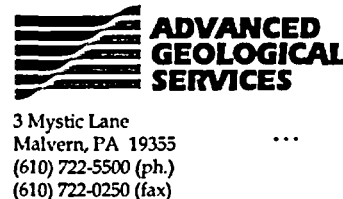


**APPENDIX A**

**ADVANCED GEOLOGICAL SERVICES DIGITAL OPTICAL TELEVIEWER  
REPORT**

Reference: 03-254-1  
September 26, 2003



Mr. Patrick Pontoriero  
MACTEC, Inc.  
Carnegie Office Park  
700 North Bell Avenue, Suite 200  
Pittsburgh, PA 15106

Subject: Results of Optical Televiwer Logging  
Church Rock Site  
Gallup, New Mexico

Dear Mr. Pontoriero:

Advanced Geological Services (AGC) is pleased to submit this letter report that presents the results of digital optical televiwer (DOPTV) logging performed at the above referenced site. The fieldwork was performed on July 29 and August 15, 2003. The purpose of the logging was to determine the depth and attitude of fractures created during hydrofracturing of groundwater well HF-3. The logging was performed in HF-3 before and after hydrofracturing to compare results. Also logged was an observation well that was drilled after hydrofracturing was completed.

## 1.0 METHODOLOGY

The optical televiwer data were acquired using a Robertson Geologging Micrologger II system with digital optical televiwer probe. The optical televiwer probe combines the axial view of a downward looking digital imaging system with a precision ground hyperbolic mirror to obtain an undistorted 360° view of the borehole wall. The probe records one 360° line of pixels at 0.003-ft depth intervals. The sample circle can be divided into 720 or 360 radial samples to give 0.5° or 1° radial resolution. The line of pixels is aligned with respect to True North and digitally stacked to construct a complete, undistorted, and oriented image of the borehole walls. The data are 24-bit true color and may be used for lithologic determination as part of the interpretation. Since the acquired image is digitized and properly oriented with respect to borehole deviation and tool rotation, it allows accurate determination of dip and dip direction of planar features such as fractures and bedding planes.

The attitudes of planar features are determined by digitizing the sinusoidal trace of the lineation observed on the borehole wall. The sinusoidal shape is observed in the "flattened" DOPTV image and results from the lineation created by the intersection of planar features and the cylindrical borehole wall.

## 2.0 SUMMARY OF RESULTS

### 2.1. HYDROFRACTURE WELL HF-3

The results of the DOPTV logging are presented in Attachment A. Digital versions of the logs are provided on the enclosed CD. DOPTV images of the open interval of HF-3 are provided in

Figure 1. These results provide a 360° visual comparison of the bedrock conditions before and after hydrofracturing. Hydrofracturing of the lower zone produced a large open fracture at depth of 164.1 ft. The fracture aperture is approximately 2 inches. The fracture attitude is approximately 12° to the northwest.

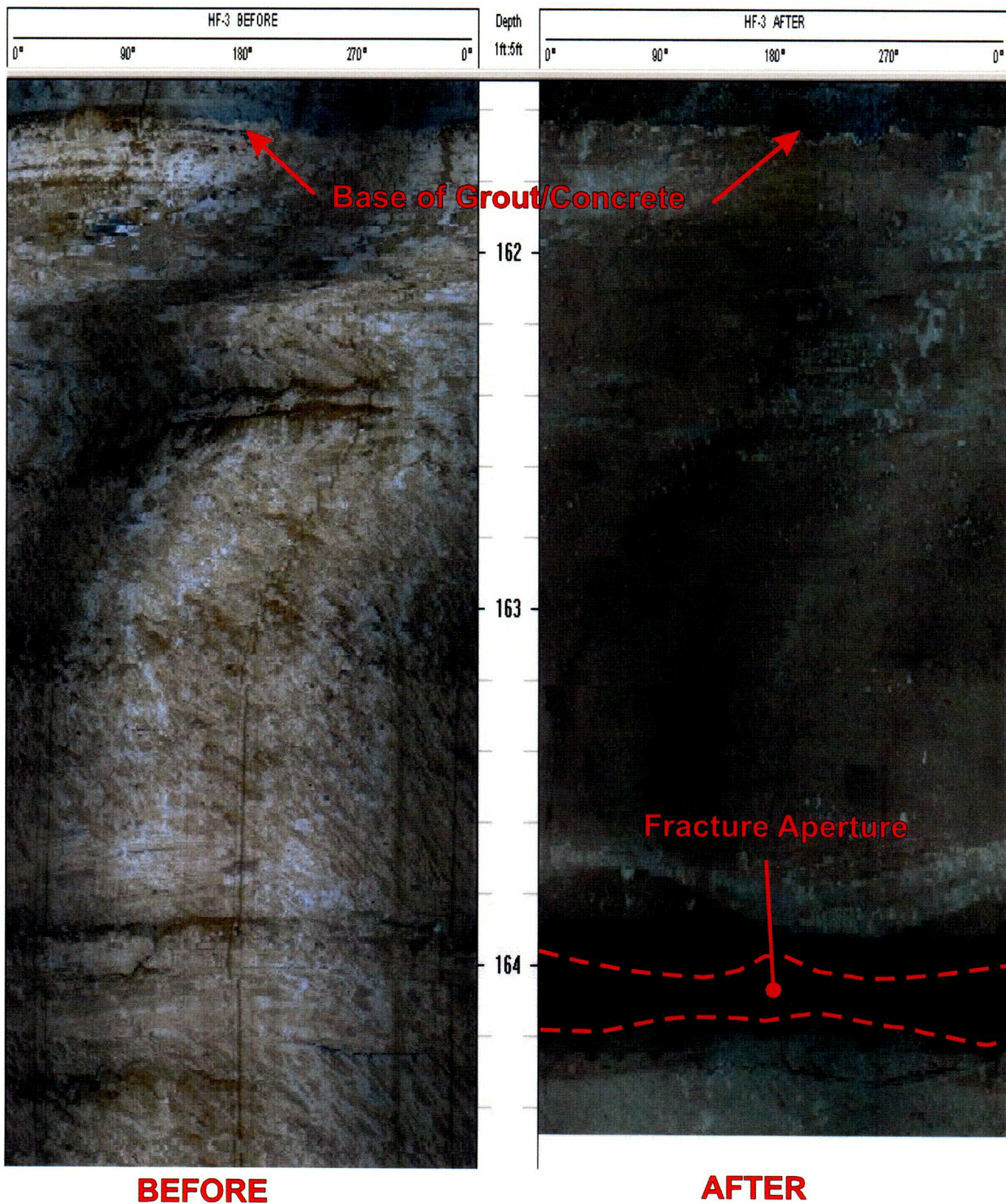
Figure 2 presents DOPTV images of the casing perforations for the upper hydrofracturing zone. The track on the left is a "flattened" 360° view. The track on the right is 3-D or "virtual core" display of the data. Eight casing perforations are observed.

## *2.2. NEW OBSERVATION WELL*

The results of the DOPTV logging are presented in Attachment A. Digital versions of the logs are provided on the enclosed CD. Figure 3 presents an example log of the representative fractures observed in the New Observation Well. The "Structure Projection" log indicates the mapped fracture configuration. The "Tadpole Plot" track provides a graphical representation of the fracture attitude. In this track, the fracture dip is determined by the values along the X-axis shown in the log title. The orientation of the tadpole represents the azimuthal dip direction. Finally, the "Polar Log" is a stereographic representation (or stereonet) of the fracture attitude. The stereonet is a poles of the planes representation with an equal-area (Schmidt net), southern hemisphere projection.

Table 1 presents a listing of the attitude of fractures observed in the New Observation Well. Graphical and statistical analyses of these data are presented in the rose diagram and stereonet in Figure 4.





