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# Frederick Farm Well Contamination: Borehole Camera Analysis of Bedrock Structure

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# Frederick Farm Well Contamination

## Borehole Camera Analysis of Bedrock Structure

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**Abstract:**

A borehole camera analysis was conducted at the Frederick Farm to characterize bedrock structure, quantify fractures, and establish the condition of the well casing. Through the use of a GeoVISION Jr.™ and recording equipment, footage of the camera decent was recorded for data analysis. The 5 ft well casing appeared intact and was properly constructed within bedrock. The well above the water table contained few fractures and appeared to be weathered. Flowing water was visible in the two main fractures, located on the south (5.5 ft depth) and south-western (13.5 ft depth) walls of the well respectively. The water table interface was observed at 31.125 ft depth. Below the water table the well was laden with many fractures. The size of the fractures appear to increase in size with depth, with the larger fractures approaching ~1 ft in thickness. Also noted in this interval were areas of enhanced chemical weathering, particularly below 62.5 ft. The bedrock fracture profile is indicative of a well built within heavily fractured karstic limestone.

**Introduction:**

Following a well contamination event at the Frederick Farm (Figures 1 and 2) in Phelps, NY, a borehole camera analysis was conducted on 11 April, 2015 by Michael D. Rodgers, a Graduate student in the Department of Biology and Environmental Science, and Hydrogeologist Paul L. Richards. The purpose of this analysis was to characterize the condition and location of bedrock fractures, and determine if there were any hydrologically active fractures present. It was also conducted to evaluate if the well casing was intact and assess if there was any leakage from within it. This work was carried out Pro-Bono, with no compensation given to any personnel involved.

**Equipment/Software:**

The analysis was conducted with a GeoVISION™ Borehole Camera case and system from Mark's Products Inc. Included in this system is a GeoVISION Jr.™ borehole camera with built in LEDs, a GeoVISION™ cable and wench system. The camera is a high resolution, submersible, black and white camera designed to be used in boreholes and wells. A PVC Flow Guard (ASTM D-2846) attachment and a compass attachment were also used. The audio/video was recorded with a Sony DVD Recorder (VRD-MC6), a microphone attachment, and then saved to a Staples 4.7GB DVD-R. Camera footage was also displayed in real-time on a Microvision (MTV-7SIRV4) 7" monitor. A VLC Media Player Software was used for video analysis/playback and video format conversion. Videos copied to Staples 700 MB CD-R. Microsoft's Snipping Tool were used for video screen-captures. All data was imported into Microsoft Excel for subsequent analysis.

**Methodology:**

At the start, the equipment was hooked up properly in accordance with the user's manual and tested for functionality. The well's pump stringer was removed to allow the well to accommodate the camera. Next the GeoVISION Jr.™ borehole camera was inserted into the well at a depth of 1 ft which is the "0 ft" mark on the GeoVISION™ cable and wench system. The video and audio voiceover recording was started using a Sony DVD Recorder with an attached microphone. The project location, date and purpose was introduced to the video audience prior to lowering the GeoVISION Jr.™ borehole camera into the well. Incremental depths were noted in the voiceover. Interesting features -- well casing, fractures, water flow, water table, ledges, and the well base -- were recorded in voiceover along with their depth and size/thickness. The camera was lowered at an average rate of ~2 ft/min. Features were described throughout the camera descent in real time. Once the base of the well was reached, the camera was pulled back up through the well and the video recording was stopped. A second camera run through the upper portions of the well was also conducted with a compass attached to the camera in order to determine feature direction. Audio and video was played back on a computer in VLC Media Player and analyzed. Screenshots were captured with Microsoft's Snipping Tool and all data was recorded in a Microsoft Excel spreadsheet. Data was than compiled into a succinct table (Table 1) and an associated graph (Figure 3). Video file format was converted into mp4 with VLC Media Player and then burned onto Staples CD-R discs to provide copies as needed.

**Results:**

*Casing:*

The analysis borehole camera footage showed that the well casing is intact. The well casing extended from the top of the well (ID #00) with rust scale in places (ID #01) -- likely due to the oxidation of the pump as it sat within the casing --down to a depth of 5 ft (ID #02). Visibility is quite good due to the lack of water and debris. No leakage was observed within the well casing, and the base of the casing was determined to be within bedrock.

*Results Above the Water Table:*

Visibility in the well was excellent, due to lack of water and debris. Just below the casing, at a depth of 5 ft was a possible fracture (ID #03), with a fracture just below that at 5.5 ft depth (ID #04). This fracture appeared to have water flowing through it and into the well. A second camera run with a compass attached shows this fracture to be located on the south side of the well. There was a small fracture (ID #05) at 11 ft depth, characterized by a darkening of bedrock which appeared to be wet. A large fracture (ID #06) was observed at a depth of 13.5 ft. Water appears to be flowing in from this fracture; the second camera run with a compass showed this fracture to be centered on the south-western wall of the well. A large fracture (ID #07) was located at a depth of 25.5 ft. This fracture appeared wet, but it was inconclusive as to whether water was actually flowing in from it; it is likely that the moisture observed was from falling water due to the cascading fractures above it. A small circular void fracture (ID #08) at a depth of 31.75 ft appears mostly dry; the water table, as well as floating pump debris is also evident at this level. The water table interface (ID #09) is located at a depth of 31.125 ft. Throughout this interval, differential chemical weathering of the well walls is evident, as noted by the uneven nature of the sides of the borehole.

*Results Below the Water Table:*

The range of visibility in this interval was reduced due to water and suspended debris. The first below water table fracture (ID #10) occurred at a depth of 34 ft and appears quite small. The top of the next fracture (ID #11) is at a depth of 34.75 ft; this fracture is large with a thickness of ~1 ft. This fracture also has pump debris lodged in it. At a depth of 36 ft, another large fracture (ID #12) is visible; this fracture is also ~1 ft thick. At 37 ft a third large fracture (ID #13) with a thickness of ~1 ft is observed. These three fractures (ID #11, #12, #13) are separated from one another by thinly bedded, weathered bedrock. A small void fracture (ID #14) is located at a depth of 38.75 ft within an interval of well wall that appears to be uniform. A fracture (ID #15) is at a depth of 40.5 ft within featureless wall. At a depth of 43 ft, several thin, clustered fractures (ID #16) are located; this feature was not noticed live, and as such are not noted in the voice over. A moderately-sized fracture (ID #17) is at a depth of 45.25 ft. A small fracture (ID #18) possibly with rock debris still within it is located at 46 ft. It too was not noticed in the live footage and voiceover and was observed during post-processing. Several small and thin fractures (ID #19) begin at a depth of 48 ft and extend down to 49 ft. At the base of these fractures lies another larger fracture (ID #20) starting at a depth of 49 ft. A fracture (ID #21) at a depth of 50.5 ft appears to be circular shaped void. The next fracture (ID #22) is located at a depth of 51 ft. Fracture (ID #23) appears to be a series of small fractures extending from a depth of 52.5 ft to 53.5 ft; these are characterized as one feature due to the small space between the individual small fractures. Just below this feature at a 53.5 ft depth is a large, moderately thick double-fracture (ID #24) with a thin slab of bedrock sandwiched between. At a depth of 54.5 ft is a small fracture zone (ID #25) with weathered bedrock. A fairly large, moderately thick fracture (ID #26) is located at a depth of 55.5 ft. At a depth of 57.8 ft is another

series of small, thin fractures (ID #27). At 59.25 ft depth is a large, ~0.5 ft thick fracture (ID #28). At 59.8 ft depth there is another large, ~0.5 ft thick fracture (ID #29), laden with rock debris. At a depth of 60.25 ft is a moderate sized fracture (ID # 30); right below it, at a depth of 60.75 is another moderate fracture (ID #31). At a depth of 61.75 is a vertical joint-fracture (ID #32) that extends down the well wall for ~0.5 ft. At 62.5 ft depth is a fracture (ID #33), below which the wall appears to be very chemically weathered; this zone extends down to 65.5 ft and encompasses the next fracture feature. At 64 ft depth is a large, moderately thick fracture (ID #34) within this heavily weathered interval. A set of small fractures (ID #35) and weathered bedrock is located at a depth of 67.5 ft. There is a bedrock intrusion (ID #36) into the well covered with debris rock and dust fragments. Just below the bedrock intrusion, at a depth of 69.5 ft is a series of small fractures (ID #37) and heavily weathered bedrock; visibility has decreased at this point due to disturbing the debris located on top of the prior bedrock intrusion. At 70 ft depth is a large, moderately thick fracture (ID #38); this appears to be the last fracture within this well. At 71.5 ft depth, the camera encountered the base of the well (ID #39).

**Discussion:**

The well casing was completely intact for this well and appeared to have no leakage within it. The casing was also built properly within bedrock. There was a cascading fracture located just below it at 5.5 ft depth. This fracture, located on the south side of the wall, allows for the flow of water and any contaminants within shallow bedrock to flow directly into the well. Similarly, a fracture at 13.5 ft depth on the south-western wall is also allowing water to flow directly into the well. The unsaturated zone had few fractures other than the two main ones that had flowing water. This zone also had evidence of chemical weathering. The saturated zone had far more/ and more frequent fractures, including large fractures which were as wide as ~1 ft of thickness. There was a lot of chemical weathering in the deeper part of the well, below 62.5 ft. Flow direction was unable to be measured because the water movement was low. In summary, the well appears to be built within heavily fractured and weathered karstic limestone. Some of these fractures appear to be hydrologically active.

**Table 1:** Raw fracture data derived from borehole camera videos.

| ID # | Depth (ft) | Mark (ft) | Time (Video #) | Thickness (ft) | Orientation | Direction |
|---|---|---|---|---|---|---|
| 00 | 1 | 0 | 0:00 (1) | NA | NA | NA |
| 01 | 3 | 2 | 2:06 (1) | NA | NA | NA |
| 02 | 5 | 4 | 3:00 (1) | NA | NA | NA |
| 03 | 5 | 4 | 3:05 (1) | NA | NA | NA |
| 04 | 5.5 | 4.5 | 4:23 (1) & 0:42 (4) | NA | Horizontal | S to N |
| 05 | 11 | 10 | 5:40 (1) | NA | Vertical | NA |
| 06 | 13.5 | 12.5 | 6:45 (1) & 1:31 (4) | NA | Horizontal | SW to NE |
| 07 | 25.5 | 24.5 | 9:35 (1) | NA | Horizontal | NA |
| 08 | 31.75 | 30.75 | 11:15 (1) | NA | Void | NA |
| 09 | 33.125 | 32.125 | 11:48 (1) | NA | NA | NA |
| 10 | 34 | 33 | 12:08 (1) | NA | Horizontal | NA |
| 11 | 34.75 | 33.75 | 12:34 (1) | ~1 | Horizontal | NA |
| 12 | 36 | 35 | 13:07 (1) | ~1 | Horizontal | NA |
| 13 | 37 | 36 | 13:18 (1) | ~1 | Horizontal | NA |
| 14 | 38.75 | 37.75 | 14:10 (1) | NA | Void | NA |
| 15 | 40.5 | 39.5 | 0:34 (2) | NA | Horizontal | NA |
| 16 | 43 | 42 | 1:08 (2) | NA | Horizontal | NA |
| 17 | 45.25 | 44.25 | 1:34 (2) | NA | Horizontal | NA |
| 18 | 46 | 45 | 1:46 (2) | NA | Horizontal | NA |
| 19 | 48 | 47 | 2:16 (2) | NA | Horizontal | NA |
| 20 | 49 | 48 | 2:32 (2) | NA | Horizontal | NA |
| 21 | 50.5 | 49.5 | 3:10 (2) | NA | Horizontal | NA |
| 22 | 51 | 50 | 3:31 (2) | NA | Horizontal | NA |
| 23 | 52.1 | 51.1 | 3:54 (2) | NA | Horizontal | NA |
| 24 | 53.5 | 52.5 | 4:26 (2) | NA | Horizontal | NA |
| 25 | 54.5 | 53.5 | 4:45 (2) | NA | Horizontal | NA |
| 26 | 55.5 | 54.5 | 5:00 (2) | NA | Horizontal | NA |
| 27 | 57.8 | 56.8 | 5:32 (2) | NA | Horizontal | NA |
| 28 | 59.25 | 58.25 | 6:09 (2) | ~.5 | Horizontal | NA |
| 29 | 59.8 | 58.8 | 6:33 (2) | ~.5 | Horizontal | NA |
| 30 | 60.25 | 59.25 | 6:48 (2) | NA | Horizontal | NA |
| 31 | 60.75 | 59.75 | 6:56 (2) | NA | Horizontal | NA |
| 32 | 61.75 | 60.75 | 7:15 (2) | ~.5 | Vertical | NA |
| 33 | 62.5 | 61.5 | 7:35 (2) | NA | Horizontal | NA |
| 34 | 64 | 63 | 8:14 (2) | NA | Horizontal | NA |
| 35 | 67.5 | 66.5 | 8:38 (2) | NA | Horizontal | NA |
| 36 | 68.75 | 67.75 | 8:43 (2) | NA | NA | NA |
| 37 | 69.5 | 68.5 | 9:43 (2) | NA | Horizontal | NA |
| 38 | 70 | 69 | 9:55 (2) | NA | Horizontal | NA |
| 39 | 71.5 | 70.5 | 10:10 (2) | NA | NA | NA |

**Figure 1:** View of Franklin Farm from NY I-90. Image via Google Maps Street View. Well house is small red building in front of the main white barns (not the red building off to the side.


**Figure 3:** View of Franklin Farm from the air. Image via Google Maps. Well house visible as small white roof; bottom-left most building.

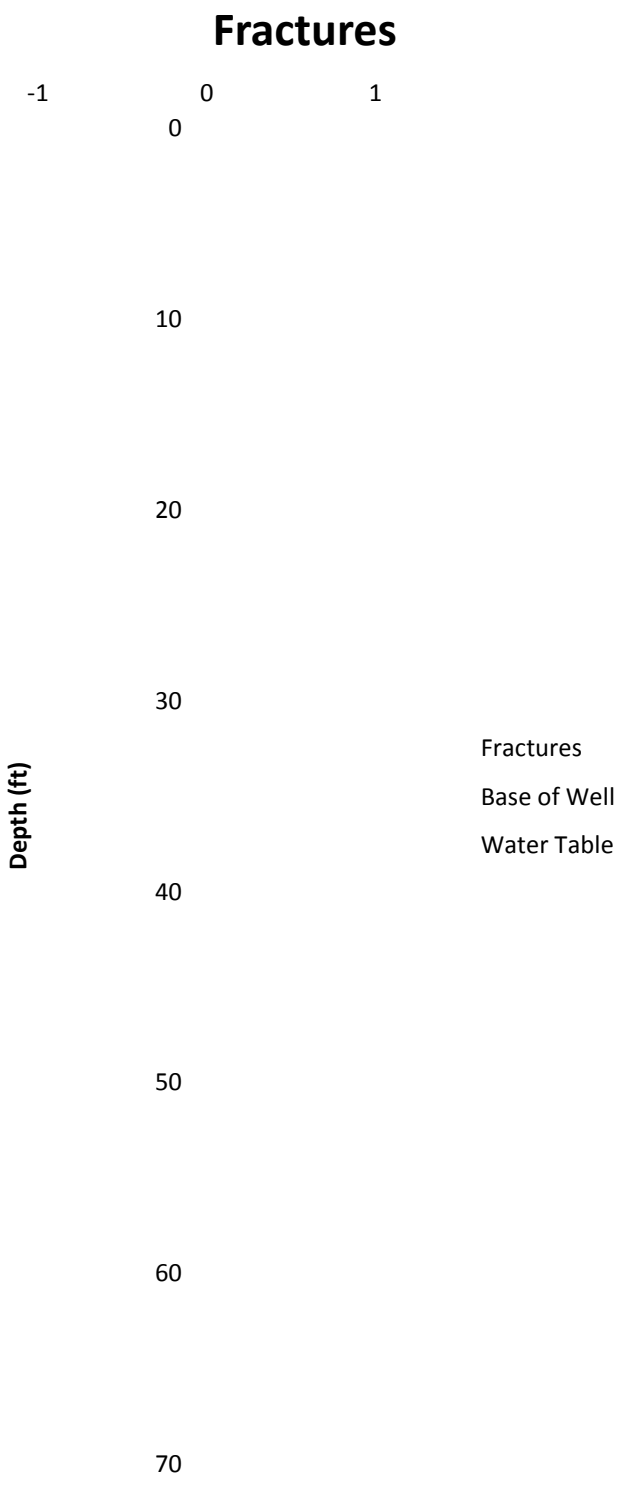
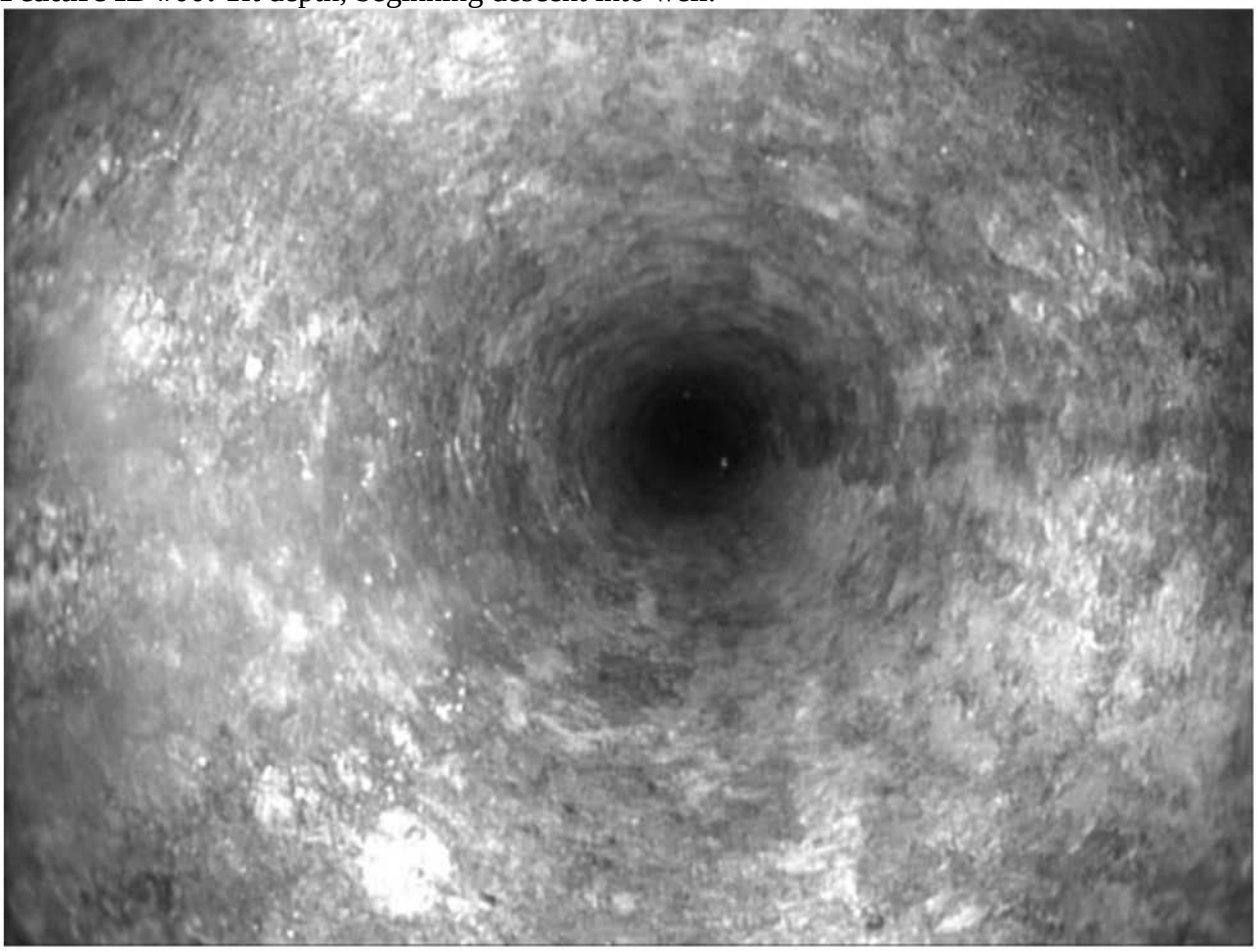


