GEO India 2018

PaperID **AU278**
Author **Suresh Kumar , Oil and Natural Gas Corporation Limited , India**
Co-Authors **J C Upreti, R B Singh Rarh, N.K Punjrath**

Role of mud logging data in predicting and preventing drilling problems in tight gas reservoirs: A case study from Vindhyan Basin

Abstract

Mud logging technology has evolved with recent advancement in engineering services. It can be used for quantitative reservoir evaluation as well as to counter different drilling complications. More importantly in frontier areas where precursor information regarding drilling complications and hydrocarbon presence is very less, mud logging acts as a very important tool.

The paper deals with the application of mud logging data to predict and prevent various drilling complications that were encountered during drilling in Vindhyan basin. Mud logging Unit installed at wells in this area has provided drilling engineers with accurate and up to date drilling information and a complete foot by foot record of drilling progress. The drilling parameters such as Weight-on-Bit, Hookload, Standpipe Pressure and Rotary Torque etc. recorded in Mud Logging Unit with sophisticated sensors and Computer systems helped to prevent complications like Drill string failure and Bit failure. The study also pertains with the utility of mud logging unit through careful monitoring of drilling fluid parameters and pit level sensors to detect Lost Circulation ahead of occurrence in wells and thus reduced drilling cost and time.

Introduction

For a long time the mud-logging companies have provided the driller and drilling engineers with rather sophisticated computer systems for data presentation and some minor data processing, while drilling a well. The computer systems have also been available for office use both with a link to the on-site computers and as a post-processing data system. Each mud-logging company delivers its own special system for recording and analysing the data. In general Mud logging includes observation and microscopic examination of drill cuttings, and evaluation of gas hydrocarbon and its constituents, basic chemical and mechanical parameters of drilling fluid as well as compiling other information about the drilling parameters. Then data is plotted on a graphic log called a mud log.

Other real-time drilling parameters that may be compiled include, but are not limited to; rate of penetration (ROP) of the bit (sometimes called the drill rate), pump rate (quantity of fluid being pumped), pump pressure, weight on bit, drill string weight, rotary speed, rotary torque, RPM (Revolutions Per Minute), SPM (Strokes Per Minute) mud volumes, mud weight and mud viscosity. This information is usually obtained by attaching monitoring devices to the drilling rig's equipment with a few exceptions such as the mud weight and mud viscosity which are measured by mud engineer.

There are several broad objectives targeted by mud logging: identify potentially productive hydrocarbon-bearing formations, identify marker or correlatable geological formations, and provide data to the driller that enables safe and economically optimized operations. The purpose of this paper is to highlight the significance of these real-time parameters to predict and prevent drilling complications. The charts and figures are taken from the well A of Vindhyan basin of India for the better illustration of the subject.

Vindhyan Basin – An overview

The Vindhyan Basin is sickle shaped and is situated in the central part of India. It is a large basin of Late Paleo-Neoproterozoic age. The south-western part of the basin is covered under a drape of basalt and in the north by the Indo-Gangetic alluvium. The basin is divided into two sectors: Chambal Valley to the west and Son Valley to the east. The Vindhyan basin has a large expanse of shallow marine sedimentary rocks with a huge sedimentary fill (a maximum of ~6000 meters in the southern part of Son Valley). Across the globe, it is estimated that 2% of Hydrocarbon is in the Neoproterozoic sediments. Mc Arthur basin of Australia (equivalent to Son Valley of Vindhyan basin) has indicated gas and dead oil from late Palaeo-proterozoic to early Meso-proterozoic sediments. Exploration activities are going on in both sectors by Oil and Natural Gas Corporation Limited of India.

Vindhyan Basin represents basinal sequence belonging to two distinct depositional cycles. The older one is dominantly calcareous and argillaceous with volcanoclasts, called Semri or Lower Vindhyan. The younger cycle, an arenaceous and argillaceous sequence, is commonly known as Upper Vindhyan. Upper Vindhyan comprises of Kaimur, Rewa and Bhander Subgroups.

