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Real-Time Evaluation of Potential Permeability Zone During Drilling Operations in a High-Enthalpy Geothermal Reservoir: A Case from Geothermal Fields in Sumatra Indonesia

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ABSTRACT

Permeability is a critical parameter for geothermal reservoir productivity. Real-time identification of potential permeable zones during drilling is essential. This study explores the use of drilling data to assess potential permeable zones in real time and compares the indications with permeable zones determined from the completion tests. The analysis utilizes well data from two geothermal fields in Sumatra. The drilling data used to identify the potential permeability includes drilling breaks characterized by sudden increase in the rate of penetration (ROP) associated with decreasing weight on bit (WOB), and dropping of standpipe pressure (SPP). Results of the completion test show that several feed zones are consistent with the observed drilling breaks, often within intervals containing multiple breaks. Based on drilling parameters analyzes, SPP is found to be the most influential indicator of drilling breaks. Significant drilling breaks, especially those with substantial SPP drops (>100 psi), tend to coincide with the major feed zones which correspond to washouts and shattered lithology, suggesting hole intersection with faults or dyke intrusion contacts. Overall, drilling break analysis provides a valuable real-time indicator for identifying permeable zones during drilling operation.

1 INTRODUCTION

Sumatra is an island in Indonesia where the current geological structure is mainly controlled by the northwest-trending Great Sumatra Fault (GSF) (Figure 1). This segmented, right-lateral strike-slip fault accommodates the oblique subduction of the Indo-Australian Plate. Many active volcanoes in the Barisan Mountain Range have formed above the subduction zone and host around 30 high-temperature geothermal resources (Hochstein and Sudarman, 1993). Among these, Supreme Energy is developing two Sumatran geothermal resources, namely Rantau Dedap and Muara Laboh (Figure 1).

Among the various properties of geothermal reservoir, permeability is one of the critical targets in geothermal development (Saitet and Rop, 2015), alongside with high-temperature zones, as it directly influences the likelihood of establishing productive wells. However, identifying and characterizing the permeability within the reservoir remains significant challenge during drilling of geothermal wells. In geothermal environment, reservoir permeability is controlled by structure geology, particularly fault zone and lithology.

The quantitative interpretation of permeable zone is commonly measured by Pressure-Temperature-Spinner (PTS) injection testing during the well completion test conducted when the well reaches the total depth (Hole, 2008). However, due to the reservoir interval in the geothermal system includes ubiquitous fracture networks, so if borehole penetrates high-intensity fractures interval it will generate anomaly trend, suggesting that permeable zone can be predicted during drilling (Al Amin et al., 2023). The real-time assessment using drilling parameters during drilling operation provides clues that the well is encountering potential permeable zones. Analyzing real-time drilling parameters can offer early insight into the location of potential feed zones before completion test is conducted. This study explores how drilling data can be utilized for real-time potential permeability assessment during drilling and to evaluate its alignment with the feed zone locations identified during the completion tests.

2 DATA AND METHODOLOGY

The analysis in this study is based on well data obtained from two high-enthalpy geothermal fields located in Sumatra, namely the Rantau Dedap and Muara Laboh geothermal fields. The study uses drilling parameters data from multiple wells including rate of penetration (ROP), weight on bit (WOB), standpipe pressure (SPP), recorded mud losses, in/out mud temperature, and temperature from MWD. The assessment specifically focuses on

identifying drilling breaks, which are defined by sudden increase in ROP, accompanied by decreasing in WOB and SPP. These indicators are systematically evaluated throughout the wellbore section