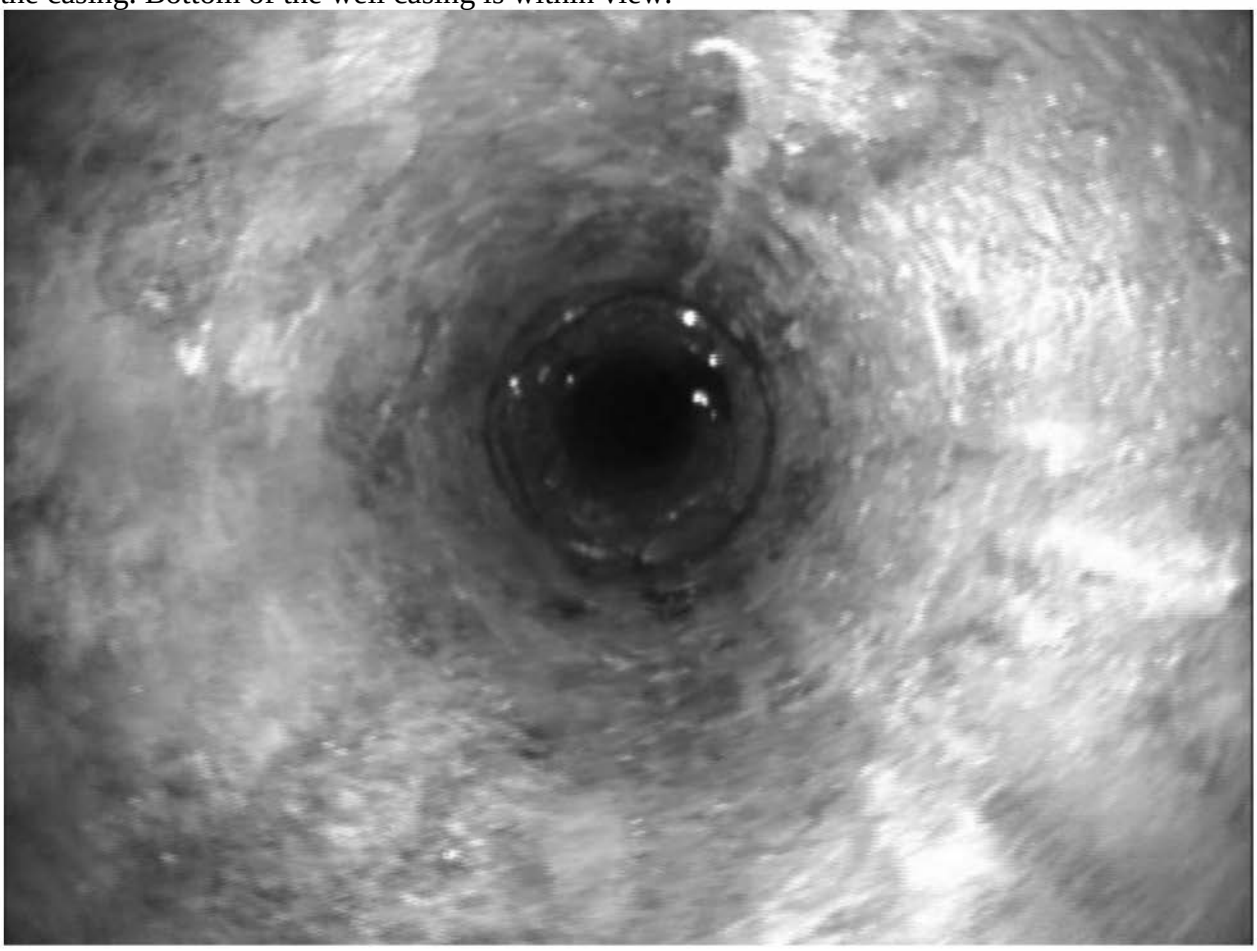

**Figure 3:** Graph of fracture depth. Points represent upper edge of fracture, not entire widths/depths.

**Appendix:**

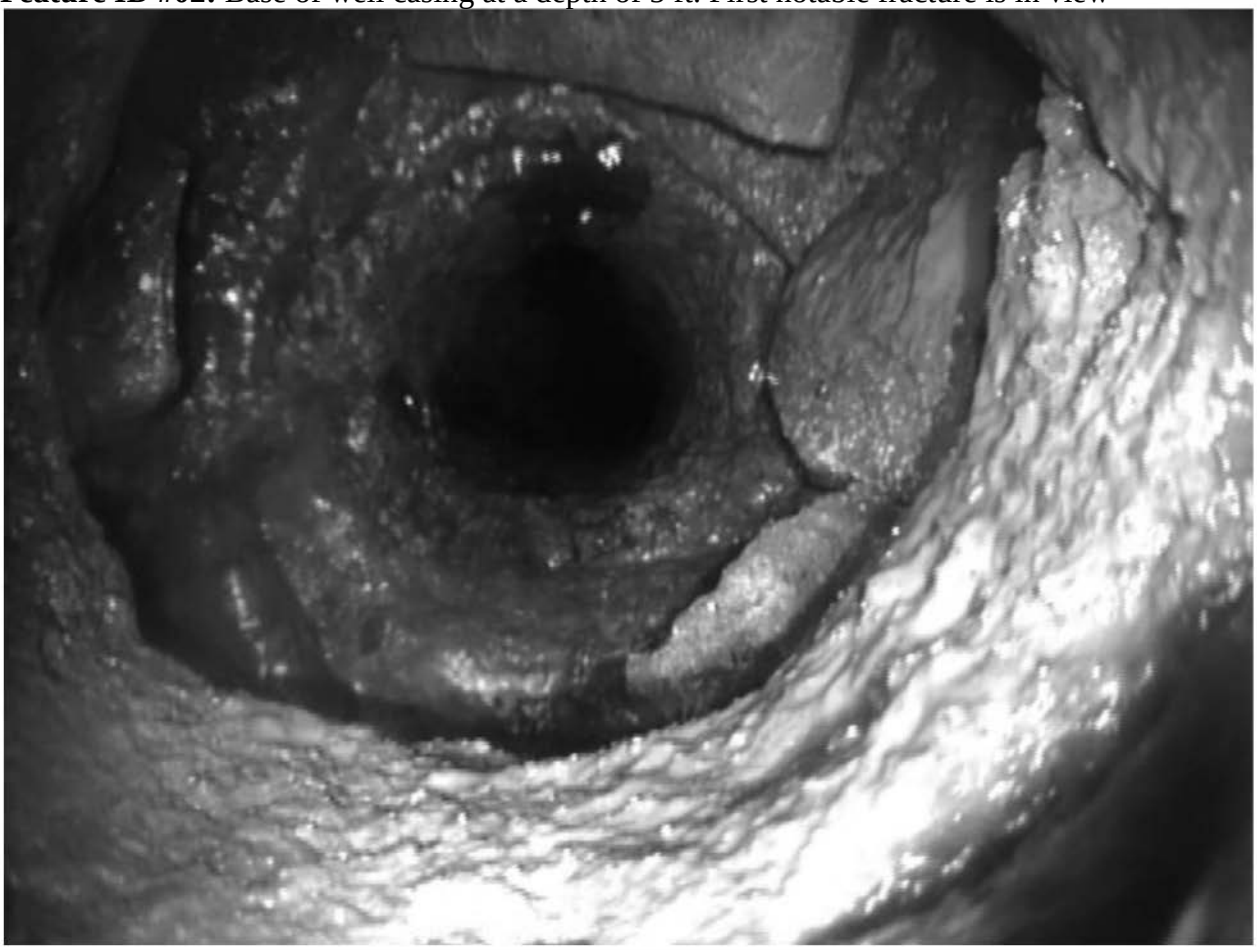
**Feature ID #00:** 1ft depth, beginning descent into well.



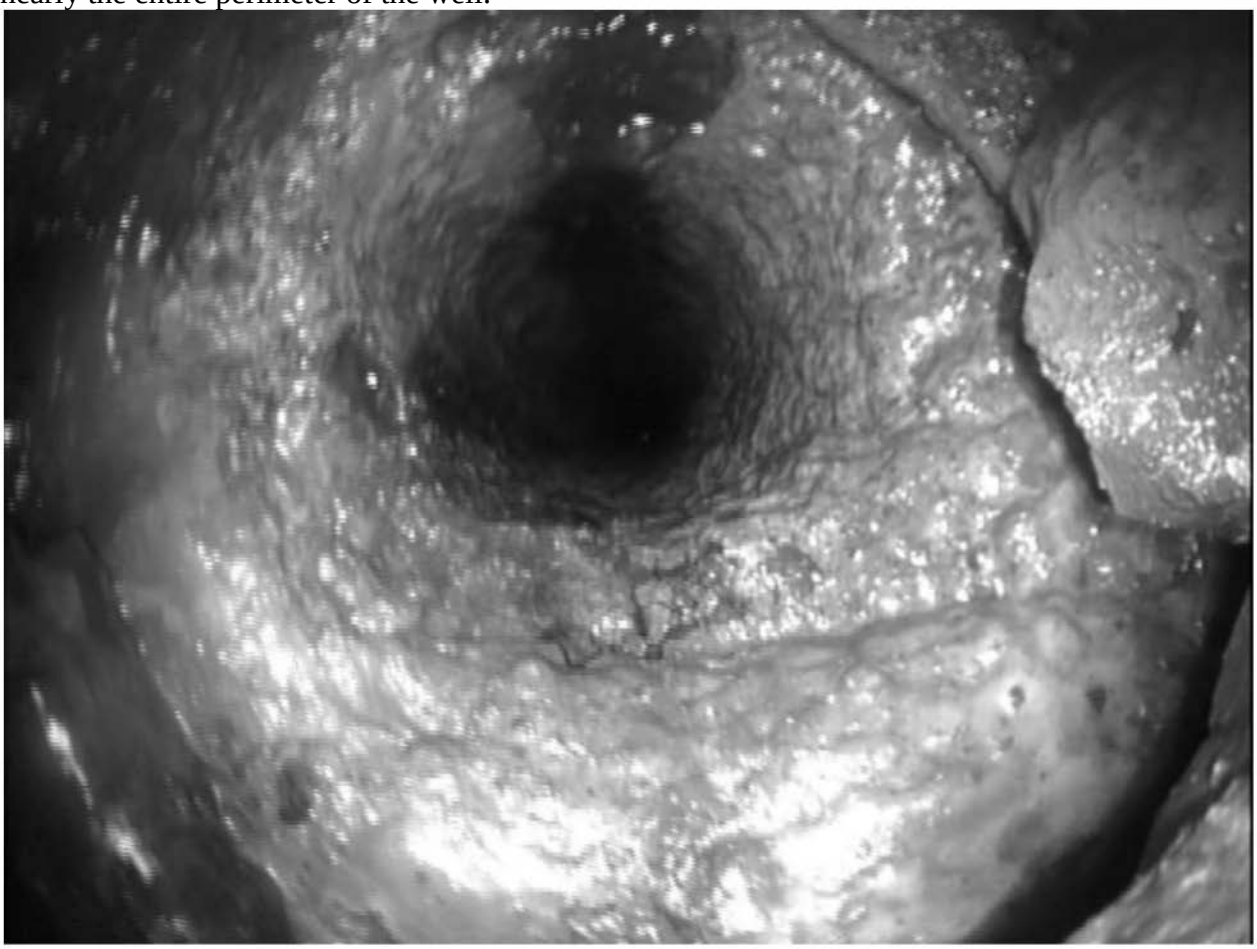
**Feature ID #01:** Halfway through the well casing at 3 ft depth. Some rust scale on the sides of the casing. Bottom of the well casing is within view.



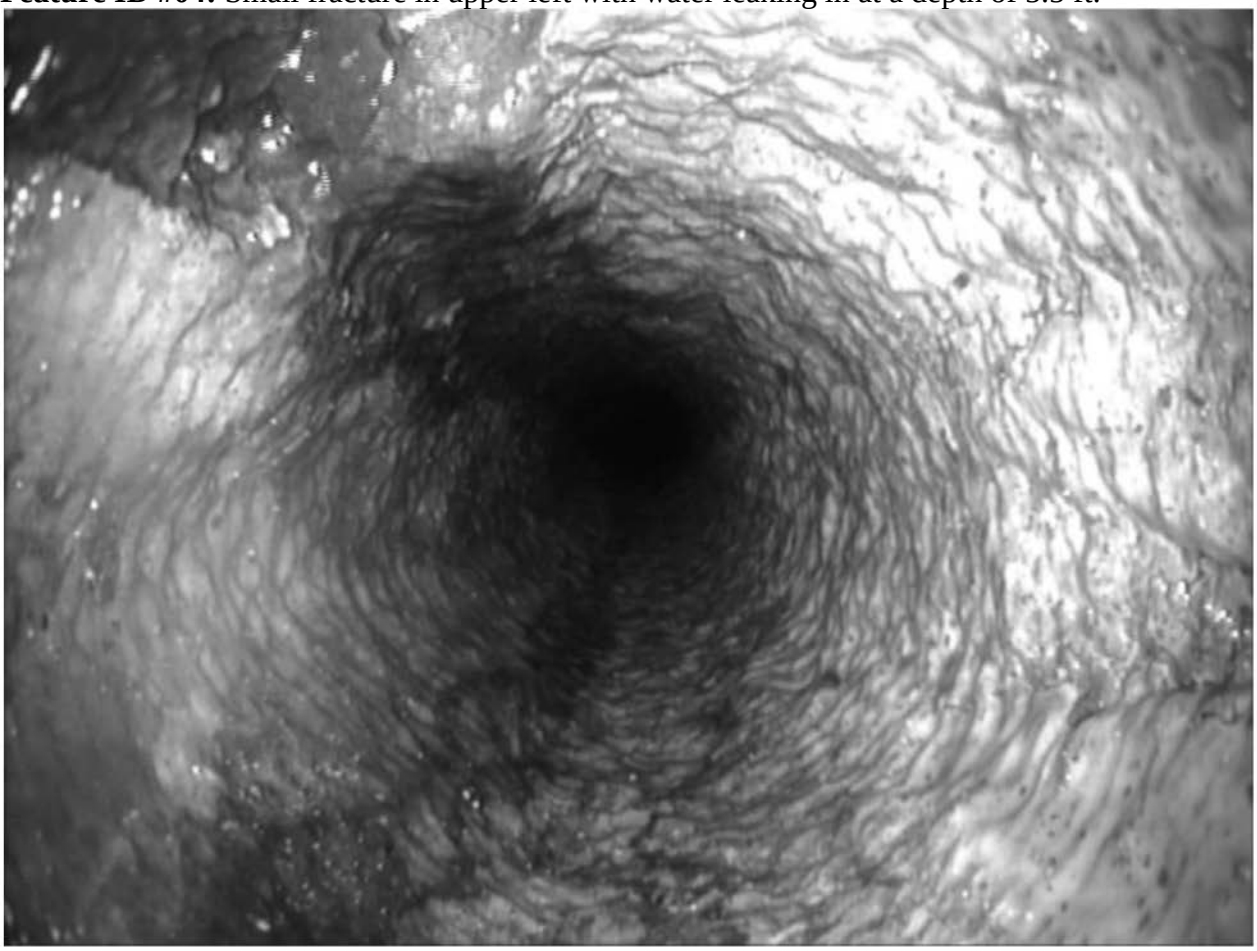
**Feature ID #02:** Base of well casing at a depth of 5 ft. First notable fracture is in view



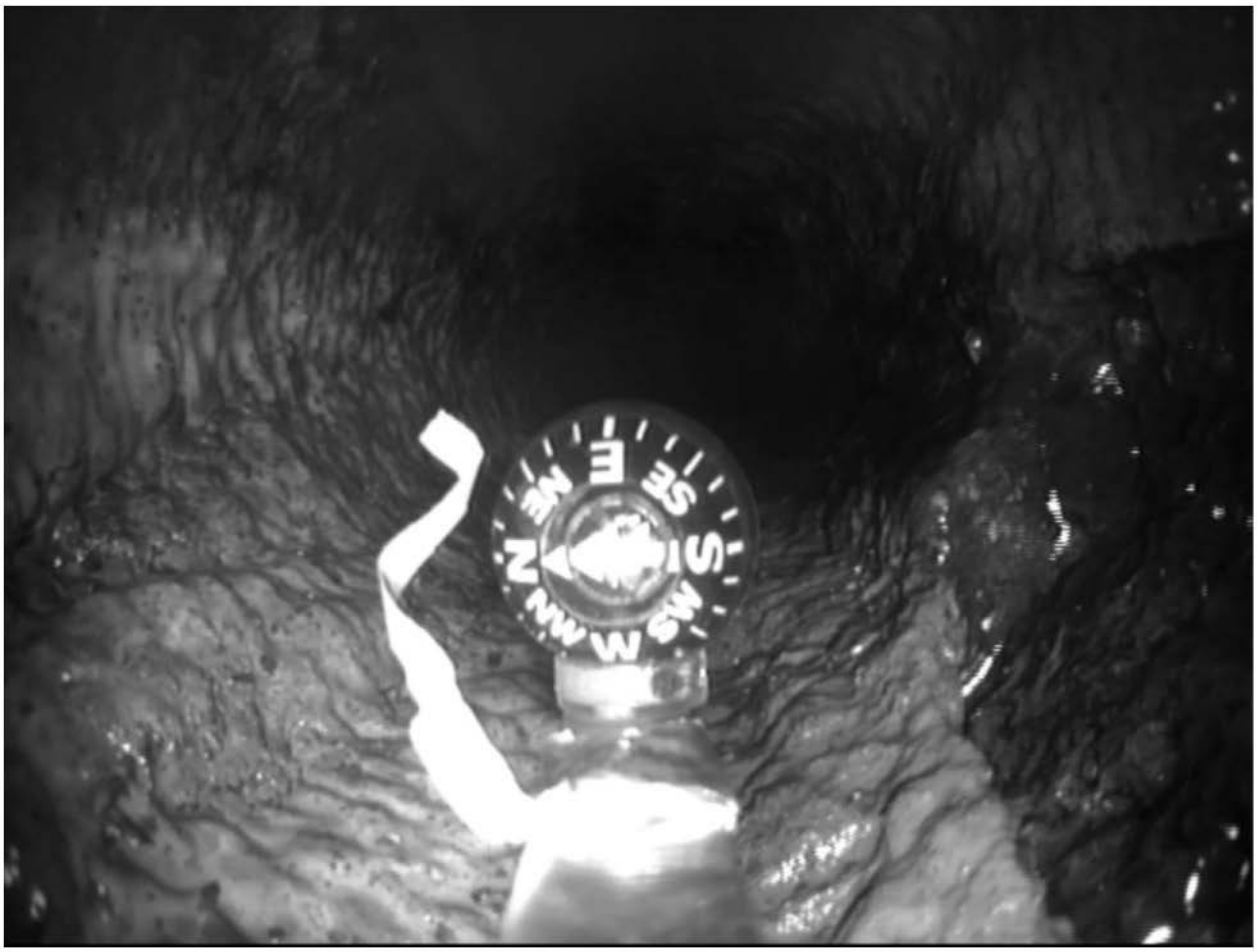
**Feature ID #03:** Fracture just below well casing at depth just past 5 ft. This feature encompasses nearly the entire perimeter of the well.