3 Mystic Lane  
Malvern, PA 19355  
(610) 722-5500  
(610) 722-0250 (fax)

JOB NO:  
03-254  
DATE:  
September 23, 2003

DRAWN BY:  
MSM  
APPROVED:  
MSM

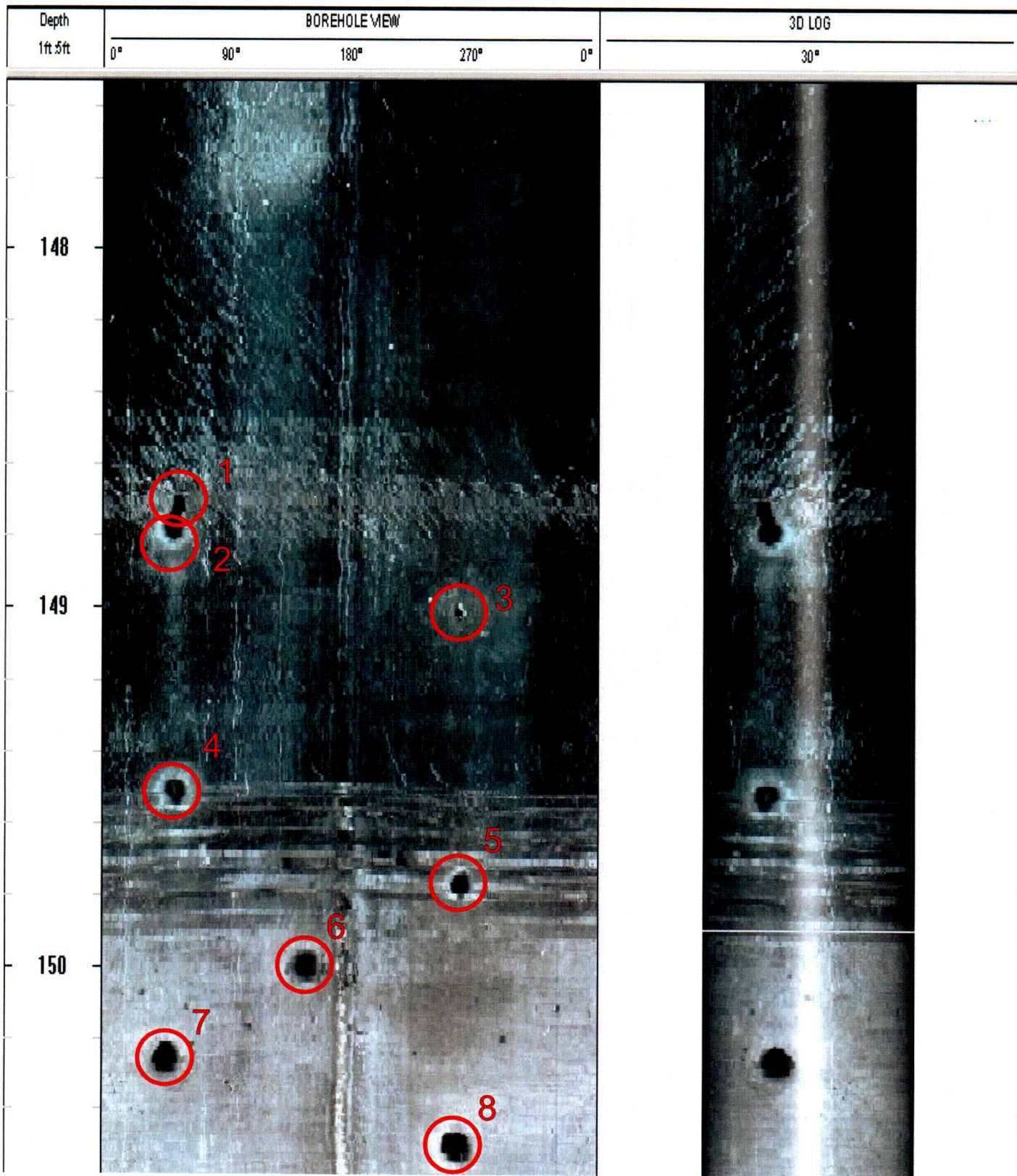
SCALE:  
NTS

**FIGURE 1**

PREPARED FOR:  
MACTEC, Inc.  
Carnegie Office Park  
700 North Bell Avenue, Suite 200  
Pittsburgh, PA 15106

360-DEGREE DOPTV IMAGES OF BEFORE & AFTER FRACTURING  
WELL HF-3, CHURCH ROCK SITE  
GALLUP, NEW MEXICO





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Malvern, PA 19355  
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JOB NO:  
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September 23, 2003

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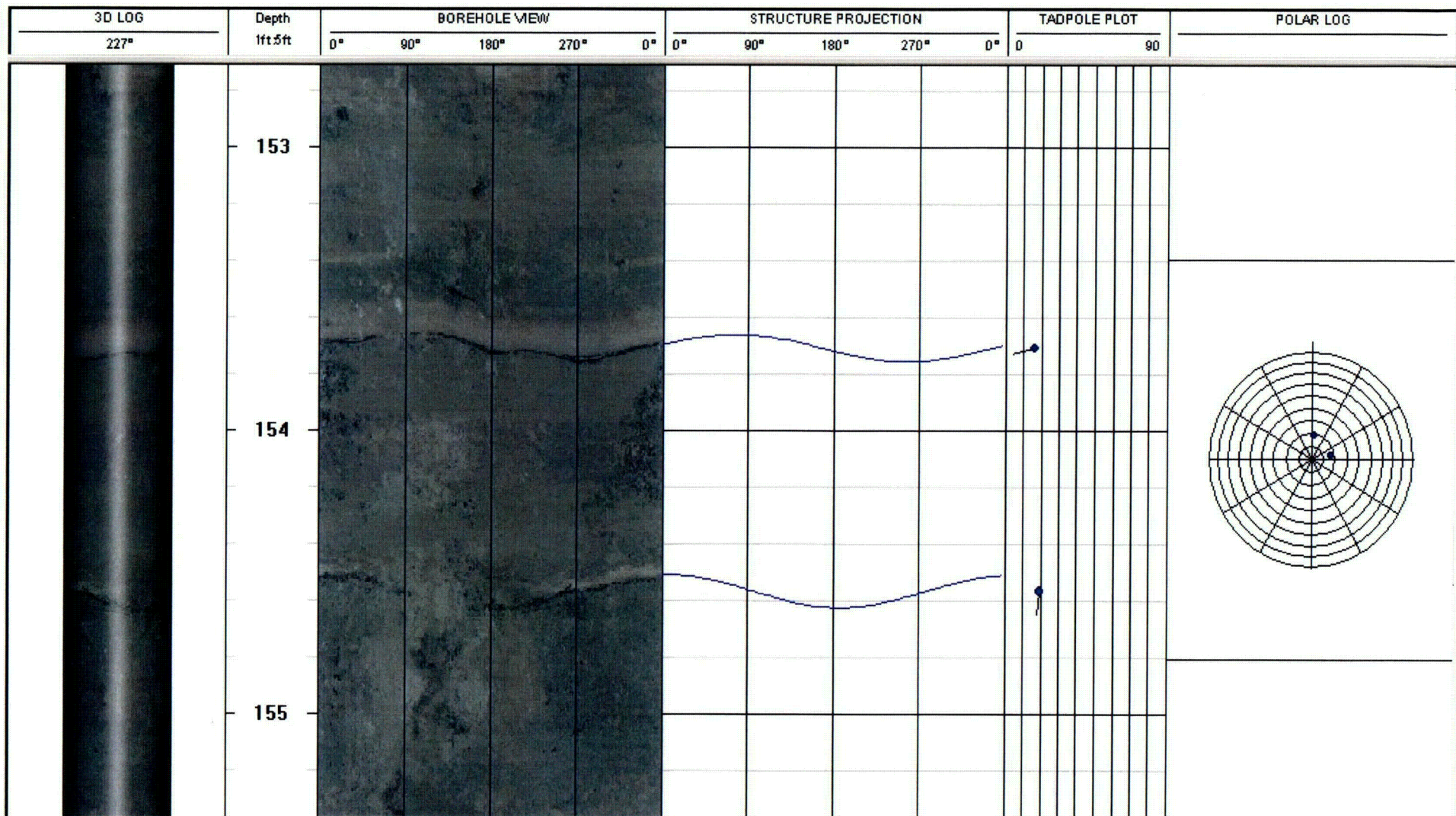
SCALE:  
NTS

