[PS]Complex Artifacts in Resistivity and Acoustic Image Data: Recognition and Use in Borehole Image Interpretation*

Mohammed Al-Khabbaz[2], Hanan Abu-Hebail[1], Mahmood Akbar[2], Badruzzaman Khan[1], Salem Al-Sabea[1], Mona Rashaid[1], Robert Laronga[2], Alexander Aviantara[2], Sandeep Chakravorty[2], and Rohoullah Dashti[1]

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Abstract

Borehole images acquired through wireline and lwd logging provide vital high-resolution information to characterize the structural and sedimentological features of subsurface lithology encountered while drilling a well. These image data are very sensitive to the borehole and logging conditions which create image artifacts.

Image artifacts are features seen on the borehole image logs which are not related to formations logged. They are always present in one form or the other, and are routinely dealt with by every image interpreter. Generally, three different major conditions can give rise to such artifacts. The first occur while drilling the well, and are referred to as drilling-related features. The second type of image artifact is generated while logging. The parameters used while logging the image tools and borehole conditions give rise to this type of artifacts. The third and final stage of image artifact generation can happen at the processing stage, which is an important stage of data handling to convert the data acquired by the imaging tools to represent actual formation responses. Some of the initial artifacts may be removed during processing, but others may remain or get enhanced if the parameters are not used correctly while processing. These artificial image responses need to be defined properly and dealt with in a very systematic and cautious manner while interpreting

image logs. Borehole geologists need to know the origin or the artifacts, i.e. generated due to drilling, during logging, or at the processing stage. Once identified and separated, the image data can then be analyzed to extract true formation properties.

Each imaging tool has its own artifacts which can generally be dealt with independently in most cases, however in special cases, combining different image data can help identify complex artifacts in a comprehensive way. Several papers describe common artifacts seen on the different image logs, both as individual datasets and as integrated observations. This paper highlights some of the complex image artifacts not described before and can be used as a reference in addition to commonly observed artifacts. These have been observed in the image data, acquired in different conditions across complex carbonate reservoirs of Kuwait.

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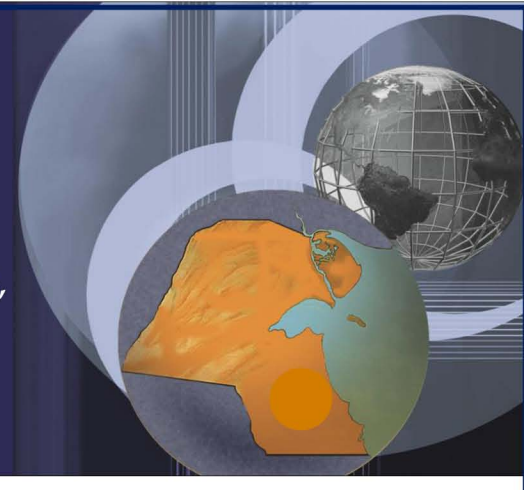
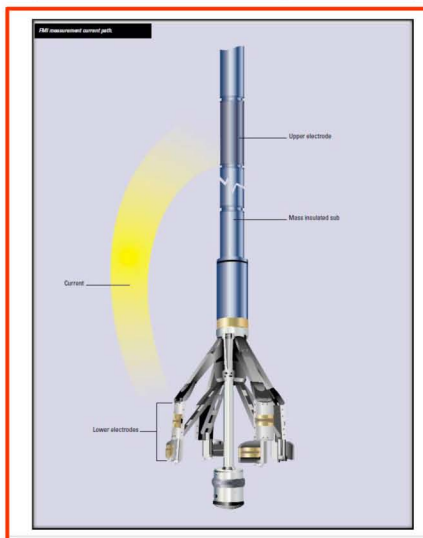
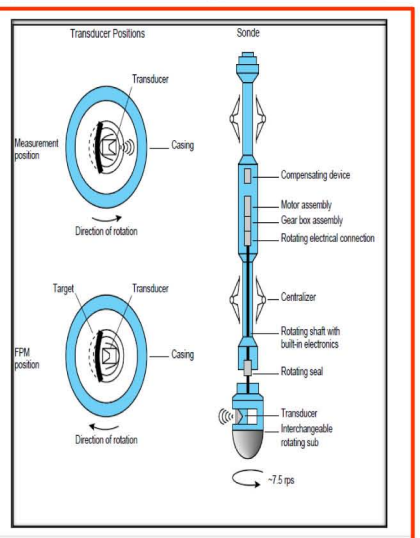
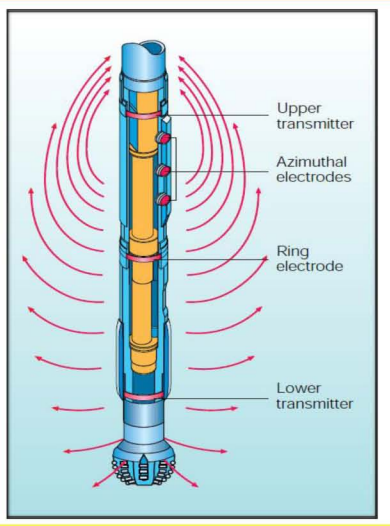


