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Cement logs evaluation Ghadames Basin, (Al Wafa Gas field), case study, Libya

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ABSTRACT

The acoustic logging method is the most commonly used to qualify a cement job. It can be run several hours or several days after the cement placement and evaluates the quality of the bond (acoustic coupling) between the casing, the cement and the formation. It measures the attenuation of the sound signal as it propagates through the casing, cement and formation and returns to the sensor. This technique and will help spot free pipe, partially bonded or fully bonded pipe. The aim of this paper is analyses and evaluates cement logs data in two wells within Al Wafa Gas field, the cement logs analysis results of two wells shown variables cement condition behind the casing. The well A24-NC169A, analysis showing a good cement condition for both casing and formation as the signature of cement logs showing very low amplitude reading due to high attenuation of waves in cement bound log because the cement was good behind casing. The well A56-NC169A, showing variable results, as good cement condition behind the casing bond to casing, formation, micro- annual and channeling condition. The gamma- ray ranging from 40 to 150, as sand to shaly sand sediments, transit-time was normal, cement bound log recorded variables from low, medium to high amplitude (18 to 56) due to different wave attenuated depending on cement condition (good to partially cement). Variable density log showing variable results (Formation arrive, casing arrive, no casing arrive and no formation arrive, all depending on cement behind the casing. In general, the results revealed good cement condition.

تقييم السجل الإسمنتي بحوض غدامس (حقل الوفاء) دراسة حالة ليبيا

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الكلمات المفتاحية:
تقييم سجلات الاسمنت
ظروف الاسمنت
حوض غدامس
سجل ترابط الاسمنت
سجل الكثافة المتغير
طريقة التسجيل الصوتي

الملخص

طريقة التسجيل الصوتي هي الأكثر استخدامًا لتأهيل وظيفة الأسمنت. يمكن تشغيله بعد عدة ساعات أو عدة أيام من وضع الأسمنت وتقييم جودة الرابطة (اقتران صوتي) بين الغلاف والأسمنت والتكوين. يقيس توهين الإشارة الصوتية أثناء انتشارها من خلال الغلاف والأسمنت والتكوين والعودة إلى المستشعر. تساعد هذه التقنية على اكتشاف الأنابيب الحرة، أو الأنابيب المرتبطة جزئيًا أو الكاملة. تهدف هذه الورقة إلى تحليل وتقييم سجلات الأسمنت في بئرين داخل حقل الوفاء للغاز، ونتائج تحليل سجلات الأسمنت لبئرين تظهر متغيرات حالة الأسمنت خلف الغلاف. يُظهر تحليل البئر A24-NC169A حالة الأسمنت الجيدة لكل من الغلاف والتكوين لسجلات الأسمنت تظهر قراءة سعة منخفضة جدًا بسبب التوهين العالي للموجات في سجل ترابط الأسمنت لأن الأسمنت كان جيدًا خلف غلاف. البئر A56-NC169A، يظهر نتائج متغيرة، مثل حالة الأسمنت الجيدة وراء رابطة الغلاف للغلاف والتكوين والتجويف الحلقي وظروف القناة. تتراوح أشعة جاما من 40 إلى 150، مثل الرمل إلى الرواسب الرملية الصخرية، كان وقت العبور طبيعيًا، وسجل سجل ترابط الأسمنت متغيرات من السعة

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المنخفضة والمتوسطة إلى العالية (18 إلى 56) بسبب الموجة المختلفة الموهنة اعتمادًا على حالة الأسمنت (جيد للأسمنت جزئيًا). سجل الكثافة المتغير يظهر نتائج متغيرة (وصول التكوين، وصول الغلاف، عدم وصول الغلاف وعدم وصول التكوين، كل ذلك يعتمد على الأسمنت خلف الغلاف بشكل عام، كشفت النتائج عن حالة جيدة للأسمنت.

Introduction

Oil engineering need to know some variables during and after drilling, to well integrity evaluation wellbore, such as cement that provides complete zone isolation protects the environment, enhances drilling safety and optimizes production. Without high quality, cement filling the annulus between the casing and the formation, casing that is not protected cement might be prone to corrosion by formation fluids.

To properly perform a cement evaluation, the objectives of the cement job must be understood and a decision made as to how the success of the cement operation.

A primary cement job can be failure if the cement does not isolate undesirable zone, this will occur if:

•The cement does not fill the annulus to the required height between the casing and the borehole.

•The cement does not provide a good seal between the casing and borehole and fluids leak through the cement sheath to surface.

Well cementation, pumping cement into the annulus between the casing and rock or between two casings after drilling, is a key step of well completion to keep well and formation integrity.