**FIGURE 2**

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700 North Bell Avenue, Suite 200  
Pittsburgh, PA 15106

DOPTV IMAGES OF EIGHT CASING PERFORATIONS  
WELL HF-3, CHURCH ROCK SITE  
GALLUP, NEW MEXICO





3 Mystic Lane  
Malvern, PA 19355  
(610) 722-5500  
(610) 722-0250 (fax)

JOB NO:

03-254

DATE:

09/26/03

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MSM

APPROVED:

MSM

SCALE:

NTS

PREPARED FOR:

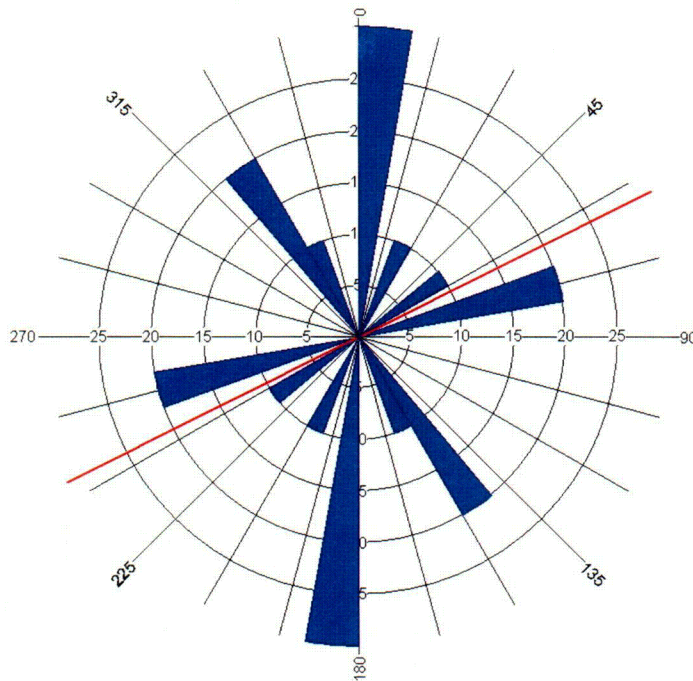
MACTEC, Inc.  
Carnegie Office Park  
700 North Bell Avenue, Suite 200  
Pittsburgh, PA 15106

FIGURE 3

DOPTV LOG OF REPRESENTATIVE FRACTURES  
NEW OBSERVATION WELL, CHURCH ROCK SITE  
GALLUP, NEW MEXICO

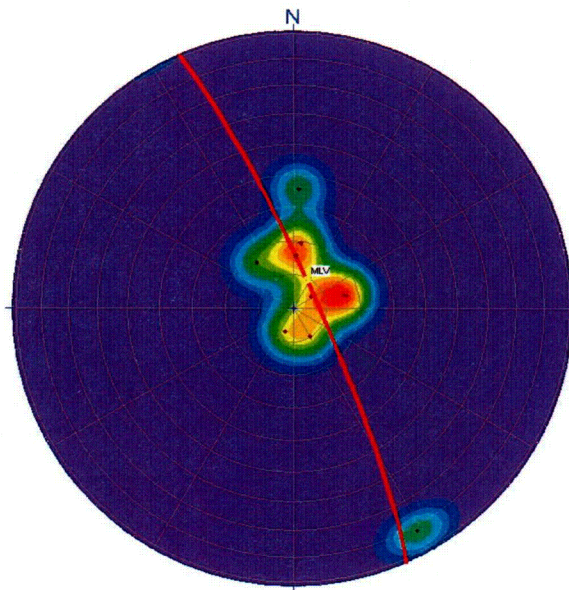


# ROSE DIAGRAM OF FRACTURE AZIMUTH



Calculation Method .... Frequency  
 Class Interval ..... 10 Degrees  
 Length Filtering ..... Deactivated  
 Azimuth Filtering ..... Deactivated  
 Data Type ..... Bidirectional  
 Population ..... 10  
 Maximum Percentage .... 30.0 Percent  
 Mean Percentage ..... 16.7 Percent  
 Standard Deviation .... 7.78 Percent  
 Vector Mean ..... 63.3 Degrees  
 Confidence Interval ... 54.49 Degrees  
 R-mag ..... 0.55

# STEREONET OF FRACTURE ATTITUDE



24.0  
 22.0  
 20.0  
 18.0  
 16.0  
 14.0  
 12.0  
 10.0  
 8.0  
 6.0  
 4.0  
 2.0  
 0.0

Projection ..... Schmidt (Equal Area)  
 Number of Sample Points .... 10  
 Mean Lineation Azimuth .... 25.0  
 Mean Lineation Plunge ..... 80.7  
 Great Circle Azimuth ..... 336.0  
 Great Circle Plunge ..... 83.0  
 1st Eigenvalue ..... 0.841  
 2nd Eigenvalue ..... 0.142  
 3rd Eigenvalue ..... 0.017  
 LN ( E1 / E2 ) ..... 1.776  
 LN ( E2 / E3 ) ..... 2.153  
 (LN(E1/E2) ] / (LN(E2/E3)) .. 0.825  
 Spherical variance ..... 0.1205  
 Rbar ..... 0.8795

MLV = Mean Lineation Vector



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 Malvern, PA 19355  
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 03-254  
 DATE:  
 September 23, 2003

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 MSM  
 APPROVED:  
 MSM

SCALE:  
 NTS

## FIGURE 4

PREPARED FOR:  
 MACTEC, Inc.  
 Carnegie Office Park  
 700 North Bell Avenue, Suite 200  
 Pittsburgh, PA 15106

FRACTURE ANALYSIS OF CH-3  
 CHURCH ROCK SITE  
 GALLUP, NEW MEXICO



**Table 1: Attitude of Fractures Observed in New Observation Well.**

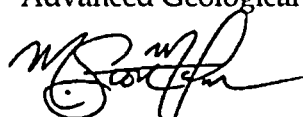
DEPTH	DIP DIRECTION	DIP
136.6	331.0	81.4
141	182.6	35.7
148.8	328.9	9.5
151.1	183.2	15.6
151.2	20.3	7.1
153.7	256.5	16.1
154.6	186.8	19.4
156.2	254.5	15.3
157.2	236.3	6.3
158.3	141.8	17.2

### **3.0 CLOSING**

The data collection and interpretation methodologies used in this investigation are consistent with standard practices applied to similar geophysical investigations. The correlation of geophysical responses with probable subsurface features is based on the past results of similar surveys although it is possible that some variation could exist at this site.

Please contact us if you have any questions regarding this survey. We appreciate your business and look forward to working with you again.

