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Well Control Challenges of Shallow Gas at Faras Field in Agiba Petroleum Co. in the Western Desert, Egypt (Case Study)

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Abstract

Shallow gas presents a major worldwide problem for the drilling industry. The records show that almost one-third of all blowouts have been caused by shallow gas. Well control of shallow gas at Faras field in the western desert of Egypt presents numerous well control challenges. The first sixteen wells in this area faced many drilling problems like well control events and mud losses at the surface hole. During drilling 17.5" surface hole section of well X-1 in 2002 had blowout due to the flow of a huge amount of shallow gas while tripping out before running 13.375" casing and rig burnet.
This paper presents a case study describing the shallow gas problem that leads to a blowout and the solution-oriented approach. The shallow gas problem leads to change in the drilling program by taking into consideration all standard drilling practices. Safety precautions beginning from hammering 20" conductor pipe to accommodate the diverter and install a diverter on the 20" conductor pipe with an automatic hydraulic valve to divert any gas flow far away from the rig site, then drilling 8.5" pilot hole and enlarge the same to 17.5" hole section as well as cleaning the hole. Using heavily weighted drilling fluids up to Mwt 12.5 ppg to overcome the expected high pressure in shallow formations and added gas control additives to cement job for this section, then proceed with the next intervals till total depth.
This paper provides an advanced and in-depth study for well control challenges of shallow gas at Faras field and presents a comprehensive analysis of safe drilling shallow gas zone & excess precautions to avoid shallow gas problems for future drilling of shallow gas wells..

***Keywords**:.*

1. Introduction

Facing shallow gas always has been challenging in exploration and development drilling operations. Shallow gas refers to near-surface gas containments that are not expected to be right under the bit. Near-surface formations always are unconsolidated and do not need any special well control considerations, but the presence of a pressurized gas layer will change everything and will put anything in danger especially when gas reaches the surface and just needs a little spark to turn everything to ash after a huge explosion.

On the other hand, using heavily weighted drilling fluids for controlling formation pressure may not work in the entire open hole and result in medium to severe mud losses. Most often, severe losses are following by the flow of formation fluid to the annulus, which is called kick, or more seriously, a blowout. Blowouts may just take a few seconds to strew the mud column away, which results from saltwater or shallow gases. Sometimes, because of losing wellbore wall support exerted by the mud column due to complete loss, it tends to tighten and will stick the drill string.

The occurrence of each phenomenon will result in losing dollars because of either time spent for curing them or leaving instruments in the hole. These irrecoverable events could be prevented by conducting an integrated geomechanical study before drilling and being aware of shallow gas signs while drilling in conjunction with an appropriate well control procedure will help to mitigate shallow gas consequences [1].

Shallow gas blowouts have caused more drilling rigs to be lost than any other type of well control problem. There have been many other cases where shallow blowouts resulted in severe rig damage although the rig was not totally lost [2]. Shallow gas kicks will occur in situations when suitable precautions are not taken or when the precautions are not sufficient to stop the kick. Equipment and procedures must therefore be in place to allow gas to flow from the well safely until the producing zone is isolated or depleted or at least until the risk to personnel can be minimized [3].

1.1. Causes of shallow kicks

Shallow gas is the most serious single cause of kicks leading to blowouts [4]. This statistic emphasizes the fact that shallow gas kicks are more likely to result in blowouts than kicks taken in deeper drilling [5]. The following list contains the causes of shallow gas flows [6].

- Swabbing;
- Core volume cutting;
- Improper hole fill-up on trips;
- Abnormal pressures- charging or structural crest of gas zone;
- Lost circulation during drilling or cementing Gas migration through cement.

In 1995 started drilling the first well in this area and during an exploratory & development drilling wells at Faras field facing several drilling problems especially while 17.5” surface hole section such as well control events and mud losses. Long Non-Productive Time (NPT) was associated with regaining control over the well and curing the mud losses.

Drilled more than forty wells in this area and all the wells consist of three sections starting from surface hole section 17.5" x 13.375" casing which planned to be drilled around 500 ft through moghra formation, medium hole section 12.25” x 9.625” casing which planned to be drilled around 1500 ft through dabaa and apolloina formation then the production hole section 8.5” x 7” casing which planned to be drilled to TD through abu-roash and bahariya at 3500-3600 ft [7].

During drilling well X-1 which was planned to be drilled to a total depth of 3600 ft, stared drilling surface hole 17.5” with Mwt 10 ppg of salt-saturated mud to depth 511 ft. While pulled out the second stand and started to break out same, mudflow came out from the annulus and the diverter has been closed and mudflow has been diverted to the vent line, but due to the huge amount of sand & gas which accumulated around the rig site due to occasionally absence of wind at that time had a spark from sand friction at the end of the vent line and Fire caught on sub-base, mast, and mud system [8].

