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geoLOGIC NEWS

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in this issue:

President’s Corner

A message from our President, Hal Miller:

Is a Perfect Storm on the Horizon?

Is the oil and gas industry setting itself up for a “perfect storm” shortage of technical skills? At SCA we are hearing concerns expressed by managers at many of our client companies that, following dramatic staff reductions, a very high percentage of their remaining staff are early career geoscientists and engineers. Loss of senior professionals has created a vacuum in the technical mentor ranks. It has also created rapid upward mobility for this new generation of geoscientists and engineers, and some have already moved into technical leadership and front line supervisory roles with relatively limited experience. There is no question that these new oil finders are exceptionally capable and highly motivated. However we frequently hear those remaining senior managers expressing deep concern that critical and in some cases fundamental technical skill gaps exist in their organizations.

Every generation of oil finders must climb the learning curve, normally through industry training and experience-broadening work assignments under the mentoring and guidance of the preceding generation. Despite powerful new tools, improved data and enhanced understanding of reservoirs, the subsurface remains a realm of complexly interrelated variables that even the most capable and experienced geoscientists and engineers spend entire careers learning to unravel. Now, when the industry can least afford to waste money on poor opportunities that suffer from inadequate technical evaluation, many of the best oil finding organizations in the industry are slashing training budgets and allowing centuries (millennia?) of experience to march out the door.

Training funds are often regarded as “discretionary” when corporate budgets are tight. We also hear concerns that sending survivors to training is optically unacceptable when colleagues are losing their jobs. Yes, that modern carbonate depositional environments field trip to the Bahamas is probably inappropriate, but learning proper mapping or interpretation skills is hardly frivolous. Most front line managers recognize that cutting tens of thousands of dollars on training makes little impact on budgets in the tens of millions, and little sense if the result is inferior technical work. Core skill training is essential to career development, an appropriate use of time when work programs are slow, an important morale booster, and a clear signal to survivors of downsizing that they are valued by the organization.

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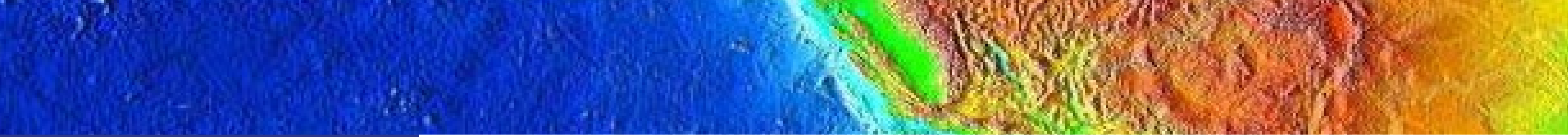

Exploring the Ten Habits: Habit 6

Successful oil finders ensure that their cross sections are balanced in order to confirm that their interpretations are reasonably correct.

by Bob Shoup

Cross sections are an excellent tool to help an interpreter resolve correlation problems, understand the nature of the reservoir distribution, and to ensure the three-dimensional validity of the interpretation. With the exception of correlation sections which are used to help an interpreter make consistent correlations, cross sections must be balanced. Of course, this assumes interpreters are making cross section in the first place. Unfortunately many interpreters do not make cross sections. As we teach around the world, we find that less than half of our students have ever made a cross section.

If you recall our discussion of Habit 2 we discussed the story of a veteran geophysicist who had almost 20 years of experience exploring in and mapping growth fault related plays and prospects in the Gulf of Mexico. When he was transferred to a fold and thrust belt region he mapped the key faults with listric geometry and the folds similar to extensional hanging wall rollovers (Figure 1). This resulted in a series of dry holes that led to a costly lawsuit. In the trial, the seismic interpretation and maps were found to have over 100 mistakes and mis-ties.

These mistakes could easily have been avoided if the interpreter had made a cross section across his maps. It would have been quickly apparent that the cross section was not balanced and, therefore, the maps were not valid. Cross sections across compressional structures must be balanced to be valid (Figure 2).

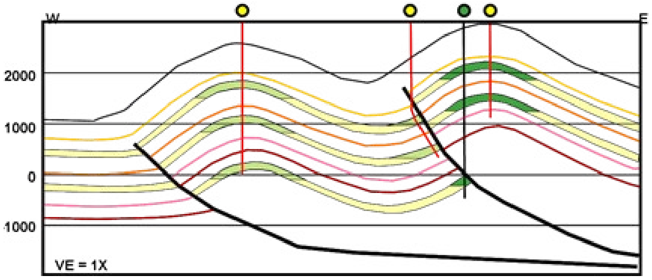

Figure 1: Improper interpretation of an imbricate fault propagation fold

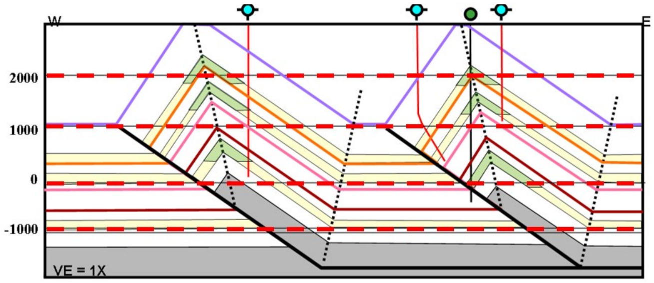

Figure 2: Balanced cross section across the same imbricate fault propagation fold seen in Figure 1

The kinematic relationship between compressional folds and the faults that form them are well understood. There are a number of nomograms and tables available for the interpreter to help them make geologically reasonable interpretations and balanced cross sections. Several of them can be found in Tearpock and Bishke (2003). We highly recommend that interpreters working in compressional fold belts take a structural geology class to familiarize themselves with these kinematic relationships and to learn the appropriate methods needed to ensure valid interpretations and maps. The cost of a class is a few thousand dollars. The cost of a dry hole is a few tens of millions of dollars. And for our interpreter discussed above, the cost of not learning how to interpret and map compressional folds was his career.

But what about cross sections across extensional or diapiric structures, must they be balanced? Since material can flow or slide out of the plane of the section, or the structures are connected to a downdip compressional toe structure, cross sections across extensional folds need not be balanced. However, there are methods that interpreters can use to make geologically and geometrically valid cross sections across extensional structures.

