DRILLING ACTIVITIES AND PARAMETERS ANALYSIS TO OPTIMIZE STUCK PIPE PREVENTION IN A GEOTHERMAL FIELD

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Keywords: *geothermal, drilling, non-productive time, stuck pipe*

ABSTRACT

Geothermal drilling has been an issue with its high cost taking up to fourty-percent of total field development cost. This high cost can still increase significant amount caused by the long duration of geothermal drilling due to non-productive time. The long duration for non-productive time represents problems encountered in geothermal well drilling. One of the most frequent problems is the stuck pipe, a condition whereby the drill string cannot be pulled or moved. Generally, the stuck pipe is classified into differential sticking and mechanical sticking.

This study is analyzing the occurrence of stuck pipe empirically with qualitative and quantitative analysis. The analysis is done through offset-well data consists of drilling activities and drilling parameters. The drilling activities cover the duration of productive time and non-productive time, including activities before and during the stuck pipe. Meanwhile, the drilling parameters consist of torque, standpipe pressure, rate of penetrations, revolution per minute, pumping rate, well inclination not to mention lithological data from formation evaluation log. The objectives of this study are to determine the wells with stuck pipe occurrence, most troublesome depth intervals, possible type and cause of sticking, parameters cut-off and patterns, and also lithology type with most frequent stuck pipe occurrence. This study also includes the challenges in analyzing the available drilling data of this field. In results, all possible stuck pipe were mechanical sticking and occurring in Andesites-dominated rocks located in high-temperature reservoir zone with no exact drilling parameters cut-off and patterns are found.

1. INTRODUCTION

Drilling cost and also power plant cost are the highest cost in geothermal field development. However, compared to oil/gas drilling which takes up to 25% of the total cost (Khodja, Khodja-Saber, Canselier, Cohaut, & Bergaya, 2010), geothermal drilling can take up to 40% of the total cost (Kipsang, 2015). With its heterogeneous subsurface, geothermal drilling often encounters activities which lead to NPT (Non-Productive Time). One of the geothermal fields even showed-off a number of 70% NPT during drilling (Marbun, Aristya, Pinem, Ramli, & Gadi, 2013). This high number of NPT is the main cause of high drilling cost.

Research and technologies have been developed to tackle these serious problems in geothermal drilling. Stuck pipe is one burdensome issue during drilling, which occurs in 15% of wells (Schlumberger, 1991). The occurrence of the stuck pipe gives direct impact of additional drilling time and drilling cost. A stuck pipe event can result in more than one day (24 – 36 hours) of curring activity until the pipe can be freed (Netwas Group Oil, 2020). To this extent, the more day for freeing the stuck pipe, the more day and cost for renting the whole rig equipment and crews. Otherwise, it can reach up to the time where freeing the stuck pipe is not economic at all compared to sidetracking (Muqeem, Weekse, & Al-Hajji, 2012), an activity where new wellbore path is made away from the original path.

Nonetheless, the factors causing the stuck pipe is varied. Aside from physical parameters such as subsurface condition, mud properties and other drilling parameters, stuck pipe, the same with other drilling hazards, is also believed to be affected by the performance of the drilling crew itself (Hbaieb, Converset, Foster, & Yezid, 2018). In such wise, this study will also conduct the analysis of drilling activities, covering the activities before stuck pipe and also the curring method for stuck pipe itself.

The goal of this study is to analyze the drilling activities before and during stuck pipe which is elaborated with the drilling parameters. The drilling parameters analysis is aiming to look up to for pattern within stuck pipe cases with the same cause and other supporting analysis such as the inclination degree cut-off for troublesome hole. In addition, several challenges during analyzing and processing the available drilling data are also discussed in this study.

2. BASIC THEORY

Stuck pipe is basically the condition whereby the string cannot be moved or rotated due to sticking. Commonly, the occurrence of stuck pipe is categorized into two type, differential sticking and mechanical sticking.

2.1 Differential Sticking

This type of sticking is happening due to the pressure differences between the mud column and the formation pressure. The more the differences, the higher chance of pipe being stuck to the wellbore. The mud cake thickness is also playing role in increasing the differential pressure. In conclusion, the key factor of differential sticking are the contact area between pipe and wellbore and pressure difference between inside the hole (sticking force) and inside the formation (formation force), which are shown in Figure 1.

