# Appendix 3. Borehole geophysical logs from boreholes near the Transmitter Site on Howard Mountain, near Machiasport, Maine

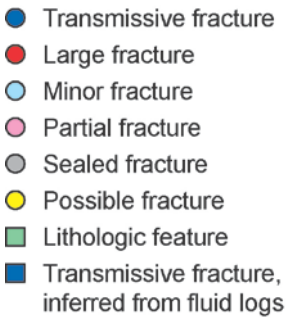
# Explanation Information for Appendixes

## Abbreviations on log plots:

| | |
|---|---|
| Acou Caliper, in inch | caliper measured by acoustic televiewer, in inches |
| ATV | acoustic televiewer traveltime |
| ATV Amp | acoustic televiewer amplitude |
| ATV Amp, in mV | acoustic televiewer amplitude, in millivolts |
| Azi | azimuth |
| Caliper, in inch | 3-arm mechanical caliper, in inches |
| deg | degrees |
| dev | deviation |
| DO | dissolved oxygen |
| Eh, in mV | electromotive potential, in millivolts |
| EMI Cond, in mmho/m | electromagnetic induction conductivity, in millimhos per meter |
| Frax | fracture |
| FRX | fracture |
| gal/min | gallon(s) per minute |
| gpm | gallon(s) per minute |
| Fl Cond, in µS/cm | fluid conductivity, in microsiemens per centimeter |
| Gamma, in CPS | natural gamma radiation, in counts per second |
| HPFM Amb, in gal/min | heat-pulse flowmeter, under ambient conditions, in gallons per minute |
| HPFM Pump, in gal/min | heat-pulse flowmeter, under pumped conditions, in gallons per minute |
| LH | lower hemisphere |
| Lith | lithologic feature |
| ls | land surface |
| Max | maximum |
| Min | minimum |
| Mtn | Mountain |
| O2 ppm | dissolved oxygen, in parts per million |
| OTV | optical televiewer image |
| pH | pH |
| R8, in Ohm-m | normal resistivity with electrode spacing of 8 inches, in ohm-meters |
| R16, in Ohm-m | normal resistivity with electrode spacing of 16 inches, in ohm-meters |
| R32, in Ohm-m | normal resistivity with electrode spacing of 32 inches, in ohm-meters |
| R64, in Ohm-m | normal resistivity with electrode spacing of 64 inches, in ohm-meters |
| SP, in mV | spontaneous potential, in millivolts |
| SP Cond, in µS/cm | specific conductivity, in microsiemens per centimeter |
| SPR, in Ohm | single point resistance, in ohms |
| Std. Dev. | standard deviation |
| T-Frax | transmissive fracture |
| tad | tadpole |
| Temp, in deg F | temperature, in degrees Fahrenheit |
| TN | true north |
| toc | top of casing |
| tt | travel time |
| Tx | transmissive |

## Image log interpretation:

Interpretations of structure from the image logs are shown in three forms, including projection, stereo, and tadpole plots. A consistent color code was used for all three plots. In addition, lithologic features are shown in the tadpole and stereoplots with squares, so as to distinguish them from interpreted fractures. Fractures interpreted as transmissive and shown with blue dots, were determined to be transmissive using the heat-pulse flowmeter. Transmissive fractures coded with blue squares were inferred to be transmissive from fluid conductivity, temperature, or other water-quality parameter logs.



Example of interpretation of borehole imaging data:

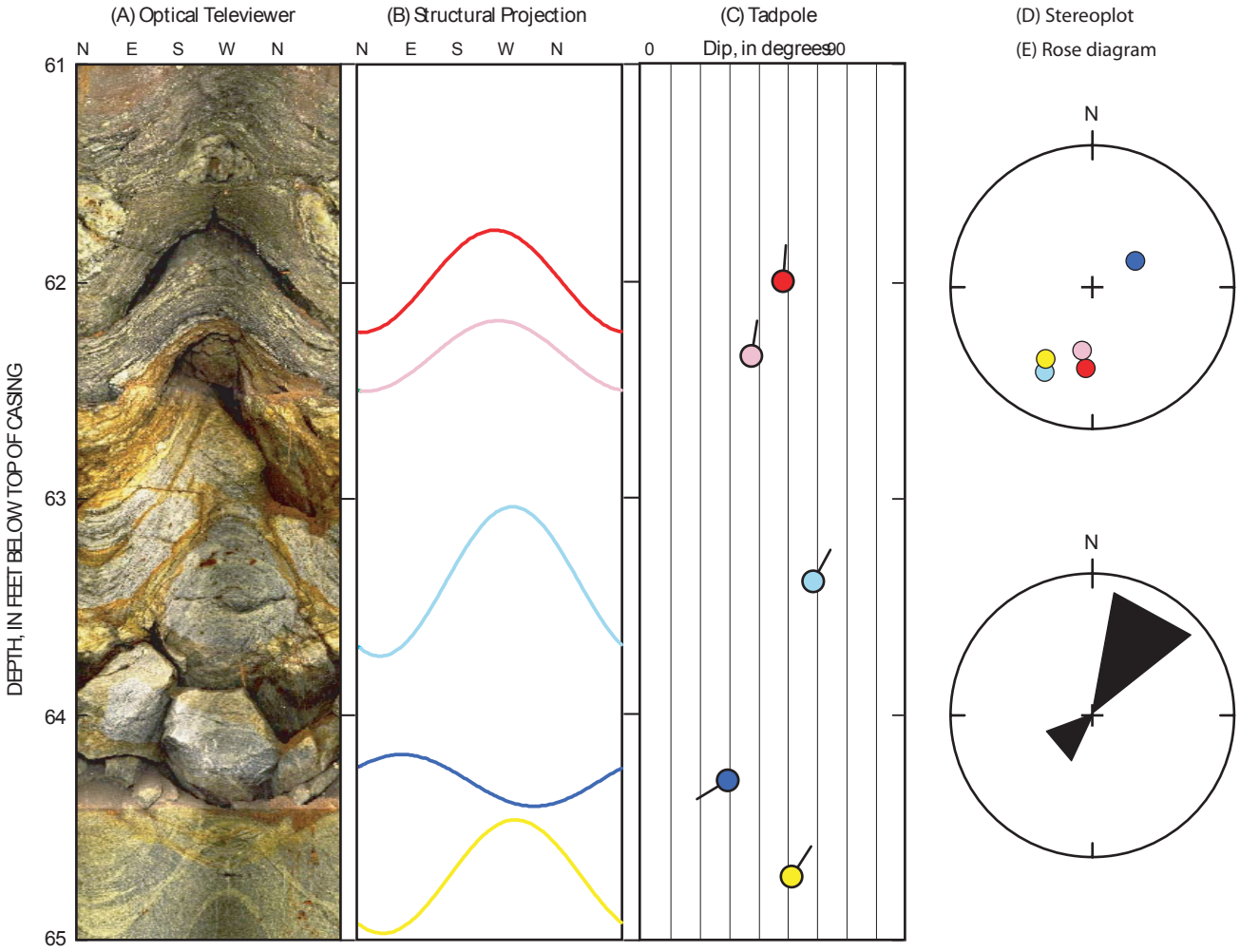



Figure. Example of interpretation of borehole imaging data.
(A) Optical televiewer image and the corresponding interpretation of planar data in (B) structural, (C) tadpole, and (D) stereographic projection plots. The trace of the features on the structural projection (B) directly overlays on the image (A). In the tadpole plot (C), depth is plotted along the y axis, and the magnitude of dip is plotted on the x axis. The tail of the tadpole points in the direction of dip relative to True North, which is at the top of the page. The poles to the planar features are shown in a lower-hemisphere equal-area stereonet (stereoplot) (D), which reduces the plane to a point. (E) Rose diagram, which shows frequency of dip direction.

# Appendix 3.

## Borehole geophysical logs from boreholes near the Transmitter Site on Howard Mountain, near Machiasport, Maine

**A. Borehole DW-6**

**Figure 3A–1**. Caliper, acoustic caliper, gamma, electromagnetic conductivity, fluid temperature, specific conductance, dissolved oxygen, pH, reduction oxidation, multi-space resistivity, oriented acoustic and optical borehole images, and heat-pulse flowmeter logs for borehole DW-6, near Machiasport, Maine.

**Figure 3A–2.** Borehole deviation logs for borehole DW-6, near Machiasport, Maine.

**Table 3A–1.** Interpretation of acoustic televiewer logs for borehole DW-6, near Machiasport, Maine.

**Figure 3A–3.** Projection, tadpole, and stereoplots of interpretation of borehole image data for borehole DW-6, near Machiasport, Maine.

**Figure 3A–4.** Interpretation and modeling of heat-pulse flowmeter logs for borehole DW-6, near Machiasport, Maine.

**B. Borehole DW-10**

**Figure 3B–1**. Caliper, acoustic caliper, gamma, electromagnetic conductivity, fluid temperature, specific conductance, dissolved oxygen, pH, reduction oxidation, multi-space resistivity, oriented acoustic and optical borehole images, and heat-pulse flowmeter logs for borehole DW-10, near Machiasport, Maine.

**Figure 3B–2.** Borehole deviation logs for borehole DW-10, near Machiasport, Maine.

**Table 3B–1.** Interpretation of acoustic televiewer logs for borehole DW-10, near Machiasport, Maine.

**Table 3B–2**. Interpretation of optical televiewer logs for borehole DW-10, near Machiasport, Maine.

**Figure 3B–3.** Projection, tadpole, and stereoplots of interpretation of borehole image data for borehole DW-10, near Machiasport, Maine.