(Continued on P8)

A Practical Method for Wellbore Stability Analysis

by Mao Bai

Wellbore instability can have substantial negative implications on drilling operations including the partial or total loss of a wellbore due to elevated stresses and pore pressures that cause fatal kicks, large scale borehole collapse, and severe tight-hole conditions; prolonged drilling downtime required to fix non-operations related wellbore mechanical failures; and the significant expenditures involved in undertaking remedial measures.

Wellbore stability analysis is a necessary step in predicting and implementing preventive measures to minimize the impact of wellbore failure. Such analysis requires good quality data from offset wells, at the minimum including:

- drilling events and incidents from drilling records;
- pore pressure measurements (e.g. RFT, DST, MDT, etc.);
- minimum horizontal stress determination by field tests (e.g. LOT, XLOT, DFIT, MiniFrac, etc.);
- orientation of principal stresses from image logs and oriented calipers (e.g. FMI, EMI, UBI, OBMI, etc.);
- wireline logs (e.g. GR, RES, DT, RHOB, CAL, etc.);
- maximum horizontal stress from considering tectonic stresses and conducting analytical calculations;
- rock strength from laboratory testing (e.g. triaxial, uniaxial or UCS, polyaxial, etc.).

From this information a sensible geomechanical model can be constructed which provides the essential inputs for a wellbore stability simulation.

Often data available from the offset wells are limited. In extreme cases only basic wireline logs (i.e., GR, RES, DT, RHOB, and CAL) are available and the hole size measurement may only be from a one-arm caliper (i.e., not from an oriented caliper). When the available data are constrained, the quality of any wellbore stability study using conventional methods is highly questionable.

The Wellbore Quality Index method (WQI, [1]) maximizes the quality of the wellbore stability evaluation that can be obtained under scarce data conditions by identifying the suitable wellbore stability impact factors that may dominate the process.

Wellbore Quality Index Method (WQI)

In Fig. 1, the observed wellbore enlargement in Track 1 shows a somewhat similar trend as the predicted wellbore failure in Track 2. However, the quality of the prediction cannot be verified because there is no evidence that the wellbore enlargement in Track 1 is due to breakout (i.e., stress-induced wellbore mechanical failure). Verification requires data from an oriented multi-arm caliper or image logs that are not available for this well. Since a measure of wellbore quality can be used to judge the degree of wellbore stability (e.g., poor, intermediate, or good condition), the Wellbore Quality Index (WQI) is introduced below to assess the mechanisms of wellbore stability.

WQI is defined as:

$$WQI = (CAL - BS) * (SFG - MW) \quad (1)$$

where WQI, (CAL – BS), and (SFG – MW) are assumed to have positive values.

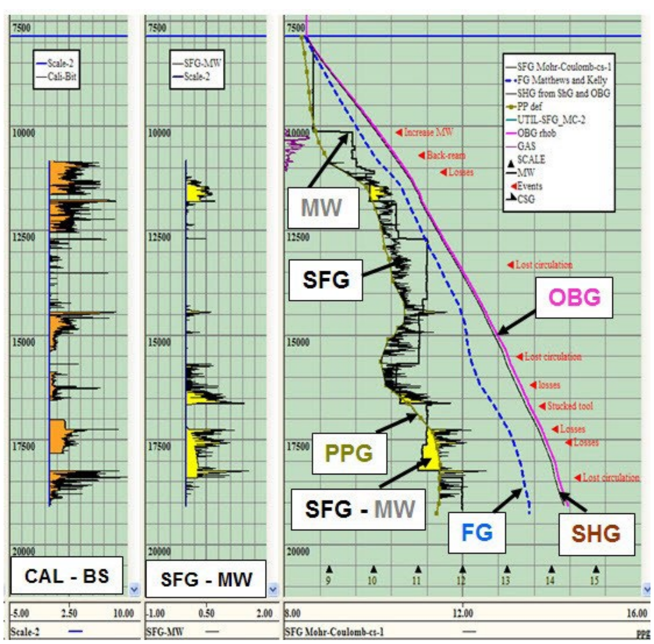

Figure 1: Result of Wellbore Stability Analysis
[Track 1: caliper - bit size (CAL-BS); Track 2: shear failure gradient - mud weight (SFG-MW); Track 3: results of geomechanical analysis]

(Continued on P4)

FEATURED INSTRUCTOR
Mao Bai, Ph.D.

Mao Bai received his M.Eng. degree from the China Coal Research Institute in 1982, M.Sc. degree from the University of Newcastle upon Tyne in England in 1986, and Ph.D. degree from Pennsylvania State University in 1991. All three degrees were associated with rock mechanics in mining engineering.

Dr. Bai worked as a research associate/senior research associate at the University of Oklahoma, Rock Mechanics Institute from 1991 to 2000, primarily focused on developing coupled numerical models for fluid flow/rock deformation in naturally fractured reservoirs. As a senior engineer at TerraTek (a Schlumberger company) from 2000 to 2007, Dr. Bai worked on simulation of hydraulic fracturing in tight shale gas reservoirs. From 2007 to 2008 he worked as a senior geomechanics specialist at Geomechanics International (a Baker Hughes company), providing wellbore stability studies for the drilling sector of the oil and gas industry. From 2008 to 2013, he worked as a principal consultant/senior advisor at the global consulting division of Halliburton, conducting geomechanics investigation projects for oil and gas companies worldwide. As a staff geomechanics specialist at BHP Billiton from 2013 to 2015, Dr. Bai provided geomechanics analysis services in stimulating both conventional and unconventional reservoirs to multiple production units in the company.

Dr. Bai is a prolific author, having written several technical books and approximately 150 papers for technical journals and professional conferences. In addition, he taught geomechanics courses at numerous locations in the US and abroad. His teaching style is unconventional: he does not use the “cookie-cutter” method but builds on his work experience in guiding the course attendees to master the essential technical contents of the course.