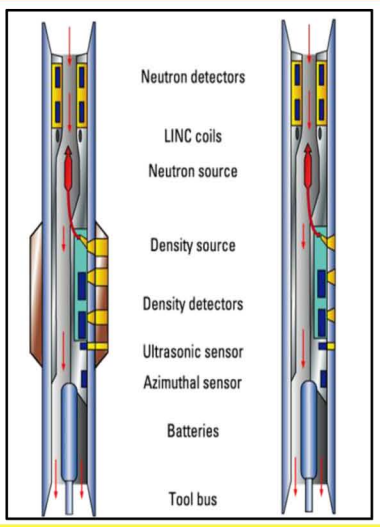
BOREHOLE IMAGE TYPES

Full-bore Formation MicroImager | **Oil-Base MicroImager** | **Ultrasonic Borehole Imager** | **Geovision** | **Azimuthal Density Neutron Tool**









Conveyance Wireline

Conveyance Drill-Pipe

Fullbore Formation MicroImager (FMI): Electrical Imaging Tool, works in water based mud environment with 0.2 inch resolution.

Oil-Base MicroImager (OBMI) : Electrical Imaging Tool, works in oil based mud environment with 0.4 inch resolution.

Ultrasonic Borehole Imager (UBI): Acoustic Imaging Tool, works in both oil and water based mud with 0.2 to 1 inch resolution.

Geovision (GVR): Electrical Imaging Tool, works in water based mud environment with 2 to 3 inch resolution.

Azimuthal Density Neutron Tool (ADN) : Density-Neutron Imaging Tool works in oil and water based mud environment with 6 inch resolution.

ARTIFACTS

Drilling Related Artifacts

- Ghost Hole
- Induced Fractures
- Spiral Hole
- Petal Centerline fracture
- Oil smearing
- Key seat
- Air-filled borehole
- OBMI Desiccation cracks

Logging Related Artifacts

- Stretched images associated with increased OBMI Pad Pressure
- Traces of OBMI Pads on UBI Image
- UBI Centralizers Traces
- UBI Decentralization

Processing Related Artifacts

- Algorithm artifact
- Honey Comb
- Horizontal wells processing windows

DEFINITION

Drilling Related Artifacts

These artifacts are associated with drilling activity e.g. borehole breakouts and drilling induced fractures which develop due to differential formation and borehole fluid pressures.

