2nd Edition 2018

geoLOGIC NEWS

A publication of Subsurface Consultants & Associates, LLC

SCA and IHRDC Team Up for Global Training

A message from our President

I am extremely pleased to announce that SCA has entered into a Joint Marketing Agreement with IHRDC, a Boston-based company that offers an extensive catalog of competency assessment and management tools, web-based e-Learning, oil and gas management courses, virtual learning and mentoring services, and petroleum industry learning simulation games. Dave Donohue, IHRDC's President, founded the company almost 50 years ago and is a pioneer in applying innovative learning technology to meet our industry's training needs. In addition to their headquarters and learning facilities in Boston, IHRDC has offices and representatives in many worldwide locations.

The technology of learning is rapidly evolving, and the current trends are focused on less traditional, more "blended" learning experiences presented in a format that makes learning more engaging to the participants. Through IHRDC, SCA has enhanced our classroom format with a more comprehensive and blended suite of offerings including modularized lectures, applied exercises, team participation in challenging business simulation "games," field trips, and digital and virtual learning offerings. We also add the capability to help our clients design complete training programs based on highly effective, industry-accepted, competency-models.

Together SCA and IHRDC provide a full menu of high quality, technologically current learning resources that addresses the evolving expectations of our oil and gas industry clients. We welcome your recommendations and participation.

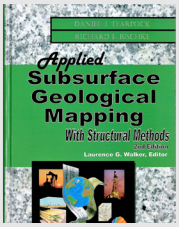
Hal Miller
President

in this issue:

spotlight:

30-YEAR ANNIVERSAY

This year SCA celebrated serving the industry for over three decades. See **P11** for details!



JANUARY 2019:

Our flagship course is being offered at a substantial discount for unemployed / underemployed.

More details on **P10**!

SCA
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Stay connected with SCA

Screening Volumetrics in Petrel© for Quick Resource Evaluations

by Laurie Green, MSc, PG

Understanding the possible range of hydrocarbon volumes in an exploration lead or prospect is fundamental to evaluation of the economics of a project, yet there is seldom sufficient data (or time) to perform detailed volumetric calculations using a 3D geologic or simulation model. Simple screening methods may provide sufficient information to make decisions – for example, to bid on a block, rank prospects for drilling, or participate in a farmout. Other useful options in the volumetrics operations include creation of area or volume/depth functions and polygons around closure areas.

Uncertainty and Volumetric Calculations

The volume of hydrocarbons in a reservoir is defined by many factors. Principle among these are structure, porosity, net/gross and gas/oil/water saturation and contact depth. It is the responsibility of the geoscientist to establish uncertainty ranges of values for each factor and calculate the combined effect on hydrocarbon volumes.

Structural uncertainty falls into two categories – discrete and continuous. Examples of discrete uncertainty would be structural models with different fault patterns, or the use of a different seismic velocity model. Each interpretation would be handled as an individual scenario. Continuous structural uncertainties could include picking uncertainty along seismic horizons or depth uncertainty on maps constructed from sparse data.

The ranges and variance of porosity, net/gross and fluid saturations can be established from existing wells using Petrel's© statistics panel for each property, or defined from nearby analogues.

Traditionally, volumes were calculated using only the estimated high, low and "best technical" values for each factor due to limitations of time and technology. Even when statistical methods like Monte Carlo analysis were used, the validity of the defined P10/P50/P90 values were questionable because maps could not be visualized to make sure they made geologic sense.

As discussed below, Petrel's© advanced "Map-Based Volumetrics" can be used to calculate and display hundreds of unique results ("cases") defined by variance in the reservoir's structure, porosity and net/gross. Contact depths can be shifted incrementally within a specified range and reservoir volumes calculated for each. Results are summarized in spreadsheets and histograms, where individual P10/P50/P90 cases can be selected for visualization and further analysis.

Automating Volume Calculations

As a project moves from the exploration phase through appraisal into production, additional well and seismic data will be acquired, structures will be remapped and volumetrics will need to be recalculated. If those calculations are built into a workflow, they can be run automatically to incorporate the new information and generate new volumetric reports and maps. This approach ensures standardized processes and minimizes the chance of errors.

Volumetrics in Petrel©

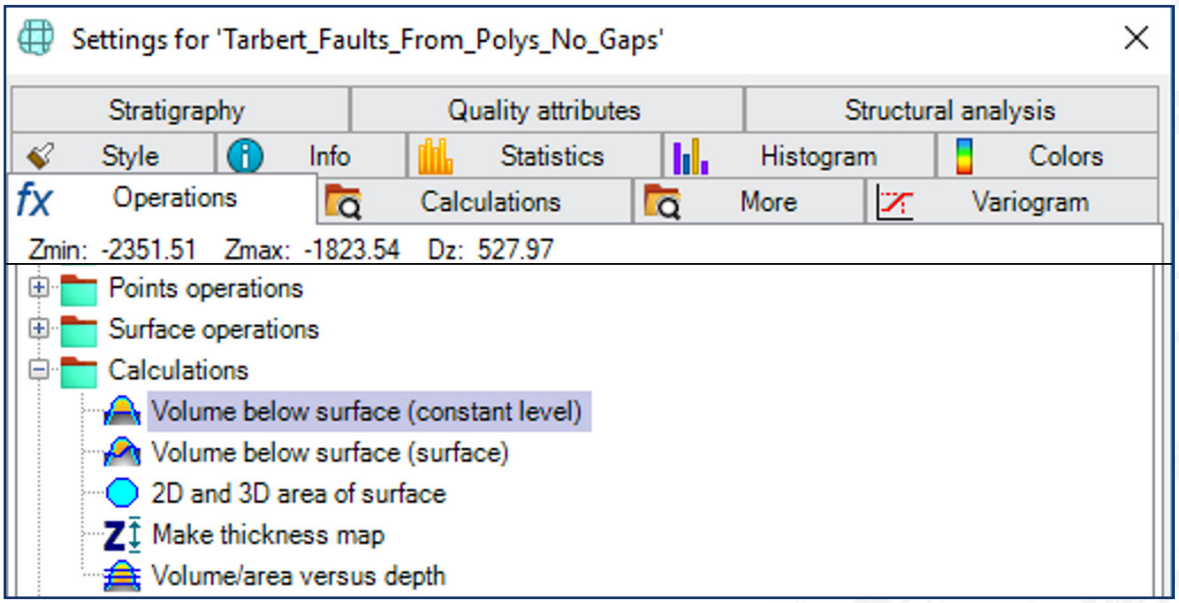
Petrel© offers several methods to generate quick volumetric estimates using maps which should already exist for a prospect – at the minimum, a depth surface and a contact. The method selected will depend on the amount of additional data available and the project's requirements for more or less detail and accuracy.