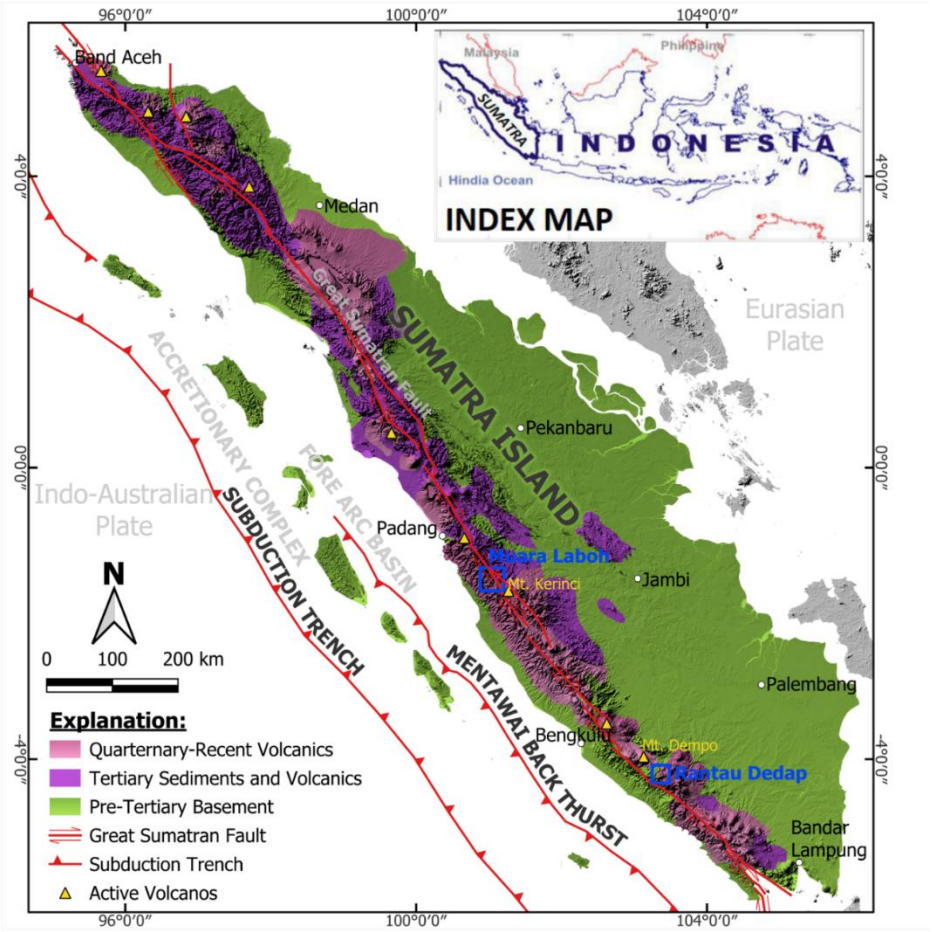


Figure 1. Sumatra Island and its regional tectonic setting map (Modified from Barber et al., 2005). Rantau Dedap and Muara Laboh (blue box) located along the Barisan Mountain Range and Great Sumatran Fault.

to identify potential permeable intervals encountered during drilling. For this study, a drilling break is considered valid when data anomaly from at least two of the drilling parameters above (ROP, WOB and SPP) occurred concurrently. Furthermore, the anomalies are only classified as drilling breaks when they occurred under rotary drilling conditions. The reliability of drilling breaks as permeability indicator is systematically compared with feed zone locations identified from the completion test.

The completion tests are designed to identify potential feed zone locations in the well, to determine the properties of reservoir such as temperature and pressure, and to provide an estimate of the total effective permeability (Hole, 2008). The series of tests as illustrated in Figure 2 include Pressure-Temperature-Spinner (PTS) injection surveys to locate feed zones, Multiple-Rate Injectivity Tests to evaluate injectivity index, and Fall-Off Tests (FOT) to assess formation permeability and pressure behavior (Humaedi et al., 2016).

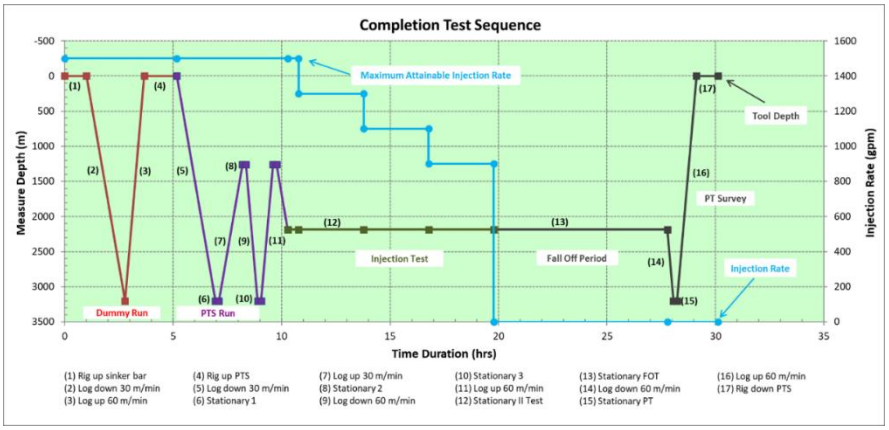


Figure 2. General Well Completion Test Sequence diagram show the series of the tests that conducted during well completion.

3 RESULT AND DISCUSSION

3.1 Result

3.1.1 Rantau Dedap

Drilling of geothermal production wells in the Rantau Dedap field primarily targets permeability associated with N–S and NE–SW trending geological structures, lithological contacts, and primary permeability within the debris flow deposit. Drilling break analysis has been conducted during drilling operations to identify the potential locations of feed zones in each well as presented in the Table 1 below. The drilling break analysis presented here focuses on the reservoir section, where drilling conditions are mostly characterized by total lost circulation. The interpreted drilling breaks are compared with the feed zones identified from well completion tests (Table 2).

Table 1. Summary of drilling breaks identified in Rantau Dedap production wells. Red boxes indicate drilling breaks that coincide with feed zones, blue boxes represent feed zones occurring 10–30 m after a drilling break, and purple boxes denote feed zones occurring 10–30 m before a drilling break.

Well ID	Depth	Drilling Parameter			Loss Circulation
		ΔRoP (m/hrs)	ΔWoB (Lb)	ΔSPP (psi)	
Well-1	1333	7	3	85	TLC
	1422	4.6	4	60	TLC
	1489	3	5	200	TLC
	1912	9	8	34	TLC
	2129	3	9	12	TLC
	2222	10	11	78	TLC
	2304.5	9	8	13	TLC
	2518	12	18	58	TLC
	2537.5	5	1	9	TLC
	2557.5	6	1	0	TLC
	2564	7	16	0	TLC
	2579	12	1	0	TLC
	2618	2	8	0	TLC
	2674.5	7	8	16	TLC
Well-2	1630	10	6.6	100	TLC
	1640	8	3	100	TLC
	1690	17	13	20	TLC
	1710	30	0	0	TLC
	1865	17	9	30	TLC
	1923	1	0	0	TLC
	1947	6	0	0	TLC
	1968	13	8	0	TLC
	1977	35	10	318	TLC
	2013	6	5	0	TLC
	2023	7	6	0	TLC
	2050	7	8	0	TLC
	2078	11.2	8	0	TLC
	2098	13	2	50	TLC
	2113	21	22	100	TLC
	2143	3.2	24	150	TLC
	2165	5	20	125	TLC
	2208	6.3	45	200	TLC
Well-3	1438	4	31	650	TLC
	2481	5	18	0	TLC
	2508	7	11	0	TLC
	2527	10	35	0	TLC
	2563.5	3	28	20	TLC