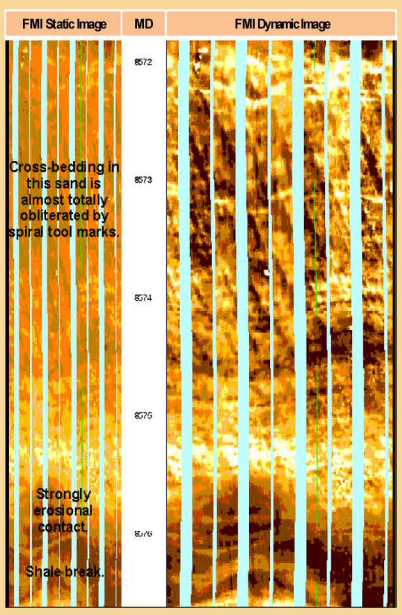
Logging Related Artifacts

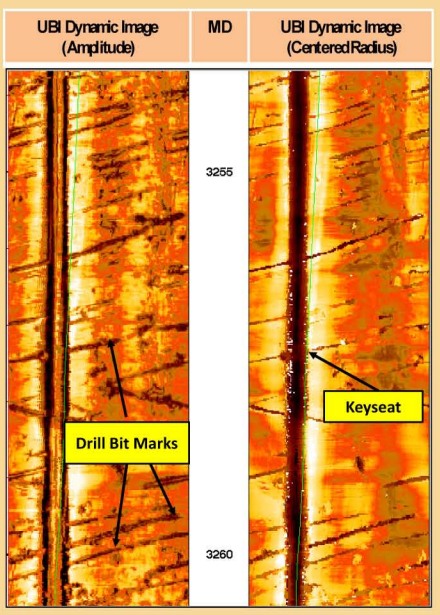
These artifacts are developed due to adverse logging conditions and incorrect tool parameters . For example, if OBMI pad pressure is increased beyond zero psi in a rugose borehole then it will result in stretched image features.

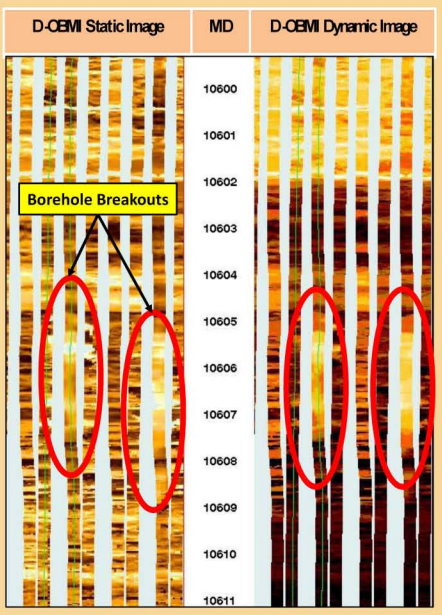
Processing Related Artifacts

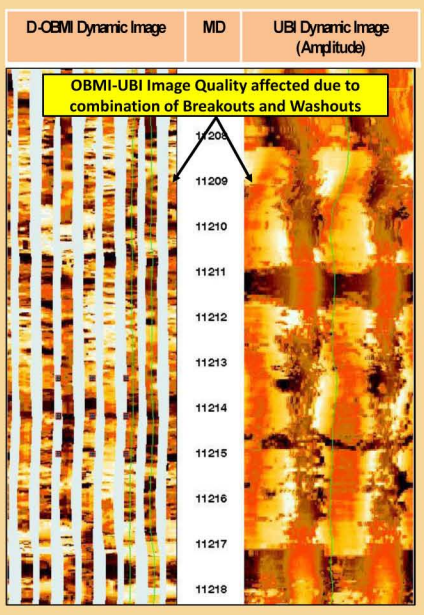
These artifacts are introduced while data processing, this could be a result of human error or software limitation. For example, setting up processing windows or features induced due to software algorithm.

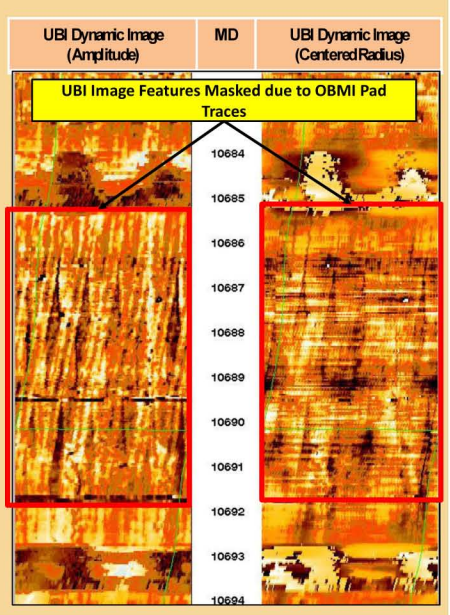
EFFECTS OF ARTIFACTS ON IMAGE INTERPRETATION











