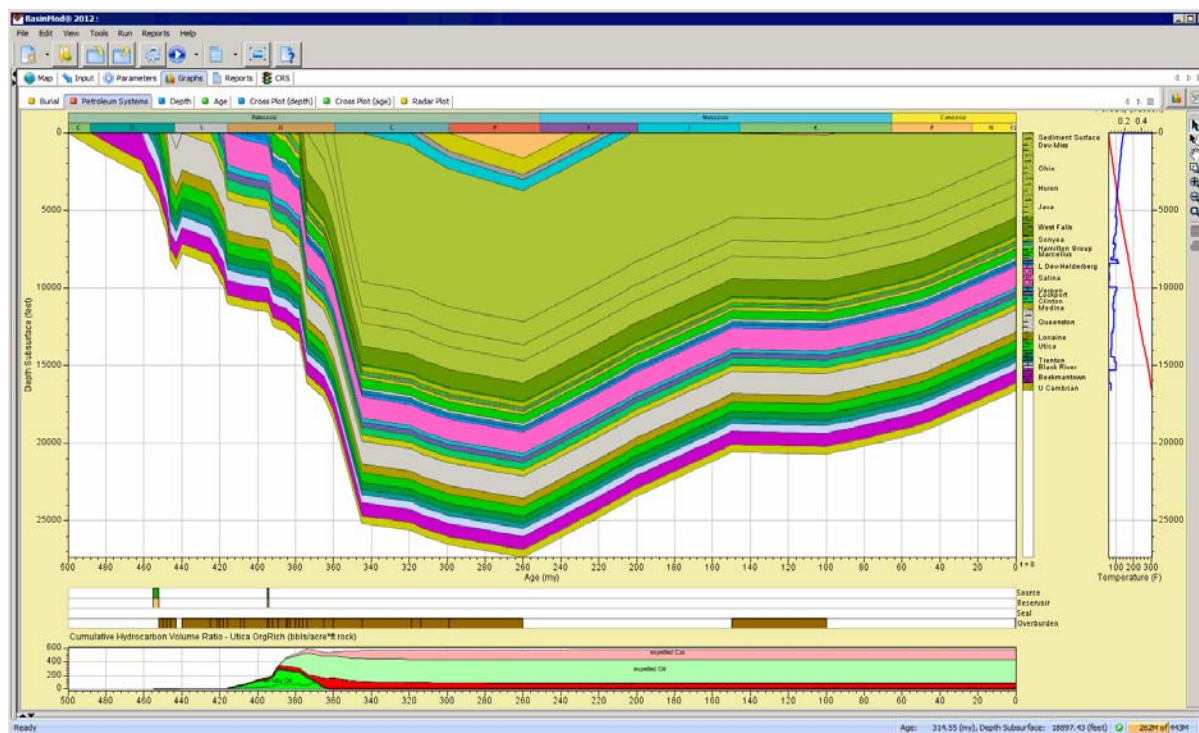
PETROLEUM SYSTEM PLOT

BasinMod®
2014 New Capabilities
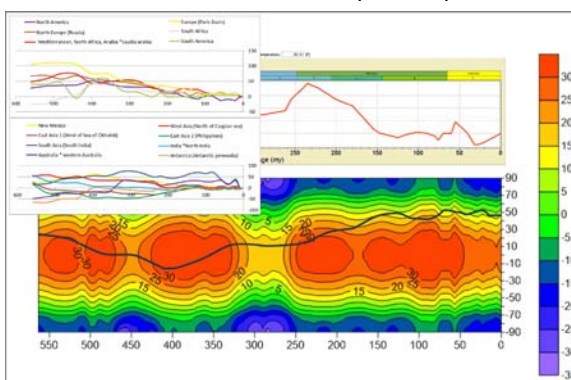
Audit Trail - Roll back to a previous state

- Use the Audit Trail to record changes as well as roll back to a previous version of the project.

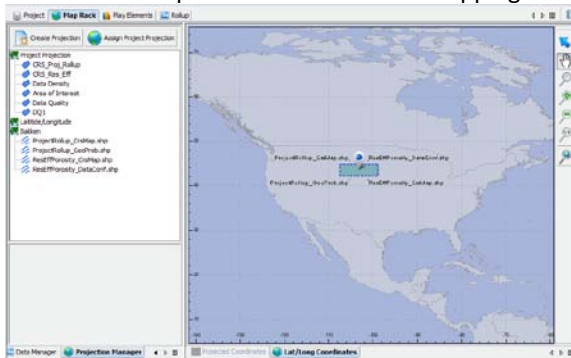RETURN TO PREVIOUS CONDITIONS

Paleo Surface Temperatures

- Account for continent movement and temperature change through time.
- Also can account for sea depth temperatures.

CHANGE IN SURFACE TEMPERATURE PER LATITUDE AND AGE
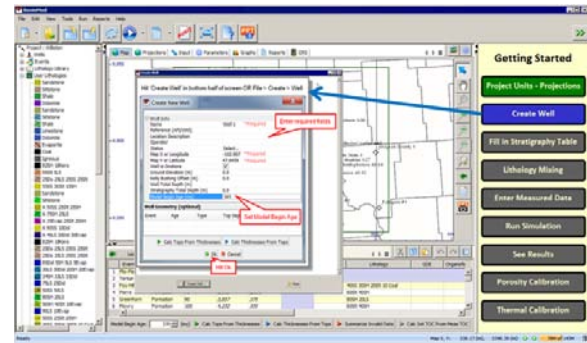
Map Projection Manager

- Define multiple map projections to handle data from multiple sources for ease of mapping.

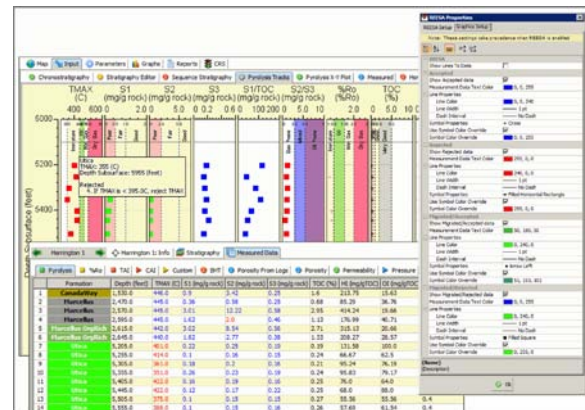VIEW AND MANAGE SHAPEFILES AND WELLS

Workflow

- A built-in step-by-step guide to building a well model assists the user.

WORKFLOW DIRECTS MODEL BUILDING

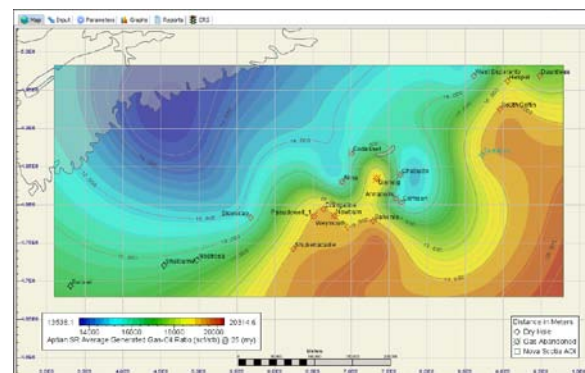### REESA – Rock Eval Expert Systems Analysis

- Filter and interpret Rock-Eval Pyrolysis data according to user-editable rules
- Display values as Accepted, Rejected, or Migrated.

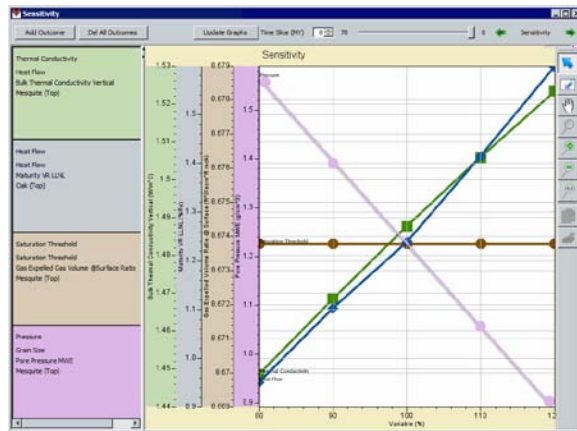FILTER AND COLOR CODE PYROLYSIS DATA

Paleo Maps

- Draw maps at any user-specified age.