The properly cemented well with low permeability cement (less than 0.1 md) ensures the hydraulic isolation between the reservoirs layers and shallow aquifers [1], which can guarantee production efficiency as well as the production safety. In addition, good cement placement in a cased well is also critical for underground gas storage (UGS) and CO2 storage [1]. For cementing quality control, it is necessary to image the structures.

The cement bonding evaluation method is one of research hot topics in acoustic well logging. According to the tool source frequency, cement bonding evaluation methods can be divided into sonic (around 20 kHz) and ultrasonic methods (several hundred thousand Hz). The sonic method, first proposed by [2], is a qualitative or semi-quantitative method. A sonic wave (with frequency of about 20 kHz) is excited and the attenuation of waves is then measured along the borehole axis direction with certain receiver spacing. The attenuation is mainly from the shear coupling of the material behind the casing [3], which is higher in a good bonding condition than that in a bad bonding condition· [4]. Cement bond logging (CBL) derives the attenuation factor from the first arrival amplitude only, whereas variable density logging (VDL) uses the amplitude of the full waveform. There are two industry standard measurements of the CBL/VDL tool, with a 3-ft spacing for recording the casing wave and a 5-ft spacing for the full wave, respectively. Figure 1 shows a schematic diagram of a CBL/VDL measurement in a single casing model. From outermost, the media are formation (rock), cement, casing, borehole fluid, and the tool. The bonding interfaces are label as II and I for the second and the third acoustic interfaces away from the tool in a single casing model [4]· ·Several factors affect the measurement such as the thickness of the cement (the amplitude of the casing wave increase when the cement-sheath thickness is less than 2 cm, with either good bonding or bad bonding condition), [5], [6], [7] .Mud properties (gas bubbles in the mud decrease the amplitude), instrument eccentricity (the amplitude reduced significantly) and micro-annulus (amplitude increased. [5]. In addition, the CBL can only evaluate the bonding condition of bonded interface I between the casing and cement. The VDL, translating the full waveform amplitude to a way of variable density, overcomes the shortage of CBL to some extent. Combining with CBL, VDL can evaluate the bonded interfaces I and II qualitatively. However, due to the cumbersome size of traditional acoustic logging transmitters used in the CBL/VDL method, the azimuthal resolution is relatively low since the attenuation attribute is averaged for all azimuths during the measurement· [5].

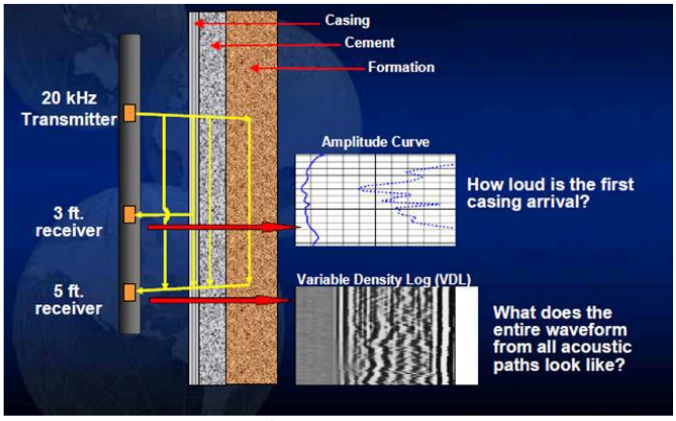


Figure1. Principle of CBL and VDL measurement. [3]

Location of study area.

Al Wafa Gas field, located in the southwestern part of Ghadames Basin, southwest Libya (Figure 2). It is about 100 Km to the south of the city of Ghadames. It was discovered in 1964 by Shell Libya, by drill the well D1; while the north part was discovered by Sirte Oil Company in 1991 by drill well A1 were started production in 2004, located between Latitudes (28° 40' and 29° 00'N) and Longitudes (17° 21' and 18° 00'E).

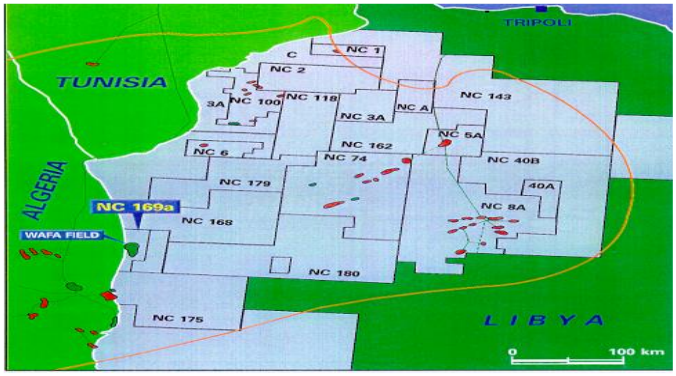


Figure 2. Al Wafa Gas field location map in the Ghadames Basin [8]

Materials and Methods.