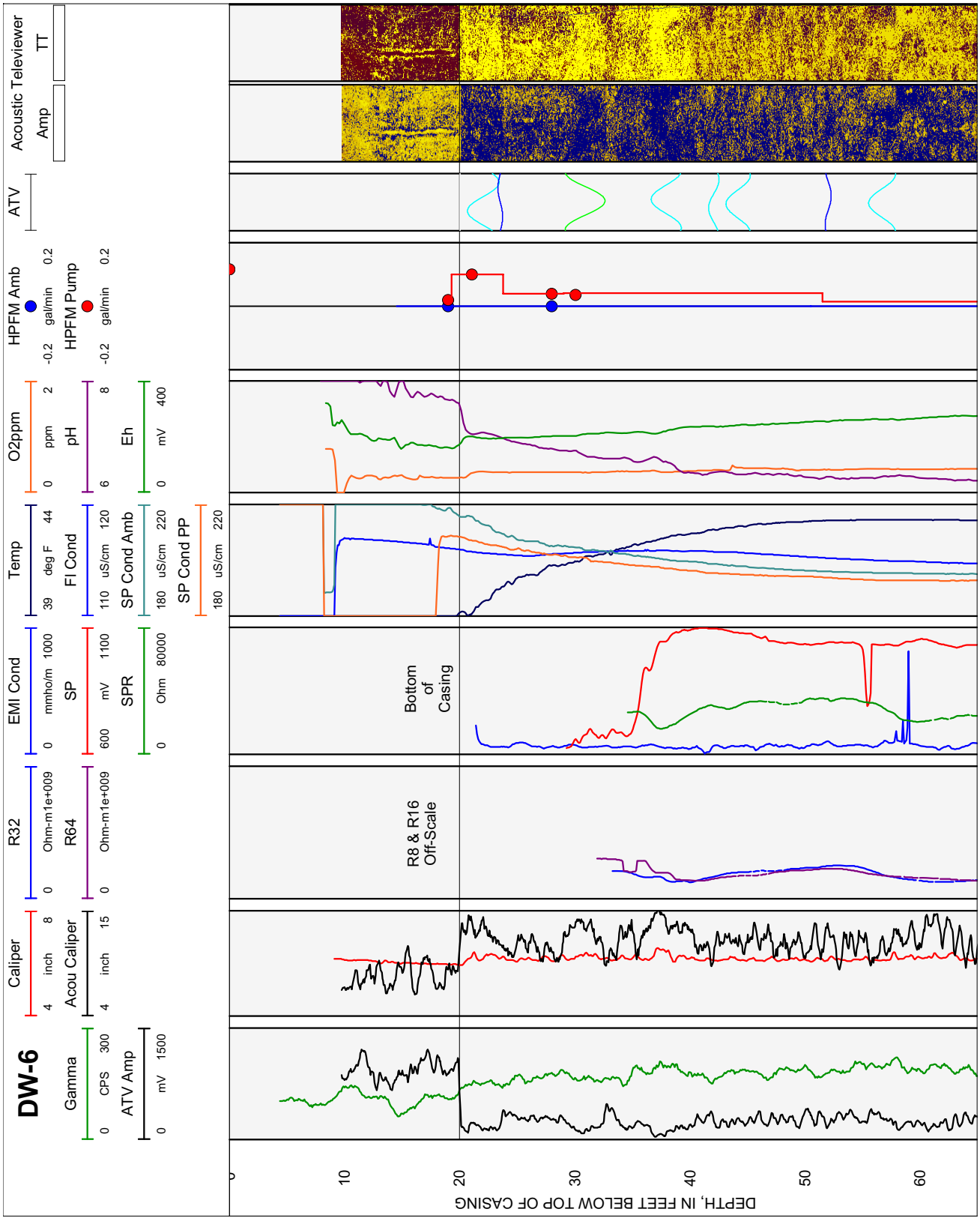



**Figure 3A-1.** Caliper, acoustic caliper, gamma, electromagnetic conductivity, fluid temperature, specific conductance, DO, pH, reduction oxidation, multi-space resistivity, oriented acoustic and optical borehole images, and heat-pulse flowmeter logs for borehole DW-6, near Machiasport, Maine.

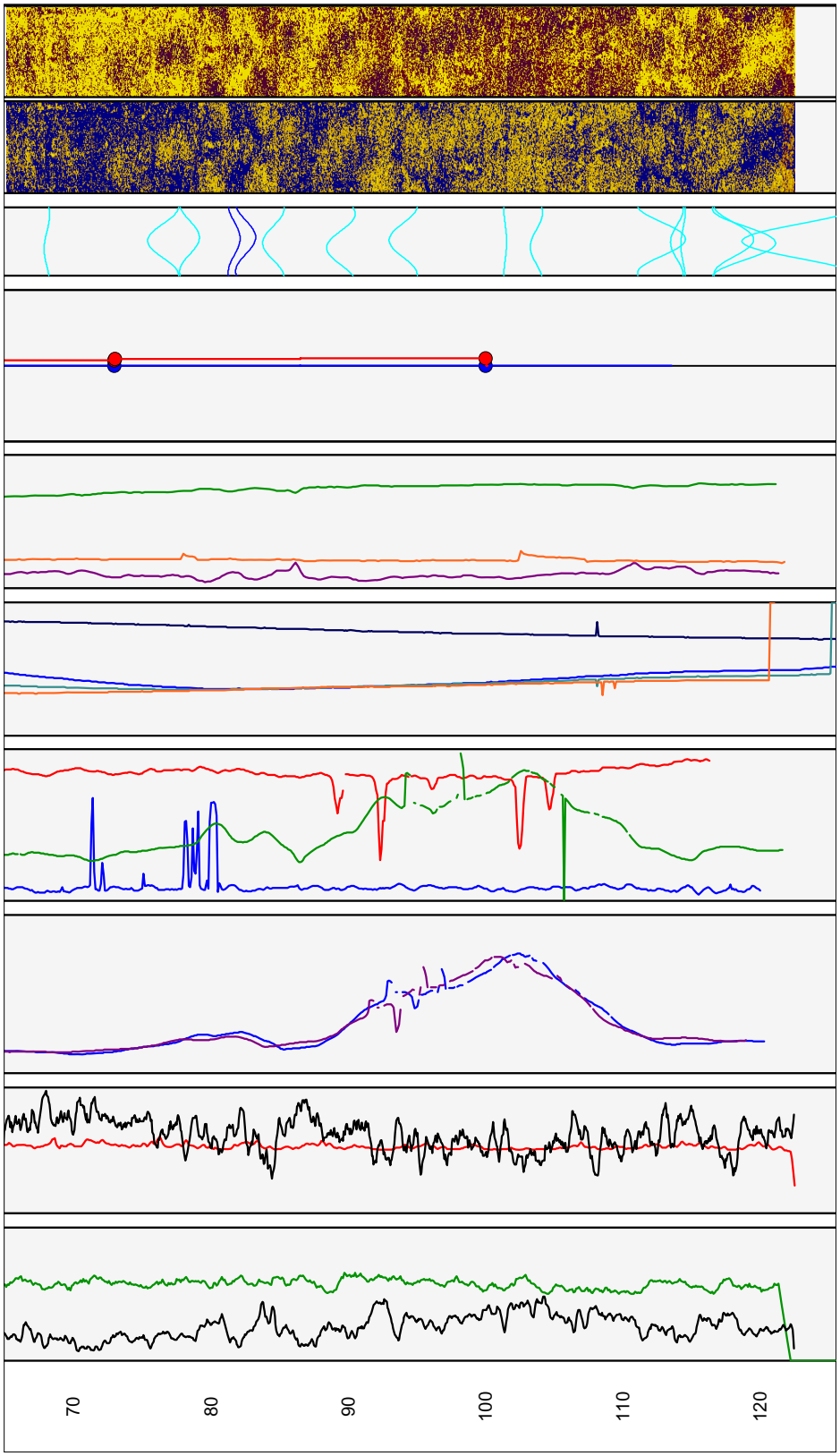



**Figure 3A-1.** Caliper, acoustic caliper, gamma, electromagnetic conductivity, fluid temperature, specific conductance, DO, pH, reduction oxidation, multi-space resistivity, oriented acoustic and optical borehole images, and heat-pulse flowmeter logs for borehole DW-6, near Machiasport, Maine.—Continued