Dates for upcoming courses taught by Mao Bai:

Petroleum Geomechanics

06/13-14/16	Houston, TX
11/07-08/16	Houston, TX

Injection Geomechanics

06/15-16/16	Houston, TX
11/09-10/16	Houston, TX

A Practical Method continued from P3

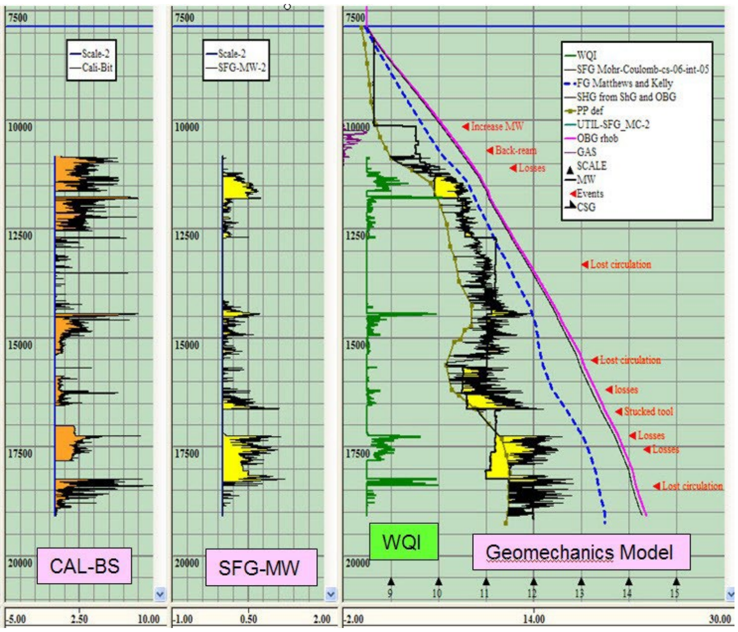

Figure 2: Six Peaks of WQI at Various Depth Intervals [Track 1: caliper - bit size (CAL-BS); Track 2: shear failure gradient - mud weight (SFG-MW); Track 3: Wellbore Quality Index (WQI), geomechanics model and results of analysis]

The following rules are known from Eq. (1):

✓Confirmed wellbore failure: WQI ≠ 0 only when both (CAL – BS) ≠ 0 and (SFG – MW) ≠ 0.
✓Possible wellbore failure: WQI = 0 when either (CAL – BS) = 0 or (SFG – MW) = 0.
✓The severity of the wellbore failure is proportional to the magnitude of WQI [i.e., depending on the magnitudes of both (CAL - BS) and (SFG - MW)].

The expression of WQI in Eq. (1) makes sense for the following reasons:

• WQI is a wellbore mechanical impact assessment function. For example, WQI has a non-zero value only when both wellbore mechanical impact assessment (SFG - MW) and wellbore enlargement assessment (CAL - BS) are non-zero.
• WQI is an objective wellbore assessment function (i.e., non-biased) because WQI can be zero when the wellbore enlargement assessment (CAL – BS) is zero even though the wellbore mechanical impact assessment (SFG – MW) is non-zero, and vice versa. Note that the value of (CAL – BS) is due to multiple factors (i.e., the cause can be either mechanical or non-mechanical).
• The success of the WQI method relies on its ability to determine the actual wellbore failure mechanisms (i.e., mechanical, chemical, thermal, hydraulic, operational impact, or measurement errors, etc.).

Adding WQI to the case shown in Fig. 1, Fig. 2 depicts the six peaks of WQI (green color) on Track 3 at the critical depth intervals of 11430’, 11750’, 14450’, 17250’, 17590’, and 18290’. Note that WQI does not resemble either (CAL – BS) or (SFG - MW). Rather, WQI characterizes the combined effects of (CAL – BS) and (SFG – MW) as defined in Eq. (1).

Mechanisms of the WQI Method

The implications of WQI can be further explored in Fig. 3. Five horizontal bars (light gray) cover the logs and WQI at the depth intervals with the six peaks in WQI (#4 bar covers two WQI peaks). In Track 1, all the peak zones of WQI appear to be in the low gamma ray zones, indicative of loose sands. In Track 4, all the peak zones of WQI are in the low density zones, an indication of unconsolidated formation rocks. Tracks 5 and 6 show the consistent trends between (CAL - BS) and (SFG - MW). Track 7 shows six peaks of WQI. In Track 8, all the peak zones of WQI are in the zones of low rock strength.

The results in Fig. 4 reveal that the wellbore failure is caused dominantly by stress-induced mechanical impact. This demonstrates that the hole enlargements shown in the one-arm caliper data are likely breakouts. This observation excludes the possibility of wellbore failure due to other non-mechanical factors (i.e., chemical, hydrological, thermal, operational, or bad measurement data, etc.). From this example, we see that WQI can help identify the wellbore failure mechanisms even though the measurement data are not sufficient. In this case, WQI, hole enlargement (i.e. CAL – BS) and wellbore shear failure (i.e. SFG – MW) all show consistent trends. It should be cautioned, however, that this is not a universal rule. Exceptions do exist as the mechanical impact becomes less or non-dominant.

