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Hole Collapse Experience During Cleaning Flow in Wildcat Well in Denizli Field, Turkey

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ABSTRACT

As per the lithological properties and field practices it can be easily said that the metamorphic rocks in Aegean Region in Turkey are quite durable and stable. Based on previous experiences about the formation durability it was decided to perform the cleaning flow in open hole before running 7" slotted liner; however, it was observed that hole was collapsed unexpectedly and unusually. In this study it is tried to find the reasons behind this hole collapse case history. Sample and caving analysis are carried out as the main evidence of the problem occurs.

1. Introduction

Denizli Well was drilled close to Denizli city.

Figure 1: The figure above is the map view of the well

The closest well drilled by Turcas was 45 km. west of Denizli, also there was no any close offset wells drilled by other companies; nearest offset well is about 10 km away from the well. That is why the well can be categorized as a wildcat well.

The 9 5/8” casing was run to 1,592 m where the metamorphic rocks were first penetrated. The 8 ½” section was drilled to 2,675 m and from 9 5/8” casing shoe till total depth (TD) only metamorphic rocks are drilled. However, the rate of penetration (ROP) in the metamorphics was quite higher than the offset wells of Turcas. While drilling, it was observed that the metamorphism degree of the Menderes Metamorphics is pretty low compared to Turcas offset wells, which are located approximately 60 km west.

At TD, a Pressure-Temperature Survey was taken and it was decided to abandon the hole due to the low bottom hole temperature, and thus the well would be terminated without running 7” slotted liner due to the economic reasons. During the final trip when reaching the 9 5/8” casing shoe hole was displaced by water and well flow was observed unexpectedly. Because of the natural flow it was decided to perform a cleaning flow in open hole without running 7” slotted liner. The cleaning flow was held around 8 hours with a compressor. During the test, 71 °C temperature on surface and 142 tons/hr flow were observed. Just after the test it was observed that the weir box was completely full of clays sized formation cuttings. Because the results were higher than the expectations it was decided to run 7” slotted liner to the bottom. Prior to run 7” slotted liner it was decided to hold a bit trip to check the hole conditions. However, just on the 9 5/8” casing shoe depth, hole drag was observed and it was required to perform hard reaming in all open hole section. Hard reaming was hold from 9 5/8” casing shoe to 2,572 m. where the last marble lithology was observed. Reaming last around 41 hours, although hole was circulated for couple of bottoms up prior to run 7” slotted liner cutting and cavings were still being observed on surface. Then 7” slotted liner was run successfully to 2,572 m. without any drag and the well was abandoned.

In the following sections the operations sequences are explained in detail and it is tried to find the causes of hole collapse. Also lessons learnt are included in order to optimize future operations and eliminate similar problematic cases.

2. Operational Sequences

2.1 Drilling 8 ½” Hole Section

9 5/8” casing was run to 1,592 m and performed cementing operation with 80% excess. However, only cement contamination was observed on surface, although there was no loss during the operation.

8 ½” section was drilled from 1,592 m to 2,675 m. with directional assembly and tricone bit. ROP was quite higher than the other offset wells of Turcas which are 45 km west of Denizli Well. Especially from 1,800 m to 2,000 m ROP was gradually increased from 5m/hr to 15 m/hr. Then it was gradually decreased to 5 m/hr again from 2,000 m to 2,400 m.

