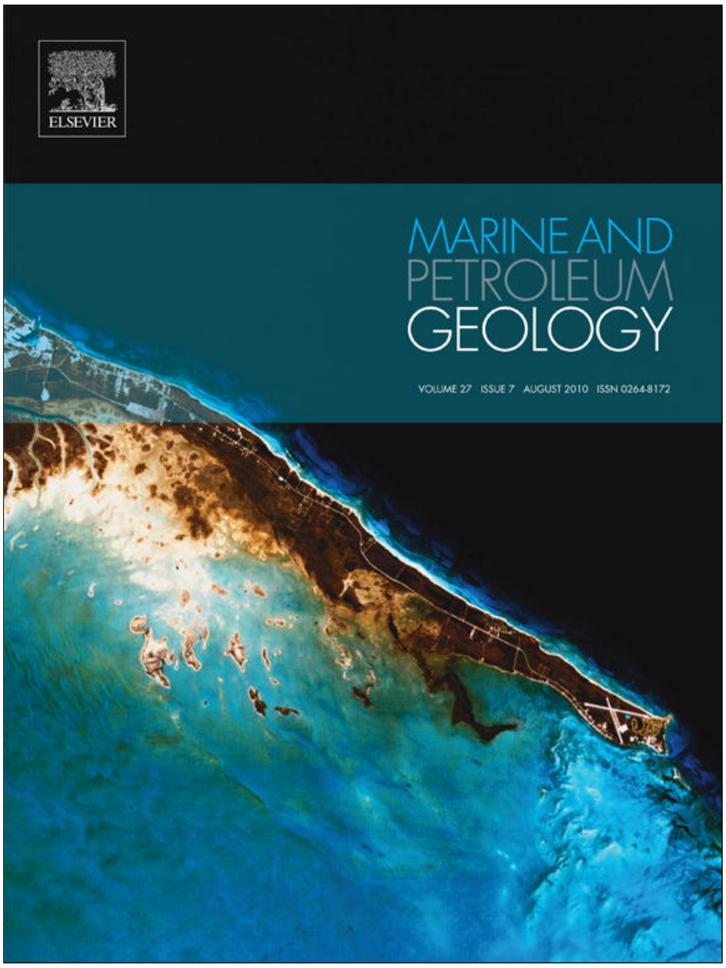
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Discussion

Was LUSI caused by drilling? – Authors reply to discussion

Nurrochmat Sawolo, Edi Sutriono, Bambang P. Istadi*, Agung B. Darmoyo

Energi Mega Persada, Wisma Mulia 22nd Floor, Jl. Jend. Gatot Subroto 42, Jakarta 12710, Indonesia

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1. General

This paper is the Authors' reply to Davies et al. (2010) discussion of the original Sawolo et al., 2009 paper. The Authors wish to thank Dr. Davies and his colleagues for the discussion and continued contribution to this interesting case study.

The original paper and the ensuing discussion address whether a connection exists between the Banjarpanji-1 well and the LUSI mud volcano, and so they focus on the condition of the Banjarpanji-1 well.

In this reply, the positions of the Authors and Davies et al. (2010) (including previous papers of Davies et al. (2008, 2007), Rubiandini et al. (2008) and Tingay et al. (2008)) on the Banjarpanji-1 drilling data and analysis are compared point-by-point, to enable the reader to understand the basis for the respective positions. This discussion is grouped into four logical sequence to make it easy for the readers to follow; which is, i) the dataset used for the analysis, ii) the method of analysis, iii) the result of the pressure analysis on the condition of the casing shoe and its possible connection to the mud flow, and iv) other evidence and information from the Banjarpanji-1 well drilling.

The main issue between the Authors and Dr. Davies and his colleagues is on the dataset and evidence in analyzing the condition of the Banjarpanji well. It is obvious that Dr. Davies papers lack the complete dataset; this is puzzling to the Authors since Lapindo Brantas have been open and offered scientists to examine and access their drilling data. Strangely, Dr. Davies never took up on the offer, and instead, they continue to "cherry-pick" drilling data that supports their hypothesis and disregarded the weightier dataset that does not. In the opinion of the Authors, if Dr. Davies and his colleagues were to integrate all the available data into their analysis, then their conclusions would likely be different.

By comparison, the Authors have fully integrated the entire dataset, from which it becomes apparent that the hypothesis of a connection between the Banjarpanji-1 well and the LUSI mud volcano is not supported by data.

2. Point-by-point summary of authors' response

Issue	Sawolo et al. (2009)	Davies et al. (2010) discussion	Remarks
Dataset – The use of Integrated vs. 'Cherry Picked' data			
Type and breadth of information used on fracture possibility	Complete set of information used to investigate condition of the well – Pressure, Active mud volume, Pumping and flow information, Hook load, Speed of trip, Mud Engineers report, etc.	Use Pressure vs. Time data only (Fig. 1D)	Analyzing well condition based on a single piece of information is misleading and leads to a flawed conclusion.

* Corresponding author.
E-mail address: bambang.istadi@energi-mp.com (B.P. Istadi).

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Issue	Sawolo et al. (2009)	Davies et al. (2010) discussion	Remarks
Example: Was a fracture propagated from the wellbore (Fig. 1D – region marked 2) that finally breached the surface?	**No**, because: • Well was killed, it no longer have pressure and energy (Fig. 7) • No associated fluid loss (Fig. 1A) • Well did not collapse and BOP was able to be opened (Fig. 1B) • Drill string is a closed system. A pressure creep in the drill string does not represents a drop in open hole pressure (Fig. 7 of Sawolo et al., 2009) • Sudden press loss was due to bleed-off pressure to line up (piping & valve) connection prior to pumping of soaking fluid (Fig. 1A and B) • High pressure during injection tests confirm well intact and not fractured (Sawolo et al., 2009)	**Yes**, shown as a pressure creep in Fig. 1D – region marked 2.	Cherry picking data leads to a wrong conclusion.
Dataset – leak-off test: technique, interpretation and result			
Leak Off Test interpretation when oil-based mud is used.	Interpretation technique based on Fracture Closing Pressure, which accounts and compensates the high compressibility of oil-based mud (Fig. 2).	Interpretation technique based on Inflection Point during pressure build up.	Due to the high compressibility of oil-based mud, LOT is not interpreted at the inflection point. Lapindo use similar LOT interpretation technique as Unocal, Santos and Medco; the latter two were partners in the drilling of the Banjarpanji-1 well.
Leak Off Test at the 13-3/8" casing shoe at 3580 ft.	LOT = 16.4 ppg is supported by nearby offset wells (Fig. 4)	LOT = 15.4 ppg on the table and 15.8 ppg on its write up (Fig. 2).	Why Davies et al. (2010), have two interpretations from a single LOT chart? Both Davies' LOT values are not supported by nearby offset wells (Fig. 4)

(continued)

Issue	Sawolo et al. (2009)	Davies et al. (2010) discussion	Remarks
Dataset – BHP methods and result			
Main Bottom Hole Pressure (BHP) estimation method	Engineer's fill up method in Banjarpanji 1 well Result at total depth = 12.8 ppg (Fig. 5)	Method unknown Result at 6986′ depth = 15.1 ppg (Davies et al., 2007)	Engineer's fill up method is a field-proven BHP estimation method. Davies' method in estimating the BHP is unknown without any publicly available reference.
Supporting methods to the BHP estimation	■ Static Influx Test (SIT) ■ Mud weight ■ Log – Resistivity ■ Log – Sonic ■ Dc – exp	■ No comments ■ No comments ■ Not advocated ■ Not advocated ■ Not advocated	These supporting methods arguably have limitations and lower reliability that the main BHP estimating method; however, when used as a check they enhance the credibility of the BHP estimate. Davies' 15.1 ppg BHP is not supported by these secondary estimating method (Fig. 5)
Analysis method – taken at the drill pipe leg			
Is the drill pipe side (leg) valid for pressure analysis?	**No**, because the float valve creates a pressure restriction in the drill pipe (Fig. 7 of Sawolo et al., 2009)	**Yes**, because the pressure restriction is eliminated.	Mud logger RTD shows pressure restriction exists.
Analysis method – taken at the annulus leg			
Is the annulus side (leg) valid for pressure analysis?	**Yes**, because there are no pressure restriction. The well has not caved in at the time of the measurement and therefore valid for analysis (Fig. 1B)	**No**, it is invalid as the well caved in creating a pressure restriction in the annulus	Mud logger RTD confirms that the pressure measurement was taken about six hours **before** the well caved in (Fig. 1B).
Other issues – no drags and unlikely to swab			
Was there any significant drag when pulling out of hole?	Mud logger RTD 28th May 2006, shows a relatively small overpull of 10,000 lbs without the signature of drag	A 30,000 lbs overpull was reported in the Daily Drilling Report 28th May 2006.	The overpull reported in the daily drilling report is not supported by the mud logger RTD. Must check key statements in reports against raw data such as mud logger RTD.

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(*continued*)

Issue	Sawolo et al. (2009)	Davies et al. (2010) discussion	Remarks
Was there any swabbing when pulling out of the hole?	The slow pulling speed and absence of drag from RTD suggests that swabbing is unlikely.	Severe swabbing, which brought large quantities of formation fluids into the wellbore	An influx into the wellbore (a kick) is due to a formation pressure that is higher than the hydrostatic pressure exerted by the mud, including but not limited to swabbing (Unocal Basic Well Control, 2001)
Other issues – amount of influx			
What was the influx volume?	~370 bbls from mud logger RTD.	~360 bbls and 390–600 bbls (Davies et al., 2008) ~750 bbls Davies et al. (2010)	Davies et al. high influx volumes are not supported by mud logger RTD. Davies was inconsistent and changed his influx volume estimate to ~750 bbls. Need to state reasons of change and evidence
Other issues – was the well killed?			
Was the well killed?	**Yes**. Both annulus and drill pipe pressures were bled off (Fig. 1C), the BOP was opened, and the well did not flow.	**No**. An underground blowout occurred on 28th and 29th May 2006. Ability to open BOP was due to a cave-in which formed a pressure seal.	The well was killed as the BOP was able to be opened and circulated for 3 h **prior** to the well caving in (RTD data, Fig. 1B and C). With the well killed, there was no pressure or energy to propagate fractures from the well.
Other issues – length of open hole section			
Did the long open-hole section jeopardize well integrity?	**No**. The open-hole length was not unusual for the area. Other operators in the area have drilled longer open-hole sections (Table 3).	**Yes**. Casing setting depths deviated from the pre-drill design, and the longer-than-planned open-hole section made the well fragile and prone to breach.	Open-hole length is not a measure of well integrity as proven by other operators in the area.
Other issues – well safety and integrity			
Is the well safe?	**Yes**, kick tolerance was sufficient to drill to total depth.	**No**, the drilling window was too narrow.	Tingay et al., 2008, used incorrect input and uncorroborated data.
What were the key inputs for the safety calculation?	Pore pressure = 12.8 ppg LOT = 16.4 ppg. Based on integration of full data set.	Pore pressure = 14.6 – 15.1 ppg. LOT = 15.8 – 16.4 ppg.	Tingay et al., 2008, used incorrect input data. See section on 'Dataset for analysis'.

(*continued*)

Issue	Sawolo et al. (2009)	Davies et al. (2010) discussion	Remarks
Well Design "Design plot – Base case 9-5/8" casing" Fig. 11A	Safety check of the actual well condition with 5720 ft open hole using Landmark's CasingSeat™ casing design software shows the well is safe	Casing design was a significant deviation from the original plan and resulted in a significant open hole section (Davies et al., 2010).	Even with the significant open hole section, Landmark's CasingSeat™ casing design software suggested that the well was safe
Other issues – was there a channel between the well and the mud flow?			
Was there a conduit between the wellbore and the mud flow?	**No**. Such a conduit is inconsistent with the high pumping and injection pressures.	**Yes**. The drilling morning report suggests a possible channel	Pumping mud downhole at a high pumping pressure and high injection test pressures prior to cementing confirms intact casing shoe.
Other issues – was the flow through the wellbore?			
Bit was still stuck two months after mud eruption suggested that the mud flow did not pass through the well	At flow rates around 100,000 m^3 per day, the wellbore would be eroded and the bit will fall to the bottom. Finding the bit in its original position two months later suggests that the mud flow did not pass through the well.	Does not prove well remained intact and that an underground blowout was not occurring.	Lab report showed hot water came out from the eruption, not the synthetic oil-based drilling fluid. The well did not suffer drilling mud losses even after the eruption occurred.
Other issues – no near casing fluid flow			
Sonan and Temperature logs taken during well re-entry shows a quiet response.	The quiet response of the logs suggests the absence of near casing fluid flow. Absence of this flow suggests that there is no underground blowout	Absence of a near casing flow does not show that the well was killed. Davies further suggests that the fracture position is diverted deeper (Fig. 13) due to a 'cement plug'	Cement plug was laid one day after the mud flow had started. Massive mud flow diverted away by newly laid green cement plug is unrealistic.
Other issues – can a newly laid green cement plug block a mud flow?			
Can a newly laid green cement plug block a mud flow?	**No**, it is physically impossible.	The original fracture and mud flow was through the casing shoe. Later, the cement plug blocked this flow, and created new deeper fractures at around 5000 ft. (Fig. 13B)	Green cement has almost no cohesive strength and is easily washed away by fluid flow up the wellbore. It does not have sufficient compressive strength to withstand the pressure required to create new fractures.

