PS Real-time Wellbore Stability Analysis: An Observation from Cavings at Shale Shakers*

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Abstract

Drill cuttings are considered representative of the lithology being drilled in a wellbore. However, the fragments that are two to three times larger and/or having odd shapes compared to the regular cuttings are commonly understood as cavings from the wall of the borehole and they are seldom of any help in compilation of a lithology. In fact, cutting description manual recommends ignoring cutting sizes greater than half an inch. Nevertheless, these cavings carry critical information that needs expert decoding concerning impending or happening wellbore instability, formation overpressure and overall well behavior evaluation.

In this article, several real-time cases are presented as road signs along with few exception and practical complication in real-time interpretation. Cavings can be produced due to several mechanisms, such as underbalance drilling, stress relief, pre-existing planes of weakness or simply by mechanical action of the drilling process and/or drilling tools. The use of cavings to understand borehole instability and its mechanism entails correct description coupled with proper interpretation, which can be tricky and require a good amount of experience as well as overall understanding of the geology, geomechanics and drilling system and process. Therefore, a simplified approach is made to describe the cavings morphology and its interpretation in terms of wellbore stability. The relative amount of cavings in the bulk sample is also an indication of the degree of instability of the borehole walls.

Cavings are the first and foremost indicator of wellbore deterioration, and the correct interpretation or knowledge of cavings can help save

millions of dollars by using appropriate prevention/remedial actions. The most noticeable and predictive cavings for wellbore stability and formation pressure are those of clay and shale. Collectively size, shape, appearance and relative percentage of the cavings compared to the total load of what is coming at the Shale-Shaker versus time are necessary to keep track of the health of the wellbore. Hence, listening to the wellbore by monitoring continuously of what is coming at the shaker by an expert set of eyes during any drilling fluid circulation pre-drilling, syn-drilling or post-drilling operation is essential.

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ABSTRACT

Drill cuttings are considered to be representative of the lithology being drilled in a wellbore. However, the fragments that are two to three times larger and/or have odd shapes compared to the regular cuttings are commonly understood as cavings from the wall of the borehole, and they are seldom of any help in compilation of a lithology. In fact, the cutting description manual recommends ignoring cutting sizes greater than half an inch. Nevertheless, these cavings carry critical information that needs expert decoding with regards to impending or happening wellbore instability, formation overpressure, and overall well behavior evaluation.
Several real-time cases were studied as road signs, along with a few exceptions and practical complications in real-time interpretation. Cavings can be produced due to several mechanisms, such as underbalanced drilling, stress relief, pre-existing planes of weakness, or simply by mechanical action of the drilling process and/or drilling tools. The use of cavings to understand borehole instability and its mechanism entails correct description coupled with proper interpretation, which can be tricky and require a good amount of experience as well as overall understanding of the geology, geomechanics, and drilling system and process. Therefore, a simplified approach was made to describe the cavings morphology and its interpretation in terms of wellbore stability. The relative amount of cavings in the bulk sample is an indication of the degree of instability of the borehole walls.
Cavings are the first and foremost indicator of wellbore deterioration, and the correct interpretation or knowledge of cavings can help save millions of dollars by using appropriate prevention / remedial actions. The most noticeable and predictive cavings for wellbore stability and formation pressure are those of clay and shale. Collectively, size, shape, appearance, and relative percentage of the cavings compared to the total load of what is coming at the shale-shaker versus time are necessary to keep track of the health of the wellbore. Hence, listening to the wellbore by continuous monitoring of what is coming at the shaker by an expert during any drilling fluid circulation pre-drilling, syn-drilling, or post-drilling operation is essential.

This poster highlight the significance of cavings analysis in real-time wellbore stability monitoring from rig-site and cavings observed during drilling of different sections are described

CASE STUDY

In this study a well was monitored 24x7 by Real-time geomechanics support from rig-site. Key challenges in the well were:

- **Data reference:** no offset well
- **High Pressure High Temperature (HPHT) well:** Over 18000Psi pressure, ~170°C temperature expected at well TD
- **Narrow safe mud weight window/ Wellbore stability**