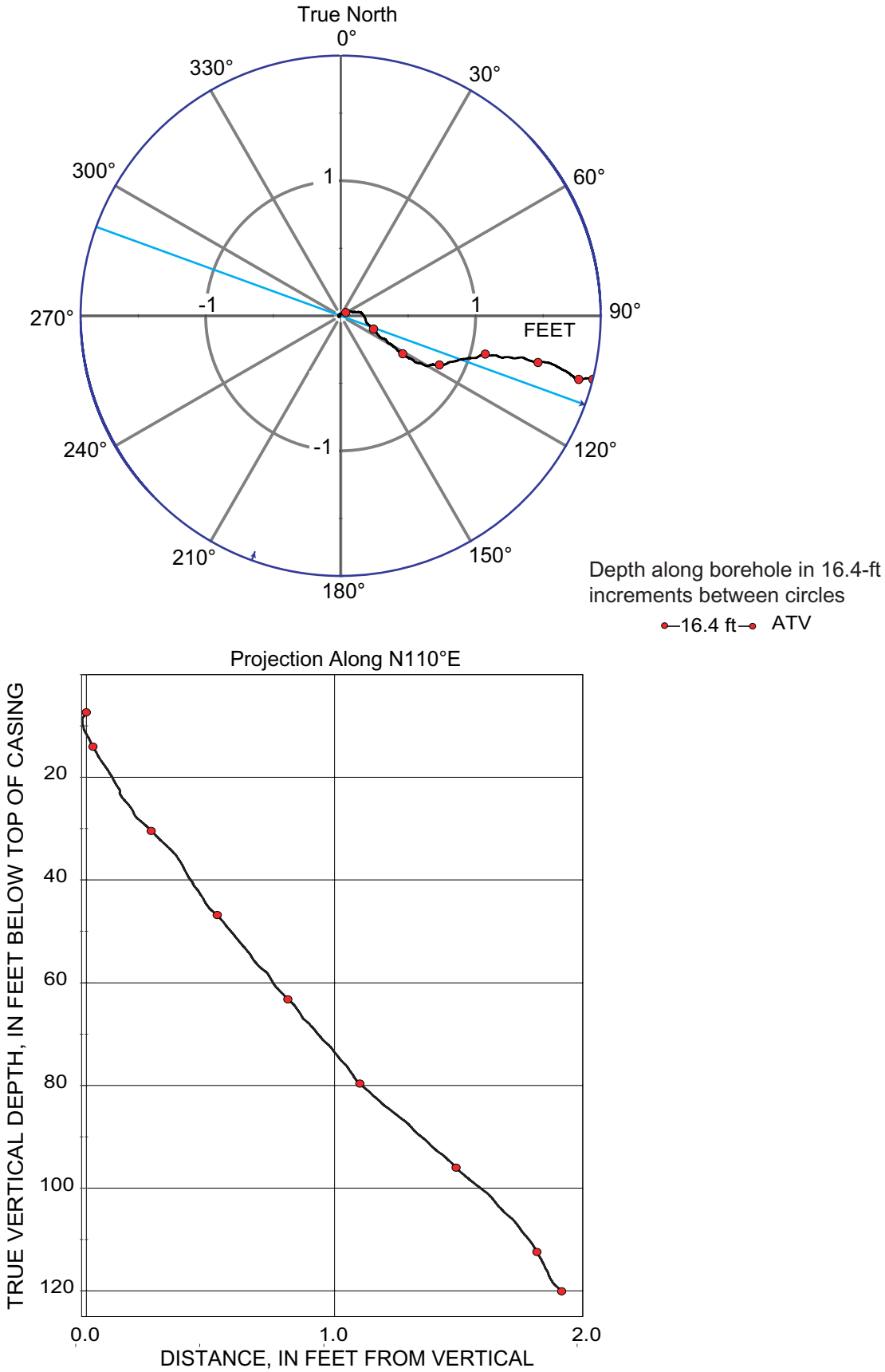



**Figure 3A-2.** Borehole deviation logs for borehole DW-6, near Machiasport, Main. Blue line on radial plot (top) is line of projection for vertical plot (bottom).

[ft, foot; ATV, acoustic televiewer]

**Table 3A–1.** Interpretation of acoustic televiewer logs for borehole DW-6, near Machiasport, Maine.
[Televiewer data are corrected for deviation and magnetic declination, so orientations are relative to true north; depths are below top of casing, which is 1.8 feet above land surface; dip azimuth is given in degrees east of true north; strike is reported in right-hand-rule (RHR)-azimuthal degrees east of true north and where the direction of dip is 90 degrees to the right of strike; --, no measurement]

| Depth, in feet | Depth, in meters | Dip azimuth | Strike, in RHR | Dip | Dip direction | Dip descriptor | Comment |
|---|---|---|---|---|---|---|---|
| 20.03 | 6.10 | 0 | 270 | 0 | -- | Horizontal | Bottom of casing |
| 22.03 | 6.71 | 305 | 215 | 79.53 | NW | Nearly vertical | Minor fracture |
| 23.53 | 7.17 | 89 | 359 | 39.11 | E | Moderate | Transmissive fracture |
| 30.92 | 9.42 | 188 | 98 | 81.60 | S | Nearly vertical | Possible fracture |
| 37.95 | 11.57 | 18 | 288 | 79.00 | N | Nearly vertical | Minor fracture |
| 42.08 | 12.83 | 323 | 233 | 60.48 | NW | Steep | Minor fracture |
| 44.17 | 13.46 | 349 | 259 | 76.50 | N | Nearly vertical | Minor fracture |
| 52.01 | 15.85 | 220 | 130 | 46.26 | SW | Moderate | Transmissive fracture |
| 56.68 | 17.28 | 354 | 264 | 77.66 | N | Nearly vertical | Minor fracture |
| 68.04 | 20.74 | 321 | 231 | 37.75 | NW | Moderate | Minor fracture |
| 76.55 | 23.33 | 4 | 274 | 77.22 | N | Nearly vertical | Minor fracture |
| 78.45 | 23.91 | 201 | 111 | 70.59 | S | Nearly vertical | Minor fracture |
| 81.68 | 24.89 | 196 | 106 | 59.58 | S | Steep | Transmissive fracture |
| 82.53 | 25.15 | 203 | 113 | 70.75 | SW | Nearly vertical | Transmissive fracture |
| 84.54 | 25.77 | 352 | 262 | 71.88 | N | Nearly vertical | Minor fracture |
| 89.45 | 27.26 | 327 | 237 | 76.24 | NW | Nearly vertical | Minor fracture |
| 94.01 | 28.65 | 7 | 277 | 75.96 | N | Nearly vertical | Minor fracture |
| 101.41 | 30.91 | 177 | 87 | 21.16 | S | Shallow | Minor fracture |
| 103.67 | 31.60 | 332 | 242 | 60.07 | NW | Steep | Minor fracture |
| 112.77 | 34.37 | 193 | 103 | 81.72 | S | Nearly vertical | Minor fracture |
| 113.92 | 34.72 | 357 | 267 | 61.50 | N | Steep | Minor fracture |
| 114.36 | 34.86 | 341 | 251 | 31.77 | N | Moderate | Minor fracture |
| 118.21 | 36.03 | 176 | 86 | 80.01 | S | Nearly vertical | Minor fracture |
| 122.77 | 37.42 | 2 | 272 | 86.47 | N | Nearly vertical | Minor fracture |

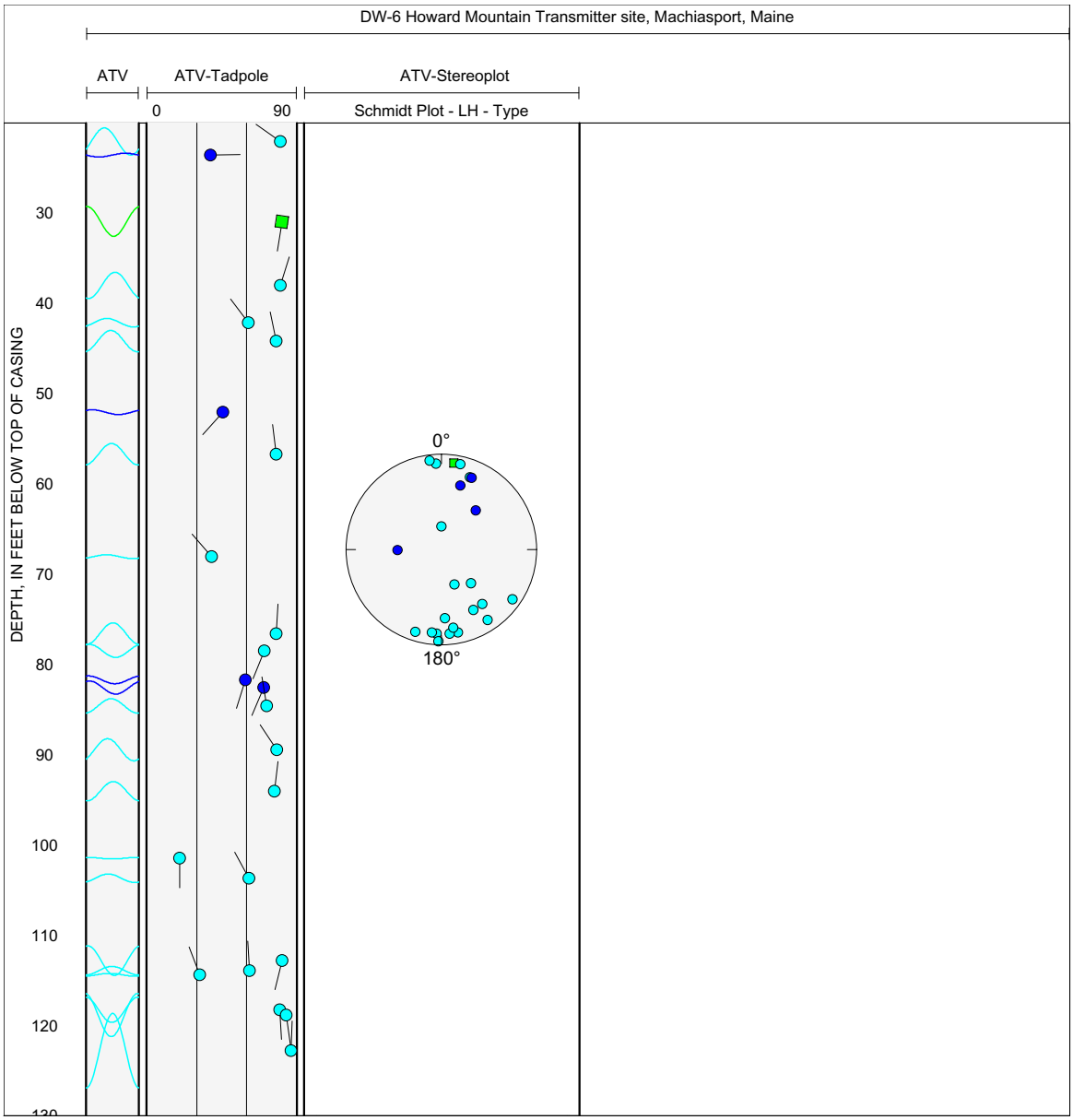



**Figure 3A-3.** Projection, tadpole, and stereoplots of interpretation of borehole image data for borehole DW-6, near Machiasport, Maine.