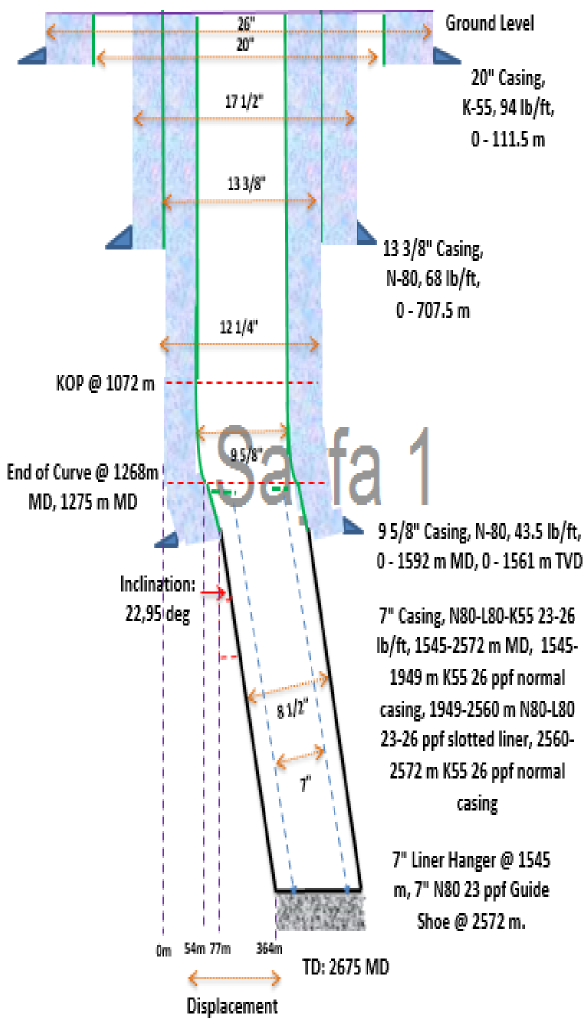

Figure 2: The figure above is Denizli Well sketch

While drilling there was no major caving observation on surface. At 1,812 m the string was mechanically stuck in Quartzite lithology while sliding, acid operation was conducted with success to free the string. The stuck was considered as a mechanical stuck due to the under gauged bit which became smaller gauge than bearing stabilizer. Before the acid spot several attempts were tried with oil spud without success. For the future cases acid spot is recommended to be tried directly as soon as possible. It was the only unusual case while drilling. 8 ½" hole section was drilled without any other trouble.

The well was drilled directionally, however directional drilling reduced the efficiency of operations and it limited total depth to be drilled due to the pick-up/slack-off weight and torque/drag.

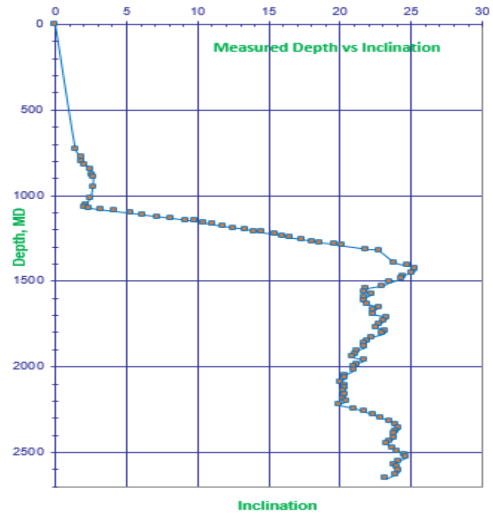

Figure 3: The figure above is measured depth vs inclination

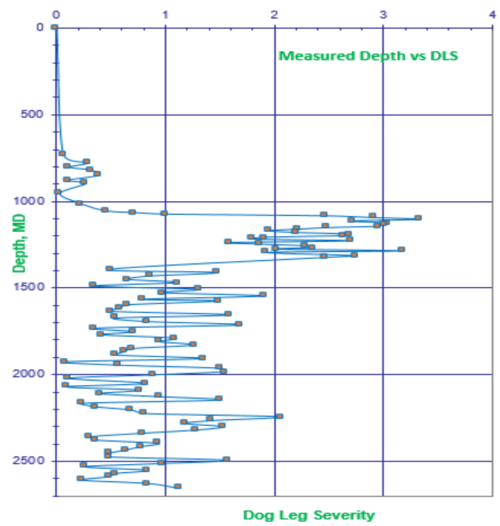

Figure 4: The figure above is measured depth vs dog leg severity

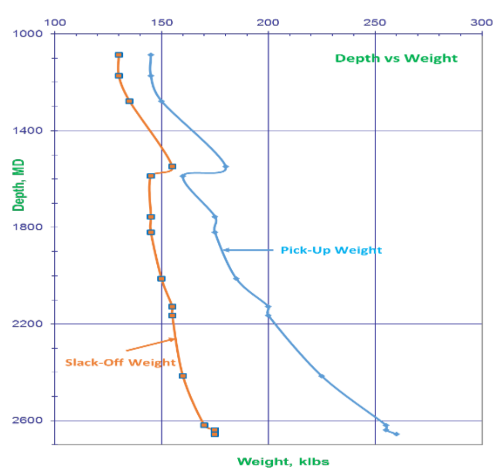

Figure 5: The figure above is measured depth vs pick-up / slack-off weight

After completing drilling phase, the Pressure-Temperature Survey was taken with open end drill string, maximum bottom hole temperature was measured as 78 °C on bottom and it was decided to abandon the hole.