Well ID	Depth	Drilling Parameter			Loss Circulation
		ΔRoP (m/hrs)	ΔWoB (Lb)	ΔSPP (psi)	
Well-4	1453.5	11.3	15	70	PLC
	1470.5	6	23	99	PLC
	1476.3	15	13	59	PLC
	1655	3	22	Hivis	TLC
	1758	1	36	88	TLC
	1776.3	3	37	138	TLC
	1784.2	5	26	0	TLC
	1804.2	29	31	160	TLC
	1808.9	11.5	31	Hivis	TLC
	1813.3	12.5	19	50	TLC
	1825.6	0	10	38	TLC
	1842.4	2	14	28	TLC
	1848.7	0	18	44	TLC
	1861.1	0	35	105	TLC
	1899.5	2	24.6	25	TLC
	1934.7	4	18	Hivis	TLC
Well-5	1388	3	3	82	TLC
	1667.2	6.2	24	54	TLC
	1859.5	4	5	145	TLC
	2495.7	4.2	18	Hivis	TLC
Well-6	1459	12	8	0	TLC
	1540	7	5	0	TLC
	1615	5	0	20	TLC
	1706	5	3	30	TLC
	1789	12	3	0	TLC
	1830	4	10	0	TLC
	2408	8	9	130	TLC
Well-7	1659.5	18	0	50	Full return
	1734	8	7	200	Full return
	1743	20	10	50	Full return
	1752	18	2	80	Full return
	1988	18	0	9	Full return
Well-8	2309	26	6	0	TLC
	1812	10	3	533	TLC
	2106	10	16	310	TLC
	2237.5	8	15	0	TLC
	2267.5	17	12	0	TLC

Well ID	Depth	Drilling Parameter			Loss Circulation
		ΔRoP (m/hrs)	ΔWoB (Lb)	ΔSPP (psi)	
Well-8	2355.5	19	4	0	TLC
	2361	9	6	0	TLC
	2385	8	8	0	TLC
	2408.5	8	10	0	TLC
	2410.5	7	12	13	TLC
	2412	6	14	0	TLC
	2415	5	17	0	TLC
	2438	8	10	7	TLC
	2442.5	6	15	0	TLC
	2446.5	7	7	15	TLC
Well-9	1938.4	6.2	30	41	TLC
	1965.9	8	29.6	35	TLC
	2044.6	12	20	50	TLC
	2105.3	2	25	46	TLC
	2115.5	3	31.6	28	TLC
	2121.9	4.9	31.7	hivis	TLC
	2133.6	1.4	28.2	33	TLC
	2192.8	6	15	36	TLC
	2230.7	2	23	50	TLC
	2275.3	6.4	29.4	33	TLC
	2304.8	4.4	31.7	28	TLC
	2310.3	3.9	39.7	hivis	TLC
	2317.8	1.5	27.8	hivis	TLC
	2324.6	2.3	38.8	22	TLC
	2337	2.3	36.6	37	TLC
	2345.2	4.6	34	14	TLC
Well-10	1102	12	6	160	Full Return
	1933	2	4	0	TLC
	2010	15	9	Hivis	TLC
	2086.5	10	6	0	TLC
	2210	10	6	0	TLC
	2278.5	7	13	0	TLC
	2467	19	6	0	TLC
	2470.5	18	13	0	TLC

Table 2. Summary of feed zone locations in Rantau Dedap production wells. Red boxes indicate drilling breaks that coincide with feed zones, blue boxes represent feed zones occurring 10–30 m after a drilling break, and purple boxes denote feed zones occurring 10–30 m before a drilling break.

Well ID	Depth (mMD)	Contribution (%)
Well-1	1309	3
	1609	34
	1809	23
	2129	1
	2629	3
Well-2	1587	5
	1729	2
	1980	73
	2097	17
	2198	3
Well-3	1419	Inflow
	1699	Inflow
	1839	13
	2009	85
	2559	2

Well ID	Depth (mMD)	Contribution (%)
Well-4	1409	1
	1643	1
	1782	4
	1849	5
	2169	87
	2299	7
Well-5	1364	60
	1529	10
	1699	21
	1809	5
	2109	4
	2509	1
Well-6	1589	4
	1629	18
	1809	43
	1849	9
	2389	27

Well ID	Depth (mMD)	Contribution (%)
Well-7	2059	13
	2309	86
	2649	1
Well-8	1809	29
	1909	4
	2059	7
	2149	3
	2339	51
	2429	6
Well-9	2109	50
	2209	25
	2284	25
Well-10	1859	21
	1909	13
	2059	22
	2159	25
	2309	2

The analysis in Rantau Dedap field shows that drilling break parameters vary significantly between wells. In general, the ΔROP for drilling breaks ranges from 1 to 40 m/hrs, although in some cases drilling breaks occur without any notable change in ROP. The ΔWOB ranges from 2 to 40 Lb although in several events they are not associated with actual WOB drop. The ΔSPP appears to be the most important parameter for validating drilling breaks, as SPP decrease indicates fluid losses into permeable formations. ΔSPP values also vary widely, ranging from 0 up to 318 psi. It should be noted that in several cases, SPP anomalies cannot be identified especially when high-viscosity mud is used during drilling.