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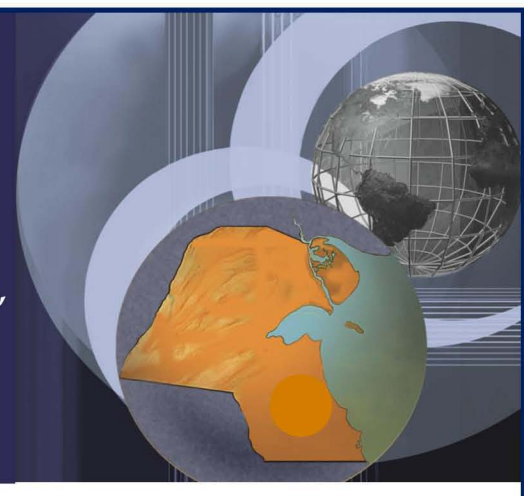
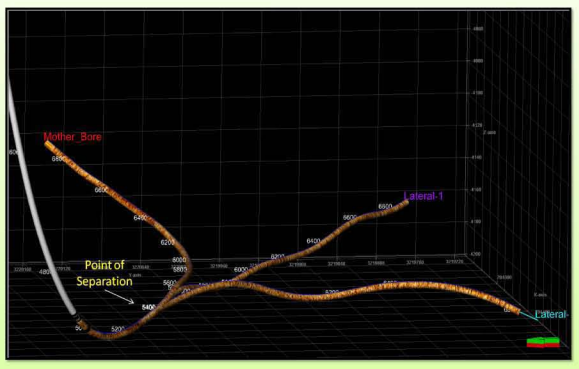
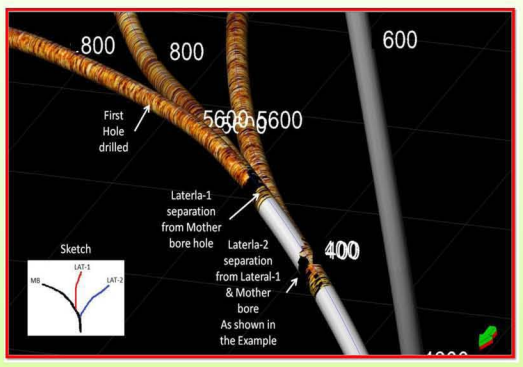
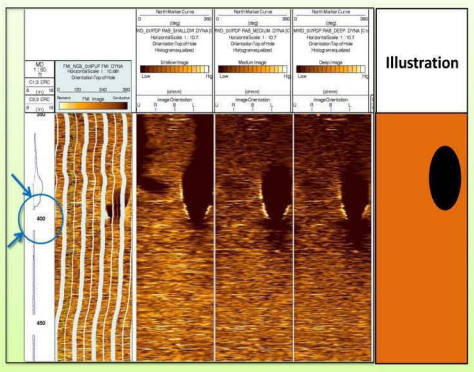