The methodology used in this study is acoustic method, the tool used transmitter bombarded the sidewall by high sound wave energy, which are passing through mud, casing, cement, formation, and wave attenuation producing indicate cement condition, behind the casing. Furthermore, the CBL/VDL logs are non-directional and can only provide an average reading of the CBL amplitude around the wellbore. Showing Figure1, Figure 3.

Past interpretation of Cement Bond logs has been essentially base upon a qualitative comparison between the log response in the zone of interest and the responses in the "fully cemented" and the "un cemented" intervals. Most of the variables influencing the magnitude of the signals were recognized in an earlier paper'; however, insufficient laboratory data were available at that time for quantitative evaluation of these variables. Early attempts to use the numerical amplitudes of the signals without full knowledge of their significance resulted in erroneous comparisons between various types of cement. An extensive program was under take to evaluate, both experimentally and theoretically, the attenuation phenomenon and to study the effects of the more common variables [9].

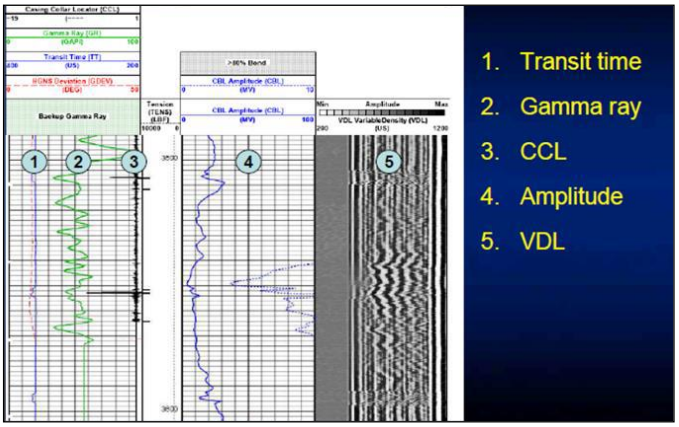


Figure 3. Presentation of CBL, VDL, GR, CCL and TT logs. [2]

Results and discussions

The sedimentological characteristics identified in the lithology data and tied to wireline log patterns, together with the petrophysical properties of potential reservoir units, are summarized in the following paragraphs (after, as shown in Table 1. Specified each condition of the cement in the well by analysis the data from transit-time, cement bond log amplitude attenuation and various density log, the free pipe condition detect as the TT remaining stable. The VDL revelled casing arrival strong and no change in formation arrivals signal,

Table 1: Principle Cement Bond log Qualitative Interpretation [10]

Condition	Transit Time*	CBL Amplitude	VDL
Free Pipe	Normal	High	Casing arrivals, Usually No formation arrivals
Good bond to casing and formation	Normal to High/Noisy	Low	No casing arrivals, Formation arrivals
Good bond to casing NOT to formation	Normal to High / can be Noisy	Low	No casing arrivals, No formation arrivals
Poor bond to casing	Normal	Medium to high	Strong casing arrivals, No formation arrivals
Micro-annulus	Normal	Medium to high	Casing arrivals, Formation arrivals
Channeling	Normal	Medium to high	Casing arrivals, Formation arrivals
Eccentered Tool	Low	Low	It depends!

Analysis of cement logs in the Well A24-NC169a.

A typical acoustic log is shown in Figure 4, where the various graphical outputs are showing good cement behind the casing, the zone (from 8550 to 8630 feet) represent by Middle Devonian Aouinet Ouenine B' F3 sandstone, also evaluate the quality of the reservoir, which characterized by a homogenous lithological sequence as indicated by a blocky homogenous for the upper 80 feet. The signature of CBL shown very low signature during high wave attenuation effect by present of good cement behind the casing from depth (8630 to 8700) feet. Gamma-ray signature increasing due to deteriorating in properties from homogenous sand lithological to a very silty and shale sand interval, CBL amplitude values ranging from medium to high due to low signature attenuated reveled poor cement behind the casing, the other results in well show good cement behind the casing.