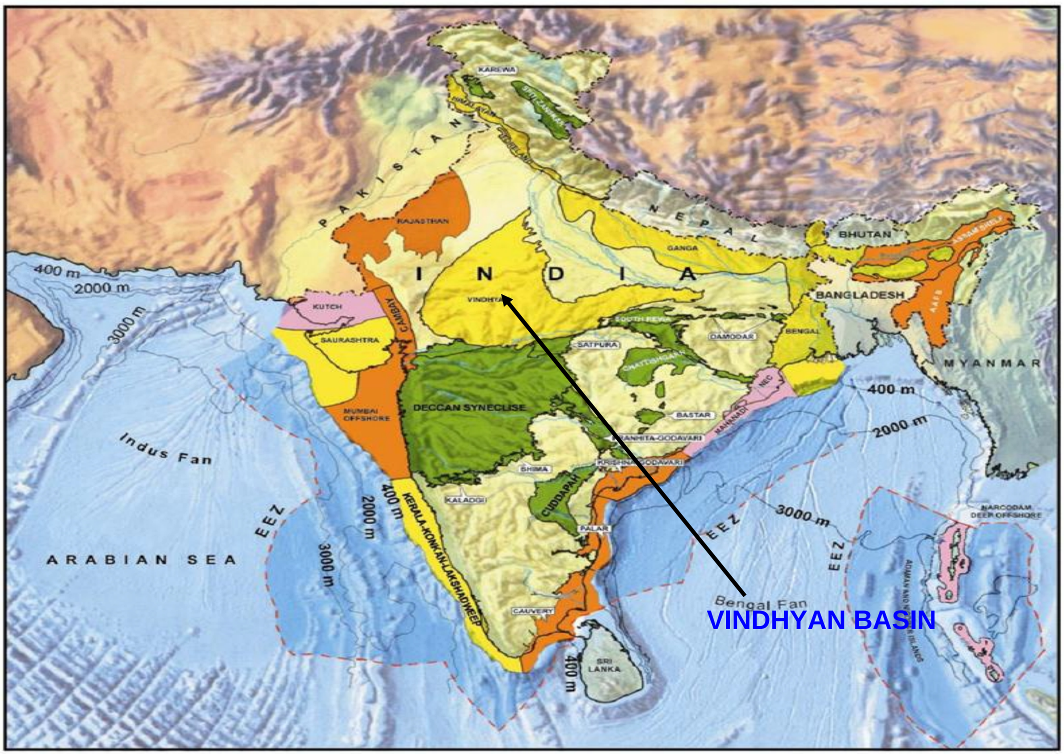

Fig 1. Vindhyan Basin with reference to sedimentary basins of India

WEST VINDHYAN BASIN (CHAMBAL VALLEY) — CHITTOR-BUNDI AREA (After Prasad, 1976)

SUPERGROUP	GROUP	SUBGROUP	STRATIGRAPHY
VINDHYAN SUPERGROUP	UPPER VINDHYAN GROUP	BHANDER GROUP	DHOLPURA SHALE
			BALWAN LIMESTONE
			MAIHER SANDSTONE
			SIRBU SHALE
			BUNDI HILL SST
			SAMARIA SHALE
			LAKHERI LIMESTONE
			GANURGARH SHALE
		REWA	GOVINDGARH SST
			JHIRI SHALE
			INDARGARH SST
			PANNA SHALE
		KAIMUR	AKODA MAHADEV SST
			CHITTAUR FORT SST
	LOWER VINDHYAN GROUP		SUKET SHALE
			NIMBAHERA LST
			BARI SHALE
			JIRAN SST WITH CONGL.
			BINOTA SHALE
			KALMIA (GLAUC.) SST
			PALRI SHALE WITH PORCL.
			SAWA SST WITH CONGL.
			BHAGWANPURA LST.
			KHARDEOLA SST.
			KHAIRMALIA ANDESITE
ARAVALI GROUP			
BUNDELKHAND GNIESS			

WEST VINDHYAN BASIN (CHAMBAL VALLEY) — GWALIOR-KARAULI AREA After Prasad, 1984)