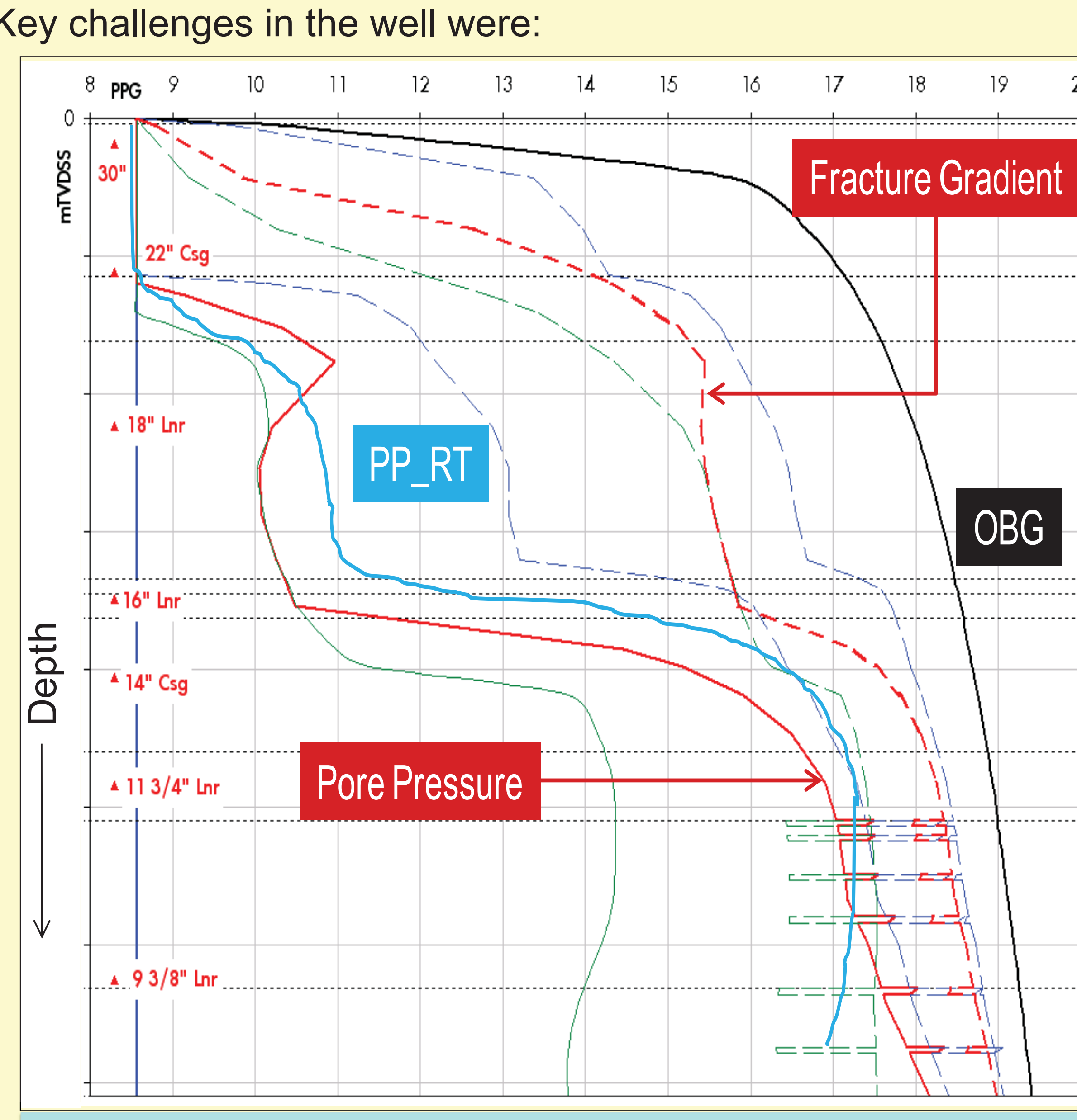
Cavings description helps to determine the mode of cavings formation. Cavings analysis is required to identify types of cavings. Size, shape, appearance and percentage of the cavings in the sample is necessary to keep track of the health of the wellbore.

Shape can be described using the following type of terminology, or more descriptive terms can be used: Angular/Blocky/Oblate/Tabular/Platy/Elongate/Splintery.

Size (dimensions): length, width, thickness of the largest and the average cavings should be recorded.