2. Well control challenges of shallow gas at Faras field

To carry out successful drilling wells in Faras field without losing NPT and safely there are challenges to control shallow gas problems in this area and overcoming the same as following:

- Mitigate and help to prevent shallow gas problems, follow all standard drilling practices and required safety precautions in this area as per blew detailed procedures.
- Analyze all the drilled wells to know the root causes and to avoid this problem again.
- Introduce the best practices to enhance well control procedures while drilling shallow gas area.
- Raise the level of awareness of well control shallow gas by effective training courses for drillers and drilling operation teams.
- Share all the incidents with all the drilling personnel via lesson learned log, problem over-view description, and root cause analysis reports.

3. Field data

The Faras field is located in the Egyptian western desert, in the northern part of the Ras Qattara Lease, it is separated from the El Mohr field by the main fault which represents the structural closure as shown in Figure 1.

Faras field was discovered in 1995, after the drilling of well F-1X; oil production started in November 1996 from the wells F-1X, F-2, and F-3. In December 1999 water injection flooding started to increase the recovery of the field [9].

The Faras reservoir lies at a depth of about 3000 ft SSL and the reservoir formations are Abu-Roash Level G and Bahariya. The two units are members of the Albian-Cenomanian succession of the western desert the initial reservoir pressure has been fixed in 1360 psi at 2900 feet. As shown in Figures 2, 3 and Table 1.

Figure 1. Faras area map

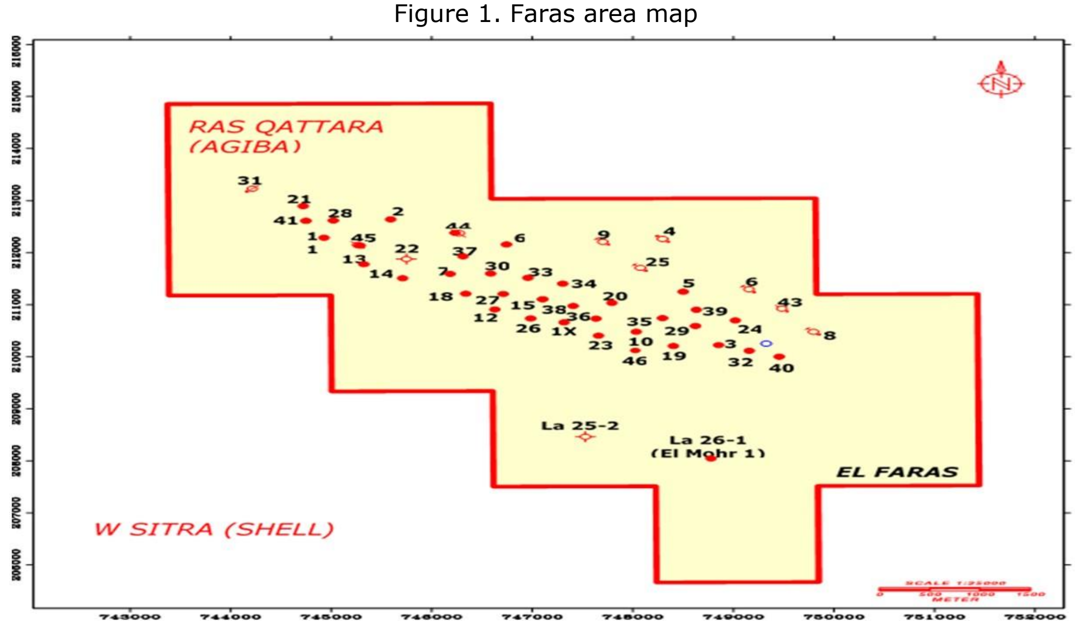

Figure 2. Faras deployment lease location map

Table 1. General data for Faras area [10]

Production start-up	November 1996
Initial pressure, PSI	1360 @ 2900 FT/SS
Initial oil production rate	3500 BOPD
Production peak	10410 BOPD @ July 2006
Injection start-up	December 1999