MAP OF GAS-OIL RATIO AT 25 MYBP
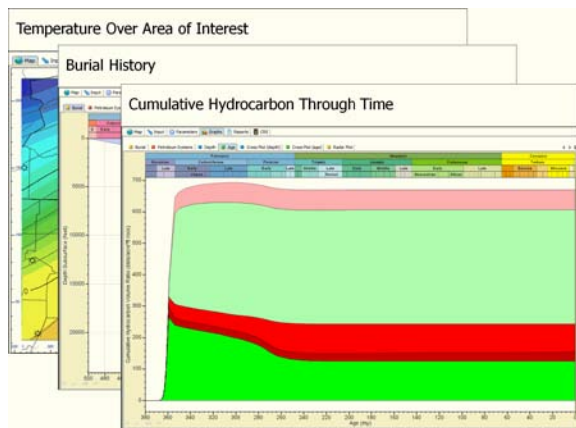
Sensitivity Plots

- Vary input parameters (erosion, heat flow, temperature) to see effects on output values (maturity, generation, expulsion, etc.)

SEE EFFECTS ON OUTPUT VALUES
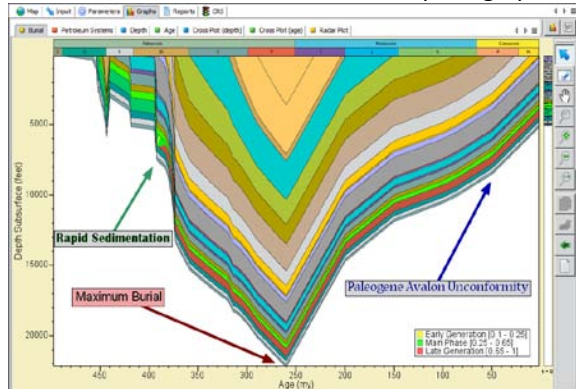
PowerPoint Generator

- Select maps and graphs for an automatically generated PowerPoint presentation.

AUTOMATICALLY GENERATE POWERPOINT REPORTS
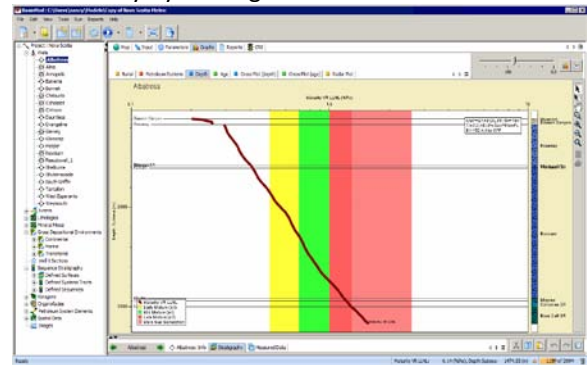
User Notation of Graphs

- Add text boxes and arrows to maps or graphs.

BURIAL HISTORY GRAPH WITH USER NOTATIONS

Depth Graphs through Time

- Draw depth graphs at any user-specified age merely by moving a slider.

MAP OF MATURITY AT 73 MYBP
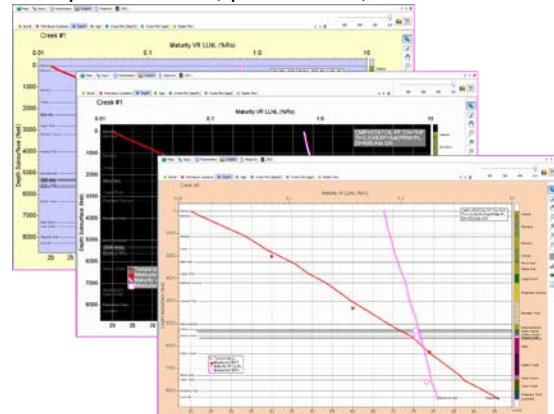
New Lithology Library with 65 new mixes

- Select from an expanded list of lithologies which can be mixed for additional lithologies.
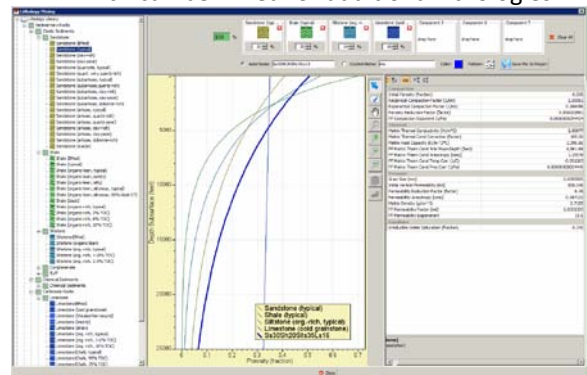
MIX NEW LITHOLOGIES FOR ADDITIONAL MIXES

Graphics Themes

- Create collections of graphic appearances for presentations, publications, etc.

SAVE "THEMES" OF GRAPHIC APPEARANCES

Platte River Associates, Inc.

Unconventional Resource Module
for BasinMod®

Unconventional resource plays differ from conventional plays with respect to the problems to be solved and the parameters to be considered. In these plays, organic shales must be assessed both as source rocks and reservoirs. Source rocks with great potential will not be economically viable if they aren't producible. The Unconventional Resource Module (URM) for BasinMod® provides specifically designed capabilities to evaluate these parameters.

Methane Adsorption
- Predict the quantity of gas which can be stored as a function of reservoir pressure by using gas storage capacity data from Langmuir isotherms.
- Extrapolate methane adsorption potential for different temperatures and for different amounts of organic carbon.

ISOTHERMS SHOWING VARIATION OF METHANE ADSORPTION POTENTIAL FOR A RANGE OF TOC VALUES
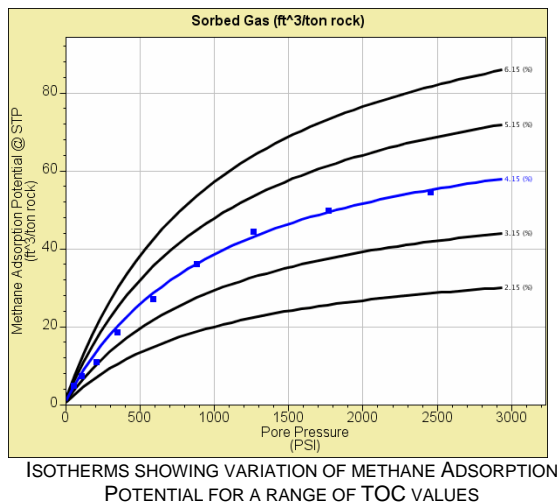
Nanoporosity
- Model porosity that forms as organic matter is transformed to hydrocarbon. Significant amounts of methane can be stored in nanoporosity.

Organic Matter Volume Percent
- Model the volume of generated hydrocarbon using organic matter volume percent rather than weight percent. The volume percent of organic matter is a factor in calculating nanoporosity and also determines whether a source rock is kerogen-supported or matrix-supported.

Oil Generation Pressure
- Account for increase in pressure due to volume expansion as solid organic matter is transformed to liquid hydrocarbons, especially in source rocks that are very rich and when generation occurs rapidly.
- Augments pressure created by effective stress during burial.
- May contribute to overpressure and natural fracturing.

Gas Expansion Pressure ("Uplift Excess Pressure")
- Account for excess pressure that cannot be modelled solely by effective stress by using gas expansion pressure. This is a key factor in certain plays such as Appalachia and the Barents Sea.

Brittleness
- Identify intervals with the best characteristics for stimulation and fracturing using analysis of brittle and ductile mineral compositions.
- Calculate and map a Brittleness Index using a proprietary calculation method that combines Young's Modulus and Poisson's Ratio derived from sonic and density logs.
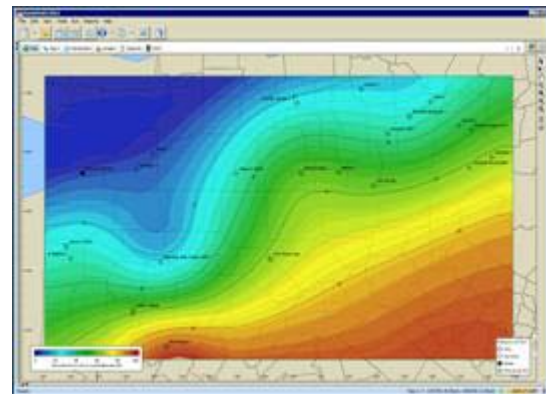

BRITTLENESS INDEX MAP

Compositional Kerogens

- Model generation and expulsion of individual hydrocarbon components, including liquids. Liquids are especially important in resource plays such as the Eagle Ford, where trends of gas and associated liquids occur in relation to different levels of maturity.