Kind regards,  
Advanced Geological Services



M. Scott McQuown, M.Sc., P.G.  
*Senior Geophysicist*

Attachments

**ATTACHMENT A  
GEOPHYSICAL WELL LOGS**

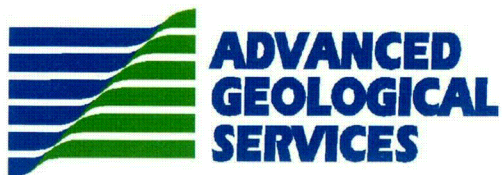
Color Key to Structure Logs

Yellow - Grout/bedrock Contact

Blue - Fracture

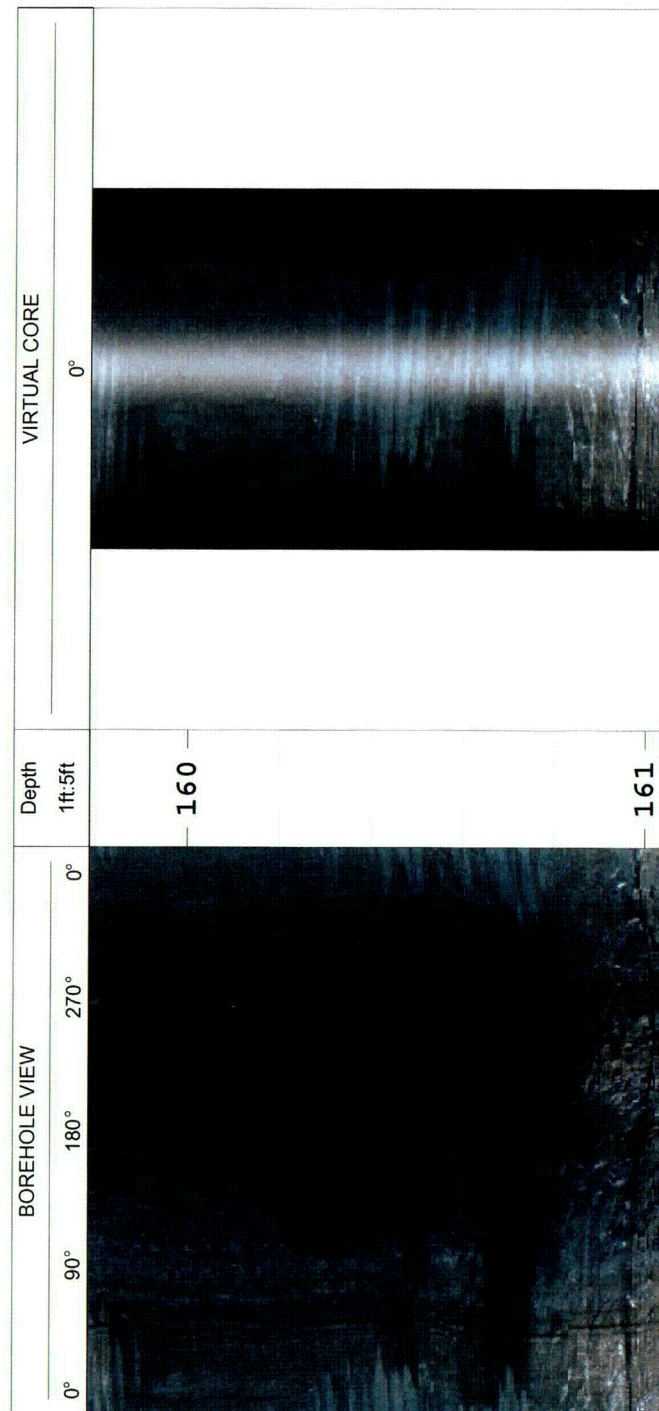
Green - Bedding Plane

Magenta - Bedding Parting



# HF3Before

CO MACTEC WELL HF-3 FLD CHURCH ROCK CTY GALLUP STE NM FILING No	CLIENT		MACTEC		
	WELL ID		HF-3		
	FIELD		CHURCH ROCK		
	CITY		GALLUP	STATE NM	
LOCATION		OTHER SERVICES			
SEC		TWP	RGE		
PERMANENT DATUM		ELEVATION		K.B.	
LOG MEAS. FROM		GROUND SURFACE	ABOVE PERM. DATUM	D.F.	
DRILLING MEAS. FROM				G.L.	
DATE			TYPE FLUID IN HOLE		
RUN No			SALINITY		
TYPE LOG			DENSITY		
DEPTH-DRILLER			LEVEL		
DEPTH-LOGGER			MAX. REC. TEMP.		
BTM LOGGED INTERVAL					
TOP LOGGED INTERVAL					
OPERATING RIG TIME					
RECORDED BY					
WITNESSED BY					
RUN	BOREHOLE RECORD			CASING RECORD	
NO.	BIT	FROM	TO	SIZE	WGT.