GROUP	STRATIGRAPHY
	DECCAN TRAP
BHANDER GROUP	UPPER BHANDER SST.
	SIRBU SHALE
	LOWER BHANDER SST
	SAMARIA SHALE
REWA SUB-GROUP	UPPER REWA SST
	JHIRI SHALE
	LOWER REWA SST
	PANNA SHALE
KAIMUR SUB-GROUP	AKODA MAHADEV SST
TIROHAN GROUP	TIROHAN BRECCIA
	CONGLOMERATE
	TIROHAN LST.
	GLAUCONITIC BEDS
	SST WITH CONGLOMERT.
GWALIOR GROUP	
BUNDELKHAND GNIESS/ GRANITE	

EAST VINDHYAN BASIN (SON VALLEY) — DAMOH-REWA AREA (After Srivastava et al. 1983)

SUBGROUP	FM.	STRATIGRAPHY	Mt.
		LAMETA FM.	
BHANDER SUBGROUP	HAVELI FM.	MAIHER SST	87
		SIRBU SHALE	80
	BETWA FM.	NAGOD LST	112
		GANURGARH SHALE	45
REWA SUBGROUP	ADHESAR FM.	GOVINDGARH SST	55
		JHIRI SHALE	34
	ADWA FM	ASAN SST	64
		PANNA SHALE	34
KAIMUR SUBGROUP	CHURK FM.	DHANDRAUL QRTZ.	185
		SOMAN SCARP SST.	140
	RAMPUR FM.	BIJAIGARH SHALE	34
		DOMARKHOKA QRTZ.	95
SEMRI GROUP	ROHTAS FM	BHAGAWAR SHALE	420
		ROHTAS LST	
	KHEINJUA FM.	BASUHARI (GLAUCONITIC) SST.	320
		MOHANA (FAWN) LST	207
		CHARKARIA (OLIVE) SHALE	561
	CHOPAN FM.	JARDEPAHAR PORCILLINITE	555
		KAJARAHAT LST	335
		BASAL CONGLOMERATE	
BIJAWAR GROUP			
BUNDELKHAND GNIESS			

EAST VINDHYAN BASIN (SON VALLEY) — MIRZAPUR-ROBERTGANJ AREA (After Sastri & Moitra 1984)

GROUP / SUBGROUP	STRATIGRAPHY
	SUB-RECENT LATERITE
KAIMUR GROUP	DHANDRAUL SANDSTONE
	MANGESAR FORMATION
	BIJAIGARH SHALE
	GHAGHAR SANDSTONE
	SUSNAI BRECCIA
	SASARAM SANDSTONE
ROHTAS SUBGR.	BHAGAWAR SHALE
	ROHTASGARH LST
KHEINJUA SUBGR	RAMPUR GLAUCONITE
	SALKHAN LST
	KOLDAHA SHALE
PROCEL SUBGR	DEONAR PORCELLINITE
MIRZAPUR SUBGROUP	KAJARAHAT LST
	ARANGI FORMATION
	DEOLAND FORMATION
BIJAWAR / MAHAKOSHAL GROUP	
BUNDELKHAND GNIESS	

Table 1: Generalized stratigraphy of Vindhyan basin

Mud Logging– A Rig site Information Source

Mud Logging was introduced as a commercial service in 1939. Mud Logging provides for continuous onsite inspection, detection, and evaluation of the rocks as they are being drilled with regards to correlation and potential hydrocarbon production. The process of acquiring this data and its subsequent evaluation are very important factors for all drilling programs. It provides a clean, well-lighted laboratory area with a stable electrical supply and is continuously operated by Geologists or geologically trained technicians. The sensors, measuring physical quantities and transforming them to analogue or digital signals, represent the base for the mud-logging data. The mud logging sensors are installed on the different components of drilling rig. The components of a drilling operation that have a part in mud logging operations are given in the fig. 2.