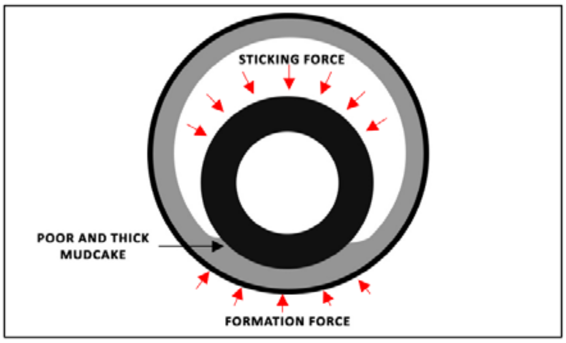

Figure 1. Differential Sticking Illustration (Sugar Land Learning Center, 1999)

There are two factors that may increase the chance of differential sticking, overbalance drilling and deviated hole.

- Overbalance drilling
  It is really common in overbalance drilling to generate poor and thick layer of mud cake especially in porous and permeable formation such as sandstone. The thicker the mud cake, the easier it gets for the string to be in contact with the surface of the mud cake. Yet, a slightly overbalance drilling somehow must be done in term of safety. Therefore, the drilling mud have to be supported with mud properties that produce good layer of cake to reduce the potential of contact. In other words, a thin and low permeability of cake is most desirable during drilling while keep the well under control. In addition, an excessive overbalance drilling can increase the possibility of stuck pipe while extreme underbalance might also increase the possibility of kick or even blow out.

- Deviated hole
  The more deviated the borehole, the tendency of the drill string to lend on one side due to gravitational force will increase as well. This circumstance might produce differential sticking when more contact between drill string and borehole wall happens.

In reality, differential sticking is less likely to happen in geothermal drilling compared to oil/gas drilling due to sandstone formation which have coarse grains with significant porosity and permeability (Talreja, Kumar, Nakhle, Kumar, & Kakrania, 2018) is more susceptible in having differential sticking. Geothermal drilling's formation mostly consists of igneous rock which have varied porosity and permeability. The porosity and permeability within igneous rock are made out of fracture which means that this permeability is less homogeneous compared to sandstone. Hence, this heterogeneous permeability causes the drilling mud and all its content to flow into the formation and cause formation damage rather than being filtered surround the wellbore and generate a thick layer of mud cake. Not to mention, the excessive overbalance drilling in geothermal can still less likely cause differential sticking, which is going to be proven later on with this study.

2.2 Mechanical Sticking

Several references such as Bowes & Procter, 1997, and Warren, 1940, have defined multiple reasons causing the mechanical sticking. To ease this study, the writer has summarized several reasons into three main categories, which are inadequate hole cleaning, formation instability and wellbore geometry. The inadequate hole cleaning and formation instability can also be defined as hole pack-off.

- Inadequate hole cleaning
  Inadequate hole cleaning is a condition where the cuttings produced during drilling cannot be lifted entirely to the surface. Wells in high angle is more likely to result in inadequate hole cleaning whereby the drilling cuttings are forming cutting bed in the low side of the hole. The existence of cutting bed can cause the BHA stuck during pulling. A study has shown that a directional well with 30o angle can increase the mechanical sticking risk (Weakley, 1990)

  One of the early diagnosis to indicate the mechanical sticking is the excessive torque and drag during pulling.

- Formation instability
  As previously mentioned that the geothermal system consists of fractures; these fractures can highly cause mechanical sticking. Naturally, surrounding the fractures or faults, the rocks' shapes are angular and thin with varied bonding between pieces, most likely weak bonding. When the drilling come across this condition, the vibration from BHA will loosen the fractures rocks followed by the collapse into the wellbore. This condition is actively occurring in tectonically active zones which lies within the geothermal system itself.

  The tectonic condition that causes the mechanical sticking is not only in fractures or faults but also in a stressed-formations which is common in geothermal subsurface condition. The tectonic activity has caused the rock to be compressed or stressed. This condition can cause collapse when drilled.

  Another circumstance with high formation instability potential is reactive shale formation. Several shales has high reactivity toward the water which caused swelling when drilling with water-based mud such as montmorillonite, kaolinite and illite. The swelling of this shale or later to be called as 'clay swelling', will cause wellbore instability and tend to collapse over the borehole. This event only occurs in reactive formation (Bowes & Procter, 1997)

- Wellbore geometry
  Sometime during drilling deviated hole, the tendency of the drill string rotation will cause it slightly out of the track and generate another small hole path alongside the main borehole. This small unintentionally hole called as keyseat. The existence of keyseat can cause stuck pipe when the tool joint or BHA accidentally slides into it. However, the occurrence of keyseat has a higher likelihood of sandstone formation compared to the igneous rock formation. Keyseat might happen because by nature, sandstone is more plastic and soft compared to igneous rock. Hence it is easier for the drill string to grind on the sandstone wellbore side.

