DOE/NV/25946--1448

GEOLOGY OF THE
SOURCE PHYSICS EXPERIMENT SITE
CLIMAX STOCK
NEVADA NATIONAL SECURITY SITE

March 2012

Prepared for:

U.S. Department of Energy
National Nuclear Security Administration
National Center for Nuclear Security

Prepared by:

Margaret Townsend, Lance B. Prothro, and Curtis Obi

Underground Test Area and Boreholes Programs and Operations
Environmental Restoration
National Security Technologies, LLC
Las Vegas, Nevada

DISCLAIMER

DOE/NV/25946--1448

GEOLOGY OF THE
SOURCE PHYSICS EXPERIMENT SITE
CLIMAX STOCK
NEVADA NATIONAL SECURITY SITE

March 2012

Prepared by:

Margaret Townsend, Lance B. Prothro, and Curtis Obi

Underground Test Area and Boreholes Programs and Operations
Environmental Restoration
National Security Technologies, LLC
Las Vegas, Nevada

This page intentionally left blank.

Abstract

A test bed for a series of chemical explosives tests known as Source Physics Experiments (SPE) was constructed in granitic rock of the Climax stock, in northern Yucca Flat at the Nevada National Security Site in 2010–2011. These tests are sponsored by the U.S. Department of Energy, National Nuclear Security Administration's National Center for Nuclear Security. The test series is designed to study the generation and propagation of seismic waves, and will provide data that will improve the predictive capability of calculational models for detecting and characterizing underground explosions. Abundant geologic data are available for the area, primarily as a result of studies performed in conjunction with the three underground nuclear tests conducted in the Climax granite in the 1960s and a few later studies of various types.

The SPE test bed was constructed at an elevation of approximately 1,524 meters (m), and consists of a 91.4-centimeter (cm) diameter source hole at its center, surrounded by two rings of three 20.3-cm diameter instrument holes. The inner ring of holes is positioned 10 m away from the source hole, and the outer ring of holes is positioned 20 m from the source hole. An initial 160-m deep core hole was drilled at the location of the source hole that provided information on the geology of the site and rock samples for later laboratory testing. A suite of geophysical logs was run in the core hole and all six instruments holes to obtain matrix and fracture properties.

Detailed information on the character and density of fractures encountered was obtained from the borehole image logs run in the holes. A total of 2,488 fractures were identified in the seven boreholes, and these were ranked into six categories (0 through 5) on the basis of their degree of openness and continuity. The analysis presented here considered only the higher-ranked fractures (ranks 2 through 5), of which there were 1,215 (approximately 49 percent of all fractures identified from borehole image logs). The fractures were grouped into sets based on their orientation. The most ubiquitous fracture set (50 percent of all higher-ranked fractures) is a group of low-angle fractures (dips 0 to 30 degrees). Fractures with dips of 60 to 90 degrees account for 38 percent of high-ranked fractures, and the remaining 12 percent are fractures with moderate dips (30 to 60 degrees). The higher-angle fractures are further subdivided into three sets based on their dip direction: fractures of Set 1 dip to the north-northeast, fractures of Set 2 dip to the south-southwest, and Set 3 consists of high-angle fractures that dip to the southeast and strike northeast. The low-angle fractures (Set 4) dip eastward. Fracture frequency does not appear to change substantially with depth. True fracture spacing averages 0.9 to 1.2 m for high-angle Sets 1, 2, and 3, and 0.6 m for Set 4. Two significant faults were observed in the core, centered at the depths of 25.3 and 32.3 m. The upper of these two faults dips 80 degrees to the north-northeast and, thus, is related to the Set-1 fractures. The lower fault dips 79 degrees to the south-southwest and is related to SPE Set-2 fractures. Neither fault has an identifiable surface trace.

Groundwater was encountered in all holes drilled on the SPE test bed, and the fluid level averaged about 15.2 to 18.3 m below ground surface. An informal study of variations in the fluid level in the holes conducted during various phases of construction of the test bed concluded that groundwater flow through the fractured granitic rocks is not uniform, and appears to be controlled by variations in the orientation and degree of interconnectedness of the fractures. It may also be possible that an aplite dike or quartz vein may be present in the test bed, which could act as a barrier to groundwater flow and, thus, could account for anisotropy seen in the groundwater recovery measurements.

This page intentionally left blank.

Table of Contents

This page intentionally left blank.

List of Appendices

This page intentionally left blank.

List of Figures

List of Figures (continued)

List of Plates

List of Tables

This page intentionally left blank.

List of Acronyms and Abbreviations

CD	compact disk
cm	centimeter(s)
DTRA	Defense Threat Reduction Agency
ft	foot (feet)
IGAT	Interagency Geotechnical Assessment Team
in.	inch(es)
ISRM	International Society of Rock Mechanics
Kgd	granodiorite
km/s	kilometer(s) per second
Kqm	quartz monzonite
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
m	meter(s)
mm	millimeter(s)
MzPg	Mesozoic granodiorite
MzPq	Mesozoic quartz monzonite
NCNS	National Center for Nuclear Security
NSTec	National Security Technologies, LLC
P-wave	Compressional wave
RQD	Rock Quality Designation
SGZ	surface ground zero
SME	subject matter expert
SNL	Sandia National Laboratories
SPE	Source Physics Experiment
S-wave	Shear wave
TD	total depth
Tkg	Tertiary granodiorite
Tkq	Tertiary quartz monzonite
UGT	underground nuclear test
UGTA	Underground Test Area
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
WP	working point

This page intentionally left blank.

Geology of the Source Physics Experiment Site, Climax Stock
Nevada National Security Site

1.0 Introduction

The National Center for Nuclear Security (NCNS) has been established at the Nevada National Security Site (NNSS; formerly Nevada Test Site) by the U.S. Department of Energy, National Nuclear Security Administration. The NCNS is conducting a variety of studies that are designed to increase the understanding of certain basic physical phenomena associated with underground explosions and to develop technologies that might be used detect underground nuclear explosions in support of verification activities for the Comprehensive Test Ban Treaty.

The initial NCNS project consists of conducting a series of explosive tests, known collectively as the Source Physics Experiment (SPE), in granitic rocks at the Climax stock in northern Yucca Flat at the NNSS. The SPE test series is specifically designed to study the generation and propagation of seismic waves. Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), Sandia National Laboratories, (SNL), and the Defense Threat Reduction Agency (DTRA), in conjunction with National Security Technologies, LLC (NSTec), the Management and Operations contractor at the NNSS, are designing and conducting these tests, and will use the data obtained to improve the predictive capability of their calculational models for detecting and characterizing underground explosions. The first SPE test was conducted in May 2011, and a second was conducted in October 2011; additional tests at this site are planned.

A variety of geologic data, described in this report, were acquired from the site by NSTec to provide input to the calculational modelers. This report was prepared by geologists of the NSTec Underground Test Area (UGTA)/Boreholes Programs and Operations group.

1.1 Site Selection

In February 2010, subject matter experts (SMEs; representatives from NSTec, LANL, LLNL, and SNL) for the proposed SPE tests developed preliminary criteria for selecting a site in the Climax granitic body, pending further development of the experiment design. These preliminary requirements included:

- "Homogeneous" granite, with surface weathered zone as thin as possible
- No obvious faults in the area, though it was recognized that there would be fractures, even in the unweathered granite at depth
- Avoid lithologic contacts, including the contact between the quartz monzonite (Kqm; also Tkq or MzPq on various maps) and the granodiorite (Kgd; also Tkg or MzPg) that make up the Climax stock (preference for quartz monzonite or granodiorite was not specified)
- Position as close as feasible to existing roads and other infrastructure
- Keep appropriate distance from the surface ground zeros of the three underground nuclear tests (UGTs) conducted in the Climax stock

- Other criteria were based on expected hole depth and distance to instrument holes, as determining factors in the size of the site.

NSTec geologists selected three locations as potential sites at the Climax stock for the SPE. The report prepared to present information about these locations is provided in Appendix A (NSTec, 2010). The SME group selected the southernmost site (Site #1 on Figure 1), which is closest to the access road, and at which there was already a graded area and a pit that could serve as a mudpit for drilling.

1.2 Site Description

The SPE test bed was constructed on a drill pad that is located approximately 347 meters (m) (1,140 feet [ft]) south-southwest of the U15a headframe. The pad is located on a southeast-dipping slope, at an elevation of approximately 1,524 m (5,000 ft). The test bed was designed to consist of a 36-inch (in.) diameter source hole at its center, surrounded by six 8-in. diameter instrument holes arranged in two rings of three (Figure 2). The drilling plan included an initial core hole at the location of the Source Hole that would provide information on the geology of the site and rock samples for later laboratory testing.

All holes were drilled to depths ranging from 57.9 to 60.7 m (190 to 199 ft). The instrument holes in the inner ring (U-15n#1, #2, and #3) are each 10 m (33 ft) from the Source Hole, and positioned 120 degrees apart. The instrument holes in the outer ring (U-15n#4, #5, and #6) are each 20 m (66 ft) from the Source Hole and staggered so that they are 60 degrees off the positions of the holes in the inner ring. The placement of the instrument holes was determined from the position of a hole in the outer ring (U-15n#4), whose location was selected to be on a line from the U-15n Source Hole to U16b Tunnel, approximately 24.6 kilometers (15.3 miles) away (coincident with one of the planned geophone lines). Instrument Hole U-15n#1 was replaced in August 2011 by Instrument Hole U-15n#1a, which is located 3.1 m (10 ft) northwest of hole U-15n#1. U-15n#1a and other holes planned for the site will be described in a future report.

See Appendix B for detailed information about the construction of the holes at the SPE site.

1.3 Scope of Document

This document presents geologic data collected in support of the first two SPE tests. Much of this information, mainly concerning the fracture characteristics, was provided to the calculational modelers in preliminary form as it was acquired, but it is compiled here in one source document for easy reference. Also included here is a discussion of information obtained about the perched groundwater encountered at the SPE site. This document also includes additional background geologic information for the Climax stock area summarized from previous work conducted at the stock in support of historical underground nuclear testing and other projects.

Appendices A through L are included to provide detailed information on the construction of the SPE test bed, data obtained from logging of core and geophysical borehole logging, and various supporting information relevant to the understanding of the geologic characteristics of the SPE site. Appendices C, F, and J were not printed, but are included on the compact disk (CD) attached to this report.

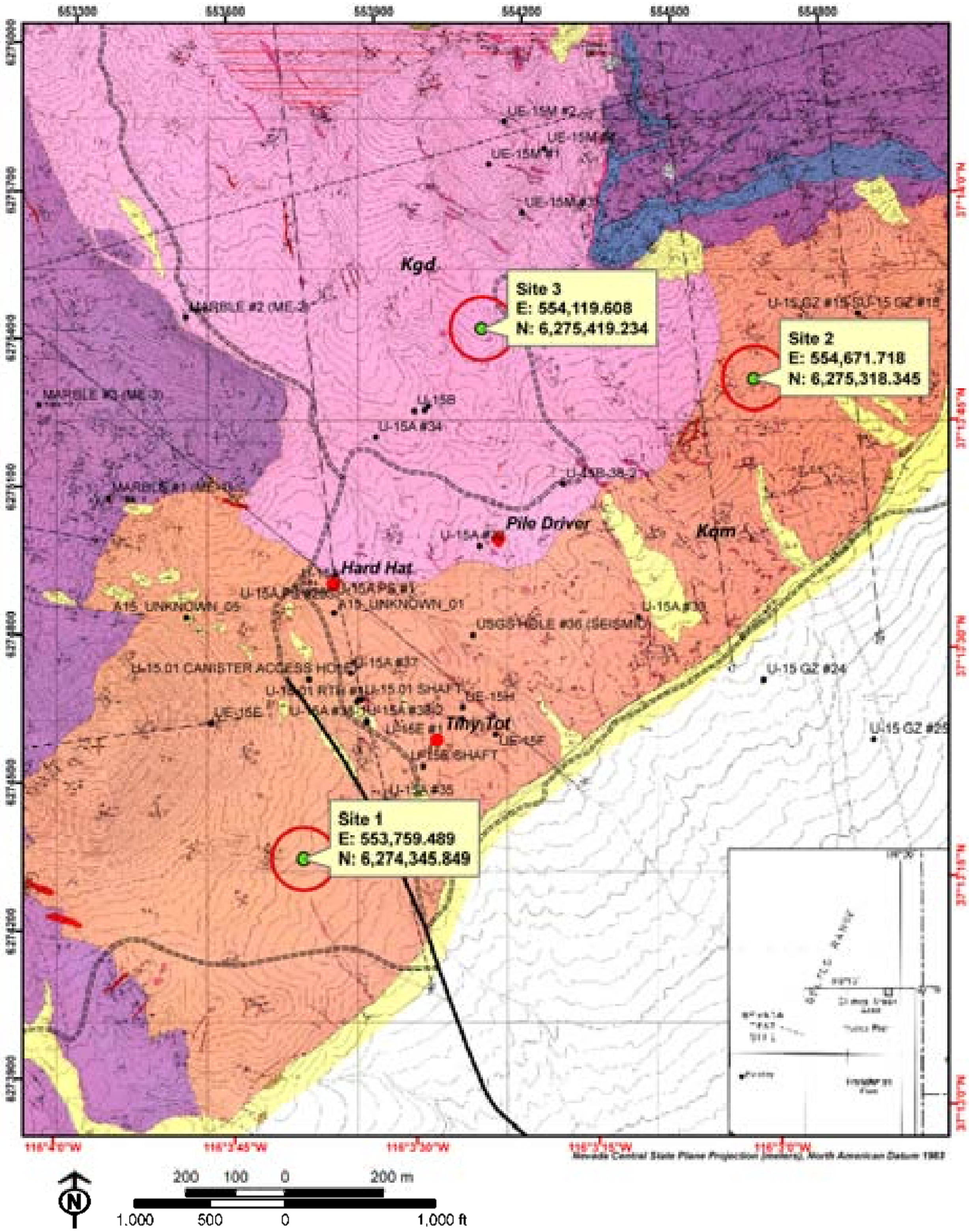


Figure 1
Map of Climax Stock Area Showing Three Potential Sites Considered for Location of SPE Tests
Red dots mark locations of underground nuclear tests.
Geology is from Houser and Poole, 1960, See full map with legend in Plate 1.

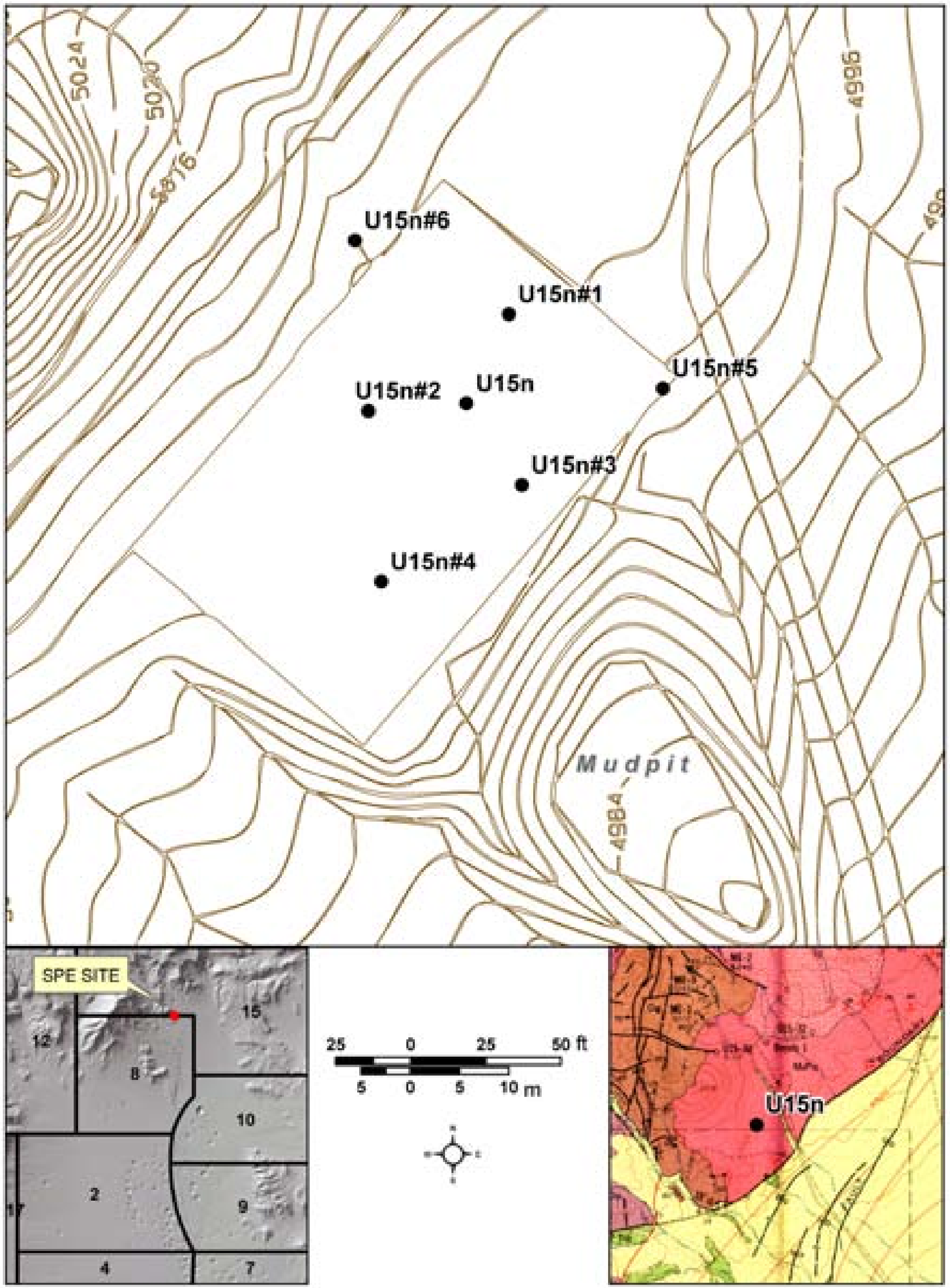


Figure 2
Map of Source Physics Experiment Site in Southern Portion of Climax Stock
(Inset at lower right shows geology from Barnes et al., 1963. See full map with legend in Plate 2)

2.0 Geology

The Climax stock was selected as the site of the first set of SPE tests because its granite lithology provides a relatively "homogenous" medium and because, as the site of three historical UGTs, abundant geologic, seismic, and ground shock data are available for comparison to expected SPE test data.

The Climax stock, located in the northeast corner of the NNSS, in Area 15, is largest of three exposed granitic masses at the NNSS (Slate et al., 1999). The U.S. Geological Survey (USGS) has published three geologic maps that include the area of the stock (Houser and Poole, 1960; Barnes et al., 1963; Sargent and Orkild, 1973). The stock has been extensively characterized in support of the three UGTs conducted there, the LLNL Spent Fuel Test, and several proposed projects. At least three summary reports have been written, in which basic physical and geologic properties, including fracture data, are provided (Maldonado, 1977; Orkild, et al., 1983; Blouin et al., 2003).

2.1 Previous Studies

Most earlier geologic studies at Climax stock were concerned primarily with the character of the granite body at the depths of the nuclear test working points, which ranged from 110.9 m (364 ft) (U15e, TINY TOT) to 293.5 m (963 ft) (U15a, HARD HAT) to 416.7 m (1,367 ft) (U15a.01, PILE DRIVER) (Figure 3). The earliest geologic studies were conducted by the USGS and the Lawrence Radiation Laboratory (now LLNL) in support of these tests; SNL and the U.S. Army Corps of Engineers Waterways Experiment Station also conducted numerous supporting studies.

Characterization, ground motion, and structural response data for HARD HAT and PILE DRIVER, conducted in 1962 and 1966, respectively, were compiled in support of the DTRA Hard Rock Data Review in 2002 (DTRA, 2003). As part of that effort, all existing geotechnical, seismic, and response data were reviewed and evaluated in the attempt to develop a database of granite properties and response regarding nuclear explosions.

The earliest studies were conducted on the "Granite" exploratory hole (also known as U-15a#31), which was drilled from the surface at the site of the U-15a HARD HAT emplacement hole. Other studies included surface geologic mapping (Houser and Poole, 1960; Barnes et al., 1963), chemical and petrographic studies (e.g., Houser and Poole, 1959; McArthur and Misz, 1960), measurements of material properties on samples from drill holes and tunnel workings (Houser and Poole, 1959), aeromagnetic surveys to determine the general configuration of the stock (Allingham and Zietz, 1962), and determination of the age relations of the two lithologies (granodiorite and quartz monzonite) that make up the body (Houser and Poole, 1961). Naiser and Maldonado (1981) reported fission-track dating on samples from Climax stock.

Most of the HARD HAT, PILE DRIVER, and TINY TOT drifts were mapped in detail (discussed in various papers compiled in DTRA [2003] and in Cording [1967]), and numerous core holes were drilled and sampled to characterize the granite test beds before and after the tests (chimney delineation, etc.).

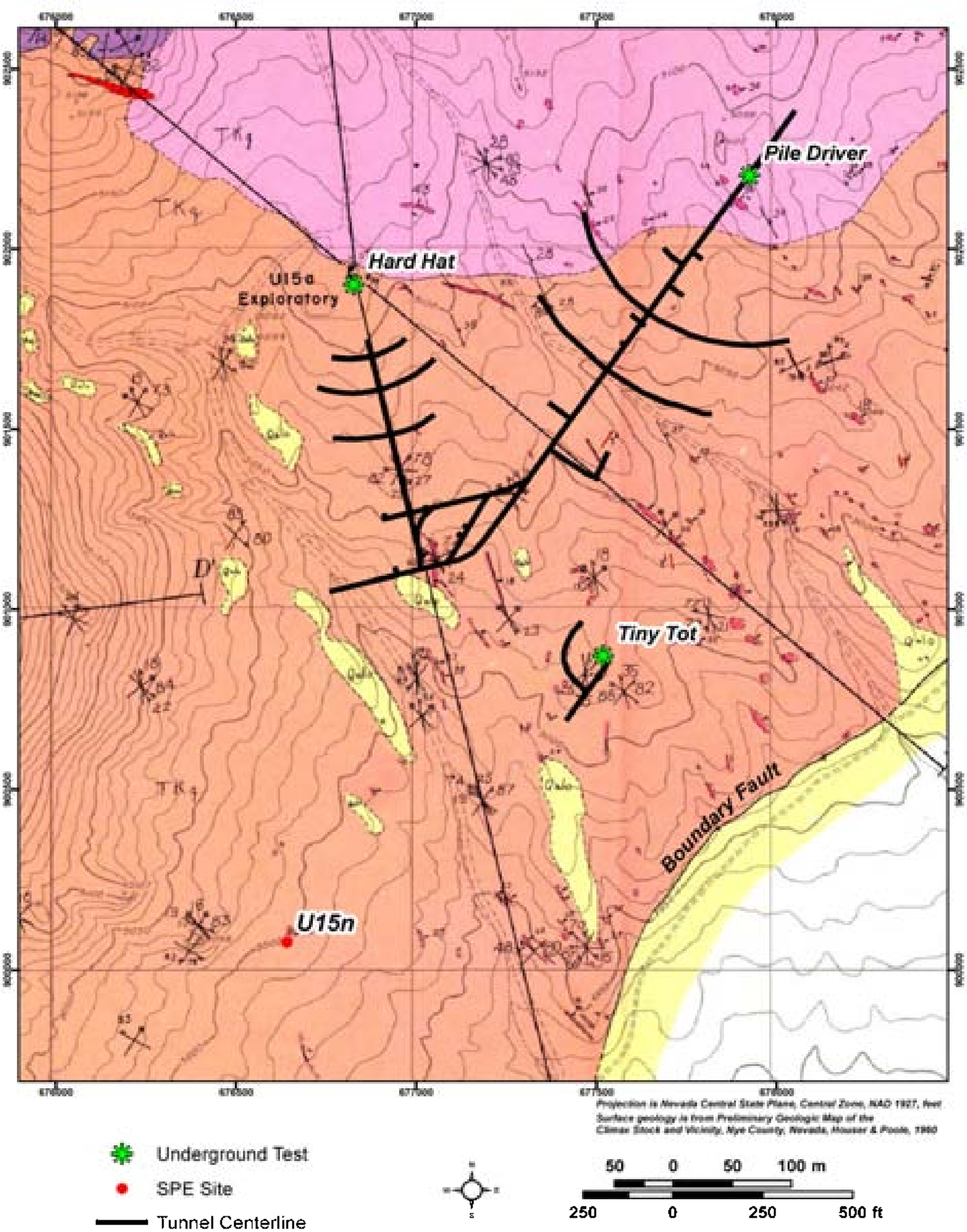


Figure 3
Map Showing Layout of Drifts Constructed for the Three Nuclear Tests Conducted at Climax Stock
All drifts not at same elevation. See Houser and Poole (1960), presented as Plate 1, for explanation of surface geology notations.

To explore the feasibility of using granitic rock for the underground storage of spent nuclear reactor fuel, in the late 1970s, LLNL constructed a test bed near the shaft station at the PILE DRIVER level, which consisted of three parallel drifts and several core holes. LLNL mapped the geologic structure of the drifts, logged the core in detail, and conducted many physical and chemical studies on samples. A large body of data from this effort is available in the literature, including a report on the structural geology of the site (Wilder and Yow, 1984).

In the early 1980s, the USGS conducted studies at the request of the Defense Nuclear Agency (now DTRA) to update the understanding of the geometry of the Climax stock. They conducted comprehensive magnetic and gravity measurements, including a new aerial magnetic survey. In addition, they conducted field mapping and trenching to improve the understanding of the three main faults that define the stock structurally. A comprehensive report of these studies, which includes a summary of previous work, was published by the USGS (Orkild et al., 1983). In 2004, the USGS (Phelps et al., 2004) reevaluated the body of gravity and magnetic data for the region using more modern analytical tools to update again the understanding of the configuration of the stock for groundwater modeling studies.

In 1996, four core holes were drilled for the Defense Special Weapons Agency (now DTRA) at a site approximately 1,482 m (4,862 ft) north of the U15a shaft to characterize the upper 61 m (200 ft) of the granodiorite for a proposed tunneling project. The degree and depth of weathering at this site and other locations at the Climax stock were evaluated by Shellum (1996) as part of this investigation, as described in Section 2.2.3.

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office UGTA Sub-Project constructed a three-dimensional hydrostratigraphic framework model for the Yucca Flat–Climax Mine Corrective Action Unit in support of the Nevada Environmental Restoration Project at the NNSS. All available geologic and geophysical data from drill holes and surface geophysical surveys were incorporated into the model, using EarthVision as the platform. The construction of this model, which includes all of Yucca Flat as well as Climax stock, is documented in Bechtel Nevada (2006), and an electronic version of the model has been made available to various entities that are tasked with modeling data from the SPE. In addition, the Desert Research Institute developed a hydrogeologic flow model for the Climax stock in support of the UGTA Sub-Project (Pohlmann et al., 2007) that includes an appendix in which are compiled all fracture data available for the underground workings at the stock.

2.2 Geologic Setting

This section provides a summary of the geology of the Climax stock, taken primarily from the sources mentioned above.

The Climax stock is a composite granitic intrusive of Cretaceous age, composed of quartz monzonite and granodiorite, which intrudes sedimentary rocks of Paleozoic and Precambrian age (Figure 4). The granite body is exposed at the base of Oak Spring Butte, in extreme northern Yucca Flat. The surface exposure of the stock is approximately 2.4 square kilometers (0.93 square miles) in area, and large areas are eroded pediment surface with scattered outcrops protruding above it. Tertiary volcanic rocks, consisting of ash-flow and ash-fall tuffs, overlie portions of the pre-Tertiary sedimentary rocks and the stock.