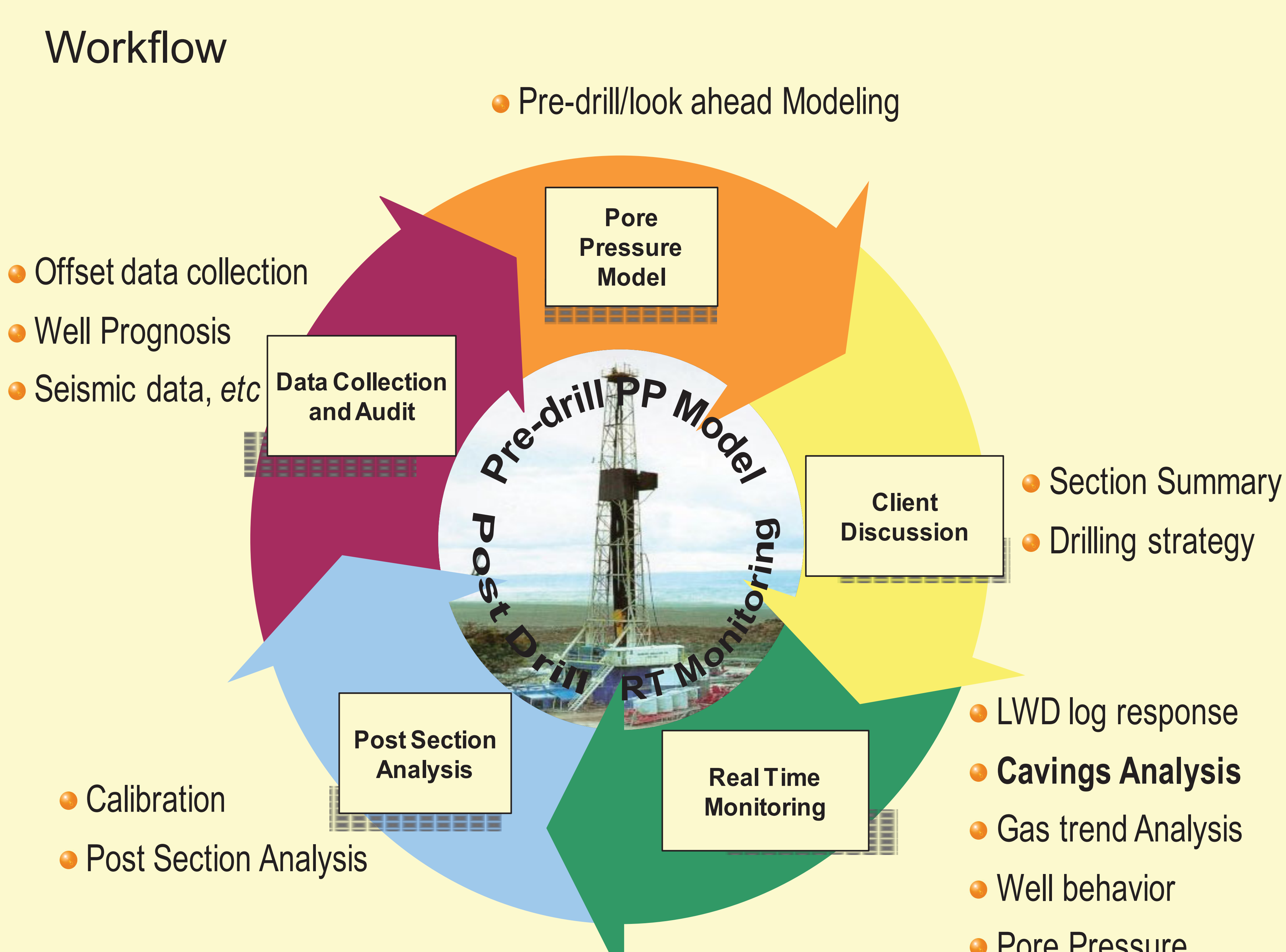
Appearance: Lithology and colour must be recorded. Any other visible features should also be recorded and described. Of particular importance are structural features such as bedding, laminations, fracture surfaces, other surface morphology.