C17



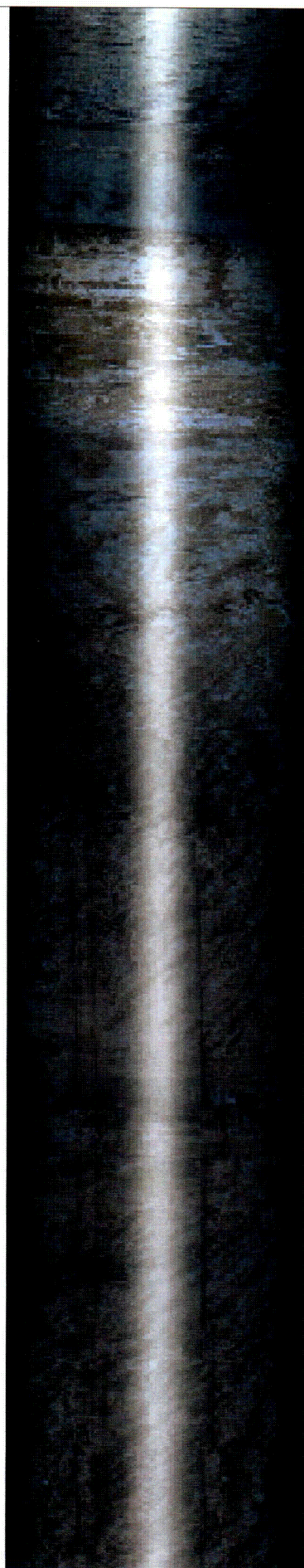


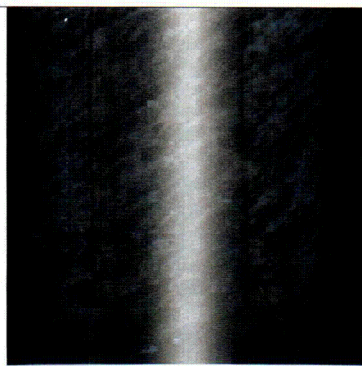
162

163

164

165



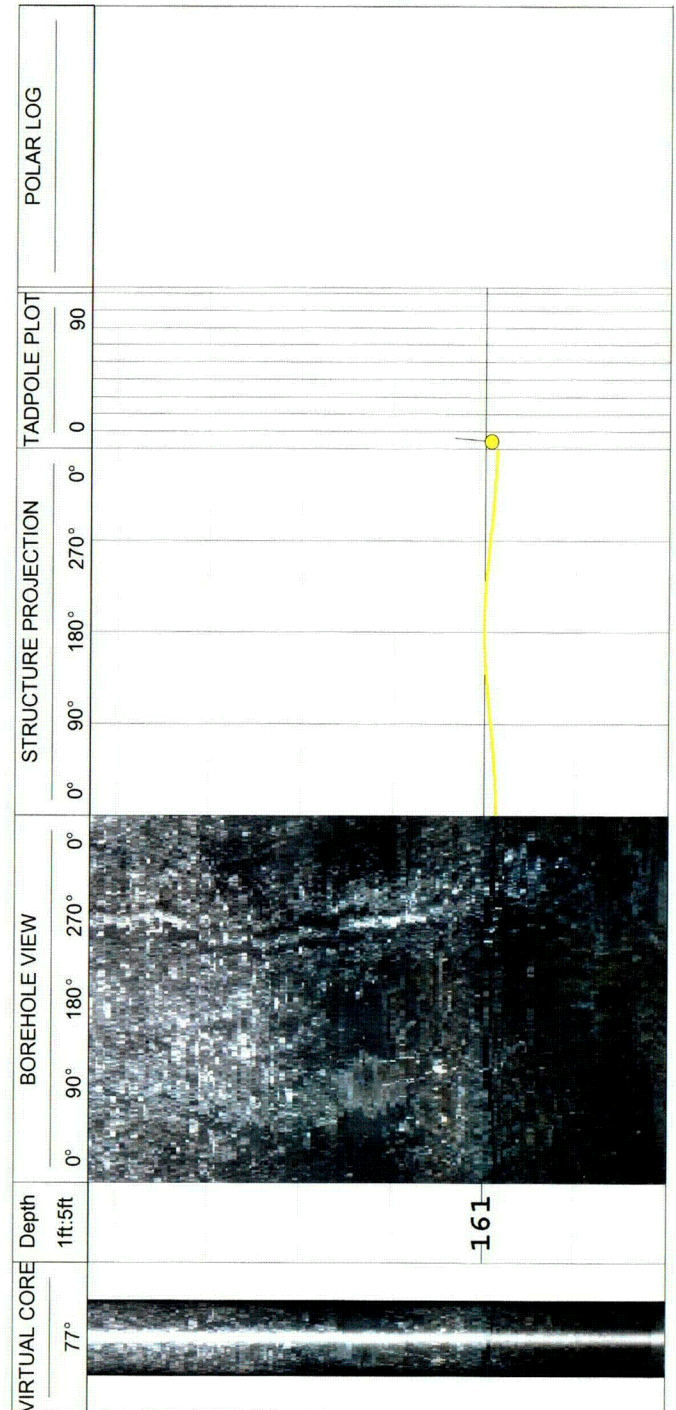






# HF-3 After

CO MACTEC WELL HF-3 FLD CHURCH ROCK CTY GALLUP STE NM FILING No	CLIENT		MACTEC		
	WELL ID		HF-3		
	FIELD		CHURCH ROCK		
	CITY	GALLUP	STATE	NM	
	LOCATION		OTHER SERVICES		
	SEC	TWP	RGE		
PERMANENT DATUM		ELEVATION		K.B.	
LOG MEAS. FROM	TOP OF CASING		ABOVE PERM. DATUM	D.F.	
DRILLING MEAS. FROM				G.L.	
DATE			TYPE FLUID IN HOLE		
RUN No			SALINITY		
TYPE LOG			DENSITY		
DEPTH-DRILLER			LEVEL		
DEPTH-LOGGER			MAX. REC. TEMP.		
BTM LOGGED INTERVAL					
TOP LOGGED INTERVAL					
OPERATING RIG TIME					
RECORDED BY					
WITNESSED BY					
RUN	BOREHOLE RECORD			CASING RECORD	
NO.	BIT	FROM	TO	SIZE	WGT.

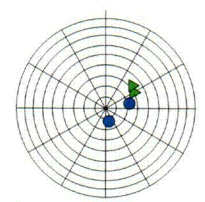
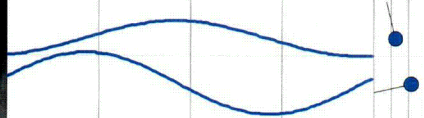
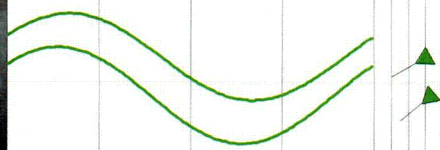




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163

164





CO MACTEC  
WELL CH  
FLD CHURCH ROCK  
CTY GALLUP  
STE NM  
FILING No

CLIENT MACTEC  
WELL ID NEW OBSERVATION WELL  
FIELD CHURCH ROCK  
CITY GALLUP STATE NM

LOCATION OTHER SERVICES

SEC TWP RGE

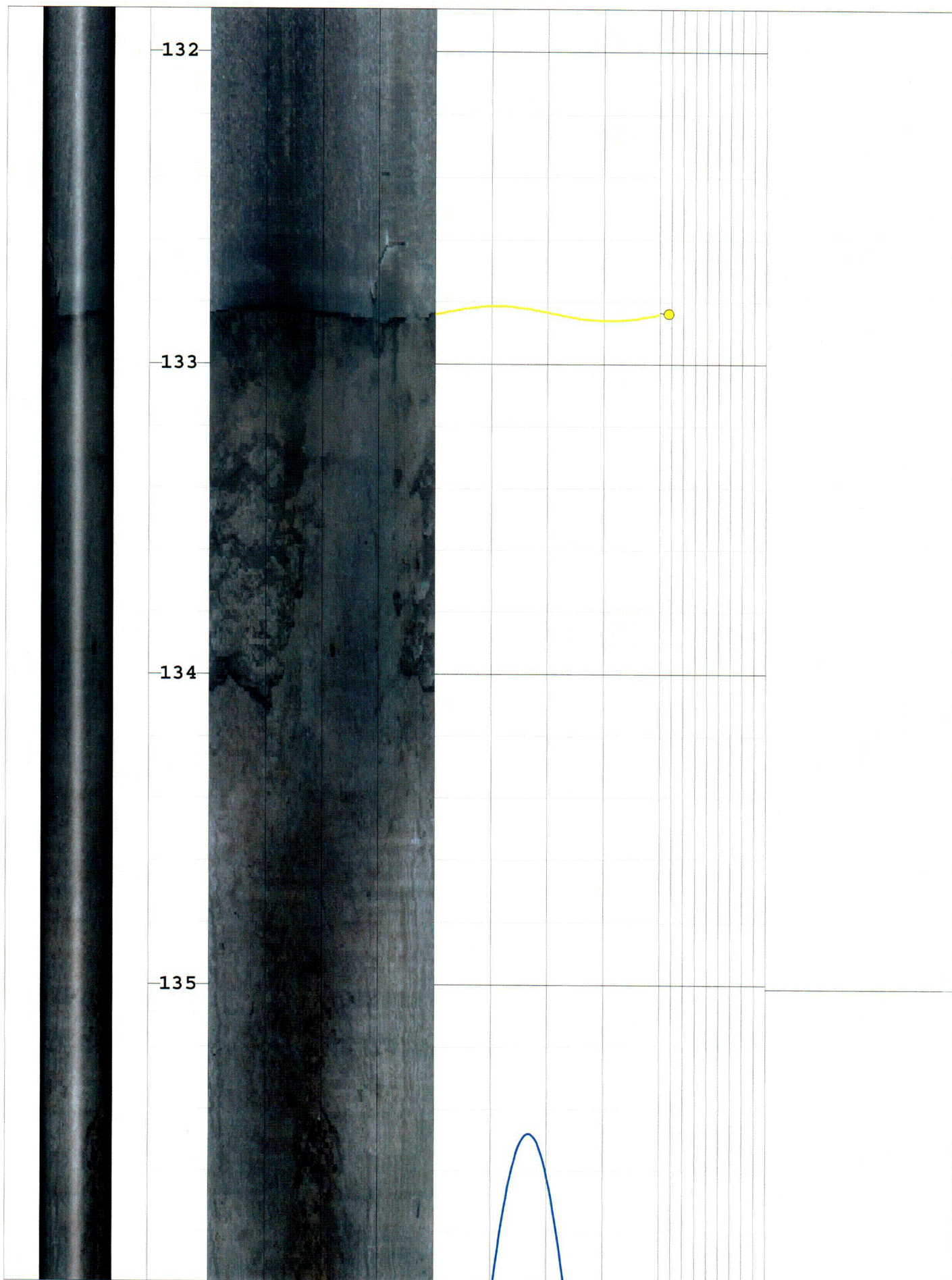
PERMANENT DATUM ELEVATION K.B.  
LOG MEAS. FROM GROUND SURFACE ABOVE PERM. DATUM D.F.  
DRILLING MEAS. FROM G.L.