(*continued*)

Issue	Sawolo et al. (2009)	Davies et al. (2010) discussion	Remarks
Other issues – well condition prior to pulling out of hole			
What was the condition of the well prior to pulling the drill string out of the well?	Mud losses cured. Well stable for 7 h (Daily Drilling report and RTD 27th May 2006) before the drill string was pulled from well.	Well unstable, severe mud losses in progress prior to pulling the drill string out of the well.	Davies' position is not supported by mud logger RTD, which shows the well was in a stable condition for 7 h before starting to pull out of hole. Davies needs to provide proof of his claims.

3. Dataset for analysis

In the weeks and months after LUSI first erupted, publicly available data from Banjarpanji-1 was limited, and so early analysis from external parties relied on assumptions to fill the data gaps. Since then, the full dataset has been made public by Sutriono (2007) and Sawolo et al. (2008, 2009), and is further explained and supplemented in this reply. Banjarpanji drilling data access was offered in a number of international conferences (Istadi et al., 2008 in London and Sawolo et al., 2008 in Cape Town) for any scientist and practitioners to verify its authenticity. This allows any interested party to integrate the entire dataset into its analysis instead of relying on mere assumptions.

3.1. Mud logger's real time data (RTD)

Mud logger's RTD comprises the set of recorded drilling parameters and other well data that is automatically measured and stored in the mud logger's computer. The Authors consider the RTD to be the most reliable data, because it is continuous, quantitative and unbiased.

Analysis on the well's condition to determine what took place at the bottom of the hole must be based on a full dataset or otherwise its conclusion will be misleading. For example, the drill pipe pressure decrease or creep (Fig. 1D – region marked 2) was interpreted by Davies et al. (2010), as *'fluids leaking from the open hole'*. The sudden pressure drop to zero was interpreted to be due to fluid breach at the surface.

In the absence of any other information, Davies et al. (2010) conclusion might be understandable. However, this conclusion is quickly revealed as nonsense when other information from the same period is integrated:

- The well was killed and it no longer has any pressure and energy to propagate any fracture. See Fig. 7.
- There were no associated fluid losses. See Fig. 1A.
- BOP was opened and circulation was possible (Fig. 1B), suggesting well has not collapsed
- The drill string is a closed system due to the non ported float valve (Fig. 7, Sawolo et al., 2009). A decrease in drill pipe pressure or pressure creep does not represent a drop in the open hole pressure.
- The sudden pressure loss was due to bleed-off at the surface. The drilling morning report shows the operation at the time was to prepare for pumping soaking fluid around the drill bit and its bottom hole assembly in order to get it free from the differential sticking. This operation is also shown in Fig. 1B and C.
- If the claim of fractures and breaching to the surface is true, then the pumping of soaking fluid would not result in a pressure increase such as shown in Fig. 1C. A pressure increase would not be possible in a fractured well.
- Results of the pressure tests suggest that the well was intact and not fractured (High injection test in Sawolo et al. (2009)).

This other information does not support such a claim. Using a more complete set of information, Sawolo et al. (2009), can interpret the condition of the well and able to substantiate with more accuracy than an interpretation based solely on a pressure data (Fig. 1D).

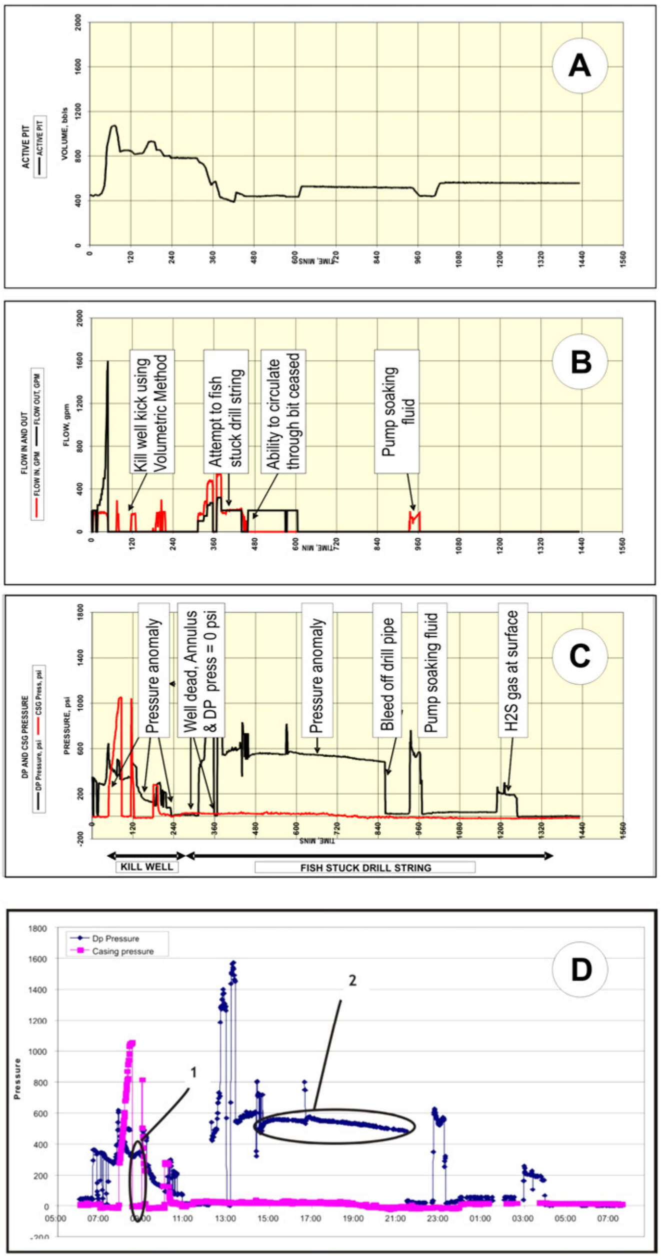


Fig. 1. A,B,C – Active tank volume, Flow in/out and Pressure vs. Time curve. These and other mud logger RTD information show the well condition at any time. Davies et al. used the Pressure information only, shown in Fig. 1D. Sawolo used the complete dataset.

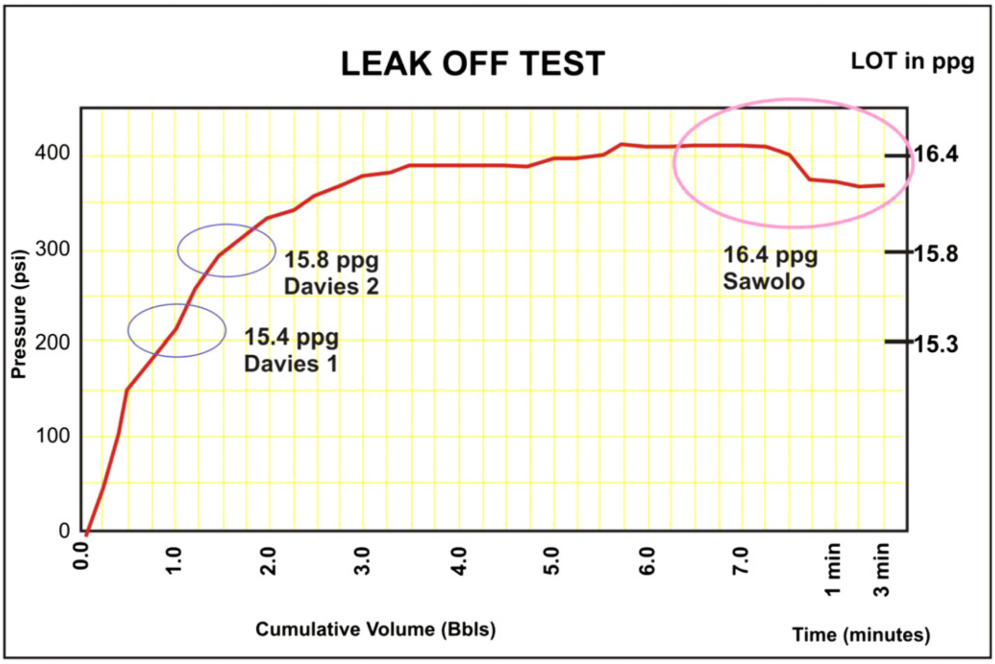


Fig. 2. LOT curve showing a smooth curve that is typical of LOT done on shale using oil-based mud. LOT pressure was interpreted as 16.4 ppg by Sawolo et al. (2009) (red circle) and 15.4 ppg (Davies 1) 15.8 ppg (Davies 2) showed by Davies et al. (2010) (blue circles). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

3.2. Leak Off Test (LOT) data issues

In order to measure formation strength at the casing shoe, a LOT is done after each casing string is set and cemented (Bourgoyne et al., 1984). In Banjarpanji-1, the interpretation and value of the LOT is different between the Authors and Davies et al. (2010), as follows:

The position of the Authors is the LOT at the 13-3/8'' casing shoe of 16.4 ppg calculated by Lapindo Brantas is valid and consistent with wells in the region.

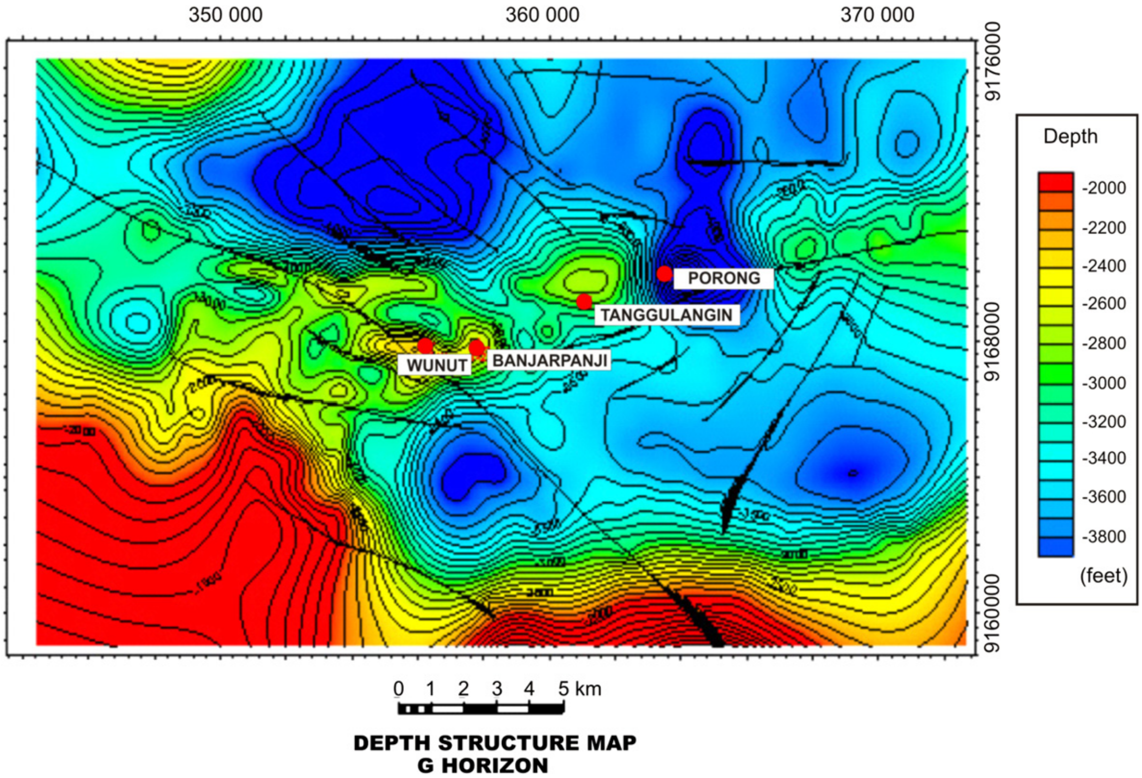


Fig. 3. Structure map of Banjarpanji-1 and the nearby Wunut, Tanggulangin and Porong wells. It shows that at the casing shoe depth of 3580 ft. Banjarpanji-1 well lies within Wunut field structural closure, hence the Banjarpanji-1 LOT should resemble Wunut's.