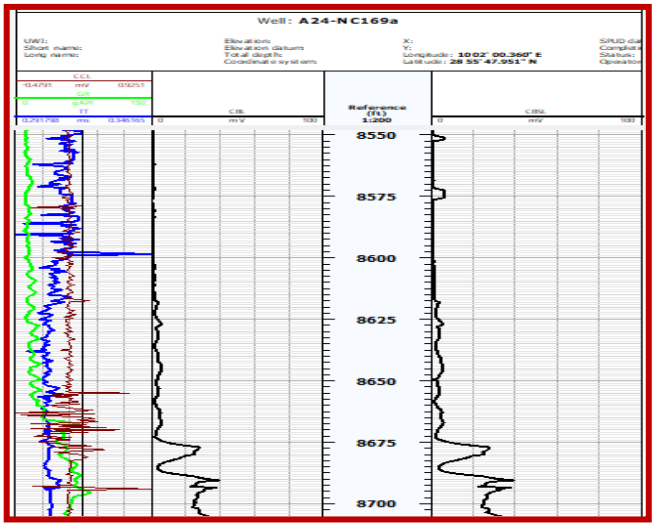


Figure 4: Well A24-NC169a, show well placement simulation with a good zonal isolation.

Analysis of cement logs in the Well A56-NC169A.

The figure 5 shown variables cement conditions in well A56 at the zone (2850 to 3000 feet), gamma-ray ranging from (45 to 120), transit-time record (335) millisecond, the cement bound log record high amplitude with 60 millivolt indicate of bad cement bond in according to Table 1 consider free piper, Variable Density Log (VDL)

Record casing arrive, no formation arrive record.

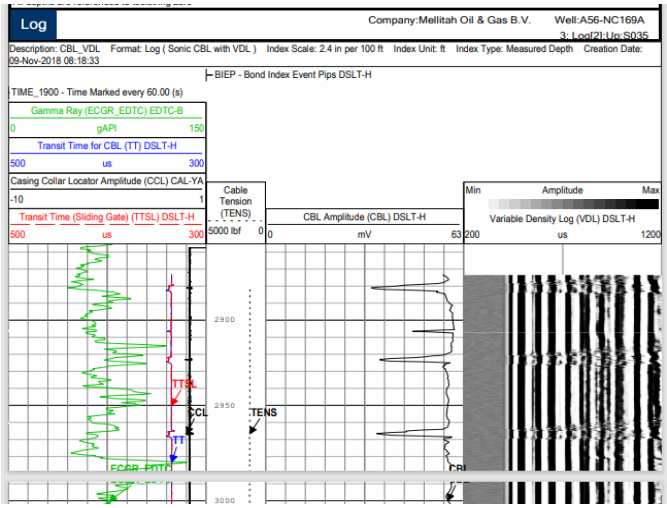


Figure 5: Cement Evaluation Log, CBL, TT, CBSL, CCL and GR for Well A56-NC169A, depth (from 2900 -3000 feet).

The figure 6 the cement logs recorded at zoon (3000 to 3450 feet), GR raining from (60 to 105) as the lithology shale sand, TT stable with 335 milliseconds, CBL record medium to high amplitude (19 to 44) due to signature attenuated represent particle cement to good cement, VDL record casing arrive.