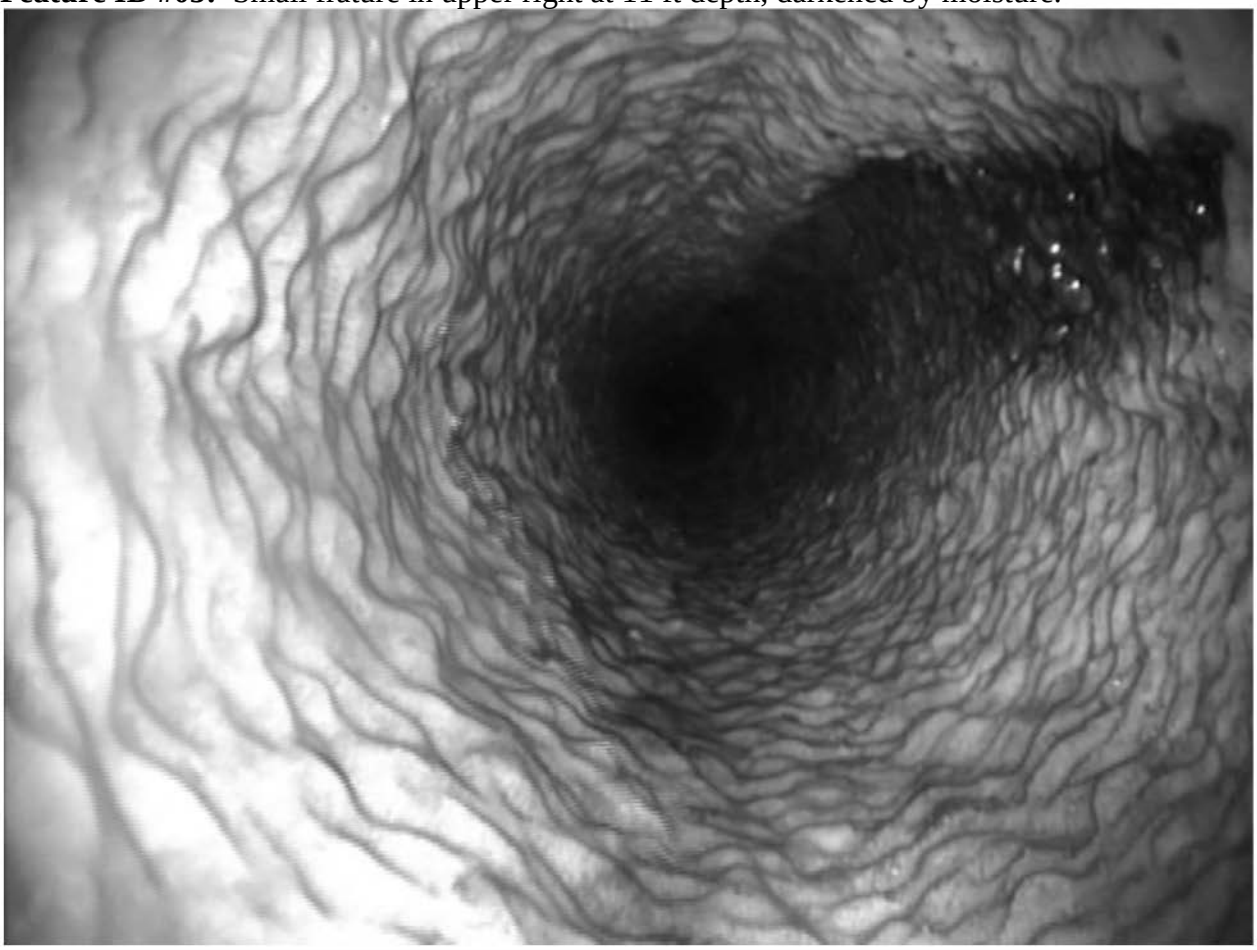
**Feature ID #04:** Small fracture in upper left with water leaking in at a depth of 5.5 ft.



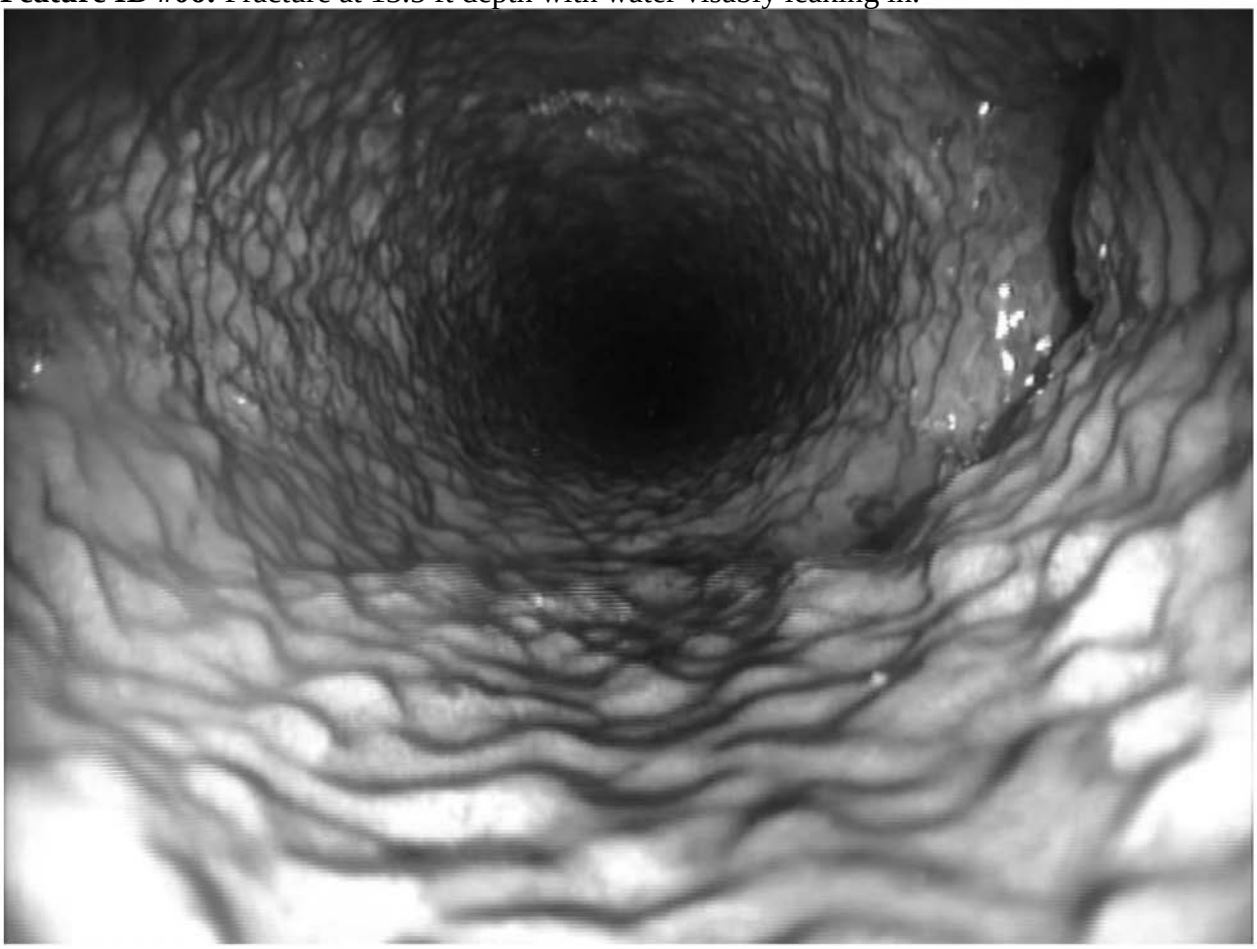
**Feature ID #04:** Water leaking in through fracture at 5.5 ft depth; compass shows feature on south side of the well.



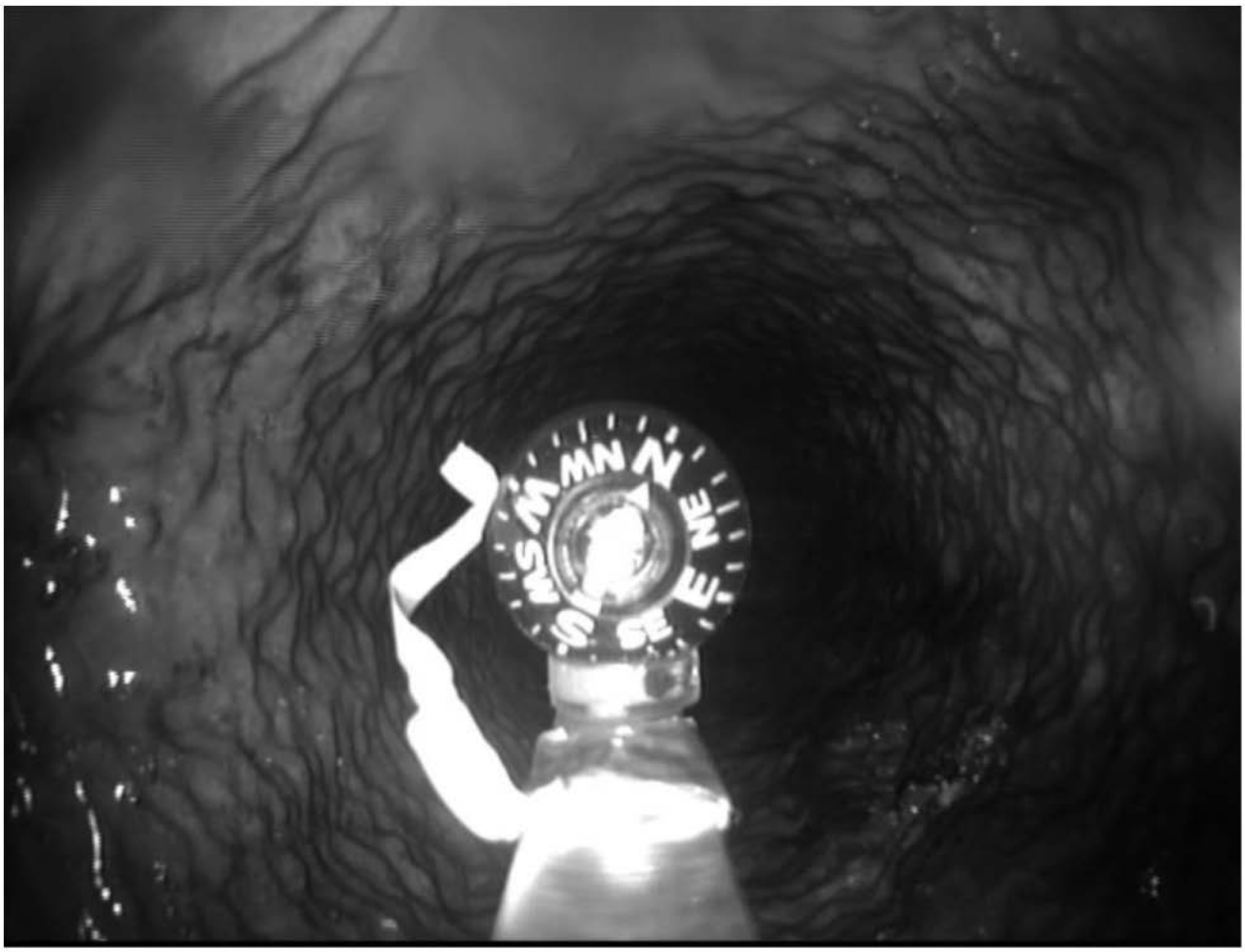
**Feature ID #05:** Small frature in upper right at 11 ft depth, darkened by moisture.



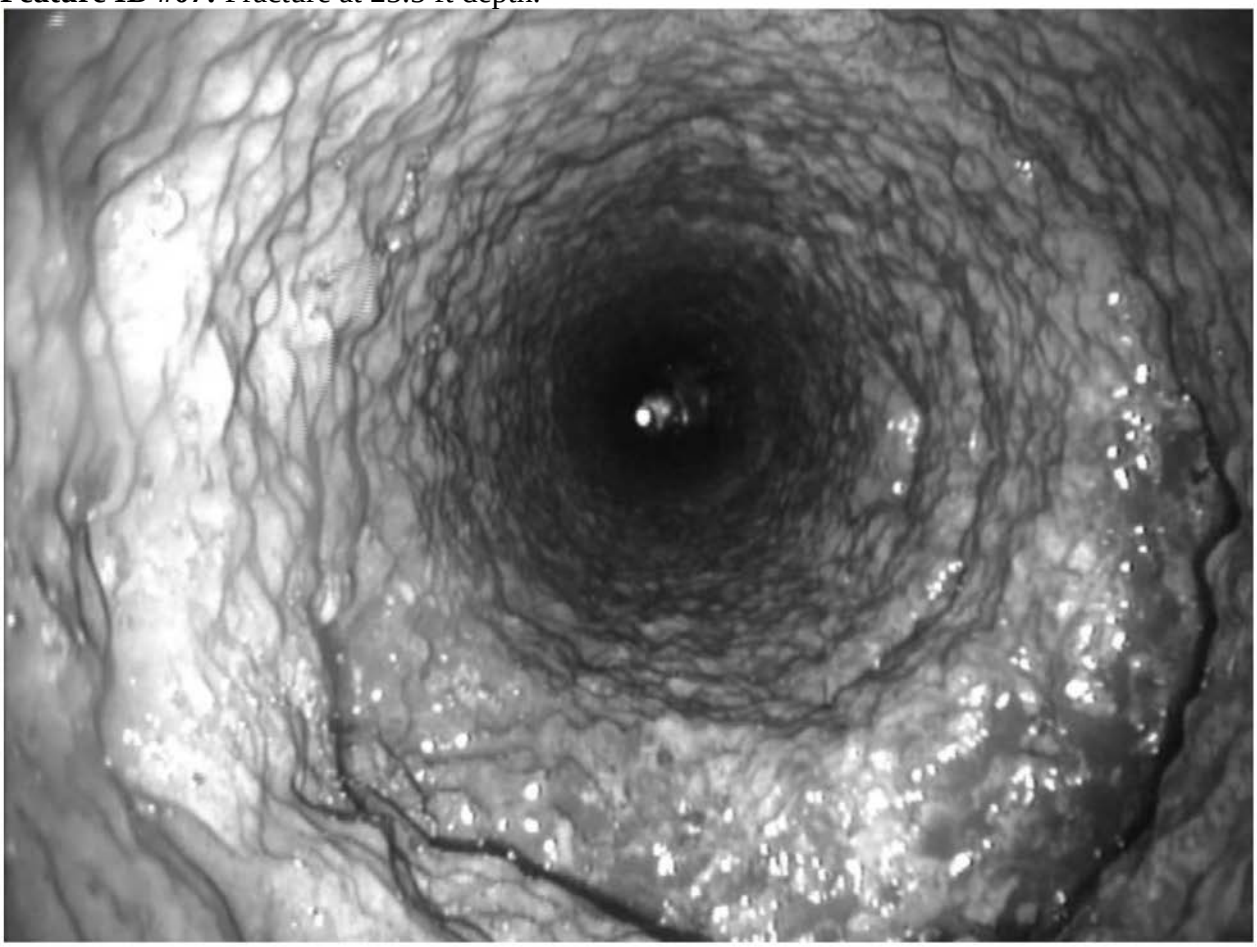
**Feature ID #06:** Fracture at 13.5 ft depth with water visably leaking in.