Petrel's© single-surface and two-surface methods are simple operations which calculate deterministic values for Gross Rock Volume (GRV). To estimate in-place resources, additional operations would need to be performed using Petrel© or a spreadsheet to apply zone-average net percentage porosity and water saturation factors.

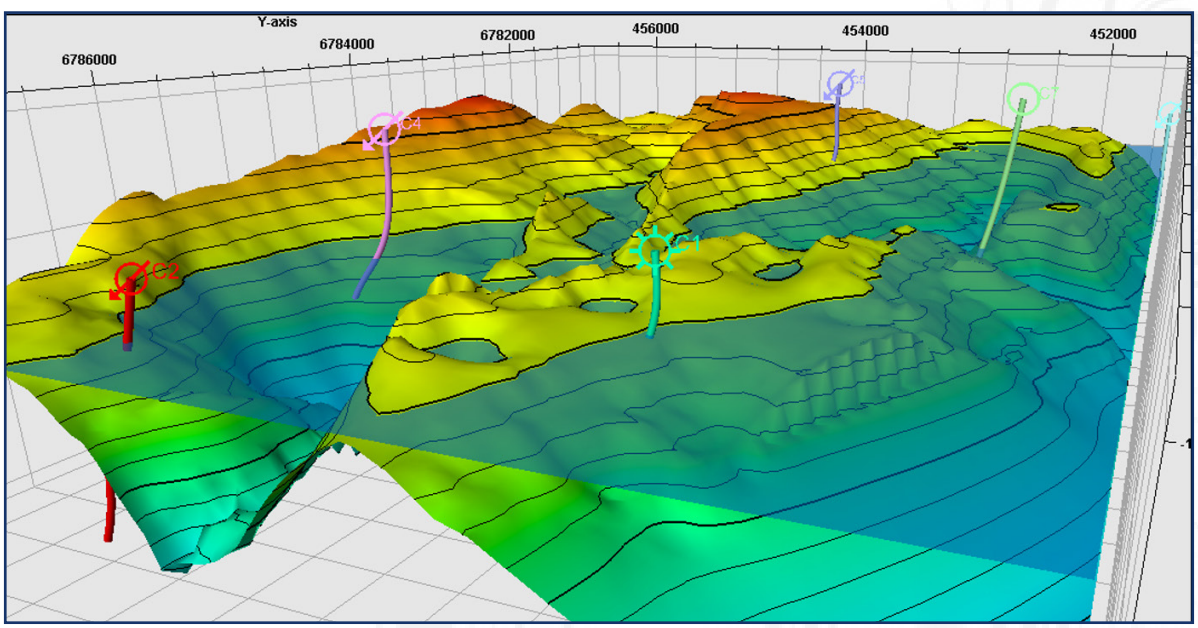
The map-based method is significantly more advanced, yet relatively straightforward to implement. Besides calculating a variety of volumetric quantities such as recoverable hydrocarbons for multiple zones, it can create property height maps and perform uncertainty analysis based on variance of structure, porosity and net/gross.

Single-Surface and Two-Surface Volume Calculations

The single-surface and two-surface methods are accessed through the Settings \ Calculations \ Volume operations for a surface. The operations are named "Volume below surface (constant level)" and "Volume below surface (surface)" respectively:

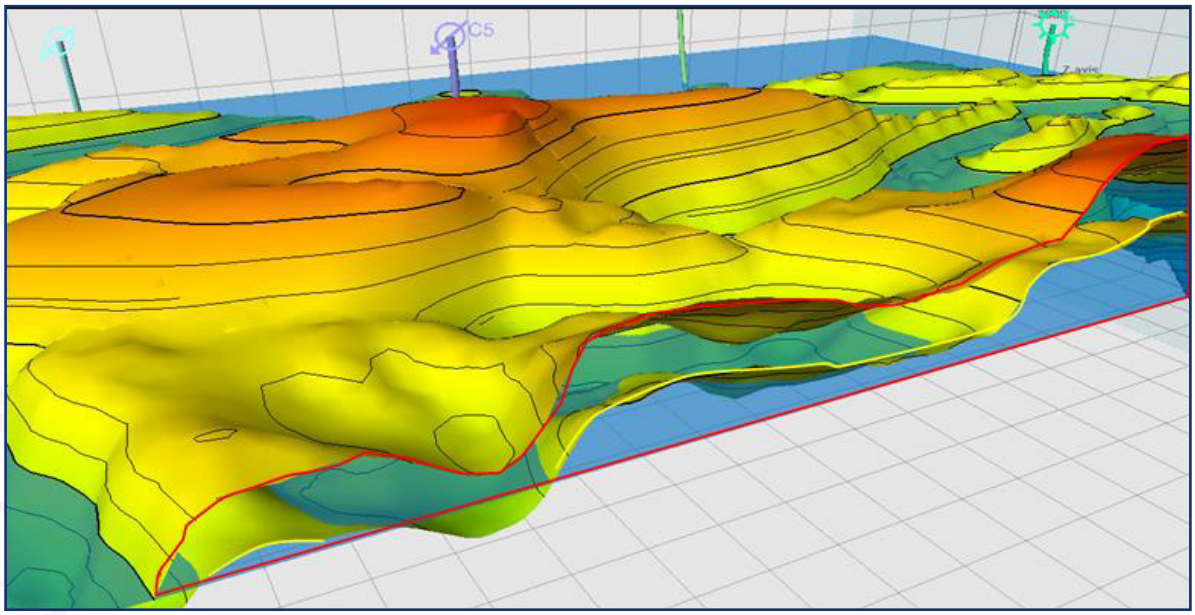


The single-surface method calculates the volume between structural surface and a flat contact. It is suitable for order-of-magnitude, quick-look estimates within a boundary such as a lease outline. It can also exclude volumes within fault polygons.