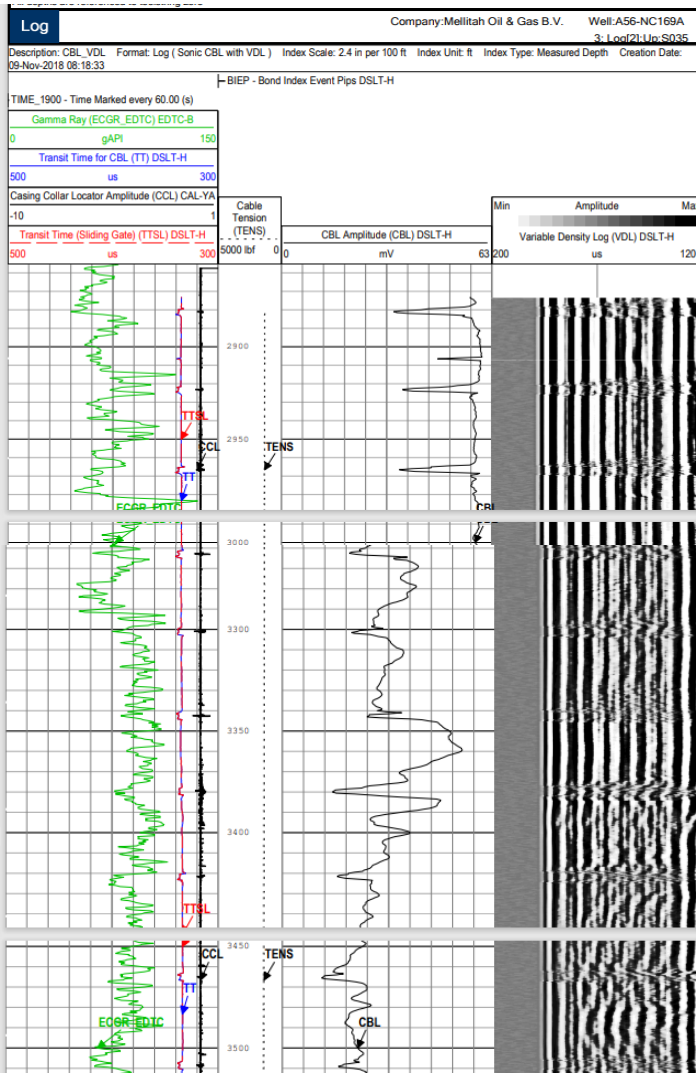
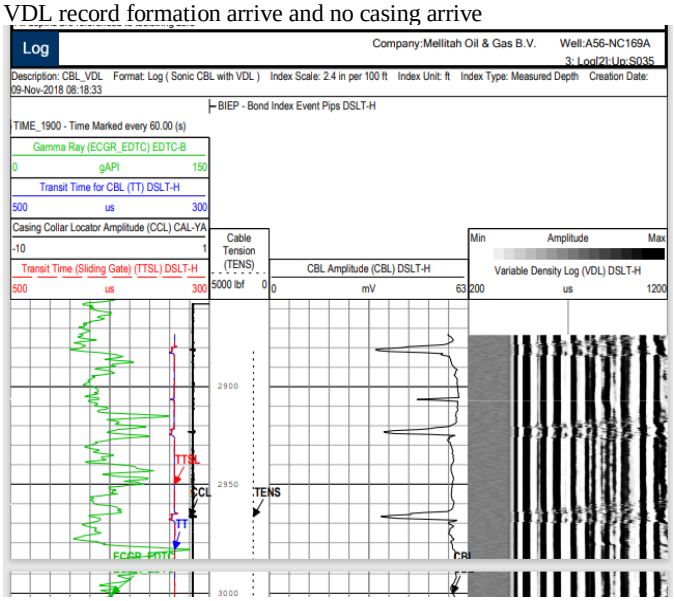


Figure 6: Cement Evaluation Log, CBL, TT, CBSL, CCL and GR for Well A56-NC169A, depth from (3000 -3500 feet).

Figure 7 is a representation of the zone (3500 to 4050feet), the cement logs including gamma-ray raining from (40 to 150) as the lithology start with shale sand to shale, TT normal with 335 milliseconds. CBL record medium to high amplitude (19 to 40) due to signature attenuated represent partielle cement to bonne cement. VDL record formation arrive and no casing arrive



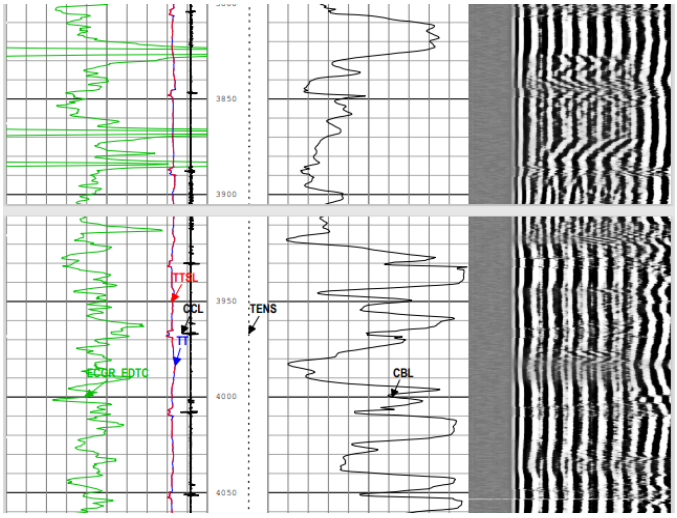


Figure 7: Cement Evaluation Log, CBL, TT, CBSL, CCL and GR for Well A56-NC169A, depth (from 3500 -4050 feet).

From depth (3930 to 4150 feet), gamma-ray raining from (40 to 90) as the lithology start with shale sand to shale, TT normal, CBL record from low to very high amplitude (6 to 60) due to high attenuated in good cement to low attenuated in poor cement .0encountered.

From depth (4150 to 4450 feet), gamma-ray raining from (45 to 100) as the lithology start with sand to shale, TT normal, CBL record medium to high amplitude (25 to 56) due to high attenuated in good to partielle cement, to low attenuated in poor cement bond, VDL record formation arrive and no casing arrive encountered.

From depth (4500 to 4450 feet), gamma-ray raining from (45 to 100) as the lithology start with sand to shale, TT normal, CBL record medium to high amplitude (25 to 56) due to high attenuated in good to partielle cement, to low attenuated in poor cement bond, VDL record formation arrive and casing arrive indicate to micro-annulus or channeling condition.