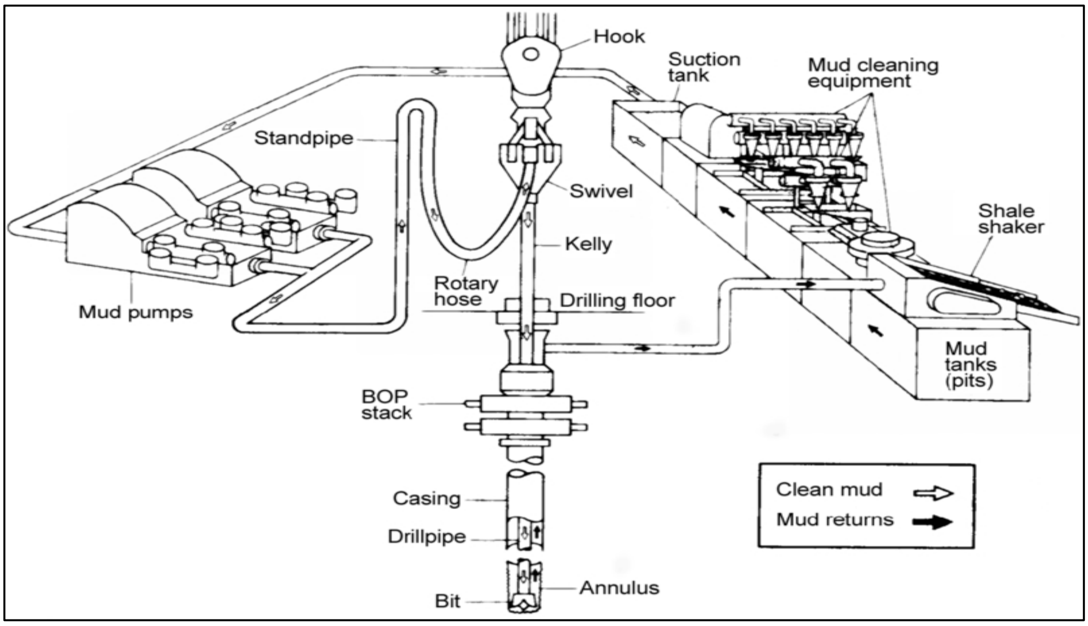

Fig 2. Drilling fluid flow path during drilling operations

Mud logging– An Information leading to Solution

An exploratory well A was traversed through Bhander, Rewa and Kaimur subgroups of Upper Vindhyan and Suket Shale and Nimbahera limestone formations of lower Vindhyan. Since it was an exploratory well, a role of mud logging unit was so crucial and it stood high in its reputation. All information acquired through mud logging sensors was utilized to resolve few complications. The complications and methodology to predict them is described here.

Lost Circulation

Lost circulation occurs when a fractured, or very high permeable, formation is being drilled. Complete mud is lost to the formation and this reduces the height of the mud column in the borehole. Lost circulation can also occur if high mud weight which exceeds the formation gradient is used. Whatever the cause of lost circulation it does reduce the height of the column of mud in the wellbore and therefore the pressure at the bottom of the borehole. The consequences of lost circulation can be as little as the loss of a few dollars of drilling fluid, or as disastrous as a blowout and loss of life. Therefore close monitoring of tanks, pits, and flow from the well is of utmost importance to quickly assess and control lost circulation. This is what is taught and practiced at the well site. If the amount of fluid in the wellbore drops due to lost circulation (or any other reason), hydrostatic pressure is reduced, which can allow a gas or fluid which is under a higher pressure than the reduced hydrostatic pressure to flow into the wellbore and caused blowout.

Mud logging unit has both potentiometric and ultrasonic sensors placed at Suction tanks, Intermediate tanks, and Shale shaker tanks and continuously recorded volume of drilling fluid present in these tanks during drilling. The total volume of drilling fluid changes continuously with depth as the hole volume increases. Rapid increases in pit volume may mean an influx of reservoir fluids, and well control measures may need to be implemented. A rapid decrease in volume indicates a downhole loss of mud, and lost-circulation material (LCM) will probably be added to the drilling fluid. Vindhyan basin does not have much lost circulation zones except some partial mud loss at unconformity bound surface between lower Vindhyan and upper Vindhyan. In well A partial mud loss occurred at this surface which was cured well before the actual happening of the problem. The basic interpretation performs increase or decrease in pit levels and course of action to be taken in cases of lost circulation is described below:

Description	Possible Origin	Check/enquire	Action/inform
No Variation	Very slow ROP coupled with water addition, Float stuck	Check Floats, Check sensor, connections, Vary the pulley and check the signal reception	Clean the float with water so that it is free. Test the connections
Slow and regular, increase 0.5 to 3 Cu.m/hr.	Water or mud addition at surface, Slow influx of water/oil or gas	Pit levels and sensor Gas/pit gain rates	Note the gain and inform driller/chemist/Tool pusher, Put comments on real time charts
Oscillations < 1Cu.m/hr.	On floater due to heave or due to sensor being close to agitator	Check calibration	If necessary change the position and recalibrate
Fast but small increase1 to 3 Cu.m/hr.	Water or oil influx, Gas influx preceded by slow increase due to gas expansion	Check SPP, Enquire with driller, Check ROP/ Gas/Returns/ MW/ Cond/Temp	Monitor active pit volumes. Inform driller/chemist/Tool pusher. Put comments on real time charts
Fast and large volumes > 20 Cum	Mud transfer, Water/oil or Gas influx preceded by gradual increase and drill break	Check with chemist, Check ROP/ Gas/Returns/ MW/ Cond/Temp	Monitor active pit volumes. Inform driller/chemist/Tool pusher. Put comments on real time charts. Shut in well and monitor SIDPP & SICPP.
Slow and regular decrease 0.5 to 3 Cu.m/hr.	Increase in hole volume, Operations of Desander/ Desilter/Rig Degasser. Filtration loss in hole	Check the hole volume, increase in volume, increase in relation to decrease in pit volume, check pits for leakage	Inform the chemist /Mud engineer
Fast decrease > 3 Cu.m/hr.	Mud transfer, Mud loss at surface, Mud loss in well	Check with chemist for any transfer, Check the SPP, ROP and type of Lithology if any	Inform the chemist /Mud engineer. Inform driller. Put comment on real time charts

Table 2. Interpretations in Pit levels during Drilling

Drill string failure

The term drill string is used to describe the tubulars and accessories on which the drill bit is run to the bottom of the borehole. The drill string consists of drill pipe, drill collars, the Kelly and various other pieces of equipment such as stabilisers and reamers, which are included in the drill string just above the drill bit. The drill collars and the other equipment which is made up just above the bit are collectively called the Bottom Hole Assembly (BHA).

It is not uncommon for the drill pipe to undergo tensile failure (twist off) whilst drilling. When this happens, drilling has to be stopped and the drill string must be pulled from the borehole. The part of the string below the point of failure will of course be left in the borehole when the upper part of the string is retrieved. The retrieval of the lower part of the string is a very difficult and time consuming operation. The failure of a drill string can be due to excessively high stresses or corrosion.

A mud logging unit is very useful asset to prevent happening of such failures. It continuously monitors drilling parameters and drilling fluid parameters so as to predict any such failure on the basis of behaviour of these parameters. The important parameters which the mud logging crew has to watch out are Weight on hook/hook load, Weight on Bit, Stand pipe pressure, and Pump rate (SPM). One of the major reasons for drop in SPP is Mud Cut (cut in the drill string) and the logger has to be very careful to monitor and report the drop in SPP to the driller immediately. A drop of 2 to 3 kg/cm2 over 5 to 10 minutes without any changes in Mud might be an indication of Mud Cut. In such a case the driller will stop drilling and check for the drop and then pull out. A case of drill string failure taken from well A showing relationship of above said parameters are described here.