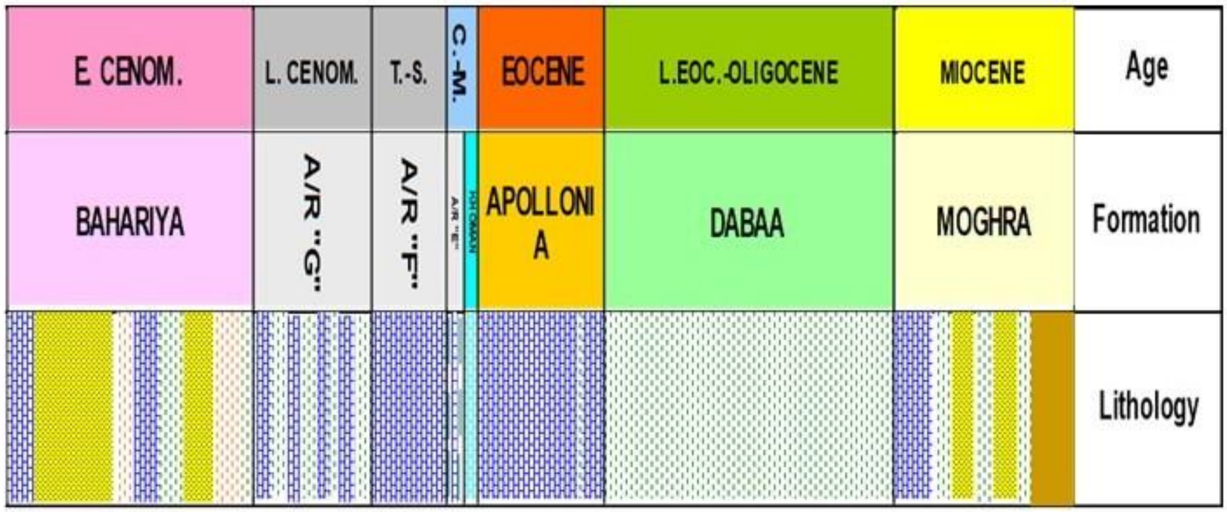

Figure 3. Stratigraphic column for Faras area

4. Case study for drilling well X-1

Faras field includes in more than forty drilled wells and had a blowout event at well X-1 as details:

4.1. Plan summary

Well X-1 is a development and vertical well was planned to drive 20″ conductor to 150 ft and installed diverter. Drilling 17.5″ hole to 500 ft and running 13.375″ casing, Install BOP stack. Drilling 12.25″ hole to 1500 ft and running 9.625″ casing. Drilling 8.5″ hole to 3600 ft (TD) and running 7″ production casing.

4.2. Blow out event

20″ conductor pipe was driven to depth 145 ft (refusal point). N/U 21.25"-2000 psi diverter system and tested the same as per the standard procedure. Drilling 17.5" hole to 511 ft with Mwt 10 ppg of salt-saturated mud, circulation and sweep hole with a high viscous pill, dropped totco bar. Observed well, static okay, calibrate trip tank to fill the hole while tripping and started to pull out of the hole. After pulled out the second stand and started breaking out the same, mudflow came out from the annulus. At once the diverter has been closed and the hydraulic valve opened automatically and mudflow has been diverted to the vent line. The vent line started to flow a huge amount of sand & gas which accumulated around the rig site due to the occasional absence of wind at that time. Suddenly fire started most probably due to a spark resulting from sand friction at the end of the vent line. The fire caught on the sub-base, mast, and mud system. The emergency team was called to the head office and simultaneously to implement the emergency action required. Immediately, contacted all sister companies in the area to send fire trucks and equipment to help fire-fighting. All power has been switched off and the rig crew started to pull back the (diesel tanks, engines, SCR room, koomey unit, storeroom, rig site camp, radio room, and workshop, welding shop, and oxygen cylinder) away from the hazardous area. While the fire period, the Mast fall down in the direction of the mud system, the dog house fall down on the ground and destroyed also mud logger service unit was burnt. As shown in Figures 4 and 5. After two hours the fire started to slow down due to a decrease in gas flow and the fire crew succeed to put -off the fire and continued cooling down around the rig. Observed well for two days the same was static.

4.3. Action is taken to secure well

Cleared location around the rig and hazardous area. Filled up the cellar with compacted formation. Fabricated 13.375" flange and connected with mud cross-wing valve. Fabricated entry guide consisting of a stab-in guide, pump out sub and lifting sub weighting stabilizers, and stabbed into drill collar top connection on the rig floor. Pumped 53 bbl 11 ppg mud, followed by 68 bbl cement through the drill string, got pressure increased to 600 psi and had leaking around stab in the guide, switched to the annulus and pumped 78 bbl cement, had cement level to the surface. Measured gasses around the rig, found it nil; measured cement level inside drill string, found the same at cellar bottom; measured cement level inside the cellar, found it 6 ft from the top of the cellar. Filed cellar with cement. Measured gas around the rig site, gas nil. Observed well, static condition.