**INTERPRETATION OF FLOWMETER DATA AND INPUT VALUES FOR FWRAP**

| | | |
|---|---|---|
| **Elevation of measuring point** | 200 | feet |
| **Number of fractures** | 3 | |
| **Well diameter** | 6 | inches |
| **Drawdown** | 10.54 | feet |
| **Depth to ambient water level** | 8.86 | feet |

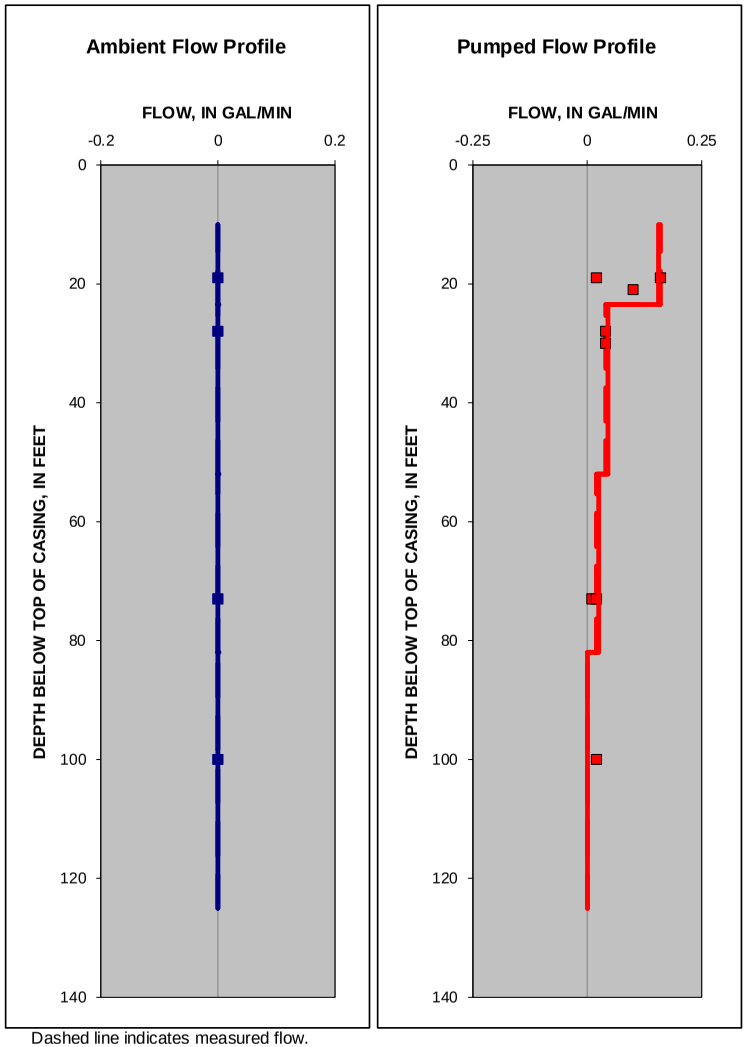
| Fracture number | Depth (ft) | Ambient flow above fracture (gal/min) | Pumped flow above fracture (gal/min) |
|---|---|---|---|
| 3 | 23.5 | 0 | 0.16 |
| 2 | 52.0 | 0 | 0.04 |
| 1 | 82.0 | 0 | 0.02 |

**MODELED OUTPUT RESULTS FROM FWRAP**

| | | |
|---|---|---|
| **Elevation, ambient water level** | 191.14 | feet |
| **Elevation, pumped water level** | 180.60 | feet |

| Fracture number | Depth (ft) | Ambient flow above fracture (gal/min) | Pumped flow above fracture (gal/min) | Zone trans-missivity ($ft^2/d$) | Water level (ft) | Elevation of water level (ft) | Percent trans-missivity |
|---|---|---|---|---|---|---|---|
| 3 | 23.5 | 0 | 0.156 | 1.75 | 8.86 | 191.14 | 74 |
| 2 | 52.0 | 0 | 0.045 | 0.28 | 8.86 | 191.14 | 12 |
| 1 | 82.0 | 0 | 0.025 | 0.35 | 8.86 | 191.14 | 15 |

| | | |
|---|---|---|
| **Total borehole transmissivity** | 2.4 | ($ft^2/d$) |
| **Sum of squares error** | 0.00007 | $(gal/min)^2$ |
| **Root mean square error** | 0.00481 | (gal/min) |




Dashed line indicates measured flow.
Solid line indicates modeled flow.
Points indicate measured heat-pulse flowmeter data.

**Figure 3A–4.** Interpretation and modeling of heat-pulse flowmeter logs for borehole DW-6, near Machiasport, Maine.
[gal/min, gallon per minute; ft, feet; $ft^2/d$, feet squared per day; positive values of flow are upward flow, negative values of flow are downward flow]

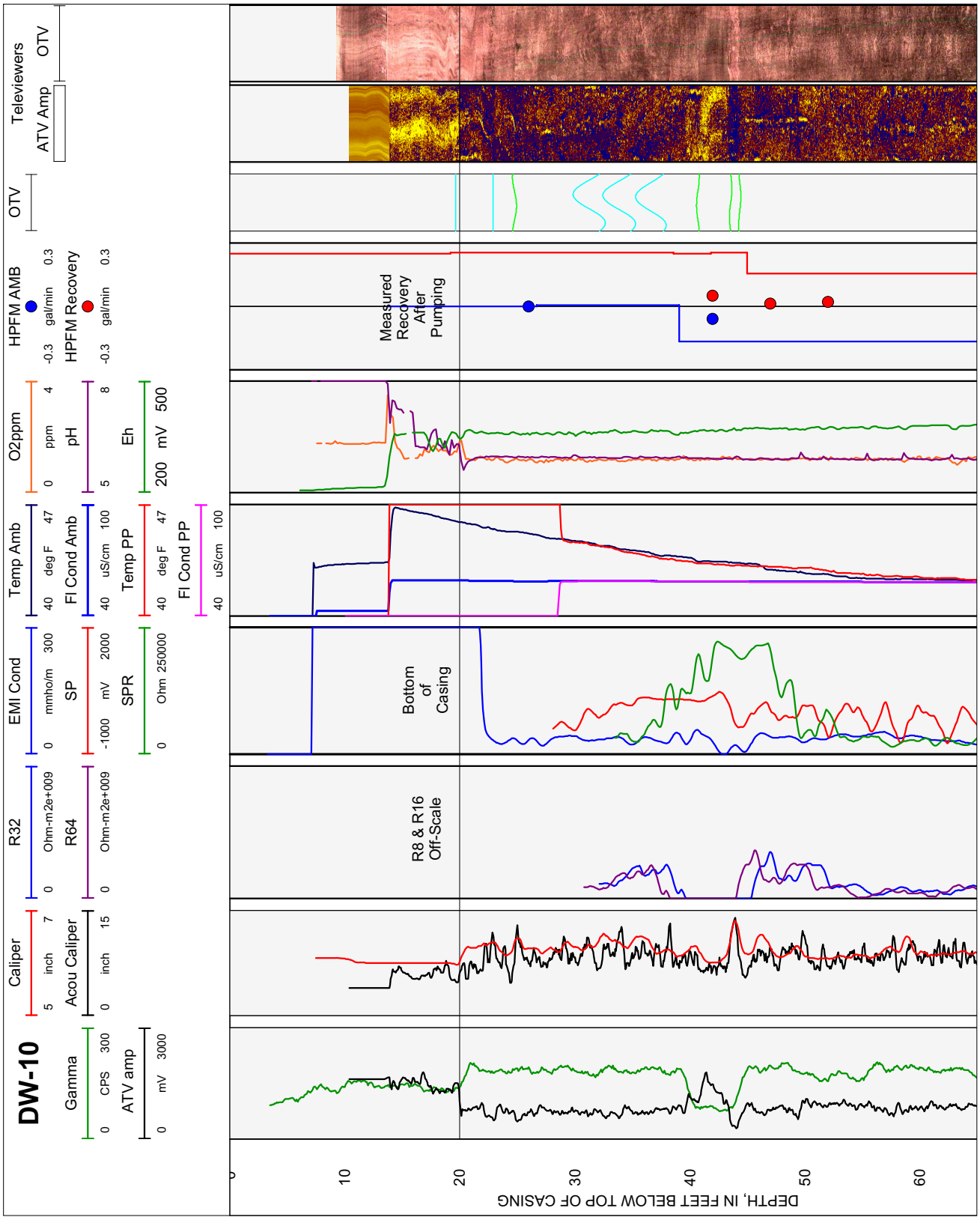



**Figure 3B-1.** Caliper, acoustic caliper, gamma, electromagnetic conductivity, fluid temperature, specific conductance, DO, pH, reduction oxidation, multi-space resistivity, oriented acoustic and optical borehole images, and heat-pulse flowmeter logs for borehole DW-10, near Machiasport, Maine.