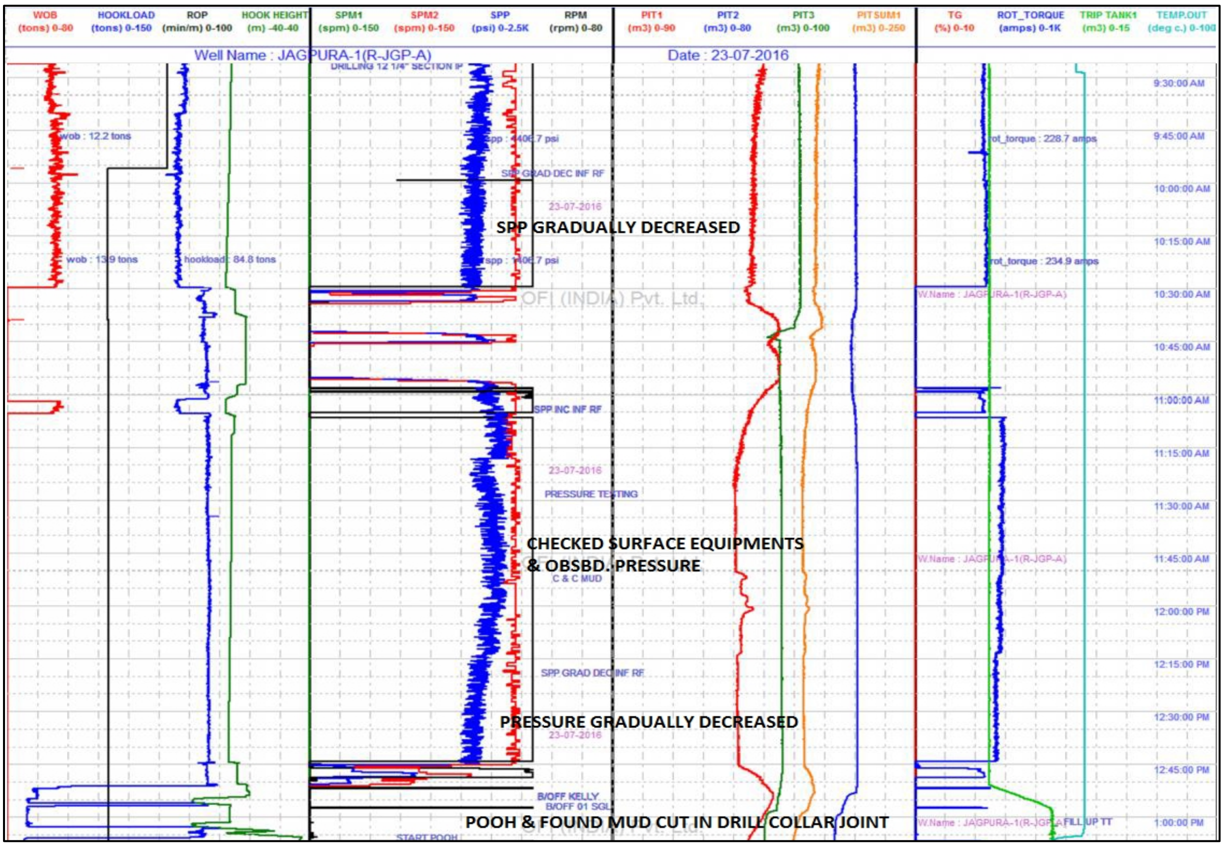

Fig 3. Interpretation of Drill string failure

Bit failure

A drilling bit is the cutting or boring tool which is made up on the end of the drill string. The bit drills through the rock by scraping, chipping, gouging or grinding the rock at the bottom of the hole. Drilling fluid is circulated through passageways in the bit to remove the drilled cuttings. When drilling an oil well it is desirable to drill as long as possible without wearing the bit to the point of catastrophic bit failure. Optimum bit use occurs when a bit is worn sufficiently that the useful life of the bit has been expended, but that wear is not so extensive that there is a high likelihood of mechanical failure which might result in leaving a portion of the bit in the well. The performance of a bit is a function of several operating parameters, such as: Weight on bit (WOB), Rotations per minute (RPM), Drilling fluid properties and Hydraulic efficiency. The drilling engineer must be aware of the impact of the operating parameters on the performance of the bit. A gradual increase in rotary torque could indicate bit wear. This could be cross checked by checking for metal pieces in the cutting sample in mud logging unit and the number of hours that the bit has been drilling in relation to its rating. In fact any fluctuating increase in the torque has to be informed to the driller, who will cross check by lifting the string off bottom and rotating. A similar response would indicate the stabilizers are hitting the side of the hole. Whilst a decrease off bottom and an increase on bottom would indicate that the bit is worn out and has to be pulled out immediately to avoid fishing problems.

A system capable of detecting the early stages of bit failure, with the additional capability of warning the operator at the surface would be of great value in solving the problem of drilling to the point of catastrophic bit failure. In well A mud logging unit continuous monitored parameters like rotary torque, rotation per minute and weight on bit provided bit failure detection and surface operator warning capabilities. The behaviour of drilling parameters against onset of any bit failure is given in fig. 5.