DATE		TYPE FLUID IN HOLE	
RUN No		SALINITY	
TYPE LOG		DENSITY	
DEPTH-DRILLER		LEVEL	
DEPTH-LOGGER		MAX. REC. TEMP.	
BTM LOGGED INTERVAL			
TOP LOGGED INTERVAL			
OPERATING RIG TIME			
RECORDED BY			
WITNESSED BY			

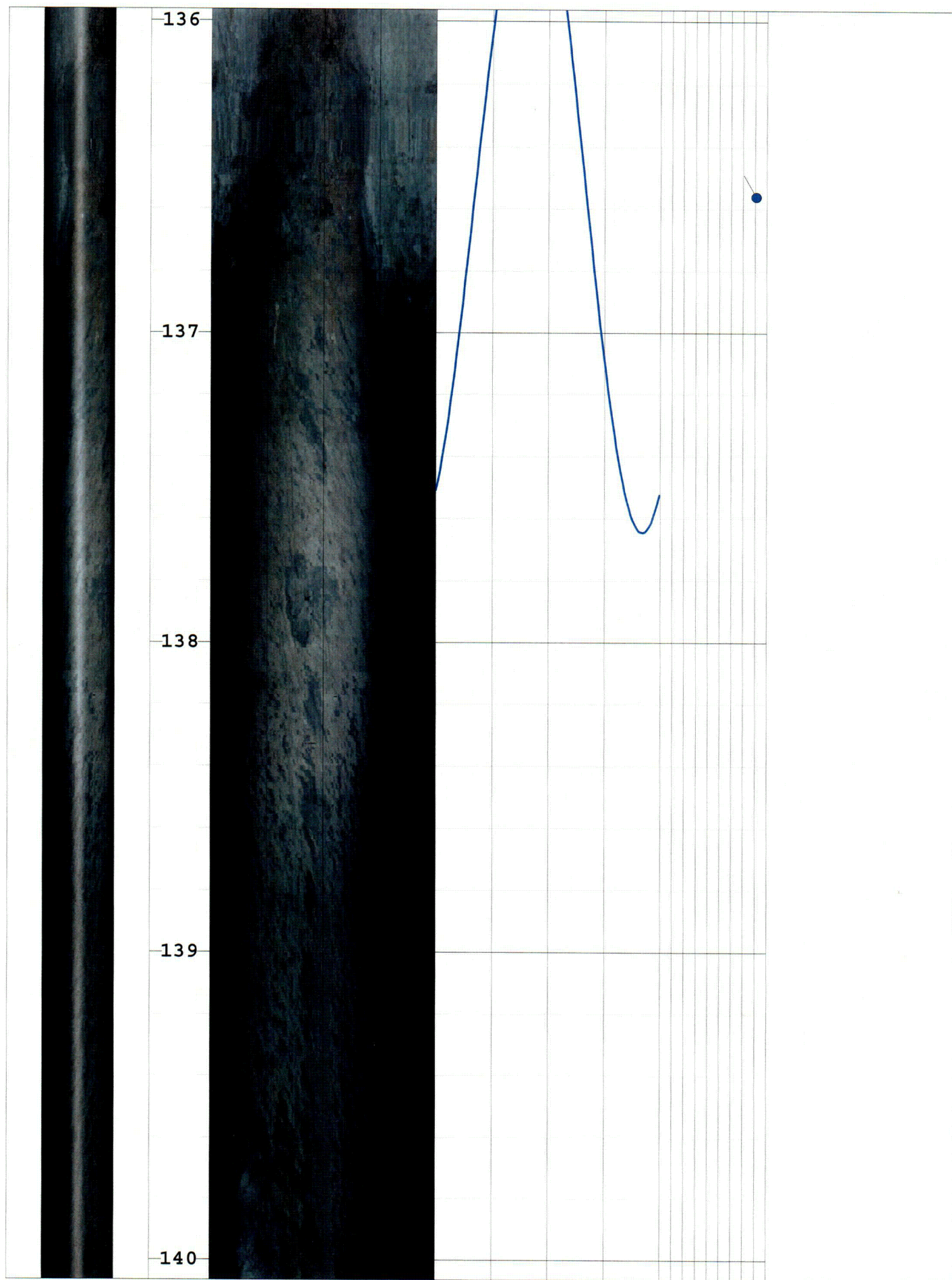
BOREHOLE RECORD				CASING RECORD			
RUN NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO

3D LOG 227°	Depth 1ft:5ft	BOREHOLE VIEW 0° 90° 180° 270° 0°	STRUCTURE PROJECTION 0° 90° 180° 270° 0°	TADPOLE PLOT 0 90	POLAR LOG	







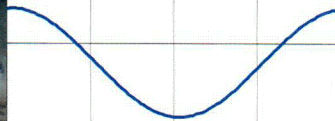


141

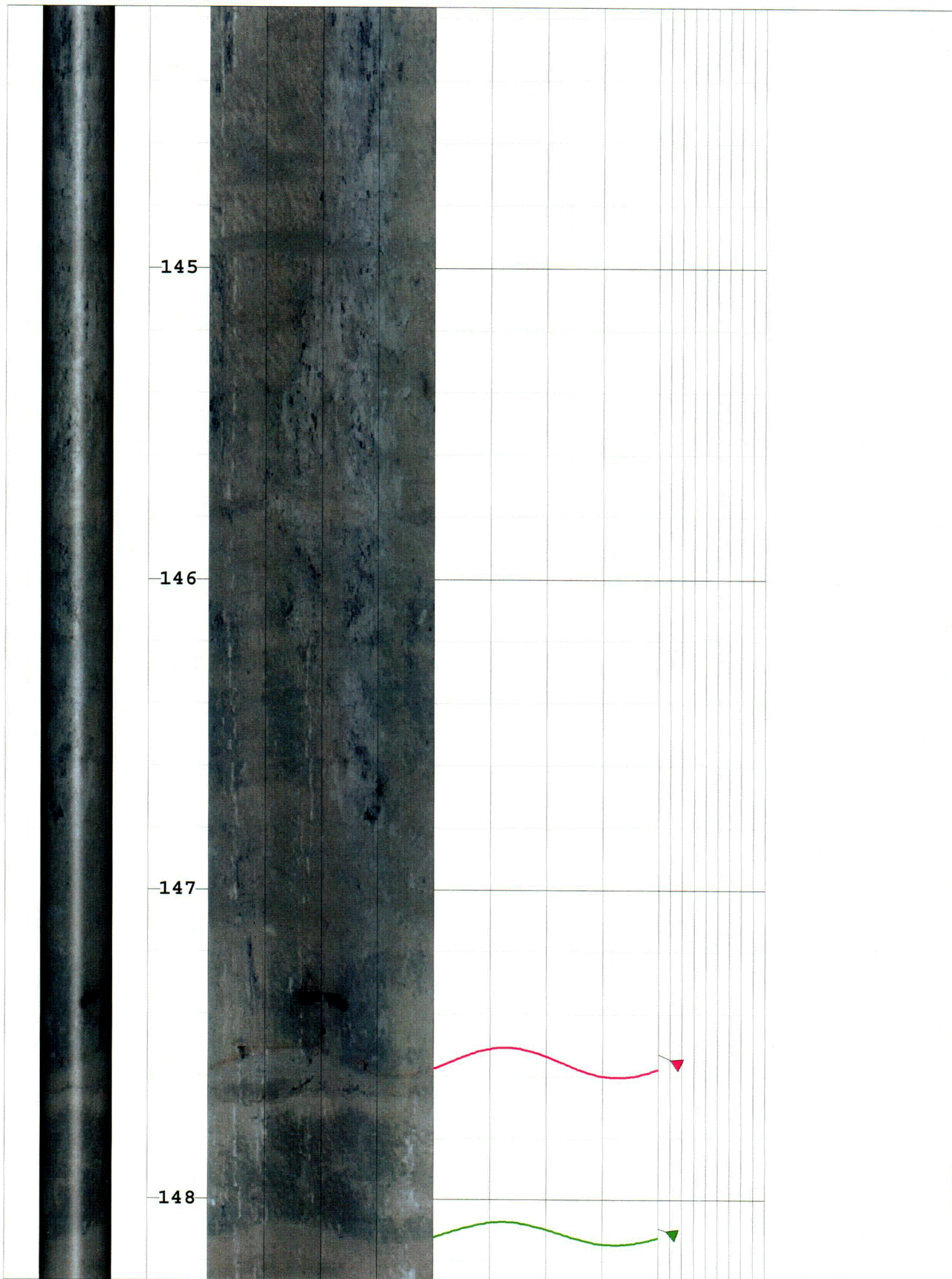
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143