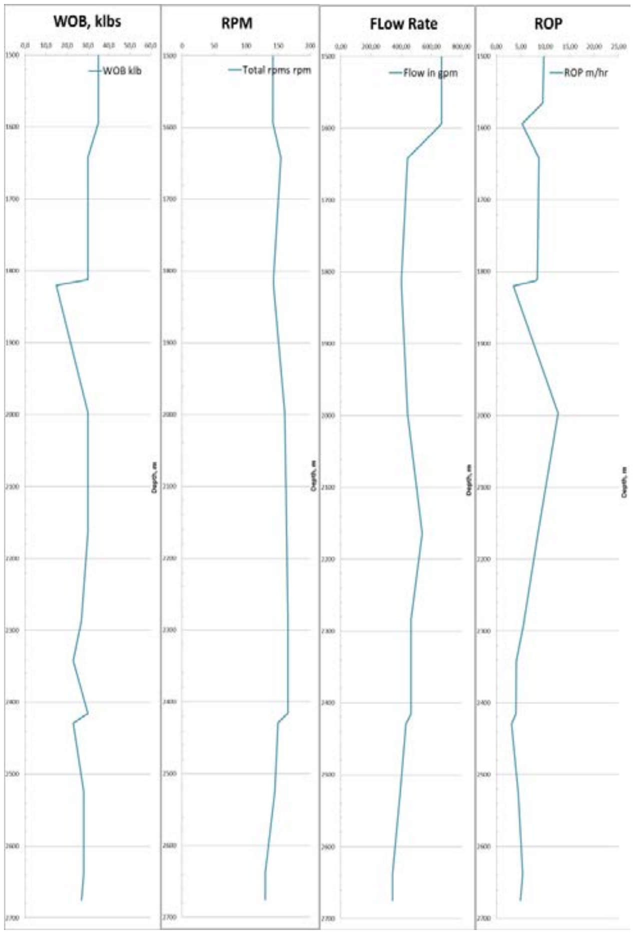

Figure 6: The figure above is Denizli Well 8 ½" hole drilling parameters

Just after Pressure – Temperature survey it was tried to pump inside the drill pipes; however, it was observed that drill pipes were plugged. The pipes were tripped out and 20 m of drill collars on bottom was seen totally plugged with formation cuttings.

Figure 7: The figure above is the formation cuttings inside the drill collars

2.2 Cleaning Flow Operations

After the decision taken to abandon the hole it was decided to displace the hole with fresh water on 9 5/8” casing shoe. After displacing the hole it was observed natural flow (8-10 tons/hr), and then it was decided to perform cleaning flow by means of compressor.

5” open end drill pipes were run to 350 m and cleaning flow was performed around 8 hours by means of compressor because of the limited capacity of the mud pit. Testing results included maximum temperature on surface at 71 °C, maximum flow with compressor of 142 ton/hr, maximum flow with natural flow of 44 ton/hr.

At the end of the cleaning flow it was seen that the weir box level was stable and weir was full of clay sized cuttings which were not seen while drilling. Also mud pit was discharged by vacuum truck and it was seen that the mud pit was full of the same clay sized cuttings.

Figure 8: The figure above is the clay sized cuttings in mud pit cuttings during the cleaning flow

2.3 Running 7” Slotted Liner

As per the cleaning flow results which were better than expected it was decided to run 7” slotted liner on bottom. Prior to liner running it was decided to hold a bit trip to check the hole conditions.

First 50 bbl mud was pumped to kill the well but well flow continued. Then slick BHA was run to 9 5/8” casing shoe and from casing shoe to surface well water was displaced by 8.8 sg mud, hydrostatic balance was stabilized.

During the circulation intense formation cuttings was seen on shale shakers.

Figure 9: The figure above is the formation cuttings on shale shakers while circulating at 9 5/8” casing shoe

It was tried to run on elevator; however, the drill string drag was seen just on the 9 5/8” casing shoe. Then hard reaming was started from casing shoe, during circulation pack off and excessive over pull / torque were seen couple of times. Also excessive cuttings and cavings were observed on shaker all through reaming interval.