DRILLING RELATED ARTIFACTS

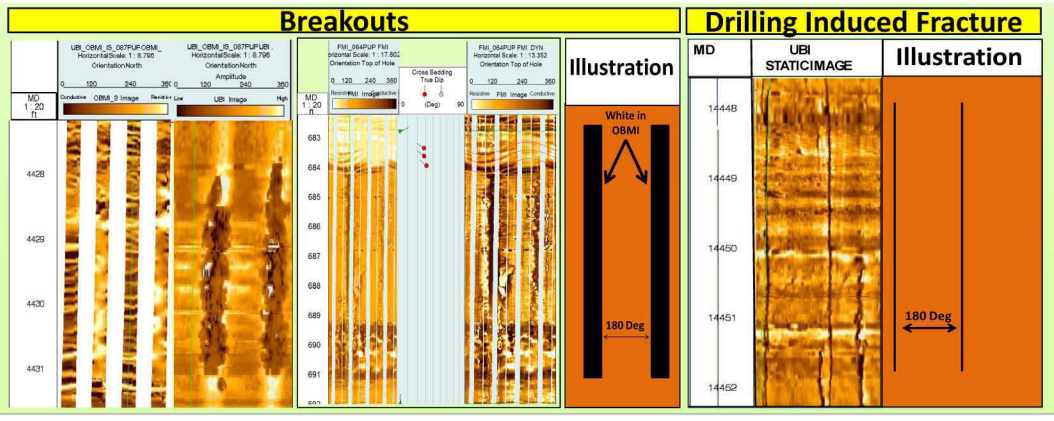






Ghost Hole

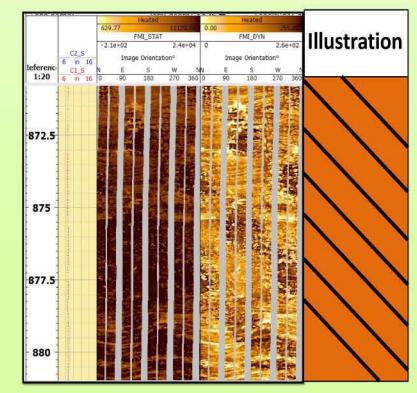
In a multilateral scenario, it is possible to record image of the other borehole at the intersection point. This feature is termed as Ghost hole. If not identified properly it could result in major errors while performing the advanced image based analysis (viz. porosity analysis, SRES computation etc).



Breakouts & DIF

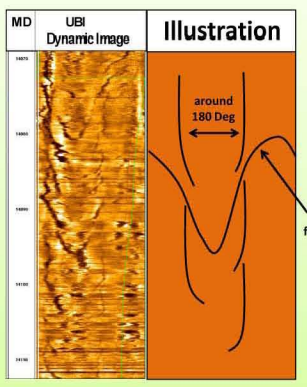
Breakouts and Drilling Induced Fractures (DIF) result due to the differential borehole fluid pressure vis-à-vis Formation Pressure.

BFP < Fm. Pr.= Breakout
BFP > Fm. Pr = DIF



Spiral Hole

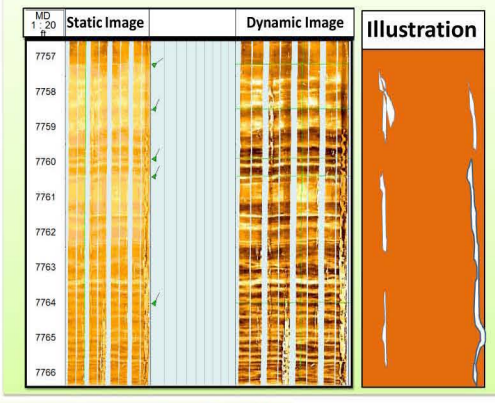
Image logs record angular stripes in spiral holes resulting in poor image quality, which affects further processing and interpretation.



Petal & Centerline Fracture

Petal fractures are curved fractures that begin on the edge of the wellbore and curve parallel to the centerline fracture. Petal fractures that grow to become a centerline fracture or that join with a centerline fracture are termed Petal-Centerline fractures. These fractures develop ahead of the bit due to excessive bit weight and mud pressure.

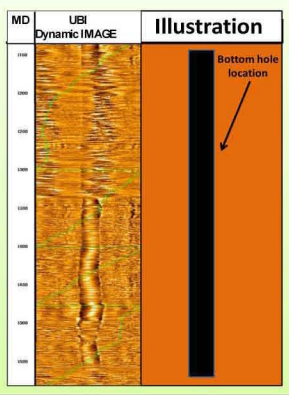
The presence of these induced fractures leads to uncertainity in accurate interpretation of natural fractures.



Oil Smearing

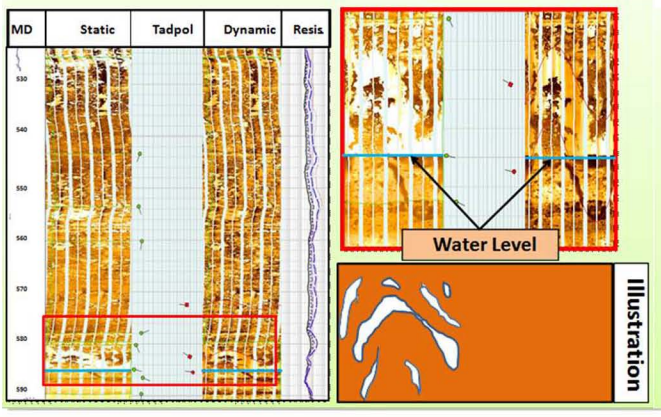
Oil smearing can be either due to oil oozing from the formation or due to oil expulsion from the pads of the electrical imaging tool.