Shale Library

- A shale lithology is typically thought of as clay-rich, but most shale resource plays are quartz-rich. BasinMod includes a library of shale lithologies which are commonly found in unconventional resource plays. These lithologies enable more realistic modelling of source and reservoir properties, especially those properties which contribute to brittleness and fracability.
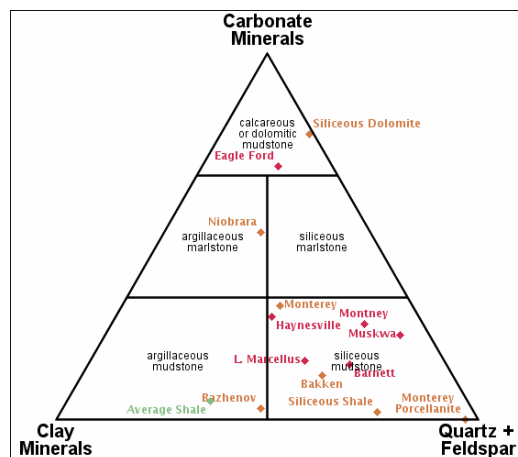
TERNARY DIAGRAM SHOWING SHALE COMPOSITIONS OF MAJOR UNCONVENTIONAL RESOURCE PLAYS

Sequence Stratigraphy

- Determine the vertical distribution of organic-rich source rock intervals by correlation with Maximum Flooding Surfaces.
- Recognize intervals of enhanced producibility by identifying Maximum Flooding Surfaces and Condensed Sections, which commonly have appropriate petrophysical properties for brittleness, such as low clay content and abundant quartz.
- Spatially define the organic rich source rock interval by automatic correlation of surfaces across the project area.
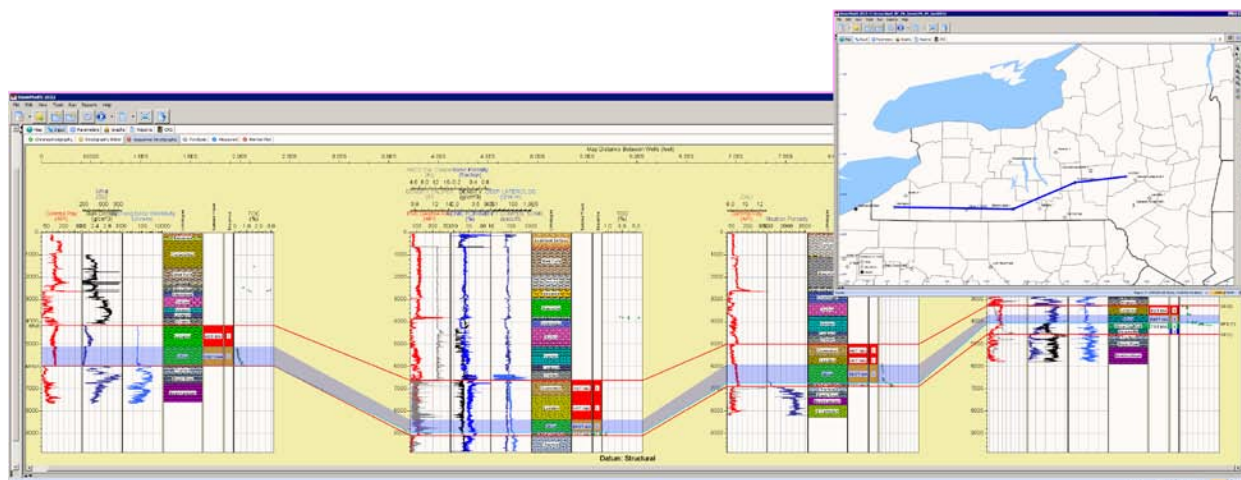

SEQUENCE STRATIGRAPHY CROSS-SECTION IN NEW YORK SHOWING CORRELATION OF SEQUENCE BOUNDARIES (RED), THE MAXIMUM FLOODING SURFACE (CYAN), AND THE SYSTEM TRACT (SHADED BLUE)

BasinMod Bridge
for BasinMod®

Using Bridge, BasinMod® models can be created by dragging and dropping various data from industry-standard data bases, such as Petra® or IHS® 297 into BasinMod. All known incoming data formats are supported.

An automated workflow facilitates the selection, quality control, and editing of data to be imported.
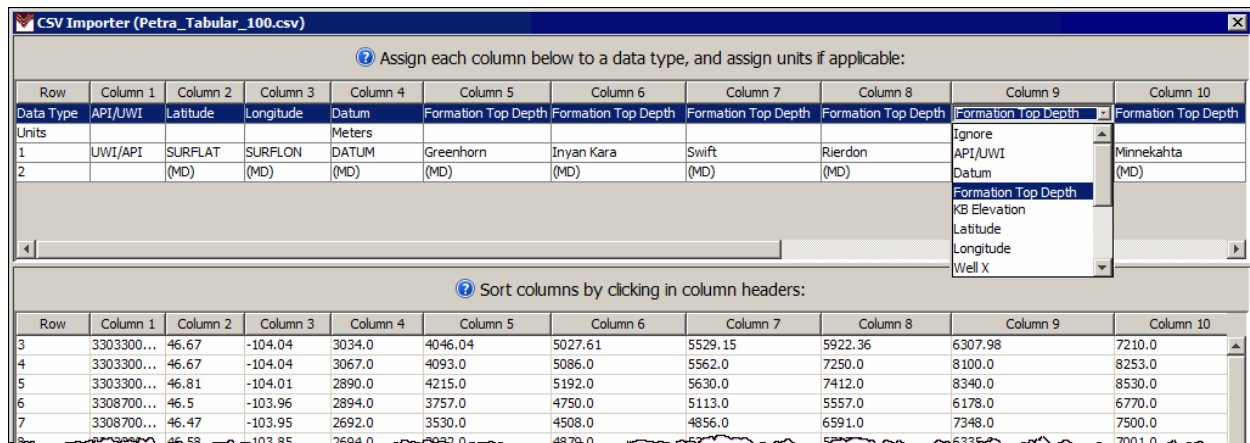

During the import process, formation names can be standardized.

Once models are created in BasinMod, information which is needed for modelling but which is typically not available from third party applications can be added within BasinMod via Globalizers. Edits of key parameters can be made to any or all models, greatly reducing the time needed for data entry. For example, in a play with tens or hundreds of wells, a kerogen can be rapidly assigned to the source rock for all models or a selected group of models.

Bridge also facilitates the seamless import of many measured data types. These can be used for modelling and calibration. These measured data can be mapped and viewed spatially.
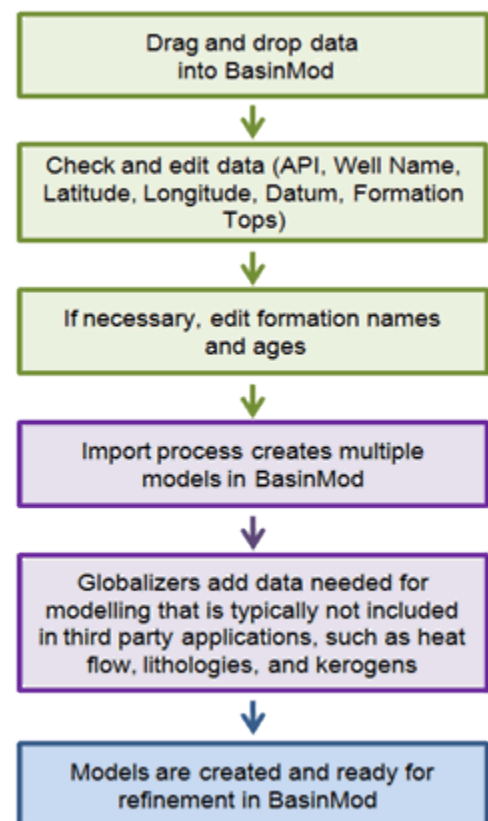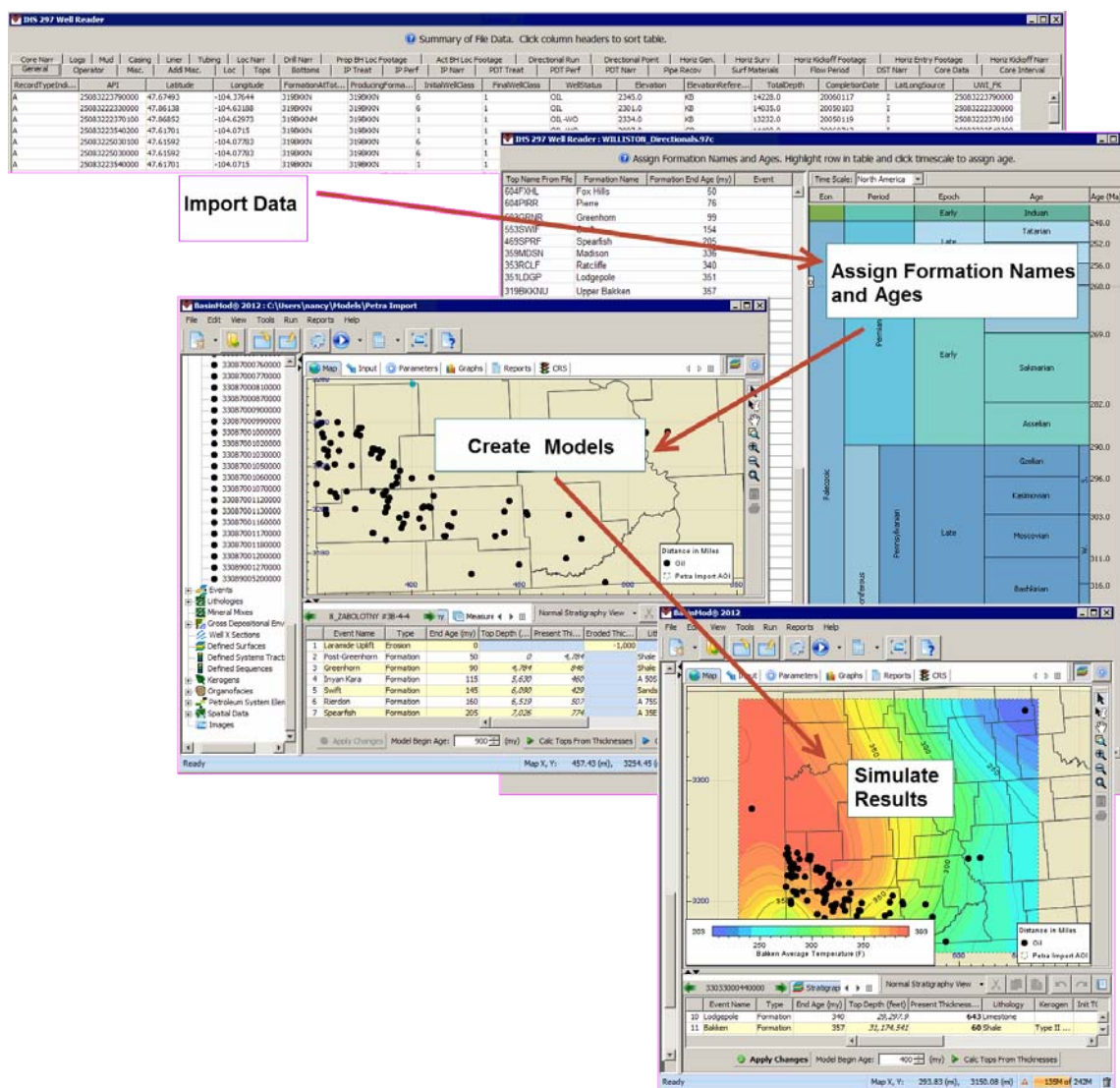
Using Bridge for BasinMod, multiple models can be constructed from industry-standard data bases, and can be ready for modelling in a matter of minutes.