Drilling breaks that coincide with feed zones generally display anomalies in all three drilling parameters (Table 1) with ΔROP values ranging from 2 and 9 m/hrs, ΔWOB between 9 and 32 Lb, and ΔSPP between 0 and 318 psi. In several cases, multiple drilling breaks are observed within a relatively short interval, and subsequently, a feed zone is identified within or between these breaks. For instance, there is a well showing a strong correlation between drilling breaks and feed zone locations (Figure 3). Out of the three feed zones identified in this well, two exhibits direct relationship with drilling breaks but the most significant feed zone, located at a depth of 2109 mMD, is located within the interval of multiple drilling breaks.

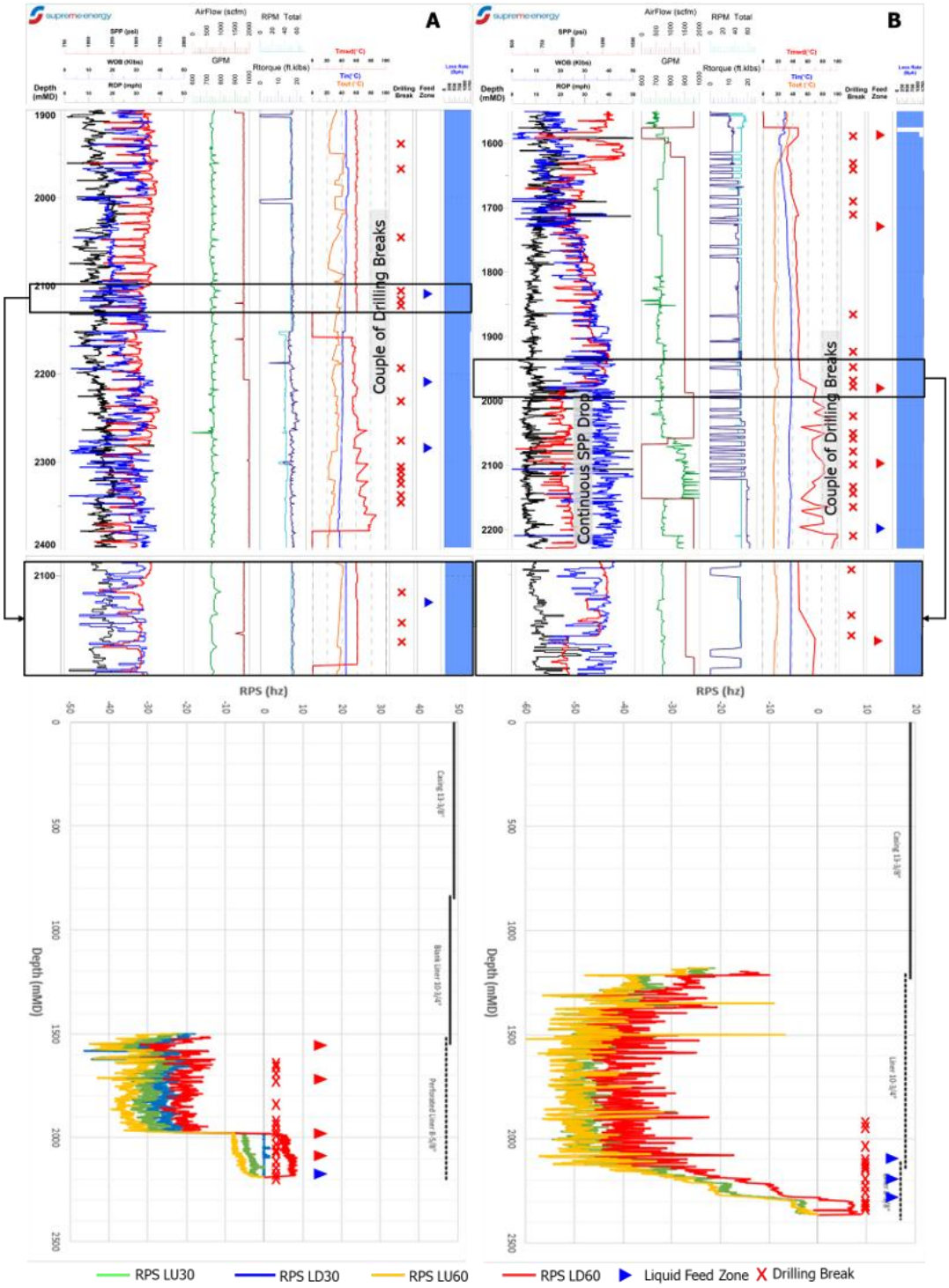


Figure 3. Drilling parameter and spinner logs show, (A) the most significant feed zone in the well lies within an interval multiple drilling break. In contrast, (B) the largest feed zone is marked by significant break, followed by a continuous SPP decrease as drilling progressed.

Another well shows strong correlation between drilling breaks and feed zones, with at least four out of five feed zones are associated with drilling breaks (Figure 3). The drilling break identified at 1977 mMD coincides with the largest feed zone of the well. The break is characterized by significant increase in ROP (35 m/hrs) and a sharp decline in SPP (381 psi), followed by a continuous SPP decrease during drilling progression. Additionally, this drilling break is accompanied by a 20°C temperature increase during drilling.

Several wells encounter drilling breaks but none of them are correlated with the feed zone locations. They are mainly characterized by only decrease in WOB and an increase in ROP, without SPP drop (Table 1 and Table 2).