Excessive oil smearing restricts the identification of distinct geological features.



Key Seat

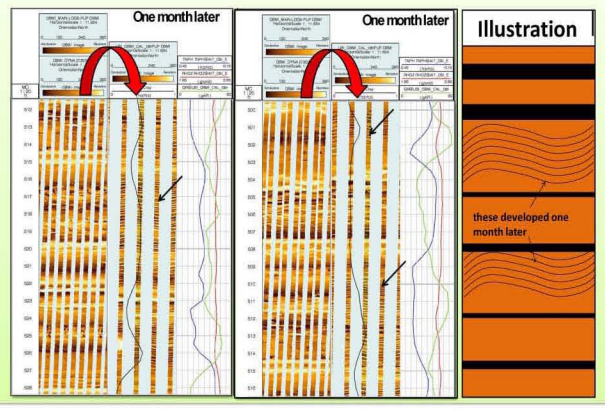
Key seat are traces of drill string on borehole wall. They tend to develop in high angle wells where drill string drag along bottom of the well. This feature masks or break the continuity of formation features.



Air Filled Borehole

At shallow depths, above the water table, the formation is dry and filled with air. The image logs acquired shows presence of air in the form of resistive spots (i.e. white spots).

Such features are important to identify as they can be easily misinterpreted as formation features based on the image response.

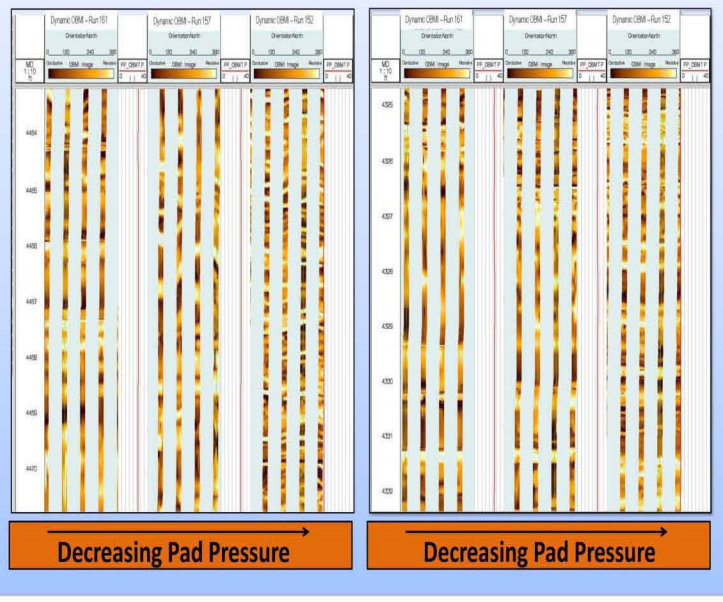


OBMI Desiccation Cracks

Desiccation cracks are often observed in argillaceous intervals in wells drilled with OBM. These cracks are developed due to the subaqueous shrinkage of muddy sediment caused by differences in salinity or chemical conditions. The desiccation cracks appear on the borehole wall mostly as non-planar but at times appear as planar features as well. They appear on the OBMI image as resistive features that can be continuous or discontinuous across the borehole.

In general, dehydration features have little effect on the interpretation of the data but in zones where they are extensive they can adversely affect the image by masking the true planar features.