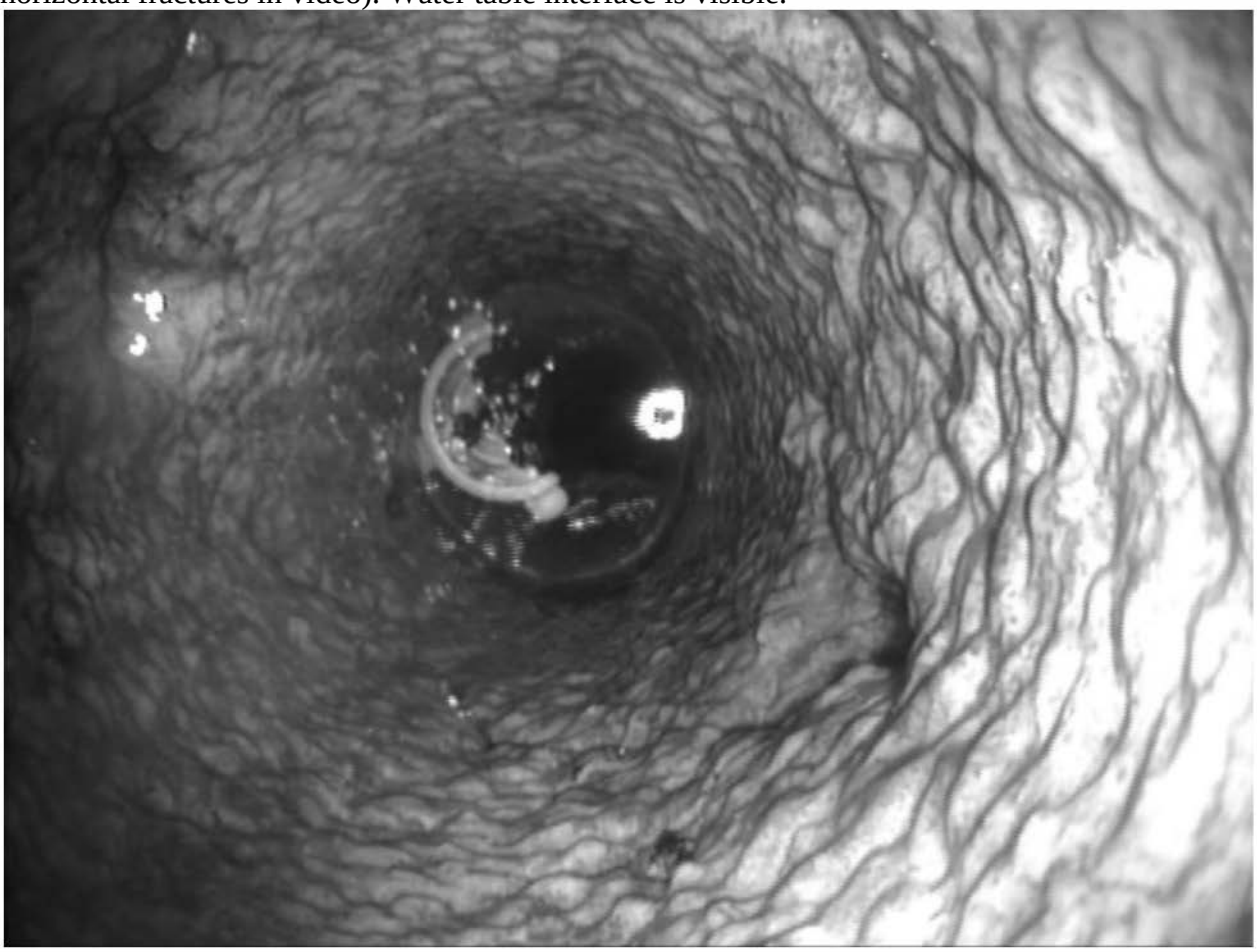
**Feature ID #06:** Water leaking in through fracture at 13.5 ft depth; compass shows feature on south-west side of the well



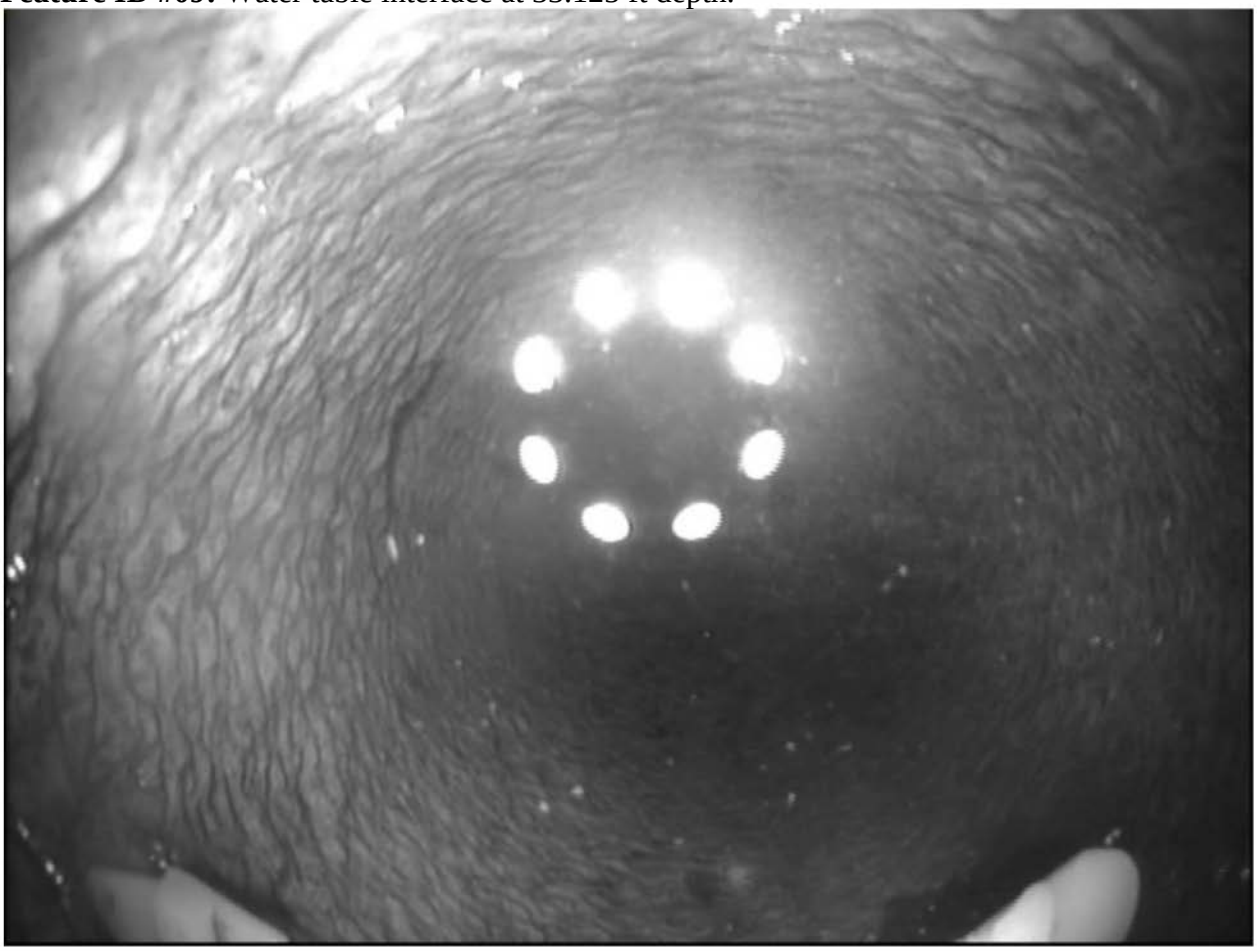
**Feature ID #07:** Fracture at 25.5 ft depth.



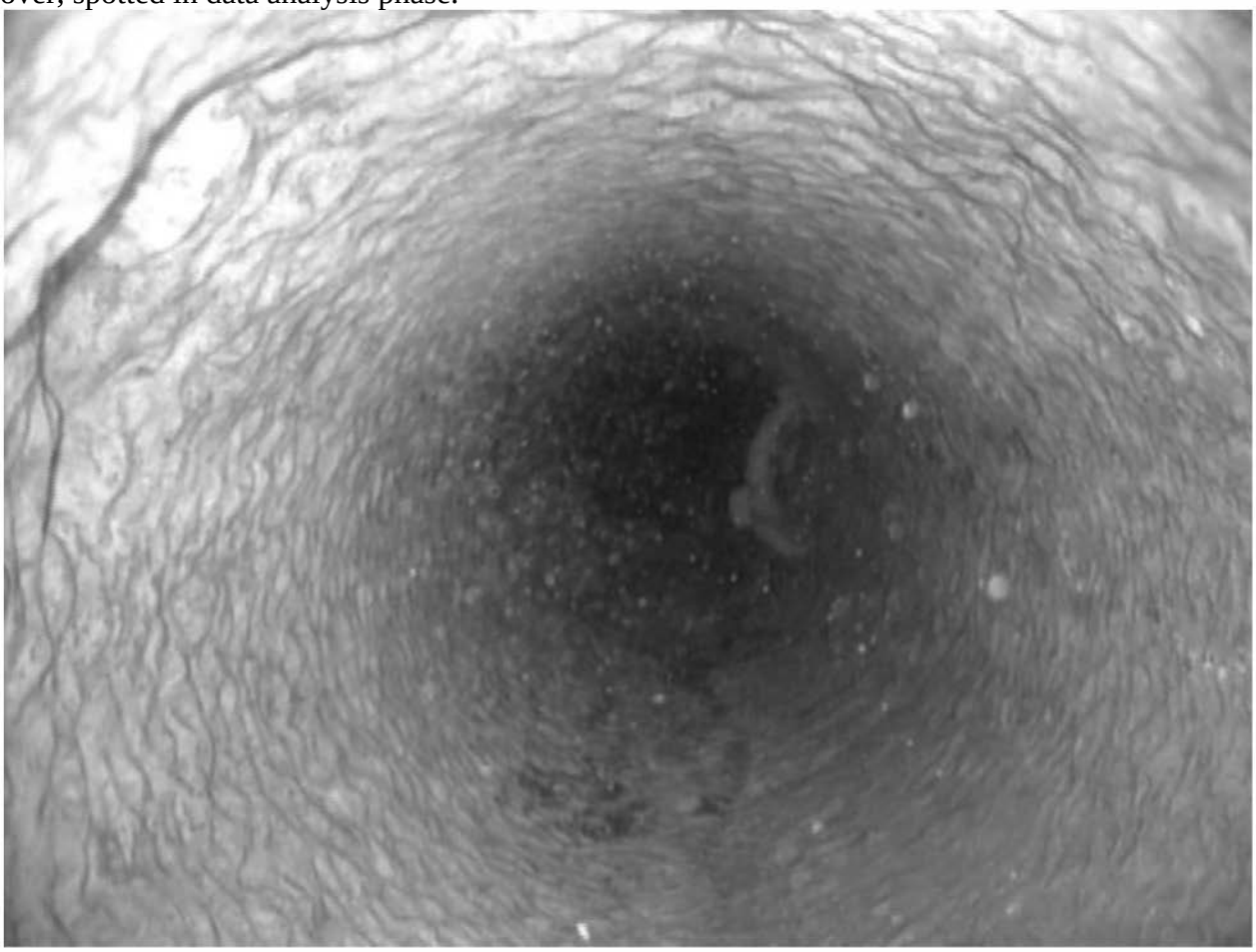
**Feature ID #08:** Two small, circular voids (upper left and middle-right) at 31.75 ft depth (called horizontal fractures in video). Water table interface is visible.



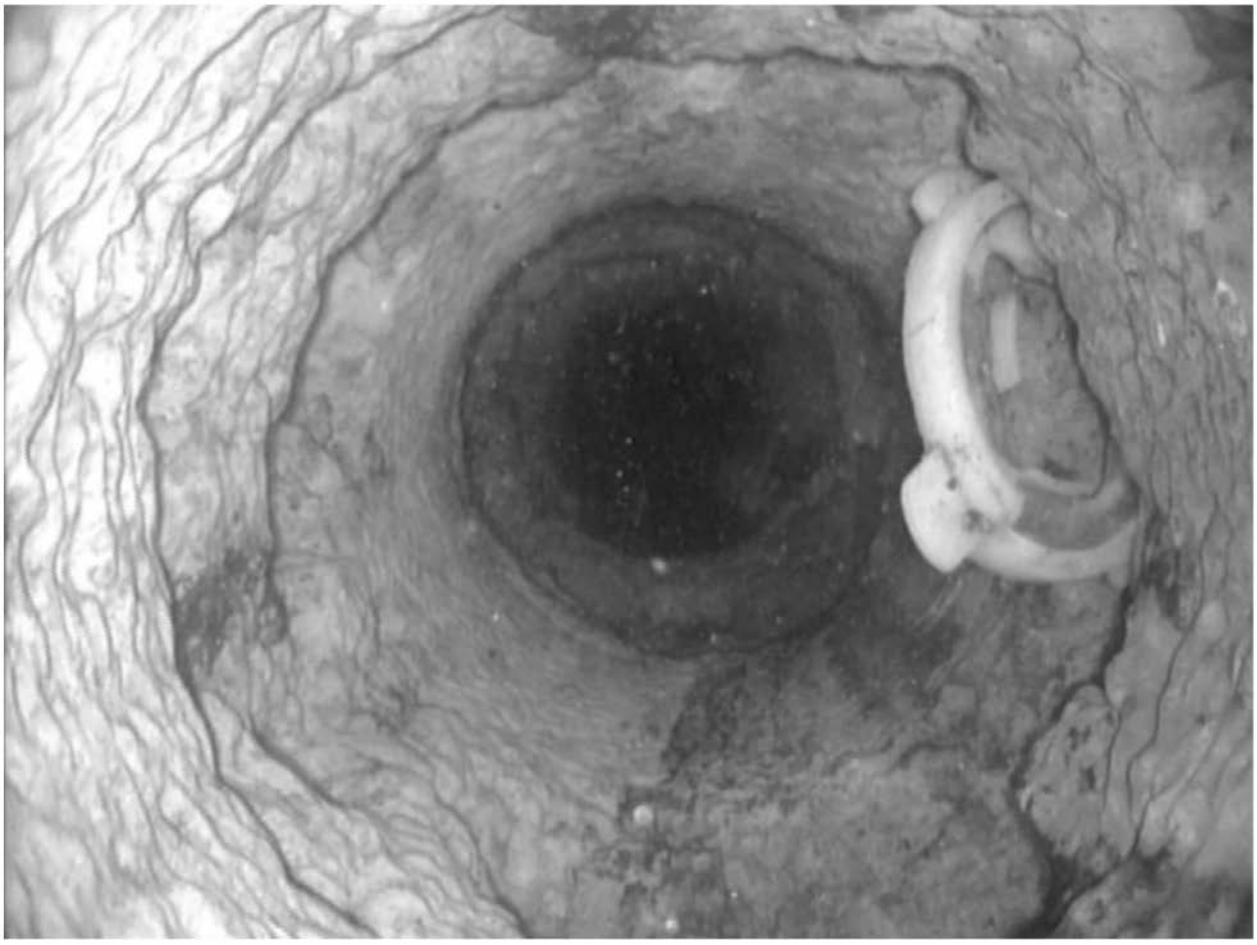
**Feature ID #09:** Water table interface at 33.125 ft depth.



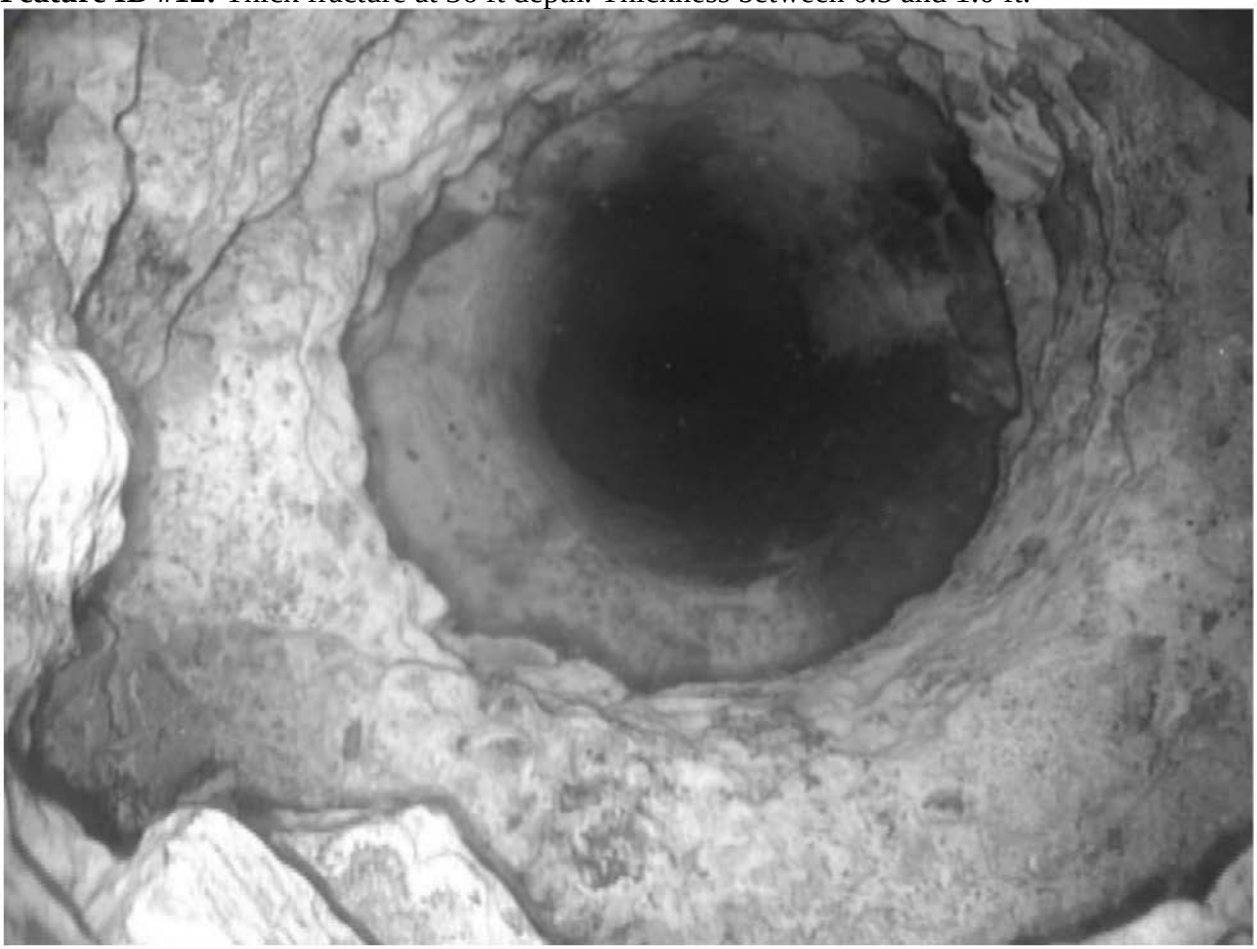
**Feature ID #10:** Small fracture in upper left at 34 ft depth. This feature was not noted in voice over, spotted in data analysis phase.