Figure 10: The figure above is the cavings and cutting samples while reaming

Figure 11: The figure above is the cavings and cutting samples while reaming in mud pit

Reaming from 1,591 m to 2,572 m lasted for 41 hours with 8.9 ppg new mud. At 2,572 m it was decided that the 7” slotted liner depth was the last depth of marble lithology.

When reaching 2,572 m hole was circulated for couple of bottoms up, the quantity of formation cutting and cavings gradually decreased; however, they continued to be seen on the surface. During the circulation 20-25 bbl/hr partial loss was observed. Then string was tripped out to surface without any major over pull.

At the end, 7” slotted liner was run to 2,572 m and hanged to 1,545 m inside 9 5/8” casing without any problem.

3. Geological Analysis

In this part it is tried to find the reasons behind this hole collapse case history. Sample and caving analysis are carried out as the main evidence of the problem occurs.

3.1 Lithological Analysis of Formations While Drilling

Turkey has a high geothermal energy potential. The Aegean region is one of the most active extensional regions in the world. Buyuk Menderes Graben system is a tectonically active extensional region and is undergoing N–S extension leading to form geothermal fields in the graben. Buyuk Menderes geothermal systems have high enthalpy reservoirs with temperature range of 120 - 240 °C (Öngür, 2010) and the graben is a structure with dimensions of about 160 km long and 8-12 km wide.

Denizli Well is located in the eastern part of Buyuk Menderes Graben. The stratigraphic sequence of the Denizli/Karakova geothermal field consists of Paleozoic metamorphic rocks of the Menderes massive and sedimentary rocks deposited during the Miocene and Pliocene. Denizli Well was drilled 2,675 m in depth. Geological stratification of Denizli Well from surface to 1,574 m consists of sedimentary rocks of claystone, sandstone, conglomerate, marl and limestone. The top of the Paleozoic aged Menderes metamorphic rocks penetrated at 1,574 m. Between 1,574 – 2,166 m, quartz schist – quartzite – mica schist intercalation was drilled. In this interval, the metamorphism degree of the Menderes Metamorphics is low compared to Turcas offset wells. At some levels quartzite resemble their weaker metamorphosed equivalent meta-sandstone. Also fault surfaces and carbonate deposits increased in this interval. Most of the quartzite cuttings give weak reaction with HCL that indicates hydrothermal fluid circulation.

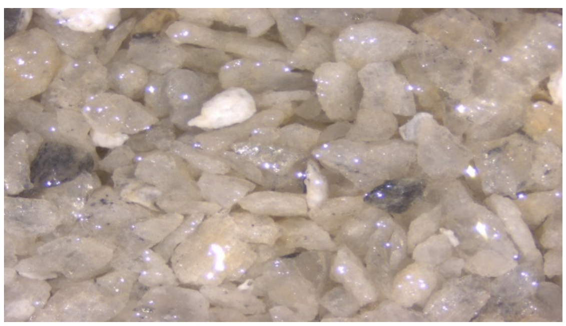

Figure 12: The figure above is some of quartzite cutting grading to meta-sandstone

Marble – calc schist was the dominant lithology between 2,166 – 2.280 m, between 2,280 – 2,400 marble dominated, and marble, mica schist, quartz schist, quartzite lithologies were then drilled to 2,470 m, including 70 m of pure marble. This section can be seen as main reservoir. Partial mud losses occurred starting with 2,420 m. Starting with 2,470 m, meta-dolomites appeared and meta-dolomite, marble lithology was drilled until 2,564 m.

Figure 13: The figure above is a marble sample from Denizli Well

At the bottom, approximately 100 m thickness of quartz schist - chlorite schist - mica schist lithologies was drilled and 2,675 m was picked as the TD of the Denizli Well.