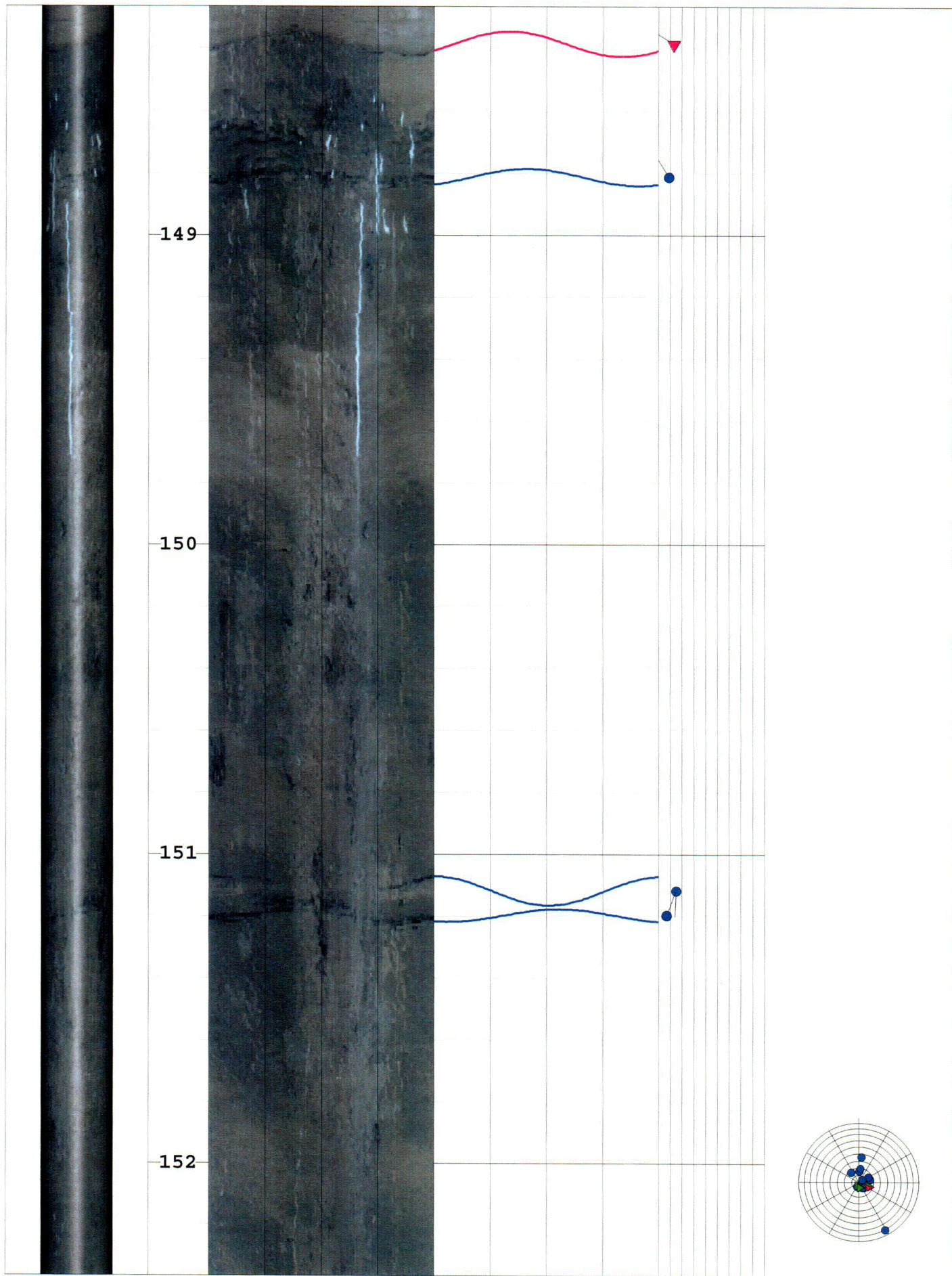
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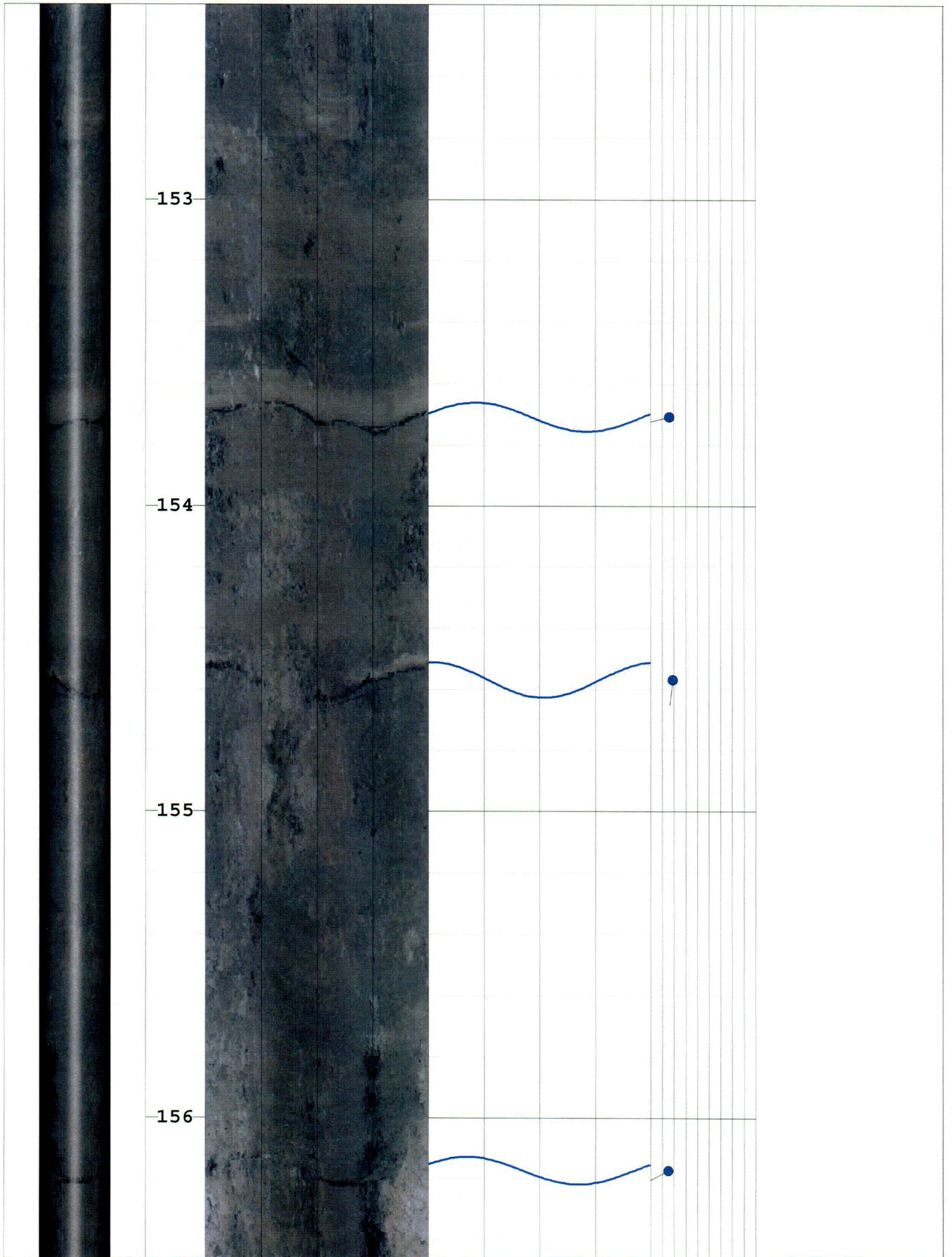