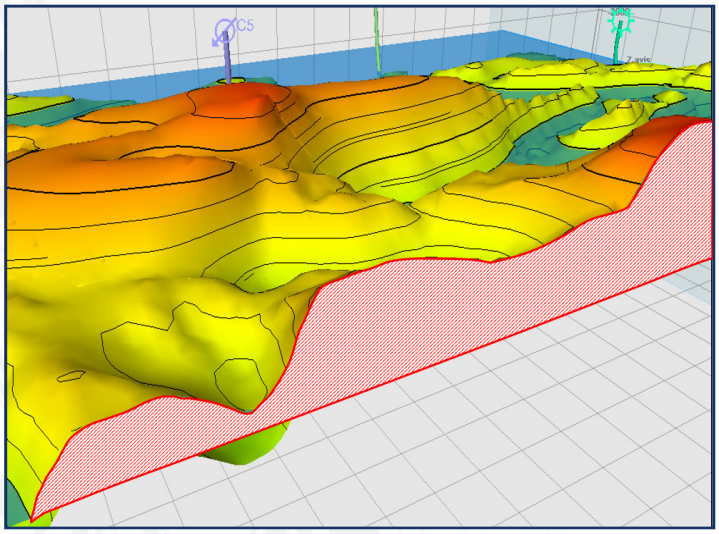


Single-surface with a flat contact

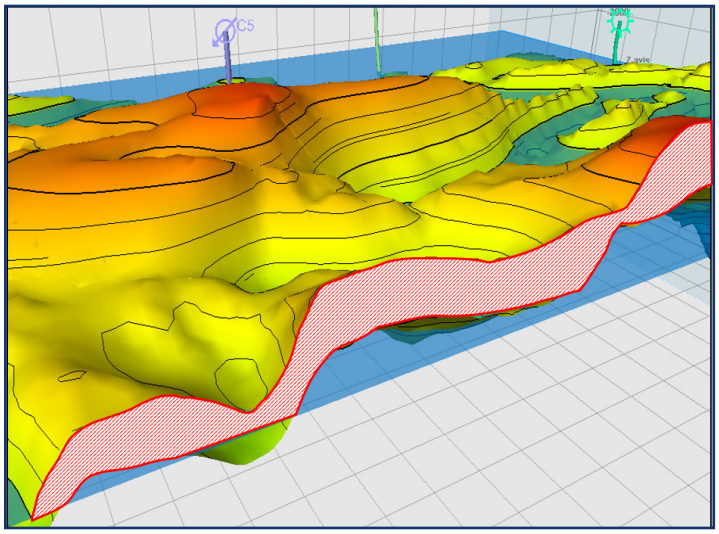
This method has significant limitations. For example, if a second surface is positioned between the original surface and the contact, the calculated volume will be too large. In the example below, portions of the top and base of the reservoir unit are above the contact. In these regions the single-surface calculation will give erroneous results.



Vertical section showing the top and base of a reservoir unit and a flat contact

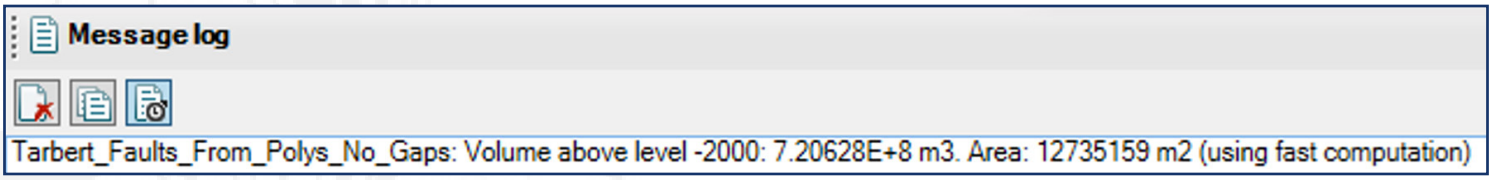


Thickness component of the gross rock volume above the contact as calculated by the single-surface method

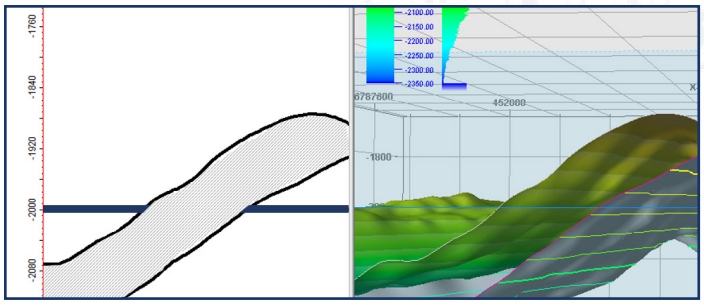


Shaded area shows the reservoir thickness above the contact

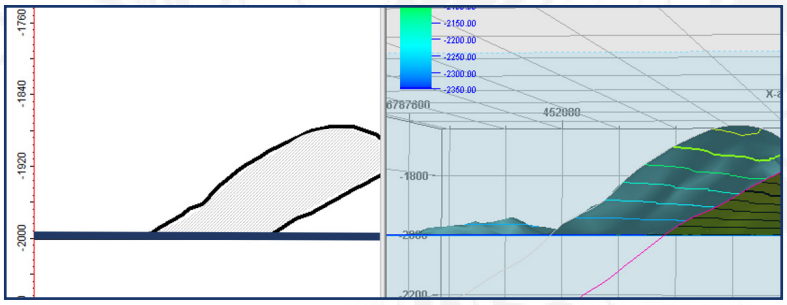
An additional limitation is that the calculated volume is reported only as unformatted text in Petrel's© Message pane:



The two-surface method calculates the Gross Rock Volume (GRV) between two surfaces and can produce reasonable estimates if the surfaces are prepared properly. For example, if a fluid contact is present, both surfaces (or at least the lower surface) must be "clipped" against the contact, as shown at the top of page 5:

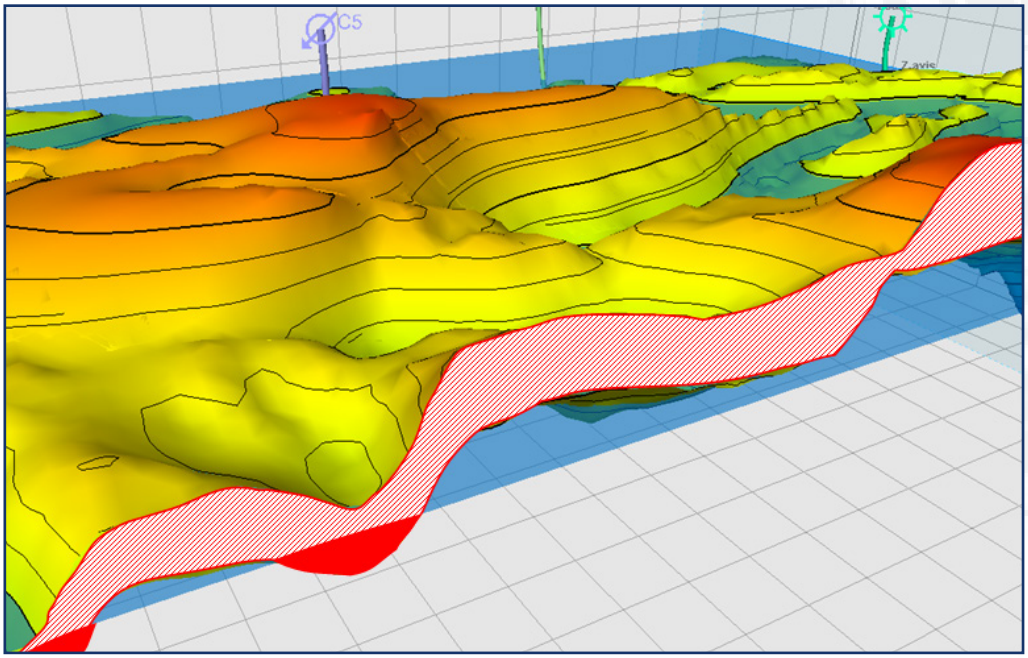


Gross Rock Volume (GRV) between two surfaces - the contact is ignored



Gross Rock Volume (GRV) between two surfaces which have been "clipped" at the contact depth

Otherwise, volume may be calculated where one or both surfaces are below the contact:



Solid regions identify regions of excess volume reported by the two-surface method

The two-surface method reports the results of a volume calculation the same way as the single-surface method, as unformatted text in the Message pane.

Map-Based Volume Calculations

This method is functionally similar to Petrel's© 3D volumetric calculations and includes many enhancements compared to the simple methods:

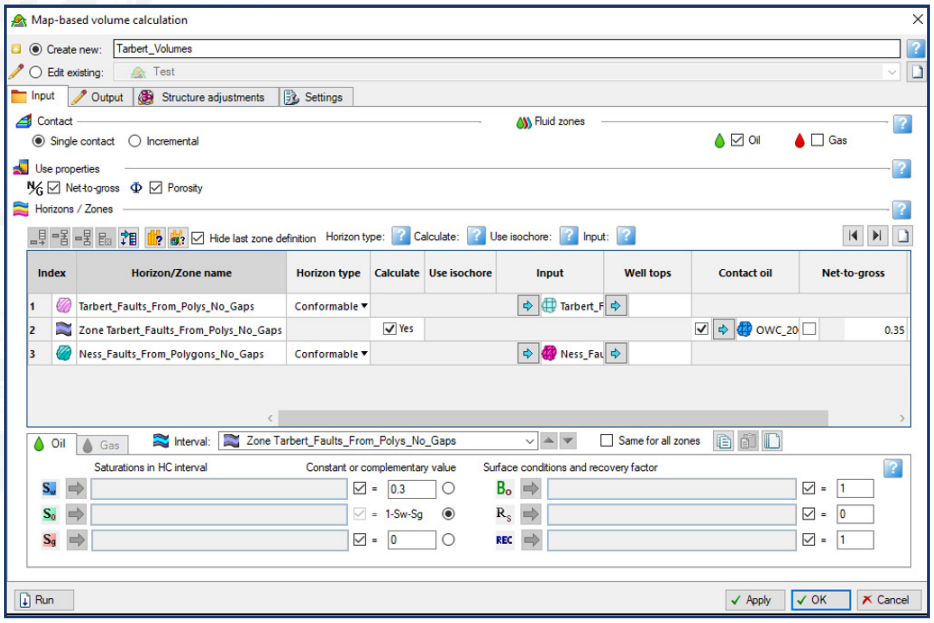
- Multiple zones within specified boundaries
- Multiple contacts of different types (O/W, G/O, etc.)
- N/G and porosity maps or constants as input
- Oil, gas and water saturation maps or constants
- Surface conditions (e.g., Bo) and recovery factors
- Validation of surface geometry (checks for crossovers)
- Uncertainty workflows for contact depth, N/G and porosity

The output options are also enhanced, generating formatted spreadsheet reports, volume height maps and area/volume vs. depth functions. Its uncertainty workflows can be used to evaluate the effects of variability in porosity, N/G and structure, or for a range of contact depths.

Contact sets	Zones	Bulk volun	Net volume	Pore volu	HCPV oil [	STOIIP (in o	Recoverat
Contact set1	Zone Tarbert_Faults_From_Polys_No_Gaps	656	328	45	31	31	31
Contact set2	Zone Tarbert_Faults_From_Polys_No_Gaps	610	305	42	29	29	29
Contact set3	Zone Tarbert_Faults_From_Polys_No_Gaps	567	284	39	27	27	27
Contact set4	Zone Tarbert_Faults_From_Polys_No_Gaps	526	263	36	25	25	25

The map-based volumetrics method is not shown as an option on most of the context-specific "ribbons" so it is most easily accessed by clicking on this icon on the mini toolbar for a selected surface: 

The dialog box has four panels – Input, Output, Structure adjustments and Settings. The Input panel is where the user can specify multiple zones, contacts and other properties. Each zone may have a different set of contacts. Properties are specified as either constants or maps – for example, porosity or N/G may have been mapped from log values.