3.1.2 Muara Laboh

The development wells drilling in the Muara Laboh geothermal field primarily targeted NW–SE and NE–SW oriented geological structures as well as fractured-permeable intrusive bodies. Similar to the Rantau Dedap field, drilling break analysis has been conducted during drilling operations to monitor the position of faults target and to provide indications regarding potential feed zone encountered in real time. The analysis presented here focuses on the reservoir section. In contrast to the Rantau Dedap field, where drilling breaks in the reservoir section are mostly associated with total loss circulation, many of the wells in the Muara Laboh field exhibits drilling breaks under partial loss conditions. The results of the drilling break analysis for the Muara Laboh wells are summarized in Table 3 which shows that feed zone locations identified from well completion tests (Table 4) are generally correlated with the observed drilling breaks during drilling.

Table 3. Summary of drilling breaks identified in Muara Laboh production wells. Red boxes indicate drilling breaks that coincide with feed zones, blue boxes represent feed zones occurring 10–30 m after a drilling break, and purple boxes denote feed zones occurring 10–30 m before a drilling break.

Well ID	Depth	Drilling Parameter			Loss Circulation
		ΔRoP (m/hrs)	ΔWoB (Lb)	ΔSPP (psi)	
Well-11	816	7.4	15.6	0	TLC
	891	31.5	6	0	TLC
	961	8	2	0	TLC
	1091	10	1	10	TLC
	1110.5	20	9	20	TLC
	1124	7	8	0	TLC
	1142	8	6	10	TLC
	1155.5	4	5	0	TLC
	1186	13	6	5	TLC
	1200	16	2	0	TLC
	1273	12	0	0	TLC
	1313	9	12	0	TLC
	1316	8	4	0	TLC
	1403	9	2	0	TLC
Well-12	704	20	8	140	PLC
	761	12	4	410	TLC
	820	14	3	50	TLC
	839	18	3	60	TLC
	842	13	6	300	TLC
	851	14	6	0	TLC

Well ID	Depth	Drilling Parameter			Loss Circulation
		ΔRoP (m/hrs)	ΔWoB (Lb)	ΔSPP (psi)	
Well-12	875	6	5	10	TLC
	902.5	5	0	80	TLC
	904.5	3	1	95	TLC
	925.5	7	1	59	TLC
	958	10	6	65	TLC
	975.5	2	5	20	TLC
	1099	16	8	78	TLC
	1105.5	20	4	37	TLC
	1107	5	6	63	TLC
	1173.5	12	1	0	TLC
	1231.5	6	0	90	TLC
	1243	15	1	150	TLC
Well-13	2803.5	15	10	250	TLC
	2830	7	5	60	TLC
Well-14	1699.5	16	3	16	PLC
	1812.5	12	5	20	TLC
Well-15	2553	5	2	0	PLC
	2564	8	0	30	PLC

Well ID	Depth	Drilling Parameter			Loss Circulation
		ΔRoP (m/hrs)	ΔWoB (Lb)	ΔSPP (psi)	
Well-16	2246	12	0	0	PLC
	2287	9	2	20	PLC
	2386.5	10	4	72	PLC
	2461.5	3	10	200	PLC
	2499.5	20	3	0	TLC
	2566	4	2	60	TLC
	2570	15	0	50	TLC
	2619.5	12	7	18	TLC
	2733	16	2	0	TLC
	2743	9	3	300	TLC
	2746	10	8	30	TLC
	2757.5	6	2	10	TLC
Well-17	2462	11.1	7.7	61	PLC
	3049	12	11.3	554	TLC
	3076	7	7.6	70	TLC
	3090	3	9.8	0	TLC
Well-18	2385	6	0	150	PLC
	2575	10	2	280	PLC
	2596	9	8	100	PLC

Table 4. Summary of feed zone locations in Muara Laboh production wells. Red boxes indicate drilling breaks that coincide with feed zones, blue boxes represent feed zones occurring 10–30 m after a drilling break, and purple boxes denote feed zones occurring 10–30 m before a drilling break.

Well ID	Depth (mMD)	Contribution (%)
Well-11	819	Inflow
	879	6
	909	10
	969	19
	1009	10
	1059	26
	1089	17
	1109	12
Well-12	709	Inflow
	789	Inflow
	829	14
	849	51
	909	15
	919	17
	1199	3
Well-13	1429	5
	1483	12
	1619	31

Well ID	Depth (mMD)	Contribution (%)
Well-13	1729	10
	1799	19
	1819	24
Well-14	1989	Inflow
	2299	4
	2549	Inflow
	2709	Inflow
	2809	94
	2989	2
Well-15	1489	27
	2052	19
	2209	24
	2309	4
	2409	3
	2459	4
	2509	1
	2559	18

Well ID	Depth (mMD)	Contribution (%)
Well-16	2489	9
	2559	4
	2599	13
	2659	19
	2749	8
	2789	47
Well-17	2459	2
	2949	3
	3049	88
	3081	7
Well-18	2209	8
	2389	15
	2569	3
	2659	3
	2759	73

Similar to the Rantau Dedap field, drilling breaks in the Muara Laboh field also exhibit variable parameters anomalies across different wells. In general, drilling parameter anomalies associated with drilling breaks in Muara Laboh show ΔROP ranging from 0 to 32 m/hrs, ΔWOB from 0 to 16 Lb, and ΔSPP between 0 and 560 psi. Almost all drilling breaks are characterized by an increase in ROP, with only three instances where drilling breaks occur without a corresponding ROP increase. All wells in this field showed at least some degree of correlation between feed zone locations and drilling breaks. This contrasts with the Rantau Dedap field, where at least two wells showed no correlation at all between drilling breaks and feed zone locations.