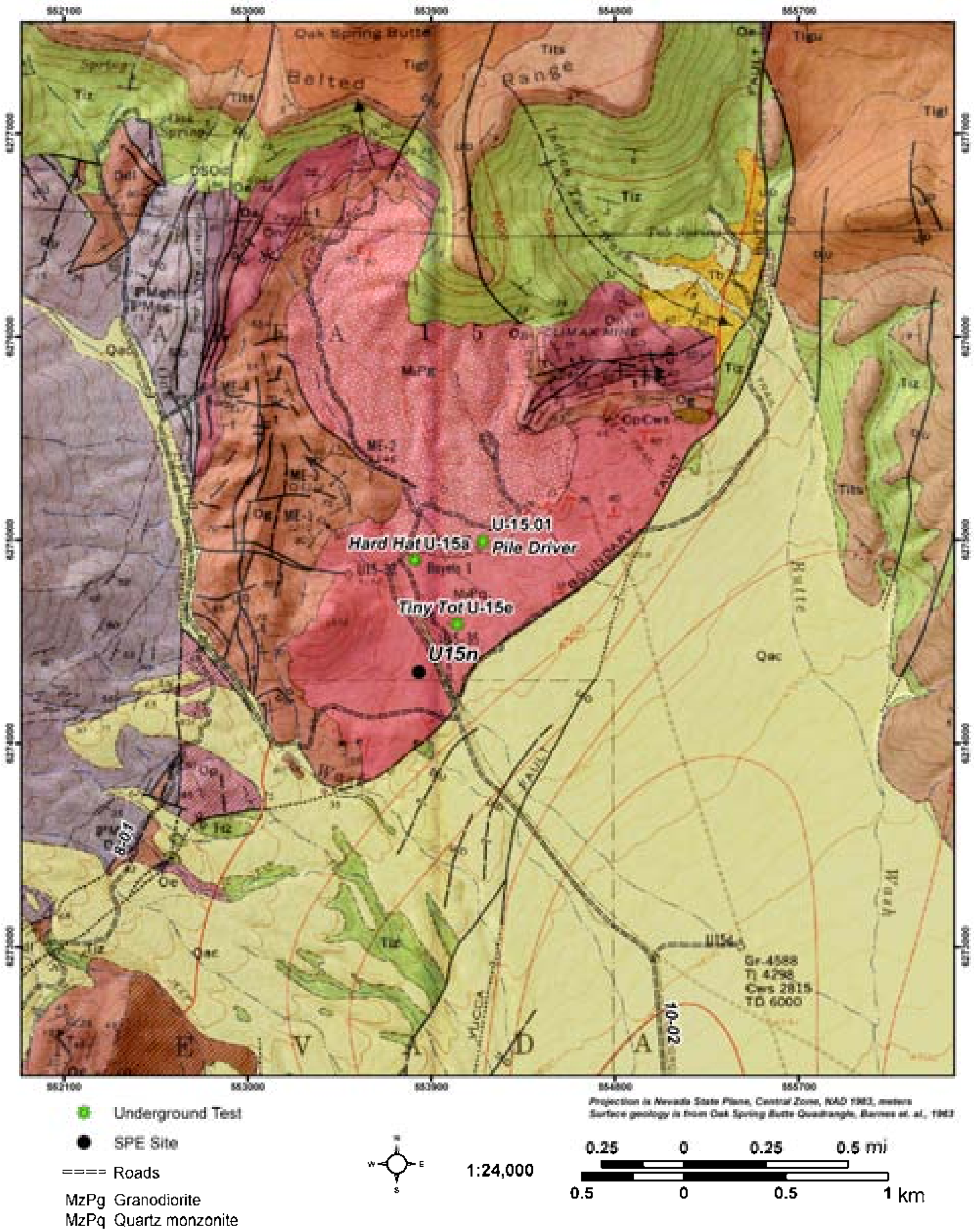


Figure 4
Geologic Map of the Climax Stock Area
Geology is from Barnes et al. (1963). See full map with legend in Plate 2.

Three major faults define the structure of the Climax area, the Tippinip fault on the west and the Boundary and Yucca faults on the east and south. The SPE site is located approximately 245 m (800 ft) northwest, at closest approach, from the Boundary fault, which separates the surface exposure of the granitic rocks from the alluvium of the Yucca Flat basin. The Boundary fault dips steeply to the southeast, and offset on it is inferred from gravity data to be approximately 245 m (800 ft) down to the east near the SPE site. The offset apparently decreases to the northeast along the fault trace, as it approaches the junction with the Yucca fault to become the Butte fault (Orkild et al., 1983). The last movement is thought to have occurred approximately 10,000 years ago (Orkild et al., 1983).

The granitic rocks at Climax stock produce a strong magnetic anomaly that has been measured by ground and aerial magnetic surveys to help to define the gross configuration of the buried intrusive body. In addition, gravity studies have improved the understanding of the three-dimensional character of the site. However, little or no density contrast is discernible between Paleozoic sedimentary rocks that surround the stock and the intrusive igneous rocks of the stock itself, making interpretation of gravity data difficult. Detailed discussions of some of these geophysical studies at the Climax site can be found in Orkild et al. (1983) and Phelps et al. (2004), among others.

2.2.1 Lithology

As described by Orkild et al. (1983), the stock is composed of an older, medium-grained, equigranular granodiorite and a slightly younger, medium-grained, coarsely porphyritic quartz monzonite. Various age-dating studies have yielded ages of approximately 100 million years. Orkild et al. (1983) describe the granodiorite as light-gray to medium greenish-gray, and consisting of 28 percent quartz, 16 percent potassium feldspar, 45 percent plagioclase feldspar, and 9 percent biotite. The average grain size is about 2 millimeters (mm), but the phenocrysts can range from 0.5 to 4.0 mm. Accessory minerals, mainly apatite, sphene, opaque iron oxides and zircon, constitute 1 to 2 percent of the rock. The quartz monzonite is porphyritic, light- to medium-gray, and consists of approximately 28 percent quartz, 25 percent potassium feldspar, 40 percent plagioclase, and 6 percent biotite. The potassium feldspar phenocrysts are as large as 15 centimeters (cm) in length and average 5 cm in length. The chemical compositions of the two granitic rock types are similar, as shown in Table 1.

The contact between the granodiorite and the quartz monzonite is generally near vertical, but it is highly irregular, with mutually penetrating fingers of each rock type. There is no glassy, chilled zone in either rock type. At one exposure of the interface in the U15a.01 PILE DRIVER workings, an isolated pocket of altered, clayey material was encountered (Merritt, 2003).

Dikes and sills, ranging in texture from aplitic (fine grained) to pegmatitic (coarsely crystalline), were mapped by Houser and Poole (1960) throughout the exposure. Extensive areas of silicification were also mapped, primarily in the granodiorite north of the SPE site. The surface exposures of both types of granite are weathered to depths ranging from about 7.6 to 38.1 m (25 to 125 ft).

Table 1
Average Chemical Composition of Quartz Monzonite and Granodiorite from Climax Stock

	Quartz Monzonite (24 samples)	**Granodiorite (24 samples)**
SiO_2	69.1	67.6
Al_2O_3	15.8	15.8
Fe_2O_3	1.5	1.8
FeO	1.3	1.6
MgO	0.6	0.82
CaO	3.2	3.7
Na_2O	3.0	3.1
K_2O	3.9	3.5
H_2O	0.89	1.0
TiO_2	0.40	0.39
P_2O_5	0.21	0.18
MnO	0.04	0.07
CO_2	0.10	0.20

From Maldonado (1977).
All values given in weight percent.

Orkild et al. (1983) note that hydrothermal alteration of the granitic rocks produced widespread but localized argillic alteration of the plagioclase feldspar and chloritic alteration of biotite. They also state that quartz and secondary minerals, such as clay minerals, sericite, feldspar, and calcite can occur in veinlets, while pyrite, chalcopyrite, limonite, and manganese, are present as fillings along joints. Most joints display some degree of mineralization and/or alteration. Quartz veinlets are widespread throughout the stock and in the surrounding Paleozoic sedimentary rocks.

The Paleozoic limestone and dolomite adjacent to the stock have been thermally and metasomatically altered to marble and tactite as much as 457 m (1,500 ft) from the contact, and minor discontinuous metasomatic effects are noted in all rocks out to a distance of 914 m (3,000 ft) from the contact. Tactite mineralogy consists of garnet, quartz, epidote, chlorite, limonite, calcite, and idocrase. Small amounts of the tungsten minerals sheelite and powellite were mined on the northeast edge of the stock (the original “Climax Mine”) in 1941.

2.2.2 Structure

The Climax stock can be said to be moderately to highly fractured, but no faults are shown on surface geologic maps of the stock. Various sources of information about fractures mapped in the workings of drifts constructed for the U15a (HARD HAT) and U15a.01 (PILE DRIVER) tests (summarized by Borg [1970] and by Wilder and Yow [1984]) and in the U15e TINY TOT workings (reported by Cording [1967]) indicate that most of the individual fractures do not persist more than a few meters, though a few more continuous faults with significant damage zones were encountered. Some of the larger faults encountered in the underground workings of the Climax stock are described here. Brief descriptions of fracture sets described in various early sources are also provided. See Section 4.2 of this report for more discussion of fractures encountered at the SPE site.

2.2.2.1 Faults

Reference has been found to only one fault encountered in the U15.01 HARD HAT drifts. This fault was parallel to the planned location of one of the radial test drifts in the HARD HAT workings, and the damage zone associated with the fault caused that drift to be abandoned for the purpose of the test (Merritt, 2003).

The U15a.01 PILE DRIVER main drift was purposely constructed along a bearing of 035 degrees azimuth, so that it was approximately parallel to one of the main high-angle fracture sets in the Climax stock and perpendicular to the other. This was unlike the U15a HARD HAT workings, which bisected the main fracture sets, encountering both at about a 45-degree angle. Only one major normal fault ("the horsetail fault") was mapped in the PILE DRIVER workings, and was intersected in several locations. It had a strike of 020 degrees azimuth and dipped 65 degrees southeast. Another fault was encountered near the end of the main drift, and produced water for approximately 24 hours. The orientation of this fault was determined from drilling (data not found), and the decision was made to move the planned working point (WP) back approximately 61 m (200 ft) to provide appropriate stand-off from the fault (Merritt, 2003).

One of the larger faults found in the LLNL Spent Fuel Test Facility has a strike of about 045 degrees azimuth, and dip of 60–65 degrees southeast, with a clay gouge zone 30.5 to 40.6 cm (12 to 16 in.) thick (Wilder and Yow, 1984). This fault projects to the surface close to the contact of the quartz monzonite and granodiorite, and appears to be one of a series of parallel faults within the stock, though none are shown on published surface geologic maps.

Two major faults were encountered in the U15e TINY TOT drifts (Cording, 1967), constructed in quartz monzonite at the depth of 122 m (400 ft) below ground surface, approximately 360 m (1,180 ft) northeast of the SPE site. One of these has a strike of 043 degrees azimuth and dip of 65 to 70 degrees southeast. Its damage zone varied in width from 0.3 to 2.1 m (1 to 7 ft) in the U15e drifts, and consisted of closely sheared and "weathered" rock with soft clay gouge 2.5 to 7.6 cm (1 to 3 in.) thick. The other fault was oriented at 330 degrees azimuth and dipped 43 degrees northeast where encountered in the drifts. This structure had a gouge zone 15.2 cm (6 in.) thick, consisting of soft clay and 1.3 to 2.5 cm (0.5 to 1 in.) of hard slickensided clay (the slicks indicated that strike-slip movement had occurred).

2.2.2.2 Joints

Maldonado (1977) compiled previously unpublished information about joints mapped by the USGS in the U15.01 PILE DRIVER main drift. This drift was driven on a bearing of approximately 035 degrees azimuth through approximately 402 m (1,320 ft) of quartz monzonite, and approximately 137 m (450 ft) of granodiorite. The joint frequency mapped in this drift was approximately 0.89 joints per foot in the quartz monzonite and 0.52 joints per foot in the granodiorite. However, including joints mapped in side drifts of other orientations driven in granodiorite, little difference was noted in joint orientation or density between the two lithologies.

As documented on the surface geologic map by Houser and Poole (1960), and described by Maldonado (1977) and by Orkild et al. (1983), three main joint sets are present at Climax stock. These have the following average orientations: a low-angle (22 degrees) set oriented 328 degrees azimuth, and two vertical sets, one oriented 296 degrees azimuth, and the other 035 degrees azimuth. In outcrop, joints are weathered and generally open. Borg (1970) notes that as many as eleven joint sets were identified in the HARD HAT drifts and nine sets were identified in the PILE DRIVER drifts, though three were considered to be the major sets. Wilder and Yow (1984) describe eight joint sets based on very detailed mapping in the three parallel drifts mined for workings of the Spent Fuel Test Facility, at the same level as the PILE DRIVER test. Of these, the three most numerous sets correspond to the three identified by Maldonado (1977) and Orkild et al. (1983). Merritt (2003) summarized the fracture data for HARD HAT and PILE DRIVER as three sets of natural joints: two with nearly vertical dips and strikes of about 306 degrees and 036 degrees azimuth, and the third with a dip of 14 to 18 degrees and (coincidentally) a strike of about 036 degrees azimuth. All of these sources note that the low-angle joint set is the most pervasive.

Cording (1967) also noted the presence of a low-angle joint system in the U15e TINY TOT drifts, with a strike of approximately 030 degrees azimuth and dip of 15 to 20 degrees to the east. Cording (1967) stated that jointing in the U15e test bed cut the rock into blocks approximately 0.15 to 0.6 m (6 in. to 2 ft) in width, and noted that limonite stains, sericite, and pyrite were present on many of the joint surfaces.

(Interesting notes: (1) Borg [1970] describes how one of the main vertical fracture sets influenced the shape of the PILE DRIVER chimney. (2) The chamber excavated for TINY TOT was designed so that the flat face of the chamber was parallel to the main northeast-trending high-angle fracture set to obtain a relatively smooth planar surface without resorting to smooth-wall or pre-split blasting techniques [Cording, 1976]).

2.2.3 Weathering

The depth of weathering was not well documented in the early geologic studies at the Climax stock, and few holes were cored in the upper weathered portion of the granite body that might provide this information.

During the site selection process for the U15e TINY TOT test, the degree of weathering was described for core hole UE-15f (Ege and Davis, 1965). This hole was drilled from the surface to the proposed WP location at a downward angle of approximately 43 degrees from horizontal along an azimuth designed to intersect the primary fracture sets at as high an angle as possible (Ege and Davis, 1965). In 1996, DTRA conducted some preliminary characterization studies in an area under consideration for construction of a tunnel complex. As part of this effort, Shellum (1996) and Shellum and Fisher (1996) evaluated the depth of weathering for granodiorite in an area approximately 1,482 m (4,862 ft) north of the SPE site, where four core holes (UE-15m#1 through #4) were drilled (Figure 5).

This section discusses methods of quantifying the degree of weathering in granite and summarizes the variability in depth of weathering in various areas of the Climax stock.

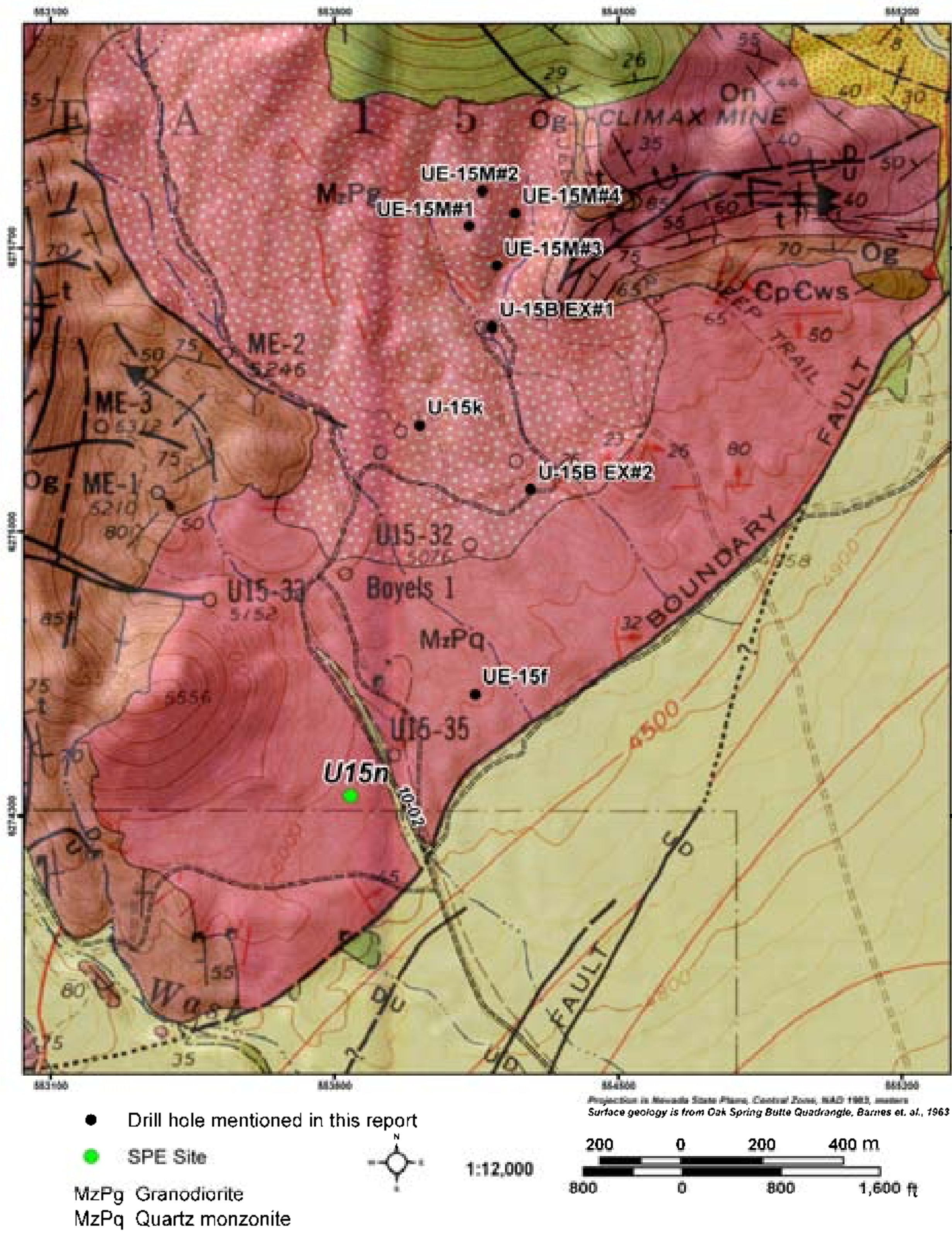


Figure 5
Geologic Map of the Climax Stock Showing Locations of Drill Holes for which Weathering Data are Presented
Open circles are other drill holes; see full map with legend in Plate 2.

2.2.3.1 General Discussion of Weathering

The state of weathering of a rock body is an important determinant in the rock's geotechnical behavior, but weathering processes are rarely uniform enough to produce gradual or predictable alterations in the geotechnical characteristics of a rock body. Thus, weathering profiles are frequently heterogeneous, mainly due to variations in weathering rates that depend on the character of the original mass, including matrix properties, jointing, topography, and groundwater conditions. Weathering has been widely studied in a variety of rock types and terrains in support of tunneling and other construction projects and, more uniquely, in support of target-defeat efforts. The depth of weathering is also an important parameter in seismic studies.

One of the most widely accepted systems for categorizing weathering of rocks is that of the International Society of Rock Mechanics (ISRM, 1981), which defines five degrees of weathering based on visual evaluation of weakening of the matrix; fracture characteristics are not explicitly considered in the ISRM weathering categories.

The U.S. Bureau of Reclamation (USBR, 2007) also developed a system for describing weathering that is similar to the ISRM system, but it incorporates fracture characteristics. See Appendix K for more information about these two systems of describing rock weathering.

It should be noted that these systems are mainly applied to obtain estimates of geotechnical characteristics necessary for construction designs. However, they may be useful for characterizing weathering variations that affect ground shock propagation because they are so widely applied.

2.2.3.2 Variability in Weathering Depth at Climax Stock

Shellum (1996) noted that the extent of highly weathered granite at Climax stock varies from about 12 to 18 m (40 to 60 ft) deep in the low-lying areas of the stock, and may only be 1 to 6 m (3 to 20 ft) deep in the hilly portions of the area. The thickness of the highly weathered zone in the area where DTRA drilled the four UE-15m core holes varied as much as 6 m (20 ft) in holes located approximately 183 m (600 ft) apart (Shellum, 1996). Shellum (1996) also examined core from three nearby holes, U-15b Exploratory #1, U-15b Exploratory #2, and U-15b-GZ, as summarized in Table 2 (Figure 5). Table 2 also includes weathering estimates for the UE-15f core hole, described by NSTec geologists for comparison to the earlier studies and with the weathering observed in U-15n core. No rock consistent with definitions of highly or moderately weathered rock was seen in the UE-15f or U-15n core. See Section 4.1.2 for more discussion of weathering observed in the U-15n core.

Table 2
Weathering Characteristics for Climax Stock

Degree of Weathering [a]	UE-15m#3 [a]	U-15b Expl#1 [a]	U-15b Expl#2 [a]	U-15b-GZ [a]	UE-15f [b]
HW	0–20	0–40?	0–50	0–100	
MW	20–35	40–80	50–65	>100	
SW	35–40	80–100	65–80		0–100
SW-F	40–50	>100	80–100		>100
F	>50				

Notes: Depths given in feet below ground surface.

HW = highly weathered
MW = moderately weathered
SW = slightly weathered
F = fresh

a Source: Shellum (1996); codes refer to ISRM classification. See Appendix K for more information on the ISRM and USBR weathering categories.
b After Ege and Davis (1965), and verified by NSTec geologists; corrected to depth below ground surface. Total depth is at vertical depth of 134 m (440 ft) below ground surface.

This page intentionally left blank.

3.0 Geologic Characterization Data for the SPE

The SPE SME group considered it a high priority to obtain geologic data for site models being developed to improve the understanding of how ground shock travels through the medium from the explosive source to close-in and outlying accelerometers and geophones. Properties that control ground shock propagation include characteristics of the medium such as density and velocity (matrix properties), but these properties are modified in the rock mass by discontinuities, which are more difficult to characterize. It is necessary to obtain material properties of the rock mass that can be parameterized for use in ground shock propagation models.

The primary sources of geologic characterization data for the SPE site are fracture data from the U-15n core hole, material properties measurements (matrix properties and fracture properties) made on selected core samples, and borehole geophysical log data, including more detailed fracture data, from the core hole and the instrument holes.

3.1 U-15n Core

The entire U-15n core hole was drilled in quartz monzonite from the bottom of the surface casing at 2.2 m (7.3 ft) to the depth of 59.9 m (196.5 ft). A total of 57.7 m (189.2 ft) was cored, and total core recovery was 57.2 m (187.6 ft), or 99.2 percent. The core diameter was 6.34 cm (2.5 in.) ("HQ" size).

Preservation of the natural water content of rock samples is important for measurement of certain material properties. Granite has low matrix porosity and thus is unlikely to lose enough moisture to affect most types of measurements. However, it was considered likely that some healed fractures could contain materials that are susceptible to drying and thus affect some planned laboratory tests, so some core samples were preserved to prevent moisture loss. The standard NNSS preservation method is to wrap fresh samples tightly in several layers of aluminum foil and coat them with unpurified beeswax (NSTec, 2011b). Geologists at the rig selected suitable samples from each drill run (minimum sound length of 15.2 cm [0.5 ft]; approximately 20 percent from each run), wrapped them in foil at the rig site, then sealed them in plastic. The aluminum-wrapped samples were given wax coatings at the end of each day, after they were delivered to Mercury. A list of the preserved samples is provided in Appendix E. Figure 6 shows photographs of some of the core from U-15n.

All core from the U-15n core hole was delivered to the USGS Data Center and Core Library in Mercury, Nevada. USGS personnel photographed each core box, and these photos can be found on their website at:

http://nevada.usgs.gov/imagefolio/cgi-bin/ImageFolio43/imagefolio.cgi?direct=NTS_Area15/U-15n&img=0

3.2 Borehole Geophysical Logs

Geophysical borehole logs can provide quantitative data on fundamental matrix properties such as density and velocity, and properties of discontinuities. In addition, borehole logs are used to determine hole conditions such as straightness (deviation) and rugosity.

Depth interval 9.6 to 11.1 m (31.6 to 36.5 ft) below ground surface.
Brown samples are preserved in beeswax.

Depth interval 54.6 to 56.8 m (179.2 to 186.5 ft) below ground surface

Figure 6
Photographs of Selected Intervals from the U-15n Core Hole
(Photos by U.S. Geological Survey, September 13, 2010)

The SME group selected the following logs to be run in the U-15n core hole:

- Caliper
- Deviation
- Density
- Natural Gamma
- Resistivity
- Full-wave Sonic/Travel Time
- Televiewer

The NSTec subcontractor Colog (a division of Layne Christensen Company) ran the logs listed below (some logging tools are run simultaneously because they are connected together on the same string). The geophysical log plots from the core hole are illustrated in Appendix F (on accompanying CD); paper plots and the digital log data were provided to the modelers.

- Caliper
- Deviation
- Density
- Natural Gamma/Caliper
- Natural Gamma/Caliper/Long-Space and Short-Space Density
- Natural Gamma/Spontaneous Potential/Single-Point Resistance/16" and 64" Resistivity
- Full-wave Sonic/Travel Time
- Acoustic Televiewer
- Optical Televiewer

Based on evaluation of the log data from the core hole, the decision was made to remove the resistivity log from the suite of logs run in the instrument holes, as it did not seem to provide relevant data for site characterization.

See the detailed discussion of fracture data from borehole logs in Section 4.2.

3.3 Material Properties Tests

Samples from the U-15n core hole were selected in April 2011 by personnel from SNL, LANL, and NSTec for laboratory testing. Phase 1 testing consisted of measurements of density, velocity, and unconfined compressive strength by SNL on ten samples (Broome and Pfeifle, 2011; reproduced in Appendix G); direct shear tests on selected fracture surfaces by SNL and LANL at the laboratory of Call and Nicholas, Inc. (Tucson, Arizona); and optical microscopy studies by LANL (the latter two studies are both in progress). SNL, LANL, and NSTec personnel selected a second group of samples from the U-15n core in September 2011, to supply material for Phase 2 tests, which will consist of triaxial testing of damaged material from the fault zones and of intact granite, as well as additional tests on fracture surfaces under both dry and saturated conditions. See Table 3 for a list of samples selected for testing.