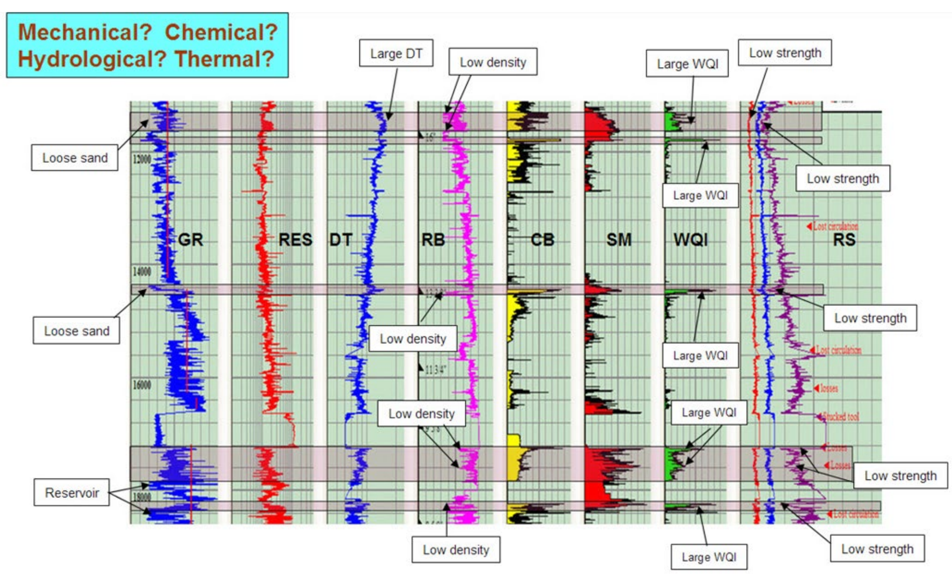

Figure 3: Evaluation of Wellbore Stability Using WQI Method [Track 1: gamma ray (GR); Track 2: resistivity (RES); Track 3: sonic travel time (DT); Track 4: density (ROHB); Track 5: caliper - bit size (CAL-BS); Track 6: shear failure gradient - mud weight (SG-MW); Track 7: Wellbore Quality Index (WQI); Track 8: rock strength (RS), cohesion coefficient (red), internal friction angle (blue), and unconfined compressive stress (UCS, purple)]

(Continued on P5)

 continued from P4

Dimensionless Analysis of WQI Method

It may be noted from Eq. (1) that WQI has a dimension (i.e., unit). This raises the question of whether the analysis in the previous example is case dependent. To address this question, we reformulate Eq. (1) and put WQI into a dimensionless form as follows:

$$WQI = (CAL - BS) / CAL * (SFG - MW) / SFG \quad (2)$$

A dimensionless form is an abstract form that can be applied to any generic case. The following parametric sensitivity analysis will be based on the dimensionless formulation of WQI shown in Eq. (2).

With the dimensionless analysis, there are no direct implications for the previous example (i.e., dimensional analysis) even though the case continues to be referenced. With the variations in rock strength laws [e.g., Lal [2], (red) and Horsrud [3] (blue)], allowable breakout widths (i.e., 00 (green), 300 (red), and 600 (blue)), and internal cohesion coefficient scaling index (i.e., 0.6 (green), 0.8 (red) and 1.0 (blue)), the comparisons between the result from dimensionless WQI (DL-WQI) and dimensional WQI (D-WQI) are given in Fig. 4. The differences are significant, especially at the deeper depths.

To further understand the differences between dimensionless WQI and dimensional WQI, the mud-shale interaction due to chemical effects (i.e., osmosis pressure due to differences in water activities and salinities between drilling mud and formation shales) is simulated. The dimensionless WQI with the chemical effect [more chemical effect (red, mud-water activity 0.86), less chemical effect (blue, mud-water activity 0.88), and shale water activity 0.9] is shown in Fig. 5. A higher gamma ray usually indicates that the formation is shalier. In Fig. 5, a significant DL-WQI implies that the mud-shale interaction is more severe at deeper depths. Conversely, the less significant DL-WQI at the shallower depths indicates that wellbore failure is primarily the result of stress-induced mechanical impact or some other impacts.

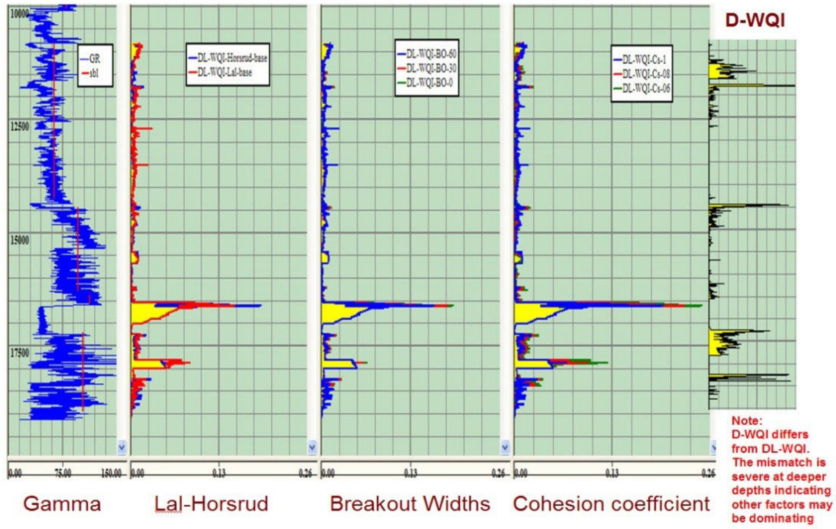

Figure 4: Result from Comparison between Dimensionless (DL) WQI and Dimensional WQI [Track 1: Gamma ray (GR); Track 2: DL-WQI from Lal and Horsrud rock strength laws; Track 3: DL-WQI from breakout widths of 00, 300 and 600; Track 4: DL-WQI from cohesion scaling indices of 0.6, 0.8 and 1.0; Track 5: D-WQI from previous example]

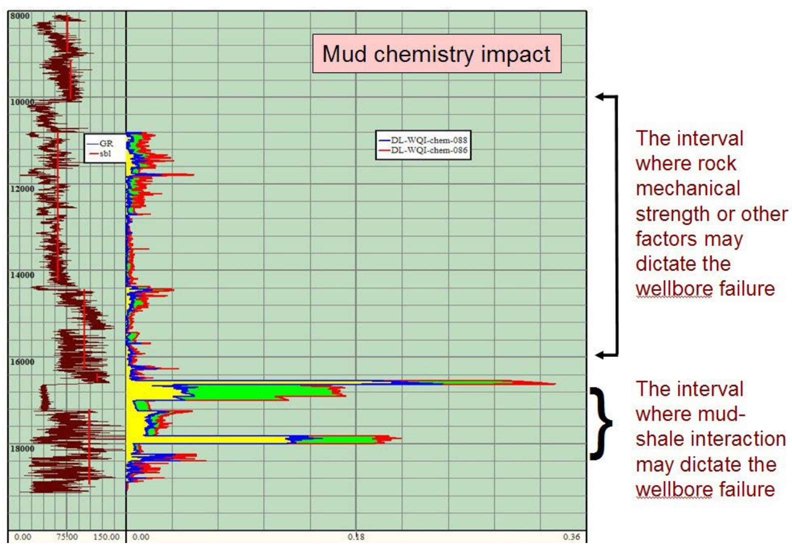

Figure 5: Mud - Shale Interaction due to Chemical Effects [Track 1: Gamma ray (GR); Track 2: comparison of WQI between more chemical effect (red, more salinity difference between mud and shales) and less chemical effect (blue, less salinity difference between mud and shales)]

Combining the results from Figs. 4 and 5, dimensionless WQI (DL-WQI) can be divided into Four zones (Fig. 6). Most of the data is in Zones 1 and 2. Data in Zones 3 and 4 are sparse and are at deeper depths.