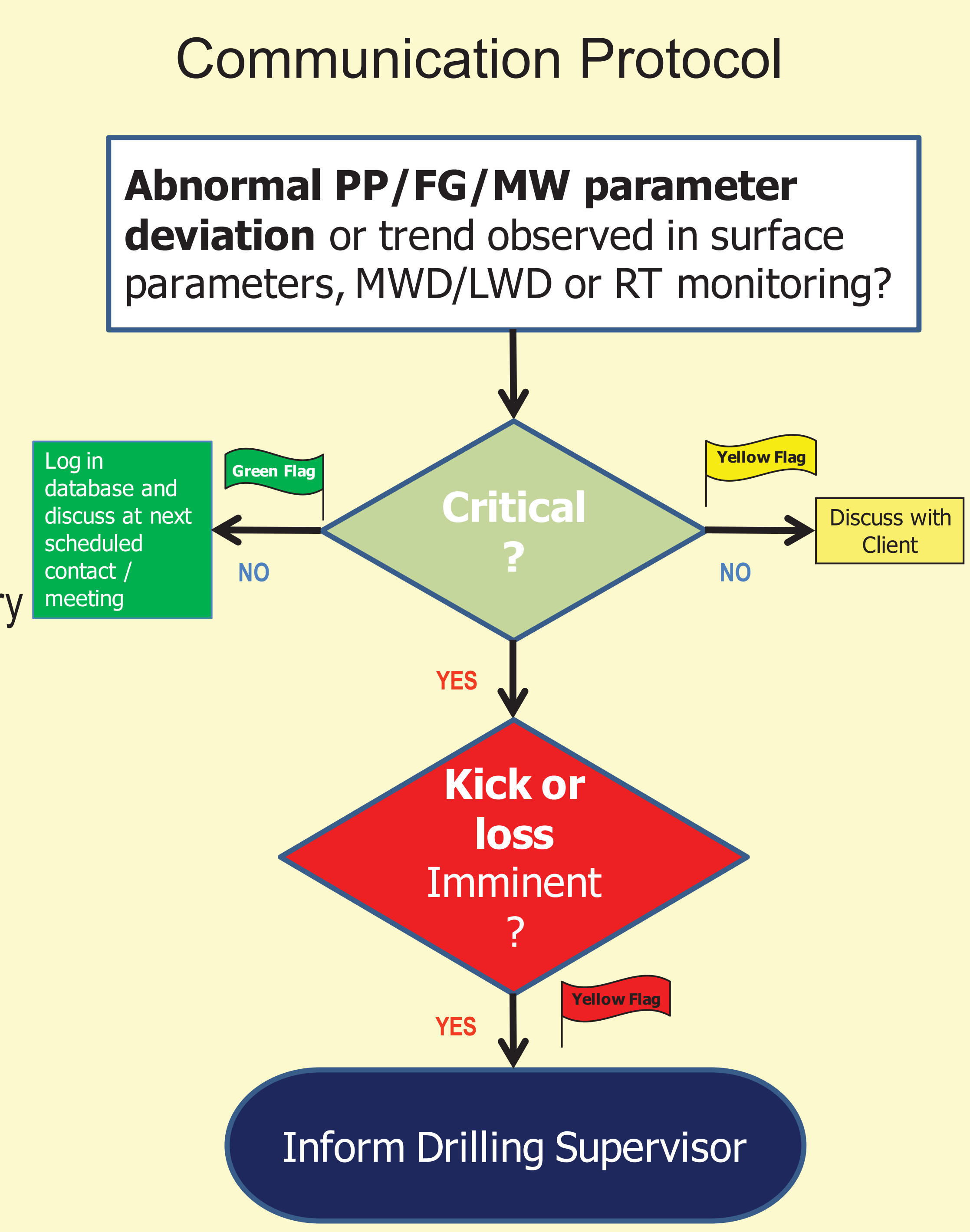
Percentage of cavings with reference to cuttings on shakers should also be recorded for trend analysis (increasing or decreasing with depth or mud weight change)



Pre-drill (Red curve) and real-time estimated (Blue curve) pore pressure profile along with fracture gradient & overburden gradient.