Table 3
List of Samples from the U-15n Core Hole Selected for Material Property Testing by SNL and Petrographic Characterization by LANL

<table>
<tr><th>Sample Top (feet)</th><th>Sample Bottom (feet)</th><th>Sample Length (feet)</th><th colspan="2">Proposed Tests</th></tr>
<tr><td colspan="5">Phase 1: General Characterization (UCS completed June 2011; see Appendix G for SNL report)</td></tr>
<tr><td>13.5</td><td>14.5</td><td>1.0</td><td colspan="2" rowspan="12">• Density
• Ultrasonic Velocity (Compressional and Shear)
• Unconfined Compressive Strength (UCS)
o (Young’s Modulus, Poisson’s Ratio)
• Thin sections</td></tr>
<tr><td>29.2</td><td>30.0</td><td>0.8</td></tr>
<tr><td>49.3</td><td>50.2</td><td>0.9</td></tr>
<tr><td>50.2</td><td>51.1</td><td>0.9</td></tr>
<tr><td>70.0</td><td>70.9</td><td>0.9</td></tr>
<tr><td>86.5</td><td>87.4</td><td>0.9</td></tr>
<tr><td>107.6</td><td>108.8</td><td>1.2</td></tr>
<tr><td>131.5</td><td>132.4</td><td>0.9</td></tr>
<tr><td>153.6</td><td>154.4</td><td>0.8</td></tr>
<tr><td>156.5</td><td>157.7</td><td>1.2</td></tr>
<tr><td>176.5</td><td>177.2</td><td>0.7</td></tr>
<tr><td>192.2</td><td>192.9</td><td>0.7</td></tr>
<tr><td>23.7</td><td>24.7</td><td>1.0</td><td colspan="2" rowspan="13">Other tests, including:
• Direct shear on fracture surfaces
• Direct tension on fracture surfaces
• Split Hopkinson Bar
• Thin sections</td></tr>
<tr><td>30.3</td><td>31.2</td><td>0.9</td></tr>
<tr><td>33.2</td><td>33.7</td><td>0.5</td></tr>
<tr><td>39.4</td><td>40.1</td><td>0.7</td></tr>
<tr><td>81.4</td><td>82.0</td><td>0.6</td></tr>
<tr><td>104.0</td><td>105.1</td><td>1.1</td></tr>
<tr><td>121.8</td><td>122.4</td><td>0.6</td></tr>
<tr><td>154.9</td><td>155.5</td><td>0.6</td></tr>
<tr><td>162.7</td><td>163.5</td><td>0.8</td></tr>
<tr><td>165.4</td><td>166.2</td><td>0.8</td></tr>
<tr><td>172.2</td><td>173.3</td><td>1.1</td></tr>
<tr><td>177.2</td><td>178.2</td><td>1.0</td></tr>
<tr><td>179.2</td><td>179.9</td><td>0.7</td></tr>
<tr><td colspan="5">Phase 2: Characterization of fractures and fault zones (in progress)</td></tr>
<tr><td>72.1</td><td>72.6</td><td>0.5</td><td rowspan="2">Low-angle fracture pair</td><td rowspan="2">Triaxial shear</td></tr>
<tr><td>72.6</td><td>72.8</td><td>0.2</td></tr>
<tr><td>75.1</td><td>76.5</td><td>1.4</td><td>Fault zone</td><td>Triaxial compression</td></tr>
<tr><td>76.5</td><td>77.7</td><td>1.2</td><td>Fault zone / preserved</td><td>Triaxial compression</td></tr>
<tr><td>83.9</td><td>85.1</td><td>1.2</td><td>Fault zone / preserved</td><td>Triaxial compression</td></tr>
<tr><td>85.1</td><td>85.8</td><td>0.7</td><td>Fault zone</td><td>Triaxial compression</td></tr>
<tr><td>85.8</td><td>86.5</td><td>0.7</td><td>Fault zone / preserved</td><td>Triaxial compression</td></tr>
<tr><td>87.4</td><td>88.2</td><td>0.8</td><td>Fault zone</td><td>Triaxial compression</td></tr>
<tr><td>125.2</td><td>125.6</td><td>0.4</td><td rowspan="2">Low-angle fracture pair</td><td rowspan="2">Triaxial shear</td></tr>
<tr><td>125.6</td><td>125.8</td><td>0.2</td></tr>
<tr><td>136.7</td><td>137.3</td><td>0.6</td><td rowspan="2">45-degree angle fracture pair</td><td rowspan="2">Triaxial shear</td></tr>
<tr><td>137.3</td><td>137.8</td><td>0.5</td></tr>
<tr><td>140.3</td><td>140.8</td><td>0.5</td><td rowspan="2">Low-angle fracture pair</td><td rowspan="2">Triaxial shear</td></tr>
<tr><td>140.8</td><td>141.0</td><td>0.2</td></tr>
<tr><td>147.3</td><td>148.1</td><td>0.8</td><td>Intact</td><td>Triaxial compression</td></tr>
<tr><td>149.8</td><td>150.5</td><td>0.7</td><td rowspan="2">High-angle fracture pair</td><td rowspan="2">Triaxial shear and triaxial compression</td></tr>
<tr><td>150.5</td><td>151.8</td><td>1.3</td></tr>
<tr><td>151.8</td><td>152.4</td><td>0.6</td><td>Intact</td><td>Triaxial compression</td></tr>
<tr><td>152.4</td><td>153.1</td><td>0.7</td><td>Intact / preserved</td><td>Triaxial compression</td></tr>
<tr><td>153.1</td><td>153.7</td><td>0.6</td><td>Intact</td><td>Triaxial compression</td></tr>
<tr><td>173.2</td><td>174.2</td><td>1.0</td><td rowspan="2">Low-angle fracture pair</td><td rowspan="2">Direct shear and triaxial compression</td></tr>
<tr><td>174.2</td><td>174.5</td><td>0.3</td></tr>
</table>

4.0 Analyses

This section includes discussions of weathering, fracturing, and groundwater as characterized at the SPE site by evaluating the core data, laboratory properties data, geophysical log data, and tags of water levels in the instrument holes and Source Hole prior to conducting the first SPE test in May 2011. In this report we use the term “fracture” to include all discontinuities, whether they are planes of offset (faults) or not (joints).

4.1 U-15n Core Data

As described in Section 3.0, core was obtained from Hole U-15n from the depth of 2.2 to 59.9 m (7.3 to 196.5 ft) below ground surface. This section describes studies conducted by NSTec geologists on the core. It also includes a discussion of velocity data obtained from borehole logs and measured on core samples.

4.1.1 Rock Quality Designation (RQD)

NSTec geologists recorded data required for calculation of Rock Quality Designation (RQD), which is a standard, internationally accepted means of estimating rock quality for engineering purposes (Deere and Deere, 1988; 1989). The RQD is a modified core-recovery percentage in which all sound core pieces more than 4 in. (100 mm) long are summed and divided by the length of the core run. Thus, RQD logging is basically a measurement of the percentage of “good” rock recovered from an interval of a borehole (see more information about RQD determination in Appendix E).

The RQD for the U-15n core hole ranges from 52 near the top of the hole to 100, generally increasing with depth, and averages greater than 80. RQD data by run are presented in Figure 7, and tabulated in Appendix E.

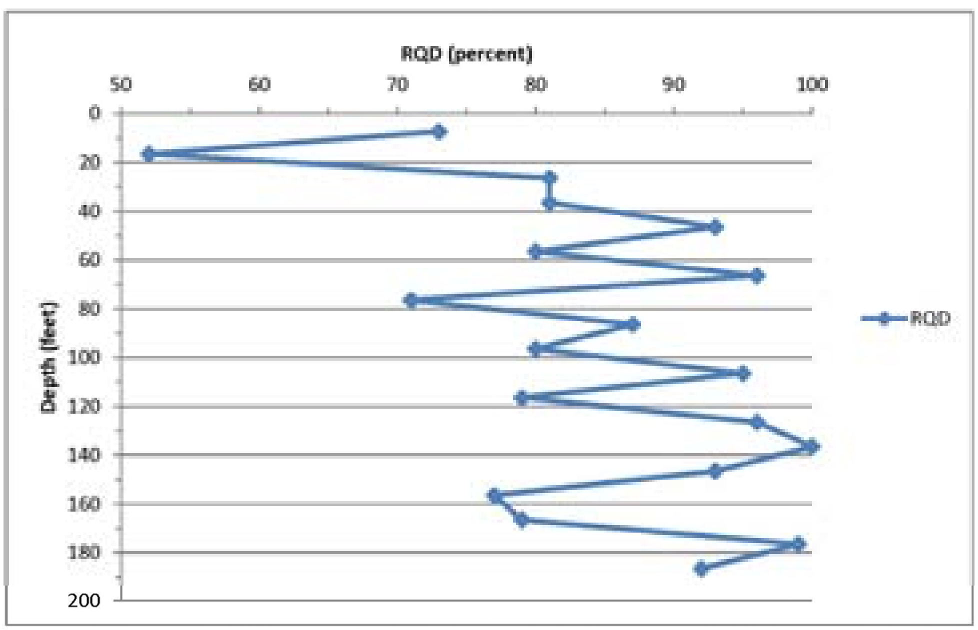


Figure 7
Plot of RQD Data versus Depth for the U-15n Core Hole

4.1.2 Weathering Evaluation

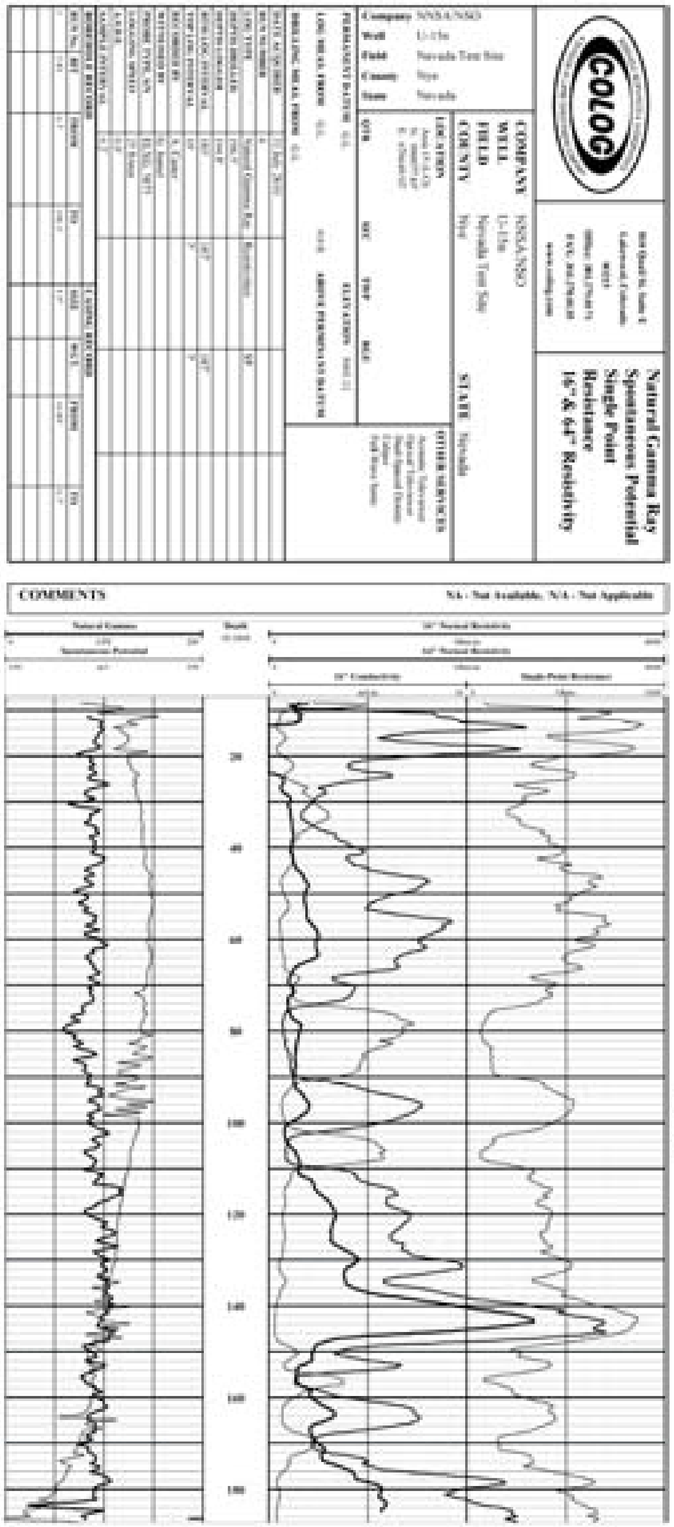
A simple gradational weathering profile, progressing from highly weathered surface rock to fresh rock at depth, was not seen in the core from U-15n, based on visual evaluation (see Appendix K for a log of weathering characteristics of the U-15n core). Zones of alteration and weathering are sporadic and appear to be controlled more by fractures than by depth. Some of the color change and mineral alteration associated with fractures described at various Climax stock locations are undoubtedly attributable to the action of groundwater, including hydrothermal processes millions of years ago when the rock was more deeply buried; therefore, a progression from highly weathered at the surface to fresh rock at depth is not typically found. The term "weathering and alteration" might be more accurate.

Most rock in the U-15n core hole was categorized using the USBR system as "slightly weathered." The slightly weathered rock in the U-15n core hole varies from largely unaltered gray quartz monzonite with iron-oxide–stained zones up to 0.63 cm (0.25 in.) wide along fractures, to rock that, although still very hard, is significantly stained throughout by iron oxides. Minor amounts of rock could be classified as "moderately to slightly weathered." These zones show some alteration of feldspar phenocrysts and some overall softening of the rock. Most of these moderately to slightly weathered zones occur above the depth of about 12 m (40 ft). The plot of RQD in Figure 7 illustrates the variability in this upper weathered portion of the hole.

The sporadic nature of weathering with depth in the U-15n core hole contrasts with core from UE-15f, where rock above the vertical depth of 30 m (100 ft) is pervasively moderately to slightly weathered, and rock below that is slightly weathered (Ege and Davis, 1965). The contrast between the two core holes, which are less than 365 m (1,200 ft) apart (Figure 5), demonstrates the variability in weathering and alteration across the stock.

The borehole geophysical logs also provide some indications of weathering at the SPE site. Figure 8 shows plots of the Colog electric log and compressional wave (P-wave) and shear wave (S-wave) velocities from the Colog full-waveform sonic log, both from the U-15n core hole. On the electric log, especially the single-point resistance curve, an area of high but quite variable resistivity is observed in the upper 6.1 m (20 ft) of the U-15n core hole. It is difficult to pick the transition to less weathered rocks from the electric log, though the fault zones also show up well as areas of low resistivity. Areas with the highest resistivity correspond to areas described as relatively unweathered quartz monzonite (such as in the depth intervals 2.1–6.1 and 43.0–44.8 m (7–20 and 141–147 ft). The resistivity of hard, stained quartz monzonite is intermediate between that of the relatively unweathered zones and the fault zones, and is variable.

The velocity data (Figure 8) also seem to reflect weathering and alteration in the core hole. The entire section above about 13.7 m (45 ft), with the exception of the interval 4.3–5.5 m (14–18 ft), has significantly lower P-wave and S-wave velocities than the section below. Borehole density and gamma logs in five of the six instrument holes show a variable zone in the upper 15.2 to 18.3 m (50 to 60 ft) that appears to correlate with the weathered zone (Figures 9a and 9b). This zone is not easily identified in U-15n#3, or it is much shallower than in the other holes.



Left: Reproduction of Colog's Electrical Log run in the U-15n Core Hole. Note high but variable resistivity in the upper 6.1 m (20 ft), low-resistivity sections near the primary fault zones at 25.3 and 32.3 m (83 and 106 ft), and a high-resistivity zone at 43.0 to 44.8 m (141 to 147 ft).

Below: Plot of compressional and shear velocity obtained from Colog's Full-Waveform Sonic Log run in the U-15n Core Hole. Note low-velocity segment at 6.1 to 15.2 m (20 to 50 ft), which may reflect surface weathering, and low-velocity segments near the depths of 25.3 and 32.3 m (83 and 106 ft), which correlate with the two primary fault zones observed in the borehole.

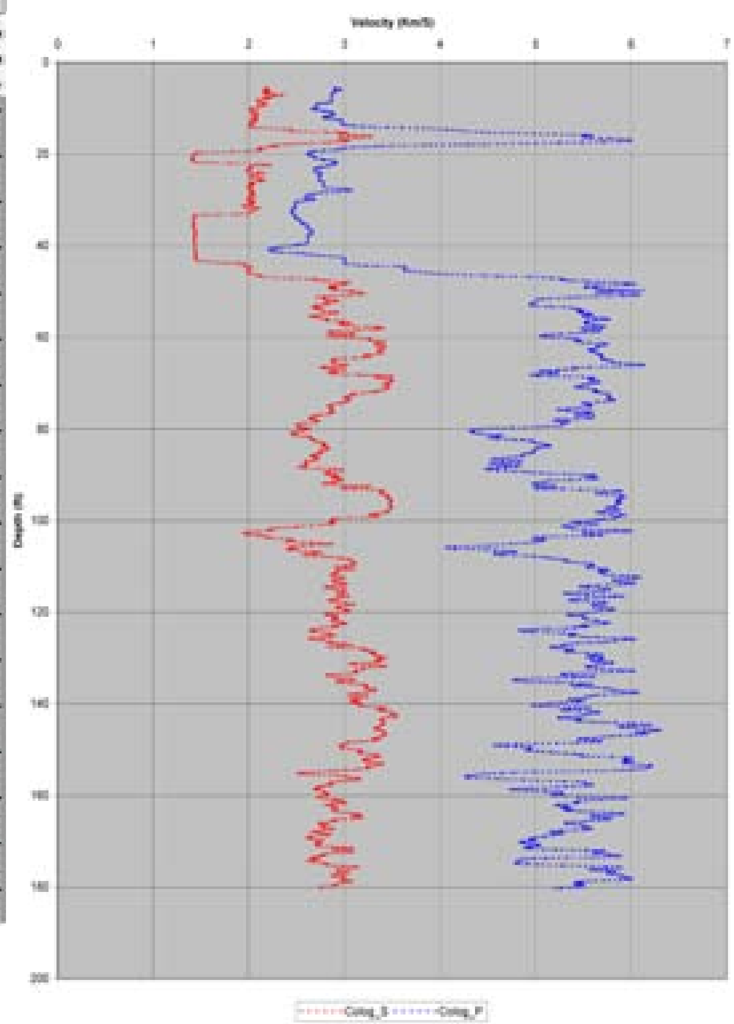


Figure 8
Examples of Resistivity and Velocity Logs from the U-15n Core Hole

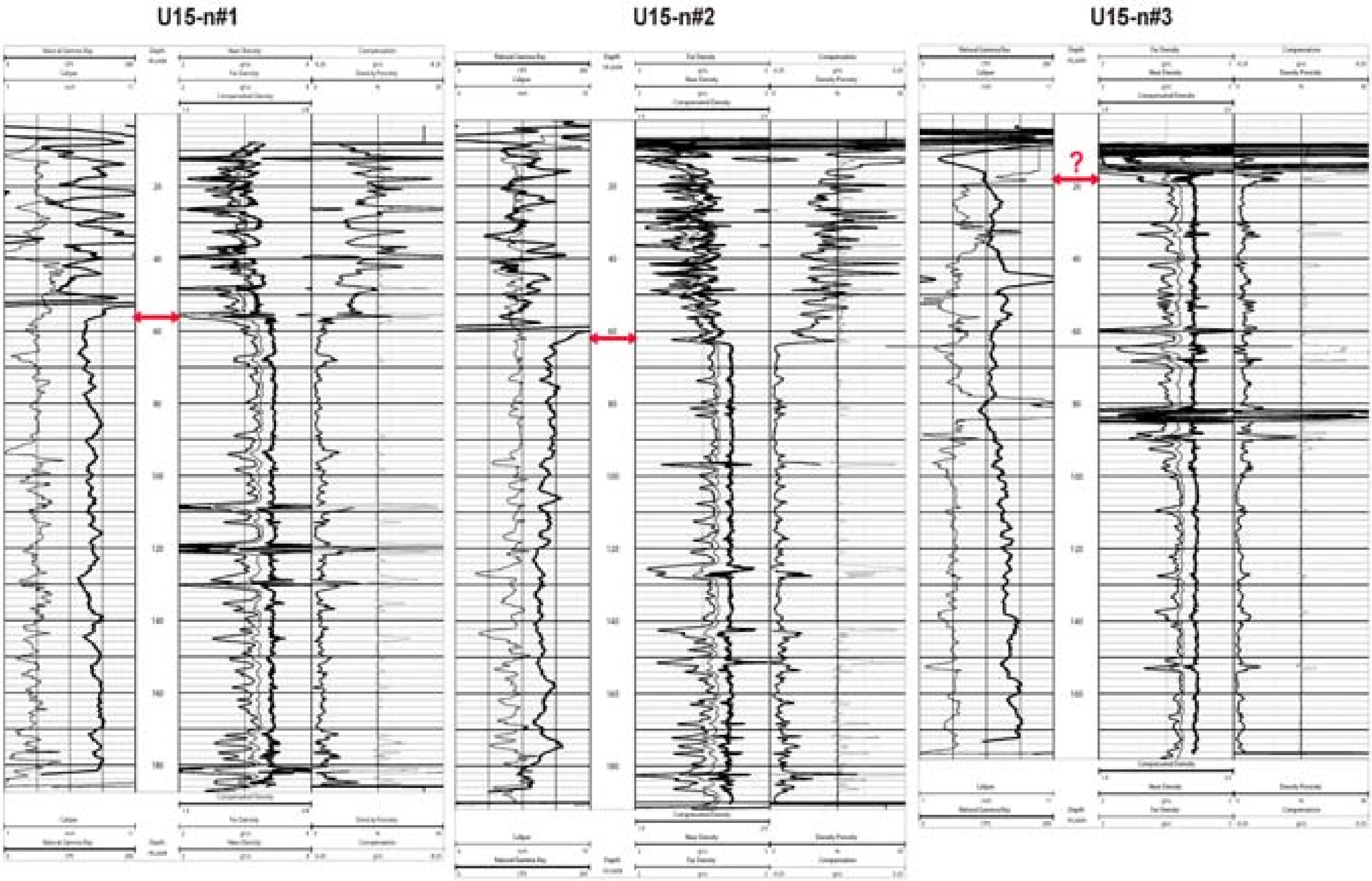


Figure 9a

Plots of Gamma, Caliper, and Density Logs Obtained by Colog in Instrument Holes U-15n#1, #2, and #3

Red arrow indicates depth of weathering as interpreted from log.

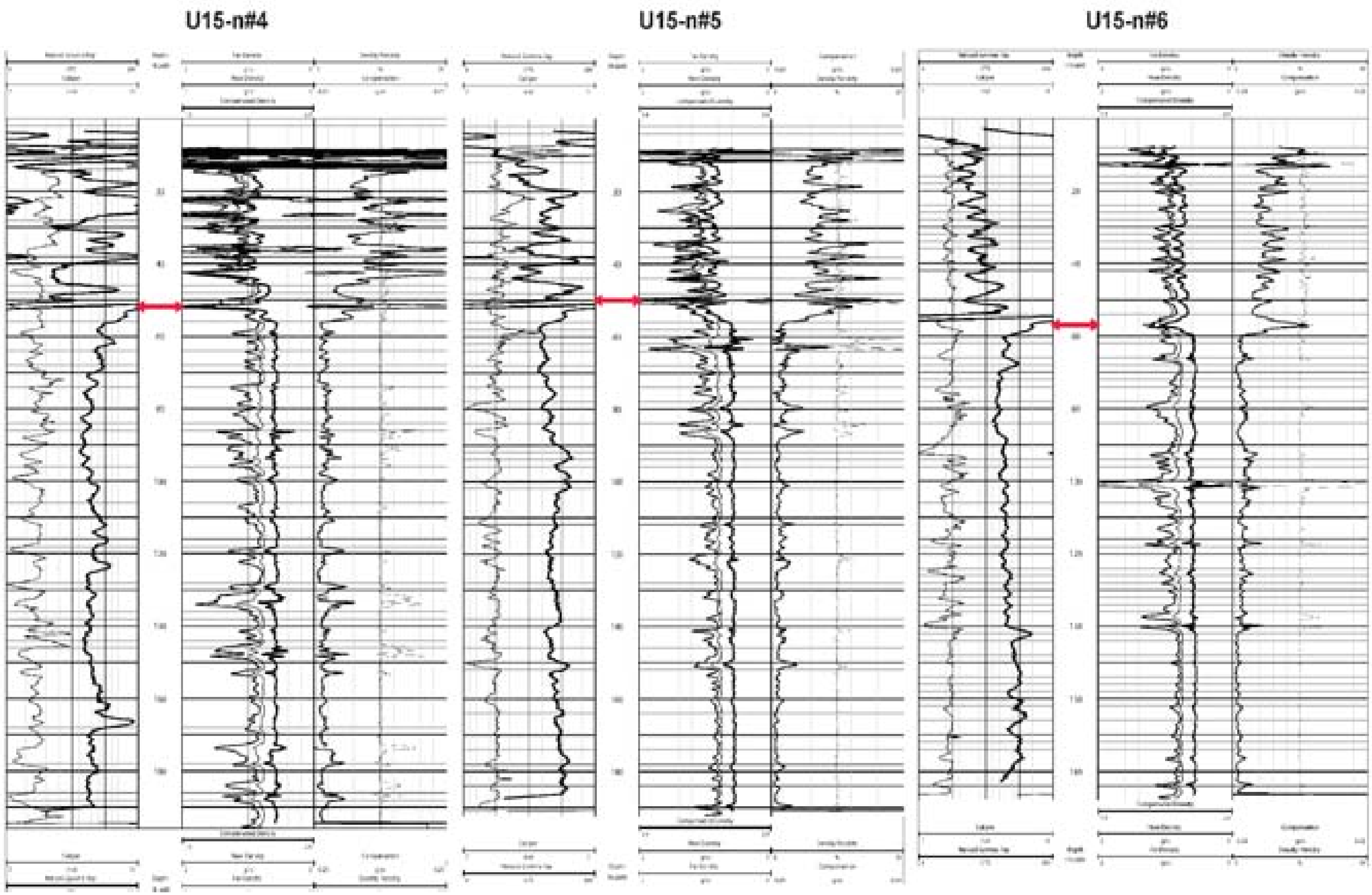


Figure 9b

Plots of Gamma, Caliper, and Density Logs Obtained by Colog in Instrument Holes U-15n#4, #5, and #6

Red arrow indicates depth of weathering as interpreted from log.

4.1.3 Evaluation of Velocity Data from the U-15n Core Hole

Medium velocity data from different scales of surveys (from higher-frequency ultrasonic measurements on discrete core samples, to lower-frequency continuous sonic logs in boreholes, to even lower-frequency surface seismic surveys) can provide useful information for characterizing a rock mass. Measurements on cores sample a small volume that likely does not contain many discontinuities, and may correlate mainly with matrix properties such as density, porosity, saturation, etc. However the borehole logs sample a larger volume that may contain numerous discontinuities that can further affect the medium velocity. The U-15n SPE site affords an opportunity to compare these different scales of velocity measurements in an environment with fewer variables than many other sites: the medium is a relatively homogenous granitic rock with only minor local weathering, though it contains numerous discontinuities.

In this section we compare data from three sets of velocity measurements: (1) borehole velocity logs obtained by Colog, (2) laboratory velocity data from core samples obtained by SNL, and (3) velocity data obtained on cores under less controlled conditions by a DTRA subcontractor on behalf of the DTRA Interagency Geotechnical Assessment Team (IGAT). Larger-scale seismic surveys such as those conducted at the SPE site by SNL are not discussed here.

4.1.3.1 Analytical Methods and Data Presentation

Colog performed a continuous full-waveform sonic survey in the fluid-filled portion of the U-15n core hole after completion of drilling activities, and obtained in-situ compressional and shear velocities (Figure 8). Of the three sets of velocity data, the Colog borehole data, derived from a continuous log of sonic velocities through the greater rock mass, are the most representative of actual field conditions, and are not dependent on availability of coherent samples.

SNL prepared and analyzed ten U-15n core samples in their laboratory (Broome and Pfeifle, 2011, reproduced in Appendix G). For each sample, SNL measured ultrasonic P-wave and S-wave velocities in the axial (parallel to core axis) direction and in two radial (orthogonal to core axis) directions, 90 degrees apart. The SNL data set is likely the most accurate though least populated of the three, but provides a comparison to the sonic velocities at specific points in the Colog surveys. The SNL sonic velocities tend to trend along the upper range of those of Colog. Additional samples were later selected for further testing, which is currently in progress (see Table 3).

Ultrasonic P-wave velocities (but not S-wave velocities) were measured on behalf of IGAT on unprepared samples from the U-15n core hole. Measurements were made in both radial (136 measurements) and axial (16 measurements) directions using a portable method at the NNSS (see data listed in Appendix H). The IGAT radial and axial velocities are not directly comparable to each other because the two readings were not necessarily measured on the same sample (as was done by SNL). However they are useful for comparing to the other data sets. The IGAT sonic velocities are mostly slower than those from the Colog borehole survey.

Figure 10 shows plots comparing P- and S-wave velocities from all three data sets from the U-15n core hole..