For example, some wells show only two closely spaced drilling breaks, which correlated strongly with the well's largest feed zone (Figure 4). The drilling parameter anomalies associated with these breaks include ΔROP values of 7 and 15 m/hrs, ΔWOB values of 5 and 10 Lb, and ΔSPP values of 60 and 250 psi. The drilling break with the most significant ΔSPP drop (250 psi) occurs exactly at the major feed zone depth. This drilling break is also

associated with a sharp temperature spike recorded by the MWD tool, followed by a sustained temperature increase.

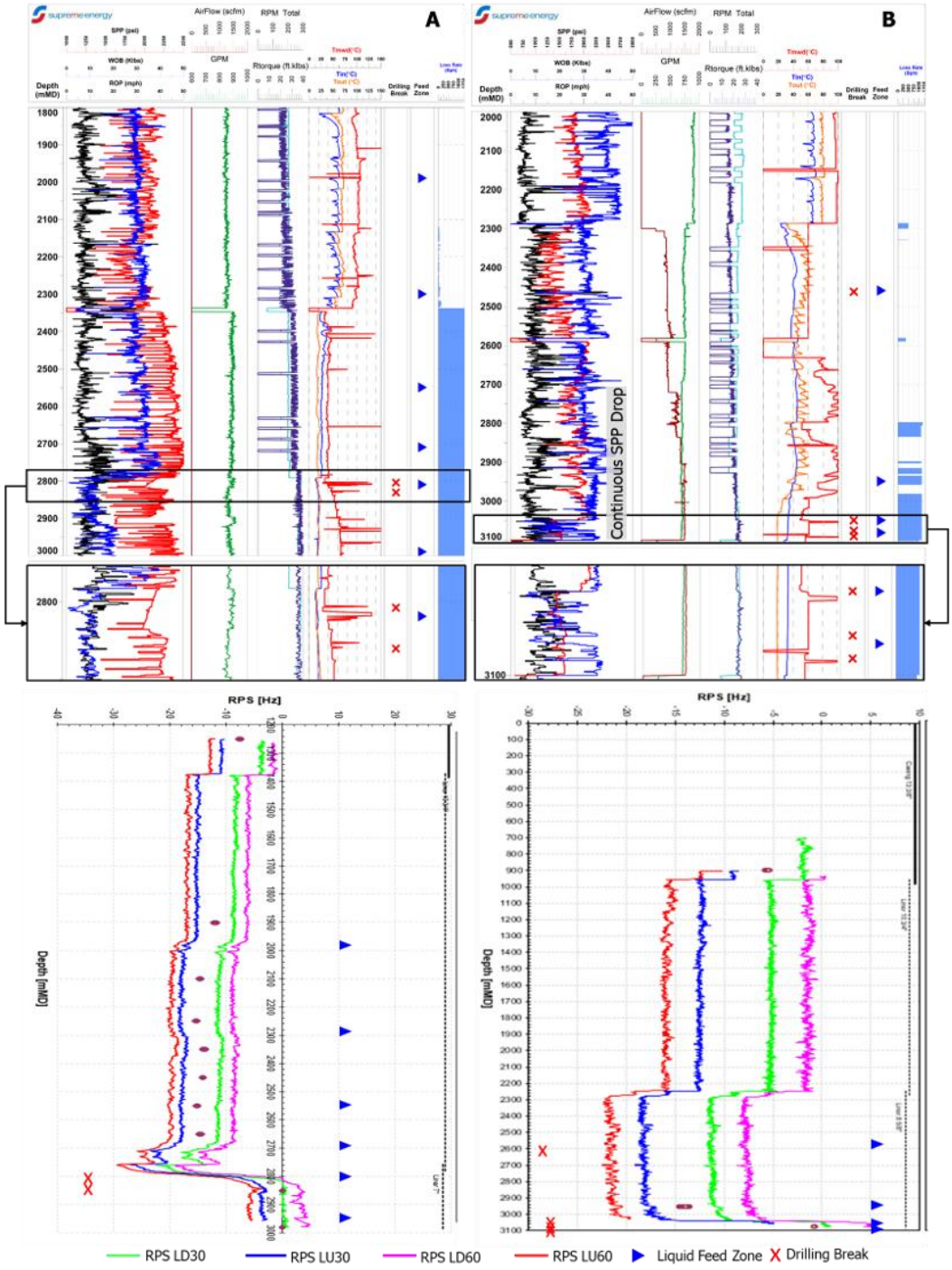


Figure 4. Drilling parameter and spinner logs show (A) two closely spaced drilling breaks matched the largest feed zone, with coinciding with a sharp MWD temperature spike. (B) Three of four feed zones were identified by drilling breaks with two feed zones within clustered intervals.

Another example of a strong correlation between drilling breaks and feed zones is observed in Figure 4. Three out of four feed zones in this well have been identified by drilling breaks during drilling operations. The anomalies are characterized by ΔROP of 3-12 m/hrs, ΔWOB between 7 and 12 Lb, and ΔSPP values of up to 554 psi. The drilling break at 3049 mMD is followed by a continuous SPP decline. Moreover, two feed zones in this well are located within the intervals of clustered drilling breaks. Interestingly, one feed zone is not associated with any drilling break but it is marked by a significant temperature increase.