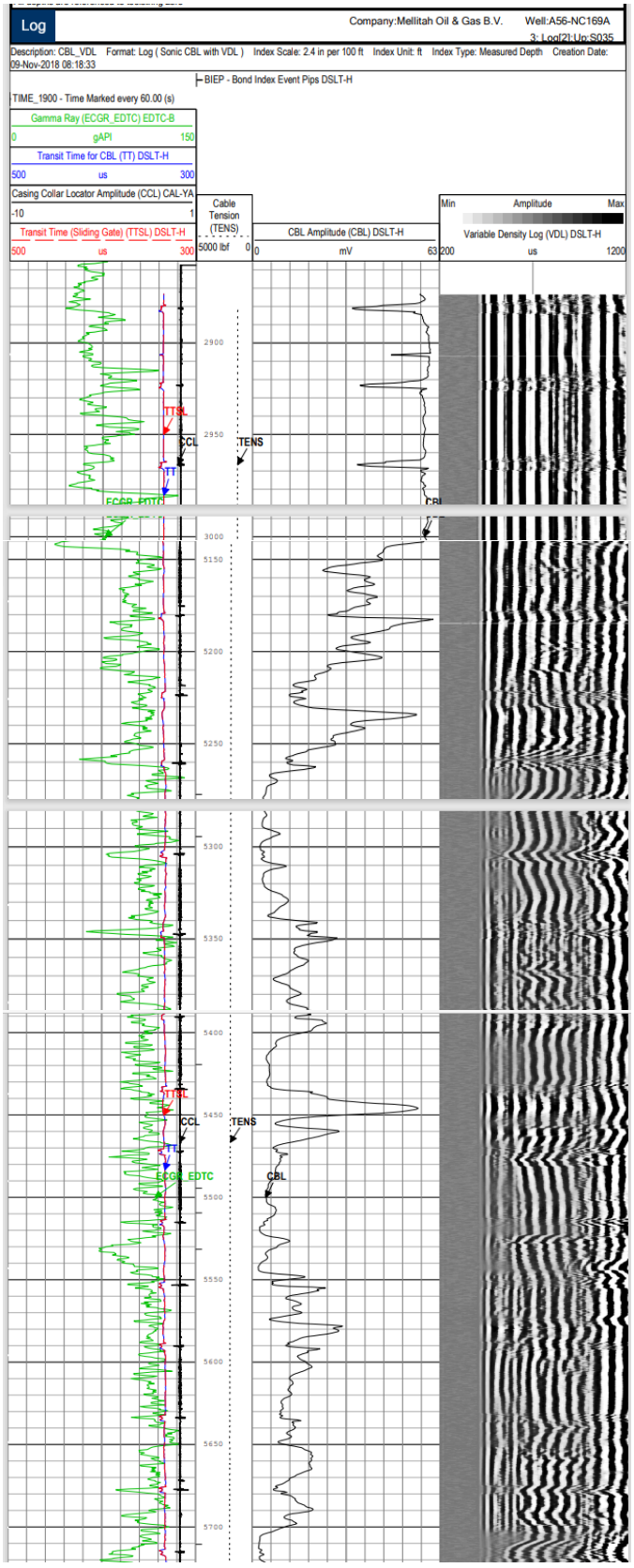
From depth (4450 to 4600 feet), gamma-ray raining from (60 to 110), TT normal, CBL record medium to high (12 to 44) due to high attenuated in good to partielle cement, the VDL record formation arrive and casing arrive indicate to micro-annulus or channeling condition.

From depth (4620 to 4820 feet), gamma-ray raining from (75 to 105), TT normal, CBL record medium to high (30 to 45) due to high attenuated in good to partielle cement, the VDL record formation arrive and casing arrive indicate to micro-annulus or channelling condition.

From depth (4830 to 5250 feet). The gamma-ray raining from (40 to 125), as lithology change from sand to shale, TT normal, CBL record variable from low to medium to

High, (5 to 30 to 55) due to variable signature attenuated as changing from particle to good to poor cement. The VDL record variable as some parts record formation arrive and casing arrive and some parts record formation arrive and no casing arrive, which it may be micro-annulus or channeling or good bound to casing and formation condition. From depth (5250 to 5750 feet), gamma-ray raining from (75 to 130), TT normal, CBL record low to medium (3 to 20) due to high attenuated in good to partielle cement, the VDL record formation arrive and no casing arrive indicate to good bound to casing and formation.