To further study the data, Fig. 7 shows the data distribution only in Zones 1, 2, and 3. Note that (DL-WQI) in Zone 2 has a similar trend as shown in the D-WQI chart. This proves that D-WQI is a mechanically dominant wellbore failure (e.g., breakouts).

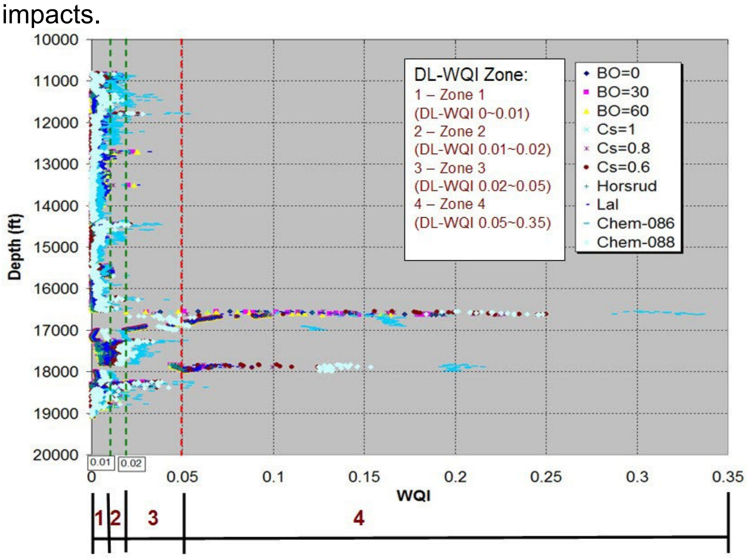

Figure 6: Result from the Combined Sensitivity Study of Dimensionless WQI (DL-WQI) from Figures 4 and 5 [Zone 1: majority of data; Zone 2 (dotted green lines): secondary data; Zone 3 (dotted green line and red line: deeper section data; Zone 4: sparse data]

(Continued on P6)

A Practical Method continued from P5

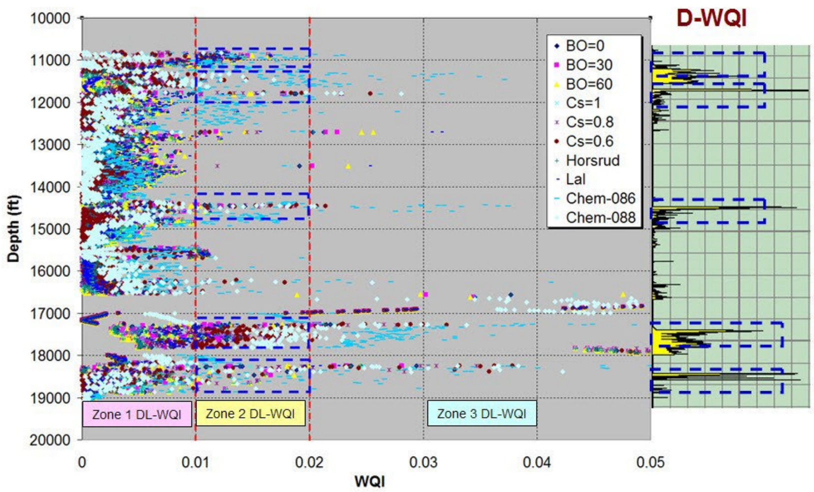

Figure 7: WQI Data Distribution in Zones 1, 2, and 3 of Figure 6 and Comparison with Dimensional WQI (D-WQI) [Dimensionless WQI (DL-WQI) in Zone 2 shows a pattern similar to dimensional WQI (D-WQI)]

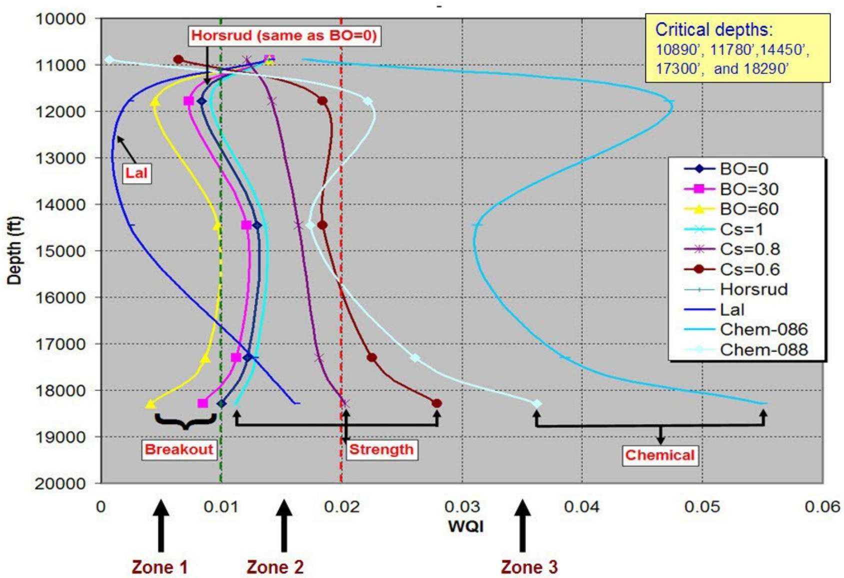

Figure 8: Comparison of DL-WQI Data at Five Critical Depths (Zone 1: wellbore failure associated with breakout widths and other factors; Zone 2: wellbore failure related to rock strengths; and Zone 3: wellbore failure linked to chemical effects)