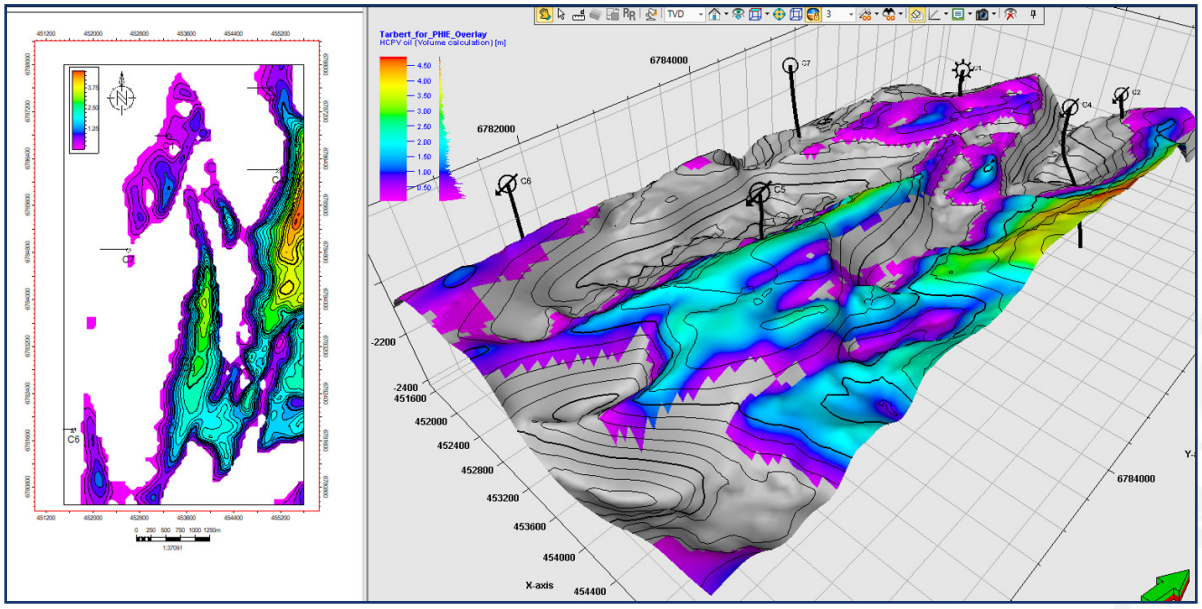


Structural surfaces are checked for crossovers and can be adjusted to tie well depths.

Properties including Bulk, net or pore volume, STOIIP or GIIP and recoverable oil or gas can be output as a formatted report which can be cut and pasted into a spreadsheet. Results can be grouped by contact sets, zones or boundaries. Reporting units can also be selected, such as barrels or cubic meters.

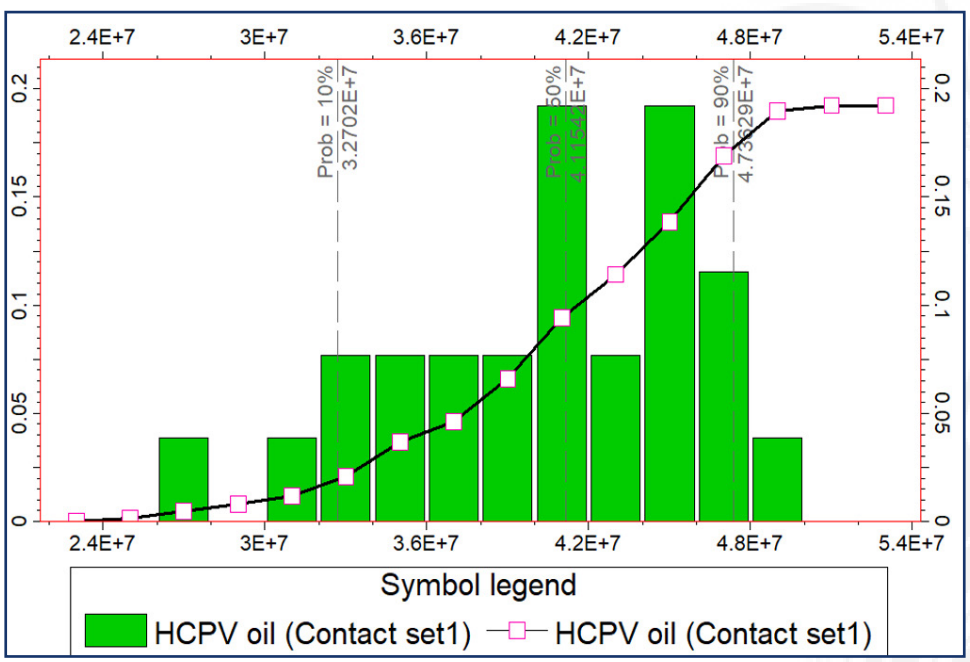
Petrel 2016.3 (64-bit)	Schlumberger				
User name	Igreen				
Date	Thursday, April 26 2018 11:06:55				
Input data					
Zone(s)	Top surface	Base surface/Isochore	Net-to-gross	Porosity	Contact Oil
Zone Tarbert_Faults_From_Polys_No_Gap	Tarbert_Faults_From_Polys_No_Gap	Ness_Faults_From_Polygons_No_Gap	0.3500	PHIE (Top Tarbert)	OWC_2000_ss
Properties in Oil interval					
Zone(s)	Sat. water	Sat. oil	Sat. gas	Bo [rm3/sm3]	REC
Zone Tarbert_Faults_From_Polys_No_Gap	0.30000	1-Sw-Sg	0.00000	1.0000	1.0000
Case	HC Area (in oil) [*10^6 m2]	Bulk volume [*10^6 m3]	HC Area (in oil)	Bulk volume	
Tarbert_Volumes	12.60	488	12.60	488	