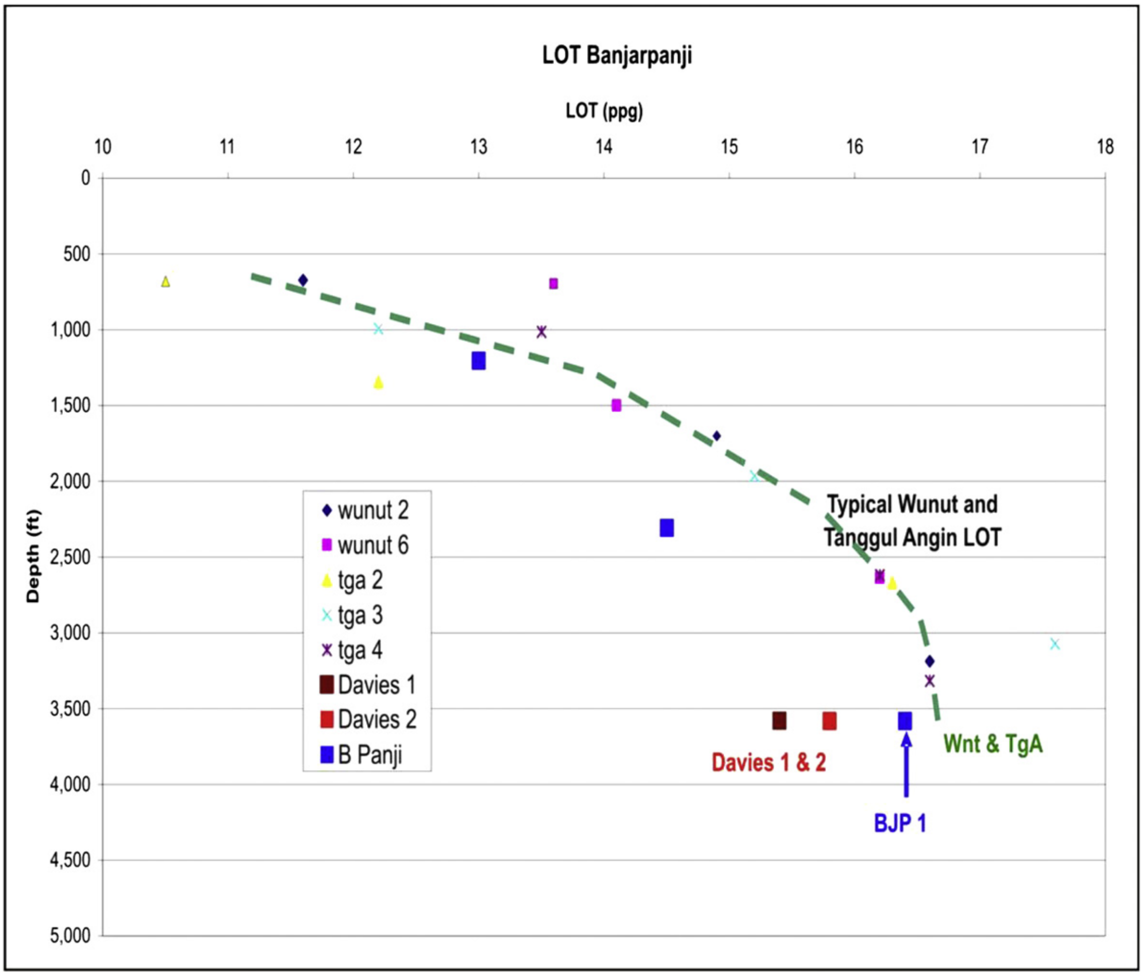


Fig. 4. The interpreted values of LOT by Sawolo et al. Davies 1 and Davies 2 are plotted with typical LOT from Wunut and Tanggulangin wells. It shows that the Banjarpanji-1 LOT of 16.4 ppg (Sawolo et al., 2009) is in line with nearby offset wells at a similar depth.

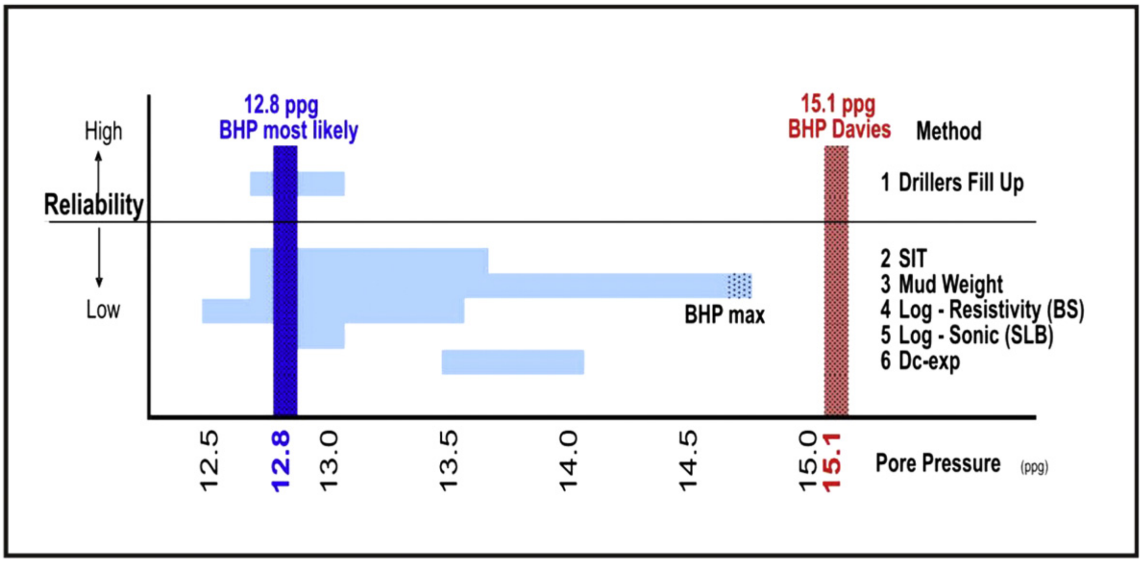


Fig. 5. Banjarpanji-1 Bottom Hole Pressure (BHP) estimation. The BHP is estimated based on a number of methods with differing reliabilities. The most likely BHP is estimated at around 12.8 ppg. Davies' BHP of 15.1 ppg is too high and not supported by other BHP estimation methods.

The position of Davies et al. (2010), is the LOT is lower at 15.4–15.8 ppg, and claimed that Lapindo Brantas used a non-industry-standard LOT procedure.

3.2.1. LOT data

The 13-3/8" casing shoe LOT at Banjarpanji-1 well was performed by the Drilling Foreman from the cementing unit. By staying at the pumping unit, the foreman controls the volume of mud being pumped to the well and at the same time records the pressures to determine the LOT. Standard industry practice is to take pressures from the cementing unit pressure gauge which is the most accurate pressure gauge at the well-site.

Davies et al. (2008), reported a completely different LOT data from an unknown source. The Author suggests that Davies clarifies the source of LOT data and the accuracy of the pressure gauge. Was the test result taken by the responsible person? Did he have control of both mud volumes being pumped and direct access to the resulting pressure readings?

3.2.2. LOT technique

There is no universally accepted LOT procedure and interpretation, so LOT methods vary between companies (Lapeyrouse, 2002). In general, the LOT is done by closing the BOP at surface and then pumping mud at a constant rate until the desired test pressure is reached or until the well starts to take whole mud. The pressure at which the formation begins to 'leak' is called the 'Leak Off ' pressure. In a plot of mud-pump pressure vs. time, this is where the curve starts to deviate from the straight line. This is how most oil and gas companies interpret the LOT graph when using non-compressible drilling fluids such as water-based mud.

However, when using compressible drilling fluids such as the oil-based mud in Banjarpanji-1, the LOT interpretation technique needs to account for fluid compressibility. The compressibility of oil-based mud is almost twice the compressibility of water-based mud (Bourgoyne et al., 1984).

Lapindo Brantas followed the Unocal Operating Guideline (1998) for oil-based mud, in which the 'fracture closing pressure' is interpreted to be the formation strength. By using the fracture closing pressure, defined as the pressure at 10 s after the pump is switched off, the effect of fluid compressibility is minimized. This technique is detailed in Sawolo et al. (2009). Similar techniques for oil-based mud LOT interpretation method are used by other oil and gas companies in the area, including both partners in the Banjarpanji-1 drilling; Santos, a major independent Australian oil and gas company, and Medco, a major Indonesian oil and gas company. As confirmed by their drilling engineers, Santos use the fracture closing pressure similar as per Lapindo Brantas, and Medco use the maximum injection pressure as their leak off pressure.

Davies et al. (2010), claim that Lapindo Brantas LOT technique is *'contrary to all industry practices'* is false. Numerous oil and gas companies use similar technique including Santos and Medco, all participants in the Banjarpanji drilling project.

3.2.3. LOT interpretation results

The Authors'; interpreted LOT at the 13-3/8" casing shoe at 3, 580 ft. as 16.4 ppg; this is plotted on Fig. 2 in the red circle. This interpretation is based on the fracture closing pressure to account for the high compressibility of oil-based mud (Sawolo et al., 2009).

Davies et al. (2010), interpreted the LOT at the inflection point of the curve with a LOT value of 15.8 ppg (Davies 2). Another value was suggested in his summary as 15.4 ppg (Davies 1). It is unknown why Davies suggested two LOT values from a single LOT curve, but these two interpretations are shown in Fig. 2 in blue circles.

3.2.4. LOT results bench-marking

LOT results should resemble those in analogous nearby wells. In the case of Banjarpanji-1, the nearby wells are in Wunut and Tanggulangin fields, some 2 km and 3 km away respectively. The Wunut field is especially analogous, because at the casing shoe depth of 3580 ft., Banjarpanji-1 is in the same structural closure as the Wunut field as shown in Fig. 3. Comparison with the Porong-1 LOT is less significant since it is some 7 km away in a different structural setting.

The different values of Banjarpanji-1 LOT interpretations are plotted with Wunut and Tanggulangin LOT in Fig. 4.

The Author's Banjarpanji-1 LOT of 16.4 ppg at 3580 ft. is consistent with offset wells in the Wunut and Tanggulangin fields. In contrast, Davies 1 and 2 interpretations are not supported by the offset well data. Similarly, Davies' claim that Sawolo's LOT of 16.4 ppg is *'unrealistically high leak off pressure', 'overestimating the pressure the well could tolerate'* and '*an erroneous value to use, is contrary to all industry practices and is an extensive overestimation of formation strength*' (Davies et al., 2010) is false. This baseless rhetoric has no place in science. If Dr. Davies had done his field work, evaluated tests of the nearby wells and performed a proper research, then his appreciation will likely be different.

Consequently, the value of LOT to be used in the Pressure Analysis section is 16.4 ppg at 3580 ft. The much lower LOT value of 15.4 ppg and 15.8 ppg (Davies 1 and 2) are used in the sensitivity analysis as its worst-case scenario.

It should be noted that all offset wells in Wunut and Tanggulangin fields were drilled using water-based mud. Using the non-compressible water-based mud, there is no issue of interpreting the data, and these LOT pressure were picked at the inflection point similar as Davies et al. (2008). One key well, Wunut 2, was drilled by a different operator, Huffco Brantas Inc, and their LOT was found to be in line with the rest of Wunut and Tanggulangin wells.

3.3. Bottom Hole Pressure (BHP)

Apart from the strength of the formation (LOT), Bottom Hole Pressure (BHP) is another important piece of information to calculate the pressure at the casing shoe.