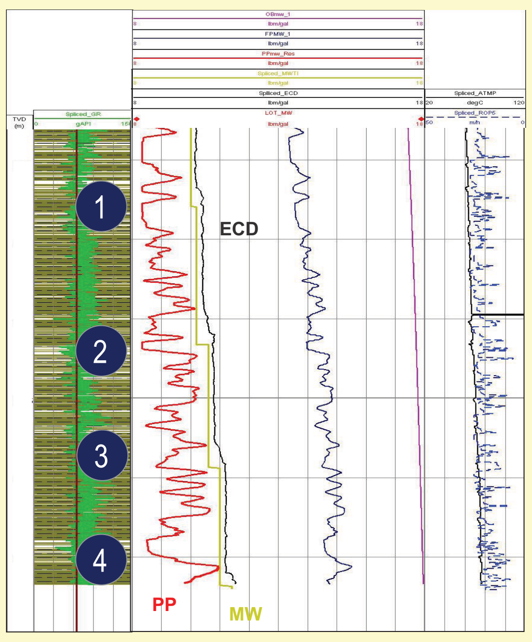
WORKFLOW & COMMUNICATIONS





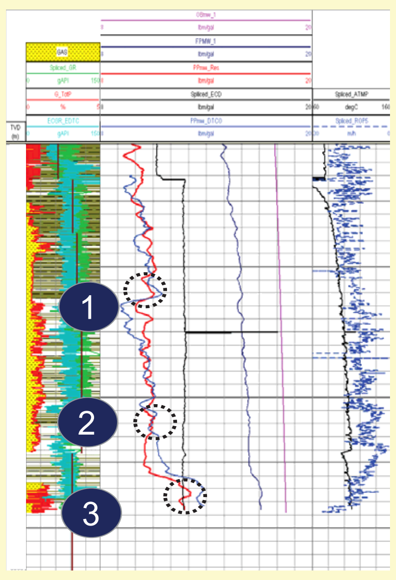
REAL TIME CAVINGS ANALYSIS

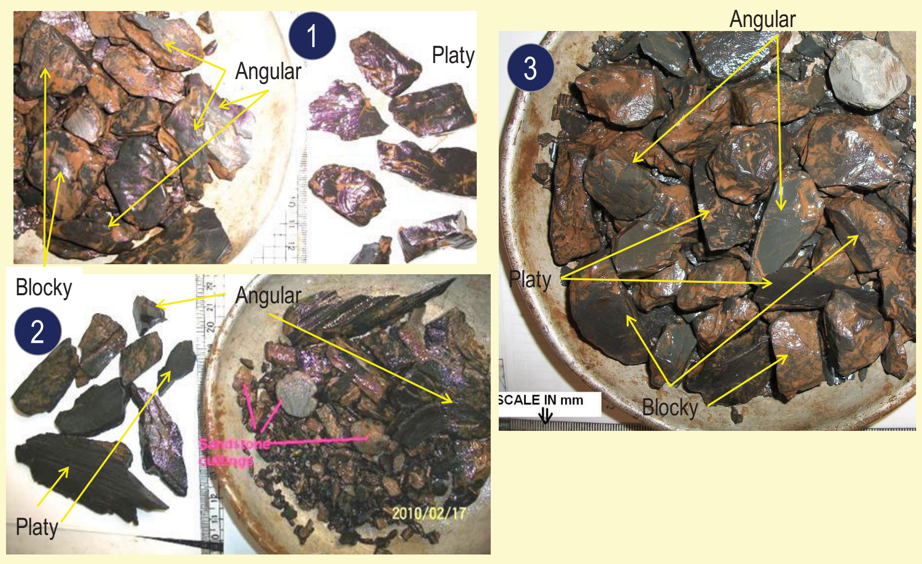
18 x 22" Section



No.	Shape	Size (cm)	%	Appearance	Analysis	Remedial Action
1.	Splintery	2 – 8	5 – 10	Dark, hard & compact	Increasing trend of cavings was reduced to tr- 5% after increasing the mud weight. Still presence of angular cavings may be interpreted at as signature of wellbore instability.	Increase mud weight for wellbore stability
2.	Splintery & Angular	2 – 8	5 – 10	Dark, hard & compact		
3.	Mainly angular	2 – 4	Tr – 5	Hard, smooth surfaces, visible bedding planes		
4.	Mainly angular	2 – 4	Tr – 5	Hard, smooth surfaces, visible bedding planes		