Figure 8 is a representation of the zoon From depth (5750 to 6300 feet), gamma-ray raining from (75 to 125), TT normal, CBL record low to medium (3 to 25) due to high attenuated in good to partielle cement, the VDL record formation arrive and no or weak casing arrive indicate to good bound to casing and formation.



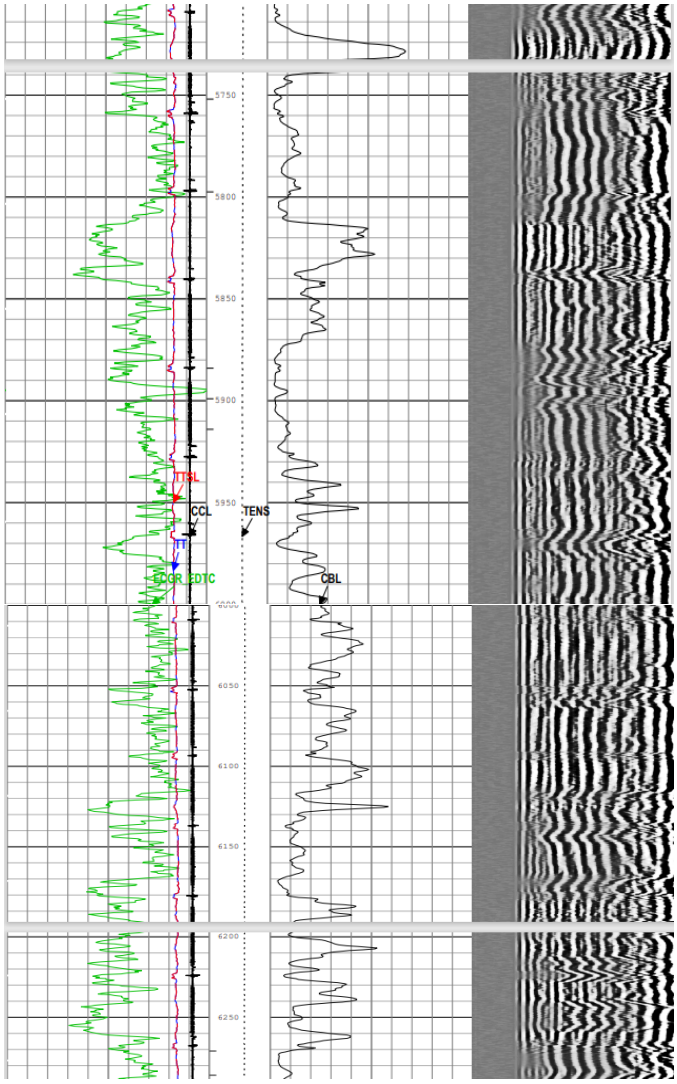
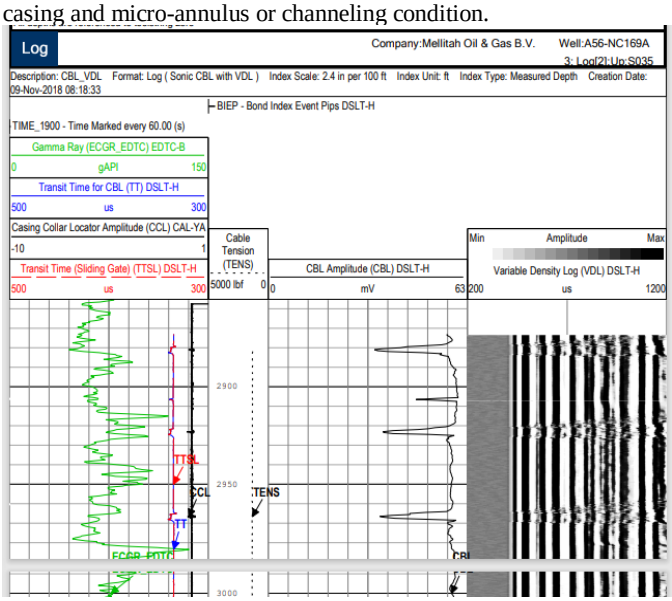


Figure 8: Cement Evaluation Log, CBL, TT, CBSL, CCL and GR for Well A56-NC169A, depth (from 5750 to 6300 feet).

From depth (6300 to 6800 feet), GR raining from (42 to 90), TT normal, CBL record low to medium to high (2 to 25 to 45) due to variable signature from high to low attenuated in a good to partielle cement, to good bound, VDL record formation arrive and no or weak casing arrive for some small sections.

The figure 9 shown zoon (6820 to 7440 feet), gamma-ray raining from (90 to 110), TT normal, CBL record medium to high (18 to 25 to 48), VDL record strong casing arrive and no or weak formation arrive for some small sections, according to table 1, poor bound to casing and micro-annulus or channeling condition.