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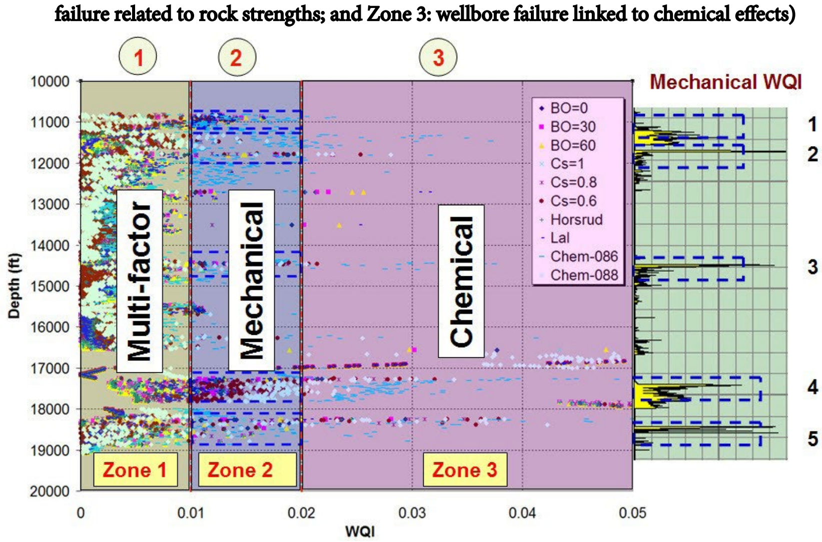


Figure 9: Mechanisms of Wellbore Failure Identified from Analysis using the Dimensionless Well Quality Index (DL-WQI) (Magnitude of WQI may be associated with sources of wellbore failure)

By examining wellbore failure at the specific depths (Fig. 8), it appears that data at Zone 1 are related to the breakout widths and other factors, data in Zone 2 are primarily associated with rock strength, while the data at Zone 3 are generally associated with mud-shale interactions (i.e., chemical effects). This further confirms the scenario shown in Fig. 7 that Zone 2 is the region where the mechanical wellbore failure becomes dominant.

The scenarios discussed in Figs. 7 and 8 can be summarized in Fig. 9 where: a) the wellbore failure in Zone 1 is attributed to multiple factors (e.g., breakout width, rock strength, chemical effects, etc.); b) the wellbore failure in Zone 2 shows dominant mechanical influences; and c) the wellbore failure in Zone 3 is primarily related to chemical effects.

Conclusions

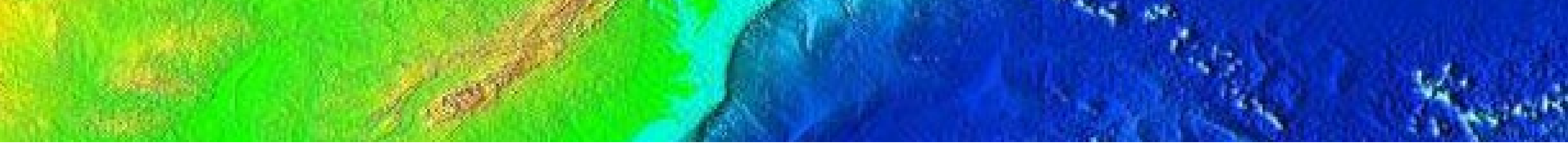
- Considering WQI method only contains two equations [i.e., Eqs. (1) and (2)], additional work needs to be done for the method to function more effectively. For the dimensional WQI method [Eq. (1)], the result needs to be calibrated against multiple logs and correlations to determine the causes of the wellbore failure. For the dimensionless WQI method [Eq. (2)], a sensitivity investigation must be conducted to determine the causes of wellbore instability from the defined zones (i.e., magnitudes) of DL-WQI. The associated analyses make the method more attractive to potential users due to the intuitive nature of the analyses.
- There are no severe constraints on using WQI. The method should always work. Naturally, the method is useless if there is no evidence of wellbore failure. It is most useful as a screening method for wellbore stability under limited data conditions. It can be used as a quality assurance index when major measurement data become available.

References:

[1] Bai, M. (2013), An objective method for wellbore stability analysis, Proc. 47nd US Rock Mech. Symposium, San Francisco, CA, USA.

[2] Lal, M. (1999), Shale stability: drilling fluid interaction and shale strength, SPE 54356, SPE LACPEC, Caracas, Venezuela.

[3] Horsrud, P. (2001), Estimating mechanical properties shale from empirical correlations, SPE Drilling and Completion, 16(2), 68-73.



Technology for Surviving a Downturn

By Mark Connor

There is an undisputed generational divide in the oil and gas industry - the “baby boomer” senior staff, the “millennial” generation and not much in between. Regardless of which group you fall in to, the chances are that you would have been affected to some degree by the recent market downturn. For those directly affected by staff reductions, job seekers are facing a market with a surplus of above average candidates and a serious shortage of available positions.

Navigating this market is a challenge and it is critical to use the most important tools at your disposal. Social media has exploded as a means to communicate and connect over the past few years, and with all the available platforms out there, you need to focus your time and attention. As a candidate for employment, there is no better platform than Linkedin. While Facebook, Twitter, Instagram or Snapchat have their place socially, Linkedin stands head and shoulders above the competition as a business networking and recruiting tool.

Regardless of your career level, it is never too late to benefit from the incredible networking capability of Linkedin. There are countless examples of senior level Geologists and Engineers who have expressed their amazement at how easy it is to track to down colleagues they worked with 30 years ago. “I had no idea he was still in the industry”, “I didn’t know she was working there” or “I haven’t spoken to him in 15 years” – phrases that we hear from highly experienced candidates who have had no reason to nurture their networks before the downturn took its toll, but now appreciate the need to use the tools available to them.

A Linkedin profile is extremely easy to build, and your connections can expand rapidly with a minimal amount of work. Uploading your resume can be a simple “copy and paste” exercise, and existing contacts can become connections by using Linkedin’s email syncing tools. An hour spent on Linkedin setting up a well written profile can give you immediate access to old contacts and make your resume available to a host of recruiters and hiring managers.

Mark Connor joined SCA in 2010 as Senior Recruiter and has since connected with countless geoscience and engineering professionals throughout the industry. As a result of these daily interactions, he has developed a firm grasp of hiring trends as they relate specifically to the geoscience and petroleum engineering employment market. He can be reached via SCA’s main line at (713)789-2444 ext. 256 or by email at mconnor@scacompanies.com.