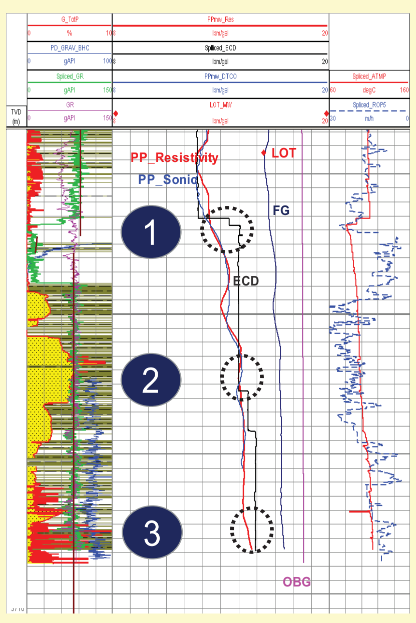
16.5 x 20" Section





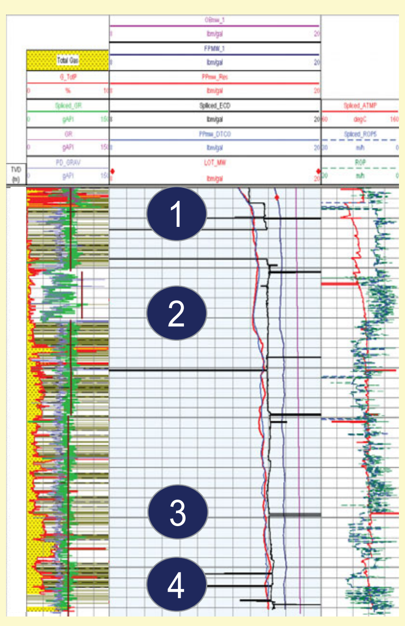
No.	Shape	Size (cm)	%	Appearance	Analysis	Remedial Action
1.	Angular, Blocky, Platy	2 – 5	Tr – 10	Dark, hard & compact	Increasing trend of angular cavings might be related to stress. Change in lithology could also be interpreted as change in pressure regime.	Mud weight increase in small steps (Narrow safe MW window)
2.	Angular & Platy	2 – 8	10 – 20	Dark, hard & compact		
3.	Angular, Blocky, Platy	2 – 5	10 – 30	olive gray (greenish) to darker grey, visible bedding planes		

14.75 x 17.5" Section



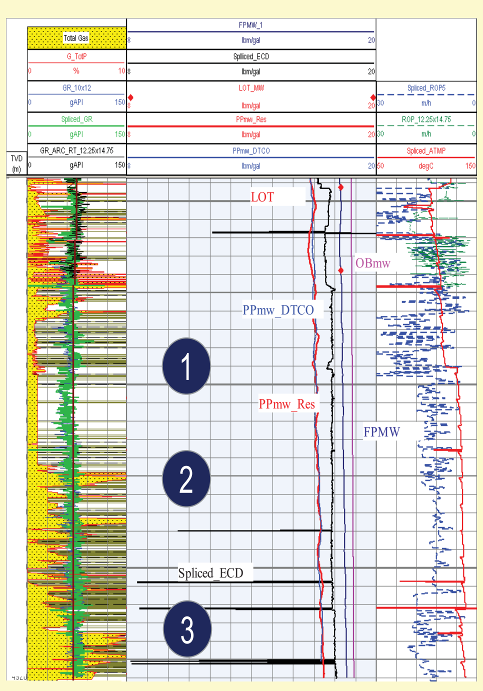
No.	Shape	Size (cm)	%	Appearance	Analysis	Remedial Action
1.	No Cavings	--	--	--		**Significant overbalance**
2.	Mainly Angular	2 – 5	10 – 20	Difference in colors of cavings olive gray (greenish) to darker grey, chocolate brown. visible bedding planes		Indicative of stress relief or increasing pore pressure. Increase in mud weight recommended
3.	Angular / Blocky	2 – 5	5 -20	Olive gray to chocolate brown color		Increase in mud weight recommended