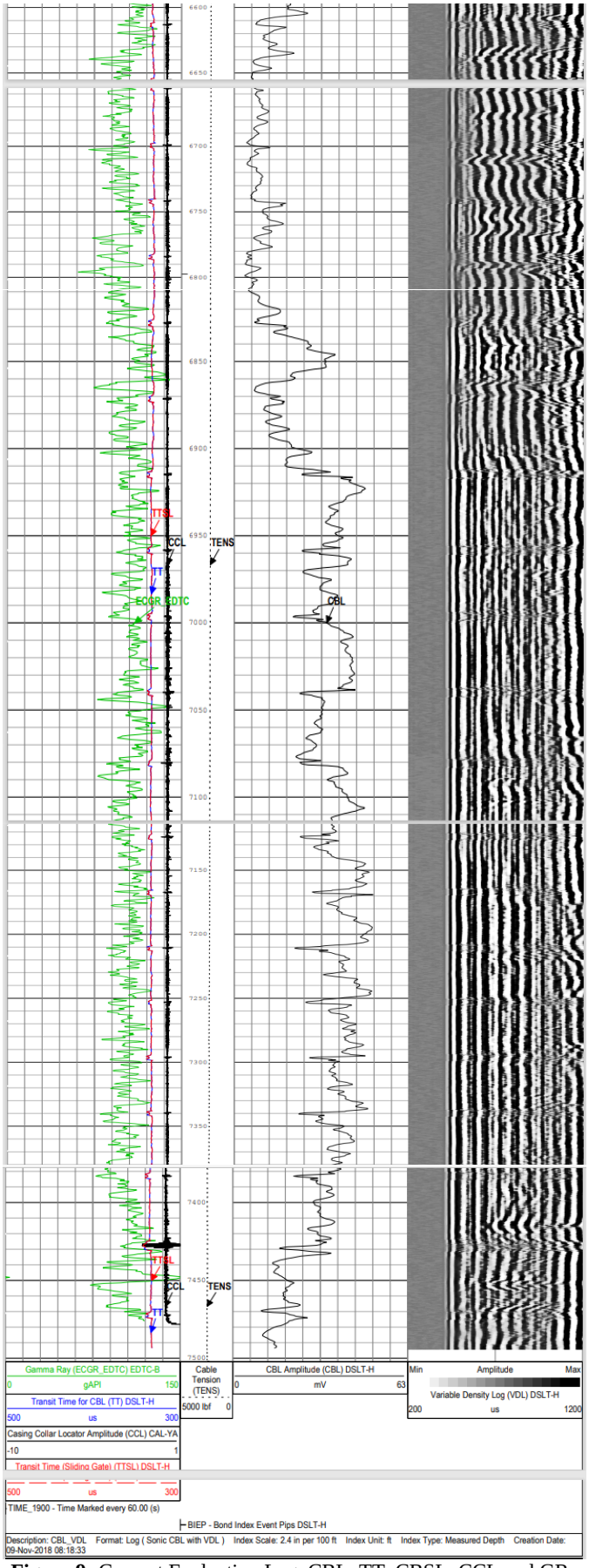


Figure 9: Cement Evaluation Log, CBL, TT, CBSL, CCL and GR for Well A56-NC169A, depth (from 6600 -7500 feet).

CONCLUSION:

The analysis and evaluation of cement logs includes cement bond log, variable density Log, Ultrasonic Imaging Tool for two selected wells (A24-NC169A and A56-NC169A) located in Al Wafa gas field, show variable cement job conditions as following:

1- The well A24-NC169A, cement logs run from (8550 to 8630 feet), for quality of the reservoir section, determined very low gamma-ray signal, cement bound log revealed very low amplitude due to high attenuation of wave passing through well cement condition behind the casing. The reservoir section characterized by a homogenous lithological sequence as indicated by a blocky homogenous one of parameters effect the cement condition.

2- The cement logs analysis results of the well A56-NC169A, showed variable cement condition behind the casing ranging from fair, good, good bond to casing and formation, micro- annual and channeling condition.

From depth (2900 to 7450 feet). The gamma ray raining from low to very high, the lithology change from sand to shale to shaly sand (40 to 150). Transit-time normal, cement bound log recorded variable from low, medium to high amplitude (2 to18 to 56) due to different wave attenuated, depend on cement condition (good to partially to poor cement), variable density log showing partially cement behind the casing.

Recommendations:

In many countries. Regulatory authorities require that cement bond logs run in every well after cementing operations to investigate the presence and quality of the cement bond behind the casing.

ACKNOWLEGMENT

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