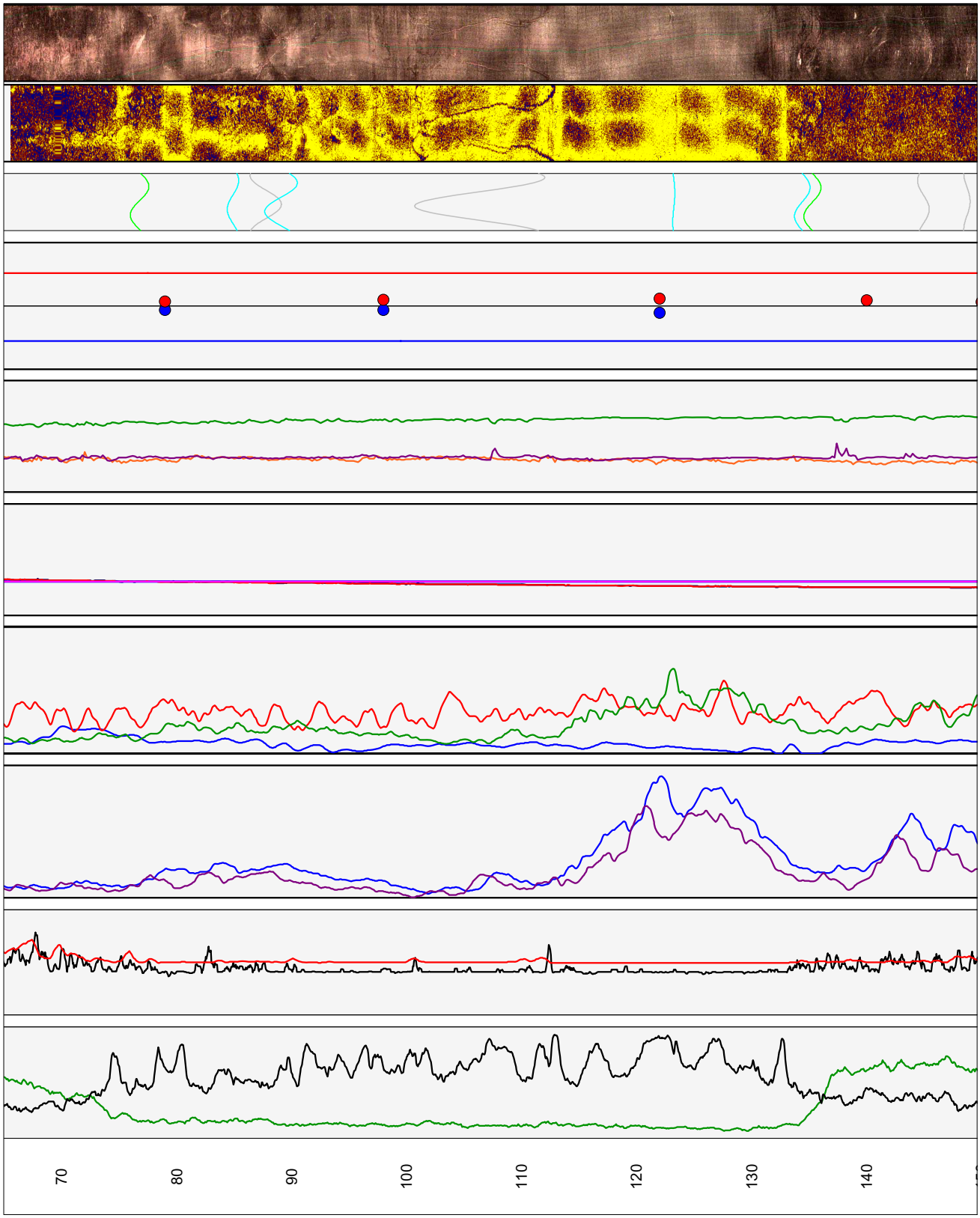



**Figure 3B-1.** Caliper, acoustic caliper, gamma, electromagnetic conductivity, fluid temperature, specific conductance, DO, pH, reduction oxidation, multi-space resistivity, oriented acoustic and optical borehole images, and heat-pulse flowmeter logs for borehole DW-10, near Machiasport, Maine.—Continued

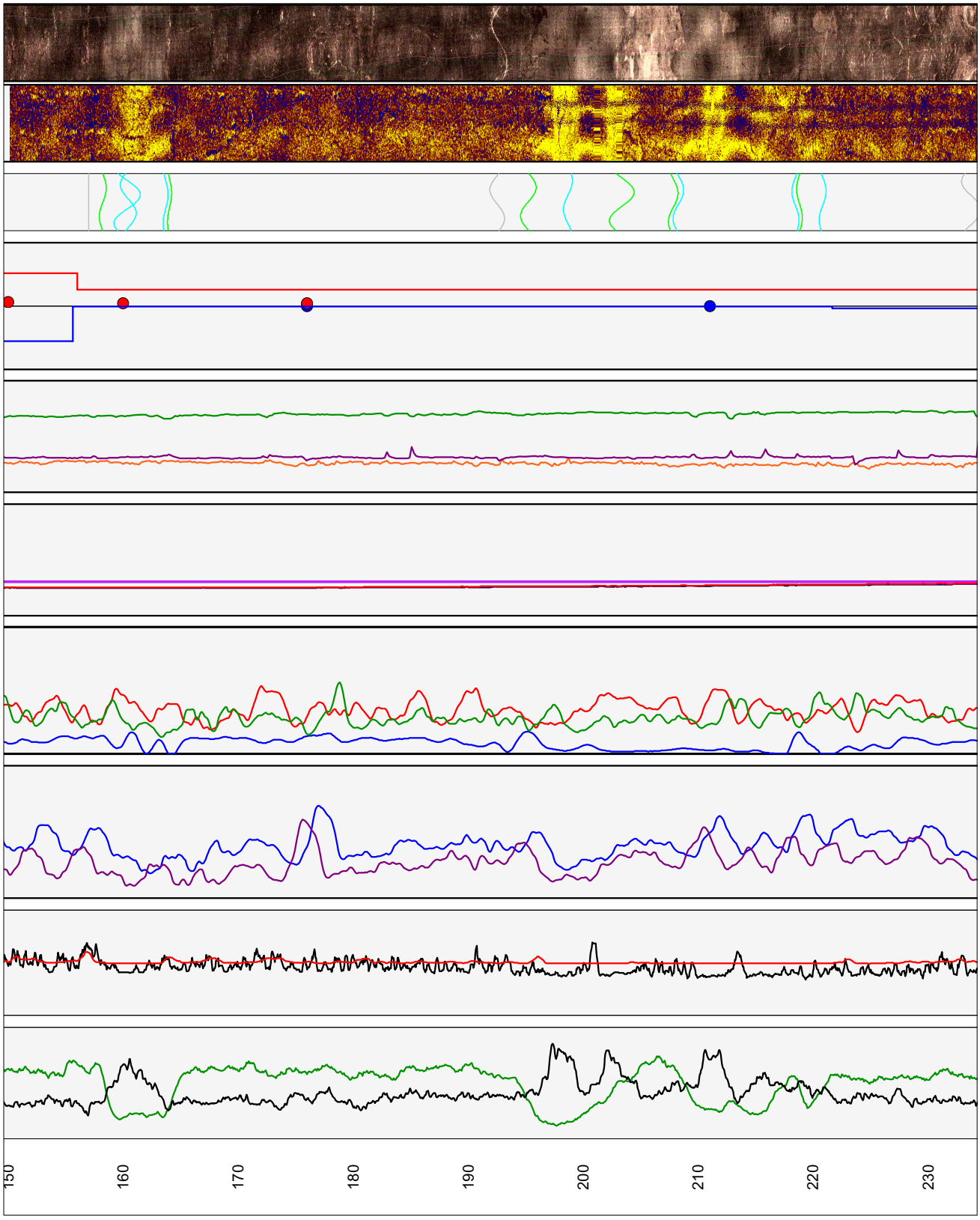
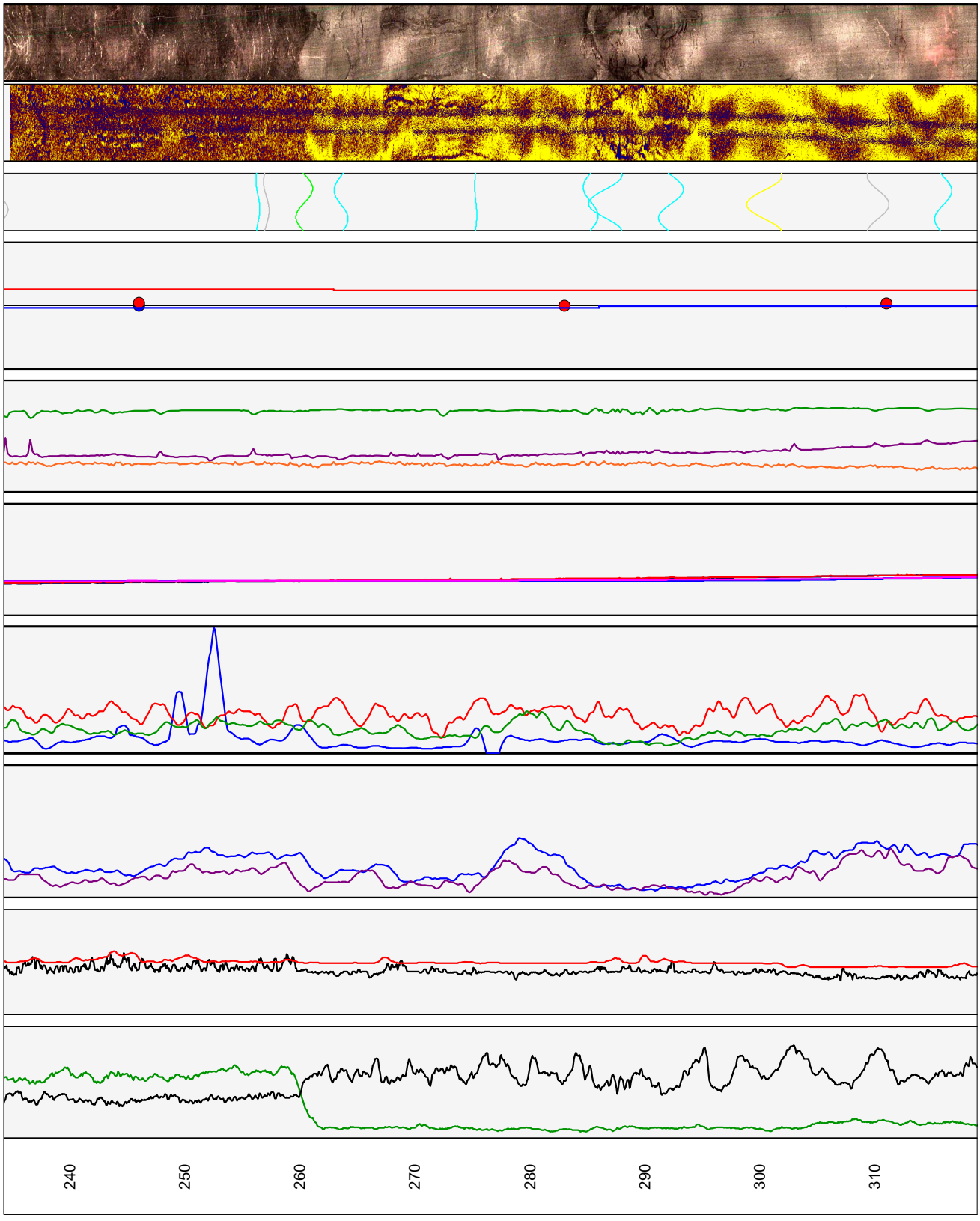