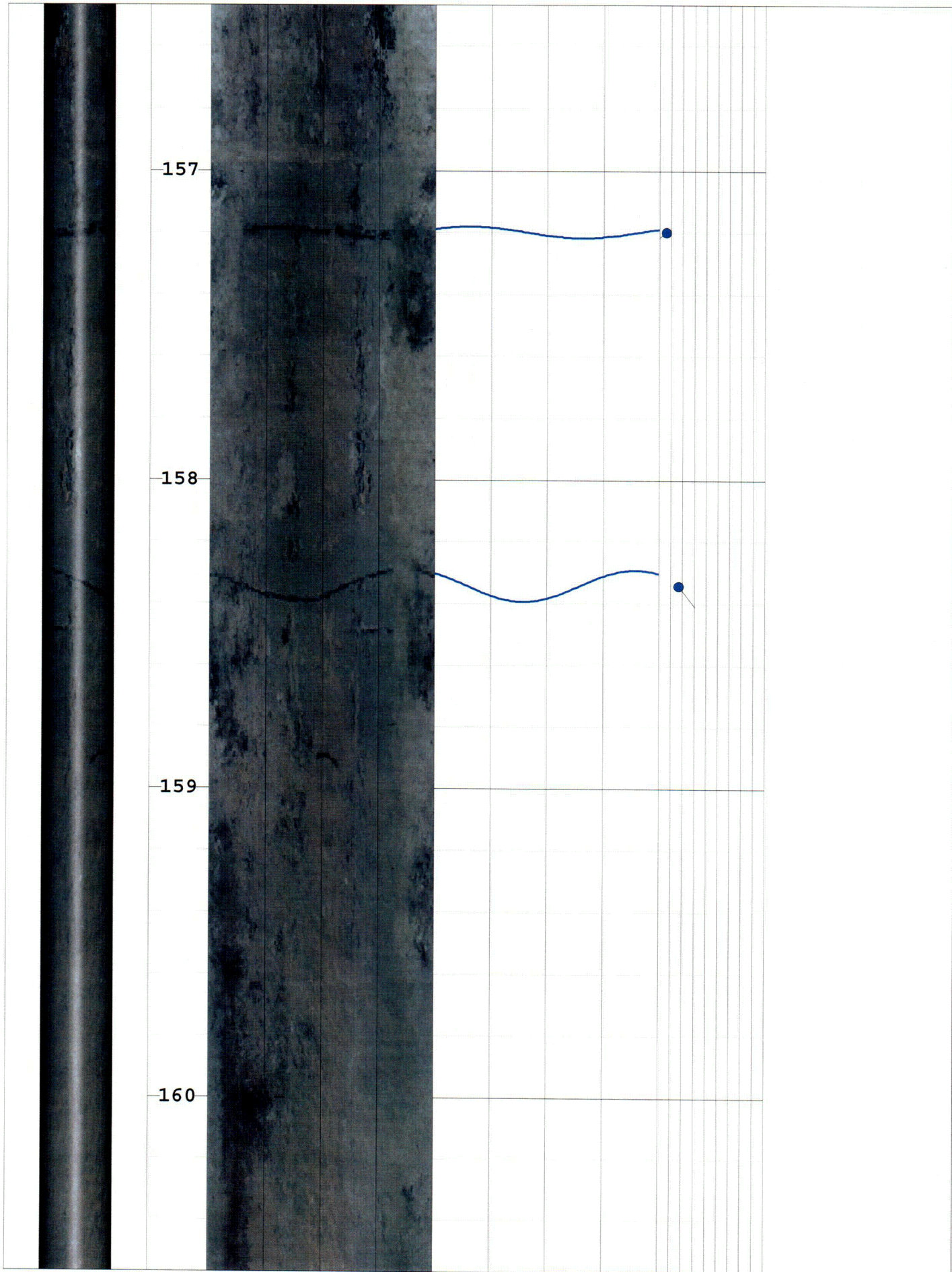












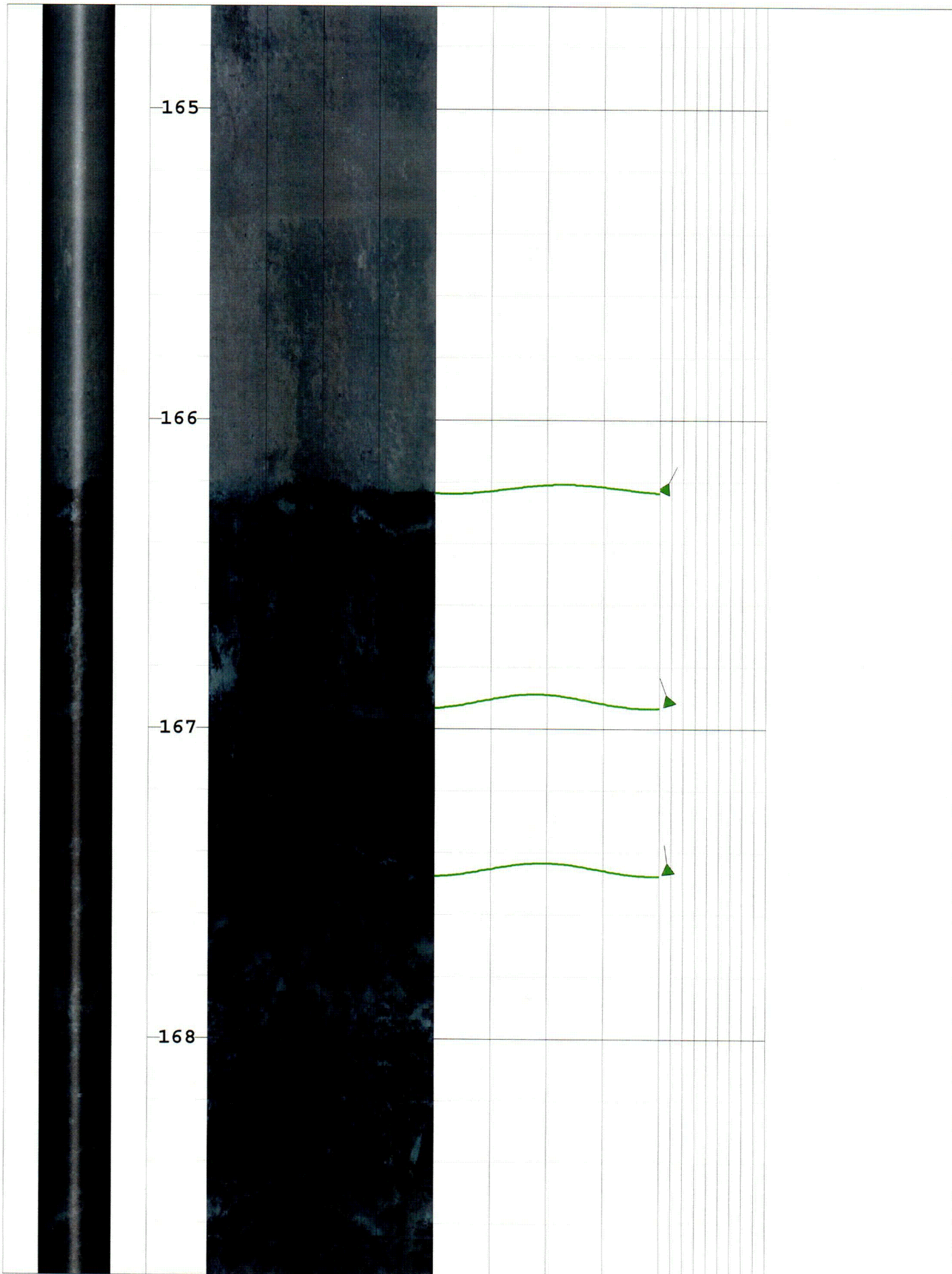


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171

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**APPENDIX B**

**PUMPING TEST DATA AND GRAPHS (CD ROM)**