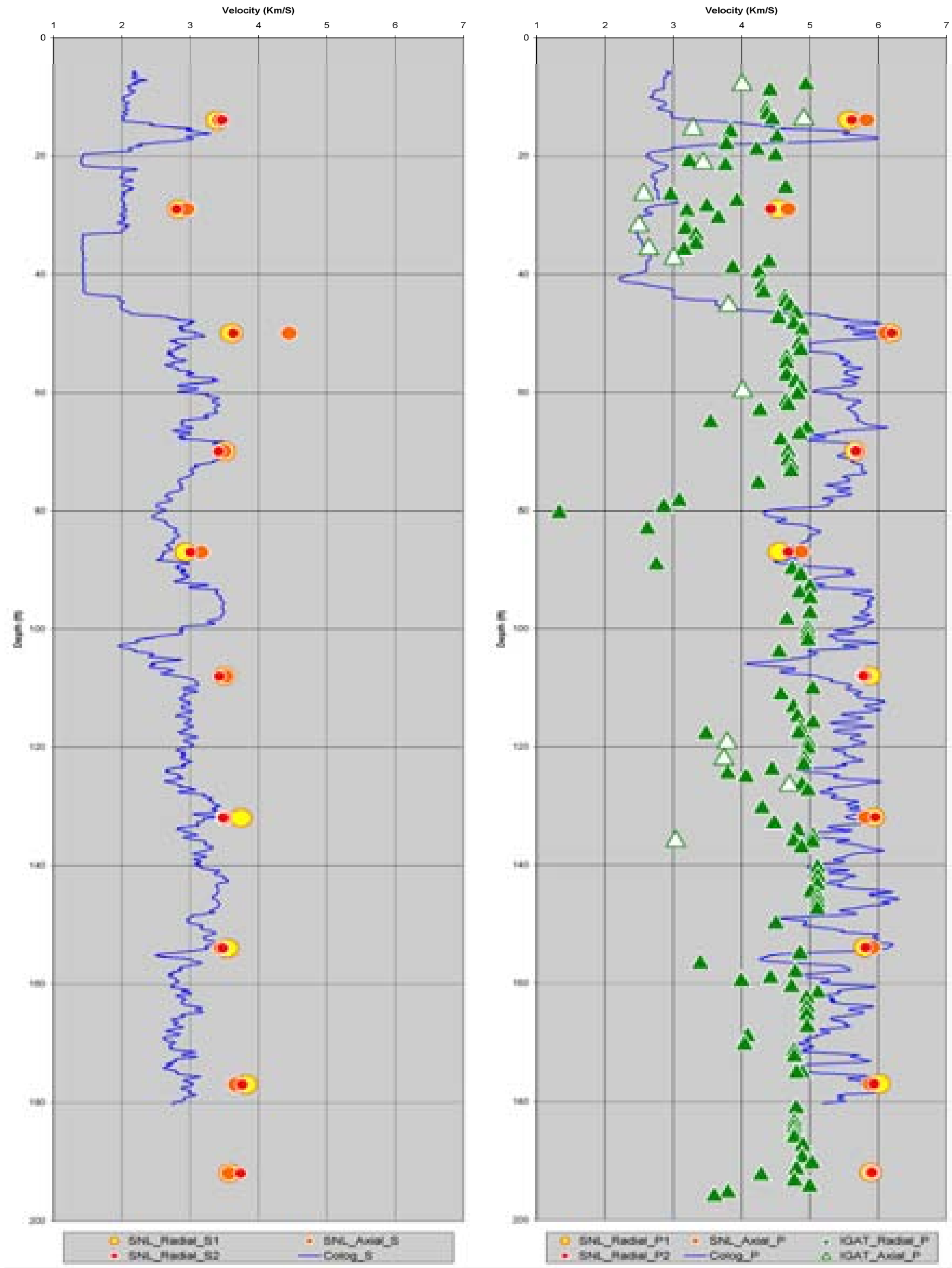


Figure 10
Plots of Shear Velocity (left) and Compressional Velocity (right) for the U-15n Core Hole

Continuous blue lines are Colog borehole data, yellow and red points are SNL data, and green triangles are IGAT data. Km/s = kilometers per second.

4.1.3.2 Discussion of Velocity from the U-15n Core Hole

A few observations can be made about these three sets of velocity data from the U-15n core hole.

- For a given Colog depth or SNL sample, P-wave velocities (3 to 6 kilometers per second [km/s]) are roughly half again faster than S-wave velocities (2 to 4 km/s).
- For a given SNL sample, axial and radial velocities are closely similar for P-waves and for S-waves.
- The continuous sampling by Colog appears to best characterize zones of faulting and alteration because of finer resolution.
- Weathered zone to the depth of 13.7 m (45 ft): The Colog and IGAT data exhibit major reductions of P- and S-wave velocities. The SNL data exhibit only minor reductions, which may be a function of the smaller number of samples tested and the variability in degree of weathering through the interval.
- Fault zone at the depth of 25.3 m (83 ft): The IGAT data exhibit major reductions of P-wave velocities, while the Colog and SNL data exhibit minor reductions. Again, the smaller number of samples tested by SNL may be a factor (several additional samples from this zone are currently being tested).
- Fault zone at the depth of 32.3 m (106 ft): The Colog data exhibit moderate to major reduction of P- and S-wave velocities, and the SNL and IGAT data exhibit minor to no reduction. Both IGAT and SNL tested fewer samples in this interval, mainly due to the poor condition of the core.

4.1.3.3 Discussion of Velocity from Instrument Holes U-15n #1 through #6

Colog also measured in situ P- and S-wave sonic velocities in nearby instrument holes U-15n #1 through #6. These data are plotted in Figure 11, and a few observations are noted below.

- The U-15n core hole and U-15n #3 were the only two boreholes with fluid levels high enough to allow sonic logging near the surface. Lower sonic velocities (indicative of weathered/altered rock) were measured in U-15n core hole down to a depth of about 13.7 m (45 ft) and in U-15n #3 down to depths of 12.2 to 15.8 m (40 to 52 ft). The top of the sonic velocity log for U-15n #5 suggests weathered/altered rock down to a depth of about 18.6 m (61 ft).
- Several isolated intervals of anomalously low velocity rock were measured in U-15n #2, with the most severe at approximately 48.8 to 56.4 m (160 to 185 ft).

4.1.4 Fracture Logging

NSTec geologists logged the core to record fracture data. The core was not oriented, so it was not possible to determine fracture orientations (these data were obtained from the borehole televiewer logs; see Section 4.2). Three main fracture sets were identified in the core, based on fracture dip magnitude. A preliminary evaluation of the core indicated that the most abundant fractures (77 percent) had very low dips (generally less than 25 degrees), a secondary set (17 percent) had dips generally less than 45 degrees, and the third set (6 percent) had dips greater than 75 degrees. A more quantitative analysis was done using borehole image logs, as discussed in Section 4.2. The core fracture log is provided in Appendix E.

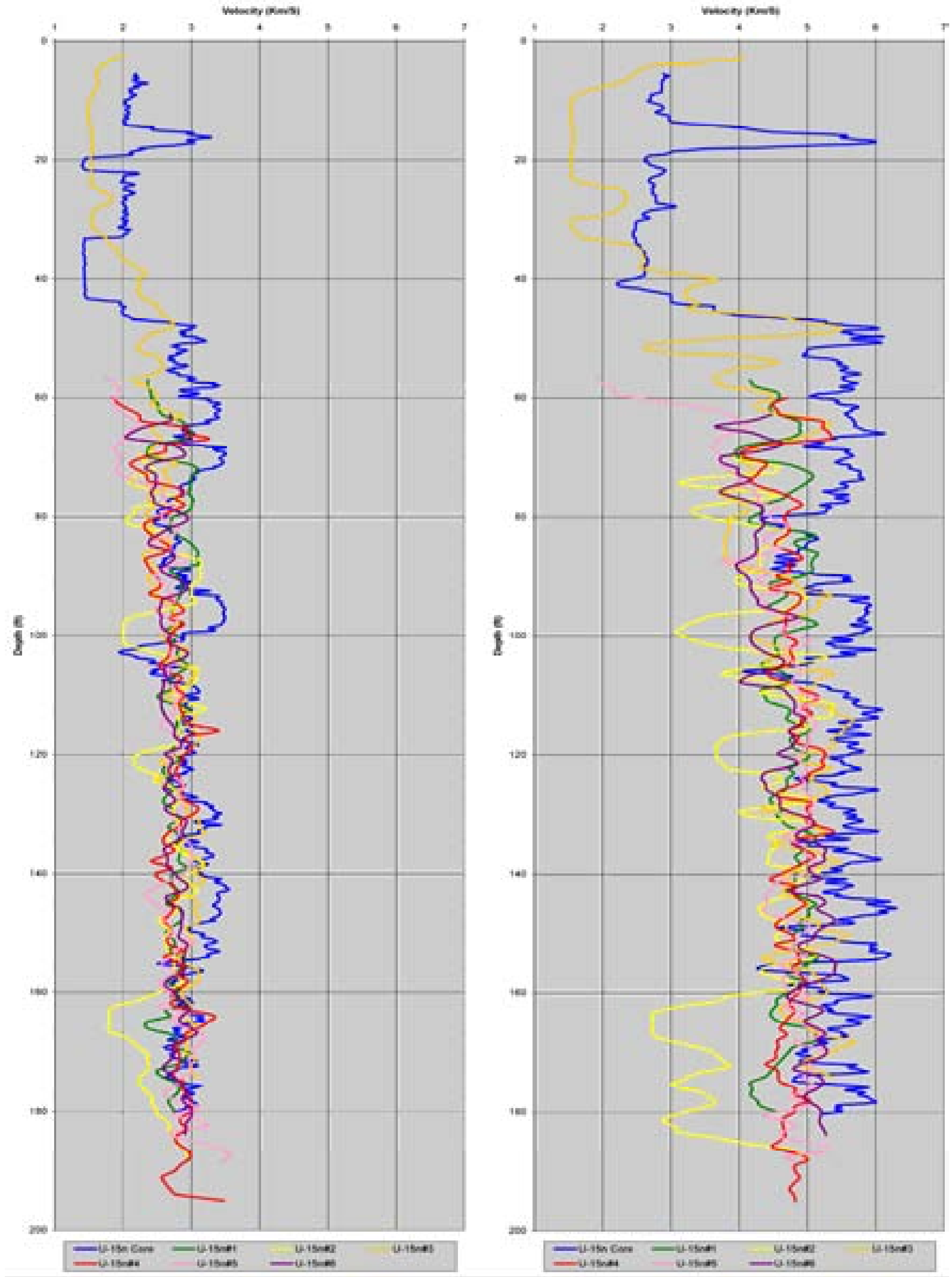


Figure 11
Plots of Shear Velocity (left) and Compressional Velocity (right) Measured in Instrument Holes U-15n#1, #2, #3, #4, #5, and #6 by Colog

Two fault zones were observed in the core, both dipping at a high angle, and crossing the midpoint of the core hole at the depths of 25.3 and 32.3 m (83 and 106 ft). Both fault zones can be seen distinctly on the caliper, density, sonic velocity, and resistivity logs. Photos of the core intervals where the fault zones were encountered are shown in Figure 12. See the preliminary report (NSTec, 2011a) on possible projections of these two fault zones in Appendix I. Neither fault has an identifiable surface trace.

The fault at 25.3 m (83 ft) in the core hole (Figure 12, upper photo) is associated with an argillized zone that extends from 23.6 to 25.8 m (77.5 to 84.5 ft) (true width approximately 0.4 m [1.2 ft]). Based on its orientation (obtained from the borehole image log), it belongs to Fracture Set 1 (see Section 4.2.2). This fault is likely the one observed in camera runs in the 36-in. diameter hole extending from 17.7 to 24.4 m (58 to 80 ft) below ground surface. (The depths do not match, even though the core hole and the Source Hole were collared at the same point, because of the difference in diameter of the two holes and because both holes deviated in different directions from vertical. The core hole deviated to the northeast, and the Source Hole deviated to the south.)

The fault at 32.3 m (106 ft) in the core hole (Figure 12, lower photo) is associated with an argillized zone that extends from 31.9 to 32.6 m (104.7 to 106.8 ft) (true width approximately 0.2 m [0.6 ft]), and which is bounded by two fracture planes. Based on its orientation (from the borehole image log), it belongs to Fracture Set 2. This fault is likely the one observed in camera runs in the 36-in. hole extending from approximately 32.0 to 37.8 m (105 to 124 ft).

4.2 Fracture Data from Borehole Image Logs

Oriented fracture data were obtained primarily from acoustic and optical televiewer (image) logs run in the core hole and all six instrument holes (data from the replacement Instrument Hole #1A are not included here). As described in Section 4.1.3, data for fractures observed in the core from U-15n were also compiled (see Appendix E), but because the core was not oriented, these data are not as useful as those from the televiewer logs.

4.2.1 Data Acquisition

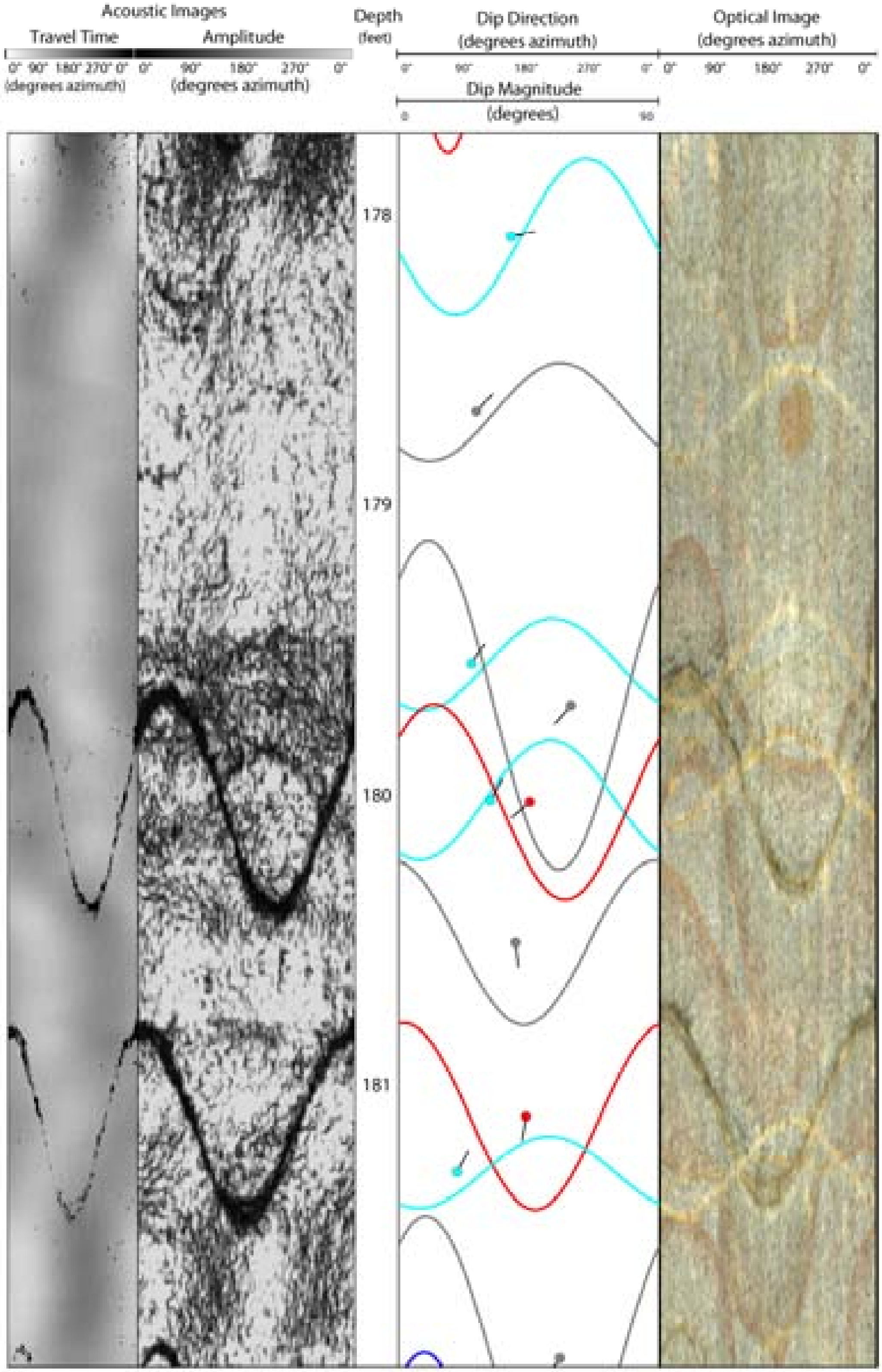
Colog ran acoustic borehole image logs within the fluid-filled portions of all seven holes. Optical borehole image logs were run in the six instrument holes to provide image log coverage of the dry upper portions of the instrument holes, although log coverage of all the optical image logs also included the fluid-filled portions of the boreholes. Only the acoustic image log was run in the U-15n core hole, but the log was able to acquire image data as high as 4 m (13 ft) below ground surface because of the high borehole fluid level at time of logging. On average, 93 percent of the drilled portions of the holes are covered by image logs.

Colog used the image log data to identify and record the orientations of all planar features observed crossing the boreholes (Figure 13). Because all the holes were drilled within granite, which has no bedding planes, all planar features identified in the boreholes are interpreted by NSTec to be fractures. Colog identified a total of 2,488 fractures, and recorded the depth and orientation (i.e., dip magnitude and direction) of each fracture. Colog assigned each fracture a ranking from 0 to 5 based on degree of openness and continuity (Figure 14). Colog corrected all fracture orientations for magnetic declination and borehole deviation, and provided in spreadsheet format the depth, orientation, and ranking for every fracture observed in each of the seven SPE drill holes (Appendix J).

Depth interval 25.0 to 27.2 m (82.0 to 89.3 ft) below ground surface.
Includes part of the upper fault zone.

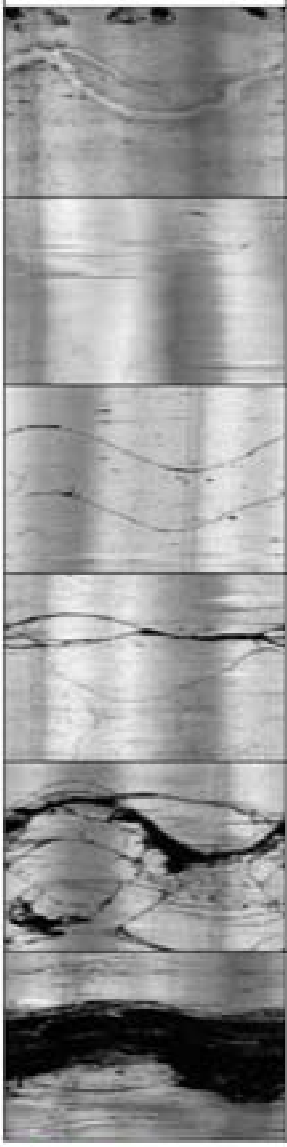
Depth interval 31.7 to 34.1 m (104.0 to 111.8 ft) below ground surface.
Includes the lower fault zone (indicated by arrows)

Figure 12
Photographs of Core from U-15n Showing the Two Main Fault Zones
(Photos by U.S. Geological Survey, September 13, 2010)

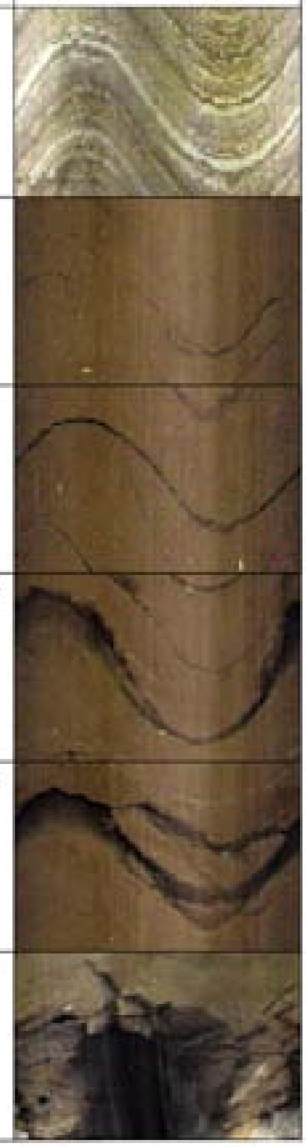


See Figure 14 for explanations of colors.

Figure 13
Example of Colog's Interpreted Image Log Data from Instrument Hole U-15n#6



Acoustic Image	Rank	Color	Observation	Flow Rating System	Optical Image
	0	Gray	No-Flow Feature (bedding, healed fracture, vein, etc.)	Sealed, No Flow	
	1	Cyan	Weak Feature (not continuous around the borehole.)	Partial Open Crack	
	2	Blue	Clear, Distinct Feature	Continuous Open Crack	
	3	Red	Distinct Feature with Apparent Aperture (visible on amplitude and travel-time image)	Wide Open Crack or Cracks	
	4	Magenta	Very Distinct, Wide, Possibly Interconnected Fracture (visible on amplitude and travel-time image)	Very Wide Crack or Multiple Interconnected Fractures	
	5	Green	Major Fracture Zone or Washed out Zone (visible on amplitude and travel-time image)	Major Fracture with Large Openings or Breakouts	



COLOG Division of Layne Christensen Company

Figure 14
Colog's Fracture Rankings

4.2.2 Fracture Analysis

All fractures observed on the image logs are interpreted to be natural fractures because the optical image logs show that secondary alteration rinds are associated with the vast majority of the fractures. Because Colog's feature rankings 0 and 1 include healed, discontinuous, and partially open fractures, subsequent analyses focused mainly on fractures ranked 2 through 5, which include distinct, continuous, and open fractures. Of the 2,488 fractures identified, 1,215, or 49 percent, are assigned rankings of 2 or higher (Figure 15). Consequently, 51 percent all of the observed features are eliminated from the analyses described here by limiting the analyses to fractures with rankings 2 or higher. Although features ranked 0 and 1 are, individually, clearly minor features, they may still be significant considering their abundance. Also, subsequent analyses do not account for sampling bias related to the tendency of approximately vertical drill holes to intercept low-angle fractures more often than high-angle fractures.

Another consideration about the fracture rankings is that rankings are applied to individual fracture planes. Thus, the rankings may not reflect the overall character of fault zones that consist of a series of closely spaced fracture planes and/or intervals of altered rock. This is particularly true of the two fault zones encountered near 25.3 and 32.3 m (83 and 106 ft) in the core hole, where closely spaced fractures and argillized rock caused severe breakouts in the 36-in. diameter Source Hole. One way to compensate for this is to look for clusters of fractures, which is discussed in Section 4.2.3.

Analysis of dip magnitudes from the Colog data indicates that the majority (88 percent) of the fractures ranked 2–5 fall into two main groups based on dip magnitude: a low-angle group that dips from 0 to 30 degrees and accounts for 50 percent of all fractures ranked 2–5, and a high-angle group that dips from 60 to 90 degrees and accounts for 38 percent of all fractures ranked 2–5 (Figure 16). The remaining 12 percent of fractures ranked 2–5 have moderate dips, between 30 and 60 degrees.

Analysis of dip directions indicates that the high-angle group of fractures consists of three main and distinct fracture sets based on dip direction (Figure 17). Set 1 fractures dip to the north-northeast between 015 and 040 degrees azimuth. Fractures of Set 2 dip to the south-southwest between 190 and 235 degrees azimuth. Sets 1 and 2 could be considered a single high-angle set with dip directions varying northeastward and southwestward off the vertical. Set 3 includes high-angle fractures that dip to the east-southeast between 110 and 145 degrees azimuth. The low-angle fractures (ranked 2–5) dip eastward and are designated Set 4 (Figure 18). Fracture frequency does not appear to change substantially with depth (Figure 19). True fracture spacing averages 0.9 to 1.2 m (3 to 4 ft) for high-angle Sets 1, 2, and 3, and 0.6 m (2 ft) for Set 4.

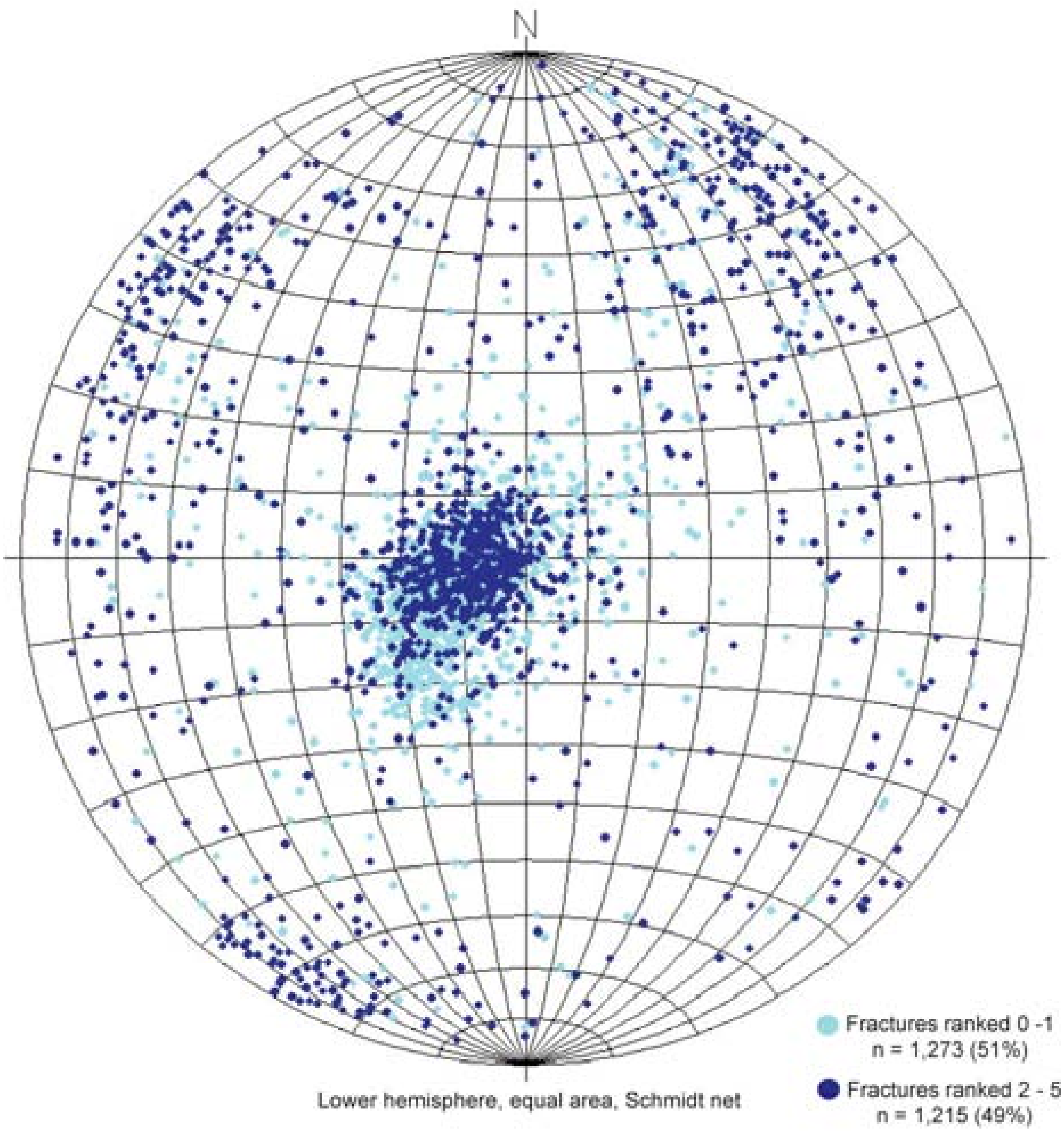


Figure 15
Stereonet Plot of All Fractures Identifed in SPE Drill Holes

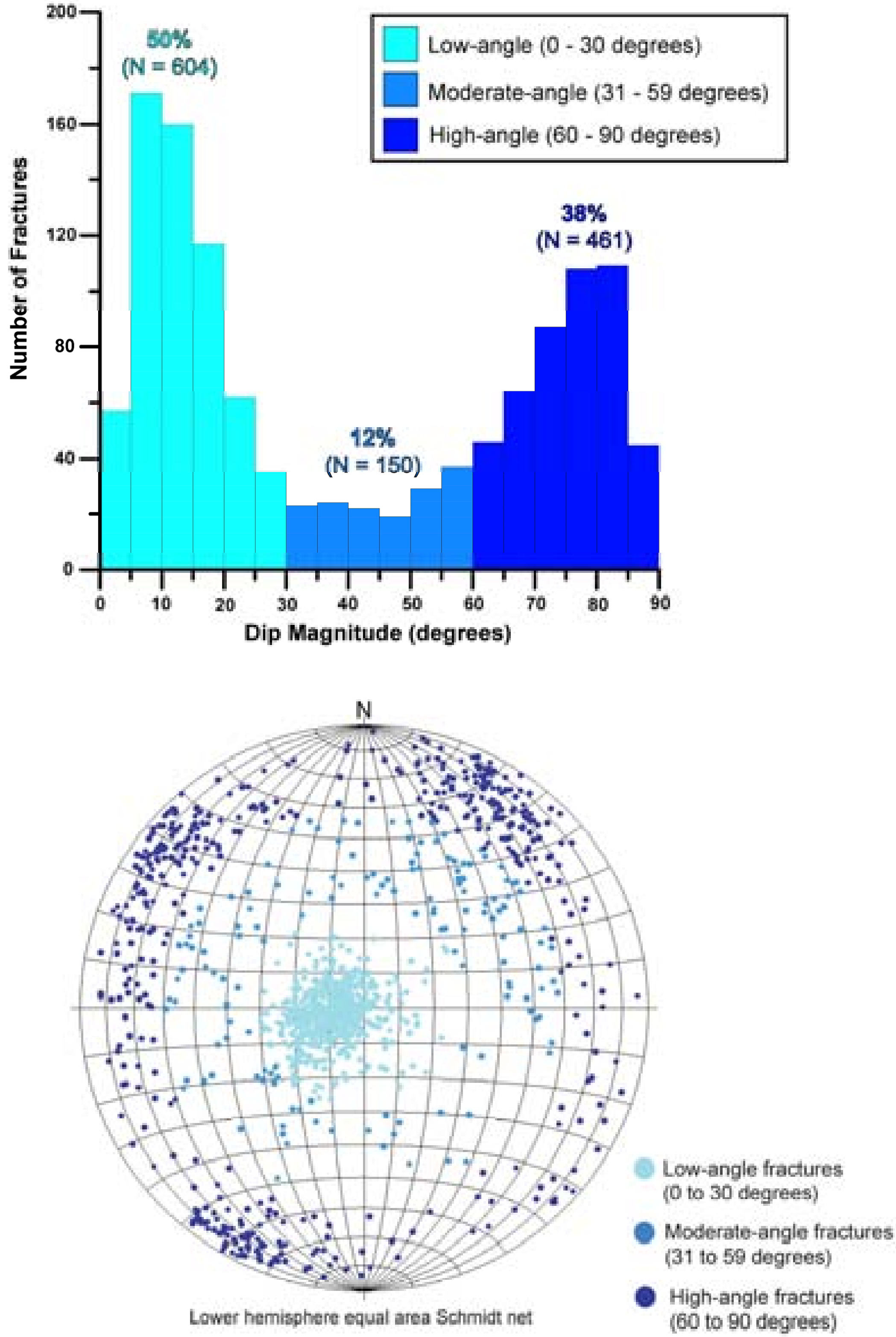


Figure 16
Dip Magnitude Histogram (top) and Stereonet Plot of Fractures with Rankings 2 through 5 Identified by Colog in the SPE Drill Holes