Output options include maps of selected volumetric quantities which can be displayed individually or draped over structure maps, such as these displays of hydrocarbon pore volume (HCPV):



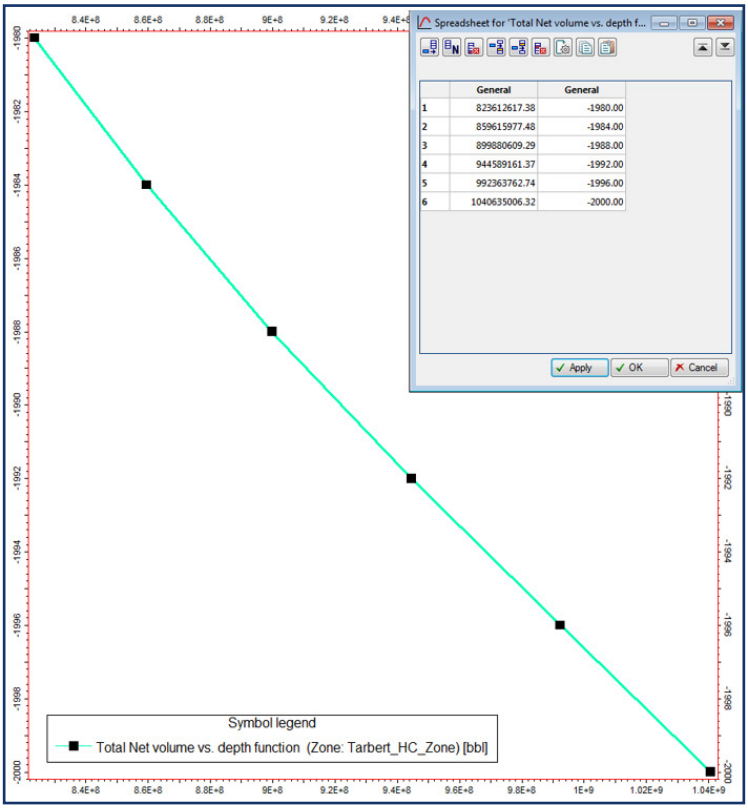
This type of display can be extremely helpful to visualize "sweet spots" in structural or stratigraphic plays.

Perhaps the most powerful feature of map-based volumetrics is its uncertainty workflow. By activating options to evaluate the effects of incremental contact depths or variability in N/G, porosity or structure for each zone, multiple cases can be generated for further analysis, including histograms to display the range of potential outcomes, along with P10/P50/P90 volumes and the cumulative distribution function (cdf):



To evaluate contacts over a depth range, the user specifies the upper and lower contact depths and the number of increments. The results are reported as formatted text and can also be displayed as depth/volume functions (see graphic at the top of page 8).

Variability in N/G and porosity properties are based on their mean and standard deviations, which can be estimated from well log calculations for each zone. Structural variability can be estimated by examining possible sources of uncertainty, such as picking errors or the results of different velocity models. A different case is generated each time the volumetric calculation is run. The calculation can also be embedded in a looping workflow, which will generate as many cases as desired.



The results of individual uncertainty cases are reported as formatted text in the same way as deterministic calculations.

To compare the results of multiple cases, selected values can be displayed in table format without having to export them to a spreadsheet. Color-coding, sorting and percentile displays make it easy to identify cases of interest, such as those which are close to P10/P50/P90 rankings:

'Map-based volume calculation'

Item	$HCPV_oil__10_6_rm3_	$Pore_volume__10_6_rm3_	$Net_volume__10_6_m3_
Tarbert_Volumes_20	49.9929316842842	71.4184750509412	425.863437931378
Tarbert_Volumes_18	47.7851139930112	68.2644497239812	383.886434109612
Tarbert_Volumes_3	45.056731556612	64.366760462748	402.026171773839
Tarbert_Volumes_6	44.4952663166938	63.5646672492052	441.381063668832
Tarbert_Volumes_5	43.8244615086139	62.6063746499143	401.32455291767
Tarbert_Volumes_7	43.6934175583064	62.4191690034298	417.175664252536
Tarbert_Volumes_24	42.1577599899816	60.2253724398914	425.901002173849
Tarbert_Volumes_4	41.5394972144995	59.342139888447	408.197108826727
Tarbert_Volumes_10	41.4099989966405	59.1571424312122	416.838702660324
Tarbert_Volumes_25	40.9913540878054	58.5590782655485	404.426590584786
Tarbert_Volumes_19	39.7288427306316	56.7554905817282	421.33124556748
Tarbert_Volumes_17	38.7376595072411	55.3395145241994	416.569022474183
Tarbert_Volumes_22	38.1278063516475	54.4682957156574	402.459082866972
Tarbert_Volumes_11	38.0042801302137	54.2918296820325	367.164718533928
Tarbert_Volumes_8	37.7939246959072	53.9913219136199	362.679507292155
Tarbert_Volumes_13	37.7681373906383	53.9544829054655	405.265669923039
Tarbert_Volumes_9	36.0378433631319	51.4826342526468	424.864487149035
Tarbert_Volumes_12	35.7495152359726	51.0707369211189	447.922894672214
Tarbert_Volumes_14	34.0765301460418	48.6807581805167	378.329803985645
Tarbert_Volumes_1	33.8861267802004	48.4087533675395	450.331717159689
Tarbert_Volumes_16	32.4739574949934	46.391368640031	363.245628322003
Tarbert_Volumes_23	31.9772460783123	45.6817808898308	420.120300911527
Tarbert_Volumes_21	30.24710594018	43.2101520789787	261.402683397712
Tarbert_Volumes_2	30.065072549695	42.9501043738573	428.187857012118
Tarbert_Volumes_15	24.0847821009631	34.4068321587494	279.713768432376

'Map-based volume calculation'