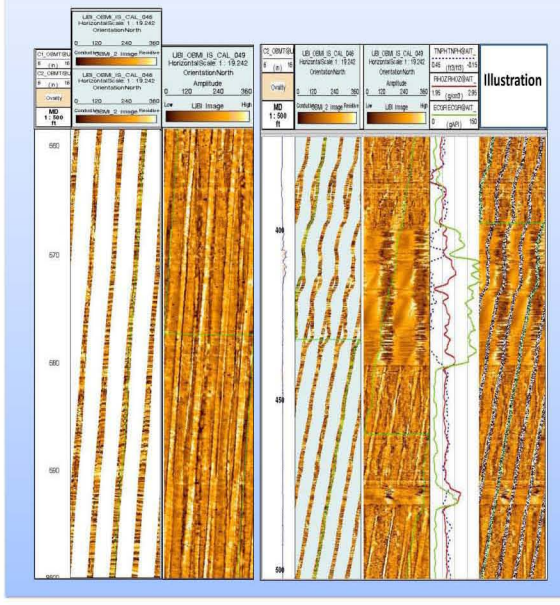
LOGGING RELATED ARTIFACTS



OBMI Pad Pressure

OBMI images are acquired with certain amount of pad pressure to ensure better pad contact with formation. But, with increasing pressure sticking becomes severe and affects the data quality.

In order to avoid such issues decreasing the pad pressure while acquisition improves the image quality.



OBMI Pad traces on UBI

Mud cake against permeable zones are scratched by the pads of OBMI tool leaving their traces. These traces are picked up by the UBI, as it is bottom tool in a OBMI-UBI suite.

The presence of these traces completely mask the formation features.

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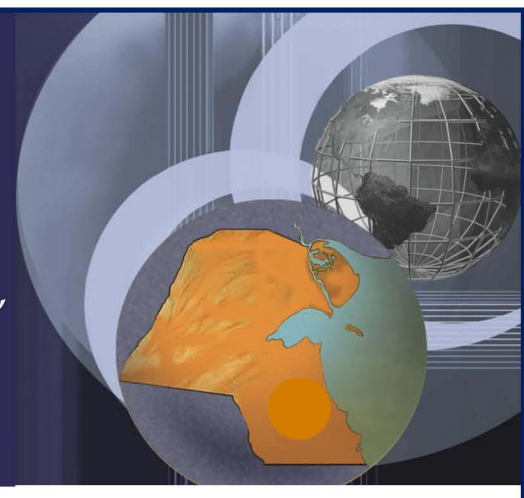
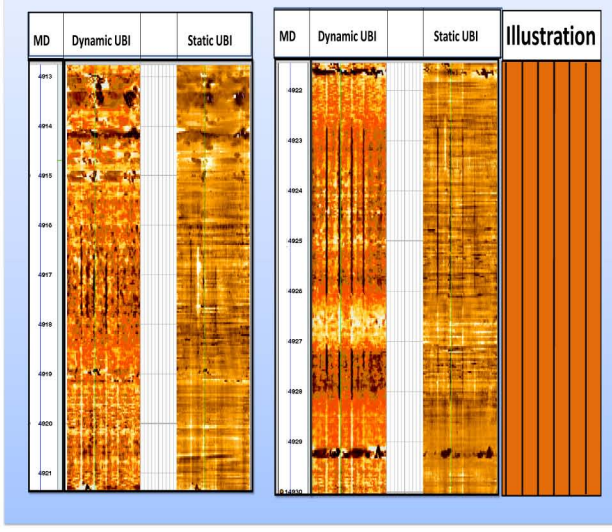
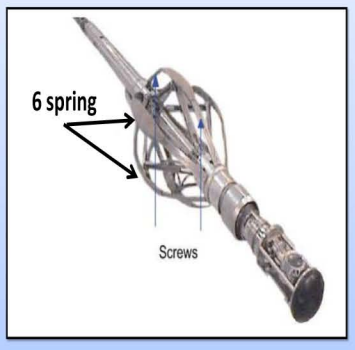