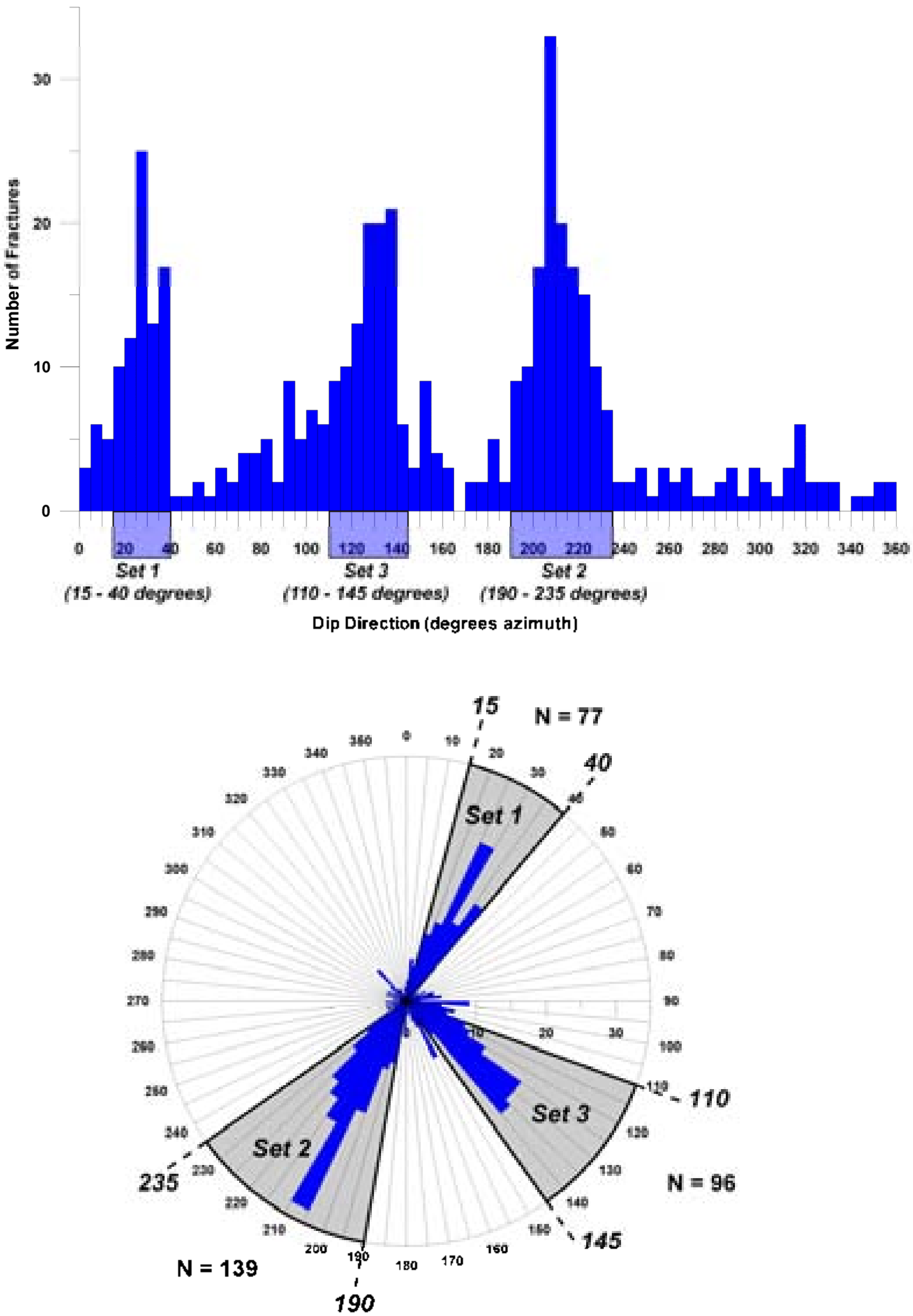


Figure 17
Dip Direction Histogram (top) and Rose Diagram (bottom) of High-Angle Fractures in All SPE Drill Holes, Showing the Three Main High-Angle Fracture Sets Identified by Dip Direction
(from the collection of fractures with dip >60 degrees and rankings 2–5 identified by Colog)

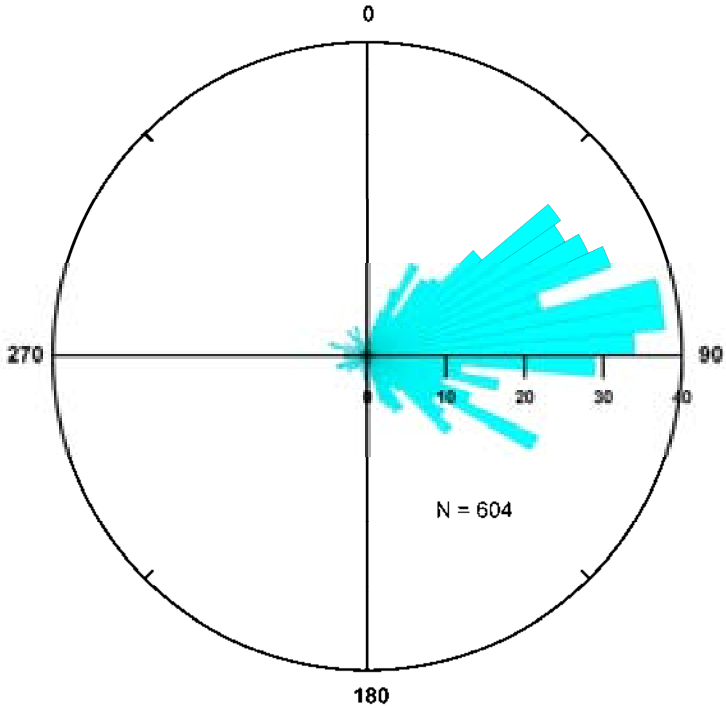


Figure 18
Dip Direction Rose Diagram of Low-Angle Fractures in All SPE Drill Holes
(from the collection of fractures with dips of 0–30 degrees and rankings 2–5 identified by Colog)

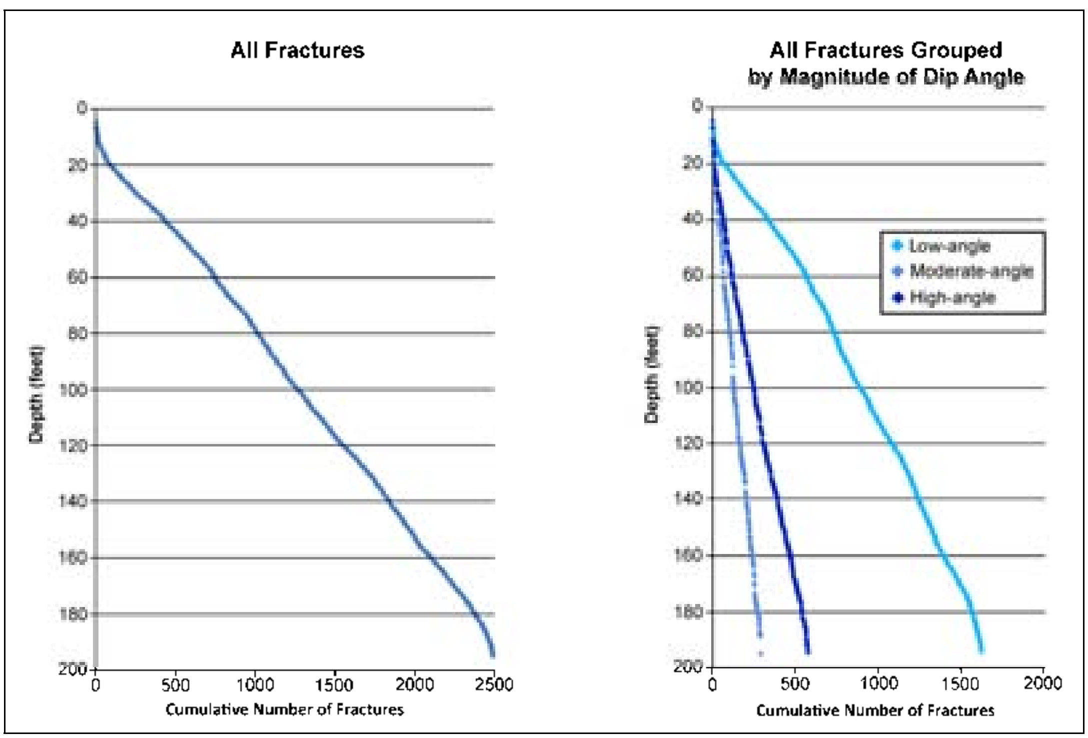


Figure 19
Plots of Cumulative Number of Fractures versus Depth for the SPE Site
(all fractures, all holes)

4.2.3 Discussion

The four main fracture sets described above are observed in all holes across the SPE site (Figures 20 and 21). These same fracture sets are also observed in outcrops near the SPE site (Figures 22 and 23). Houser and Poole (1960) produced a detailed surface geologic map of the Climax stock area including locations and orientations of prominent fracture sets observed in granitic outcrops (Figure 24). Houser and Poole (1960) recorded the orientations of 365 sets of fractures at 135 outcrops. These outcrops are located throughout the exposed portions of the stock, and include exposures of both granodiorite and quartz monzonite. It is important to note that Houser and Poole (1960) recorded the orientations of fracture sets at each outcrop location, and thus, each fracture set orientation likely represents the average orientation of multiple fractures with similar orientations. NSTec digitized each fracture set symbol on the map of Houser and Poole (1960) and recorded the strike, dip magnitude and direction, and associated lithology for each mapped fracture set.

Analysis of the surface fracture set data from Houser and Poole (1960) indicates some general similarities with fracture orientations observed in SPE drill holes. Like the fractures observed in the SPE holes, more than 80 percent of the surface fracture sets fall into either a low-angle group dipping from 0 to 30 degrees, or a high-angle group dipping from 60 to 90 degrees (Figure 25). The low-angle group is dominated by northeast-dipping fracture sets similar to the low-angle fractures observed in the SPE holes (Figure 26). The high-angle surface fracture sets show considerably more variability in orientation than the high-angle fractures observed in the SPE holes. However, both data sets show a similar approximately orthogonal pattern defined by northwest-southeast–striking and northeast-southwest–striking fractures (Figure 27). This same orthogonal pattern is observed in fractures from tunnels within the granite (Borg, 1970; Maldonado, 1977; Merritt, 2003; Appendix F in Pohlmann et al., 2007) (Figure 28). This fracture pattern appears to be independent of lithology (Figure 29).

In an effort to determine if one of the identified high-angle fracture sets is more prominent than the rest, we compared the number of fractures tabulated per set (from borehole image logs) and compared the percentage of higher-ranked features among the sets. Sets 1 and 2 (which might be considered part of one east-west–striking set with opposite dip directions) each have more higher-ranked features than Set 3. Sets 1 and 2 also include the two faults encountered in the core hole and Source Hole. However, based on the present-day minimum horizontal stress direction for this region of N50°W (Ander, 1984), fractures of Set 3, which have an average strike of northeast-southwest (parallel to the Boundary fault), are likely in a state of tension compared to fractures with northwest-southeast strikes, which may be in compression. It should be noted, however, that this discussion refers to regional stress regimes, and does not consider local stress conditions at the SPE site.

Two prominent fault zones were observed in the core samples from U-15n. The fault encountered at a depth of 25.3 m (83 ft) dips 80 degrees to the north-northeast (15 degrees azimuth), and thus is related to SPE Set-1 fractures. The fault encountered at 32.3 m (106 ft) dips 79 degrees to the south-southwest (205 degrees azimuth) and is related to SPE Set-2 fractures. Additional information regarding these faults is provided in Section 4.1.3 and in NSTec (2011a,) reproduced in Appendix I.

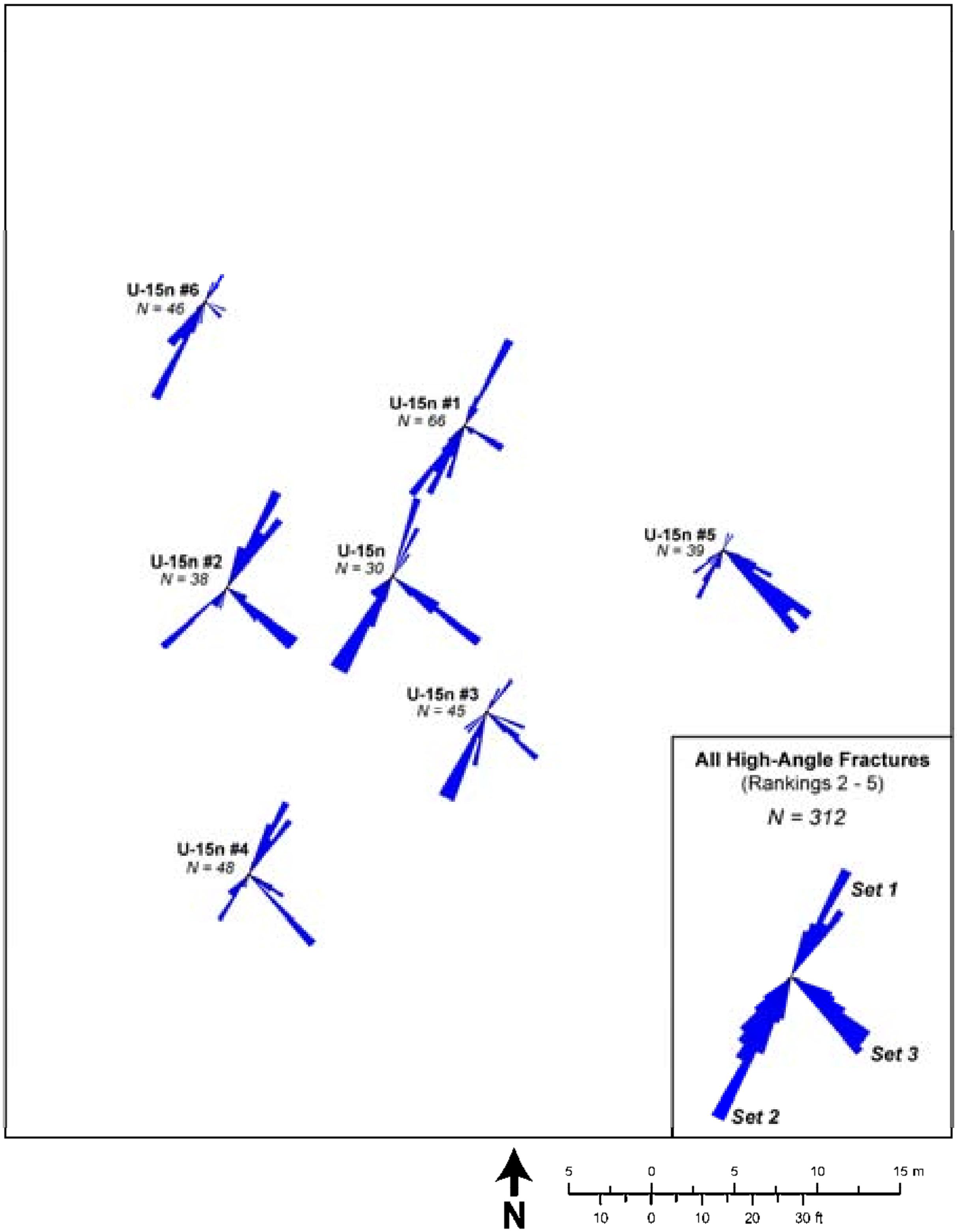


Figure 20
Rose Diagram Map of the SPE Site Showing Dip Directions of the Three Main High-Angle Fracture Sets (Rankings 2–5) in each of the Seven Holes

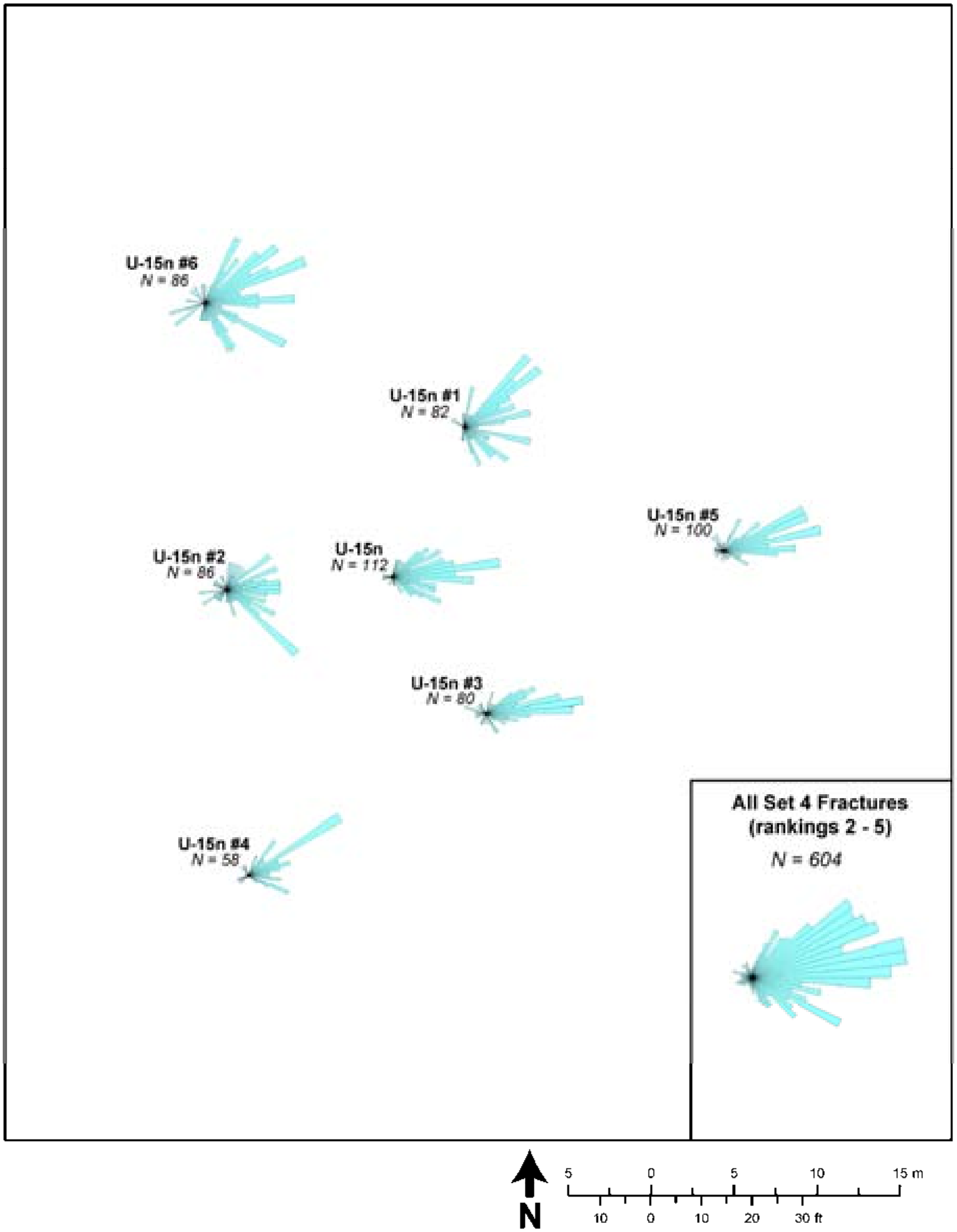
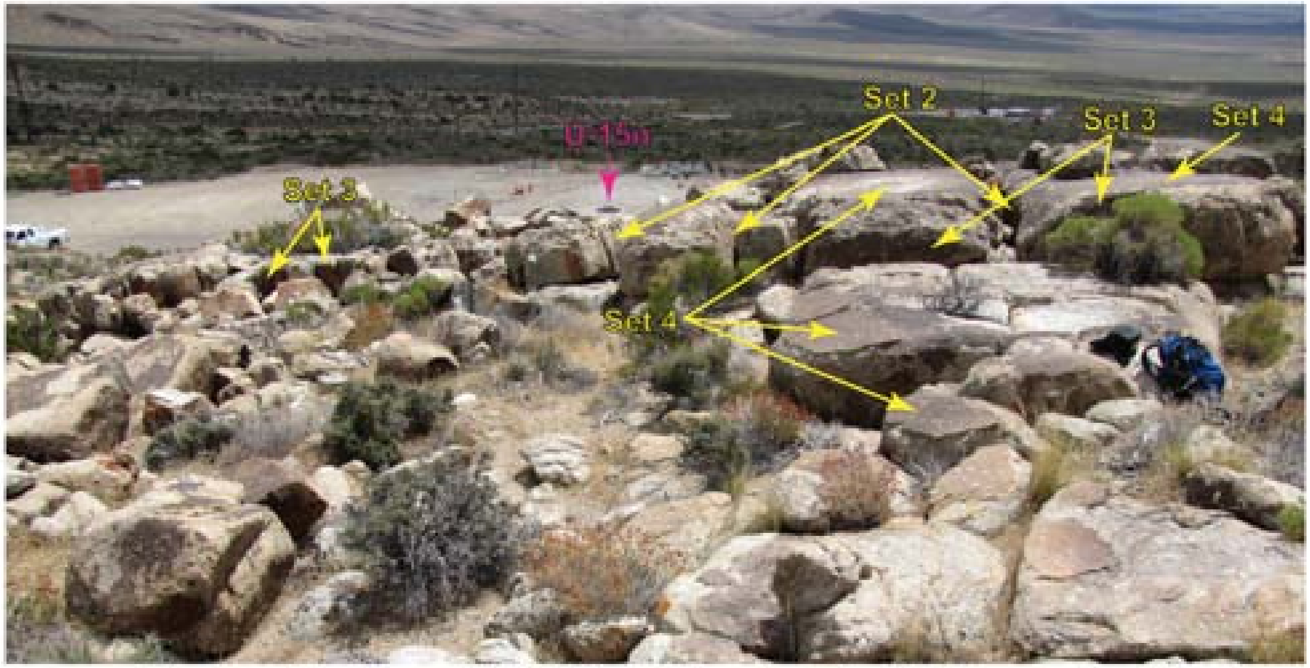
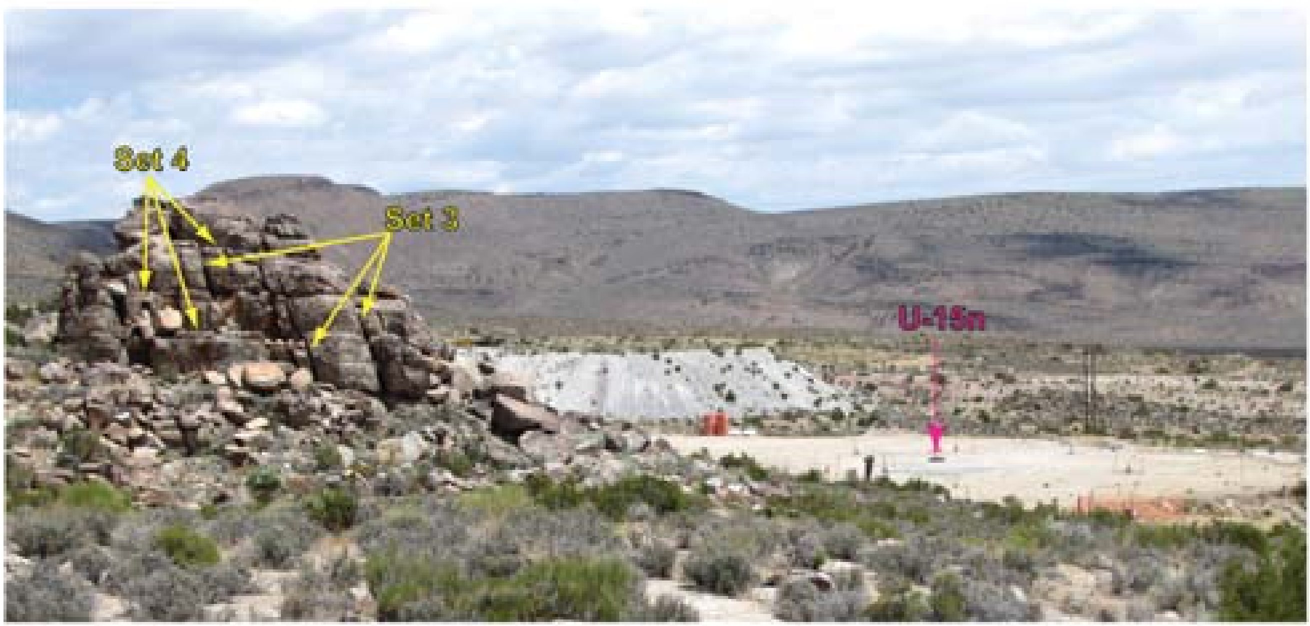


Figure 21
Rose Diagram Map of the SPE Site Showing the Dip Directions of Set 4 (Low-Angle) Fractures in each of the Seven Holes



View is southeast across the SPE site and along the strike of fracture sets 1 and 2.



View is northeast and approximately along the strike of fracture set 3.