Although several drilling breaks in Muara Laboh show strong correlations with feed zones, some mismatches have been observed. For instance, there is well having multiple drilling breaks that are not associated with any feed zone (Table 3), whereas another well has several feed zones without corresponding drilling breaks (Table 4). Similar to observations in the Rantau Dedap field, drilling breaks that are not correlated with feed zones are commonly characterized by only two parameter anomalies, typically without a significant change in SPP.

3.2 Discussion

Among the three drilling parameters used to define drilling breaks, the standpipe pressure (SPP) appears to be the most important parameter in identifying the feed zones. The data show that almost all drilling breaks associated with feed zones experience a decrease in SPP during drilling. Significant SPP drop (>100 psi) indicates a major feed zone with substantial contribution to well productivity. The other two parameters, rate of penetration (ROP) and weight on bit (WOB), may not always be strong evident for feed zone identification as these parameters can be controlled to some extend during drilling operations, where the drilling team deliberately limits WOB to avoid excessive ROP and ensure borehole and drill string safety (Al Amin et al., 2023). Conversely, some drilling breaks exhibited minimal or no SPP change but still corresponded to feed zones, which generally showed minor contributions to well performance. The absence of significant SPP response in these cases may be attributed to small-aperture fractures or limited permeability, while drilling under higher airflow conditions (higher air–fluid ratio) during total loss scenarios may also diminish the observable SPP drop (Al Amin et al., 2023).

Image log analysis on some wells show that drilling breaks that are associated with feed zones show evidence of washouts and shattered lithology (Figure 5). The washout indicates the presence of cavities, likely representing fault zones or dyke intrusion contacts. Such cavities provide highly permeable pathways connected to the reservoir, which is reflected by drilling breaks with significant SPP drops during drilling. Apart from cavities, drilling breaks correlated with feed zones are also observed in permeable high-fracture lithologies.

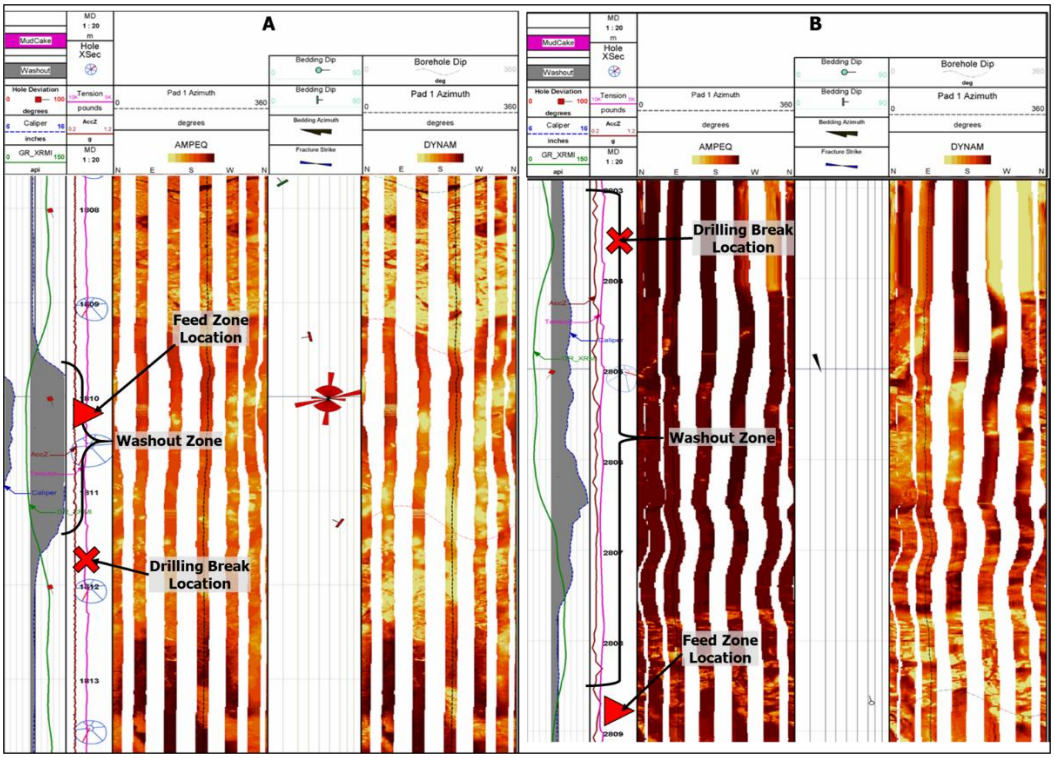


Figure 5. Image logs show the drilling break at 1812 mMD [A] and at 2800 mMD [B] are associated with washout features and shattered lithology. These intervals are likely to represent fault core zones or dyke intrusion contacts with good permeability.

Feed zones are often identified within intervals containing multiple drilling breaks. Several factors may explain this phenomenon. Drilling breaks within this interval may be originated from both open fractures and non-permeable fractures such as those sealed by minerals, with only the permeable fractures recognized as feed zones during completion test. In addition, clusters of drilling breaks may represent fractures with varying permeability, where completion test detects only the most dominant zones with minor feed zones are masked due to the limited resolution of PTS data (Massiot et al., 2017). This implies that drilling breaks do not always

correspond to a single feed zone but may instead represent cumulative indicators of fracture-dominated intervals with complex permeability distributions. Furthermore, the presence of liners during well completion testing may cause closely spaced individual feed zones to appear as a single zone (Goble and McLean, 2020).