However, Social Media can be a double edged sword. As easy as it is to generate an attractive profile and establish a network on Linkedin, an inappropriate post or comment, or a profile littered with grammatical errors can undermine your professional credibility just as quickly. The nature of the internet allows posts, comments, views and opinions to be viewed by just about anyone, not just those in your immediate network. This can include past, present and future employers, and you can be sure that any hiring manager will check a candidate’s Linkedin profile before making a hiring decision. Be well aware that privacy does not exist on the internet. If you wouldn’t shout it in a room full of people, don’t post it on the internet – once something is in cyberspace it is there forever.

Although it may seem trivial, the right choice of profile picture is also important. Linkedin is not Facebook, and the safest way to go is with a simple headshot – a candid action shot or a picture alongside family, friends or in any other social setting can detract from the professional image you are trying to convey. Use a good quality camera with a high pixel resolution, wear professional attire and choose a well-lit environment. Take the picture in front of a neutral background and crop the image to include your head and shoulders. Simplicity is key. Remember that potential employers will be making subconscious judgments about your employability, and you are the face of your brand.

Another huge advantage to be gained from Linkedin is a candidate’s ability to use it as a research tool. Should a company invite you to an interview, Linkedin in gives access to a wealth of background information on potential employers and the individuals who you will be interviewing with. Never before has it been so easy to find out if you and the hiring manager have common acquaintances or connections, a similar education background or mutual previous employers. Most companies will supply you with information regarding the interviewers you will be meeting with, so there is every opportunity to prepare and discover potential common ground ahead of an interview.

In conclusion, Linkedin is a powerful database that is expanding by the second, and any professional would be well advised to familiarize themselves with its functionality and capabilities. Used wisely, it can greatly enhance your employment prospects, further your career goals and help give you an edge in a highly challenging market.

Habit 6 continued from P2

One method is to maintain interval thickness. Whereas individual sands may exhibit marked changes in thickness over short distances, depositional sequences generally thicken or thin gradually, such that they appear to maintain a relatively consistent thickness over large distances. Only when a sequence is impacted by syndepositional growth faults or it has been eroded by an unconformity will it exhibit a large variation in thickness in a short distance.

Interpreters can use this understanding to make or review stratigraphic correlations For example the cross section in Figure 3 was constructed by entering the existing correlations in a large field. Note that there are two places on the section where the interval thickness changes, between Formation 6 and 6a between the two left-most wells, and between Formation 6e and 7, also between the two left-most wells.

The interval thickness change between Formation 6 and 6a indicates a miscorrelation. Formation 6a is a coal bed. In the middle well, the coal was picked too high; shifting the correlation down to the next coal maintains a constant interval thickness for that sequence (Figure 4).

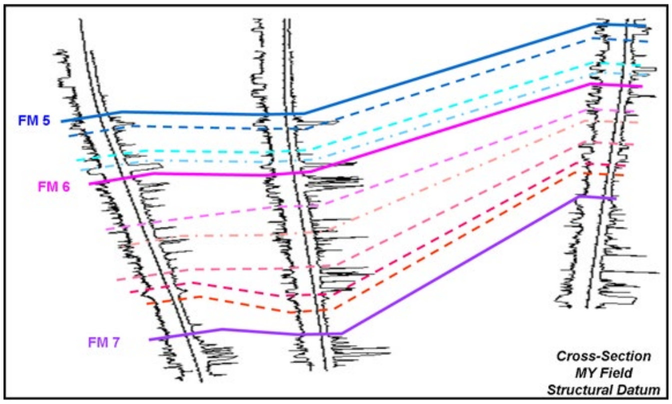


Figure 3: Cross section across MY Field
Formation correlations inherited from the operator

The interval thickness changes between Formation 6e and 7 are the result of the original interpreter missing a fault in the left-most well (Figure 4). You can see in the final interpretation that the interval thickness between all of the formations is reasonably consistent, although there is some thickening of the Formation 6 horizons into the fault.

As with compressional structures, the kinematic relationship between extensional hanging wall folds and the faults that form them are also well understood. Interpreters can measure the change in dip along a fault and use a nomogram to determine the dip rate of the front limb of the fold.

For example, the cross section shown in Figure 5 was constructed from a series of horizon structure and fault surface maps for a prospect in which several wells have been proposed, two vertical and one deviated. We can examine the cross section and see that it looks reasonable, suggesting that the maps that the cross section was drawn from are valid. We can see that the interval thickness does change slightly across the section, however, Fault A is a growth fault, and some thickening into the fault is expected.

Before we spend millions of dollars drilling three wells into this prospect, we can take an additional hour of our time to validate the maps by looking at the dip portrayed in the front limb of the fold to see if it is correct. We will use the 7675 Foot Sand as our test. Since the cross section was constructed with no vertical exaggeration, we can measure the dip of the fault directly from the cross section. The dip of the fault above the 7675 Foot Sand (β, Figure 6) is 60o and below the sand (α1, Figure 6) it is 50o. The difference is 10o (Φ, Figure 6).

Using the nomogram shown in Figure 6, we can determine that the front limb dip (θ, Figure 6) of the 7675 Food Sand should be 14o. Measuring the dip of the 7675 Foot Sand on the cross section (Figure 7), we see that it is 14o, thereby validating our maps.

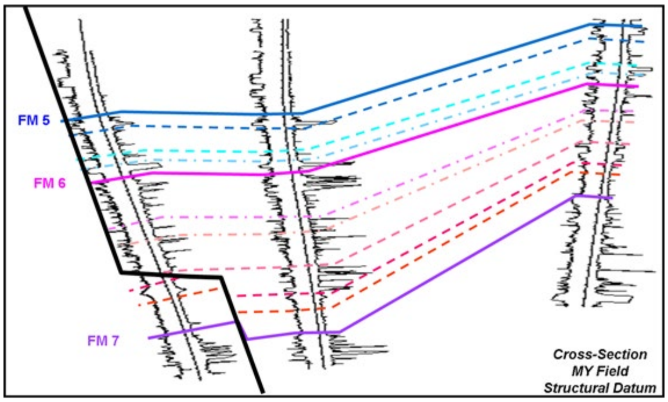


Figure 4: Cross section across MY Field
Formation correlations corrected to maintain constant interval thickness

Cross sections are an invaluable tool for helping establish and validate correlations, understanding the depositional environment and reservoir distribution, and for confirming the three-dimensional validity of our structural interpretations and maps. Are you making them?