*Petra and IHS 297 are registered trademarks of Information Handling Services Inc.

Platte River Associates, Inc.
2790 Valmont Road
Boulder, CO 80304 USA
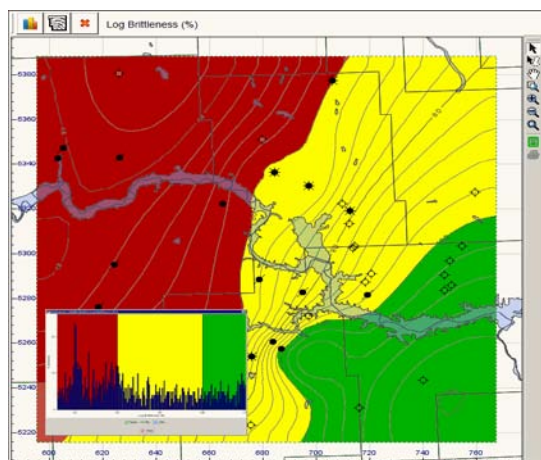www.platte.com
info@platte.com

PRA
Platte River Associates, Inc.

CRS+ Module
for BasinMod®

The CRS+ Module for BasinMod® takes petroleum systems modelling one step further by creating maps of geologic chance as part of an integrated workflow in BasinMod. The resultant spatial risk analysis is especially useful to high-grade areas of lowest risk, condemn areas of unfavorable geologic conditions for hydrocarbon potential and highlight areas of uncertain prospectivity which need further analysis or data.

A wide range of maps of calculated values can be generated from petroleum systems modelling. These can be used to create Common Risk Segment maps which are then combined via stacking stacked to create a Composite CRS or "Roll Up" Map.

Other applications commonly take into account play risk polygon maps, creating a stoplight map of risk. Platte River's approach is to use measured or calculated data (components) to represent the play elements. The user can then use the histogram analysis functionality to identify relative probability on a component level via setting thresholds.

Utilizing the Unconventional Resource Module, values such as Brittleness and Oil Generation Pressure, can be used to identify those areas in the play where favorable conditions for both hydraulic fracturing and oil generation can be delineated.

Multiple scenarios can be constructed to evaluate different components, or to consider different thresholds of the same components.
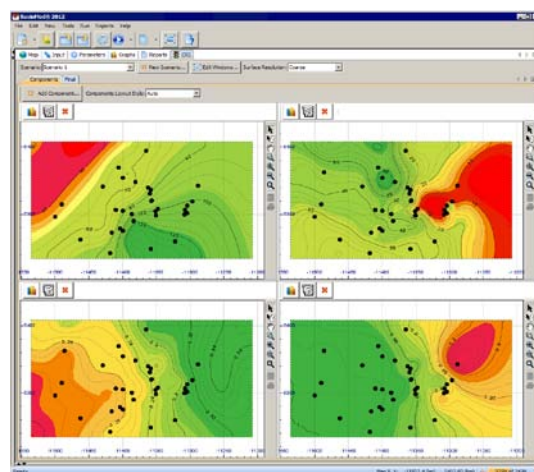

COMPONENT MAPS IN THE CRS+ MODULE

COMPONENT MAP WITH HISTOGRAM IN THE CRS+ MODULE

Maps made with CRS+ are not limited to three colors, but can take the relative probabilities of each component and place them in an ordinal framework. An example with nine levels of relative probability is presented.
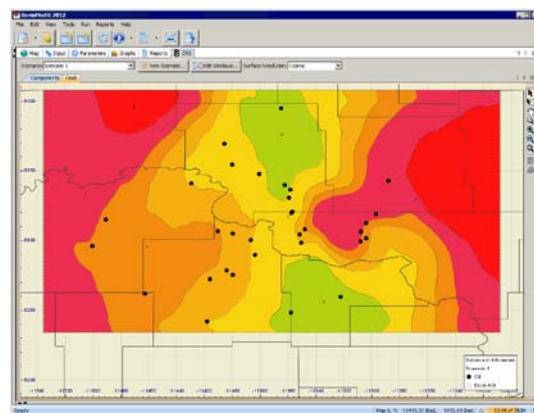
CRS+ can be used for conventional or unconventional resource plays since many alternate components can be rapidly evaluated to identify those that control the play elements.


COMPOSITE OR "ROLL UP" MA

BasinMod® Risk Overview

Address the uncertainty associated with the elements and processes of petroleum systems, plays, and prospects with BasinMod Risk. Unlike deterministic modelling programs, BasinMod Risk utilizes a stochastic approach to modelling which tests thousands of assumptions and produces a range, or probability distribution, of results.
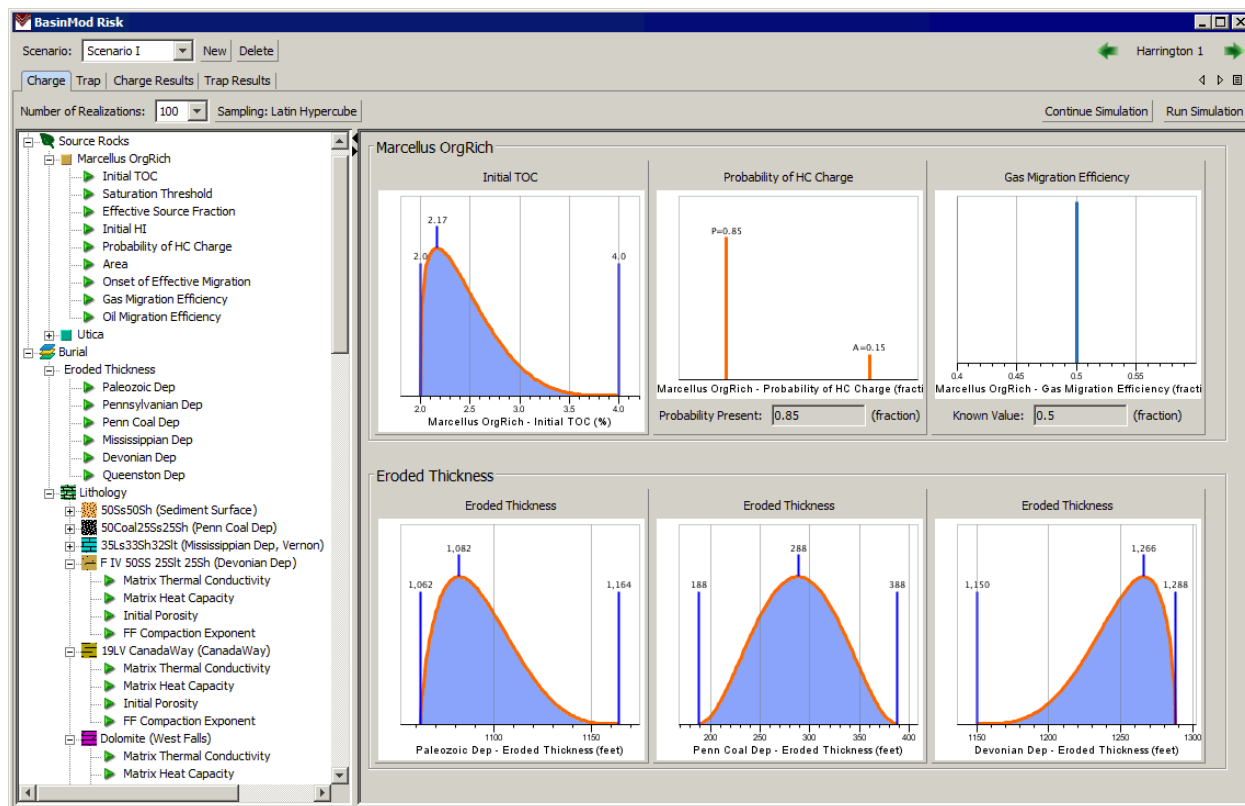
DRAG AND DROP ELEMENTS FROM THE TREE AND APPLY UNCERTAINTY.