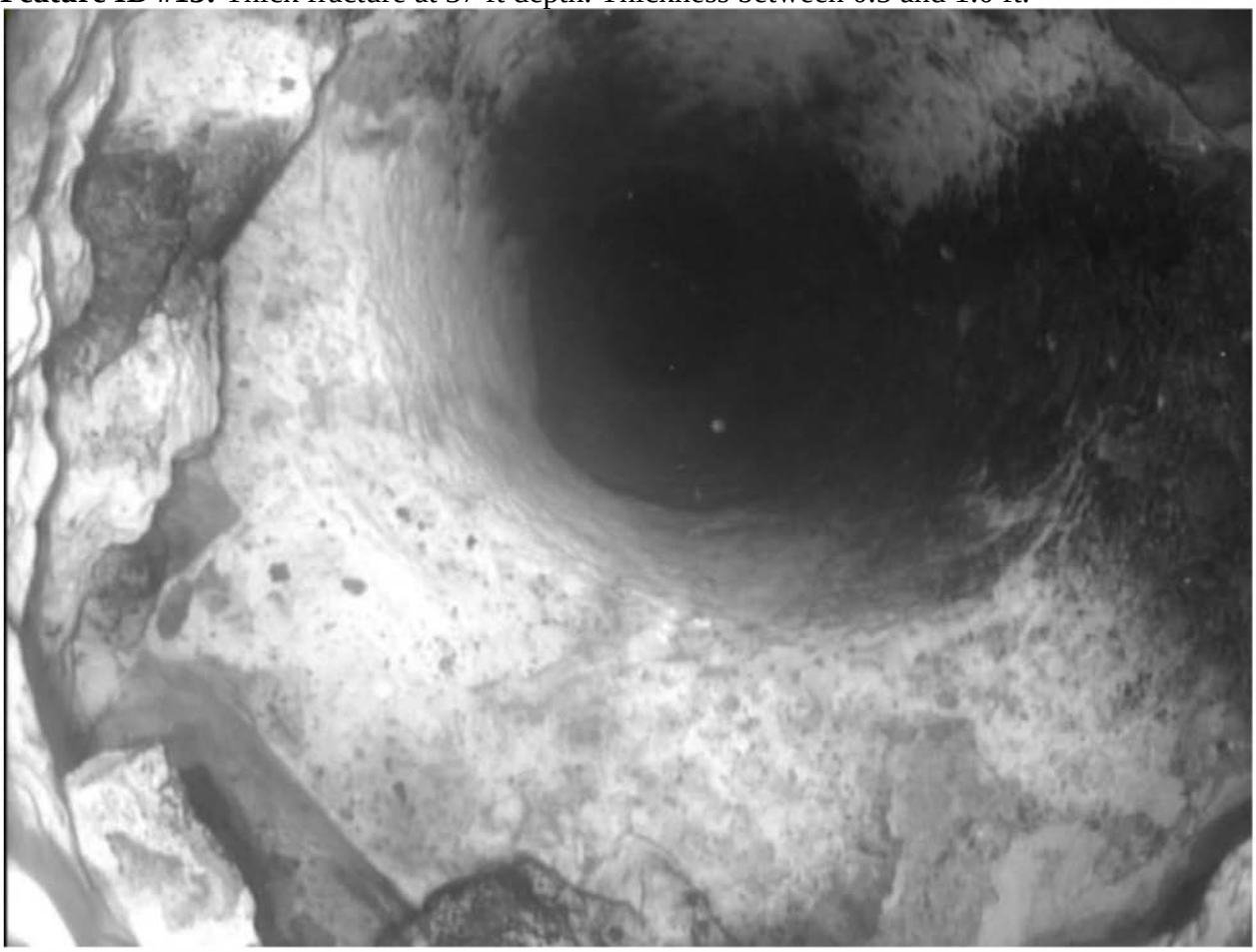
**Feature ID #11:** Thick fracture (main feature in lower right) at 34.75 ft depth. Thickness between 0.5 and 1.0 ft. Plastic pipe fixture visible at right. Additional fractures visible farther into well.



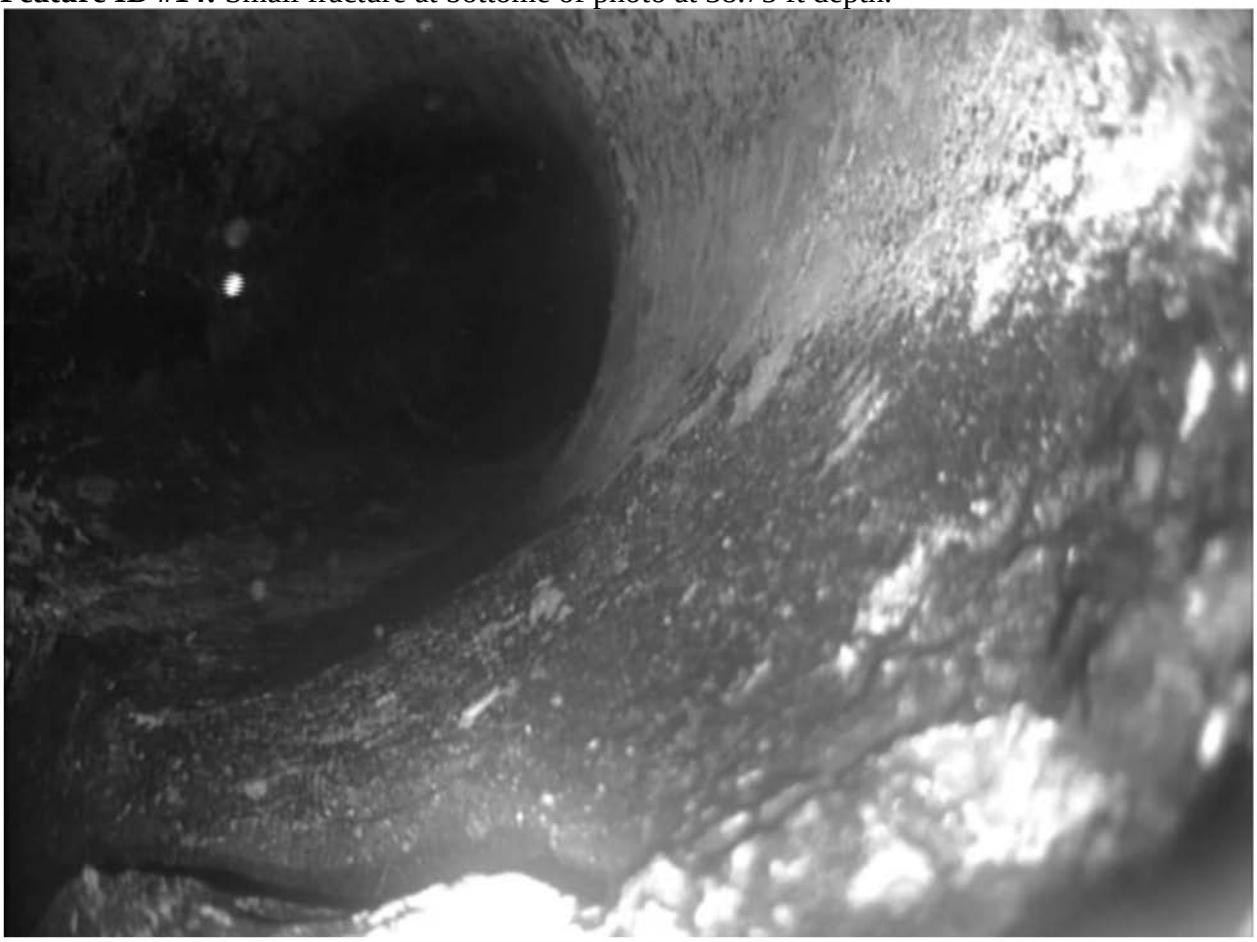
**Feature ID #12:** Thick fracture at 36 ft depth. Thickness between 0.5 and 1.0 ft.



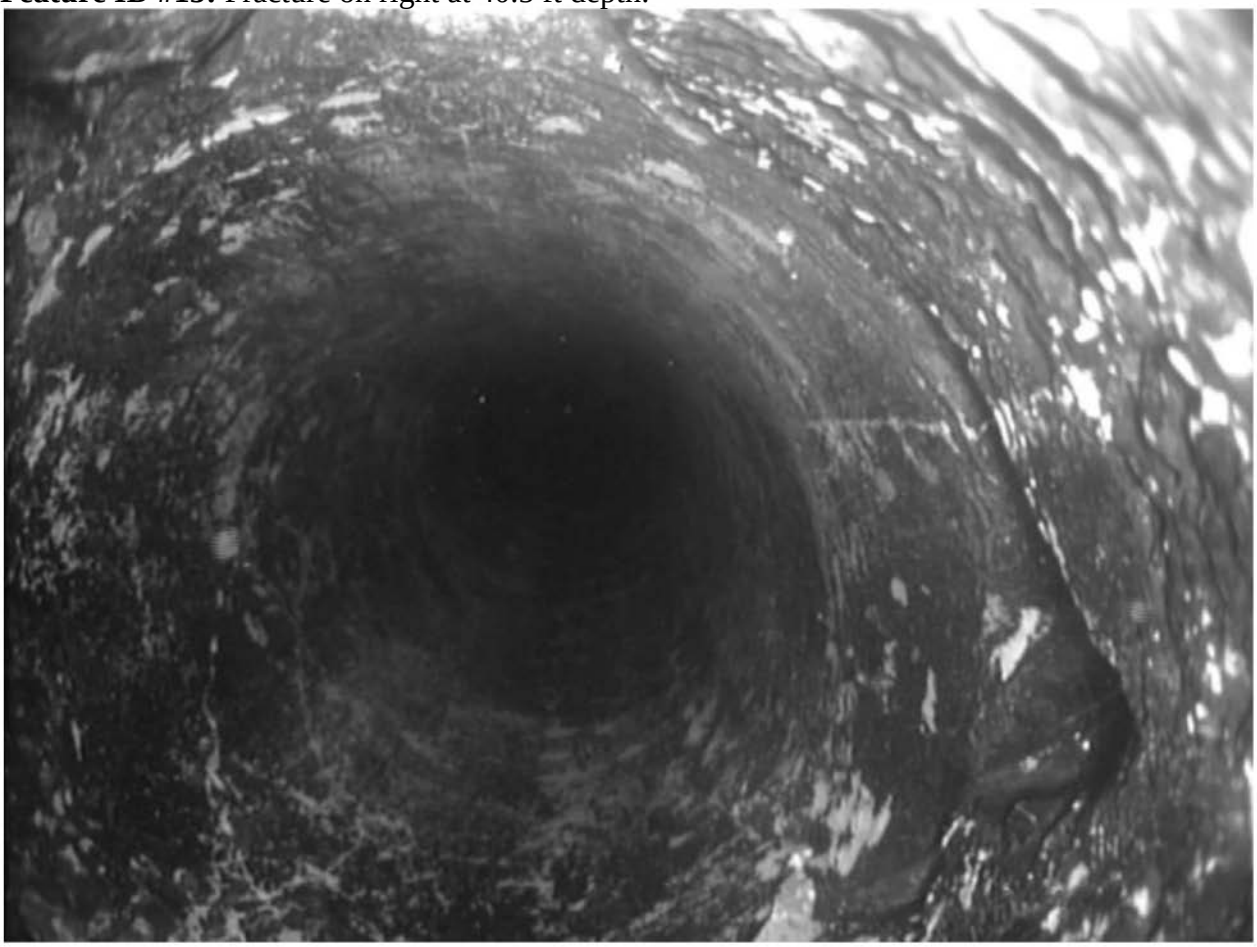
**Feature ID #13:** Thick fracture at 37 ft depth. Thickness between 0.5 and 1.0 ft.



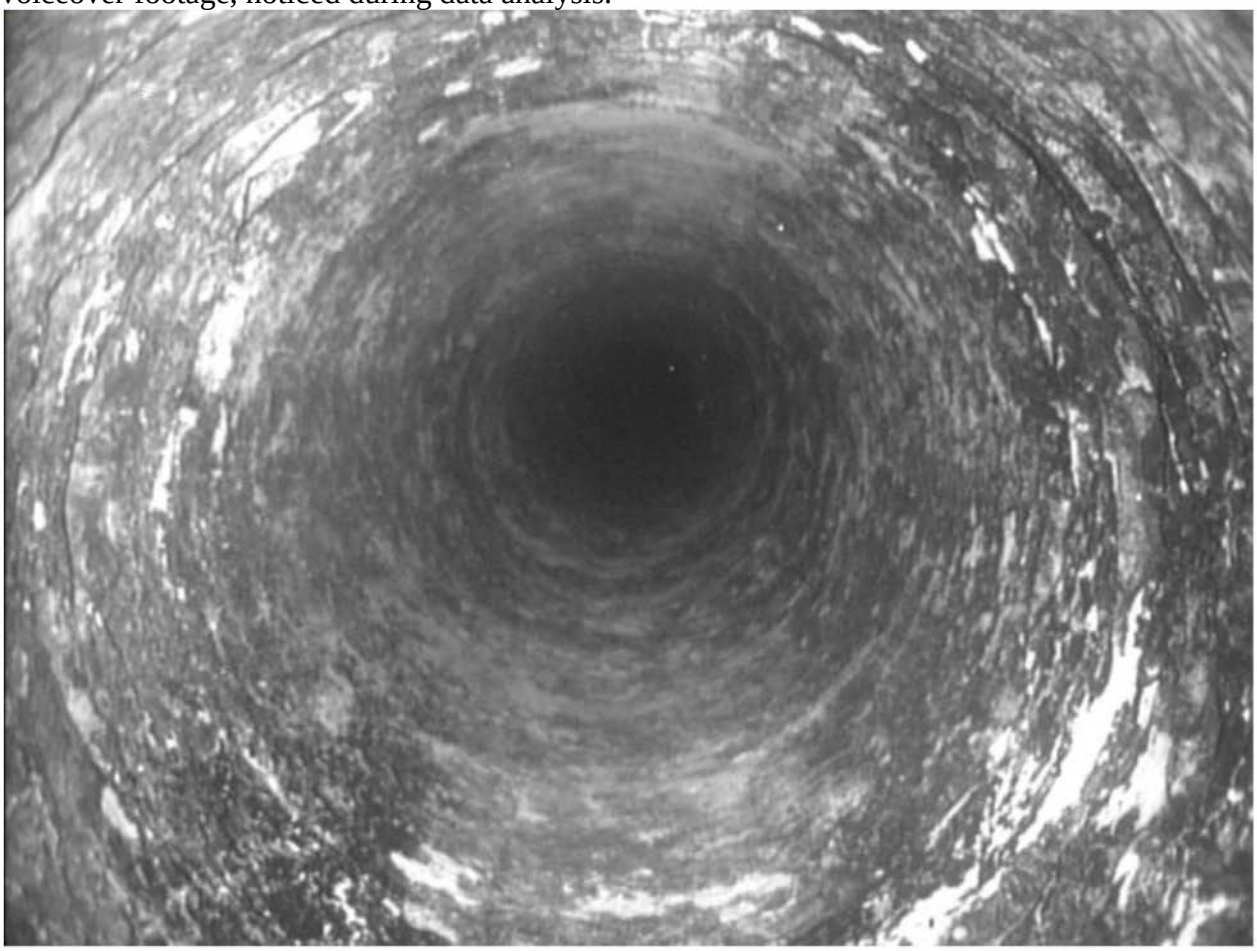
**Feature ID #14:** Small fracture at bottome of photo at 38.75 ft depth.



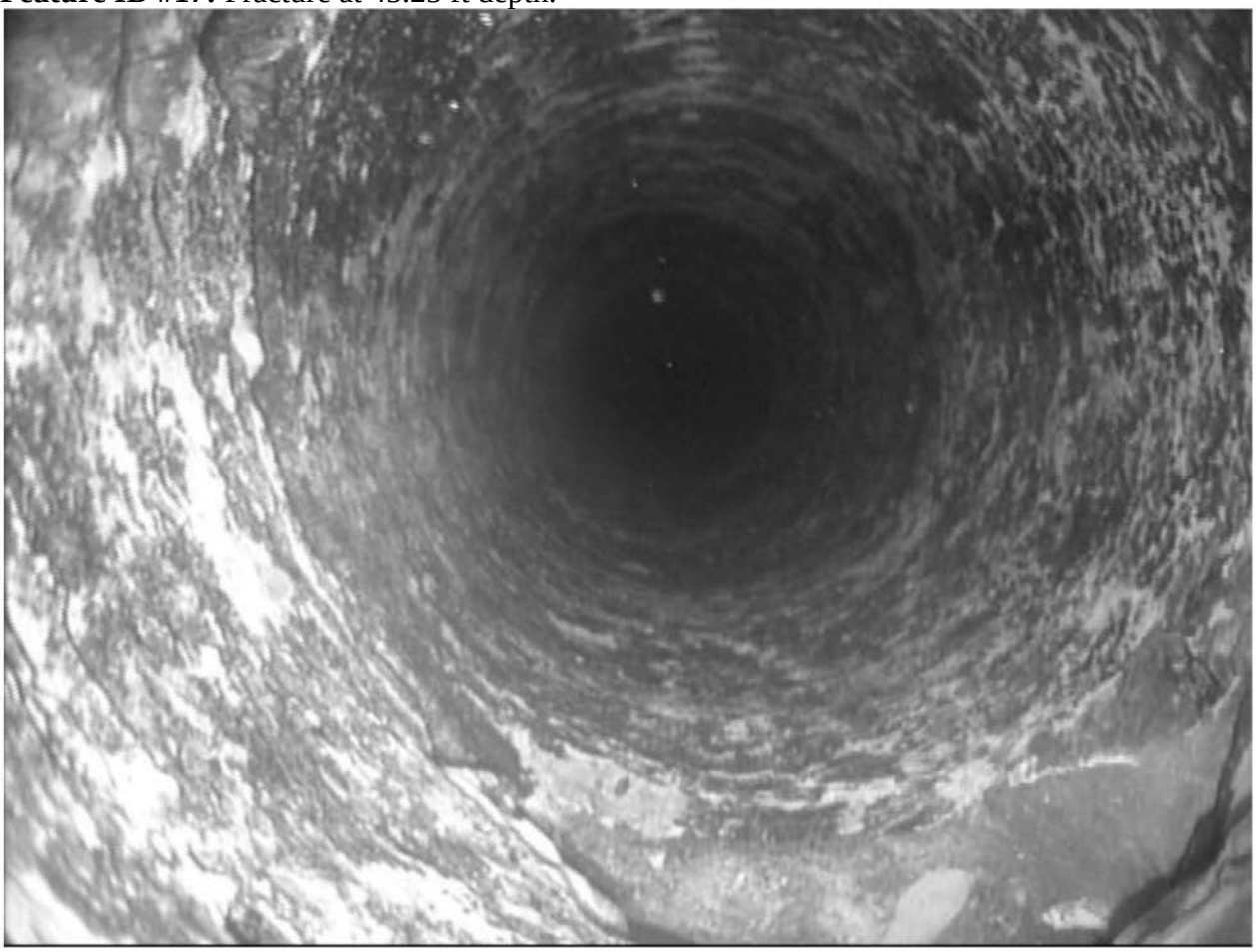
**Feature ID #15:** Fracture on right at 40.5 ft depth.