The Authors used the 'fill up method' to estimate BHP at Banjarpanji-1 at 12.8 ppg. This method is used by field engineers after a loss circulation has occurred; it is field-proven and a reliable method. Other pore pressure estimation methods based on mud weight and indirect methods are less reliable and have their own limitations. Although individually these methods may be less reliable, when used as a group they can be used to check the result from the primary method to arrive at the most credible BHP. The results of these various pore pressure-estimating methods are plotted in Fig. 5.

The Authors' estimated BHP of 12.8 ppg is supported by the other pore pressure estimation methods except for the Dc-exponent method, and so is used for subsequent pressure analysis. A maximum BHP of 14.7 ppg (Fig. 5) is used for sensitivity purposes. This range of BHP estimate is supported by all pressure estimation methods that are based on actual well data and not *'misleading and essentially contrived'* as claimed by Davies et al. (2010). This claim must be substantiated.

Davies et al. (2007), BHP estimation of 15.1 ppg is not supported by basic well data or by other pore pressure estimating methods. Davies et al. (2007), justified the 15.1 ppg by proposing that the *'drilling of the over-pressured Kujung limestone caused a kick'*. The speculation that the well penetrated any carbonate formation is not supported by cuttings or calcimetry increases. Secondly, the statement that the well took a kick is incorrect. The well suffered a mud loss not a kick when drilling at total depth, so the bottom-hole pressure has to be lower than the 14.7 ppg

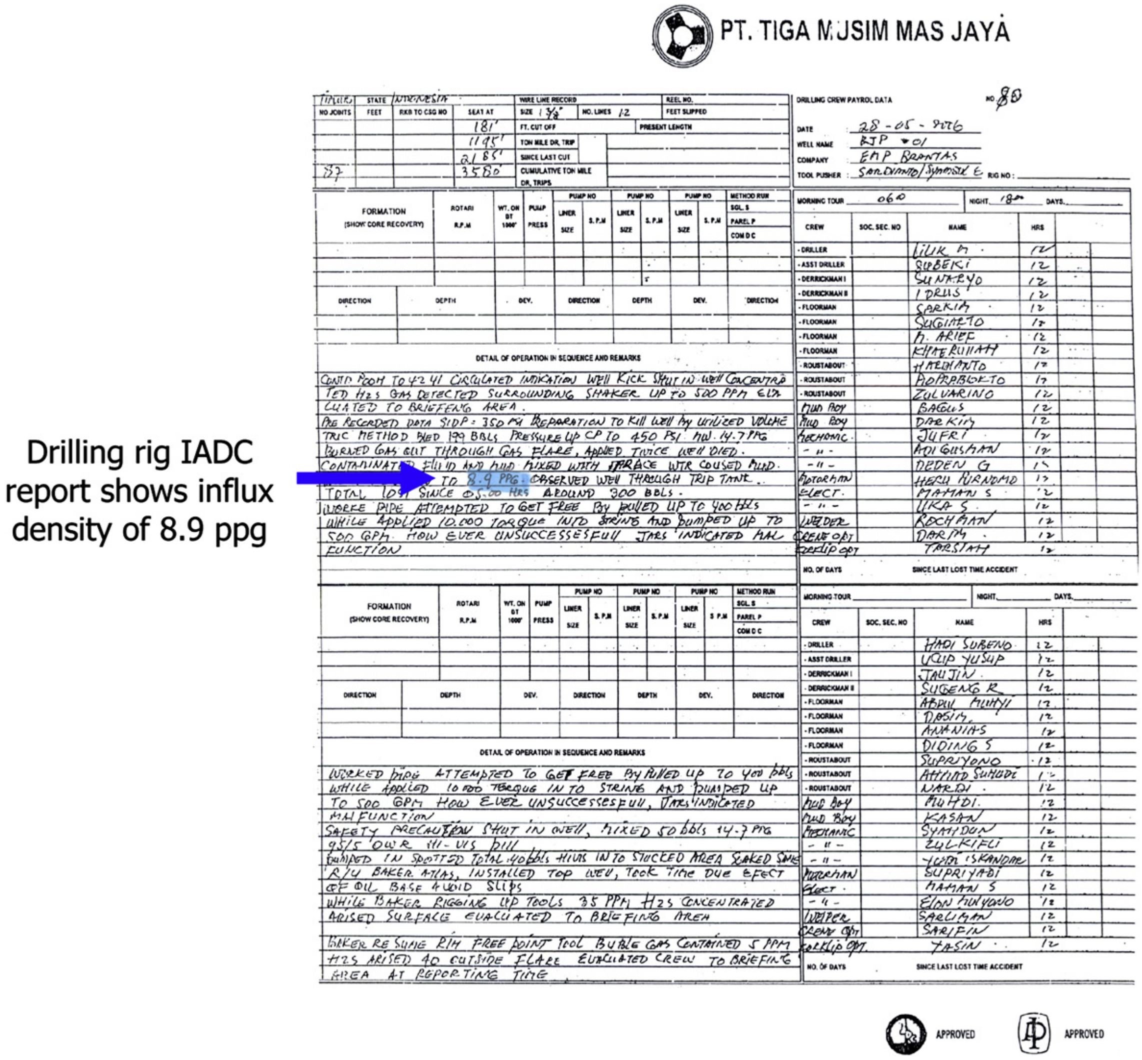


Fig. 6. Density of the influx was found to be 8.9 ppg. After the well was killed, the influx was circulated out and found to be saline water with a density of 8.9 ppg.

mud weight used while drilling. A 15.1 ppg BHP is physically impossible.

3.4. Other data for pressure analysis

Other data required to perform the pressure analysis are:

1. Maximum casing pressure = 1054 psi (Fig. 7)
   This is the highest recorded casing pressure after the BOP was closed, at which time the casing shoe experienced the highest hydrostatic pressure. At this time, the well has not caved in and forms a pressure seal (Fig. 1B), so the pressure data was valid.
2. Fluid density at the top of the well = 8.9 ppg (Daily Drilling Report date 29th May 2006).
   This fluid density was measured while circulating out the influx and shown in Fig. 6.
3. Mud weight used during the well kill = 14.7 ppg. (Daily Drilling Report date 29th May 2006).

4. Method of analysis

Sawolo et al., 2009, estimated the pressure at the casing shoe by analyzing the annulus fluid column, whereas Davies et al. (2008), analyzed the drill pipe fluid column. The differences and their limitations are discussed below:

4.1. Pressure analysis of the well

Wellbore pressure is estimated at the casing shoe, typically the weakest point of the wellbore, and compared with the LOT. If the pressure at the casing shoe is below its LOT, then the casing shoe is likely intact, and vice versa.

The wellbore pressure at the casing shoe can be estimated from either the drill pipe or the annulus, typically referred to as the 'legs' or 'legs of the U-tube'. Both approaches will give the same answer provided the input data and assumptions are reliable. We will illustrate the different approaches and reasoning of Davies et al. (2008), and Sawolo et al. (2009), in performing their analyses.

4.2. Pressure analysis on the drill pipe leg (Davies et al., 2008)

The drill pipe side is the common leg to perform a pressure analysis as it is full of homogeneous drilling mud of known density. However, for Banjarpanji-1, this approach could not be used due to the float valve on top of the drill bit. This valve acts as a one-way valve, restricting wellbore fluids and creating a pressure discontinuity between the drill pipe and the open hole section. Therefore

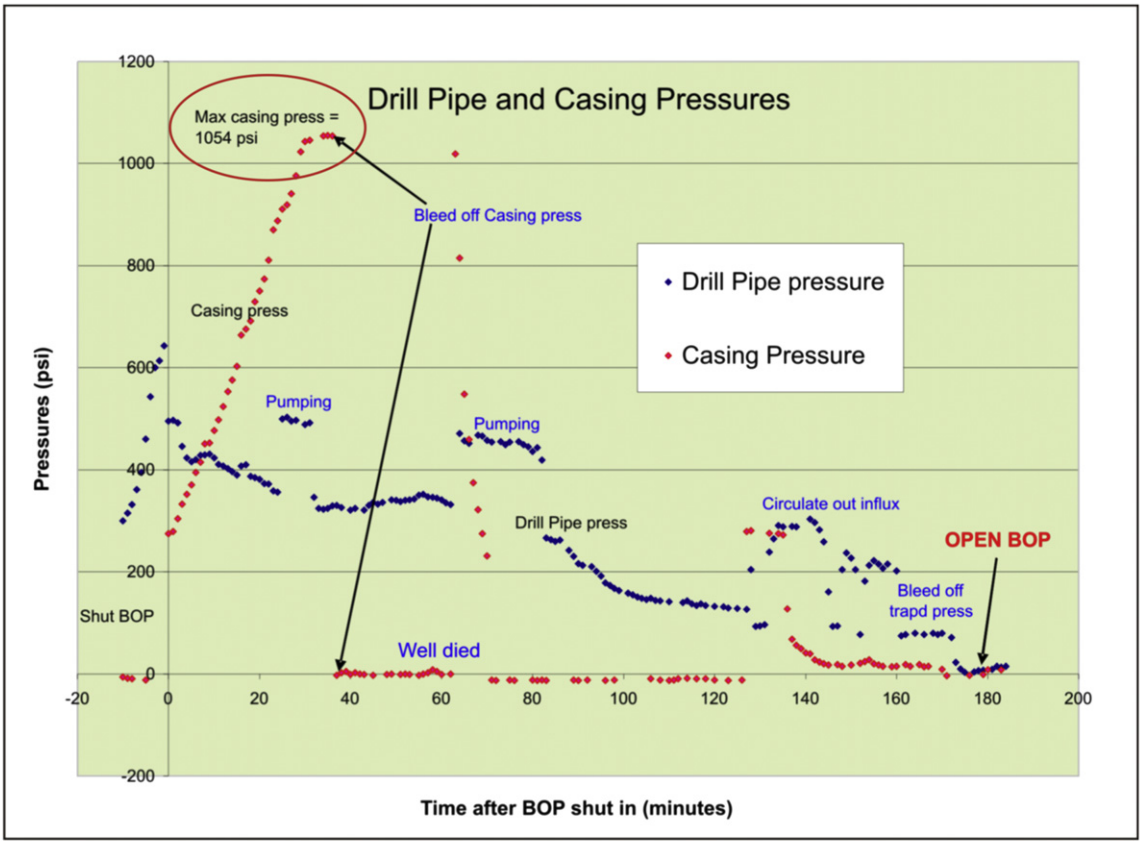


Fig. 7. Pressure time curve during the well kill. This plot showed the pressure in the drill pipe (blue dots) and the annulus pressure (red dots). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

wellbore pressure cannot be reliably estimated from drill pipe pressure. A schematic of the mud circulating system that shows the float valve is shown in Fig. 7 of Sawolo et al. (2009).

Davies et al. (2010) state two actions that purportedly eliminated the pressure discontinuity between the drill pipe and the open hole section.

- Mud was pumped (slowly) through the drill pipe during the initial casing build up which opened the float valve and removed the pressure discontinuity, thereby allowing reliable annulus pressure estimation from drill pipe pressure.

This slow pumping was not done. Pressure restriction can be eliminated by slow pumping (equivalent of 2–5 strokes per minute by idling the mud or cement pump) that just barely opens the float valve without causing an excessive pressure on the drill pipe. The mud logger RTD showed pumping was done at 42 strokes per minute (Fig. 1B and mud logger RTD) to fill the well as part of the 'Volumetric' well control method. At this high pump rate, frictional pressure losses in the drill string are significant, and so pressure estimation at the bottom of the drill string is unreliable (Field Evidence, RTD in Sawolo et al., 2009).

- The (float) valve has a small hole allowing pressure communication.

This is false. Lapindo-Brantas drilling standard is to use a non ported (no hole drilled) float valve, as shown in the Banjarpanji-1 Drilling Program. This is further confirmed by the drill pipe pressure (around 500 psi) being higher than the annulus pressure (around 280 psi) when the BOP was shut in (Field Evidence, RTD in Sawolo et al. (2009)). If a small hole was drilled in the float valve, the drill pipe pressure reading would be lower than the annulus as the drill pipe is full of heavier drilling mud whereas the annulus is filled with a mixture of drilling mud and lighter influx fluid.

The pressure restriction in the drill pipe was not eliminated. Therefore, pressure reading in the drill pipe is invalid and should not be used in any pressure analysis.