Another case for wellbore geometry is a tight hole or under gauge hole. This section of the hole is under gauge and cause an obstacle for large diameter drilling tools such as BHA. Tight hole frequently happens in geothermal due to hard abrasive formation that causes the drilling bit or stabilizer to be smaller than its initial size. Reaming is further to be performed when encountering this spot. Sometimes, the existence of under gauge hole can be analyzed after changing the bit and running the new one. Aside from under gauge equipment, a tight hole may also the result of reactive shale swelling into the wellbore. In this case, to indicate tight hole, several parameters are taken into analysis such as formation analysis, wellbore deviation, mud properties and mud weight (Mirhaj, Oteri, & Saelevik, 2013)).

3. METHODOLOGY

The flowchart of this study is shown in Figure 2. This study is conducted in empirical. The empirical methods will be based on the data collection and interpretation. The early step to start this study is to collect as many data as possible thus, the comparison within each well are valid. The collected data consist of two primary data, drilling activities and drilling parameters in support of qualitative and quantitative data, respectively.

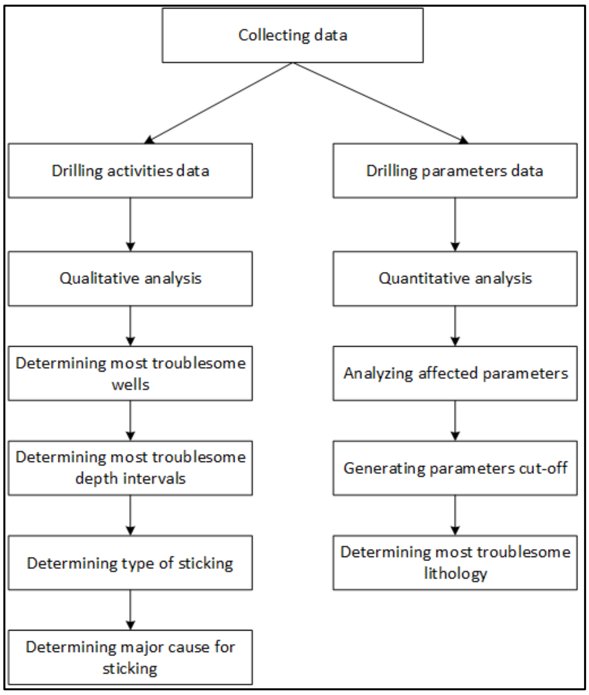

Figure 2. Study Flow Chart

In this study, the drilling activities consist of all drilling activities within the depth and also time. This data helps the analysis of events before stuck pipe with a particular depth. The goals of qualitative study are to analyze the troublesome wells, depth, and activities before the pipe is stuck. It is believed that each of the stuck pipe occurrences has its cause, whether it's an activity or the wellbore condition that might lead to a stuck pipe. Unfortunately, sometimes the causes which lead to the stuck pipe cannot be seen or observed real-time.

On the other hand, the drilling parameters data used as a quantitative analysis contains:

- Well deviation;
- torque;
- drilling rate;
- standpipe pressure;
- pumping rate;
- weight on bit;
- mud weight;
- and lithology from formation evaluation.

During the analysis, each of the drilling parameters needs to be analyzed along with other drilling parameters. In this case, the interpretation of the stuck pipe cause can be more accurate. Correspondingly, the time during drilling activities and parameters acquisition have to be the same to make sure that the drilling parameters presented are in the same event as shown in drilling activities. Simultaneously, the drilling parameters are analyzed to determine the most impactful parameter and also its cut-off. Also, the most troublesome lithology/mineral alteration is then to be identified as well. Once all the goals are achieved, a decision-tree can be constructed for as a guidance for future drilling planning within the same field.

4. CASE STUDY

This study is taking place in Field X in Indonesia. There are eighteen wells have complete drilling activities data. These wells are to be ranked based on their stuck pipe occurrence to identify the most troublesome wells. However, there are only eight wells which have complete drilling parameters data, excluding well deviation. By matching in the available data, there are only four wells to be selected which drilling activities and parameters are to be analyzed as shown in Table 1 with grey-shaded well.