**Figure 3B-1.** Caliper, acoustic caliper, gamma, electromagnetic conductivity, fluid temperature, specific conductance, DO, pH, reduction oxidation, multi-space resistivity, oriented acoustic and optical borehole images, and heat-pulse flowmeter logs for borehole DW-10, near Machiasport, Maine.—Continued

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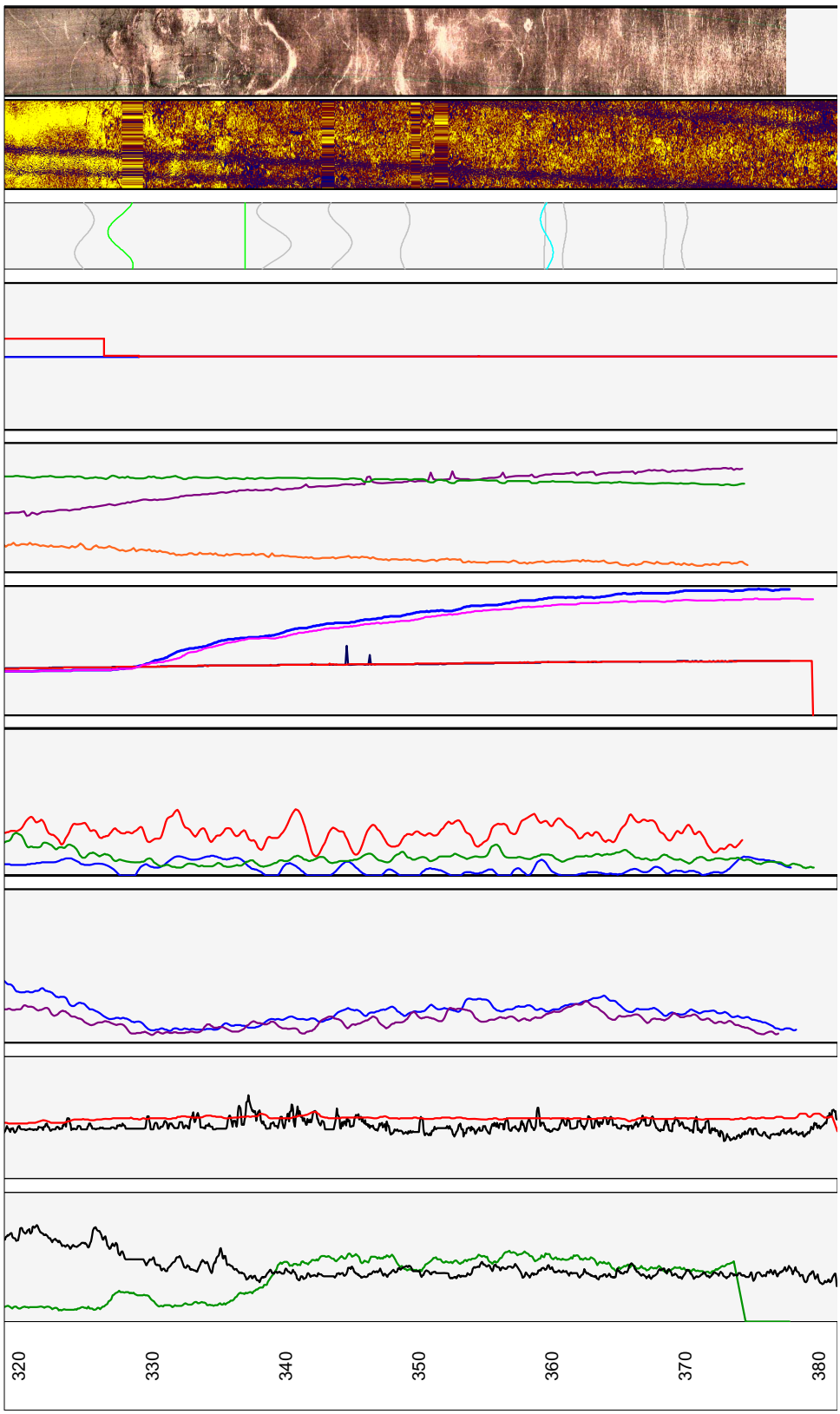


**Figure 3B-1.** Caliper, acoustic caliper, gamma, electromagnetic conductivity, fluid temperature, specific conductance, DO, pH, reduction oxidation, multi-space resistivity, oriented acoustic and optical borehole images, and heat-pulse flowmeter logs for borehole DW-10, near Machiasport, Maine.—Continued

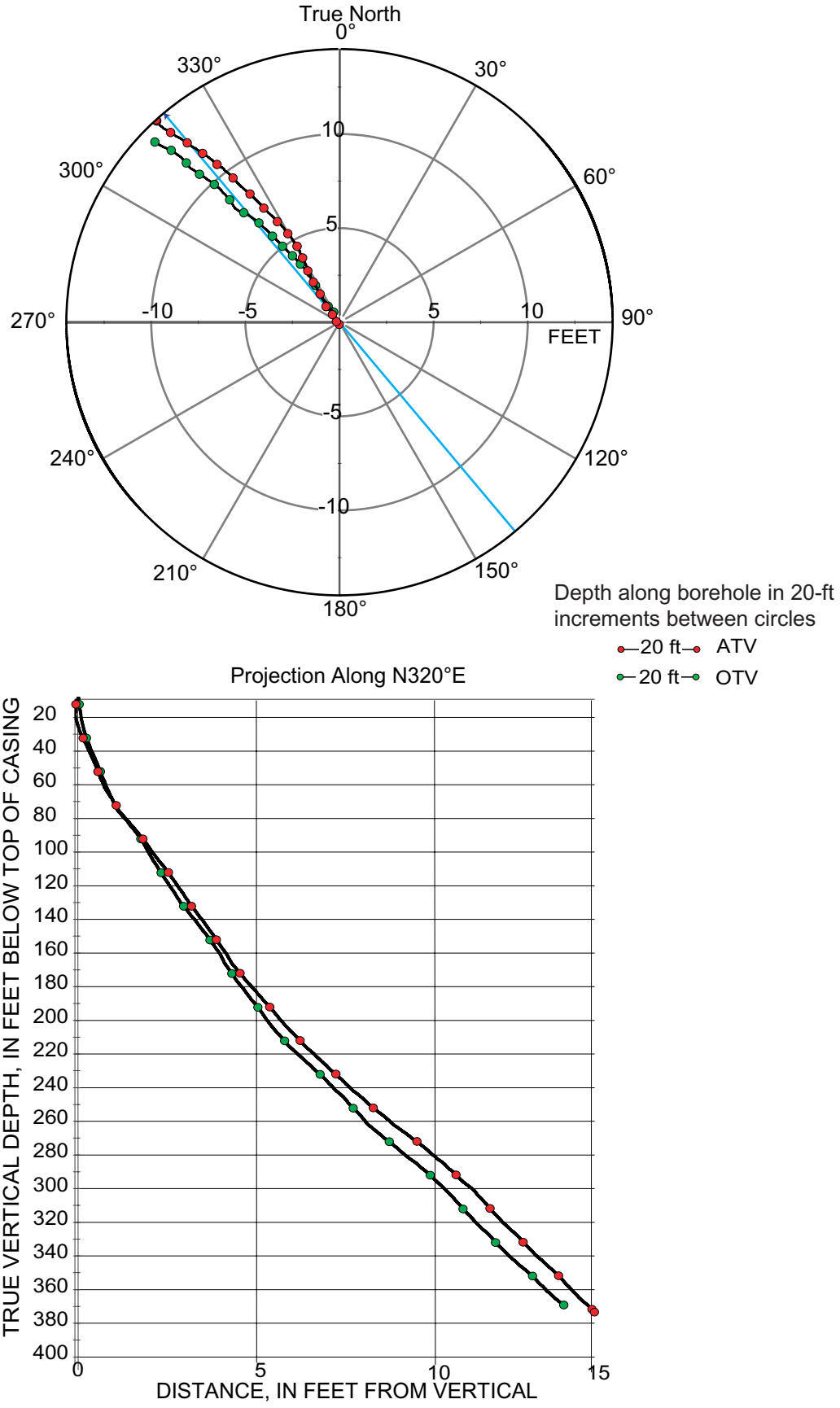


**Figure 3B-2.** Borehole deviation logs for borehole DW-10, near Machiasport, Maine. Blue line on radial plot (top) is line of projection for vertical plot (bottom).