Input:

- Users assign uncertainty to source rock parameters of Initial TOC, Initial HI, Area, Migration Efficiency, Effective Source Fraction, Probability of Hydrocarbon Charge, Saturation Threshold, etc.
- Uncertainty can also be assigned to reservoir parameters of Pore Pressure, Temperature, Porosity, Thickness, Recovery Efficiency, Net/Gross Ratio, Formation Volume Factor, etc.
- One, two, or three reservoirs can be defined.
- Lithologies and their rock properties, as well as eroded thicknesses, can also be assigned uncertainty.
- Uncertainty is assigned by means of a BetaPERT distribution where the user enters minimum, maximum, and most likely values.
- Sampling within BasinMod Risk may be done using either a Monte Carlo or a Latin Hypercube method.

Output:

- The results of the simulation are distributions of charge migrated, oil and/or gas in-place, recoverable reserves or other user defined parameters. Each of the critical components is defined by a probability distribution. Sampling the set of critical probabilities yields a distribution of prospect 'value', i.e., a

probabilistic ranking of the identified prospects. Risk can be simultaneously assessed on multiple traps within a play, or multiple compartments within a structural trap.

- Outputs include P10, P50, P90 maps of critical results including Methane Adsorbed, Oil or Gas Generated, Expelled, or Retained, and Free Gas in addition to Gas or Oil In Place Volumes and Gas or Oil Recoverable Reserves.
- Additionally, for each of the parameters with uncertainty, probability density histograms, reverse cumulative probability plots, rank correlation ("tornado" diagrams), and scatter plots are provided.
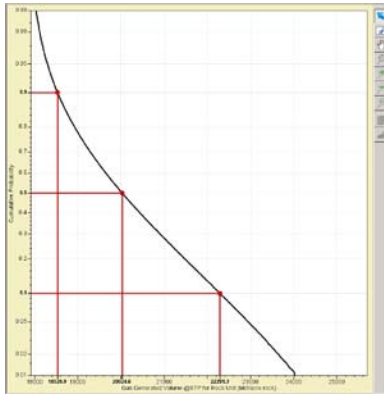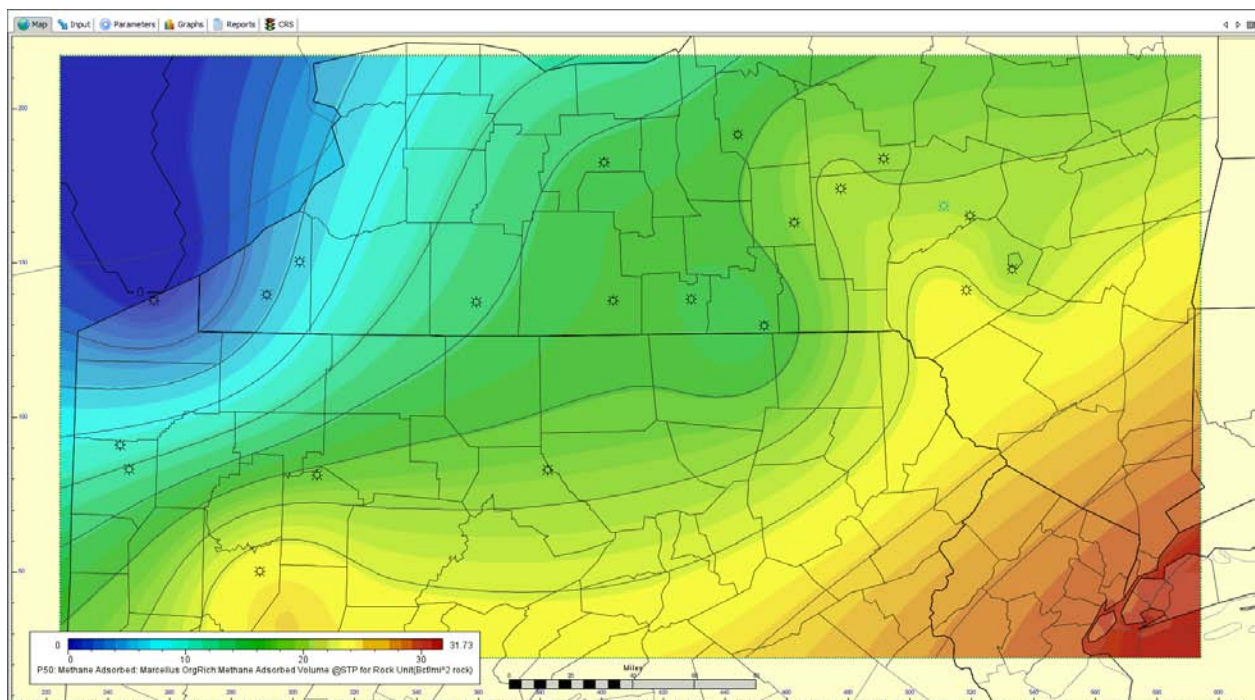

REVERSE CUMULATIVE PROBABILITY CURVE WITH P10, P50, P90 VALUES
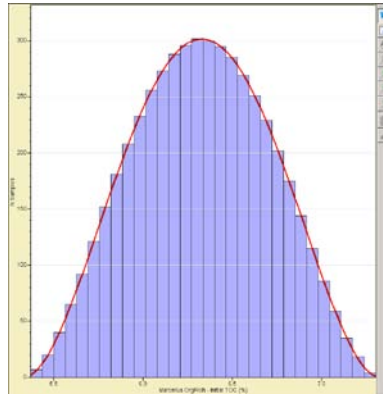
PROBABILITY DENSITY CURVE
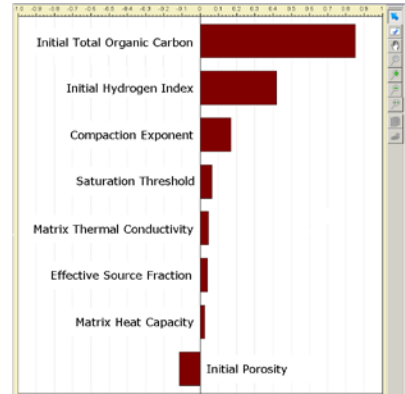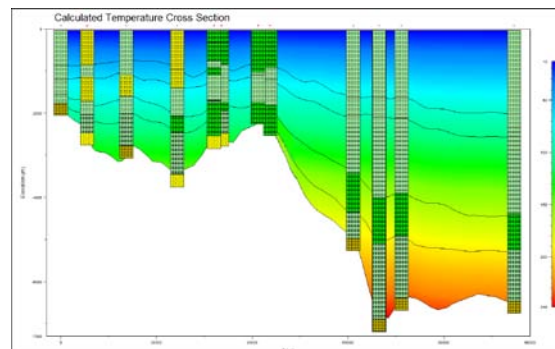

TORNADO PLOT SHOWING STRONG TO WEAK CORRELATIONS

MAP OF P50 PROBABILITY OF METHANE ADSORBED VOLUME AT STP (BCF/MI2 ROCK)

BasinView® Overview

BasinView links the products in the Petroleum Systems Suite, including BasinMod®, BasinMod Risk, and BasinFlow. Multiple BasinMod well models as well as surface grids or isopachs can be imported and used to generate surfaces for a multitude of calculated values. Results can be displayed as maps, cross-sections, and in 3-D using the three-dimensional surface viewer. BasinMod Risk models can be generated from any well or pseudowell in the project.