Reference:

Tearpock, D.J. and Bischke, R. E., 2003, Applied Subsurface Geological Mapping with Structural Methods, 2nd Edition, L. G. Walker, editor, Prentice Hall PTR, Upper Saddle River, New Jersey

(Continued on P9)

Habit 6 continued from P8

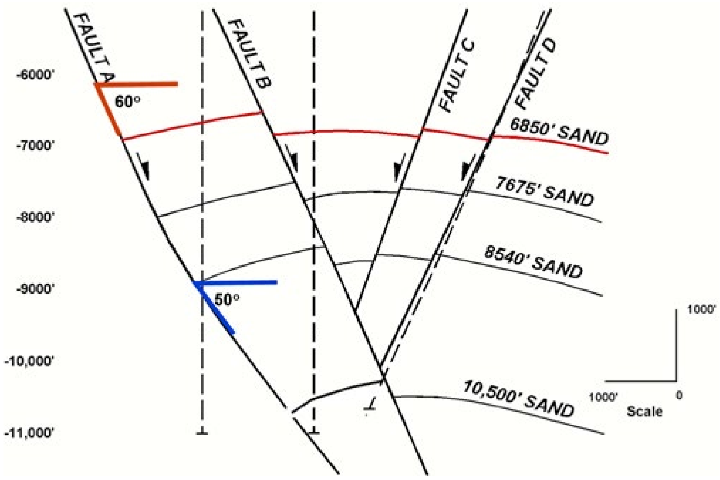


Figure 5: Cross section across a prospective structure showing fault dip above and below the 7675' Sand Dashed lines are proposed well locations

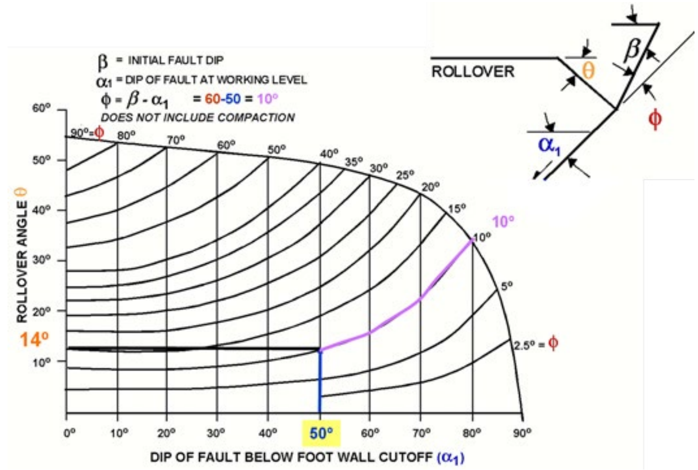


Figure 6: Nomogram for determining the front limb dip of a hanginng wall anticline (Tearpock and Bishke, 2003)

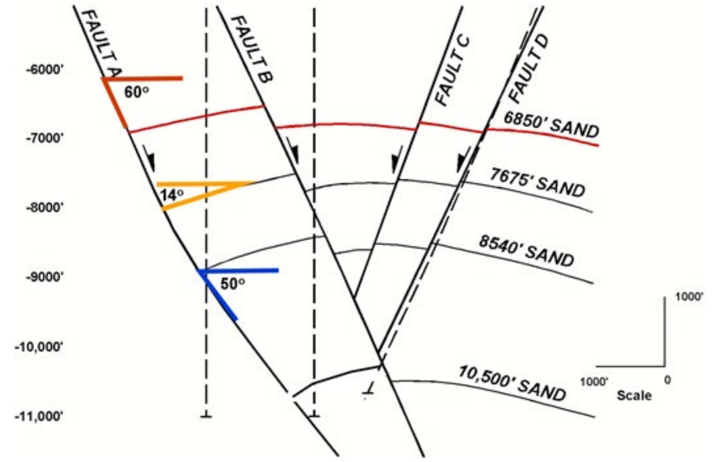


Figure 7: Cross section across a prospective structure showing dip of the 7675' Sand Dashed lines are proposed well locations

Editor's Note: To learn more about cross section construction and other tools, methods, and techniques to help ensure accurate subsurface maps, register for SCA's signature course Applied Subsurface Geologic Mapping.

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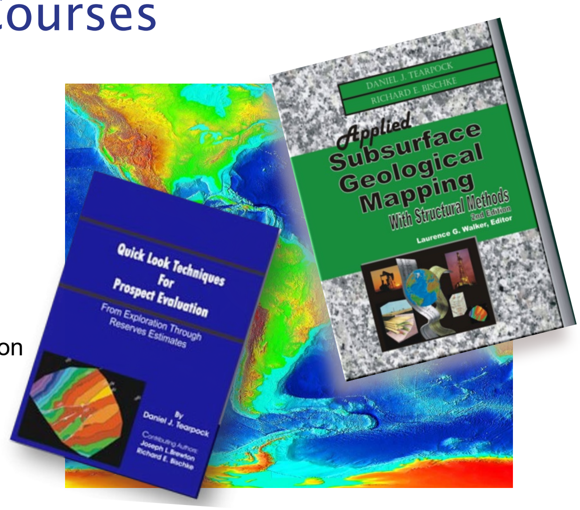

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The People & Activities of SCA

WHAM Toy Drive

HAPPY ANNIVERSARY

Mark Connor	11/01/10	5 yrs
Matthew Miller	11/12/12	3 yrs
Mary Atchison	01/19/09	7 yrs
Don Lanman	03/09/04	12 yrs

To celebrate the Christmas Holiday and give back to Houston's Westchase community, SCA was pleased to participate in the donation of gifts to the annual West Houston Assistance Ministries Toy Drive. We had a great time assisting WHAM staff and fellow volunteers to distribute toys to our neighborhood families. Through the generous efforts of WHAM and the staff of SCA, many more children were able to wake up to a happy Christmas morning.