[ft, foot; ATV, acoustic televiewer; OTV, optical televiewer]

**Table 3B–1.** Interpretation of acoustic televiewer logs for borehole DW-10, near Machiasport, Maine.
[Televiewer data are corrected for deviation and magnetic declination, so orientations are relative to true north; depths are below top of casing, which is 0.97 feet above land surface; dip azimuth is given in degrees east of true north; strike is reported in right-hand-rule (RHR)-azimuthal degrees east of true north and where the direction of dip is 90 degrees to the right of strike]

| Depth, in feet | Depth, in meters | Dip azimuth | Strike, in RHR | Dip | Dip direction | Dip descriptor | Comment |
|---|---|---|---|---|---|---|---|
| 13.97 | 4.26 | 336 | 246 | 1 | NW | Nearly horizontal | Top of cement? |
| 20.01 | 6.10 | 40 | 310 | 1 | NE | Nearly horizontal | Bottom of casing |
| 22.98 | 7.00 | 141 | 51 | 18 | SE | Shallow | Minor fracture |
| 37.75 | 11.51 | 81 | 351 | 66 | E | Steep | Minor fracture |
| 43.14 | 13.15 | 340 | 250 | 42 | N | Moderate | Transmissive fracture |
| 43.42 | 13.23 | 29 | 299 | 16 | NE | Shallow | Transmissive fracture |
| 67.49 | 20.57 | 272 | 182 | 81 | W | Nearly vertical | Minor fracture |
| 96.95 | 29.55 | 282 | 192 | 9 | W | Nearly horizontal | Minor fracture |
| 101.36 | 30.89 | 255 | 165 | 79 | W | Nearly vertical | Minor fracture |
| 106.45 | 32.44 | 333 | 243 | 85 | NW | Nearly vertical | Minor fracture |
| 112.11 | 34.17 | 181 | 91 | 22 | S | Shallow | Minor fracture |
| 123.20 | 37.55 | 197 | 107 | 19 | S | Shallow | Minor fracture |
| 134.96 | 41.13 | 242 | 152 | 78 | SW | Nearly vertical | Minor fracture |
| 156.92 | 47.83 | 79 | 349 | 13 | E | Shallow | Transmissive fracture |
| 158.75 | 48.38 | 255 | 165 | 37 | W | Moderate | Transmissive fracture |
| 160.61 | 48.95 | 247 | 157 | 78 | SW | Nearly vertical | Minor fracture |
| 163.78 | 49.92 | 236 | 146 | 43 | SW | Moderate | Lithologic feature |
| 163.93 | 49.96 | 239 | 149 | 35 | SW | Moderate | Minor fracture |
| 197.09 | 60.07 | 279 | 189 | 21 | W | Shallow | Lithologic feature |
| 197.92 | 60.32 | 280 | 190 | 51 | W | Steep | Minor fracture |
| 198.93 | 60.63 | 315 | 225 | 57 | NW | Steep | Minor fracture |
| 203.40 | 61.99 | 248 | 158 | 75 | W | Nearly vertical | Minor fracture |
| 210.94 | 64.29 | 282 | 192 | 42 | W | Moderate | Minor fracture |
| 214.98 | 65.52 | 319 | 229 | 62 | NW | Steep | Minor fracture |
| 236.60 | 72.11 | 132 | 42 | 71 | SE | Nearly vertical | Minor fracture |
| 260.39 | 79.36 | 277 | 187 | 66 | W | Steep | Lithologic feature |
| 260.44 | 79.38 | 274 | 184 | 66 | W | Steep | Lithologic feature |
| 285.56 | 87.03 | 100 | 10 | 71 | E | Nearly vertical | Minor fracture |
| 286.43 | 87.30 | 342 | 252 | 80 | N | Nearly vertical | Minor fracture |
| 292.66 | 89.20 | 267 | 177 | 72 | W | Nearly vertical | Minor fracture |
| 310.37 | 94.60 | 182 | 92 | 76 | S | Nearly vertical | Minor fracture |
| 315.76 | 96.24 | 260 | 170 | 57 | W | Steep | Minor fracture |
| 326.02 | 99.37 | 76 | 346 | 75 | E | Nearly vertical | Transmissive fracture |
| 326.73 | 99.58 | 54 | 324 | 27 | NE | Shallow | Transmissive fracture |

**Table 3B–2.** Interpretation of optical televiewer logs for borehole DW-10, near Machiasport, Maine.
[Televiewer data are corrected for deviation and magnetic declination, so orientations are relative to true north; depths are below top of casing, which is 0.97 feet above land surface; dip azimuth is given in degrees east of true north; strike is reported in right-hand-rule (RHR)-azimuthal degrees east of true north and where the direction of dip is 90 degrees to the right of strike]

| Depth, in feet | Depth, in meters | Dip azimuth | Strike, in RHR | Dip | Dip direction | Dip descriptor | Comment |
|---|---|---|---|---|---|---|---|
| 13.97 | 4.26 | 336 | 246 | 1 | NW | Nearly horizontal | Top of cement |
| 13.52 | 4.12 | 72 | 342 | 1 | E | Nearly horizontal | Bottom of casing |
| 22.68 | 6.91 | 140 | 50 | 18 | SE | Shallow | Minor fracture |
| 24.70 | 7.53 | 181 | 91 | 23 | S | Shallow | Minor fracture |
| 31.37 | 9.56 | 19 | 289 | 79 | N | Nearly vertical | Minor fracture |
| 33.57 | 10.23 | 30 | 300 | 79 | NE | Nearly vertical | Minor fracture |
| 36.73 | 11.19 | 24 | 294 | 78 | NE | Nearly vertical | Minor fracture |
| 43.21 | 13.17 | 268 | 178 | 20 | W | Shallow | Lithologic feature |
| 43.41 | 13.23 | 229 | 139 | 15 | SW | Shallow | Transmissive fracture |
| 46.05 | 14.04 | 293 | 203 | 65 | NW | Steep | Minor fracture |
| 48.61 | 14.82 | 259 | 169 | 39 | W | Moderate | Minor fracture |
| 76.27 | 23.25 | 256 | 166 | 76 | W | Nearly vertical | Lithologic feature |
| 84.05 | 25.62 | 104 | 14 | 88 | E | Nearly vertical | Fabric or layering in rock |
| 87.76 | 26.75 | 162 | 72 | 81 | S | Nearly vertical | Fabric or layering in rock |
| 88.73 | 27.04 | 289 | 199 | 75 | W | Nearly vertical | Minor fracture |
| 106.43 | 32.44 | 342 | 252 | 86 | N | Nearly vertical | Minor fracture |
| 119.96 | 36.56 | 281 | 191 | 84 | W | Nearly vertical | Fabric or layering in rock |
| 130.68 | 39.83 | 255 | 165 | 68 | W | Steep | Lithologic feature |
| 133.61 | 40.72 | 254 | 164 | 70 | W | Nearly vertical | Minor fracture |
| 134.37 | 40.95 | 257 | 167 | 71 | W | Nearly vertical | Minor fracture |
| 135.14 | 41.19 | 245 | 155 | 70 | SW | Steep | Minor fracture |
| 140.61 | 42.86 | 242 | 152 | 75 | SW | Nearly vertical | Fabric or layering in rock |
| 158.05 | 48.17 | 255 | 165 | 43 | W | Moderate | Transmissive fracture |
| 158.28 | 48.24 | 253 | 163 | 39 | W | Moderate | Lithologic feature |
| 163.52 | 49.84 | 230 | 140 | 43 | SW | Moderate | Lithologic feature |
| 163.64 | 49.88 | 228 | 138 | 34 | SW | Moderate | Minor fracture |
| 172.87 | 52.69 | 134 | 44 | 30 | SE | Shallow | Fabric or layering in rock |
| 192.50 | 58.67 | 76 | 346 | 68 | E | Steep | Fabric or layering in rock |
| 194.88 | 59.40 | 226 | 136 | 63 | SW | Steep | Lithologic feature |
| 195.07 | 59.45 | 223 | 133 | 67 | SW | Steep | Minor fracture |
| 197.66 | 60.24 | 277 | 187 | 51 | W | Steep | Minor fracture |
| 198.73 | 60.57 | 308 | 218 | 56 | NW | Steep | Minor fracture |
| 203.37 | 61.98 | 227 | 137 | 76 | SW | Nearly vertical | Lithologic feature |
| 203.45 | 62.01 | 235 | 145 | 75 | SW | Nearly vertical | Minor fracture |
| 207.94 | 63.38 | 239 | 149 | 62 | SW | Steep | Lithologic feature |
| 220.77 | 67.29 | 241 | 151 | 53 | SW | Steep | Fabric or layering in rock |
| 233.84 | 71.27 | 131 | 41 | 76 | SE | Nearly vertical | Fabric or layering in rock |
| 256.37 | 78.14 | 108 | 18 | 24 | E | Shallow | Fabric or layering in rock |
| 260.28 | 79.33 | 251 | 161 | 70 | W | Steep | Lithologic feature |
| 263.53 | 80.32 | 59 | 329 | 69 | NE | Steep | Minor fracture |
| 275.02 | 83.82 | 74 | 344 | 15 | E | Shallow | Minor fracture |
| 285.20 | 86.92 | 93 | 3 | 71 | E | Nearly vertical | Fracture |
| 286.39 | 87.29 | 336 | 246 | 77 | NW | Nearly vertical | Minor fracture |
| 292.33 | 89.10 | 259 | 169 | 73 | W | Nearly vertical | Minor fracture |
| 310.17 | 94.54 | 166 | 76 | 78 | S | Nearly vertical | Fabric or layering in rock |
| 315.59 | 96.19 | 247 | 157 | 60 | SW | Steep | Minor fracture |
| 326.70 | 99.57 | 31 | 301 | 75 | NE | Nearly vertical | Lithologic feature |
| 327.84 | 99.92 | 36 | 306 | 74 | NE | Nearly vertical | Transmissive fracture |
| 339.15 | 103.37 | 146 | 56 | 82 | SE | Nearly vertical | Fabric or layering in rock |
| 344.10 | 104.88 | 141 | 51 | 73 | SE | Nearly vertical | Fabric or layering in rock |
| 345.31 | 105.25 | 205 | 115 | 15 | SW | Shallow | Fabric or layering in rock |
| 349.00 | 106.37 | 259 | 169 | 57 | W | Steep | Fabric or layering in rock |
| 359.44 | 109.55 | 218 | 128 | 12 | SW | Shallow | Fabric or layering in rock |
| 360.91 | 110.00 | 243 | 153 | 29 | SW | Shallow | Fabric or layering in rock |
| 368.22 | 112.23 | 192 | 102 | 19 | S | Shallow | Fabric or layering in rock |
| 368.41 | 112.29 | 204 | 114 | 25 | SW | Shallow | Fabric or layering in rock |
| 369.92 | 112.75 | 262 | 172 | 35 | W | Moderate | Fabric or layering in rock |