Figure 22
Photographs of Fractures Exposed West of the SPE Drill Pad

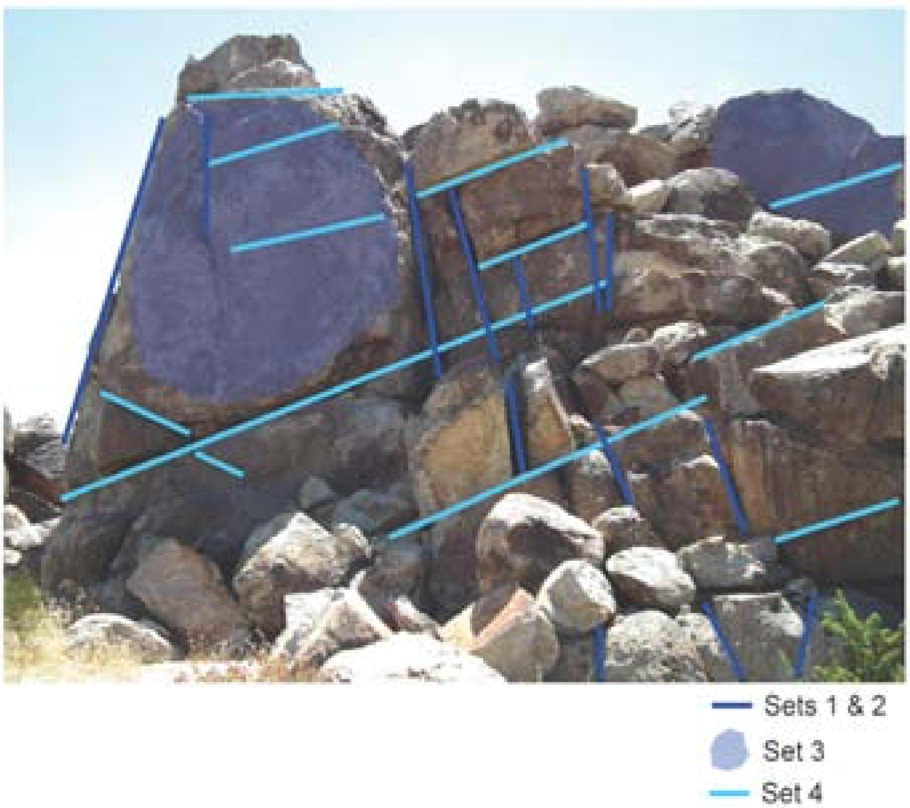


Figure 23
Photograph of Quartz Monzonite Exposure West of the SPE Site Showing Fracture Sets

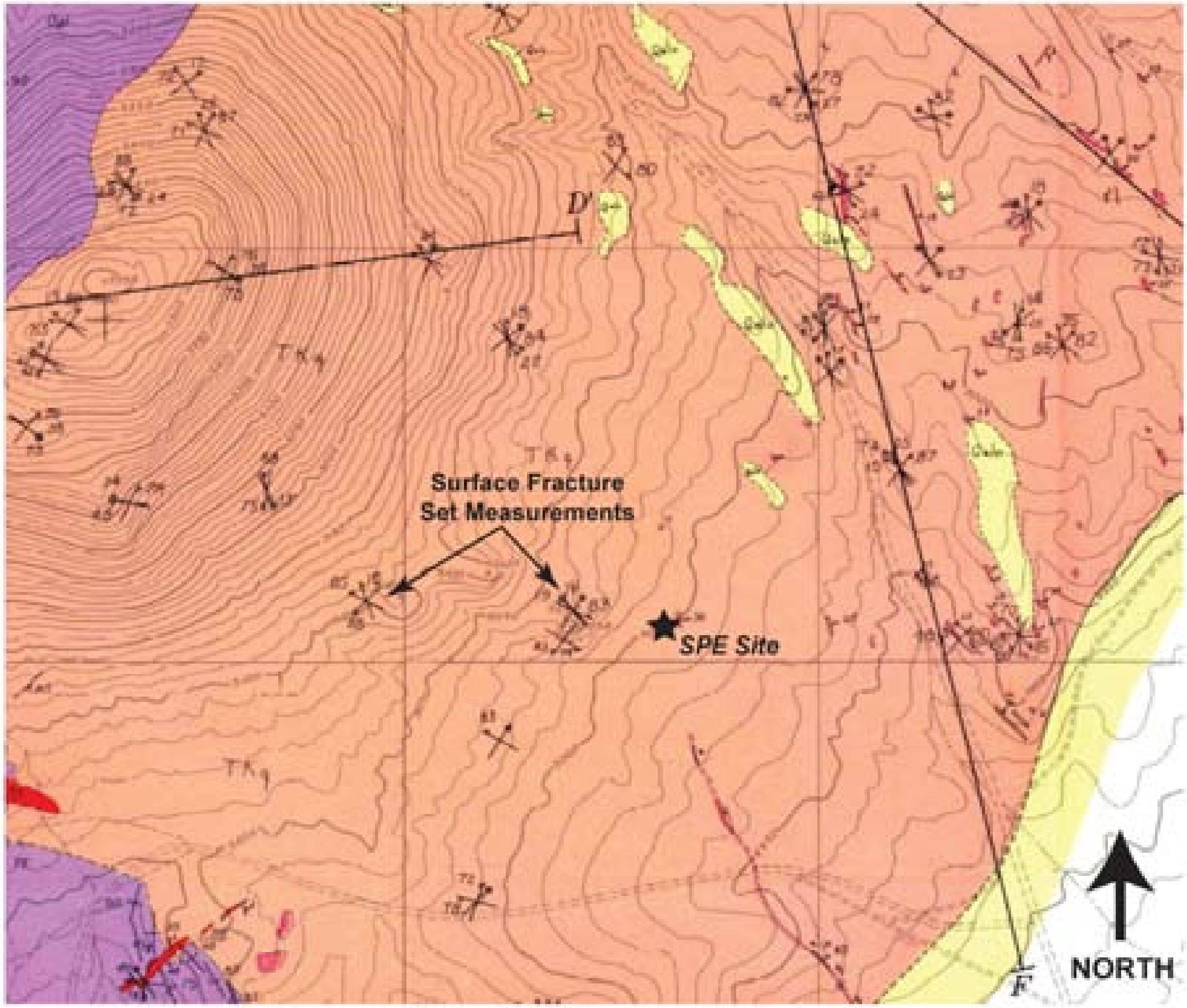


Figure 24
Portion of the Surface Geologic Map of the Climax Stock (Houser and Poole, 1960)
Showing Locations of the SPE Site and Nearby Fracture Set Measurements
See full Houser and Poole (1969) map with legend in Plate 1.

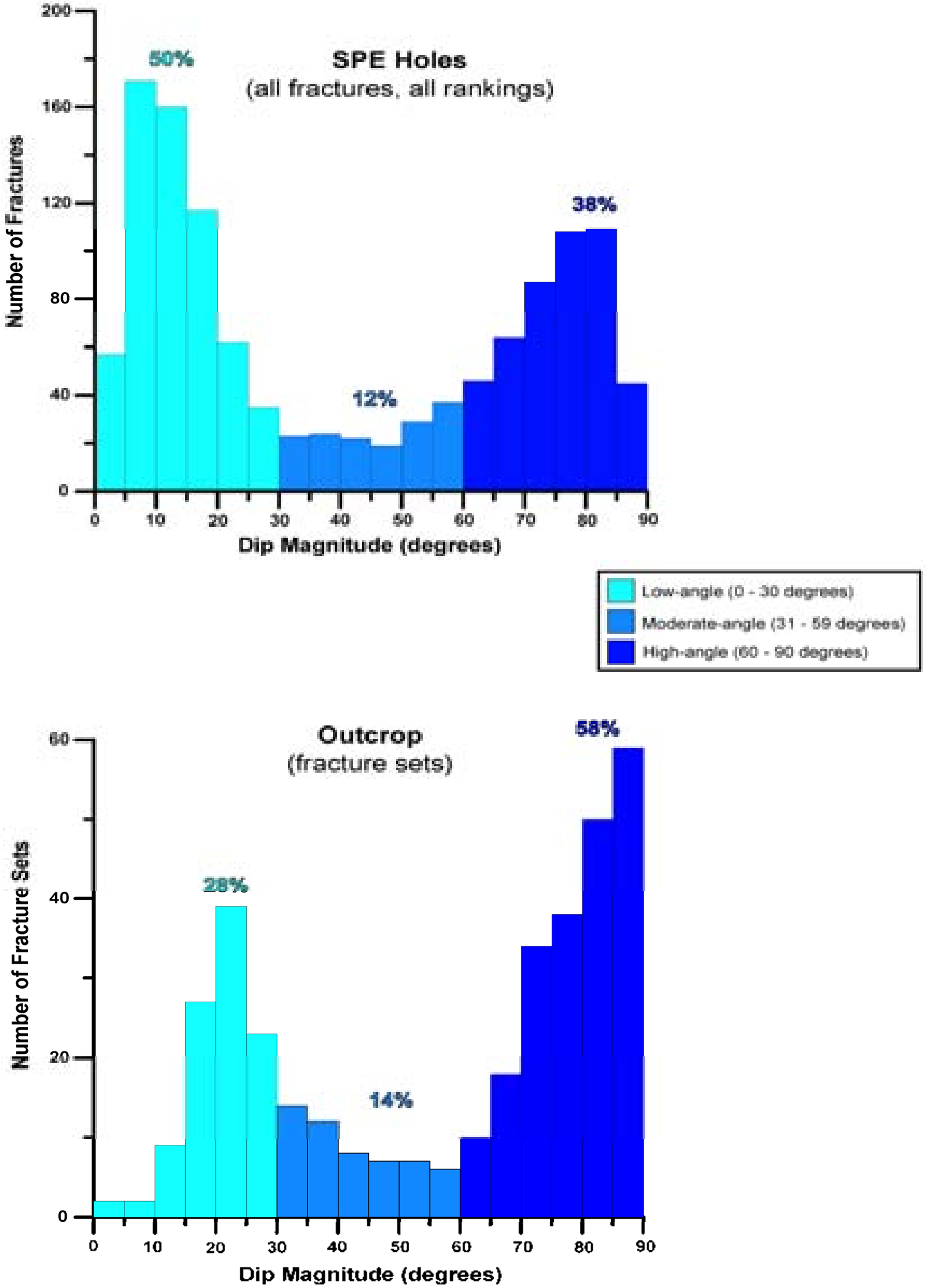
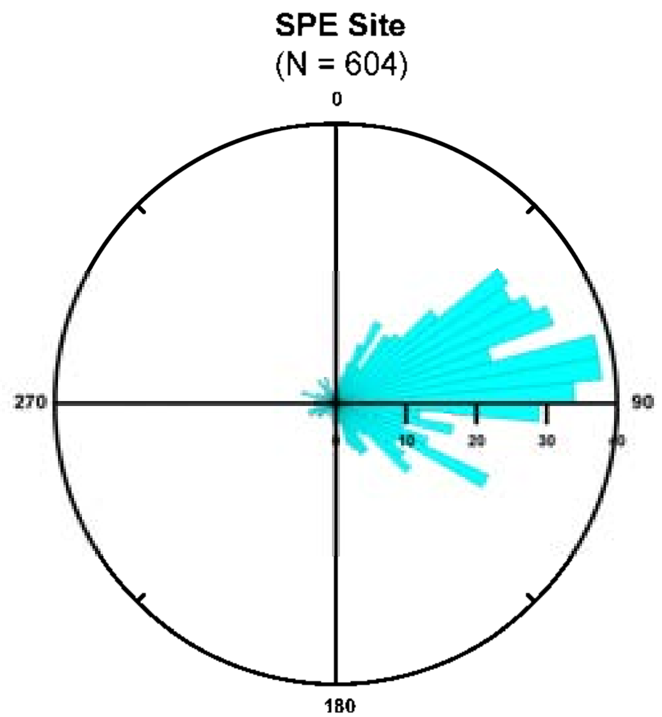


Figure 25
Dip Magnitude Histograms Comparing Fractures Observed in SPE Drill Holes with Fracture Sets Observed in Outcrop



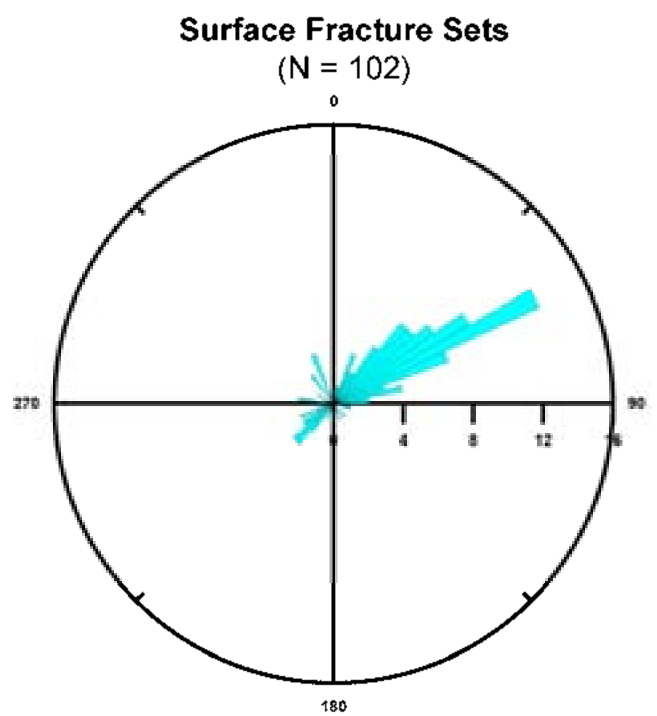


Figure 26
Dip Direction Rose Diagrams Comparing Low-Angle Fractures Identified at the SPE Site with Low-Angle Fracture Sets Observed in Outcrop
(0–30 degrees dip, rankings 2–5)

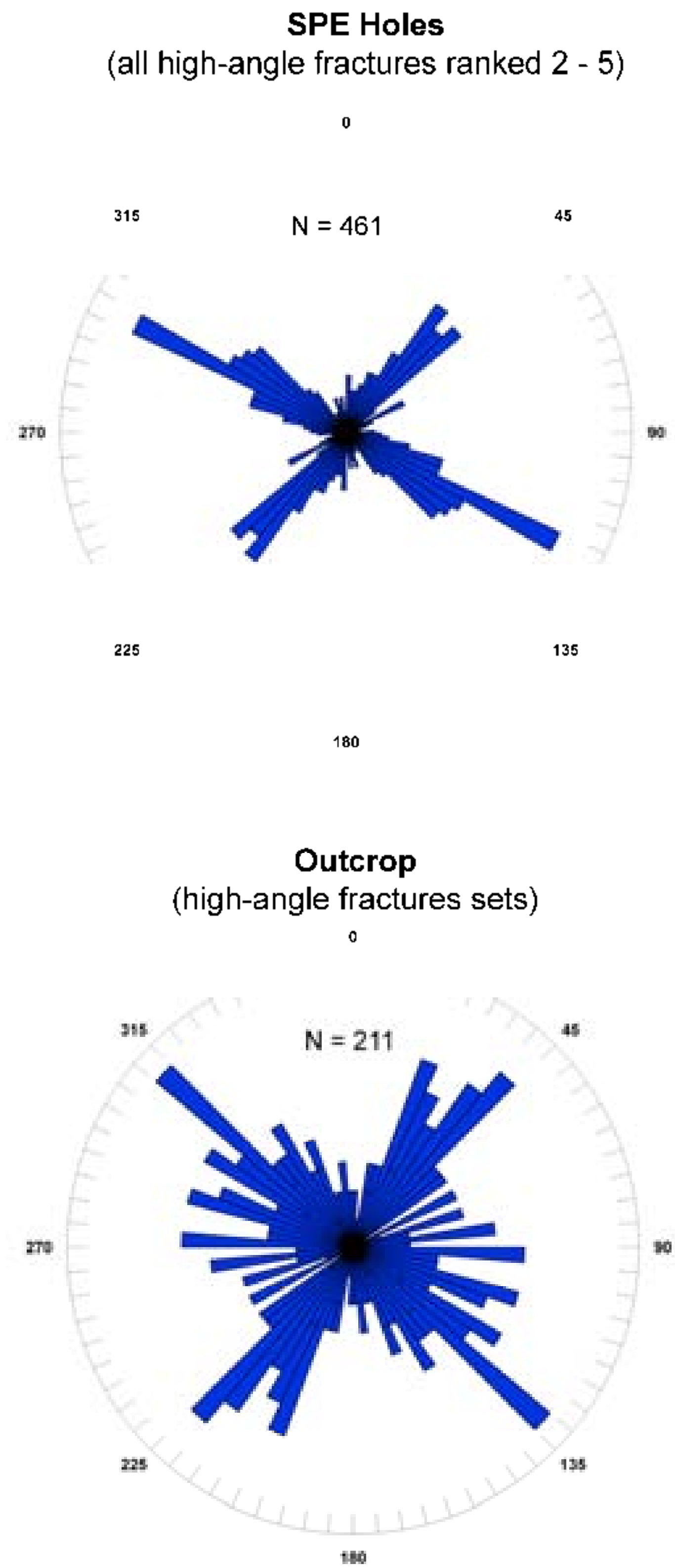


Figure 27
Bi-Directional Rose Diagrams Comparing the Strikes of High-Angle Fractures Observed within SPE Holes with High-Angle Fracture Sets Observed in Outcrop

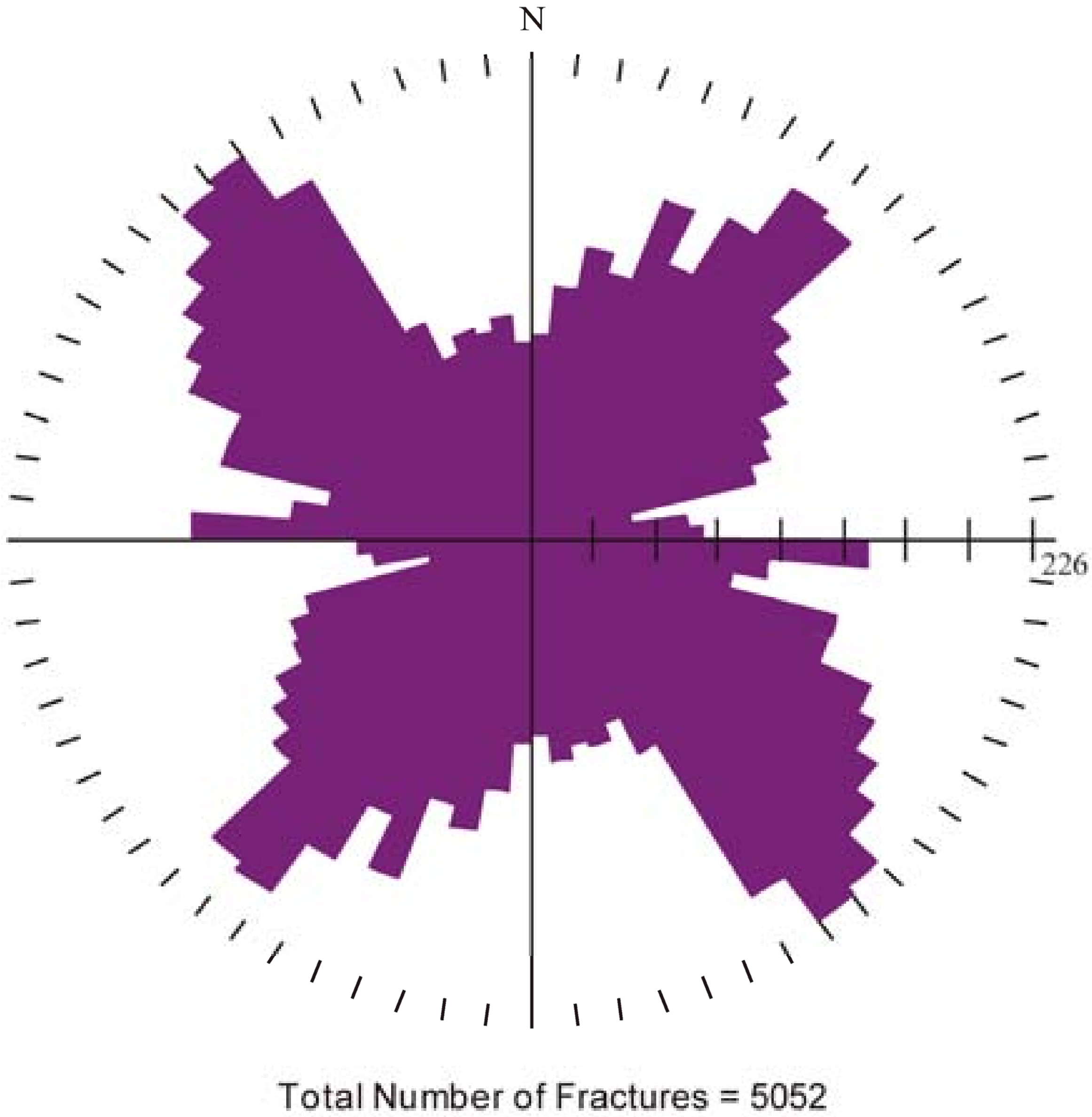


Figure 28
Bi-Directional Rose Diagram of the Strikes of Fractures Observed in the Tunnel Workings at Climax Stock
(data from Pohlmann et al., 2007)

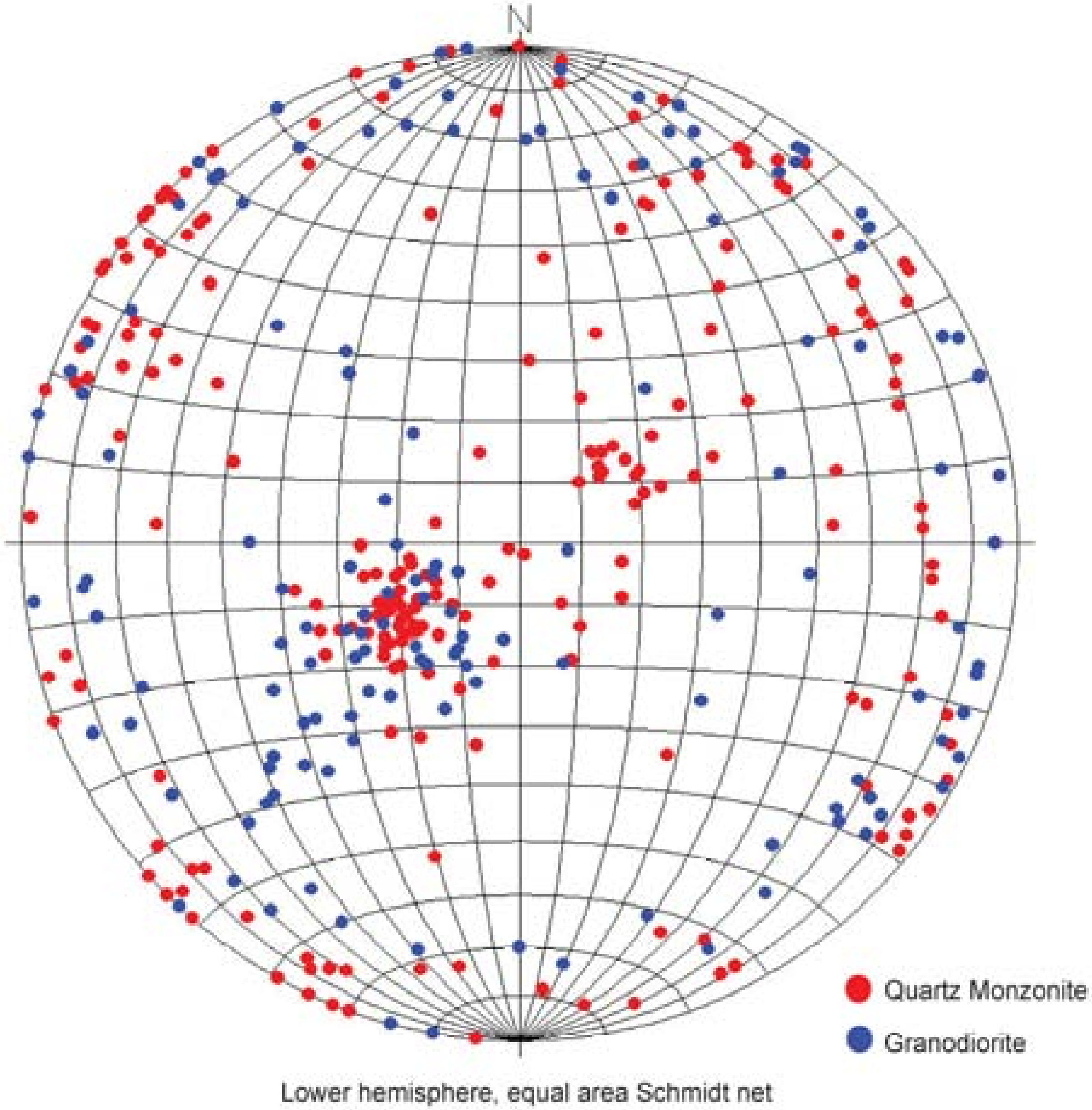


Figure 29
Stereonet Diagram of the Orientations of Surface Fracture Sets Plotted with Respect to Lithology

As mentioned previously, evaluation of fracture ranks alone may not indicate the presence of significant fault zones, but such zones might be indicated by clusters of fractures. Figure 30 shows a histogram of high-angle fractures (all ranks) per 1-ft interval in the U-15n Core Hole, based on the Colog image log data. Higher numbers of fractures are associated with both of the fault zones at 25.3 and 32.3 m (83 and 106 ft), and both zones have conspicuous intervals of lower density and velocity on borehole geophysical logs. An interval around the depth of 51.5 m (169 ft) also stands out on Figure 26, though the core in this zone does not appear to be as significantly altered as the two main fault zones. Two of the fractures in this interval, at the depths of 51.1 and 51.5 m (167.6 and 168.9 ft), have ranks of 4; all the rest are ranked 3 or less. This zone is not strongly indicated on the density log; however, the sonic log does show an area of slightly lower velocity in the interval compared to the rocks above and below the interval. A lesser cluster of fractures is apparent near the depth of 47.2 m (155 ft), and one fracture at the depth of 47.3 m (155.3 ft) has a rank of 5 (but no others have ranks greater than 3). In this interval the density log shows a short but distinctive interval of lower density, and the sonic log shows a short interval of lower velocity. The fractures in both of these intervals belong mainly to Fracture Set 2.

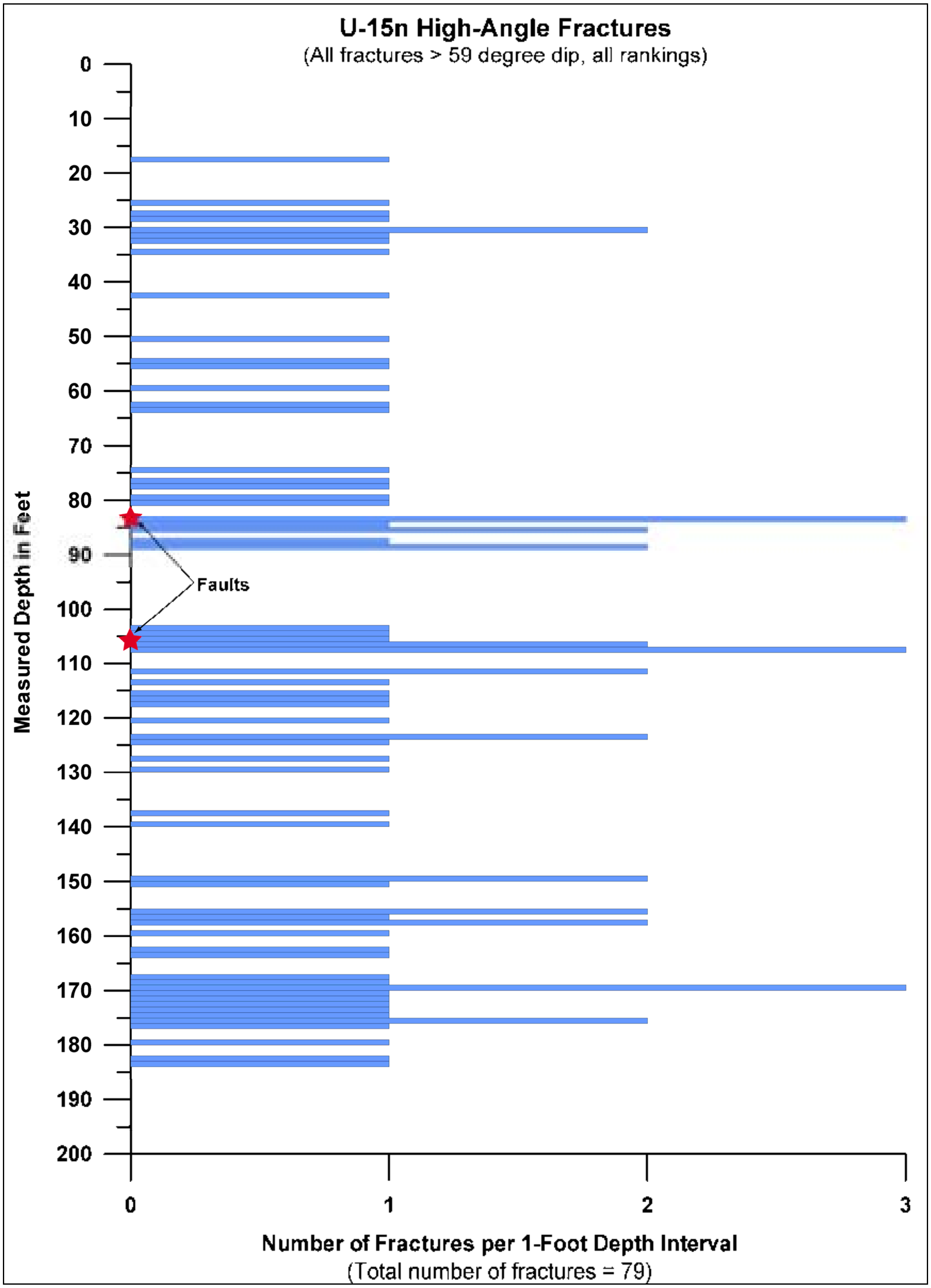


Figure 30
Plot of Number of High-Angle Fractures per Foot in Core Hole U-15n

4.3 Groundwater

The granitic rock matrix at the Climax stock is essentially impervious to groundwater, so the presence and movement of groundwater in the Climax stock is controlled by fractures, faults, topography, and local recharge. The hydrology of the Climax stock area is discussed in Murray (1981).