4.3. *Pressure analysis on the annulus leg (Sawolo et al., 2009)*

Davies et al. (2010), claimed the well caved in and packed off the drill string, thereby isolating the wellhead annulus from the open hole annulus, and making downhole pressure estimation from surface annulus pressure unreliable. The evidence cited was the lack of fluid flow up the annulus and the inability to circulate mud.

A close look at the mud logger RTD reveals that the well had not caved in at the time pressure measurements were made. Fig. 1B shows that circulation remains unrestricted until around 14:30 h on 28th May 2006. This is the time when the well finally caved in. However, annulus pressure measurement was taken six hours prior to when circulation was lost, and so was valid.

The pressure data is shown in Fig. 7.

The kill process was successful and the well was finally killed, both drill pipe and annulus pressure were bled off and the BOP was opened within three hours. The highest pressure recorded at the annulus was 1054 psi for use in the Pressure Analysis.

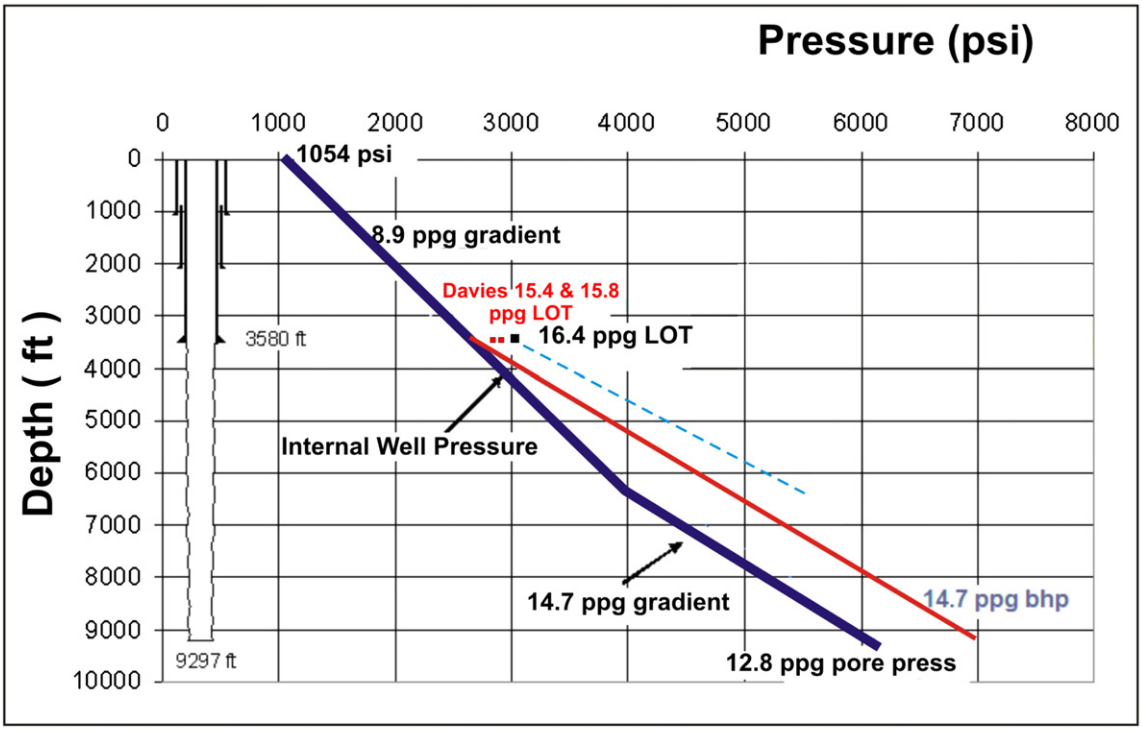


Fig. 8. Pressure analysis showing a pressure profile in the well (internal well pressure) at different depths, shown in 'Dark Blue'. The formation strength is shown in 'Light Blue' dotted line. The pressure in the well ('Dark Blue' line) stays below the formation strength ('Light Blue' dotted line) confirms that the well is intact. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

5. Pressure analysis result

The inputs for the pressure analysis of the casing shoe are as follows:

1.	Bottom Hole Pressure	= 12.8 ppg at 9297 ft.
2.	Leak Off Test	= 16.4 ppg at 3580 ft.
3.	Maximum surface casing pressure	= 1054 psi
4.	Mud weight	= 14.7 ppg
5.	Surface fluid density	= 8.9 ppg

For the worst-case sensitivity analysis, the worst-case inputs were used:

1. Bottom Hole Pressure	= 14.7 ppg, being the maximumpossible BHP (Fig. 5).
2. The Leak Off Test	= 15.4 ppg being the lowest LOT (Figs. 2 and 4) suggested by Davies et al. (2010)

The analysis based on this data and the mechanics of constructing the pressure analysis curve are described in Sawolo et al. (2009), and summarized in Fig. 8.

This curve shows that the pressure at the casing shoe was less than its fracture strength (LOT), which confirms that the well remained intact. Note that in Fig. 8, even at the worst-case condition (15.4 ppg LOT and 14.7 ppg BHP), the wellbore pressure at the casing shoe is below the LOT, and the casing shoe remained intact. Davies et al. (2010), claim that the Authors have taken *'an unrealistically high leak off pressure and unrealistically low pressure'* in its pressure analysis is again proven wrong, as the sensitivity test is performed using the lowest leak off pressure (Davies 1 LOT in Figs. 2 and 4) and the highest possible bottom-hole pressure (as shown in Fig. 5).

With the well remained intact, there is no connection between the well and the mud volcano. The underground blowout hypothesis suggested by Davies et al. (2007, 2008, 2010) is, therefore, not supported by pressure analysis.

6. Others issues

This section discusses other related field data and observations on the drilling of the Banjarpanji-1 well.

6.1. Mud losses that coincided with earthquake

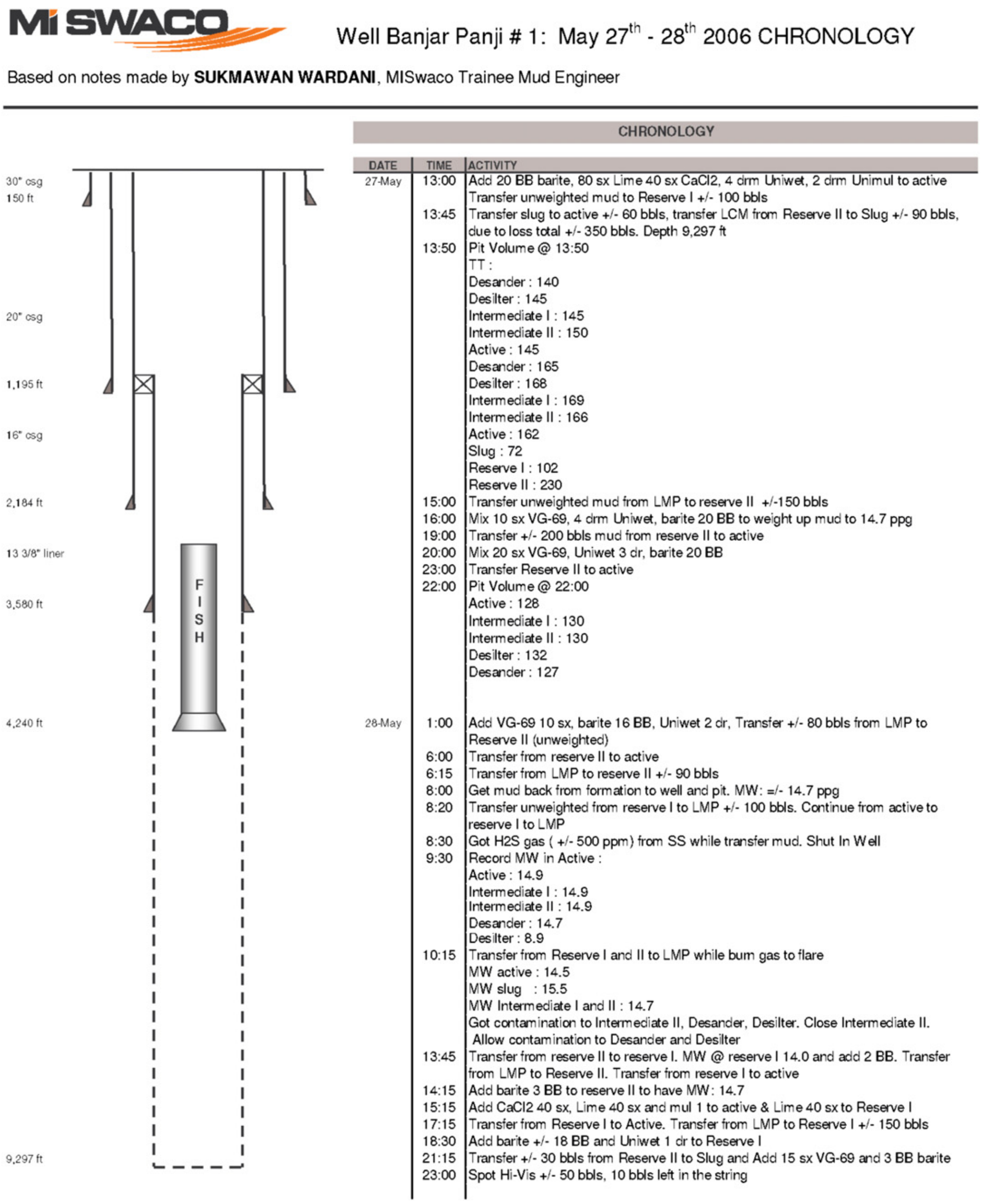
Sutriono (2007) and Sawolo et al. (2008, 2009), revealed the Banjarpanji-1 drilling dataset to interested parties, and demonstrated that this dataset does not support a connection between the well and the mud volcano. The papers note two mud losses coincided with the main Yogyakarta earthquake and the aftershocks. This information is provided for sharing purposes and to provide a platform for other researches.

As stated in the introduction of the Sawolo et al. (2009) paper, proving or disproving other hypothesis for the mud flow is beyond the scope of the paper. These include: mud volcano derived from over-pressured diapiric shale through fracture zone as conduit (Sunardi, 2007), fault reactivation (Mazzini et al., 2007, 2009), very long tectonic propagating fracture network aligned with the Watukosek fault zone (Istadi et al., 2008), earthquake (Davies et al., 2008, 2010; Manga, 2007; Mori and Kano, 2009) or geothermal activity (Sudarman and Hendrasto, 2007).

6.2. No drag and unlikely to swab

Davies et al. (2010) suggest that the statement of Sawolo et al. (2009) of '*no apparent drag… unlikely to swab*' contradicts the daily drilling report which stated *'overpull encountered over 30,000 lbs'*.