In addition to drilling breaks associated with feed zones, numerous drilling breaks are observed to not correlating with feed zone locations (Tables 1–4). Analysis of drilling parameters indicates that these drilling breaks are generally characterized by only two parameters (ΔROP and ΔWOB), with either negligible or no ΔSPP. Such conditions may occur when drilling breaks are caused by lithological contacts that are non-permeable (Figure 6), fractures with very small apertures that limit permeability, fractures already sealed by minerals, or the permeable zone has blocked by cutting during drilling. In some cases, these drilling breaks may represent zones with very low permeability that could not be detected during the completion test. This limitation of completion test may be explained by the presence of down-flows that tend to mask permeable zones located below inflow points due to constant temperature and low permeability or by balanced wellbore and formation pressures preventing fluid exchange between the well and the formation (Massiot et al., 2017).

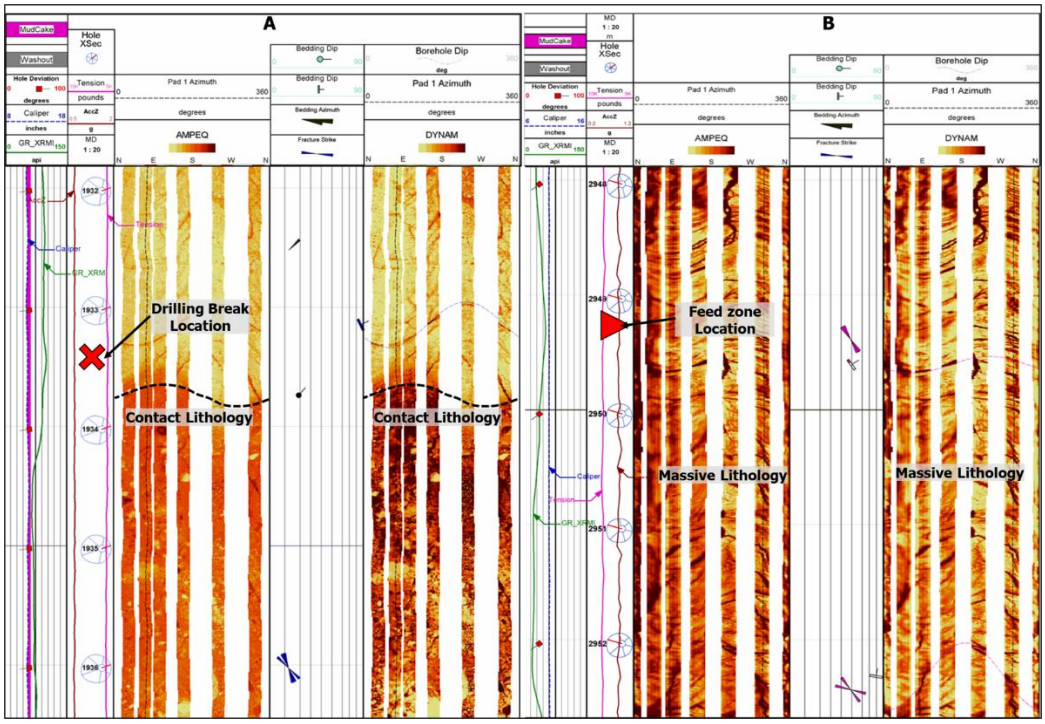


Figure 6. Image log shows, [A] the drilling break at 1933 mMD in one of Rantau Dedap well resulted from an impermeable lithological contact, showing no correlation with a feed zone. Conversely, [B] the feed zone at 2949 mMD occurred within massive lithology with few small permeable fractures, thus lacking a clear drilling break.

Notably, several feed zones are not recorded by drilling breaks. Image log analyses show that feed zone without a corresponding drilling break has been identified within relatively massive lithology containing only few small permeable fractures (Figure 6). Permeable zones dominated by partial fractures with low-aperture characteristics may fail to generate significant drilling breaks (Alamsyah et al., 2023). Such feed zones generally contribute only marginally to the overall well productivity.

Another case observed is when feed zones appear to be shifted by 10–30 m relative to drilling break locations. Such discrepancies may occur when a drilling break is masked by a larger preceding event, or when fractures at the feed zone are too small to produce a clear drilling response. In addition, the presence of liners during completion testing can influence spinner tool measurements, leading to feed zones being recorded at depths that are slightly shallower or deeper than their actual positions (Trent and McLean, 2024).

4 CONCLUSION

Drilling breaks observed during drilling are typically associated with lithological contacts, fractured lithologies, or fault core zones. Drilling breaks linked to feed zones correspond to washouts and shattered lithology, suggesting fault zones or dyke intrusion contacts with good permeability. Conversely, several drilling breaks showed no correlation with feed zones correspond to impermeable lithological contacts or tight, mineral-filled

fractures. The analysis of drilling breaks compared with completion test results indicates that significant drilling breaks, particularly those marked by substantial SPP reductions, tend to correlate with feed zone locations. These large drilling breaks indicate that the associated permeable zones are likely to become major contributors to well productivity. Nevertheless, the productivity potential and quantitative contribution of such feed zones cannot be inferred solely from drilling break observations. Quantification requires further evaluation through Injectivity Index measurements conducted during completion testing. In conclusion, drilling break analysis provides a valuable real-time indicator for identifying permeable zones and contributes to improved reservoir characterization during drilling operations. It also shows reasonable consistency with feed zone locations confirmed by completion tests.

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