Occurrences of groundwater were discussed in Orkild et al. (1983), with the conclusion that shallow depths (less than about 305 m [1,000 ft]) are "almost devoid of groundwater," and that groundwater occurs only locally in perched small volumes. Some holes drilled in support of the UGTs conducted at Climax stock are reported to have perched water at depths ranging from 25.0 to 207.9 m (82 to 682 ft), while others were dry (Orkild et al., 1983). Cording (1967) noted that dripping water was observed in only one location in the workings for the U15e TINY TOT test. This water dripped from one of the high-angle fault systems encountered in the drifts, located approximately 122 m (400 ft) below ground surface. In the present investigation, at least a moderate amount of groundwater was found in boreholes drilled at the SPE site, where the maximum depth of the first seven holes was 60.6 m (199 ft).

The presence of large amounts of water in the SPE test bed was not expected, and caused complications during drilling and installation of instrumentation. Measurements of groundwater levels in the open holes at the SPE site were made starting in December 2010, and continuing through April 14, 2011. This section provides information and discussion about the groundwater at the SPE site.

Only one deep borehole remains open in the Climax stock in which water level tags are routinely made. The USGS measures water levels quarterly in Well U-15k, located approximately 975 m (3,200 ft) northeast of the SPE site (Figure 5). The well was pumped nearly dry in 2000, and the water level has been steadily rising from the depth of 239.9 m (787 ft) on October 26, 2000, to the most recent level of 215.8 m (708 ft) below ground surface, measured on June 27, 2011 (USGS, 2011).

4.3.1 Information about Groundwater at the SPE Site

Information relevant to the discussion of groundwater at the SPE site is listed below.

- When water was first encountered in the boreholes, samples were taken for chemical analysis to try to determine whether the fluid was from natural groundwater sources or was derived from the drilling fluid. The results indicated that the chemistry of the fluid in the boreholes was significantly different from that of the drilling fluid, and thus was likely natural groundwater (Townsend, 2010; attached as Appendix L).
- The four fracture sets present at the SPE site are described in Section 4.2.
- The geology mapped by Houser and Poole (1960) predates ground disturbances from the three UGTs conducted in the stock, and depicts numerous fractures, fracture sets, aplite dikes, and quartz veins. A northward-trending aplite dike/quartz vein was mapped as close as 30 m (100 ft) south of the drill pad and can be projected to pass through the drill pad (Figure 24). This dike/vein was not identified in the boreholes of the present study, but its presence could influence local fracture patterns and therefore the presence and movement of groundwater.

- The regional topography dips toward the southeast. Underlying groundwater gradients are typically similar to the overlying topography but can be altered by changes in groundwater recharge and by differential hydrologic permeability caused by faults and fractures.
- The physical process of rotary drilling while circulating an air-foam medium expels formation water and dewaters the borehole as effectively as a pump. The response of groundwater to dewatering, and its recovery when dewatering ceases, can reveal characteristics of the aquifer. In addition, the drill sump may be recharging the local groundwater with purged formation water.
- The groundwater behavior described in this section reflects observations made in open boreholes drilled for the present investigation. It is difficult to determine the nature and movement of local groundwater that existed prior to drilling, and after stemming, because the physical act of drilling and subsequent stemming has altered the groundwater environment.

4.3.2 Description of Investigation

As described in Section 1.2 and Appendix B, the SPE test bed consists of seven boreholes approximately 58 m (190 ft) deep. The holes are located on a single drill pad that had been constructed on a gently southeast-dipping slope, at an elevation of about 1,524 m (5,000 ft) (Figure 31). The central 36-in. diameter Source Hole was drilled intermittently between August 5, 2010, and March 25, 2011. The six 8-in. diameter instrument holes were drilled in two rings around the Source Hole at 10 and 20 m (33 and 66 ft) from the Source Hole in August and September 2010. Instrument Hole U-15n#6 was not available for inspection after instruments were installed, and the hole was stemmed on September 28, 2010. Depth to water was measured intermittently in the remaining five instrument holes and Source Hole, beginning on December 23, 2010, and ending on April 14, 2011 (Table 4).

Depth to water was measured using an electric water level sounding tape. Groundwater elevations reported by NSTec previous to this report were measured from preliminary construction layout ground level elevations. Groundwater elevations presented in this report are measured from as-built survey elevations obtained from NSTec surveyors on May 26, 2011. For this reason, groundwater elevations for particular dates and times reported here may vary slightly from those previously reported.

4.3.3 Groundwater Measurements

In this section we describe a series of water-level measurements made in the SPE holes at various times during construction of the test bed. Each subsection includes a description of the site activities as relevant to water levels.

4.3.3.1 Prior to December 23, 2010—Site Idle and Rising Water

The original core hole reached a total depth (TD) of 59.7 m (196 ft) on July 28, 2010. The fluid level was measured the following day at a depth of 14.3 m (47 ft). The core hole was enlarged to a 36-in. diameter Source Hole to a temporary bottom depth of 34.1 m (112 ft) beginning on August 5, 2010, and ending on October 21, 2010. The 36-in. drill bit was left in the hole when the drill string was pulled out on October 27, 2010, and was retrieved on November 3, 2010.

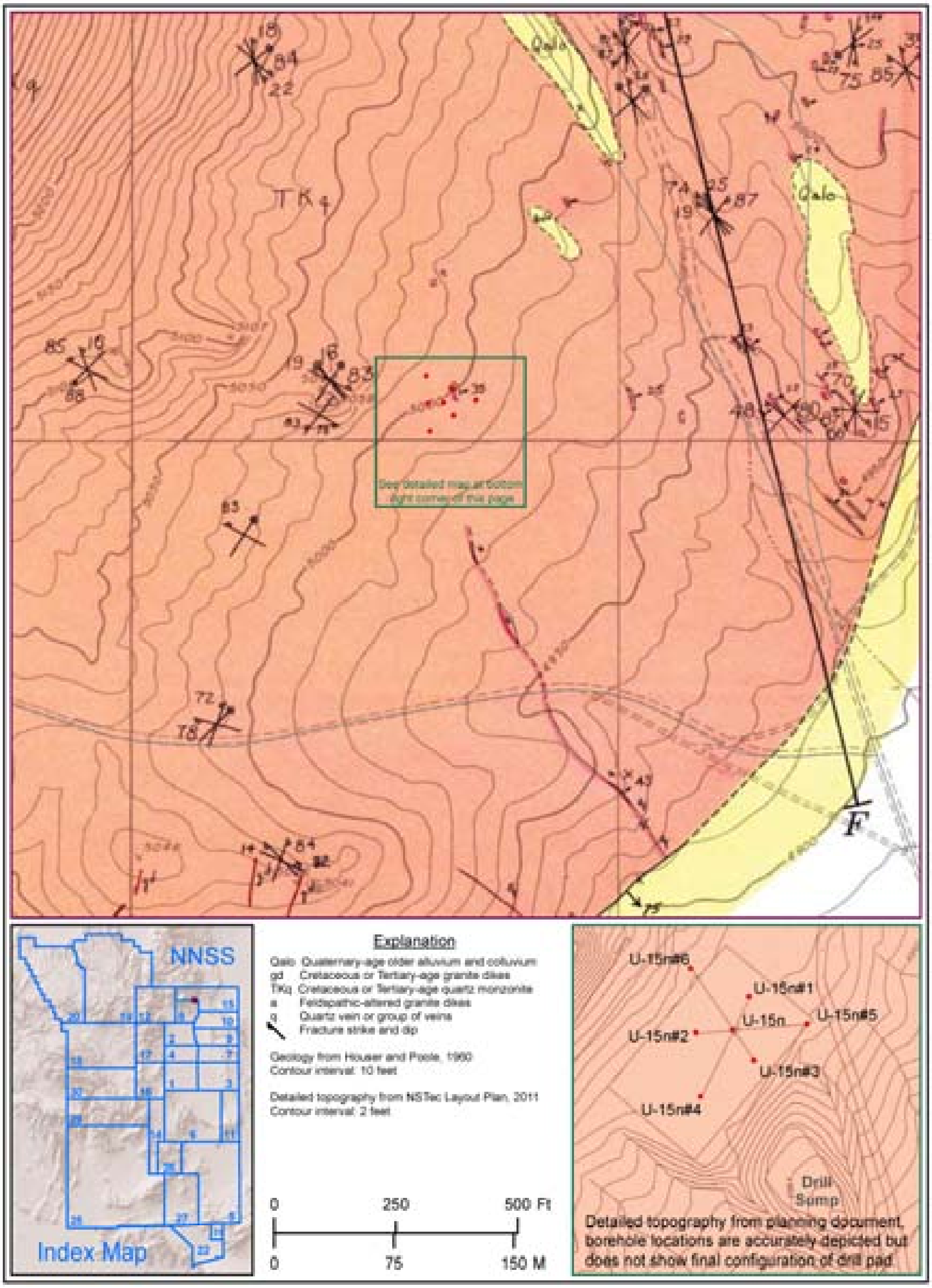


Figure 31
Portion of Geologic Map of Climax Stock (Houser and Poole, 1960) Showing Location of SPE Site

Table 4
Fluid-Level Measurements Made in SPE Drill Holes from December 2010 through April 2011

Date	Time	Baro Pres mb	U-15n (36")			U-15n #1			U-15n #2			U-15n #3			U-15n #4			U-15n #5		
			TOC Elevation		5002.37	TOC Elevation		5002.60	TOC Elevation		5002.81	TOC Elevation		5002.18	TOC Elevation		5002.29	TOC Elevation		5001.94
			Time	DTW	GW Elev	Time	DTW	GW Elev	Time	DTW	GW Elev	Time	DTW	GW Elev	Time	DTW	GW Elev	Time	DTW	GW Elev
12/23/10	7:15	867.6	9:10	59.89	4944.54	9:05	58.05	4944.55	9:00	57.69	4945.12	8:50	57.57	4944.61	8:55	58.77	4943.52	8:41	57.35	4944.59
12/23/10			15:25	59.89	4944.54	15:20	58.06	4944.54	15:19	57.72	4945.09	15:15	57.60	4944.58	15:17	58.80	4943.49	15:10	57.37	4944.57
12/28/10			8:29	59.89	4944.54	8:17	57.78	4944.82	8:27	57.69	4945.12	8:22	57.42	4944.76	8:24	58.76	4943.53	8:20	57.17	4944.77
12/28/10	15:45	862.9	16:06	59.87	4944.56	15:45	57.76	4944.84	15:59	57.78	4945.03	15:54	57.38	4944.80	15:57	58.75	4943.54	15:39	57.10	4944.84
01/06/11	7:00	874.4	8:58	59.38	4945.05	8:45	56.54	4946.06	8:56	56.61	4946.20	8:50	56.24	4945.94	8:53	57.65	4944.64	8:47	55.92	4946.02
01/06/11			15:19	59.35	4945.08	15:07	56.47	4946.13	15:17	56.57	4946.24	15:13	56.19	4945.99	15:15	57.61	4944.68	15:10	55.85	4946.09
01/19/11	11:00	864.9	11:12	56.30	4948.13	10:59	53.33	4949.27	11:10	53.88	4948.93	11:05	51.65	4950.53	11:07	55.25	4947.04	11:02	52.71	4949.23
01/26/11	13:30	874.0	13:35	54.00	4950.43	13:23	51.65	4950.95	13:32	52.30	4950.51	13:28	49.93	4952.25	13:30	53.93	4948.36	13:25	51.04	4950.90
01/26/11	14:30	873.7	14:37	53.98	4950.45	14:24	51.63	4950.97	14:35	52.28	4950.53	14:30	49.98	4952.20	14:33	53.91	4948.38	14:26	51.02	4950.92
01/27/11	13:45	872.7	13:49	53.70	4950.73	13:37	51.35	4951.25	13:47	52.07	4950.74	13:42	49.66	4952.52	13:45	53.68	4948.61	13:40	50.74	4951.20
02/03/11	9:45	877.4	9:49	51.81	4952.62	9:40	49.95	4952.65	9:47	50.48	4952.33	9:44	48.34	4953.84	9:45	52.34	4949.95	9:42	49.27	4952.67
02/09/11	9:00	872.7	8:18	50.09	4954.34	8:21	49.00	4953.60	8:33	49.12	4953.69	8:26	47.62	4954.56	8:29	51.20	4951.09	8:24	48.39	4953.55
02/09/11						9:30	48.97	4953.63	9:43	49.11	4953.70	9:37	47.52	4954.66	9:40	51.24	4951.05	9:34	48.37	4953.57
02/11/11	8:30	874.4	8:25	60.30	4944.13	8:29	51.10	4951.50	8:22	50.65	4952.16	8:37	51.85	4950.33	8:41	51.80	4950.49	8:32	50.47	4951.47
02/11/11	9:45	875.0	9:53	70.65	4933.78	9:45	51.18	4951.42	9:56	50.65	4952.16	10:05	53.19	4948.99	10:02	51.82	4950.47	10:07	50.62	4951.32
02/11/11	10:45	874.7	10:48	76.89	4927.54	10:57	51.47	4951.13	10:43	50.79	4952.02	10:57	54.29	4947.89	10:54	51.85	4950.44	11:00	50.88	4951.06
02/11/11	11:45	874.4	11:50	88.09	4916.34	11:54	51.89	4950.71	11:45	50.89	4951.92	12:00	55.55	4946.63	11:57	51.89	4950.40	12:04	51.30	4950.64
02/11/11	13:00	873.7	13:14	100.80	4903.63	12:58	52.42	4950.18	12:45	51.01	4951.80	12:53	56.58	4945.60	12:49	51.93	4950.36	12:55	51.72	4950.22
02/11/11	14:00	873.7	14:25	100.30	4904.13	14:00	52.97	4949.63	13:48	51.18	4951.63	13:53	57.60	4944.58	13:50	52.01	4950.28	13:56	52.23	4949.71
02/11/11	15:00	873.4				15:02	53.35	4949.25	14:48	51.30	4951.51	14:55	58.12	4944.06	14:52	52.10	4950.19	14:58	52.65	4949.29
02/11/11	16:00	873.4				15:59	53.66	4948.94	15:45	51.50	4951.31	15:52	58.66	4943.52	15:49	52.20	4950.09	15:56	52.97	4948.97
02/14/11	9:00	867.6	7:30	85.00	4919.43	8:59	54.73	4947.87	9:03	54.81	4948.00	9:11	59.41	4942.77	9:07	53.47	4948.82	9:15	54.06	4947.88
02/17/11	9:00	863.2	9:00	77.32	4927.11	8:48	53.55	4949.05	8:56	54.18	4948.63	8:52	57.13	4945.05	8:54	52.94	4949.35	8:50	52.86	4949.08
02/22/11	11:45	864.5	11:46	68.99	4935.44	11:36	52.29	4950.31	11:44	52.99	4949.82	11:40	55.24	4946.94	11:42	52.35	4949.94	11:38	51.60	4950.34
02/23/11			8:00	71.00	4933.43															
02/24/11	8:30	865.2	8:20	91.56	4912.87	8:22	55.03	4947.57	8:31	54.06	4948.75	8:27	61.52	4940.66	8:29	53.07	4949.22	8:24	54.33	4947.61
02/24/11	12:00	864.9	11:58	113.34	4891.09	11:55	55.45	4947.15	12:08	54.28	4948.53	12:04	63.63	4938.55	12:06	53.20	4949.09	12:00	54.82	4947.12
02/24/11	12:15	864.5	12:11	113.25	4891.18															
02/24/11	13:00	863.9	12:55	112.98	4891.45															
02/25/11			12:00	105.00	4899.43															
02/28/11			8:00	77.00	4927.43															
03/01/11						8:53	52.87	4949.73	9:04	54.16	4948.65	8:58	56.13	4946.05	9:00	52.70	4949.59	8:55	52.20	4949.74
03/09/11	9:00	875.7				10:08	56.89	4945.71	10:19	56.98	4945.83	10:14	64.61	4937.57	10:16	54.12	4948.17	10:11	56.17	4945.77
03/09/11	15:45	874.0				15:40	56.73	4945.87	15:49	57.07	4945.74	15:45	64.35	4937.83	15:47	54.21	4948.08	15:42	56.07	4945.87
03/17/11	15:30	866.9				15:26	163.82	4838.78	15:40	73.36	4929.45	15:42	136.61	4865.57	15:37	120.57	4881.72	15:30	161.81	4840.13
03/21/11	10:15	856.1	9:55	79.31	4925.12	10:03	77.40	4925.20	10:07	68.31	4934.50	10:15	76.93	4925.25	10:11	73.30	4928.99	10:20	76.52	4925.42
03/22/11	14:45	864.5	14:28	150.00	4854.43	14:32	145.93	4856.67	14:39	69.83	4932.98	14:47	116.13	4886.05	14:43	105.90	4896.39	14:51	145.77	4856.17
03/30/11	10:30	873.4	10:10	189.00	4815.43	10:22	169.10	4833.50	10:28	96.47	4906.34				10:31	151.10	4851.19	10:42	166.78	4835.16
04/04/11	9:15	874.7	9:29	91.18	4913.25	9:15	84.05	4918.55	9:26	82.56	4920.25	9:20	81.75	4920.43	9:23	78.20	4924.09	9:18	83.16	4918.78
04/05/11	8:00	865.9	7:53	115.76	4886.61	7:57	114.31	4888.29	8:08	84.91	4917.90	8:03	115.00	4887.18	8:06	106.89	4895.40	8:00	113.10	4888.84
04/06/11	8:00	864.5	7:51	135.10	4867.27	7:56	133.38	4869.22	8:09	91.27	4911.54	8:03	134.54	4867.64	8:06	123.78	4878.51	7:59	132.05	4869.89
04/07/11	8:00	854.1	7:52	153.40	4848.97	7:55	150.67	4851.93	8:06	98.20	4904.61	8:01	152.62	4849.56	8:03	139.09	4863.20	7:58	148.96	4852.98
04/11/11	9:45	872.3	9:37	148.81	4853.56	9:44	143.52	4859.08	9:48	107.00	4895.81	9:55	143.09	4859.09	9:51	126.92	4875.37	9:59	142.89	4859.05
04/12/11	9:00	864.2	8:00	189.00	4813.37	8:51	166.23	4836.37	8:55	111.33	4891.48				9:00	151.71	4850.58	9:23	164.11	4837.83
04/13/11	8:30	861.2	8:00	149.00	4853.37	8:20	144.05	4858.55	8:24	114.63	4888.18	8:33	147.80	4854.38	8:28	137.18	4865.11	8:37	142.25	4859.69
04/14/11	8:45	873.7	8:00	115.00	4887.37	8:18	115.63	4886.97	8:22	114.12	4888.69	8:33	115.43	4886.75	8:30	99.72	4902.57	8:37	114.26	4887.68

Barometric pressure in millibars (mb) recorded from the NNSS Area 2 MEDA02 NOAA weather station.
Groundwater (GW) elevation in feet calculated by subtracting depth to water (DTW) from top of casing (TOC) elevation.

Associated drill bit retainer half-rings, however, were not retrieved until February 2011. On November 4, 2010, a 30-in. diameter mandrel was successfully lowered to the bottom of the 34.1-m (112-ft) deep, 36-in. diameter Source Hole (see Appendix B for more information on drilling of the Source Hole).

4.3.3.2 December 23, 2010, to February 9, 2011—Site Idle and Rising Water

As of December 23, 2010, the site had been idle for 7 weeks with the Source Hole open to its temporary bottom depth of 34.1 m (112 ft). The site was idle for another 7 weeks, during which water levels in all open boreholes were monitored and found to be slowly recovering from previous dewatering activities (drilling and pumping), rising from depths of about 18.3 m (60 ft) to about 15.2 m (50 ft).

Groundwater elevations for December 23 and 28, 2010, and January 6, 2011, reveal the following characteristics (Figure 32):

- Groundwater elevations in all boreholes were slowly rising (recovering from prior dewatering).
- Instrument Hole #2 had the highest groundwater elevation.
- The centrally located Source Hole U-15n and eastern Instrument Holes #1, #3, and #5 had similar intermediate groundwater elevations.
- Instrument Hole #4 had the lowest groundwater elevation.

The groundwater elevation contour maps shown for this time interval do not reveal a southeast-dipping water table surface, as was expected given the site topography. Instead, relatively high groundwater elevations in Instrument Holes #3 and #5 suggest a possible groundwater mound in the east half of the drill pad.

Groundwater elevations for January 19 and 26, and February 3 and 9, 2011, reveal the following characteristics (Figure 33):

- Groundwater elevations in all boreholes continued to slowly rise.
- Groundwater elevations in the central and eastern boreholes rose above the others, with groundwater elevation in Instrument Hole #3 being the highest despite being located on the southeast edge of the well field where groundwater elevations were expected to be the lowest.
- Instrument Hole #4 continued to exhibit the lowest groundwater elevation.

The groundwater elevation contour maps shown for this time interval reveal a groundwater mound forming in the middle of the southeastern edge of the well field. A possible source of the groundwater high is artificial groundwater recharge from the shallow trench and drill sump used for disposal of drill mud and purged formation water (Figure 31).

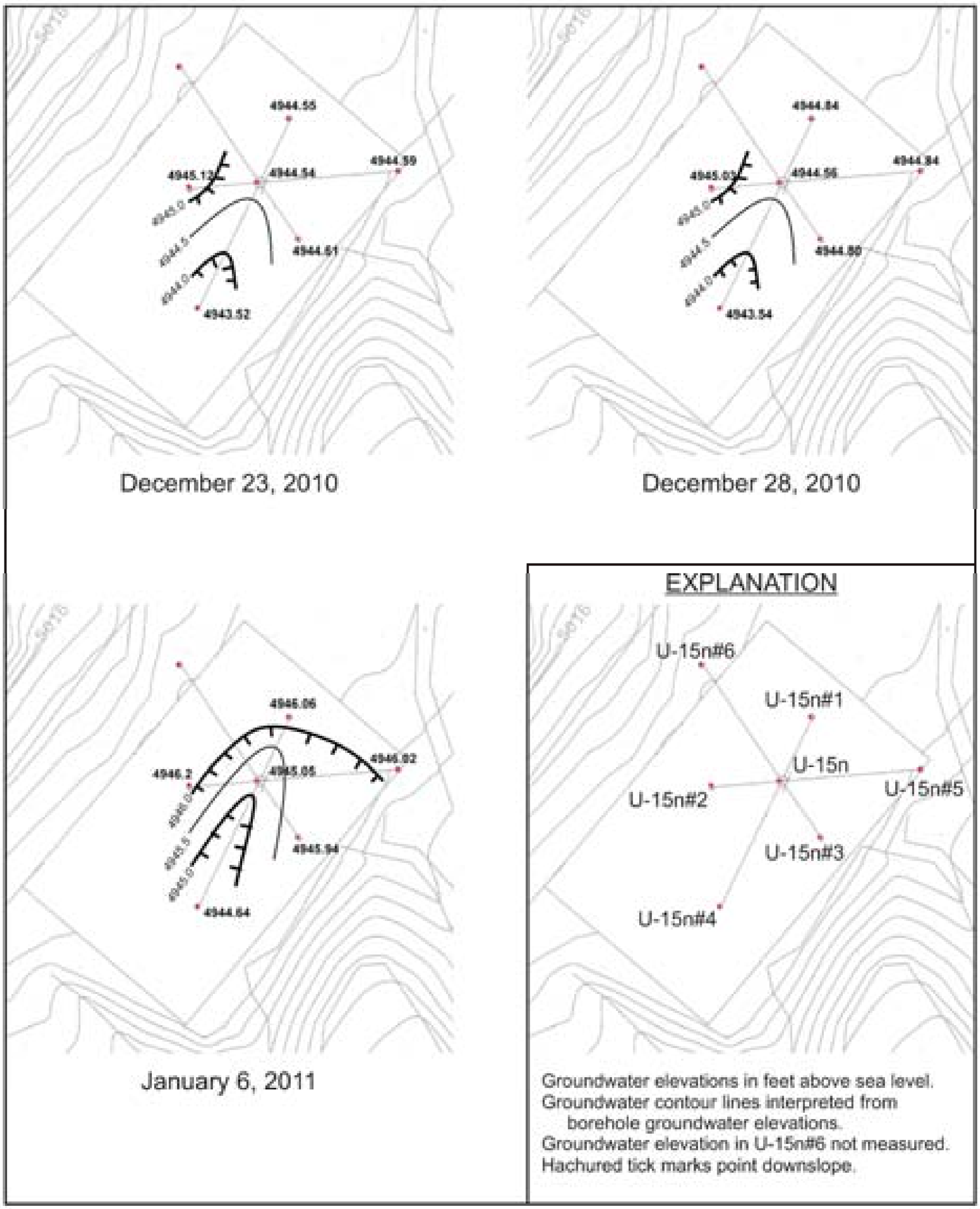


Figure 32
Groundwater Elevation Contour Maps for December 23 and 28, 2010, and January 6, 2011

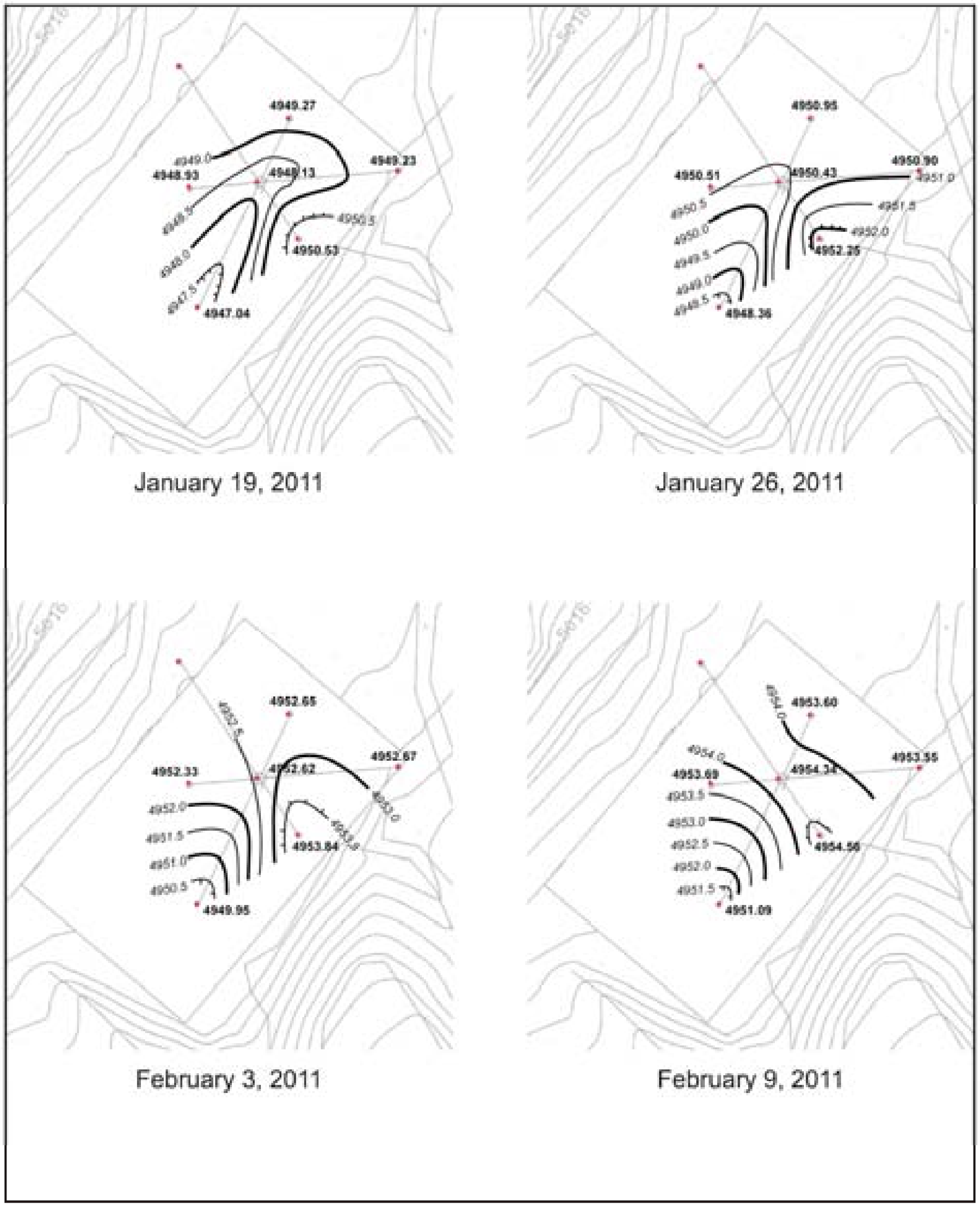


Figure 33
Groundwater Elevation Contour Maps for January 19 and 26, 2011, and February 3 and 9, 2011

4.3.3.3 February 10, 2011, to March 3, 2011—Dewater Source Hole

In mid-February 2011, efforts resumed to remove fill and to retrieve the lost retainer ring from the bottom of the Source Hole. By the end of February 2011, at least half the ring was recovered before cement was placed in the bottom of the hole. During this month, the Source Hole was dewatered twice for video logging and retrieval of the lost ring, first on February 11, 2011, then again on February 24, 2011.