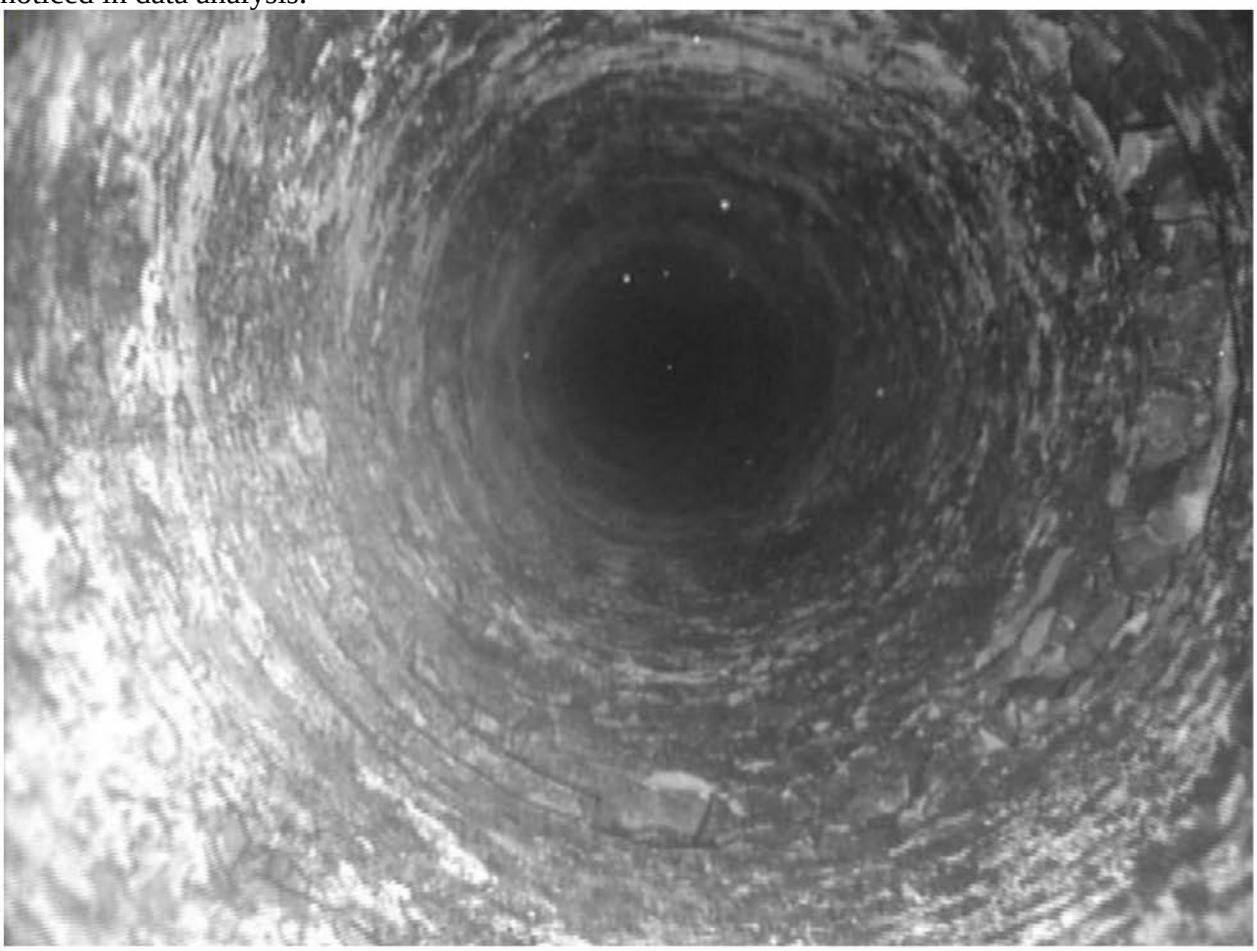
**Feature ID #16:** Very small fracture on right of photo at 43 ft depth. Not mentioned in the voiceover footage, noticed during data analysis.



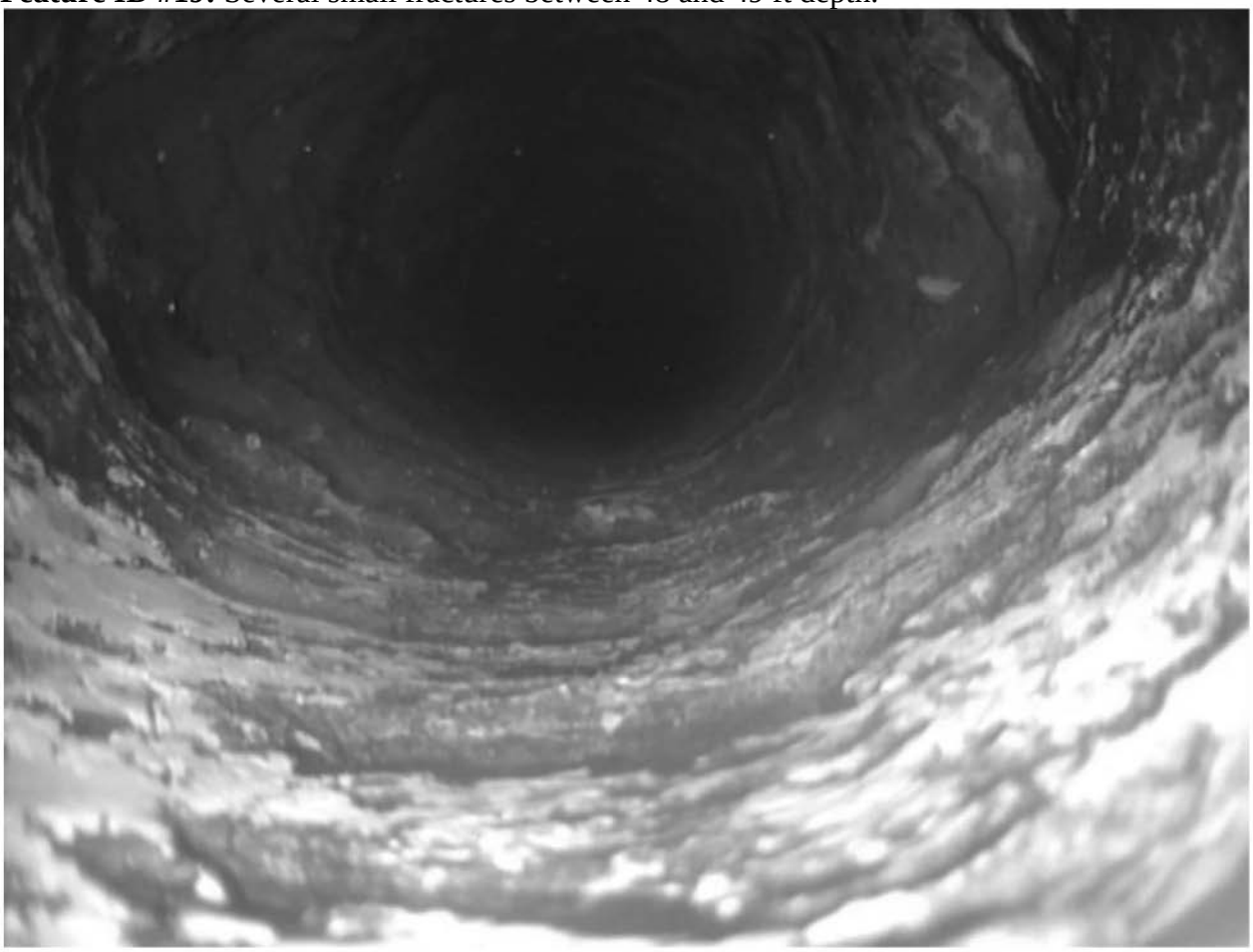
**Feature ID #17:** Fracture at 45.25 ft depth.



**Feature ID #18:** Small fracture on right of image at 46 ft depth. Not mentioned in voiceover, noticed in data analysis.



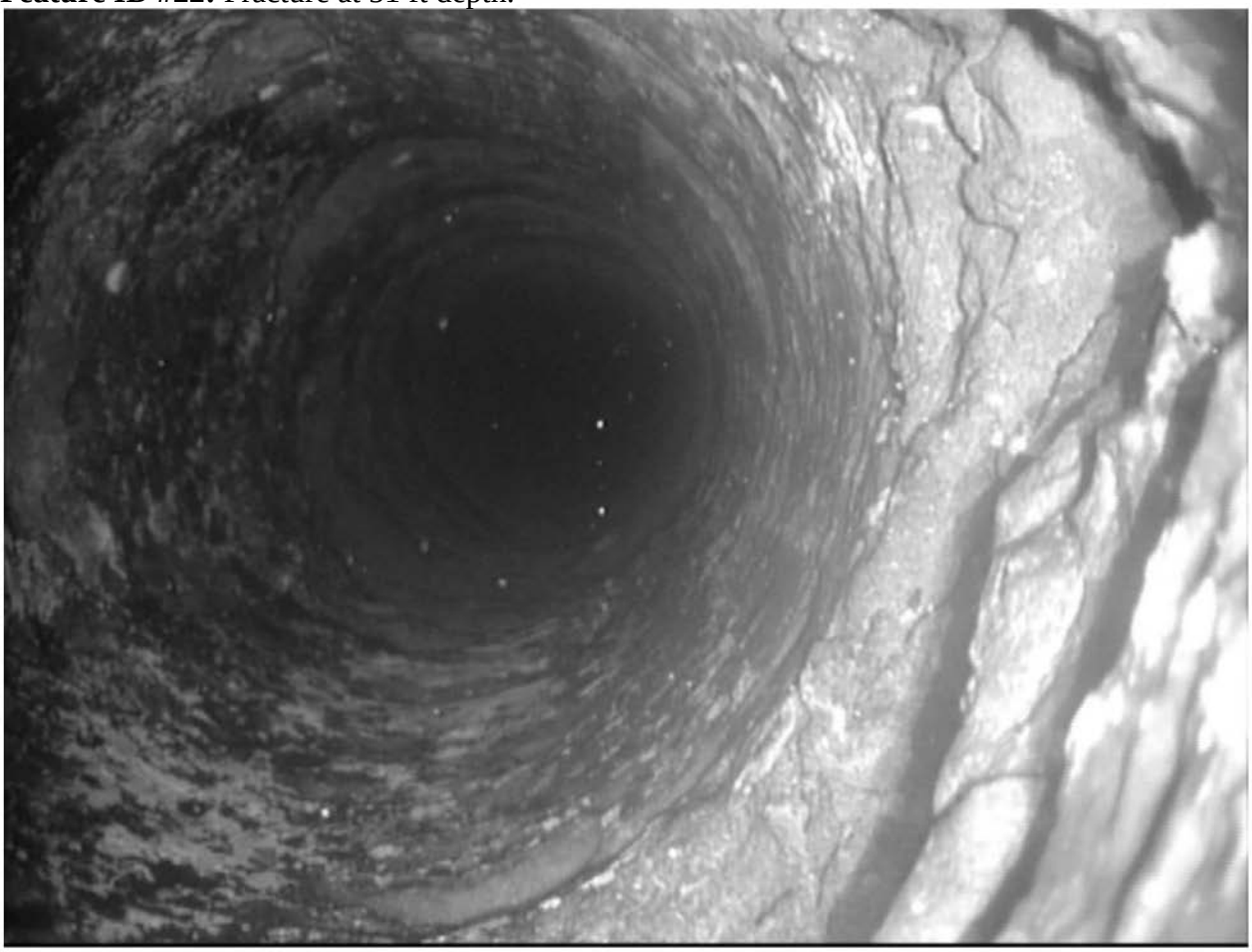
**Feature ID #19:** Several small fractures between 48 and 49 ft depth.



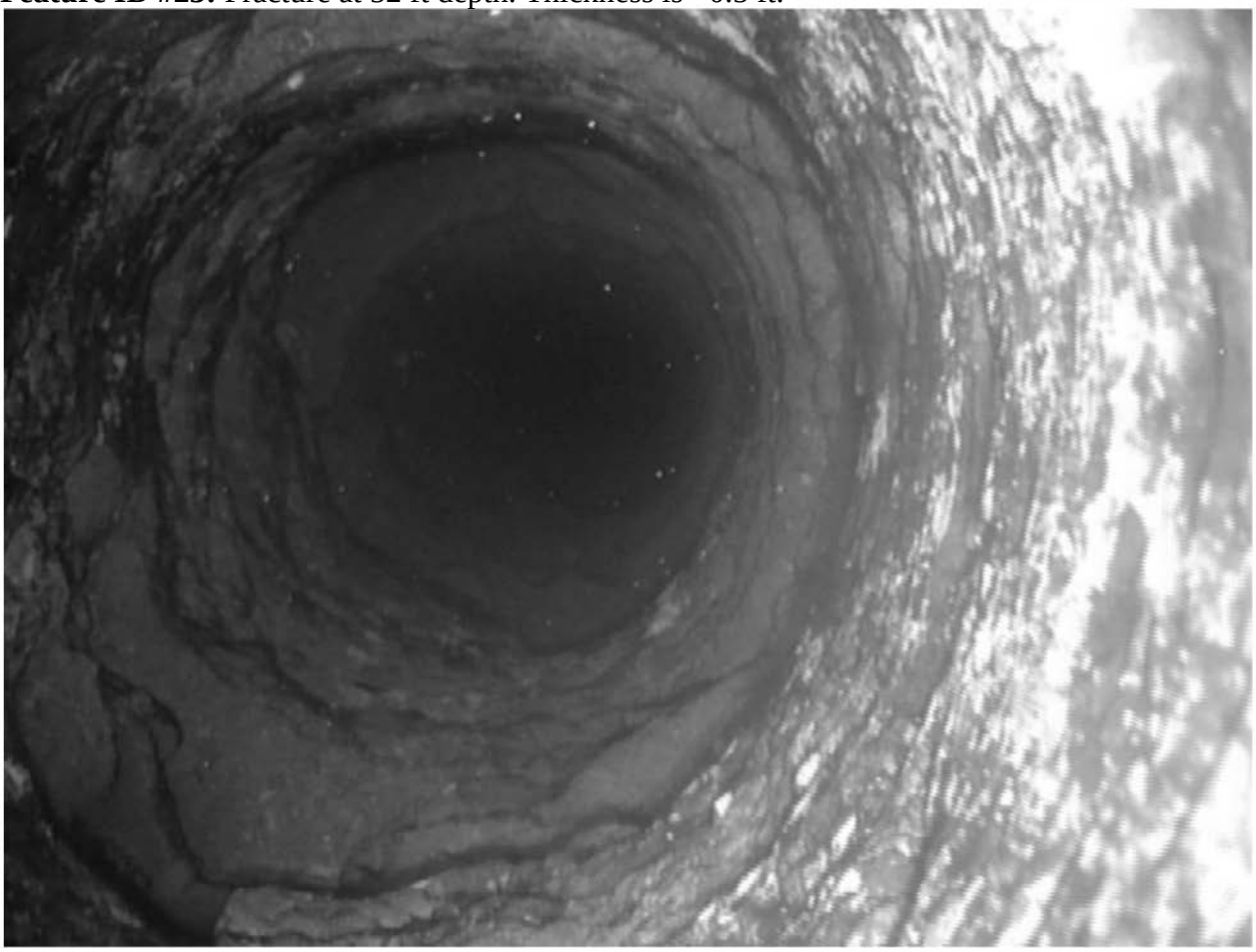
**Feature ID #20:** Fracture at 49 ft depth.

**Feature ID #21:** Fracture at 50.5 ft depth.

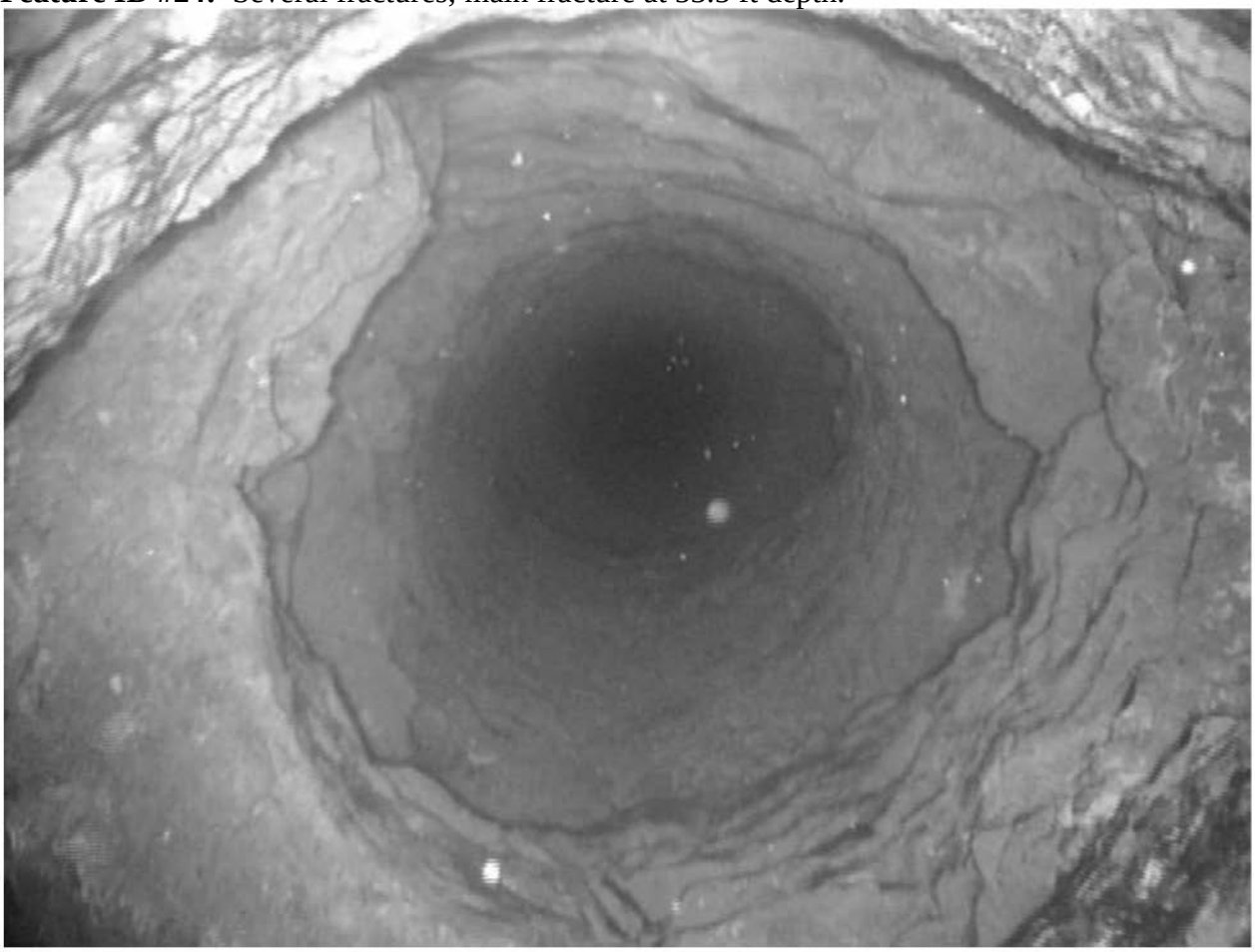
**Feature ID #22:** Fracture at 51 ft depth.