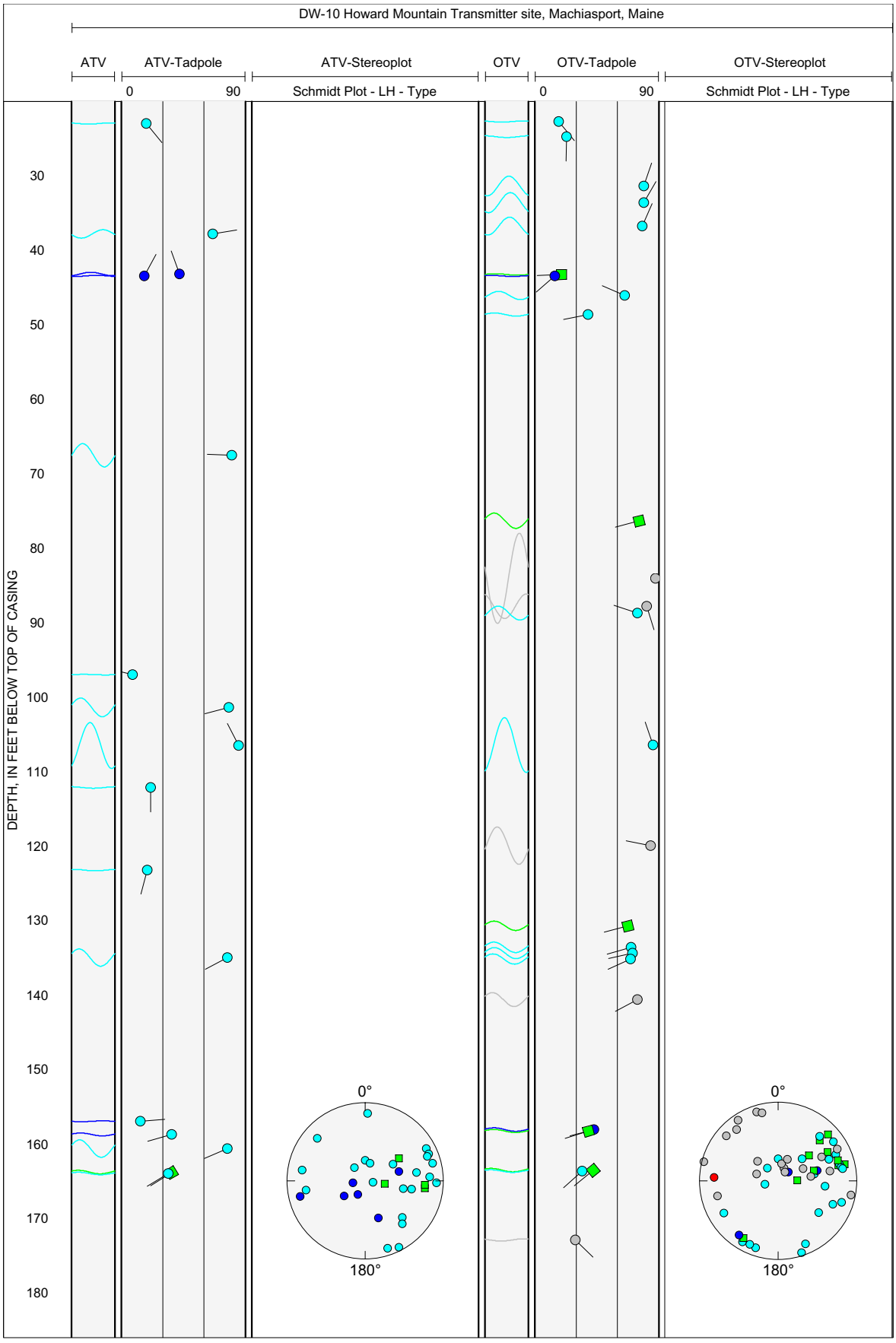


**Figure 3B-3.** Projection, tadpole, and stereoplots of interpretation of borehole image data for borehole DW-10, near Machiasport, Maine.

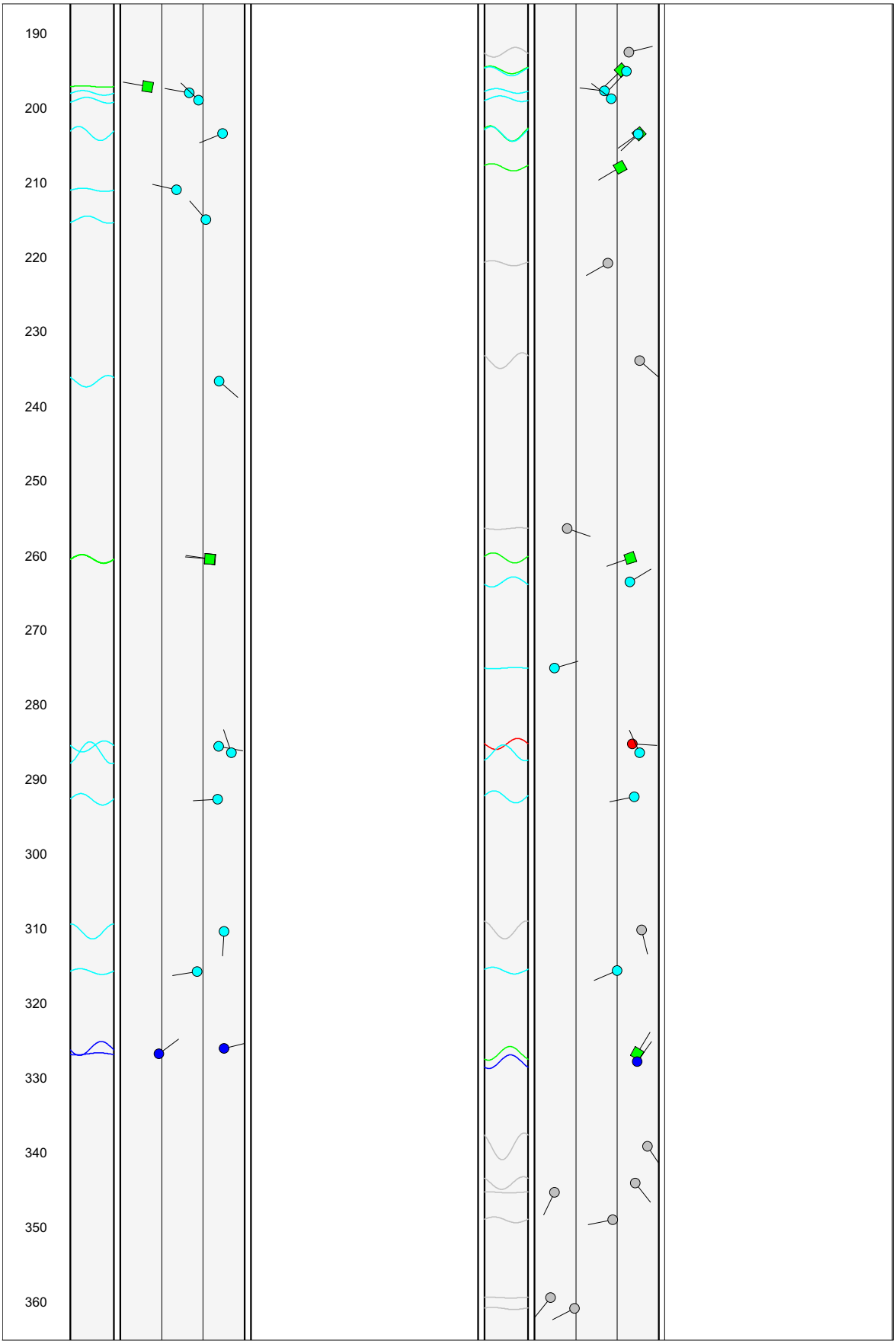


**Figure 3B-3.** Projection, tadpole, and stereoplots of interpretation of borehole image data for borehole DW-10, near Machiasport, Maine.—Continued

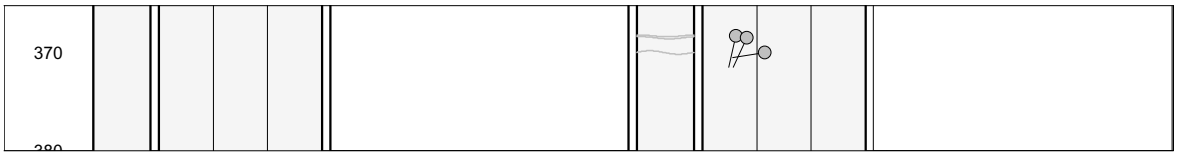


**Figure 3B-3.** Projection, tadpole, and stereoplots of interpretation of borehole image data for borehole DW-10, near Machiasport, Maine.—Continued