Table 1. List of Wells and Data Availability

#	Name of Well	Data Availability			Stuck Pipe
		Drilling Parameters	Drilling Activities	Formation Evaluation Log	
1	X-02	Yes	Yes	Yes	Yes
2	X-02A	Yes	Yes	Yes	Yes
3	X-03	Yes	Yes	Yes	Yes
4	X-03A		Yes		Yes
5	X-03AST1		Yes		Yes
6	X-03AST2		Yes		No
7	X-03B	Yes	Yes	Yes	No
8	X-04		Yes		Yes
9	X-04ST1	Yes	Yes		Yes
10	X-04ST2		Yes		Yes
11	X-04A		Yes	Yes	Yes
12	X-04AST1		Yes		Yes
13	X-04AST2		Yes		Yes
14	X-04AST3		Yes		Yes
15	X-05	Yes	Yes	Yes	Yes
16	X-05ST1	Yes	Yes	Yes	No
17	X-07	Yes	Yes	Yes	No
18	X-07ST		Yes		No

5. RESULT AND DISCUSSION

5.1 Drilling Activity Analysis

In qualitative analysis, there are four things to be determined:

- Most troublesome well;
- most troublesome depth;
- type of sticking;
- and most frequent cause for the stuck pipe.

Based on Table 2, wells with the highest NPT percentage are X-03AST2, X-04ST2, X-04ST1, X-03AST1, and X-07. However, the high proportion of NPT duration does not necessarily mean the frequent occurrence of stuck pipe. Hence, to specify the result, the ranking based on stuck pipe occurrence is conducted, and the result is well X-04, X-03, X-02A, X-04AST1, and X-04ST1 have five highest percentage for the stuck pipe. Meanwhile well X-03AST2, X-03B, X-05ST1, X-07 and X-07ST have 0% of stuck pipe occurrence as shown in Table 3.

Table 2. Well Ranking Based on NPT Proportion

Well	DT (day)	NPT (day)	NPT %
X-03AST2	17.42	0.88	5.02
X-04ST2	35.44	1.00	2.82
X-04ST1	3.77	0.08	2.21
X-03AST1	7.92	0.10	1.32
X-07	12.06	0.13	1.04
X-04AST1	9.81	0.04	0.43
X-04	29.96	0.10	0.35
X-04AST3	18.33	0.06	0.34
X-04AST2	13.60	0.04	0.31
X-05	30.81	0.08	0.27
X-02	44.65	0.08	0.19
X-04A	36.90	0.04	0.11
X-03B	24.46	0.02	0.09
X-07ST	25.79	0.02	0.08
X-05ST1	27.63	0.02	0.08
X-02A	59.29	0.04	0.07
X-03	38.15	0.02	0.06
X-03A	51.92	0.02	0.04

Table 3. Well Ranking Based on Stuck Pipe Proportion

Well	DT (day)	NPT (day)	STUC
X-04	29.96	0.10	47.25%
X-03	38.15	0.02	39.88%
X-02A	59.29	0.04	20.30%
X-04AST1	9.81	0.04	17.23%
X-04ST1	3.77	0.08	10.81%
X-02	44.65	0.08	9.85%
X-03AST1	7.92	0.10	6.43%
X-05	30.81	0.08	3.36%
X-03A	51.92	0.02	2.90%
X-04ST2	35.44	1.00	1.01%
X-04AST2	13.60	0.04	0.76%
X-04AST3	18.33	0.06	0.62%
X-04A	36.90	0.04	0.37%
X-03AST2	17.42	0.88	0.00%
X-07	12.06	0.13	0.00%
X-07ST	25.79	0.02	0.00%
X-05ST1	27.63	0.02	0.00%
X-03B	24.46	0.02	0.00%

Unfortunately, due to data limitation and availability of both drilling activities and drilling parameters data, as mentioned previously, the final wells to be analyzed are wells X-02A, X-03, X-05, and X-02 with 20.30%, 39.88%, 3.36% and 9.85% of wells' NPT were appeared to be stuck pipe duration in days respectively.

To be specific, the most troublesome depth is analyzed based on the hole size. Bottom hole depth in mMD is shown in Table 4. Based on statistics, the most frequent hole size for NPT is 12 ¼ inches for all wells except X-05 has longest duration for NPT in hole size 17 ½ inch. Nevertheless, the data shows that the longest duration for stuck pipe in all wells occurred in hole size 12 ¼ inch as presented in Figure 3.