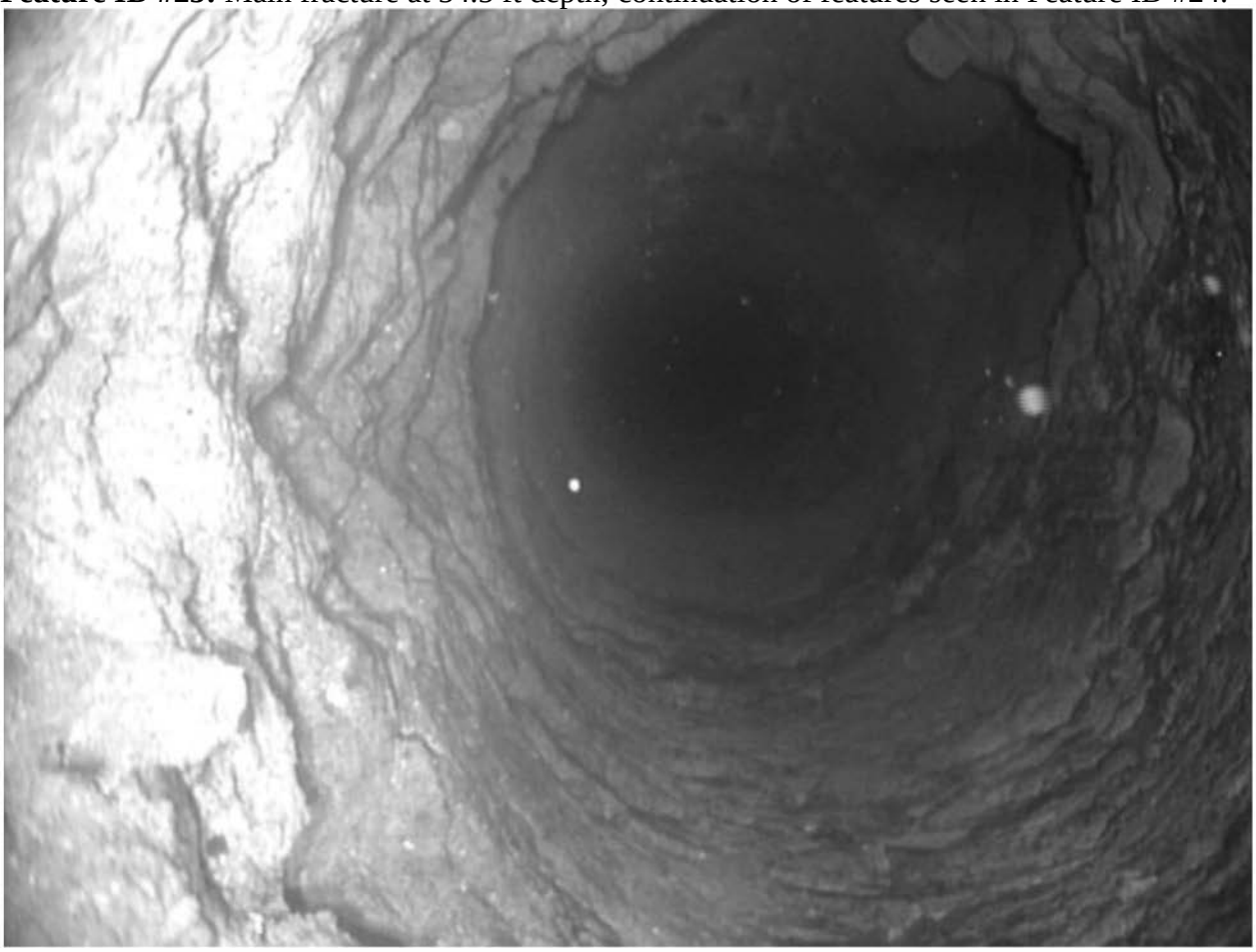
**Feature ID #23:** Fracture at 52 ft depth. Thickness is ~0.5 ft.



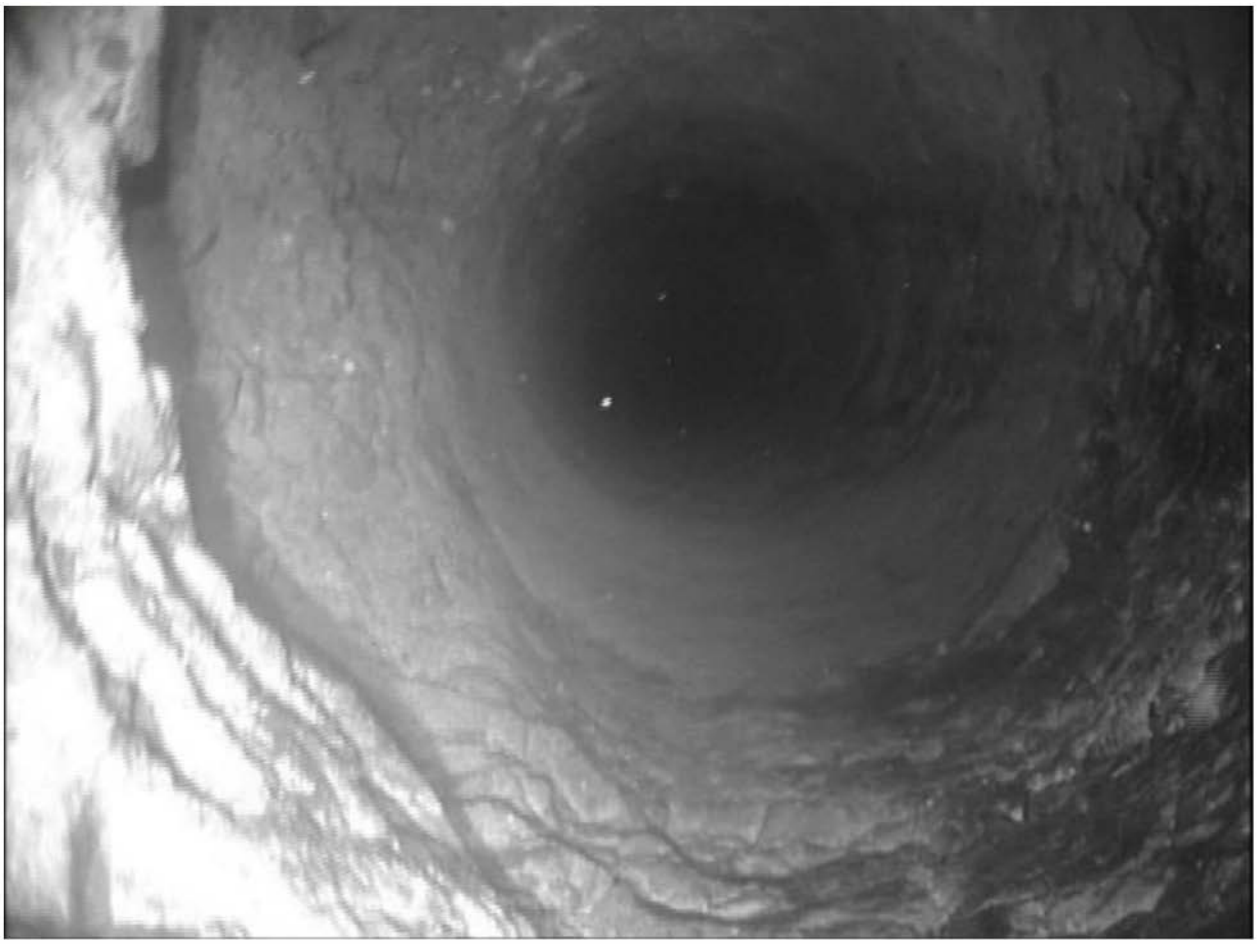
**Feature ID #24:** Several fractures; main fracture at 53.5 ft depth.



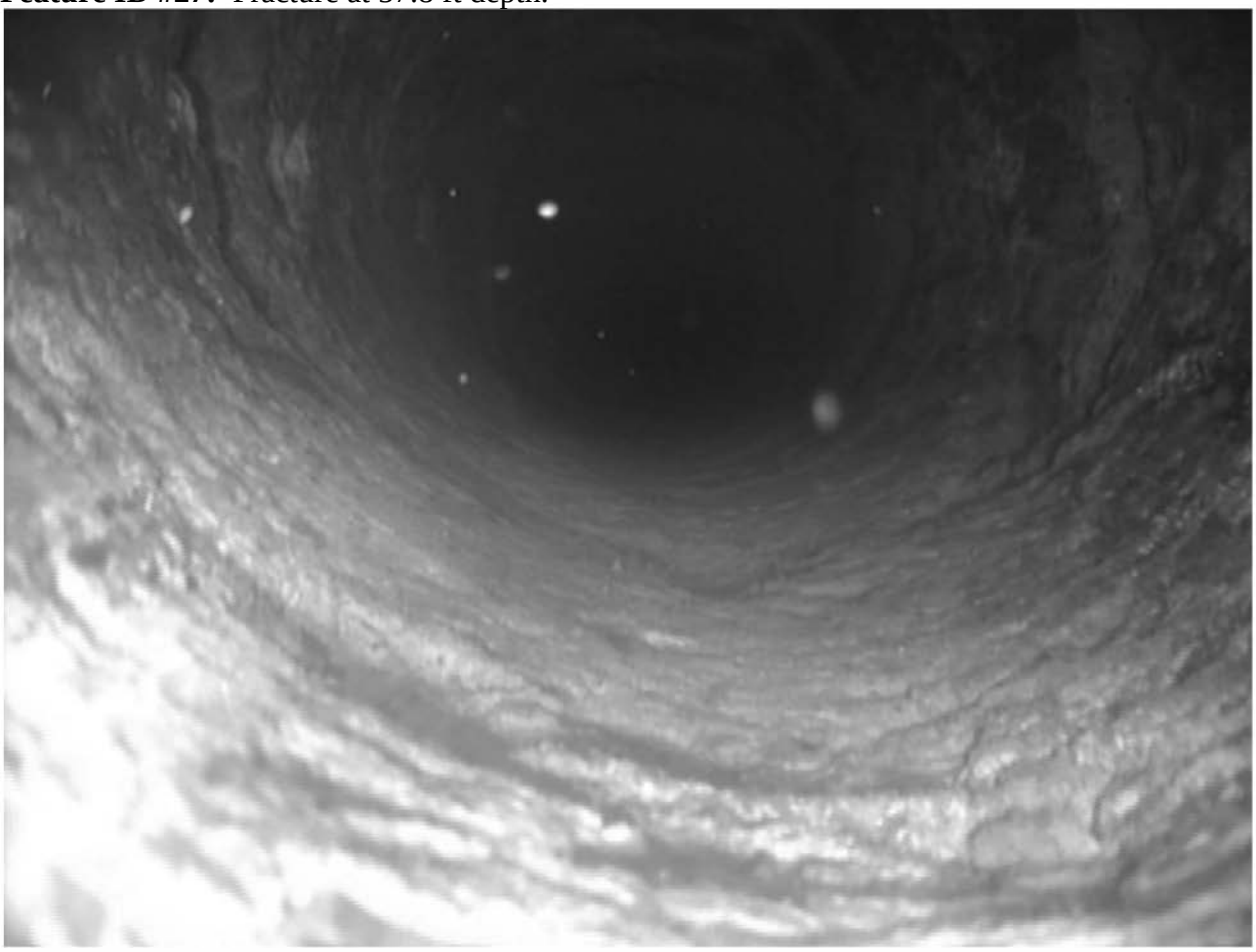
**Feature ID #25:** Main fracture at 54.5 ft depth; continuation of features seen in Feature ID #24.



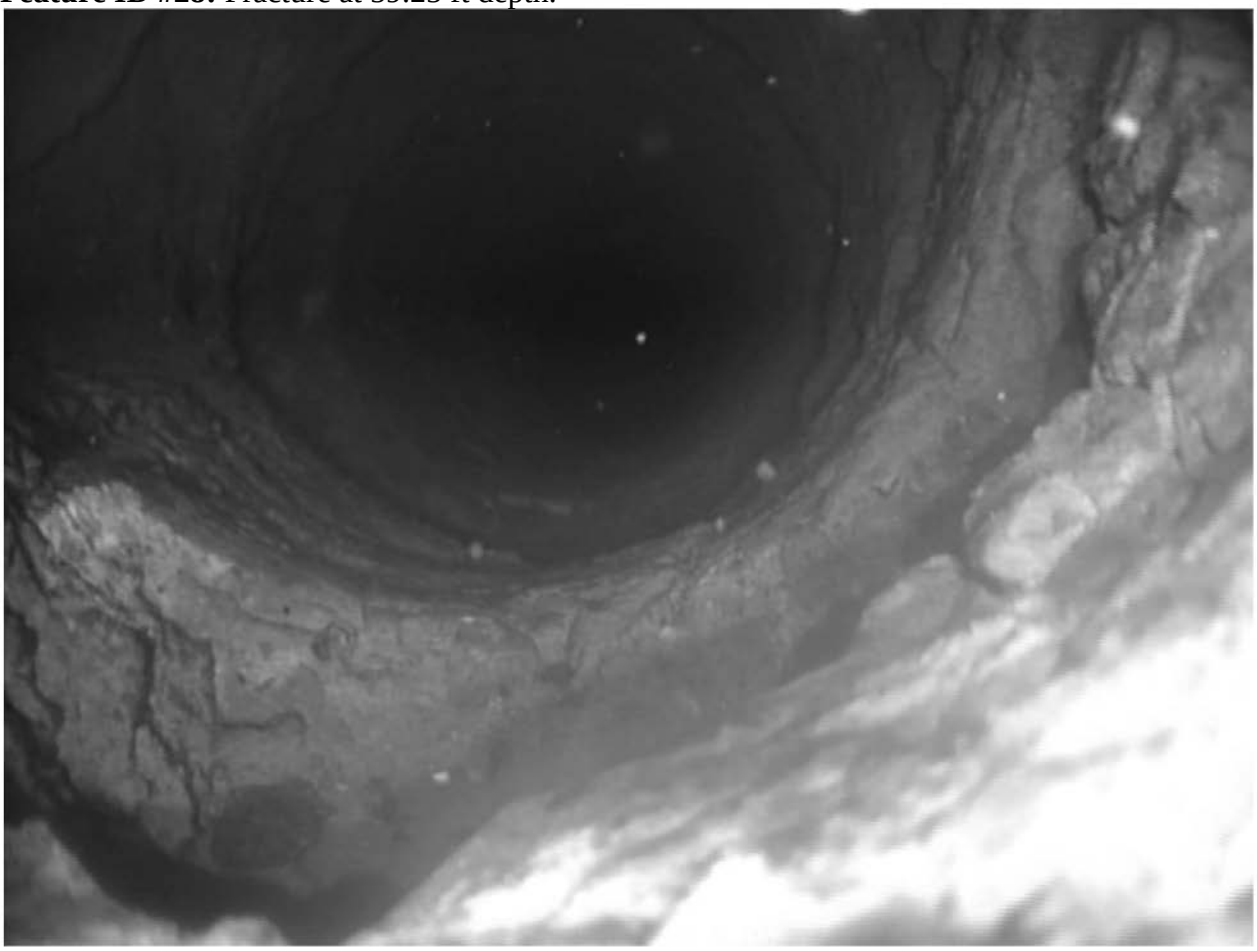
**Feature ID #26:** Fracture at 55.5 ft depth. Continuation of features from Feature IDs #24 and #25.



**Feature ID #27:** Fracture at 57.8 ft depth.



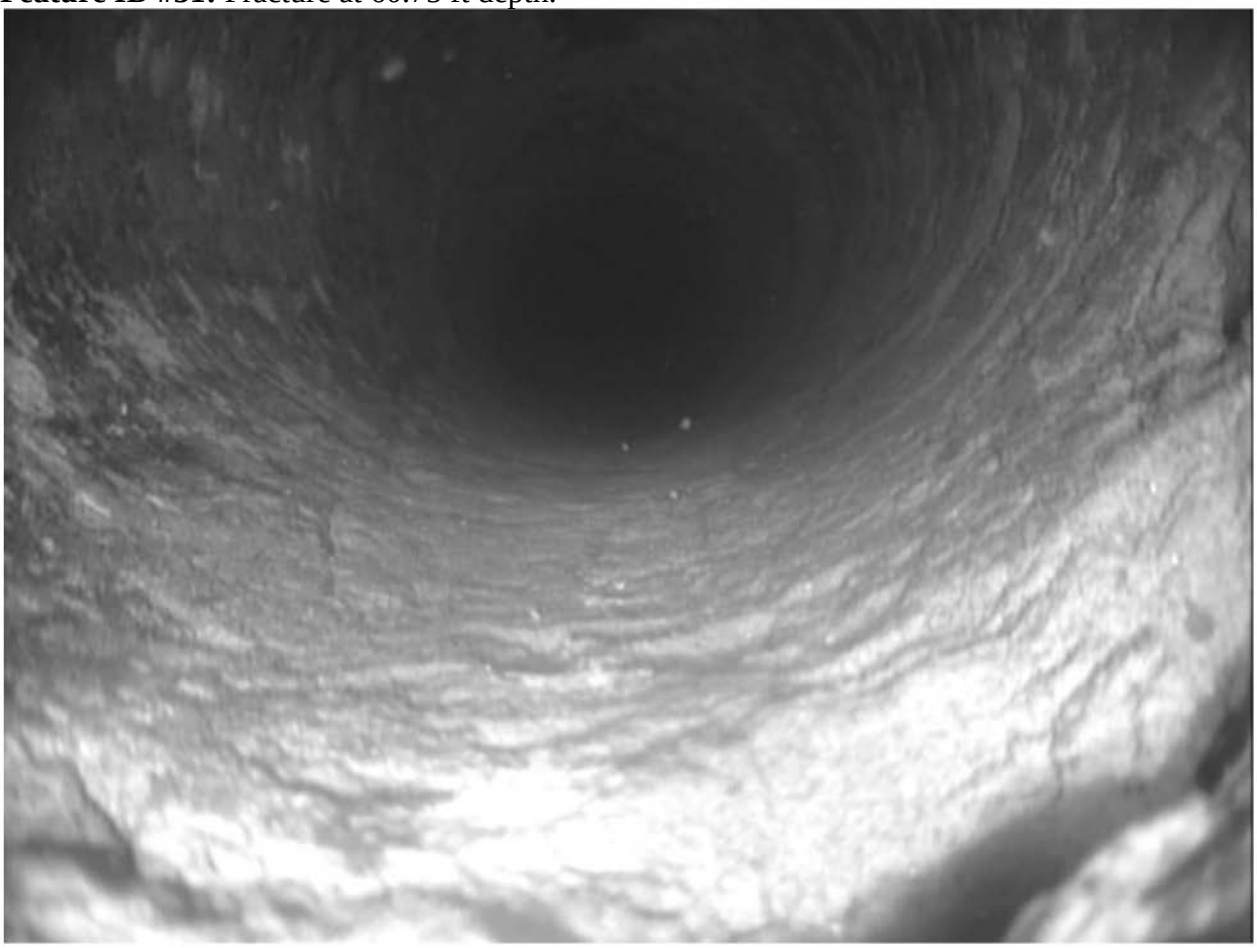
**Feature ID #28:** Fracture at 59.25 ft depth.