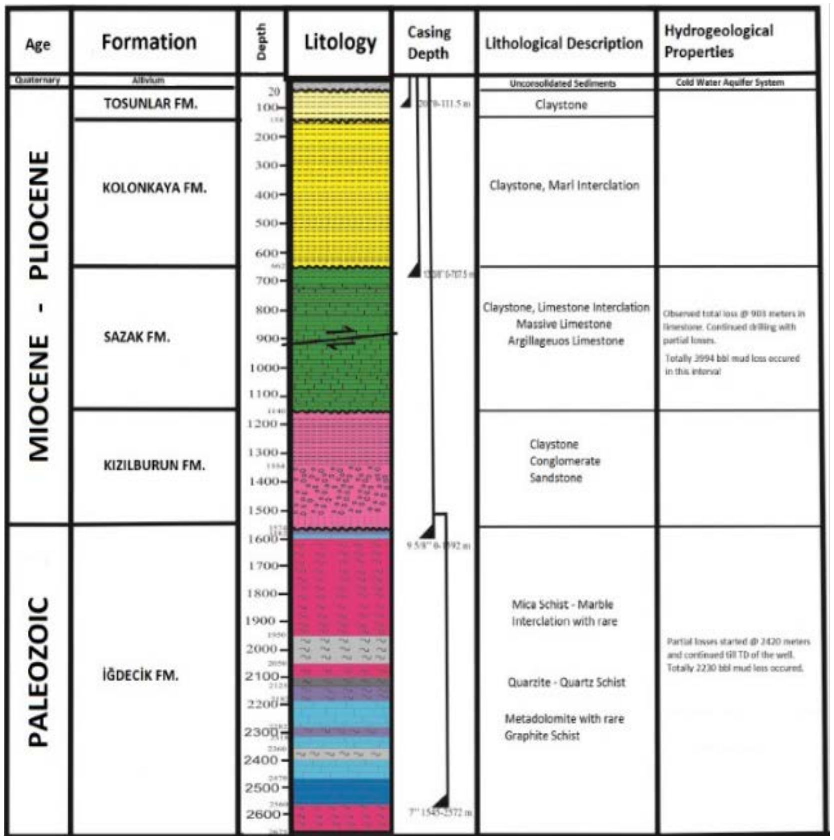

Figure 14: The figure above is Denizli Well stratigraphic log

3.2 Lithological Analysis of Cuttings and Cavings Observed While Cleaning Flow

After the cleaning flow it was observed that weir was full of clay sized cuttings. These clay sized cuttings might be interpreted as cements of low metamorphosed levels. Also, in the 8 ½" section there were observed fractured and altered levels, and clay sized cuttings might be the products of these levels.

After the cleaning flow it was decided to run 7" slotted liner. Prior to setting 7" liner it was decided to RIH with bit to check hole conditions. While RIH to bottom the drill string drag was seen just on the 9 5/8" casing shoe. Decided to ream the well. During reaming intense amount of cuttings seen on shakers. Cavings were collected and studied under binocular microscope. No marble or meta dolomite was observed as cavings, and instead, almost all of the cuttings were identified as low metamorphosed quartzite that graded to meta-sandstone, quartz schist and some of mica schist that was seen between 1,595 – 2,095 m.

4. Conclusion

In wildcat wells with limited lithological information it is not a good practice to drill a deviated hole. In this case it affected the hole cleaning efficiency while reaming after the cleaning flow.

Also it is advised to run 9 5/8” production casing much deeper as close as the reservoir in order to cover all unstable formation and possible low temperature aquifers. In this case 7” slotted liner was run successfully to the desired depth; however, it is not sure if formation cuttings and cavings would fill up inside the 7” slotted liners during the lifecycle of the well.

Bottom hole temperature was much lower than what was expected and it was very risky to continue drilling while formation was very unstable. However, if 9 5/8” production casing was covering all unstable lithologies there would be a chance to penetrate much deeper and find a much hotter reservoir. In this case it is advised to drill 8 ½” section much deeper.

It was not a good practice to perform a cleaning flow in open hole without running 7” liner where there was lack of experiences on formation stability. It is highly recommended to displace the hole with fresh water and perform the cleaning flow after running 7” slotted liner.

The well was temporarily abandoned; however important geological information was gathered in a wildcat field. A PT Log will be run after one month in the borehole. According to the PT Log result, alternative solutions for electricity can be examined such as tourism, district heating, greenhouse, modern agriculture techniques utilizing geothermal sources, hybrid renewable power generation.

The future deeper wells are planned to be drilled in the field; the information gathered and experiences had will be very useful for the efficiency of future wells’ operations. The license owner aims to find a much hotter reservoir in the deeper zones.

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