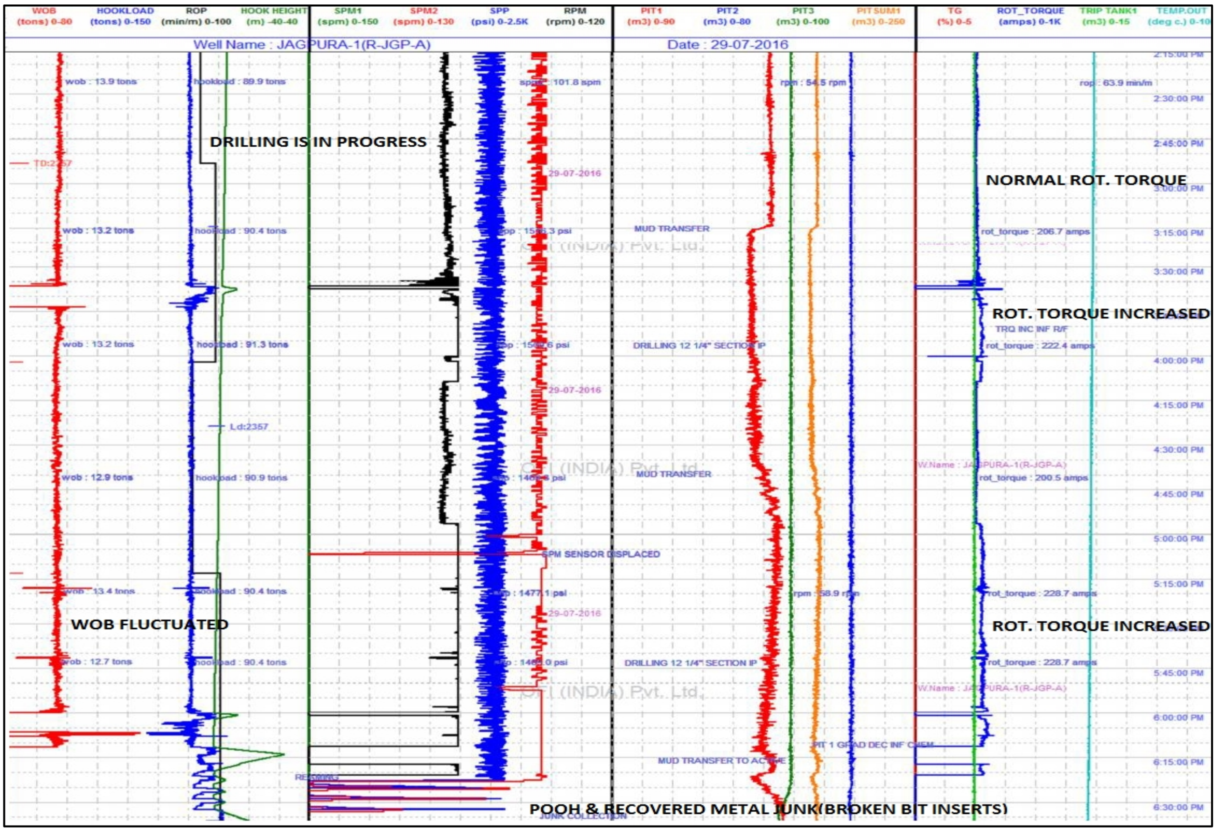

Fig 4. Interpretation of Bit failure

Conclusion

Lost circulation, Drill string failure and Bit failure can pose great problems. Such complications when encountered in a well create a lot of hindrance for drilling engineers. The problem may get so severe that the well has to be abandoned. To avoid such complications effective mud logging always proved helpful to improve drilling efficiency, safety and pre–empt downhole problems.

Acknowledgement

Author is very much thankful to Frontier basin, ONGC Dehradun for providing data and geological information. Authors acknowledge the support of drilling engineers and well site geologists of ONGC for providing their valuable constructive suggestions and assistance.

References

1. Drilling Engineering, Department of Petroleum Engineering, Heriot-Watt University
2. Bourgoyne T. Adam; Millheim K. Keith; Chenvert E. Martin; Young F.S, Applied Drilling Engineering, Society of Petroleum Engineers,1991
3. Baker Hughes INTEQ, Wellsite Geology-Reference Guide, April 1996
4. Baker Hughes INTEQ, Drilling Engineering Workbook-A Distributed Learning Course, Dec.1996
5. Alun Whittaker, Development Geology Reference Manual-AAPG Methods in Exploration Series