Display:
- Display calculated results as surfaces for multiple, user-defined time steps.
- View maps of hydrocarbon generated, expelled, and retained, maturity, porosity, permeability.
- Modify gridding parameters to enhance local features or directional trends.
- Correct crossing horizons and insert new horizons.

Input:
- Gridded data from Z-Map, ARC/Info, Surfer, and others.
- Any data in ASCII xyz format.
- Models from BasinMod.
- Cultural data such as coastlines and lease boundaries in ESRI Shapefile format.
- User-created surfaces for thickness, missing thickness, porosity, Total Organic Carbon and other values.

BASINVIEW CALCULATED TEMPERATURE X-SECTION

Output:
- Maps of calculated values at present day and at user-defined paleo ages.
- Cross-section for user-created lines on map.
- Export results in a variety of formats to other mapping packages.
- Calculated output can be used by BasinFlow to determine migration pathways and accumulation in traps.
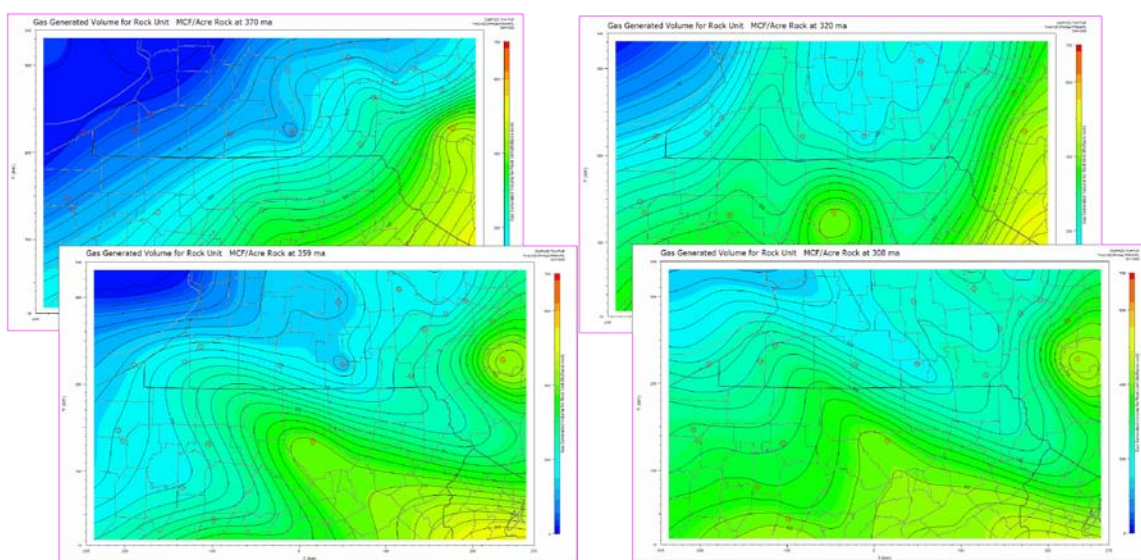
DEVELOPMENT OF GAS GENERATION THROUGH TIME

BasinFlow® Overview

BasinFlow is a flow path modeling program (2.5-D) that combines source rock and carrier bed data with hydrodynamics to model oil and gas migration and entrapment potential at the prospect, play, or basin level.

BasinFlow:

- Defines migration pathways and fetch areas.
- Identifies structural, stratigraphic, fault, hydrodynamic, and combination traps.
- Calculates oil and gas accumulation in traps.
- Models trap fill and spill.
- Models the impact of ground water recharge /discharge on migration and entrapment.
- Simulates loss of hydrocarbon during migration or though seal leakage.

Migration Dynamics:

- Buoyancy drive caused by variations in structure and the density differences between hydrocarbons and formation water - predicts structural traps.

- Capillary drive caused by variations in oil-water capillary pressure, which is a function of permeability - predicts stratigraphic and fault traps.
- Water drive caused by groundwater flow - predicts hydrodynamic traps.

Output:

- Display BasinFlow output as maps through geologic time in BasinView.
- Draw maps of traps, migration pathways, and fetch areas.
- Interrogate traps and fetch areas to obtain hydrocarbon volumes accumulated, etc.
- Display vector maps of buoyancy, capillary, and hydrodynamic drive.
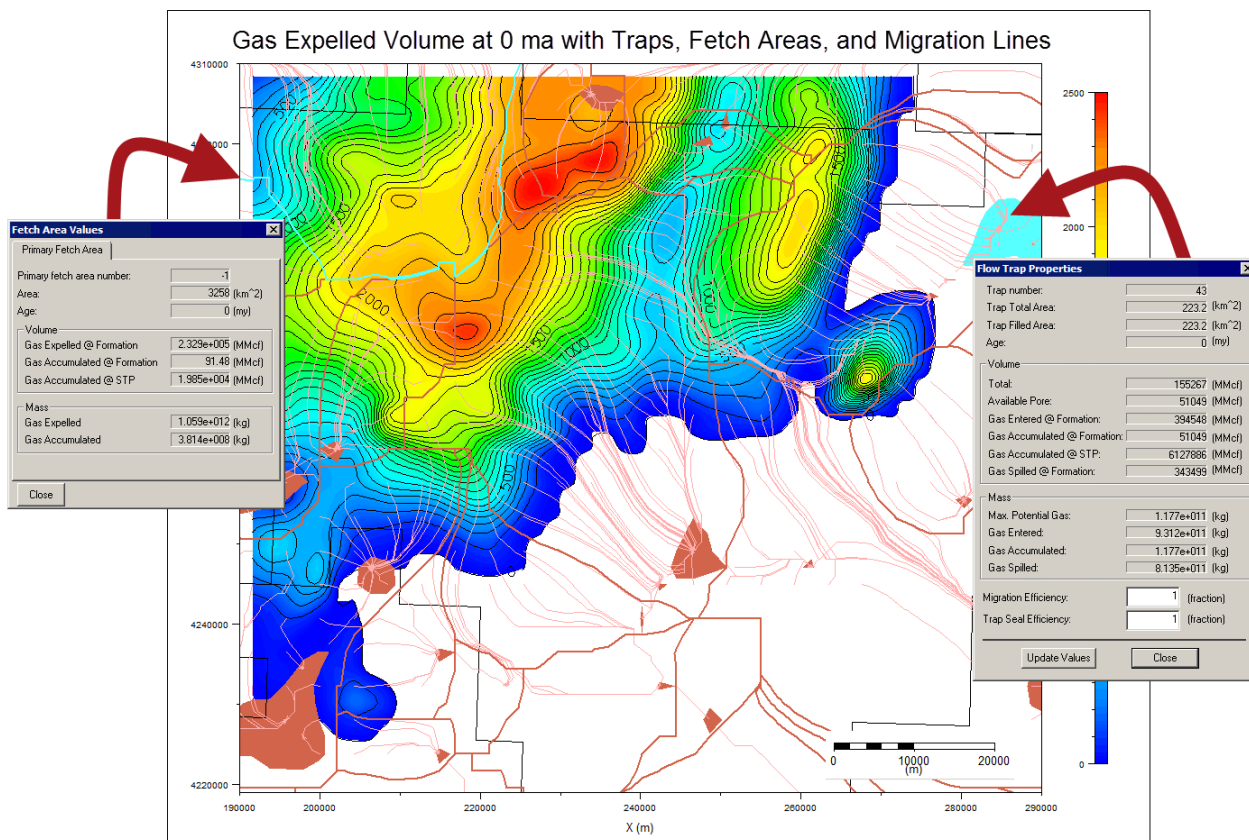
BASINFLOW MAP OF GAS EXPELLED SHOWING TRAPS, INTERROGATED TRAP PROPERTIES, FETCH AREAS, INTERROGATED FETCH AREA PROPERTIES, AND MIGRATION LINES

BasinMod 2-D Overview

BasinMod 2-D models dynamic geologic conditions within a petroleum system, by examining hydrocarbon generation from source rocks through secondary migration and accumulation in traps.

Model building:

- Import data including BasinMod model files, digitized or scanned cross sections, interpreted horizons or interpret directly from seismic lines.
- Easily handle complex stratigraphy, including complicated unconformities.
- Vary surface temperature and heat flow through time.
- Model lateral and vertical facies successions.
- Graphically display and edit chronostratigraphic section.

Calculations:

- Calculation engine combines backstripping and forward modeling.
- Calculate values for all cells in a calculation grid. The variation of pressure and fluids in adjacent cells drives migration.
- Uses finite difference method for thermal and fluid flow calculations.
- Fluid flow along faults may be or automated or manually controlled.
- Calculate effects of mobile substrates (e.g., salt, shale) through time.