Item	$HCPV_oil__10_6_rm3_	$Pore_volume__10_6_rm3_	$Net_volume__10_6_m3_
Tarbert_Volumes_20	98.00	98.00	78.00
Tarbert_Volumes_18	94.00	94.00	26.00
Tarbert_Volumes_3	90.00	90.00	34.00
Tarbert_Volumes_6	86.00	86.00	90.00
Tarbert_Volumes_5	82.00	82.00	30.00
Tarbert_Volumes_7	78.00	78.00	62.00
Tarbert_Volumes_24	74.00	74.00	82.00
Tarbert_Volumes_4	70.00	70.00	50.00
Tarbert_Volumes_10	66.00	66.00	58.00
Tarbert_Volumes_25	62.00	62.00	42.00
Tarbert_Volumes_19	58.00	58.00	70.00
Tarbert_Volumes_17	54.00	54.00	54.00
Tarbert_Volumes_22	50.00	50.00	38.00
Tarbert_Volumes_11	46.00	46.00	18.00
Tarbert_Volumes_8	42.00	42.00	10.00
Tarbert_Volumes_13	38.00	38.00	46.00
Tarbert_Volumes_9	34.00	34.00	74.00
Tarbert_Volumes_12	30.00	30.00	94.00
Tarbert_Volumes_14	26.00	26.00	22.00
Tarbert_Volumes_1	22.00	22.00	98.00
Tarbert_Volumes_16	18.00	18.00	14.00
Tarbert_Volumes_23	14.00	14.00	66.00
Tarbert_Volumes_21	10.00	10.00	2.00
Tarbert_Volumes_2	6.00	6.00	86.00
Tarbert_Volumes_15	2.00	2.00	6.00

Individual cases can be selected for further review. In the tables shown above, Cases 11, 22 and 17 are all close to the P50 ranking based on Pore volume. However, Case 4 is actually closest to the P50 ranking for Net volume, so it would be important to create maps for key properties from these cases to understand the areal distribution of the oil or gas. This can be accomplished easily by selecting that case and re-running it individually to generate a full set of property-height maps.

Summary

Decision-makers are often forced to decide between different options quickly and with limited data. Even the simplest screening volumetrics provide visual and quantitative results which will enhance understanding of a prospect. Methods which incorporate uncertainty ranges can provide input for detailed economic evaluations, and all of the methods can be re-calculated in automated workflows throughout the project's live cycle. When applied consistently to an entire portfolio, consistent screening methods should lead to better-informed decisions and outcomes.

About the Instructor: Laurie Green, MSc, PG

Laurie designed and currently teaches SCA's newest course, ***Principles of Mapping with Petrel©***. She has extensive international and domestic experience as a geophysical interpreter, geomodeler, and project manager in conventional and unconventional assets for both E&P and service companies.

Laurie has expertise in computer-based mapping and modeling systems as an interpreter, programmer, and technical trainer. She has performed integrated field studies for global clients using different software systems and understands how computer-generated maps can be used and misused in real-world projects. Laurie received her BS in Geological Sciences from Cornell University and her MSc from the University of California at Santa Cruz. She is a registered Professional Geoscientist in the state of Texas.

PRINCIPLES OF MAPPING WITH PETREL©

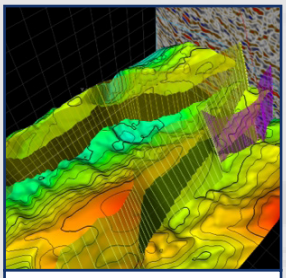
SCA's newest course covers mapping workflows in Petrel© and the geologic principles behind them

COURSE OVERVIEW:

Participants of this course will learn the techniques needed to make more accurate and geologically correct maps through:

1) proper data management
2) integration of fundamental geologic mapping principles with Petrel© mapping software tools
3) establishing an iterative process for ensuring consistency between the maps and data

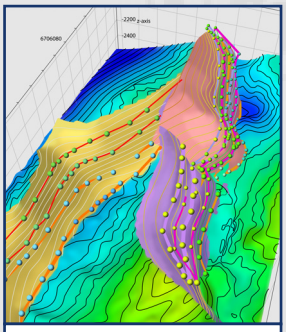
This course bridges the gap between the "tried and true" geologic principles taught in traditional pencil and paper mapping courses and the advanced computational tools available from the workstation interpretation platform.



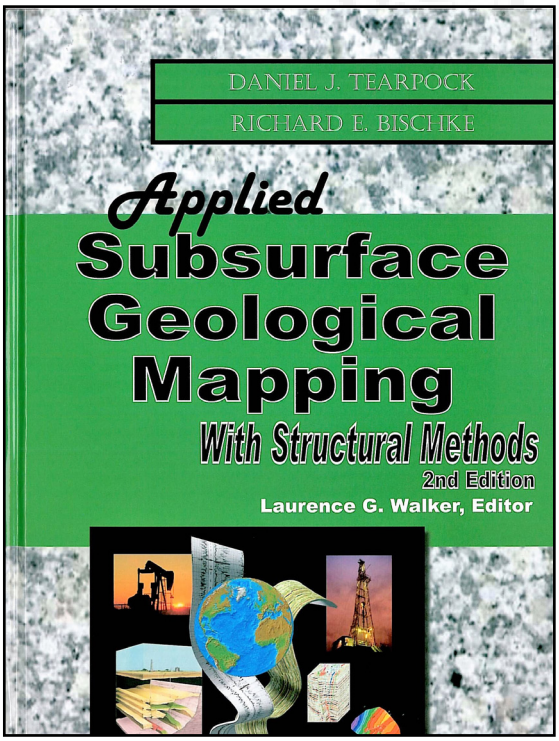
Fault connectivity patterns defined

LEARNING OUTCOMES:

- Subsurface geologic mapping methods as implemented in Petrel©
- Petrel's© mapping workflow
- Data selection and quality control
- Gridding simple and faulted surfaces with well and seismic data
- Creating consistent surfaces with horizontal well data
- Grid modification and quality control
- Single and multi-surface operations (Grid math)
- Mapping well properties (e.g., porosity)
- Quick-look volumetrics and introduction to uncertainty
- Other map types – bubble maps, log signatures, curvature
- Automating the workflow
- Creating effective presentations with standardized templates
- Documenting procedures and results



Surface gridded with fault polygons



Applied Subsurface Geological Mapping

Our flagship course covers both fundamental and advanced methods of subsurface mapping that have been used by the most proficient exploration and development geoscientists in the industry, as well as an introduction to some of the more recent advances in interpretation.