Table 4. Bottom Hole Depth per Hole Size

Well Name	Hole Size, inch	Bottom Depth, mMD
X-03	26	298.5
	17.5	848
	12.25	1464
X-02A	26	226.7
	17.5	860
	12.25	1445
	8.5	1760
X-02	26	273
	17.5	860
	12.25	2089
X-05	26	459
	17.5	785
	12.25	1555

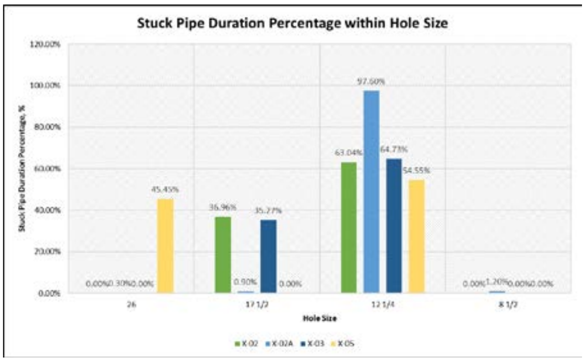

Figure 3. Stuck Pipe Duration Percentage within Hole Size

To begin the analysis, hole size 12 ¼ inch in all wells have top depth at around 800 mMD for all wells. Yet, this cannot be taken into conclusion since the formation in geothermal is quite heterogeneous due to its generation from tectonic activities instead of sedimentation that can generate a homogeneous layer of rock and mineral. Further study of generating a stratigraphic map for subsurface rocks are needed to validate the analogy. By this map, a correlation between wells can be analyzed and perform valid prediction for stuck pipe occurrence.

In support of the qualitative analysis, the possible type of sticking is defined based on the activities report analysis. In result, the possible stuck pipe type is mechanical sticking. This supports the idea of differential sticking less likelihood in the geothermal field, as mentioned in basic theory.

To narrow the results of the study, the causes for mechanical sticking in Field X have been classified into partial loss, equipment failure, hole pack-off, and tight hole. However, partial loss and equipment failure might lead to hole pack-off as well because of hydrostatic pressure reduction inside the wellbore. In addition, when partial loss and equipment failure happens, the pump is turned off in order for further reparation, changing equipment, changing the drilling fluid or circulating LCM in order to stop drilling mud losses. Once no circulation condition is done, the cuttings will fall into downhole, blocking the movement of downhole equipment or even forming cutting beds in the low side of the deviated hole which traps the BHA to be stuck later on. The possible stuck pipe causes are presented in Figure 4. Even if the sum of partial loss and equipment failure might also lead to hole pack-off, the possible most frequent causes for Field X mechanical sticking is tight hole.

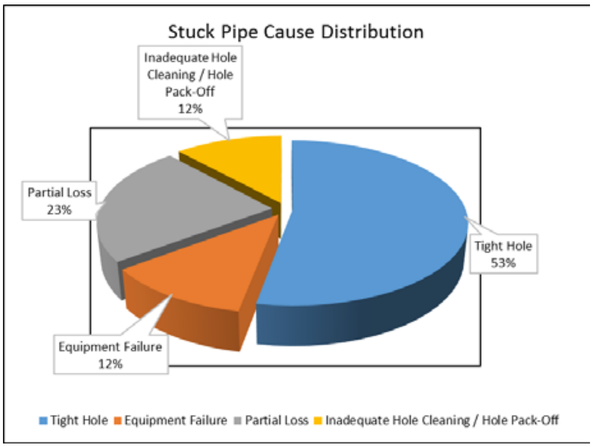

Figure 4. Stuck Pipe Causes Distribution

With the early explanation of tight hole in basic theory, the hypothesis of running a new bit is the indication of mechanical sticking due to under gauge bit. The hypothesis is analyzed through the bit changing record. The encounter of a tight hole in report and running new bit is labelled with grey shadow rows. This might occurs due to former bit worn-out. The idea is supported by the fact that igneous rock has more abrasiveness compared to the sandstone or other sedimented rock, causing drill bit used in geothermal well drilling easily worn-out. However there are only two bits' dull grades that indicate the bit worn out.

On the other hand, different cases analyzed within well X-05 where running new bit did not seem to encounter under gauge hole. As stated in the basic theory, further analysis of the formation have to be made. The early analysis of swelling shale is put into a hypothesis which is going to be elaborated later in the quantitative analysis along with the other drilling parameters to indicate any overpull for the suspected intervals.

5.2 Drilling Parameters and Lithology Analysis

Since there are no exact parameters boundaries that represent the stuck pipe occurrence of all geothermal field, drilling logs for well X-02A and X-03 were generated consisting torque, RPM, WOB, ROP, SPP and GPM. In addition to the analysis, the deviational survey results are also analyzed to determine the boundary of mechanical sticking in a deviated hole.