Output:

- Display model values, such as temperature, pressure, maturity, generation, and saturation in cross section either as continuous color or value windows at any point in time.
- Measured maturity, porosity, temperature and pressure may be displayed on the cross section for calibration.
- Draw a burial history or plot any model value versus time or depth.
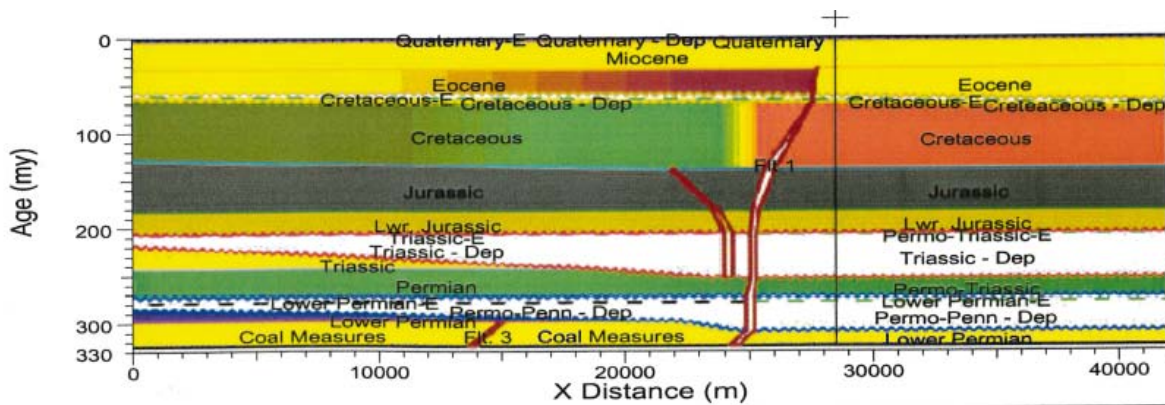- Display flow arrows for oil, gas and water.
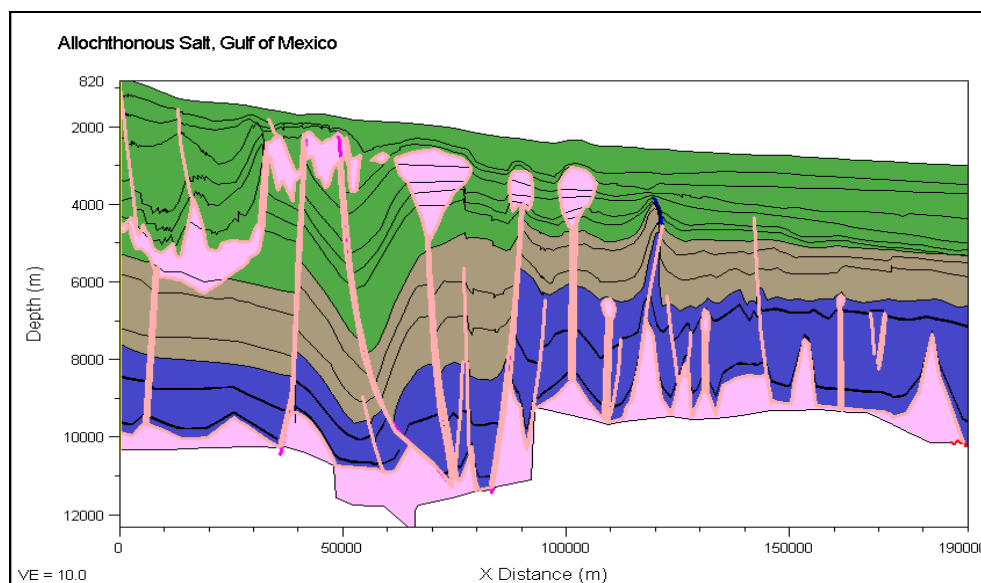
Model the entire Petroleum System from Source to Trap
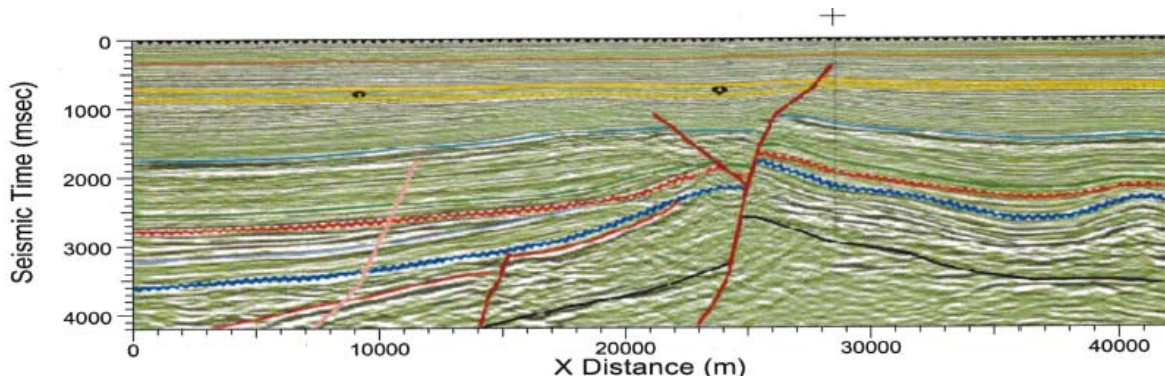
Cross Section constructed from SEG-Y file
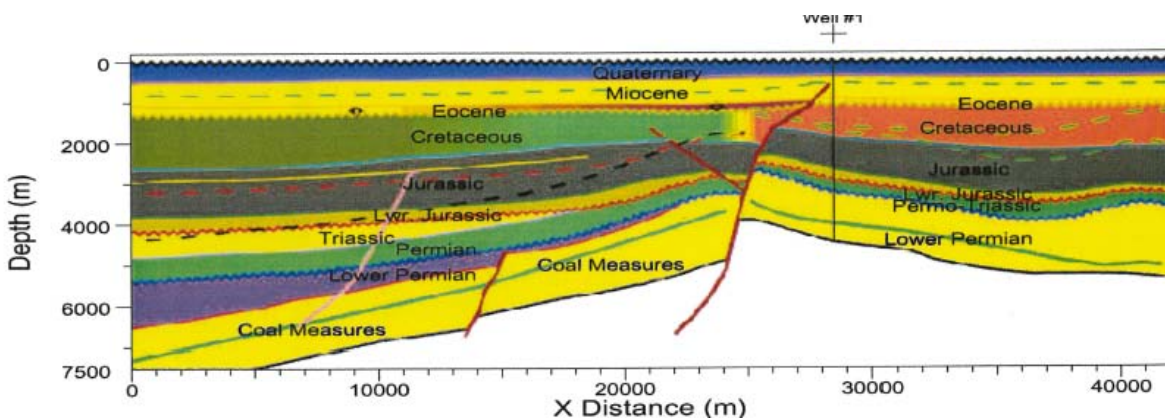
Cross section converted to depth section

Cross section displayed in chronostratigraphy (Wheeler Diagram)

PetroAnalyst®
Play Fairway Mapping and Analysis

PetroAnalyst provides a framework for the consistent, spatial evaluation of geologic risk in all types of plays from frontier areas, with sparse analog data, to mature areas with multiple grids, fields and wells.

Confidence estimates, derived from Data Density and Data Quality, can be integrated into the analysis to generate maps of Geologic Probability or Chance of Geologic Success (COS). This enables the geoscientist to avoid communicating unsupported estimates of high or low COS without sufficient data.

Composite Risk with Optional Data Reliability can be used instead of Geologic Probability for the final composite.
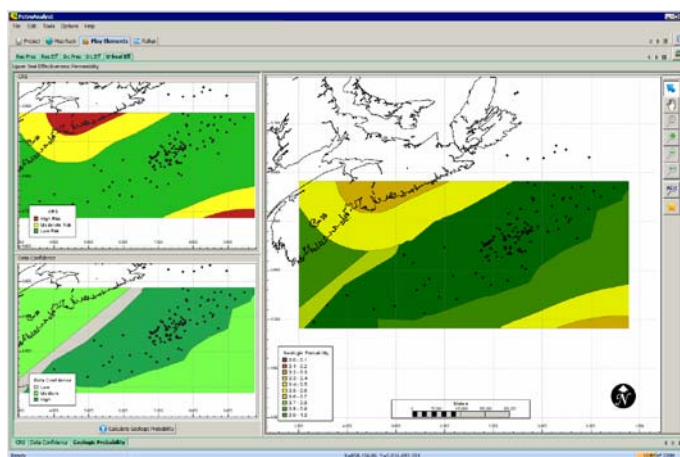
CRS Map + Data Confidence = COS

PetroAnalyst includes an interface with a guided workflow to set up the project, load/prepare all the data (polygons, grids, and/or point data), evaluate the play elements, integrate estimates of data confidence and produce a final COS map.