The daily drilling report of 28th May 2006 does indeed report 30,000 lbs of overpull, but this statement is not supported by the



MI SWACO Well Banjar Panji # 1: May 27th - 28th 2006 CHRONOLOGY

Based on notes made by **SUKMAWAN WARDANI**, MISwaco Trainee Mud Engineer

CHRONOLOGY

DATE	TIME	ACTIVITY
27-May	13:00	Add 20 BB barite, 80 sx Lime 40 sx CaCl2, 4 drm Uniwet, 2 drm Unimul to active Transfer unweighted mud to Reserve I +/- 100 bbls
	13:45	Transfer slug to active +/- 60 bbls, transfer LCM from Reserve II to Slug +/- 90 bbls, due to loss total +/- 350 bbls. Depth 9,297 ft
	13:50	Pit Volume @ 13:50 TT : Desander : 140 Desilter : 145 Intermediate I : 145 Intermediate II : 150 Active : 145 Desander : 165 Desilter : 168 Intermediate I : 169 Intermediate II : 166 Active : 162 Slug : 72 Reserve I : 102 Reserve II : 230
	15:00	Transfer unweighted mud from LMP to reserve II +/-150 bbls
	16:00	Mix 10 sx VG-69, 4 drm Uniwet, barite 20 BB to weight up mud to 14.7 ppg
	19:00	Transfer +/- 200 bbls mud from reserve II to active
	20:00	Mix 20 sx VG-69, Uniwet 3 dr, barite 20 BB
	23:00	Transfer Reserve II to active
	22:00	Pit Volume @ 22:00 Active : 128 Intermediate I : 130 Intermediate II : 130 Desilter : 132 Desander : 127
28-May	1:00	Add VG-69 10 sx, barite 16 BB, Uniwet 2 dr, Transfer +/- 80 bbls from LMP to Reserve II (unweighted)
	6:00	Transfer from reserve II to active
	6:15	Transfer from LMP to reserve II +/- 90 bbls
	8:00	Get mud back from formation to well and pit. MW: =/- 14.7 ppg
	8:20	Transfer unweighted from reserve I to LMP +/- 100 bbls. Continue from active to reserve I to LMP
	8:30	Got H2S gas (+/- 500 ppm) from SS while transfer mud. Shut In Well
	9:30	Record MW in Active : Active : 14.9 Intermediate I : 14.9 Intermediate II : 14.9 Desander : 14.7 Desilter : 8.9
	10:15	Transfer from Reserve I and II to LMP while burn gas to flare MW active : 14.5 MW slug : 15.5 MW Intermediate I and II : 14.7 Got contamination to Intermediate II, Desander, Desilter. Close Intermediate II. Allow contamination to Desander and Desilter
	13:45	Transfer from reserve II to reserve I. MW @ reserve I 14.0 and add 2 BB. Transfer from LMP to Reserve II. Transfer from reserve I to active
	14:15	Add barite 3 BB to reserve II to have MW: 14.7
	15:15	Add CaCl2 40 sx, Lime 40 sx and mul 1 to active & Lime 40 sx to Reserve I
	17:15	Transfer from Reserve I to Active. Transfer from LMP to Reserve I +/- 150 bbls
	18:30	Add barite +/- 18 BB and Uniwet 1 dr to Reserve I
	21:15	Transfer +/- 30 bbls from Reserve II to Slug and Add 15 sx VG-69 and 3 BB barite
	23:00	Spot Hi-Vis +/- 50 bbls, 10 bbls left in the string

Fig. 9. Mud engineer report showing mud transfer into the active mud tanks at 06:00 h. This and other parallel operations done on the rig at the time make the influx volume estimation uncertain.

mud logger RTD, which shows a relatively light overpull of around 10,000 lbs and no tell-tale signs of drag. In a really bad overpull condition, the 'hook-load' record will show an erratic with an increasing trend, whereas in a rough hole condition, it will simply show a bumpy erratic motion. The RTD record does not show any of this tell-tale sign and therefore the Authors believe that it is *a smooth hole* and no drag.

The RTD also shows the pulling speed was a slow *five minutes per stand* (Sawolo et al., 2009) with mud replacement. This data all suggests that swabbing was *unlikely*.

Table 1
RTD shows the volume of mud in the active mud tank remained almost constant over a four hour period, and after fresh mud was added, it remained constant for another two hours. This shows that the well was stable after the earlier major loss had been cured.

Time (27/5/2006)	Activity	Active mud tank (bbls)	Remarks
~14:30	Spotting LCM completed	232	LCM added to cure the mud losses
14:30–15:00	POOH 4 stands	205	
15:00	Started circulation through trip tank	212	Mud engineer mixing new mud
19:00	Ready to receive new mud	210	Mud volume almost constant in last 4 h. **Well in stable condition**
19:30	End of receiving mud	417	
21:45	Ready to pull out of hole	418	Mud volume almost constant in last 2 h. **Well in stable condition**

Table 2
Active tank volume during the well kick. These recorded volumes are used to estimate the influx volume.

Time (28/5/06)	Active tank (bbls)	Operations remark
06:30	350	Work on wash pipe leak. Tank volume increase, but no mud logger notification suggests a mud transfer.
07:20	450	Mud logger notifies company man
07:40	460	Flow rate started to pick up
07:52	820	Shut in BOP. Flow from well ceased
08:10	1070	Unaccounted flow after BOP was shut. With the BOP shut, there cannot be any more influx from the well. Mud transfer?

This is an instance where one has to decide what is the "harder data" – the daily drilling report or the mud logger RTD. The Authors' position is the underlying mud logger RTD carries more weight because it is automated, continuous and quantitative.

6.3. Amount of influx

The estimated influx volume in Davies et al. (2008), is ~360 bbls in the table, 390 – 600 bbls in the paper. However, a significant increase to ~750 bbls is reported by Davies et al. (2010). This inconsistency in Davies's claims, suggest a lack of understanding of the downhole conditions, the actual operations and the use of many assumptions in the claims.

The earlier Davies et al. (2008), influx volume is close to the Author's estimate of ~370 bbls. The Authors include a caveat to determine the exact influx volume, which is due to the number of simultaneous operations occurring at the same time:

- Mud loss due to the top drive wash pipe leaking (RTD data ~06:30 h)
- Circulating of mud downhole (RTD data ~07:00 h).
- Pumping of mud into the active tank (starting at 06:00 h – M-I report shown in Fig. 9).

The volume increase in the active tank of 250 bbls (shown in Table 2) after the BOP was shut in means that other operations were occurring, such as mud transfer from the reserve tanks. With the BOP closed, the volume increase could not have come from the well.

To estimate the influx volume, the Author based its calculation from the mud logger RTD. The mud volume in the active tank at the time was shown as follows:

The influx volume of 370 bbls was derived from the difference between:

Volume when the BOP was shut in	= 820 bbls (RTD 07:50 h)
Volume at mud logger notification	= 450 bbls (RTD 07:30 h)
Likely influx volume is around	= 370 bbls

This is a significantly lower than Davies' estimate.

The Authors question the reasons for the inconsistency and the high influx volume reported by Davies et al. (2010).

6.4. Was the well killed?

Pressures in the drill pipe and annulus during the 'volumetric' kill process are shown in Fig. 7. At the end of the kill, the annulus and drill pipe pressures were bled off and the BOP was opened to confirm that the well was dead.

Davies et al. (2010), claimed that the well was not killed and that cave-in of the hole explains why the blowout preventers could be opened without any surface flow taking place. This claim is inconsistent with the mud logger RTD Figs. 1B and 10 which shows that circulation was possible for three hours after the BOP was opened. The ability to circulate mud means that there was no pressure barrier in the annulus between the bit in the open hole and the surface. Therefore as no pressure was seen at the surface, the well must have been dead.

6.5. Propagation of fractures

Davies et al. (2010), propose that fracture propagation started by a fracture at the casing shoe and continued until the fracture breached the surface.

Davies et al. (2010), propose that the drill pipe pressure creep (marked 2 in Fig. 1D) is evidence that fluids were leaking from the open hole and a fracture was propagating from the casing shoe to the surface. Further, the time when the fracture reached the surface is shown by the sudden pressure drop.

This claim is not supported by the full mud logger RTD information and other drilling evidence. This is explained as the example in the 'Mud loggers Real Time Data' section at the beginning of this paper.

6.6. Length of open hole section

Davies et al. (2010) suggest that deepening the well to 9297 ft resulted in a long open-hole section that jeopardized well integrity.

Open-hole length by itself is not a safety issue. One partner in the Banjarpanji-1 well drilled two wells in their Jeruk field in Offshore East Java (see Table 3) to a similar carbonate objective. Both wells had longer open-hole sections than Banjarpanji-1, yet they were both drilled without any special safety concerns. So Davies et al. (2010), claim that the length of the open hole in Banjarpanji-1 created a safety issue is not supported by local experience.

6.7. Well safety and integrity

Well integrity depends mostly on bottom-hole pore pressure, fracture gradient and the mud weight used.

An accurate estimate of the bottom-hole pore pressure is needed in the determination of well safety. As shown in the 'Bottom Hole Pressure (BHP)' section, the most likely pore pressure is 12.8 ppg with an upper limit of 14.7 ppg as the well was being drilled with 14.7 ppg mud when it suffered a loss of circulation.

Tingay et al. (2008), based his safety window work on pore pressures from other authors: Davies et al. (2007) with 15.1 ppg and Mazzini et al. (2007) with 14.6 ppg.

- Davies et al. (2007) pore pressure of 15.1 ppg is higher than the mud weight and is not supported by other pore pressure estimation methods (see Bottom hole pressure estimation, Fig. 5). Davies pore pressure is likely to be erroneous.
- Mazzini et al. (2007) suggested two possible bottom-hole pore pressures,
  - 14.6 ppg based on Dc-exponent,
  - *12.8 ppg based on 'Fill up' volume after the loss of circulation.*

Tingay used the higher Dc-exponent-based estimate, although this technique is only applicable in shale or shaly formations (Bourgoyne et al., 1984), while the section being drilled was laharic volcanoclastic rock. It is unclear why the other pressure estimation suggested by Mazzini was not used.

The other input to the integrity test is the value of the Leak Off Test. As shown in the Dataset for Analysis section, the likely LOT

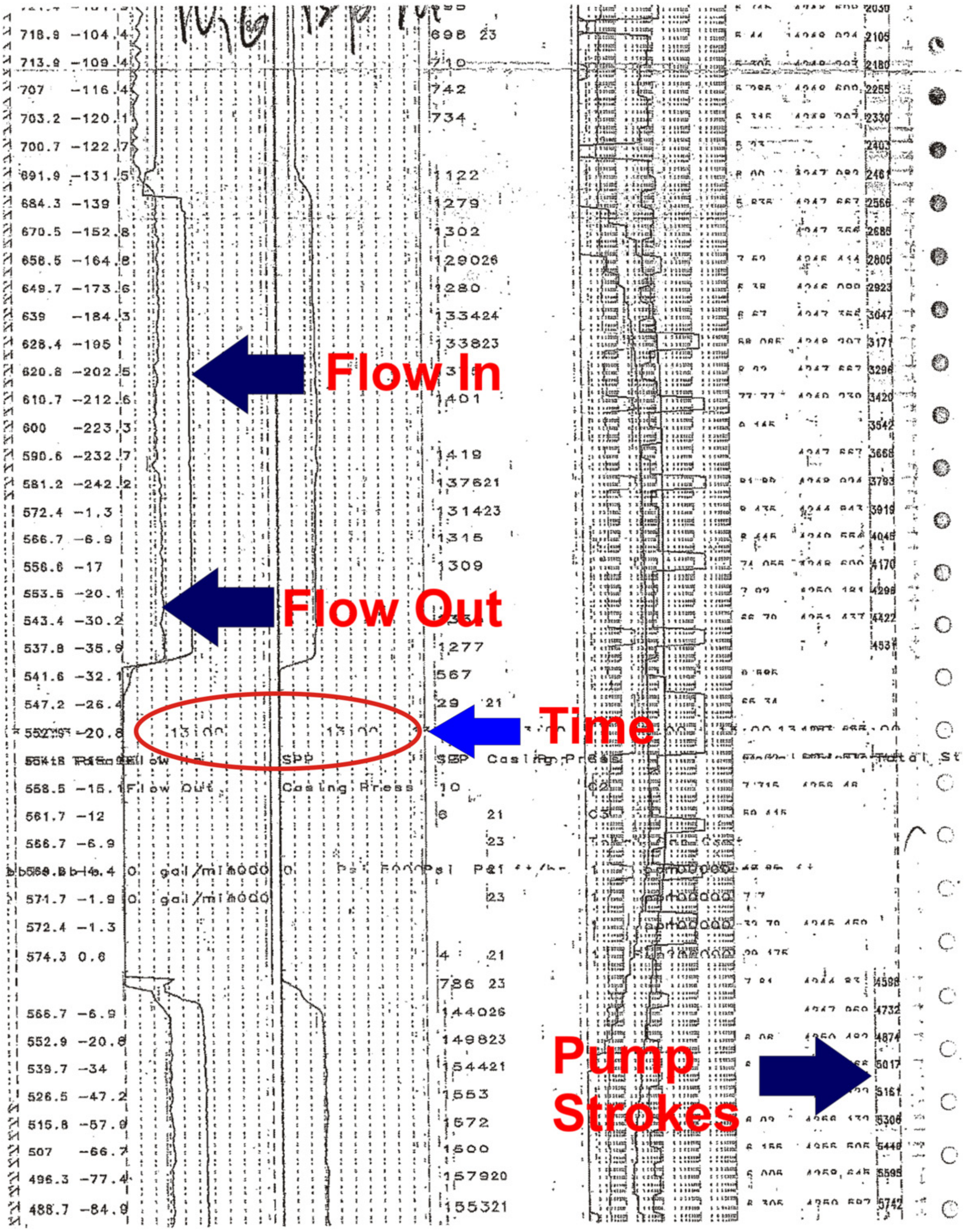


Fig. 10. Mud loggers RTD shows the ability to circulate remained for three hours after the BOP was opened. This confirms that the well was killed.

figure is 16.4 ppg, whereas Davies et al., LOT estimate of 15.4 and 15.8 ppg are much too low.