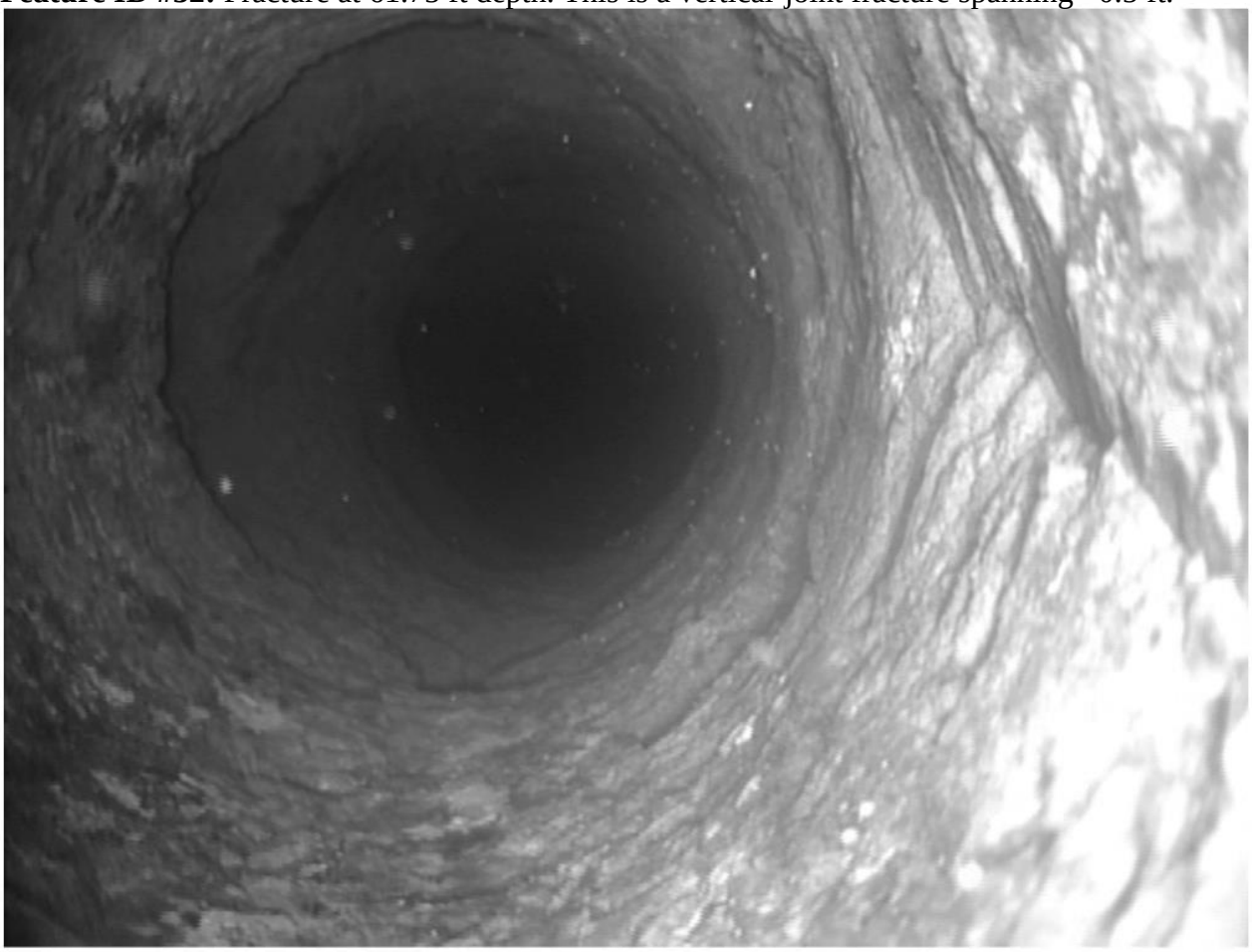
**Feature ID #29:** Fracture at 59.8 ft depth.

**Feature ID #30:** Fracture at 60.25 ft depth.

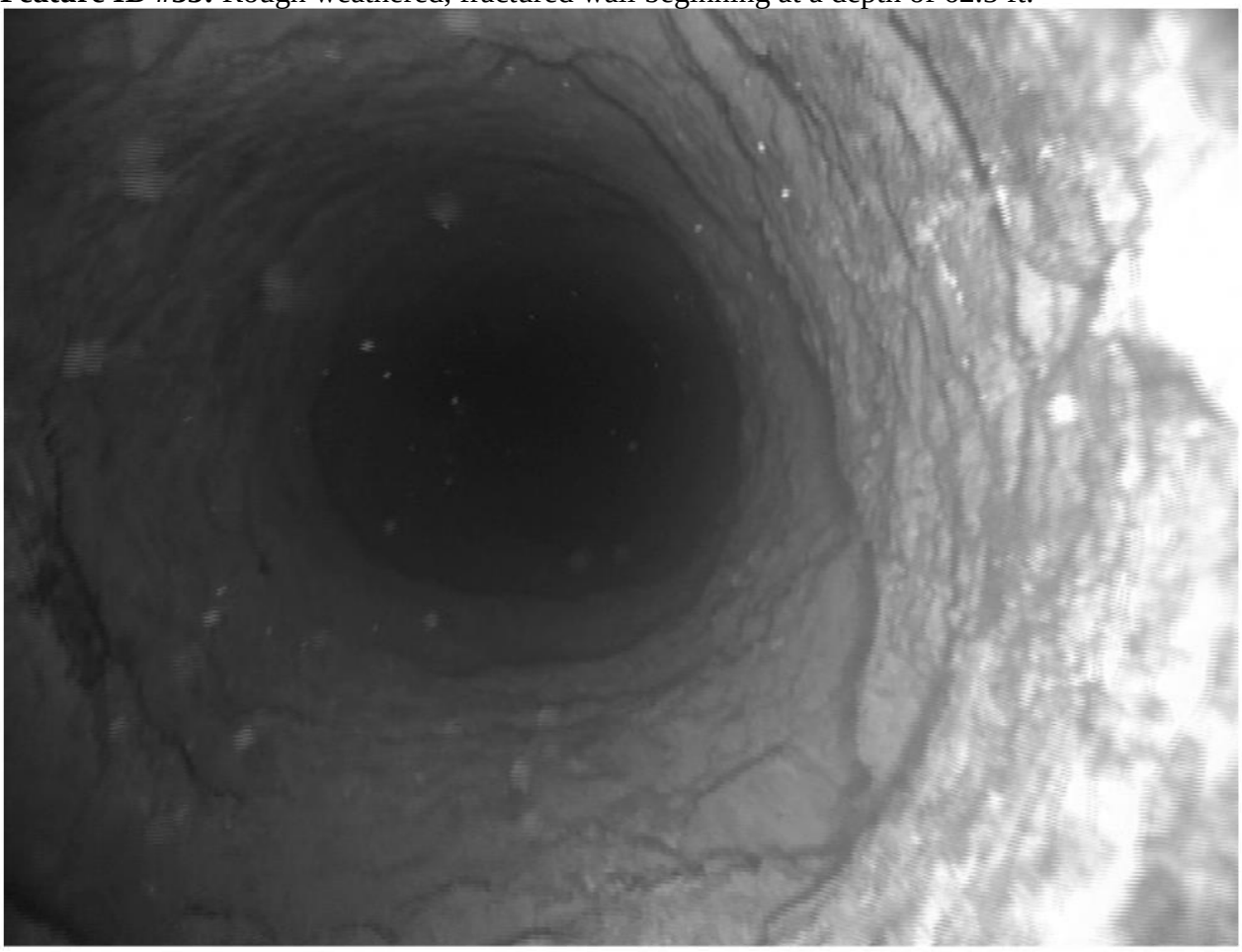
**Feature ID #31:** Fracture at 60.75 ft depth.



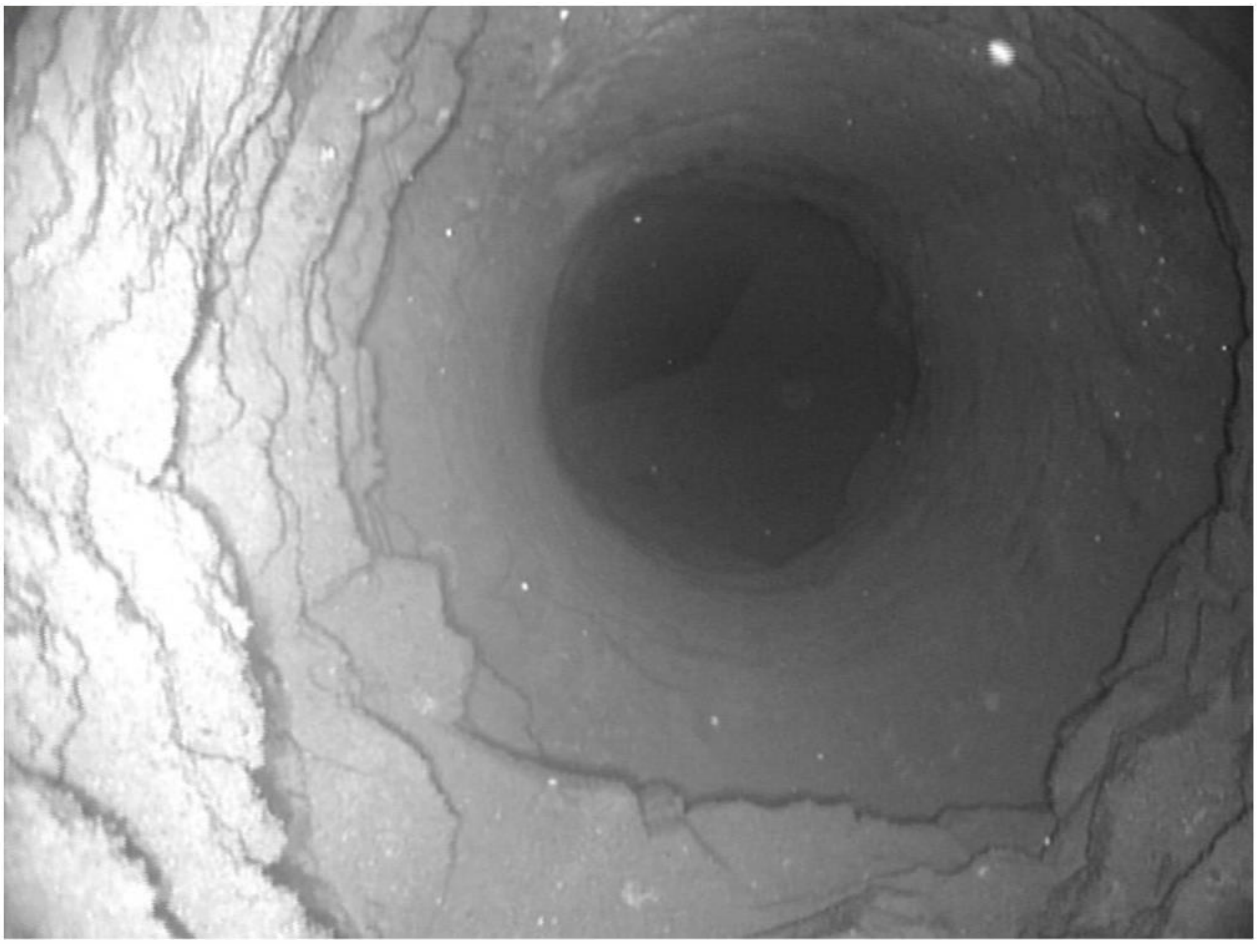
**Feature ID #32:** Fracture at 61.75 ft depth. This is a vertical-joint fracture spanning ~0.5 ft.



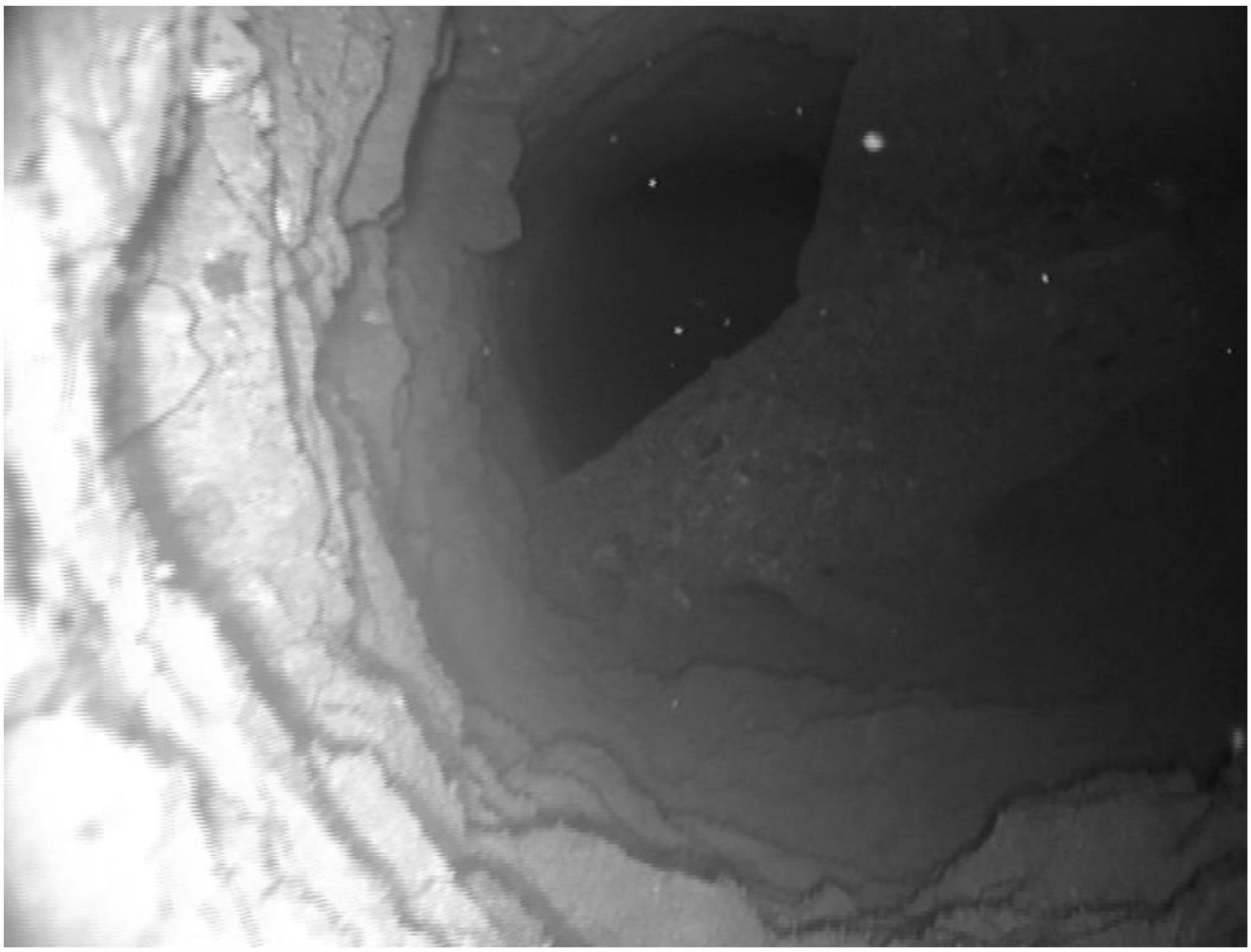
**Feature ID #33:** Rough weathered, fractured wall beginning at a depth of 62.5 ft.



**Feature ID #34:** Part of the rough fractured wall at a depth of 64 ft. Continuation of Feature ID #33.



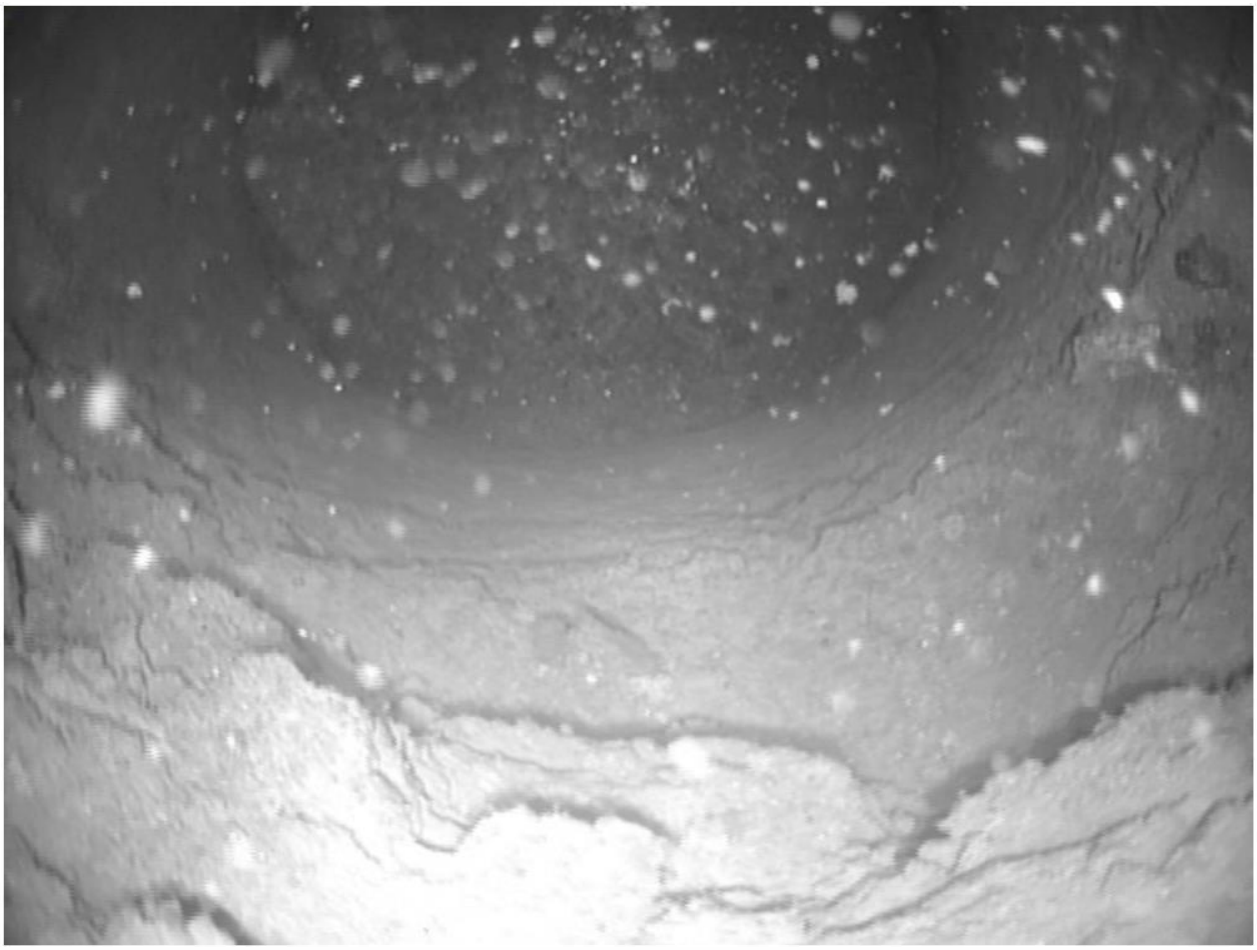
**Feature ID #35:** Continued fracturing from Feature IDs #33 and #34 at a depth of 67.5 ft. Note a bedrock intrusion lower into the well.



**Feature ID #36:** Close up of rock intrusion at 68.75 ft. Intrusion appears to be connected to wall, as opposed to fallen debris. Also note the continuation of the rough, weathered well wall.

**Feature ID #37:** Series of small fractures below bedrock intrusion at a depth of 69.5 ft.

**Feature ID #38:** Series of small fractures at a depth of 70 ft. Continuation of Feature ID #37. Base of well visible lower in well.



**Feature ID #39:** Base of well at 71.5 ft depth.