PetroAnalyst has been used for both unconventional and conventional play fairway analysis. With the former, the geoscientist can evaluate the many parameters that might control the producibility of an unconventional reservoir such as maturity, brittleness, pressure, thickness, etc. Sweet spots can be identified by evaluating each parameter individually then rolling them up into a final map.
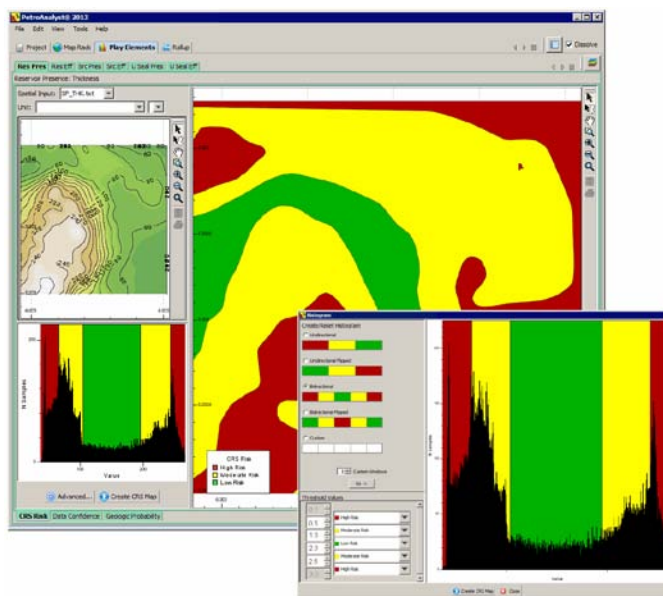
MATURITY CRS MAP DERIVED USING HISTOGRAM ANALYSIS OF GRIDDED DATA

PetroAnalyst Key Advantages:

- A consistent methodology to communicate play risks across different business units for corporate decisions

- Repository for storing all corporate memory for a play yet can rapidly integrate new data or replace erroneous interpretations, well tests and alternate scenarios

- In areas of sparse data, a library of over 200 Gross Depositional Environments (GDEs) provides the facility to define polygons and assign relative probabilities to the play elements
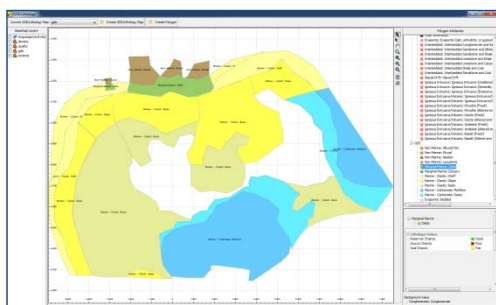

GDE ASSIGNMENT FROM IMPORTED SHAPE FILE

- Supports the identification and evaluation of the critical play element or 'proxies' that control the presence and effectiveness for the

play elements. Proxies can be used to support the evaluation of both conventional and unconventional plays

- Grid to Grid Manipulation Tool – Perform simple to complex mathematical functions on input grids with the ability to recall and use any previous equation
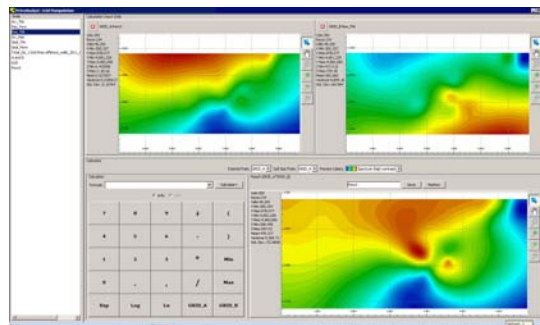

GRID TO GRID MANIPULATION TOOL

- Integrates with analog or third party databases to provide an initial framework for play analysis. This can be used in PetroAnalyst's GDE library to assign relative probabilities

- An extensive lithology library is also included where GDE's are unknown or lithology can be better used to represent the risk of presence or effectiveness of a play element

Key features:

- Audit Trail monitors changes to the project and the "undo" function permits roll back to any previous state

- Data Evaluation Tool uses radar plots to display data quality and quantity prior to modelling to highlight areas where more or better data are needed

- Customize the interface, including the geologic probability matrix, map names, and assignment of map colors to maintain consistent corporate or group Play Fairway Analysis methods

- "Drag-and-Drop" import into the Map Rack of common data types including grids, shapefiles and spreadsheets

- Manipulate input grids to create missing play element maps (ex. porosity map from a depth grid using porosity vs. depth trend)
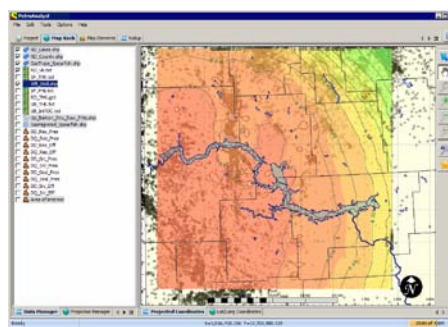
MAP RACK

- Easily resolve projection discrepancies using the Projection Manager

- Internally construct grids from point data

- Make components (proxies for presence or effectiveness) independent or dependent

- Assign relative risk levels to areas from an included library of gross depositional environments (GDE) and lithologies

- Assign common areas of risk and data confidence with included digitizing tools or conversion of shapefile polygon attributes

- Roll up areas of common risk or chance of success into play element and play level summary maps

- Identify key risks for areas on rollup maps using evaluation points, radar plots, and color filled radar plots

- Generate slides automatically populated with screenshots produced by the maps and definitions in the project

- Automatically create individual images of all maps for use in other software packages

- View a summary of all maps contributing to the final rollup map, including CRS maps, data confidence maps, geologic probability maps, or data reliability input and data reliability result maps

- Export map inputs and results as shapefiles or grids for use by other groups or disciplines
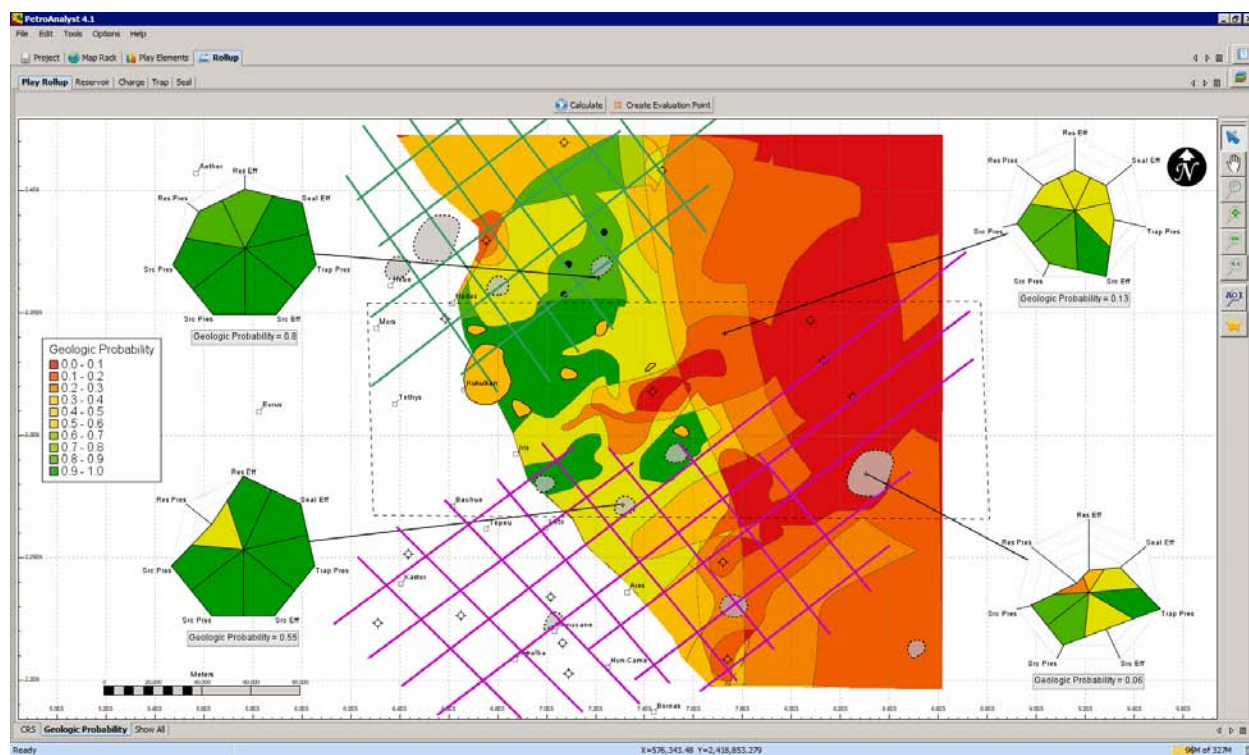
COMPOSITE ROLLUP MAP WITH COLOR FILLED RADAR PLOTS SHOWING PROSPECT COS AND INDIVIDUAL PLAY ELEMENT RISK

For more information about PetroAnalyst or to schedule a demonstration, please contact sales@platte.com

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