Based on these inputs, Tingay et al. (2008), concluded that the well was unsafe (Fig. 11B).

The analysis by Sawolo et al. (2009) shown on Fig. 11A is based on a bottom-hole pore pressure estimate that has been cross checked with other pressure estimation methods. Similarly, the value of the LOT was cross checked with offset wells in the region. The analysis was made using Halliburton Landmark's CasingSeat™ casing design software to check the safety of the well using actual drilling data from the Banjarpanji-1 well. The result of the analysis shows that the well was safe (within its 'kick tolerance') to drill down to its final depth of 9297 ft.

The Authors maintain their position that using the most reasonable estimate BHP value of 12.8 ppg, mud weight of 14.7 ppg and a LOT of 16.4 ppg, the well had a sufficient safety factor and integrity to drill to the total depth of 9297 ft. The Authors do not support the analysis of Tingay et al. (2008) because it is based on a faulty bottom-hole pore pressure estimate from a technique not suited to the situation, and which was not checked against other estimation methods.

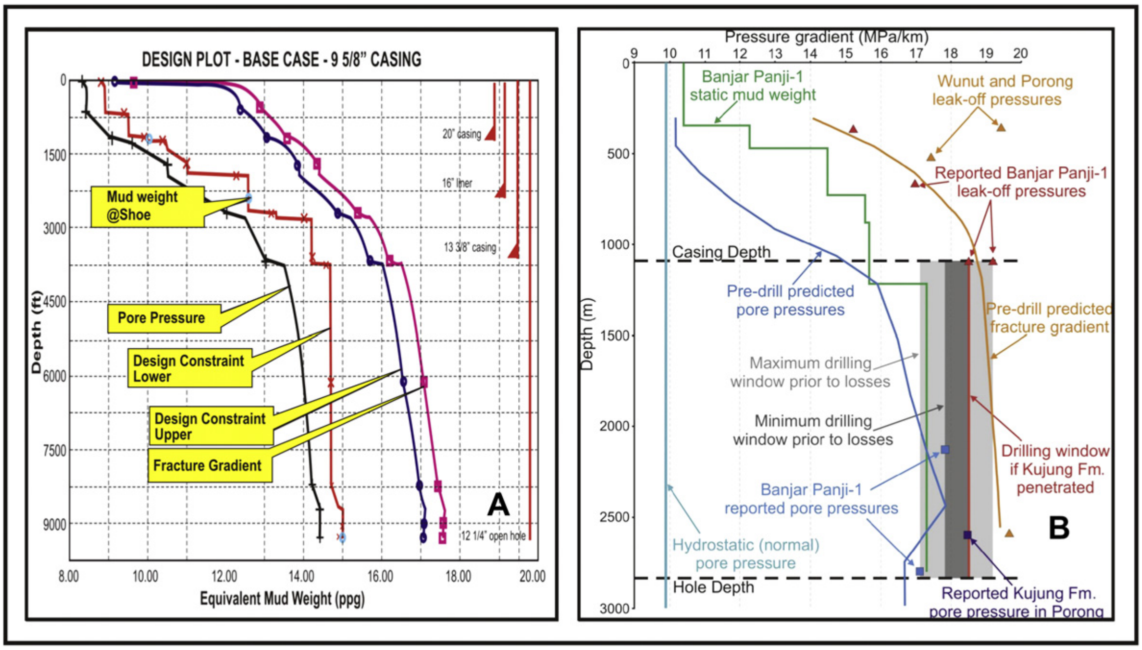


Fig. 11. Well integrity. The diagram of Sawolo et al. (2009), in Fig. 11A is based on actual mud weights and bottom-hole pore pressure from multiple methods and shows the well remains intact. The diagram of Tingay et al. (2008) in Fig. 11B is based on a 14.6 ppg bottom-hole pore pressure from the Dc-exponent.

6.8. Direct evidence for well failure?

Davies et al. (2010), cite evidence of a conduit between the well and the surface mud flow in the form of a Daily Drilling Report 30th May 2006, which stated that pumping mud downhole was coincident with decreased mud eruption intensity and longer quiet periods between eruptions.

The daily drilling report must be cross checked with other data. On the day of the mud eruption, the driller's first reaction was to find out if there was a connection between the well and the eruption, because if such a connection existed, then is should be possible to kill the mud eruption from the wellbore. So the driller pumped mud downhole and recorded the mud eruption behavior and pump pressure. He reported that pumping mud had a notable effect on the geyser-like eruption. However, after further tests, it became clear that pumping mud did not have a repeatable effect on the eruption. The continued erratic and intermittent nature of the eruption suggested that the relationship between pumping and eruption behavior was coincidental. Whereas the high pump pressures (Field Evidence in Sawolo et al., 2009) confirmed that there were no fractures and so pumping of mud was discontinued.

In summary, if there was a conduit between the well and the surface eruption, then the pump pressure would be low or even a vacuum due to the Venturi-effect from large volumes of fluid flowing out of the wellbore. But in fact the pump pressure was even higher than the Leak Off Test, which is consistent with pumping into a sealing well. This confirms that the well is intact.

Table 3
Comparison of uncased open-hole section of various wells in the area. The Jeruk field wells had longer open-hole sections than Banjarpanji-1 well, and this did not create safety concerns.

Well Name	Operator	Location	Open hole without casing
Jeruk-1	Santos	Madura Strait, targeting the same formation as Banjarpanji-1 well	5951 ft
Jeruk-2	Santos	As above	6782 ft
Banjarpanji-1	Lapindo Brantas	Onshore East Java, the same stratigraphic sections as Jeruk wells	**5,720 ft**

6.9. Was the flow through the wellbore?

The question that is most asked is 'Did the mud flow up the wellbore, fracture the formation at the casing shoe, exit the wellbore and flow to surface?' as illustrated in Fig. 12B (Table 4).

The section 'Was the well killed?' demonstrates that the well was killed and the BOP was open for about 18 h before the mud eruption was reported. If the mud flowed up the wellbore, the path of least resistance would be up the wellbore and through the wellhead as shown in Fig. 12A. But there was no flow through the wellhead.

Rubiandini et al. (2008) and Davies et al. (2008), suggests that the casing shoe at 3580 ft. was breached by internal pressure from the well, the mud flowed up the wellbore to the casing shoe, where it exited and found its way to surface. The scenario is shown in Fig. 12B point "d". In subsequent paper, Davies et al. (2010), move the fracture point deeper to around 5000 ft. as shown in Figs. 12C and 13A,B.

This inconsistency in Davies's claim, again, suggests a lack of understanding in actual operations and the use of many assumptions in the claims.

The mud-flow rate was estimated at approximately 50,000 m^3 initially, increasing to over 100,000 m^3 per day at the time of the re-entry operations. If the abrasive mud did flow up the wellbore at extremely high rate, it would be expected to erode the wellbore (Fig. 12B). Nawangsidi (2007), estimate that the resulting bore hole size would be theoretically 200 times the original wellbore size, which is a giant cave, where the drill string would fall to the bottom. Yet, two months after the first eruption, during re-entry work, the bit was still found in its original position. This suggests that the flow may never flow up the well in the first place.

6.10. No indications of near bore mud flow

Sonan and Temperature logs were run during the re-entry work to look for tell-tale noise and temperature anomalies that

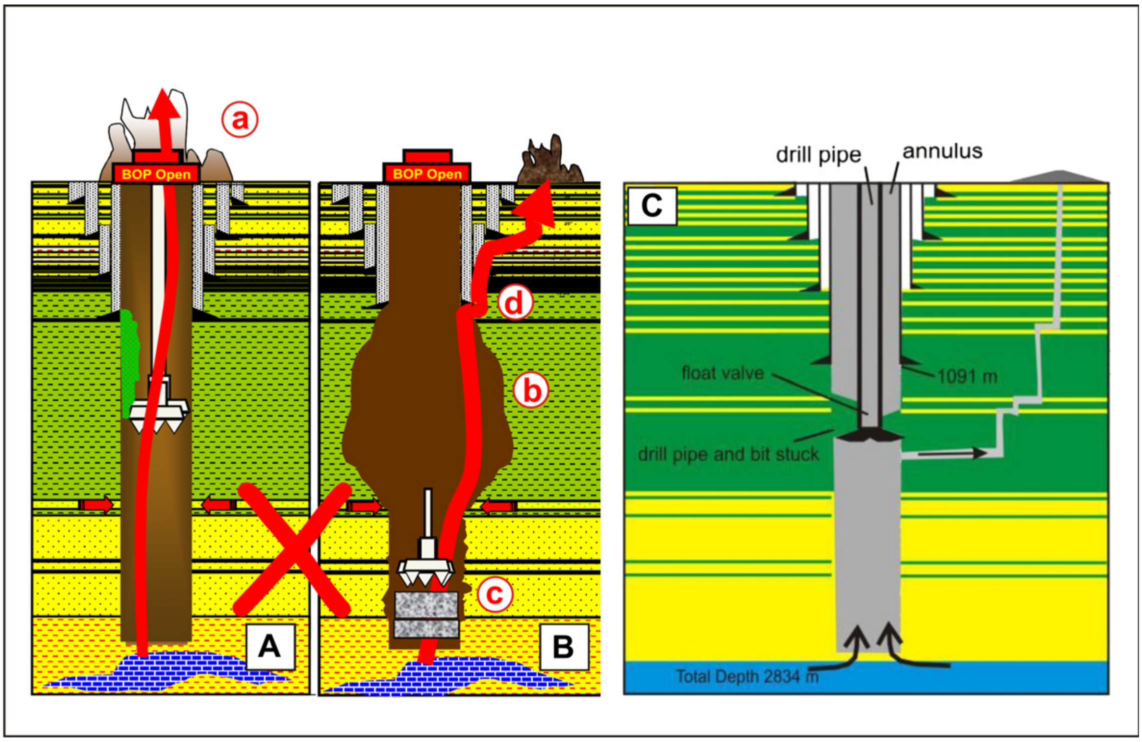


Fig. 12. Differences of opinion had the mud path is through the wellbore. The Authors position had the mud flow pass through the wellbore will result in Fig. 12A and B. Whereas Davies et al. (2010), suggest that it fractured deeper due to a cement plug Fig. 12C.

can indicate flow of fluid behind the casing. Such near-casing flow is typical in deeper wells because fracturing the cement sheath is easier than fracturing the rock formation. In this case, the logs had 'quiet' log responses and there was 'no anomaly' in the temperature log, and so there was no evidence of near casing fluid flow.

The absence of this near casing fluid flow is explained by Davies et al. (2010), due to a cement plug that blocked the fluid flow (Fig. 13B). The suggestion is not realistic since the plug was laid one day *after* the mud flow was observed. Newly laid green cement plug cannot divert such a massive mud flow.

6.11. Mud flow diverted because of green cement plug?

Davies et al. (2010), take the position that the mud flow originally created fractures at the shoe at 3580 ft. (Fig. 13A). Later, when a cement plug was placed, this plug acted to '*prevent fluids from coming up the well above the plug*', and so the mud flow created new

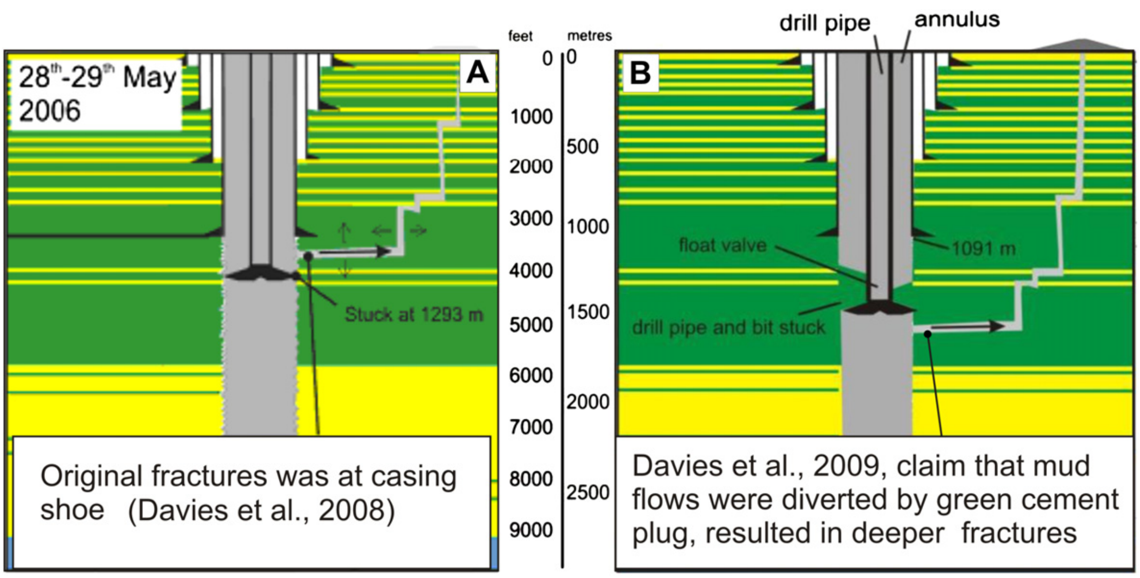


Fig. 13. Davies et al. take the position that the quiet response of the Sonan and Temperature logs was caused by a shift in the well fracture path further from the well. The original fractures were at the shoe (shown in Fig. 13A – from Davies et al., 2008) but mud flows were diverted by newly laid cement plug and fractured new formation rock deeper, at ~5000′ depth (Fig. 13B – Davies et al., 2010). This shows the inconsistencies of Davies et al. in interpreting the downhole conditions including flow path which is based solely on assumptions.