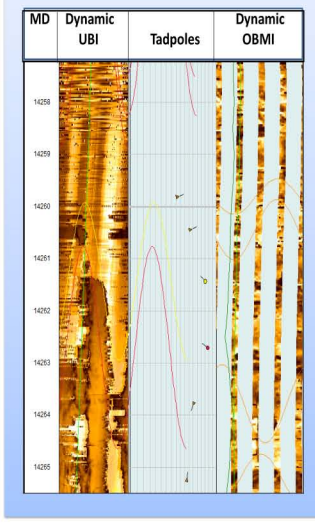
LOGGING RELATED ARTIFACTS





UBI Springs Traces

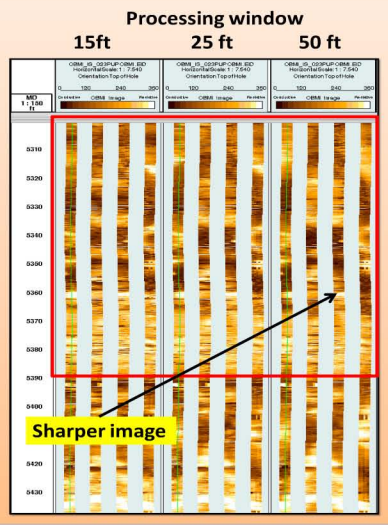
The 6 springs centralizer above the UBI tool leaves traces in a in-gauge hole, which can be picked up by UBI images. Presence of these features can at times be misinterpreted as drilling induced fractures.



UBI Decentralization

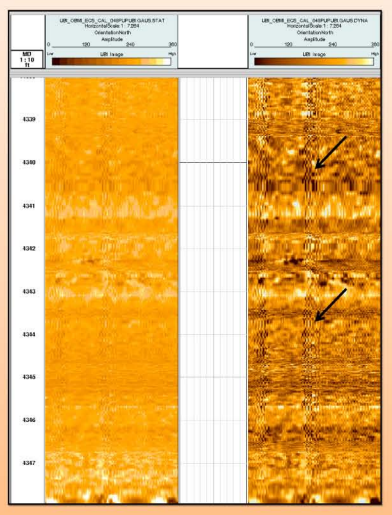
If the UBI tool is not properly centered, signals may be lost as can be seen on the UBI image.

PROCESSING RELATED ARTIFACTS



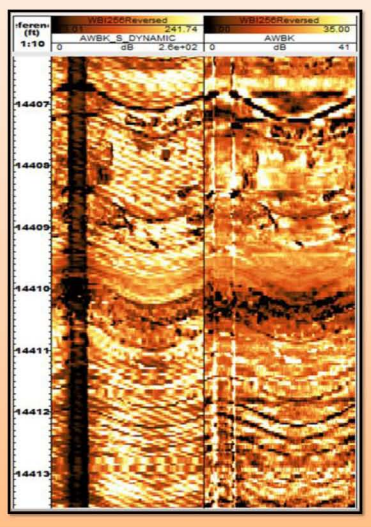
Processing Window

The image equalization is done to negate borehole and tool effects from button response. The window is 15ft for vertical wells, but for high angle features or high angle wells this window does not give proper image. To get sharper image quality, the window needs to be increased to cover more volume of data to equalize.



Honey Comb

The amplitude gain computation during UBI acquisition is a dynamic process and it needs to be corrected while acquisition. If the corrections are not properly applied it results in a pixilated texture in the UBI image data called Honey Comb texture. This error could not be rectified completely while processing the data at Data Centre.



Algorithm Artifacts

Incorrect processing parameters used while generating normalized UBI image results in appearance of inclined lines in the UBI image.

TECHNIQUES TO MINIMISE ARTIFACTS

- Healthy drilling practices to avoid inducing features on the borehole wall.
- Proper job planning to understand the well condition and customizing the tool assembly and parameters accordingly.
- Minimizing the lag time between drilling and logging to avoid severity of dehydration or mud cake formation and proper hole conditioning before logging.
- Suitable acquisition parameters should be used to avoid the artifacts developed due to padded tools/centralizers.
- Analyzing borehole images in conjunction with the deviation survey for optimizing processing parameters.

CONCLUSION

- Image log artifacts mask real geological features and result in poor image log quality.
- Proper cataloging of various artifacts is vital in standardizing borehole image interpretation workflows.
- Appropriate techniques to minimize the impact of artifacts on image quality needs to be implemented.
- Integration of borehole image data with other G & G data could beneficial in ascertaining the presence of artifacts.
- Understanding of borehole trajectory and reservoir type helps in differentiating between artifacts and geological features leading to better interpretation.