12.25 x 14.75" Section



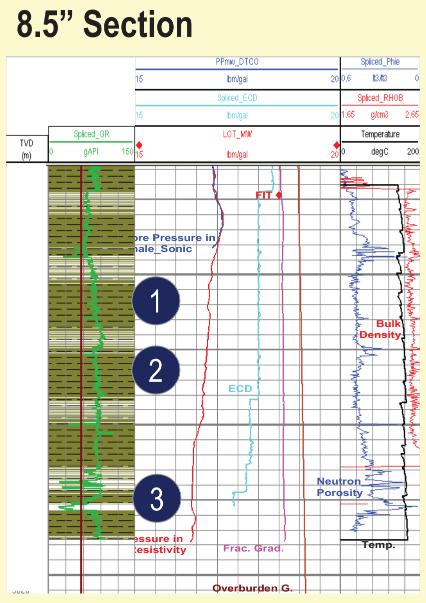
No.	Shape	Size (cm)	%	Appearance	Analysis	Remedial Action
1.	Mainly Angular	2 – 8	30 – 40	Different colored, visible bedding planes, sharp edges	Recommended to drill ahead with constant track of cavings trend	
2.	Blocky & Angular	2 – 8	Tr – 5	Hard & compact with smooth surfaces	Increasing Cavings trend due stress relief or encountered weak zone while drilling	
3.	Blocky & Angular	2 – 4	20 – 30	Hard, smooth surfaces, visible bedding planes		
4.	Blocky & Angular	2 – 4	10 – 20	Hard, smooth surfaces, visible bedding planes	Indicating hole may be having bouts of instability	

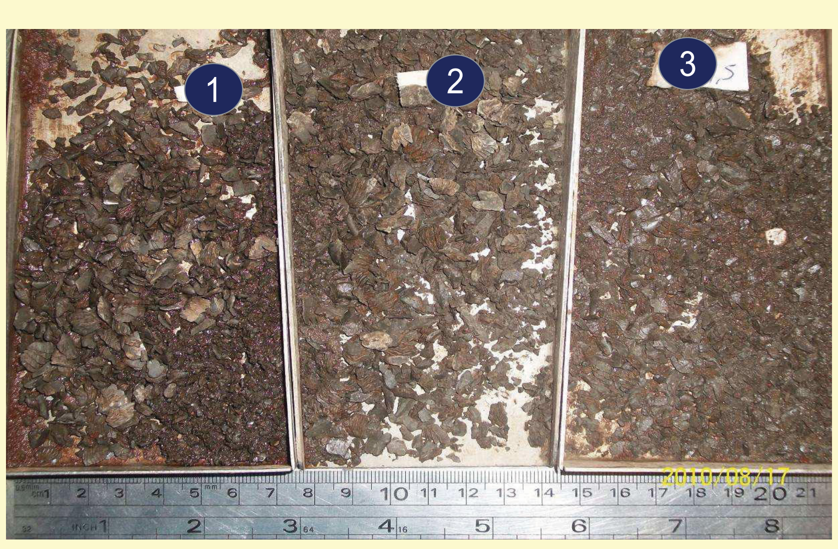
10.625 x 12.25" Section



No.	Shape	Size (cm)	%	Appearance	Analysis	Remedial Action
1.	Mainly Tabular to Sub-platy, Blocky	2 – 8	10 – 20%	Hard & compact, smooth surface	Mostly cavings were mechanically generated	
2.	Mainly Angular & Blocky	2 – 5	Tr. – 5%	Visible fractures, sharp edges	Cavings were fragile & most of them could be easily broken & crushed by hand.	
3.	Mainly Angular & Blocky	2 – 5	10 – 20%	Hard, compact & sharp edges	Increase in cavings, most likely due to reciprocation while circulating off-bottom possibly working across disturbed /weak/fractured zone	

8.5" Section





No.	Shape	Size (cm)	%	Appearance	Analysis
1.	No Cavings				As the section was drilled with significant overbalance, no cavings were reported.
2.	No Cavings				
3.	No Cavings				

Summary & Conclusion

Borehole cavings are the first and foremost indicator of wellbore deterioration during and after drilling operations and the correct knowledge and interpretation of cavings can help optimize well cost by using appropriate prevention / remedial actions and can generate significant cost savings on the order of millions of dollars. The most noticeable and predictive cavings for wellbore stability and formation pressure are those of clay and shale. The observation and interpretation of the size, shape, appearance and relative percentage of cavings, in combination with the total cavings load-versus-time estimated at the shale-shaker, forms a technical requirement to track of the health of the wellbore. Hence, listening to the wellbore by continuous 24/7 monitoring of cavings at the shaker by a dedicated specialist during drilling operations, or post-drill when a well section has reached it TD, is essential.

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