Table 4
What would have happen if the mud flow passed through the well?

Consequence if path flow originates from well	Davies Claims of mud path flow
The Authors postulated consequences if the mud flowed up the wellbore. a) Mud should have flowed through the wellhead when the BOP was in the open position. b) Later when the well caved in, it would have been much easier for the mud flow to force its way through the cave-in and up the wellbore to surface, rather than fracture 5000 ft of new formation; c) hole would likely erode from the high mud velocity, and the cement plug and >90000 lb fish should fall to the bottom of the well; d) casing shoe would likely be the exit point as it is the shallowest uncased formation which has the least formation strength. None of the above were detected, suggesting that the mud flow path was not through the wellbore.	Author's remarks: Davies' position on the mud path flow changed from the fracture at 3580 ft (casing shoe) in earlier papers (2007 and 2008) to 5000 ft in 2009 paper, where cement plug force the mud to fracture the formation. This is a major shift in concept. It is not clear i); how the new pressure analysis would look like. Are the dataset for performing this analysis assumed or measured; ii) How the fractures kept open given the higher overburden pressure at deeper depth compared to previous casing shoe depth; iii) How the 100,000 m^3/day of abrasive mud did not erode the wellbore and cause the >90000 lbs fish to fall. This rate represents almost 70% of total Indonesia's oil production from thousands of wells.

fractures below the cement plug at around 5000 ft. (as shown in Fig. 13B).

There are a number of inconsistencies with this claim:

1. The injection test performed one day after the first mud eruption and prior to the pumping of cement showed a high injection pressure (Sawolo et al., 2009). This is not consistent with a connection between the wellbore and the mud flow as shown in Fig. 13A (and based on Davies et al., 2008), as such a connection would result in a low pump pressure or even a vacuum.
2. The cement slurry was placed a day after the mud eruption was reported. The slurry was normal oilfield 15.8 ppg cement slurry mixed by Halliburton with a pumping time (setting time) of four hours. During these four hours, the cement had almost no cohesive strength or compressive strength; a very basic understanding of oil field's cementing property (Dowell Schlumberger, 1984). Therefore, if the mud were flowing up the wellbore, it would have immediately swept away the green cement slurry.
3. The pressure test after the cement had set indicated a good cement plug. Again, this is not consistent with setting a cement plug with mud flowing up the well. If mud were flowing up the wellbore, one would end up with no cement plug at all and no resistance to pumping.

The Authors disagree with Davies et al. (2010), that there was any fracture at the shoe or that the fractures moved deeper due to the cement plug that was laid one day after the mud flow had started. This is a physically impossible proposition.

6.12. Well condition before pulling out of hole

After the well was drilled to a depth of 9297 ft., it suffered a major mud loss of 130 bbls loss in 10 min. Loss-circulation material (LCM) was pumped into the wellbore and successfully plugged the losses and stabilized the well. The well was then monitored for around seven hours, during which time the well remained in a stable condition. The drill string was then started to be pulled out of hole. This is in contrast to Davies et al. (2010) claim that the decision to pull out of hole was made without verifying that a stable mud column was in place and it was done while very severe circulating mud losses were in progress.

This claim is not supported by the mud logger RTD, which shows the volume of the active mud tank was stable. Mud losses (if any) were very minor at 2 bbls in 4 h, representing 0.12% of total active mud volume. After fresh mud was added to the tank, the volume remained stable for another two hours (Table 1).

Authors' note: It is not practical to scan and attach the long hard-copy mud logger's RTD record to this paper. However, the Authors will make this RTD available to interested parties to verify the authenticity of this information.

The stable well condition was further supported by the drilling foreman, who wrote In the Daily Drilling Report of 28th May 2006:

> 'Spotted total 60 bbls loss circulating material, pull out of hole 4 stands of drill pipe to 8737 ft., monitor well through trip tank. ***Well static*** ...'

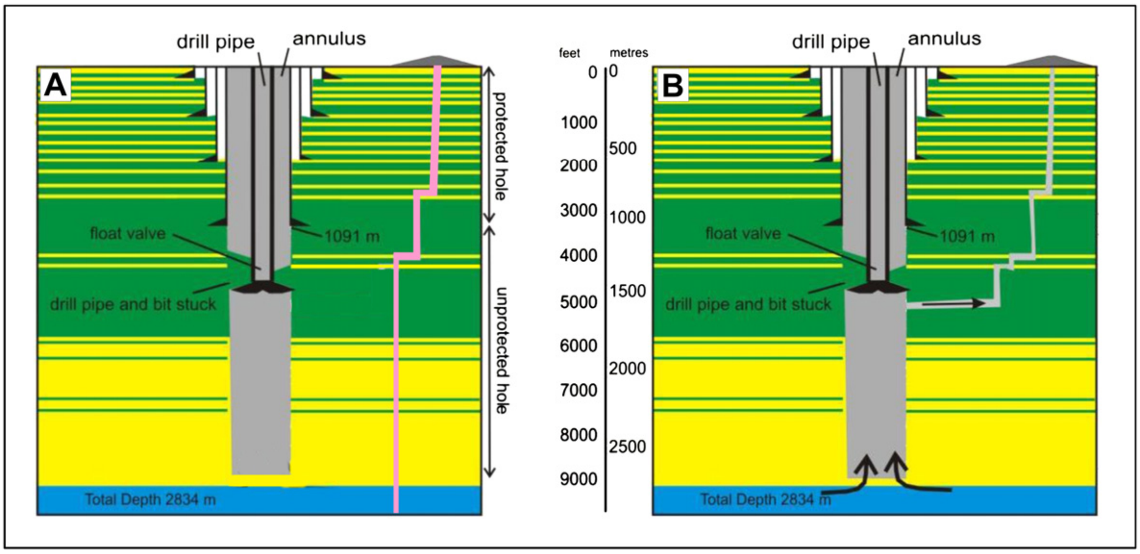


Fig. 14. The mud flow path proposed by Sawolo et al. (2009) (Fig. 14A) has no connection with the well, unlike that proposed by Davies et al. (2008, 2010) (Fig. 14B).

This statement shows that the foreman was certain that the well was in a static condition and the mud losses cured. At this condition, there is no reason why the operation of pulling out of hole cannot be started.

These evidence show that Davies et al. (2010), claim that the decision to pull out of hole was made *'without verifying that a stable mud column was in place and it was done while very severe circulating mud losses were in progress'* is again false. Davies et al. need to provide the evidence and data to support their claims.

7. Differences in opinion summary

In summary, the different opinions between Davies and his colleagues and the Authors are shown in Fig. 14.

Fig. 14A is the position taken by the Authors as described in the Sawolo et al. (2008, 2009) and further expounded in this discussion reply. It shows that the casing shoe was intact and the mud flow is independent from the Banjarpanji-1 well drilling. This conclusion is based on the analysis of fully integrated dataset and evidence from the well.

Fig. 14B is the position taken by Dr. Davies and his colleagues as described in the Davies et al. (2007, 2008, 2010), where it was claimed that the drilling operation triggered the mud flow. This claim is based on "cherry-picked" drilling data that supports their hypothesis and disregarded weightier dataset that does not, as shown in this discussion paper. The Authors believe that if Dr. Davies and his colleagues were to integrate all the available data into their analysis, then their conclusions would likely be different.

8. Conclusion

Early technical papers, such as Davies et al. (2008, 2007), Rubiandini et al. (2008) and Tingay et al. (2008) suggested a connection between the Banjarpanji-1 well and the mud volcano. These papers were based much on assumptions, unverified and partial dataset. It remains a mystery why these authors never asked or accepted our invitations to examine and access the drilling data that are open to them and any other scientists. It is unethical to use assumptions and unverified data from unknown sources for scientific publications especially considering the sensitivity of the subject and the social and economic consequences of its resulting statements and claims. When the full dataset is integrated as in Sawolo et al. (2008, 2009), it is evident that the data points to an intact casing shoe, and therefore no connection between the well and the mud volcano.

This discussion aims to fill data gaps in the earlier papers, specifically to detail:

1. The need to integrate the entire mud logger Real Time Data (RTD) into the analysis. RTD is the best data source because it is automated, continuous and quantitative, and it captures pressures, mud volumes and key operating parameters of the rig. Davies' papers used only a portion of this dataset and their conclusions are not supported by the full dataset.
2. How to determine which data to give more weight to, in instances of conflicting data. The authors of the early papers did not have access to the full dataset, and so they could not make a fully informed and rational decision on which data to use.
3. The importance of considering observational evidence outside of the RTD. This supporting evidence by itself may not be conclusive, but it helps to limit the range of uncertainty.
4. The need to update assumptions when new data becomes available. The Authors have presented additional new data which is mostly based on unbiased mud loggers RTD in Sawolo et al. (2008, 2009) and supplemented in this reply paper. The Authors find it odd for a rational scientist to continue to stick to assumptions and cherry-picked data when a full dataset is available. Numerous data sets used by Davies et al. are puzzling and inconsistent. For example Davies stated that *'We know that… in the Banjar Panji-1, the pore pressures at 2130 m… are 38 MPa (5500 psi)'*. First, what is the source and reference to this '*We know that*'? As no source is referenced in the technical paper. Second, this value is likely to be erroneous since it is strikingly higher than any of the six estimated pressures or other publicly available values. Other examples are the inconsistencies in data usage. It is difficult to understand the reason for the continually changing influx volume as it is reported without any justifications or documentations. This lack of consistency in Davies's claims, suggests a lack of understanding of the down hole conditions and the actual operations and hence the use of the many assumptions that leads to questionable conclusions. As the use of the complete dataset is of utmost importance, we continue our offer to any interested parties, scientists and drilling practitioners to scrutinize and verify the authenticity of the data.

The Authors' recent work strongly reinforces their position that the well remained intact, and there was no connection between the well and the mud volcano. The Authors disagree with Davies et al, that the casing shoe was fractured or that the fractures moved deeper due to the cement plug that was laid one day after the mud flow had started. Dr Davies et al, must know that newly laid green cement plugs cannot divert flow as they are non cohesive with low compressive strength. It is not understood why such a bizarre and physically impossible proposition is even considered.

The Authors recommend continuing the study of LUSI to help improve our understanding on the origin of mud volcanoes in the area. We must ensure, however, that any future work is done professionally and responsibly based on the result of one's actual field work, analyzing the complete dataset and the proper application of sound engineering practice.

8.1. Side note on the social side of LUSI

The Authors echo the sympathies of Dr Davies and his colleagues to the many families whose lives have been disrupted by LUSI mud volcano. It is a very unfortunate incident and there are no winners. The Authors are pleased to report that Lapindo Brantas Inc. has provided massive assistance to the villagers affected in terms of evacuation, emergency sheltering, financial assistance and permanent replacement accommodation. This assistance was provided for ethical reasons, independent of the legal process which eventually cleared all charges against Lapindo Brantas Inc. The magnitude of assistance provided by Lapindo Brantas Inc. is to our knowledge unprecedented in Indonesia.

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