Unfortunately, Figure 5 shows that there is no exact pattern that indicates the stuck pipe occurrence within X-02A even though it has the same cause of stuck pipe. As mentioned earlier, the wellbore's inclination is also analyzed to find the characteristics of troublesome intervals in X-02A. To begin the analysis, acknowledge that the most troublesome depths within X-02A was starting at the intervals of 728 – 1137 mMD. Nevertheless, the 728 – 749 mMD stuck pipe occurred due to tight hole which indicates bit wear because of rock abrasiveness and is confirmed by the bit dull grading. Yet from intervals 936 – 1137 mMD, the mechanical sticking is believed to happen because of the frequent hole pack-off. The early hypothesis of deviated hole existence might cause the formation of cutting bed and led to mechanical sticking. From the formation evaluation log, it can be seen that depth 717 mMD have an inclination angle of 21.6^o, depth 746 mMD inclined by 23.1^o, depth 767 mMD deviated by 26.4^o and 797 mMD, the deviational survey resulted in 31.2^o inclination angle. Since the hole pack off is started at 936 mMD, it is concluded that inclination angle more than 31.2^o frequently causing mechanical sticking due to hole pack-off.

Meanwhile, for well X-03, within the RPM and torque section, there is a repetitive pattern of RPM decrease and torque increase. This might happen due to overpulling during stuck pipe but does not indicate any early pattern before the stuck pipe occurs, as shown in Figure 6. The same analysis of well X-02A is done for well X-03, deviational survey analysis. In result, different with well X-02A, well X-03 only have a maximum inclination of 5^o, which means that the cutting bed formation on the low side of wellbore might not happen in well X-03.

From lithology analysis in well X-02A, depth interval of 612 – 1194 mMD are dominated with andesites-basalt. This interval is different compared to the other intervals that are not interbedded with basalts. Also, put in notes that these intervals contains silica alteration and appears to be the reservoir zone with the existence of epidote at depth 684 mMD. There are three analysis made for the lithological description. First, the most frequent mechanical sticking in well X-02A occurred after reaching out reservoir zone. Second, Pinet, 1992, shows that based from its igneous rock classification, basalt rocks have higher density compared to andesites rock which means that andesites-basalt rocks are denser compared to andesites or dacites in upper intervals. The density is assumed to be ranging from 2.8 – 3.2 g/cc which implies that the denser the rock, the less intergranular porosity appears. In conclusion, the porosity from the reservoir is made of fractures which are commonly found in the geothermal reservoir itself. The increased amount of fractures in the reservoir zone adds up the probability of hole