- Mapping techniques, examples, and exercises for extensional and compressional tectonic settings are the core of this course
- Other topics include: diapiric and strike-slip faulted structures, volumetric mapping, and use of isochore maps to explore some of the numerous pitfalls in reservoir volume determinations


SIA AGAH


ROBERT SHOUP


JIM BRENNEKE

JANUARY 14-18, 2019: We are offering *Applied Subsurface Geological Mapping* taught by Jim Brenneke to unemployed/underemployed geoscientists and engineers at a substantial discount in January. Registrants will receive **OVER 94% OFF** of our most popular class with this one-time offer - our full five-day class (valued at $3,550) for **ONLY $200**! RSVP for your seat today at **scacompanies.com**.

Upcoming Training Courses

JAN	07-08	PRMS & SEC Reserves and Resources Regulations	Lee
	14-15	Production Forecasting for Low Permeability Reservoirs	Lee
	14-18	Applied Subsurface Geological Mapping (Discounted offering)	Brenneke
	01/28-02/01	Applied Subsurface Geological Mapping	Agah
FEB	07-08	Integrating Petrophysics with Rock Properties and Production Data to Predict Organic Shale Well Performance (Midland, TX)	Barba
	11-13	The Practice of Seismic Stratigraphy in Deepwater Settings	Prather
	02/25-05/17	The Daniel J. Tearpock Geoscience Certification Program ("Geoscience Boot Camp")	SCA Staff
	25	Basics of the Petroleum Industry	Howes
	02/26-03/01	Structural Styles in Petroleum Exploration and Production	Taylor
MAR	02-03	Structural & Sequence Stratigraphy Field Course (Hill Country)	Taylor
	04-08	Sequence Stratigraphy Applied to O&G Exploration	Lopez-Gamundi
	11-15	Practical Interpretation of Open Hole Logs	Barba
	11-15	Pressure Transient Well Test Design and Interpretation	Economides
	18-20	Artificial Lift and Real-Time Optimization for Unconventional Assets (Midland, TX)	Chokshi
	18-22	Applied Subsurface Geological Mapping (Dallas, TX)	Brenneke
	18-22	Practical Seismic Exploration and Development	SCA Staff
	25-27	Reservoir Characterization for Mudrock Reservoirs	Sonnenberg
	25-29	Applied Subsurface Geological Mapping	Agah

Flagship course Bootcamp course

All courses are located in Houston unless noted otherwise.

IHRDC

IHRDC Alliance

SCA is proud to announce signature of a Joint Marketing Agreement with IHRDC, the worldwide leader in training and competency development for the oil and gas industry. IHRDC offers Instructional Programs, e-Learning Solutions, and Competency Management tools. Together SCA and IHRDC will provide the oil and gas industry with a complete menu of high-quality learning options.

SPE Honorary Membership

SCA's VP of Engineering, ***C. Susan Howes, PE, PHR***, received the prestigious SPE Honorary Membership award at the SPE ATCE in September. This is the highest honor that SPE presents to an individual and is limited to 0.1% of the total membership as a result of outstanding service to SPE.

(**SCA LEADERSHIP** pictured left to right: ***Matt Nowak, Mary Atchison, Tim Riepe, Susan Howes, Hal Miller***)

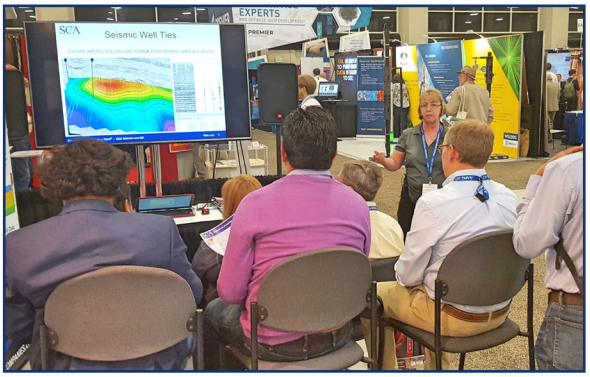
30-Year Anniversary

SCA celebrated our 30-year anniversary with many of our consultants, instructors, and other industry friends at the Karbach Brewery in November. We look forward to many more years providing exceptional training, consulting, projects and studies, and direct-hire services to the industry.

AAPG Convention

SCA had the opportunity to connect with industry clients and professional contacts at this year's AAPG ACE 2018 in Salt Lake City, UT in May. Several of **OUR INSTRUCTORS** presented key learning excerpts from their courses during the convention. Pictured right is ***Laurie Green*** presenting *Mapping with Petrel*©.

Other short presentations included *Exploring the Fundamentals* by ***Bob Shoup***, *Natural Fractures* by ***Dr. John Lorenz***, and *Petroleum Fluids* by ***Dr. Alexei Milkov***.



SPE Regional Formation Evaluation Award

Bob Barba (right), one of SCA's instructors, received the SPE Regional Formation Evaluation Award. He is pictured with 2018 SPE President, Darcy Spacy.

This award recognizes exceptional achievements in or contributions to the advancement of petroleum engineering in the area of formation evaluation encompassing core analysis, well logging, and petrophysics.

About SCA

Our Services

Subsurface Consultants & Associates, LLC provides upstream consultancy and training to professionals in the oil and gas industry. Founded in 1988 by Daniel J. Tearpock, SCA's primary services are consulting and direct-hire recruiting, training, upstream projects and studies, quality assurance, and oil and gas advisory.

Excellence That Runs Deep

SCA is considered an industry leader in subsurface exploration and development interpretation and mapping. We provide the personnel, technology, and proven methodologies that foster success by enabling better business decisions.

IACET Authorized Provider

We have been accredited as an Authorized Provider by the International Association for Continuing Education and Training, which authorizes SCA to offer CEUs for its programs that qualify under the ANSI/IACET Standard. Professionals can fulfill their requirements by attending SCA training courses.

SCA

SUBSURFACE CONSULTANTS

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