Figure 4. Damaged rig due to blowout (flow of gas)

Figure 5. Damaged rig due to blowout (flow of gas)

5. Results and recommendations

Based on the case studies for drilling wells at Faras field and blowout problem, it's clear we have to take into consideration all standard drilling practices and required safety precautions, also an implementation of the program due to unexpected high-pressure gas pocket associated with a huge amount of sand and water.

A shallow seismic survey shall be executed at any new location to determine the potential presence of shallow gas in the following circumstances:

A. For exploration in new areas

B. For a new location in a documented high risk or suspected high-risk area.

Changing the drilling program and the design of the next wells based on the following aspects:

- Hammering 20″ conductor pipe to befit the diverter and secure rig stability from any expected surface losses beneath the rig sub base.
- Install a diverter on the 20" conductor pipe with an automatic hydraulic valve to provide protection by closing the diverter and divert any water or gas flow far from the rig site.
- Perform periodic vent line check and circulate with a maximum flow rate to ensure all vent lines are free from obstructions and no back pressure exerted on shallow formations.
- Change mud program and use relatively high weighted mud while drilling the surface hole up to 12.5 ppg instead of 10 ppg to overcome any expected high shallow formation pressure. As shown in Table 2.

Table 2. Mud data for drilling 17.5″ Hole Section [11]

Mud type	Mud density (ppg)	PV (cP)	YP (lb/100ft^2)
Salt saturated	12.5	ALAP	18 - 20

- Pre-drilling investigation shallow hazard surveys should be run for the proposed location. These should be interpreted with the assistance of professional analysts.
- Shallow hazard surveys and drilling records for other wells in the area should be reviewed. This includes discussions with an operator and drilling contractor personnel knowledgeable about those operations.
- Drill pilot holes no larger than 8.5″ diameter with control the rate of penetration- no more than 100 ft/hr.
- Enlarge 8.5″ pilot hole to 17.5″ hole to +/- 500 ft (inside Moghra formation).
- Clean the hole thoroughly.
- Keep mud weight stable to prevent losses.
- Pump out of the hole while pulling out for a trip.
- Run in a hole with 13.375″ casing to depth +/- 500 ft. This casing aims to cover all shallow gas layers in moghra formation.
- Perform cement job for 13.375″ casing with adding gas control additives to control shallow gases while cement job.
- Observe well while cement job and wait on cement meanwhile monitor well then complete drilling the next two sections 12.25″ x 9.625″ and 8.5″ x 7″ to TD.

If a shallow gas flow while drilling a surface hole and before installing BOP, activate the diverter system immediately by pumping with maximum flow rate to increase ECD & divert out the gas away from the rig.

A diverter system is commonly used during top-hole drilling. A diverter is not designed to shut in or halt the flow, but rather permits routing of the flow away from the rig. The diverter is used to protect the personnel and equipment by diverting the flow of shallow gas and wellbore fluids emanating from the well to a safe distance away from the rig [12]. As shown in Figure 6. Activated diverter by stop drilling (keep pumping) then opens vent line and close diverter.

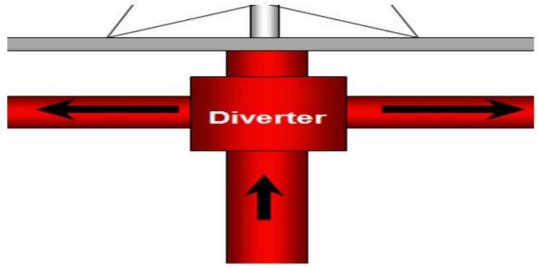

Figure 6. Simulation for diverting shallow gas while gas kick

6. Conclusion

Well control challenges of shallow gas at Faras field are some of the difficult well control situations to handle. Operators and drilling contractors should place a high priority on providing the equipment and procedures to safely deal with potential shallow gas blowouts. The records show that failure to do so can result in loss of lives and major property damage.

Knowing that it can be avoided by better planning, understanding, communications, training, procedures and lastly professional execution are key objectives.

Based on the case studies, utilizing the new drilling procedures at Faras field lead to reduce the non-productive time and cost of drilling wells, this in addition to more safe for personals and equipment.

Nomenclature

Mwt	*Mud wait*	*N/U*	*Nipple Up*
PPG	*Pound per Gallon*	*POH*	*Pull Out Hole*
TD	*Target Depth*	*MW*	*Mud Weight*
BOP	*Blow Out Preventer*	*YP*	*Yield Point*
NPT	*Non Productive Time*	*PV*	*Plastic Viscosity*
SSL	*Subsea Level*	*cP*	*centi Poise*
PSI	*Pound per Square Inch*	*ALAP*	*As Low As Possible*
BOPD	*Barrel Oil per Day*	*ECD*	*Equivalent Circulating Density*

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