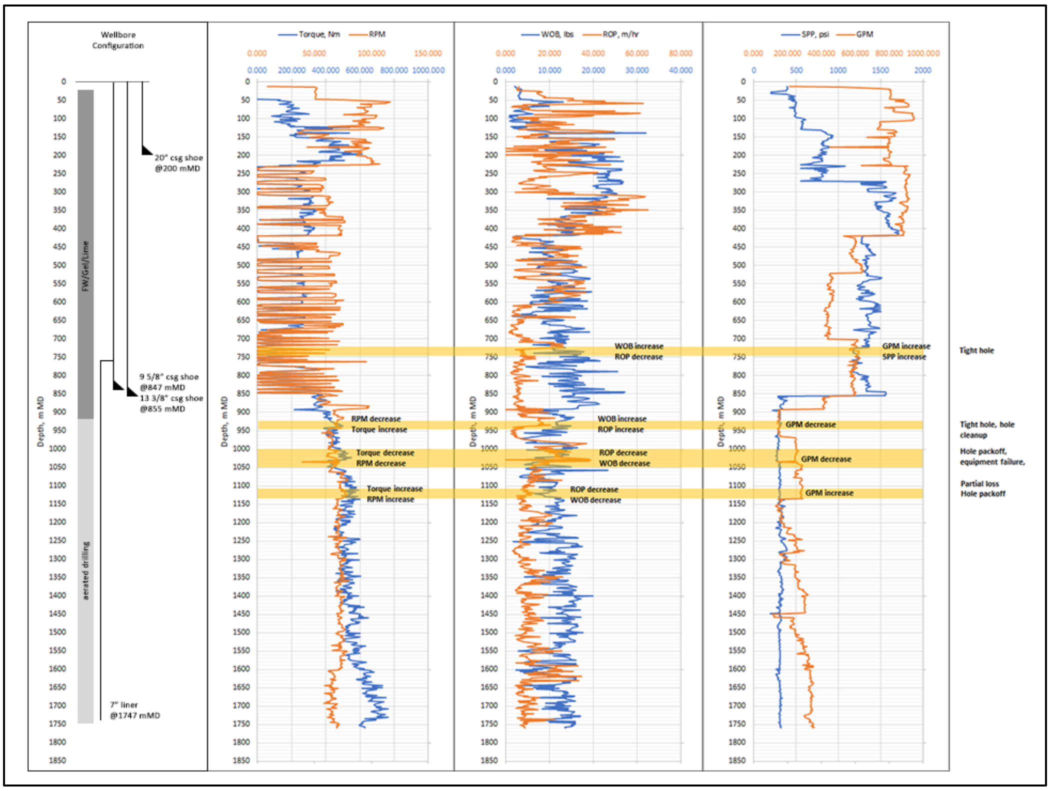

Figure 6. Wellbore Configuration and Drilling Parameters Log for X-02A

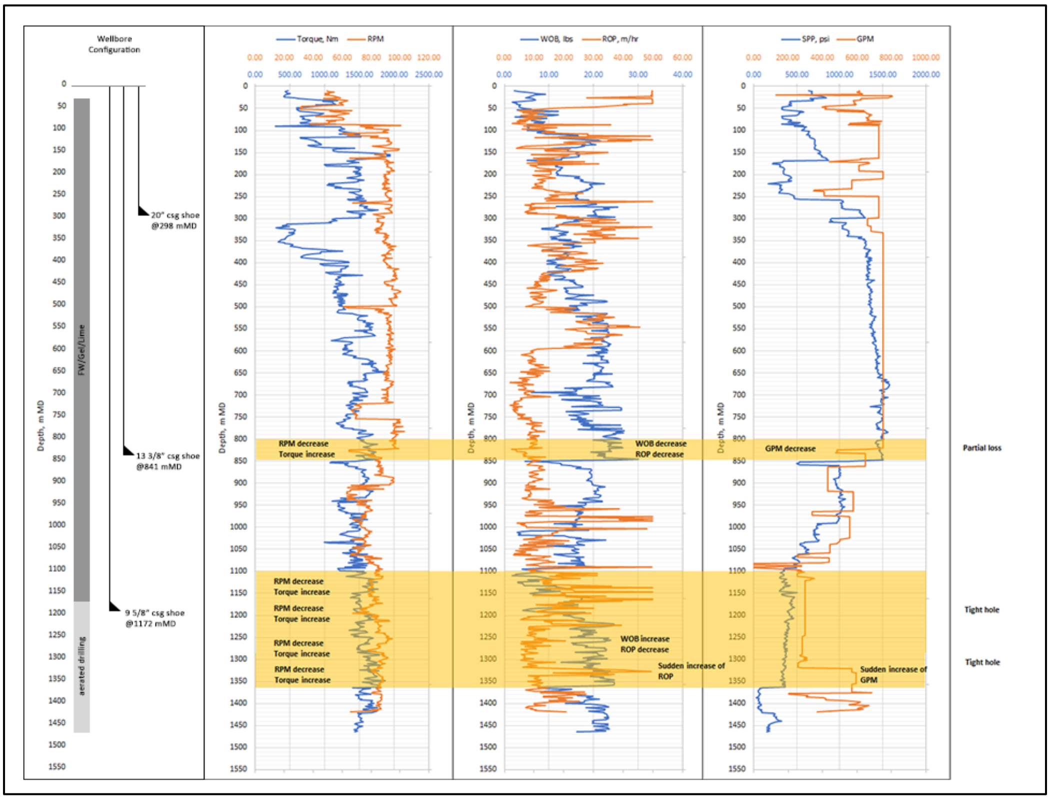

Figure 5. Wellbore Configuration and Drilling Parameters Log for X-03

pack-off events, leading to mechanical sticking as explained in basic theory. Third, silica as hydrothermal mineral within the andesites-basalt rocks increase the rock abrasiveness accelerates the bit wear rate. Within the 612 – 1194 mMD intervals, the silica content could reach up to 50%, describing the formation as medium-hard – hard lithology. This appears to be the reason for bit worn-out used to drill the intervals.

Another lithological analysis is done for interval 1100 – 1363 mMD in well X-03 which had stuck pipe caused by a tight hole. It is found that the andesites-dominated rocks lie within interval 1100 – 1363 mMD but does not have any basalt rocks like well X-02A. However, these intervals are to be found as reservoir zone as same as well X-02A which is indicated by the continuous epidote appearance and propylitic alteration. This alteration with epidote appearance indicates high temperature that ranges from 200 – 280 ^oC (Reyes & Hutt, 2000). As the stuck pipe in well X-03 was also happening while running a new bit, the effect of high temperature is later on believed to cause tool wear acceleration such as drill bit which becomes the reason of tight hole occurrence. This conclusion is also be taken into account for well X-02A which have frequent tight holes in propylitic alteration zone. Linking back to the drilling activities analysis where most common stuck pipe occurred from depth 800 mMD, it is also found that epidotes were continuously found from depth 812 mMD. In the end, it can be concluded that mechanical sticking occurrence in well X-02A and well X-03 is more likely to appear after reaching out the high-temperature reservoir zone. Similar to well X-02A and X-03, well X-02 and X-05 are also showing most stuck pipe occurrence in andesites-dominated rock with continuous occurrence of epidotes. Based from the conceptual model of Field X in Figure 7, it is also confirmed that majority of stuck pipe events in well X-02A, X-03 and X-05 were occurring in the reservoir zone.

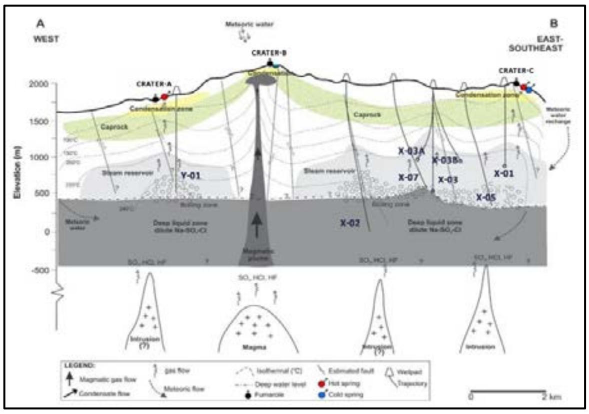

Figure 7. Field X Conceptual Model (Ashat, Pratama, & Itoi, 2018)

6. CONCLUSION

Numerous conclusions are made to summarize the study of stuck pipe occurrence in Field X. Those are:

1. The most troublesome wells for Field X are X-04, X-03, X-02A, X-04AST1, and X-04ST1. It is assumed nearby wells to be drilled may have frequent stuck pipe occurrence as well.
2. Based on stuck pipe occurrence analysis within depth, the most frequent stuck pipe occurred after reaching the average depth of 800 mMD.
3. The possible type of sticking in well X-02A, X-02, X-03, and X-05 are mechanical sticking. This takes the idea of differential sticking is less likely to occur in geothermal drilling into validation.
4. Based from the drilling activities report analysis, 53% of the mechanical sticking are caused by the tight hole which is suspected to be the results of poor hole cleaning or undergauge hole. It is assumed that after depth 800 mMD, the formation impose a high level of hardness and abrasiveness. Hence bit quality control has to be frequently performed in order to prevent a tight hole.
5. No drilling parameters pattern and cut-off are found in well X-03 and X-02A, however, the boundary of >31.2^o inclination angle indicates high probability of hole pack off in deviated hole represented by well X-02A.
6. Most frequent mechanical sticking occurred within the reservoir zone which porosity is made of fractures. This leads to hole pack-off to occur easily once the interval is drilled. The abrasiveness of andesites-dominated rock with incremental of silica content as its hydrothermal mineral and combined with high temperature indicated by propylitic alteration and epidote appearance might accelerate the bit dullness.

NOMENCLATURE

BHA	=	Bottom Hole Assembly
SPP	=	Stand Pipe Pressure
WOB	=	Weight on Bit
GPM	=	Gallons per Minute
MW	=	Mud Weight
NPT	=	Non-Productive Time
STUC	=	Stuck Pipe
REAM	=	Reaming
SFAL	=	Surface Equipment Failure
KILL	=	Killing Well
WAIT	=	Waiting
FLUD	=	Drilling Fluid Equipment Failure
RREP	=	Rig Repair
LOST	=	Lost Circulation
DFAL	=	Downhole Equipment Failure
JAR	=	Jar
MILL	=	Milling
ST	=	Sidetracking
mMD	=	Meter Measured Depth

ACKNOWLEDGEMENTS

The acknowledgement are addressed to parties who have been involved, supporting, and guiding through out the research such as:

- Zuher Syihab, S.T., Ph.D., as the head of petroleum engineering study program in Bandung Institute of Technology.
- Dimas Taha Maulana, S.T., M.T., as the author's study adviser and lecturer who have been guiding and motivating this study.
- Dorman Purba and Daniel Aditya Wilhelmus from PT Rigsis Energi Indonesia who have been intensively supporting and guiding this study.
- All lecturers in Bandung Institute of Technology especially within petroleum engineering major who have been sharing and teaching knowledges.
- Advarel Prayoga, Farhan Muhammad, Ribka Asokawaty, Dicky Alamsyah, Riviani Kusumawardani and all employees from PT Rigsis Energi Indonesia at the time who have been guiding the author throughout the study.
- Agung Mukti and Supriadinata Mirza from PT Geo Dipa Energi who have been providing the field data.

- and the other parties who cannot be mentioned one by one.

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