Groundwater elevation contour maps for February 11, 17, and 24, 2011, reveal the following characteristics (Figure 34):

- The instrument holes were relatively slow to respond to the dewatering of the Source Hole, causing a cone of depression in the water levels centered on the Source Hole.
- Other than the Source Hole, Instrument Hole #3 consistently exhibited the lowest groundwater elevation during this time interval.
- No single instrument hole consistently exhibited the highest groundwater elevation during this time interval.
- By the end of this time interval, Instrument Hole #4 exhibited the highest groundwater elevation.

When the Source Hole, open to a depth of 34.1 m (112 ft), was dewatered, groundwater levels in the instrument holes displayed relatively minor responses. Instrument Hole #3, which, prior to this time interval had exhibited relatively high groundwater elevations, responded the fastest to dewatering of the Source Hole and now exhibited the lowest groundwater elevation of the instrument holes. Instrument Hole #4, which prior to this time interval had exhibited the lowest groundwater elevations, responded the slowest to dewatering of the Source Hole and now exhibited the highest groundwater elevation. These observations suggest that, open to a depth of 34.1 m (112 ft), the Source Hole had relatively poor hydrologic connectivity to the surrounding instrument holes, with Instrument Hole #3 having more relatively more connectivity to the Source Hole (perhaps due to favorable fracture conditions), and Instrument Hole #4 having relatively less connectivity to the Source Hole (perhaps due to unfavorable fracture conditions, possibly caused by an intervening dike or vein like that described in Section 4.3.1).

4.3.3.4 March 4 to 17, 2011—Drill Source Hole to TD

Drilling resumed on March 4, 2011, and the 36-in. diameter U-15n Source Hole reached its TD of 60.7 m (199 ft) on March 17, 2011. Drilling was scheduled as a normal workday daytime operation and effectively dewatered the hole during the drilling process, so the groundwater partially recovered during the intervening nights and weekends. The Source Hole is in a critical location for creating groundwater elevation contour maps, but groundwater levels in the Source Hole could not be measured during this time interval due to the presence of the drill string. For this reason, groundwater contour maps for this time interval were not created.

On March 9, 2011, the Source Hole was advanced from a depth of 43.0 to 44.5 m (141 to 146 ft), and drilling effectively dewatered the Source Hole. Other than the Source Hole, the lowest and highest groundwater elevations on this day were measured in Instrument Holes #3 and #4, respectively, indicating that at this depth, Instrument Hole #3 was still relatively more connected, and Instrument Hole #4 was relatively less connected, to the Source Hole.

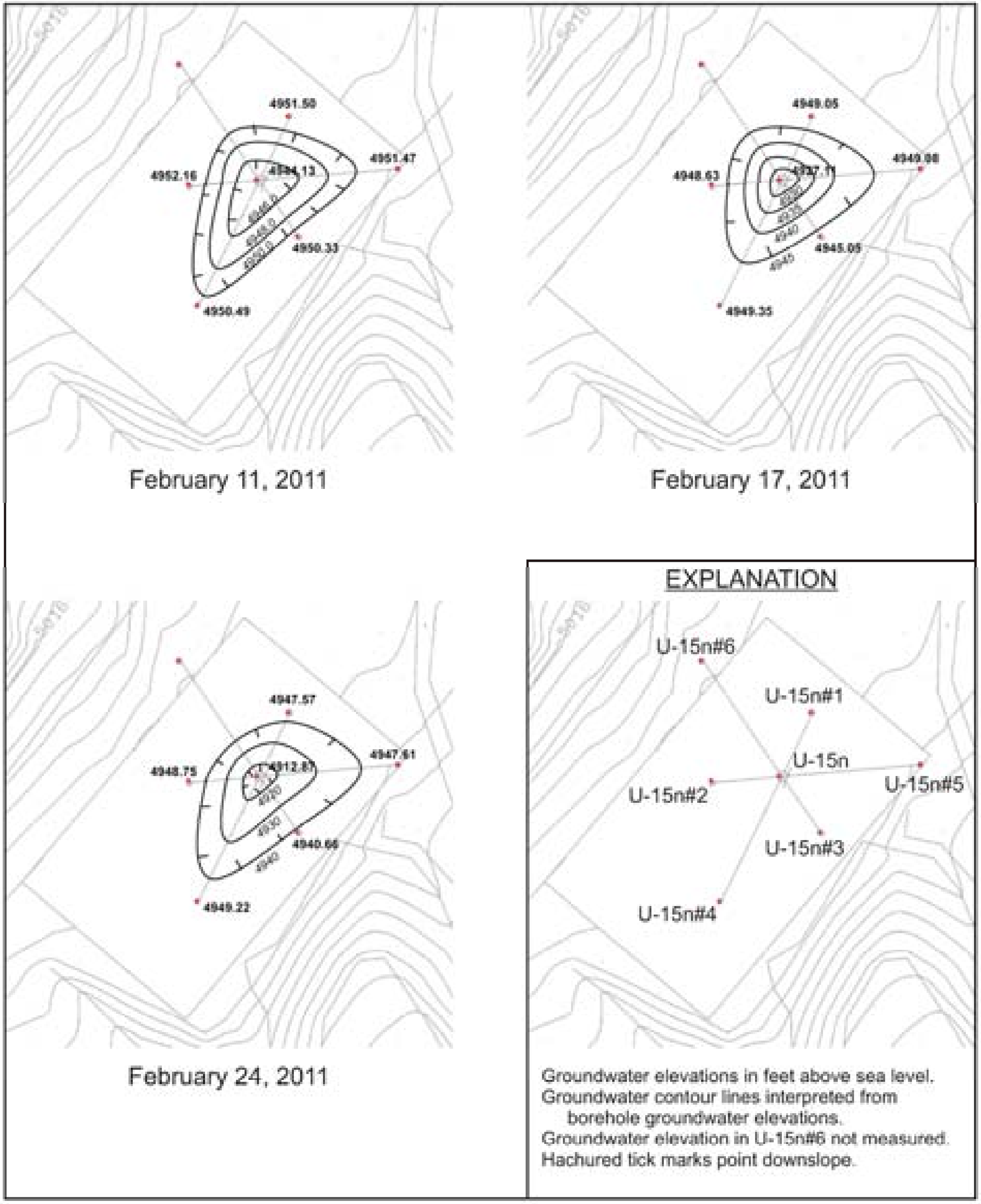


Figure 34
Groundwater Elevation Contour Maps for February 11, 17, and 24, 2011

On March 17, 2011, the Source Hole reached TD at 60.7 m (199 ft), and drilling effectively dewatered the Source Hole. Other than the Source Hole, the lowest and highest groundwater elevations following TD on this day were measured in Instrument Holes #1 and #2, respectively, indicating that at this depth, Instrument Hole #1 was relatively more connected, and Instrument Hole #2 was relatively less connected, to the Source Hole.

These observations with the bottom of the Source Hole below a depth of 34.1 m (112 ft) are in agreement with previous findings when the bottom of the Source Hole was at 34.1 m (112 ft)—that is, the eastern Instrument Holes #1, #3, and #5 are more responsive to groundwater level changes in the Source Hole than are Instrument Holes #2 and #4.

4.3.3.5 March 18 to April 14, 2011—Ream, Log, and Place Canister

After the Source Hole reached TD, a 30-in. diameter mandrel was run into the hole, but it encountered tight conditions at a depth of 42.7 m (140 ft). The hole was dewatered by pumping numerous times during this time interval, first for reaming the hole (beginning March 21, 2011), then for geophysical logging (March 30, 2011), and finally for placement of the explosives canister (April 13, 2011). Groundwater elevation contour maps for March 21, April 7, and April 14, 2011, reveal the following characteristics (Figure 35):

- During this time interval, groundwater levels in Instrument Holes #1, #3, and #5 displayed the greatest response to dewatering in the Source Hole, indicating good hydrologic communication between these holes.
- Initially Instrument Hole #4 displayed the least response to dewatering in the U-15n Source Hole, possibly due in part to natural recharge from up gradient sources.
- By the end of this time interval, Instrument Hole #2 displayed the least response to dewatering in the U-15n Source Hole, suggesting that Instrument Hole #2 is the most isolated from all the other holes.

4.3.4 Summary of Groundwater Monitoring

Based on previous reports about the geohydrology of Climax stock, geologists had concluded that any groundwater encountered at the shallow depths (upper 61 m [200 ft]) at the SPE site would be only minor amounts of perched groundwater. However, based on observations in the present investigation, at least a moderate amount of groundwater is present at shallow depths at the SPE site. The response of groundwater in instrument holes to dewatering episodes in the central Source Hole indicates that the flow of groundwater through the fractured granite rock is not uniform horizontally across the drill pad or vertically with increasing depth. This anisotropy is likely the result of fractures occurring in sets of certain orientations, apertures, spacing, and interconnectedness that vary with location and depth. The possible existence of an aplite dike or quartz vein may affect hydraulic conductivity, and drill mud and purged formation water in the sump may be recharging groundwater and causing a groundwater mound.

When the Source Hole was temporarily stopped at a depth of 34.1 m (112 ft), groundwater interconnectivity with the instrument holes was poor. When the Source Hole was drilled below a depth of 34.1 m (112 ft), groundwater communication improved with Instrument Holes #1, #3, and #5 but remained poor with Instrument Holes #2 and #4. One or more groundwater barriers or

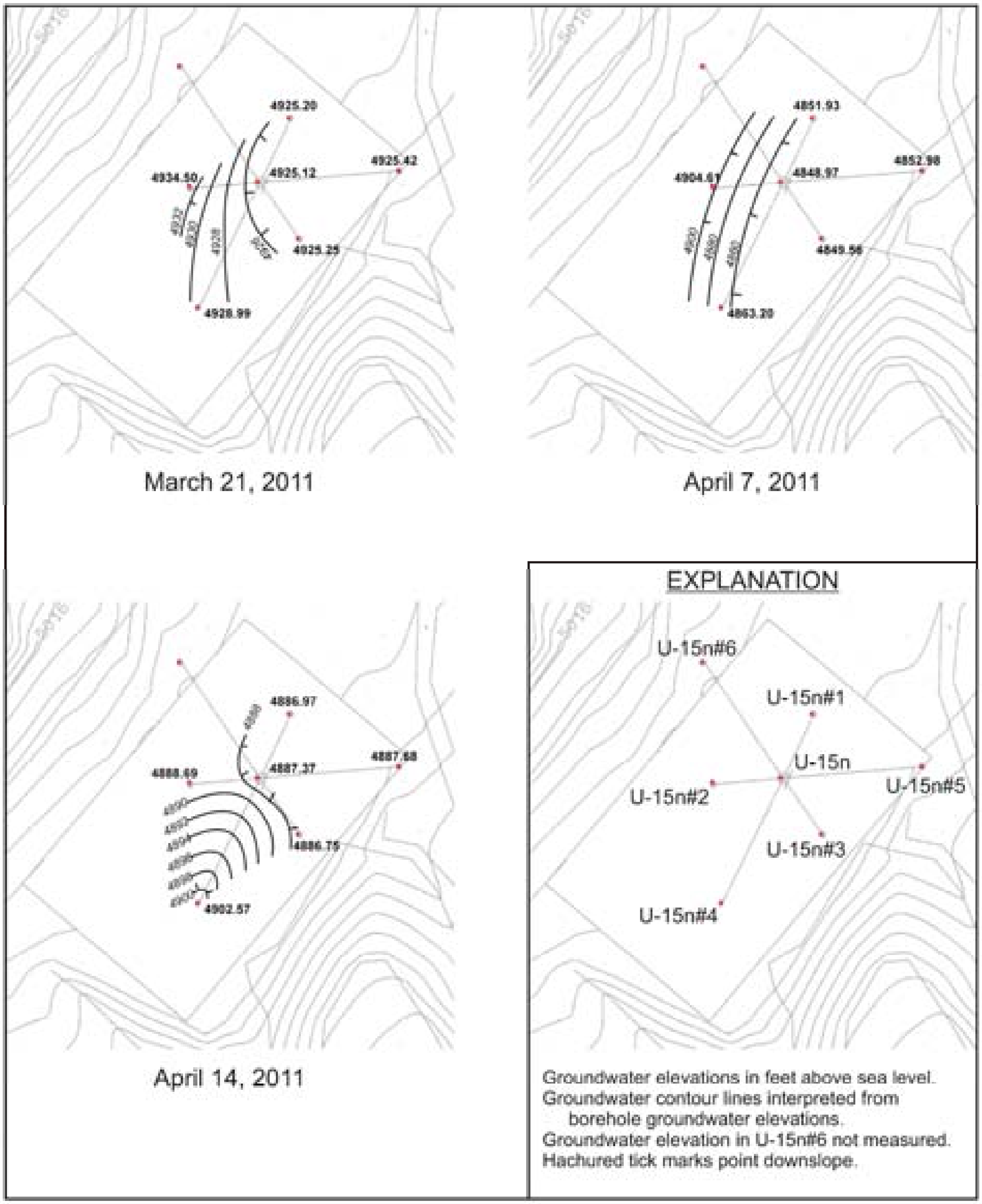


Figure 35
Groundwater Elevation Contour Maps for March 21, April 7, and April 14, 2011

some configuration of the fracture pattern and fracture interconnectivity (or lack thereof) appear to exist that separate and isolate western Instrument Holes #2 and #4 from each other, and from the Source Hole and eastern Instrument Holes #1, #3, and #5. Fractures in the eastern part of the SPE site are probably more interconnected.

As previously stated, these findings apply to the site hydrogeology for the time interval when the boreholes were open to inspection. It is difficult to determine if similar hydrogeologic conditions existed at this site before and after the time interval of this investigation—that is, has the site hydrogeology been significantly changed by the creation, existence, and subsequent stemming of the boreholes. No controlled hydrologic measurements have yet been made that could provide answers to these questions.

This page intentionally left blank.

5.0 Summary

A test bed for a series of chemical explosives tests known as Source Physics Experiments was constructed in the upper 61 m (200 ft) of the quartz monzonite of the Climax stock, in Area 15 of the NNSS in 2010–2011. The site is located approximately 245 m (800 ft) northwest, at closest approach, of the Boundary fault, one of the primary defining structures of the exposure of the Climax granite. Abundant geologic data are available for the area, primarily as a result of studies conducted in conjunction with the three UGTs conducted in the Climax granite in the 1960s and a few later studies of various types.

The first data collected to characterize the SPE site were core samples from a 159.9-m (196.5-ft) deep hole co-located with the explosives canister hole (Source Hole), on which numerous laboratory studies are being conducted. Samples of drill cuttings were collected from the three outer instrument holes and are available for examination if desired. A suite of geophysical logs was also run in the core hole and in all the instruments holes to obtain matrix and fracture properties. Detailed information on the character and density of fractures encountered was obtained from the borehole image logs run in these holes. A total of 2,488 fractures were identified in the seven boreholes, and these were ranked into six categories (0 through 5) on the basis of their degree of openness and continuity. The NSTec analysis considered only the higher ranked fractures (ranks 2 through 5), of which there were 1,215 (approximately 49 percent of all fractures identified from borehole image logs).

The fractures were grouped into sets based on their orientation. The most ubiquitous fracture set (50 percent of all higher ranked fractures) is a group of low-angle fractures (dips 0 to 30 degrees). Fractures with dips of 60 to 90 degrees account for 38 percent of high-ranked fractures, and the remaining 12 percent are fractures with moderate dips (30 to 60 degrees). The higher-angle fractures are further subdivided into three sets based on their dip direction: Fractures of Set 1 dip to the north-northeast, and fractures of Set 2 dip to the south-southwest. Sets 1 and 2 could be considered a single high-angle set with dip directions varying northeastward and southwestward off the vertical and a northwesterly strike. Set 3 consists of high-angle fractures that dip to the southeast and strike northeast. The low-angle fractures dip eastward and are designated Set 4. Fracture frequency does not appear to change substantially with depth. True fracture spacing averages 0.9 to 1.2 m (3 to 4 ft) for high-angle Sets 1, 2, and 3, and 0.6 m (2 ft) for Set 4.

Two significant faults were observed in the core from U-15n, centered at the depths of 25.3 and 32.3 m (83 and 106 ft). The upper of these two faults dips 80 degrees to the north-northeast and thus is related to the Set-1 fractures. The lower fault dips 79 degrees to the south-southwest and is related to SPE Set-2 fractures. Neither fault has an identifiable surface trace.

Groundwater was encountered in all holes drilled on the SPE test bed, and the fluid level averages about 15.2 to 18.3 m (50 to 60 ft) below ground surface. An informal study of variations in the fluid level in the holes conducted during various phases of construction of the test bed on a non-interference basis concluded that groundwater flow through the fractured granitic rocks is not uniform, and appears to be controlled by variations in the orientation and degree of interconnectedness of the fractures. It may also be possible that an aplite dike or quartz vein may be present in the test bed, which could act as a barrier to groundwater flow and, thus, could account for anisotropy seen in the groundwater recovery measurements.

Additional instrumentation holes were drilled in late 2011 for which geologic data are available, but not included in this report. NSTec geologists will report data from these holes as the analyses are completed, indicating how the newer data compare with the older data reported here.

6.0 References

Allingham, J. W., and I. Zietz, 1962. "Geophysical Data on the Climax Stock, Nevada Test Site, Nye County, Nevada." *Geophysics*, vol. 27, num. 5, pp. 599–610.

Ander, H. Dockery, 1984. Written Communication. Subject: "Rotation of Late Cenozoic Extensional Stresses, Yucca Flat Region, Nevada Test Site, Nevada." Ph.D. Thesis, Rice University, Houston, TX. 77 p.

Barnes, H., F. N. Houser, and F. G. Poole, 1963. "Geologic Map of the Oak Spring Quadrangle, Nye County, Nevada." U.S. Geological Survey Map GQ-214. Scale: 1:24,000. Washington, D.C. (Included as Plate 2)

Bechtel Nevada, 2006. *A Hydrostratigraphic Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Unit 97: Yucca Flat–Climax Mine, Lincoln and Nye Counties, Nevada*. DOE/NV/11718--1119. Las Vegas, NV.

Borg, I. Y., 1970. *Survey of Piledriver Results and Preliminary Interpretation of Three Postshot Cores in and near the Cavity*. Lawrence Radiation Laboratory Report TID-4500, UC-35. Livermore, CA.

Broome, S. T., and T. Pfeifle, 2011. Written communication prepared for the U.S. Department of Energy, National Security Administration Nevada Site Office. Subject: "Phase 1 Mechanical Testing Results on Core from Borehole U-15n, Nevada National Security Site, in Support of NCNS Source Physics Experiment." Sandia National Laboratories Report dated June 8, 2011. Attached as Appendix G.

Blouin, S., L. Costin, and K. Wohletz, 2003. "Geotechnical Site Characteristics for HARD HAT and PILE DRIVER." In *Hard Rock Database Review: Final Report and Proceedings of the HRDR Workshop; Volume 1, Unclassified Material*. Prepared by Defense Threat Reduction Information Analysis Center, DTRIAC-SR-03-V1, July 2003. Kirtland Air Force Base, NM.

Cording, E. J., 1967. Written Communication. Subject: "The Stability during Construction of Three Large Underground Openings in Rock." Thesis submitted in partial fulfillment for Ph.D. in Civil Engineering, University of Illinois. 259 p.

Deere, D. U., and D. W. Deere, 1988. "The Rock Quality Designation (RQD) Index in Practice." In *Proceedings of Symposium on Rock Classification Systems for Engineering Purposes.* ASTM Special Technical Publication 984, Philadelphia, pp. 91–101.

Deere, D. U., and D. W. Deere, 1989. *Rock Quality Designation (RQD) after Twenty Years.* U.S. Army Corps of Engineers Report No. GL-89-1, 92 p.

Defense Threat Reduction Agency, 2003. *Hard Rock Database Review: Final Report and Proceedings of the HRDR Workshop; Volume 1, Unclassified Material*. Prepared by Defense Threat Reduction Information Analysis Center, DTRIAC-SR-03-V1, July 2003. Kirtland Air Force Base, NM.

DTRA, see Defense Threat Reduction Agency.

Ege, J. R., and R. E. Davis, 1965. *Preliminary Appraisal of Proposed Tiny Tot Site #2 and Exploratory Drill Hole Ue-15f, Area 15, Nevada Test Site*. U.S. Geological Survey Technical Letter Area-15-6. Denver, CO.

Houser, F. N., and F. G. Poole, 1959. *"Granite" Exploratory Hole, Area 15, Nevada Test Site, Nye County, Nevada—Interim Report, Part A, Structural, Petrographic, and Chemical Data.* U.S. Geological Survey Report TEM-836.

Houser, F. N., and F. G. Poole, 1960. "Preliminary Geologic Map of the Climax Stock and Vicinity, Nye County, Nevada." U.S. Geological Survey, Miscellaneous Geologic Investigations Map I-328. Washington, D.C. (Included as Plate 1)

Houser, F. N., and F. G. Poole, 1961. "Age Relations of the Climax Composite Stock, Nevada Test Site, Nye County, Nevada." *Short Papers in the Geologic and Hydrologic Sciences*, U.S. Geological Survey Professional Paper 424-B, pp. B176–B177.

International Society for Rock Mechanics, 1981. "Basic Geotechnical Description of Rock Masses." *International Journal of Rock Mechanics, Mining Sciences, and Geomechanics Abstracts*, vol. 18, pp. 85–110.

ISRM, see International Society for Rock Mechanics.

Maldonado, F., 1977. *Summary of the Geology and Physical Properties of the Climax Stock, Nevada Test Site.* Open-File Report 77-356. U.S. Geological Survey, Denver, CO.

McArthur, R. D., and J. B. Misz, 1960. Geology of the "Granite" Site, Area 15, Nevada Test Site. University of California Lawrence Radiation Laboratory Report GN 7-60, April 6, 1960. Livermore, California.

Merritt, J. L., 2003. "Topics in the Design of HARD HAT and PILE DRIVER Test Structures." In *Hard Rock Database Review: Final Report and Proceedings of the HRDR Workshop; Volume 1, Unclassified Material*. Prepared by Defense Threat Reduction Information Analysis Center, DTRIAC-SR-03-V1, July 2003. Kirtland Air Force Base, NM.

Murray, W. A., 1981. *Geohydrology of the Climax Stock Granite and Surrounding Rock Formations, NTS*. UCRL-53138, Lawrence Livermore Laboratory, Livermore, CA.

Naiser, C. W., and F. Maldonado, 1981. *Fission-Track Dating of the Climax and Gold Meadows Stocks, Nye County, Nevada*. In: Short Contributions to Geochronology. U.S. Geological Survey Professional Paper 1199E, pp. 45–47.

National Security Technologies, LLC, 2010. Written Communication. Subject: “Site Selection for Source Physics Experiments in Granite at the Nevada Test Site.” Prepared by M. Townsend, L. Prothro, and D. Haugstad, March 11, 2010. Attached as Appendix A.

National Security Technologies, LLC, 2011a. Written Communication. Subject: “Projected Extent of Two Faults Encountered in Core Hole U-15n.” Prepared by UGTA/Boreholes Geology Group. March 8, 2011. Attached as Appendix I.

National Security Technologies, LLC, 2011b. “Handling and Documenting Geologic Samples,” Organization Procedure OP-2152.204, Rev. 0, May 2, 2011. Las Vegas, NV.

NSTec, see National Security Technologies, LLC.

Orkild, P. P., D. R. Townsend, M. J. Baldwin, D. L. Healey, G. D. Bath, C. E. Jahren, and J. G. Rosenbaum, 1983. *Geologic and Geophysical Investigations of Climax Stock Intrusive, Nevada*. Open-File Report 83-377. U. S. Geological Survey, Denver, CO.

Phelps, G. A., R. C. Jachens, B. C. Moring, and C. W. Roberts, 2004. *Modeling of the Climax Stock and Related Plutons Based on the Inversion of Magnetic Data, Southwest Nevada*. U.S. Geological Survey Open-File Report 2004-1345. Denver, CO.

Pohlmann, K., M. Ye, D. Reeves, D. Decker, J. Chapman, and M. Zavarin, 2007. *Modeling of Groundwater Flow and Radionuclide Transport at the Climax Mine Sub-CAU, Nevada Test Site*. DOE/NV/26838-06, Desert Research Institute Publication Number 45226. Las Vegas, NV.

Sargent, K. A., and P. P. Orkild, 1973. *Geologic Map of the Wheelbarrow Peak–Rainier Mesa Area, Nye County, Nevada*. U.S. Geological Survey Miscellaneous Geologic Investigations Map I-754, scale 1:48,000.

Shellum, C., Springfield Research Facility, 1996. Written communication to L. Ashbaugh and G. Baladi, Defense Special Weapons Agency. Subject: *Climax Granite Weathering and Engineering Properties,* September 24, 1996.

Shellum, C., and P. Fisher, Springfield Research Facility, 1996. Written communication to G. Baladi, Defense Special Weapons Agency. Subject: *Mechanical Properties for Climax Granitic Rock, NTS*. October 4, 1996.

Slate, J. L., M. E. Berry, P. D. Rowley, C. J. Fridrich, K. S. Morgan, J. B. Workman, O. D. Young, G. L. Dixon, V. S. Williams, E. H. McKee, D. A. Ponce, T. G. Hildenbrand, WC Swadley, S. C. Lundstrom, E. B. Ekren, R. G. Warren, J. C. Cole, R. J. Fleck, M. A. Lanphere, D. A. Sawyer, S. A. Minor, D. J. Grunwald, R. J. Laczniak, C. M. Menges, J. C. Yount and A. S. Jayko, 1999. *Digital Geologic Map of the Nevada Test Site and Vicinity, Nye, Lincoln, and Clark Counties, Nevada and Inyo County, California.* U.S. Geological Survey Open-File Report 99-554-A, scale 1:120,000.

Townsend, M. J., National Security Technologies, LLC, 2010. Written communication. Email to Source Physics Experiment Subject Matter Experts. Subject: "Water in the SPE Holes." December 29, 2010. Attached as Appendix L.

USBR, see U.S. Bureau of Reclamation.

U.S. Bureau of Reclamation, 2007. *Engineering Geology Field Manual*. www.usbr.gov/pmts/geology/geolman/. Accessed on October 17, 2011.

U.S. Geological Survey. USGS/DOE Cooperative Studies in Nevada Website: Water-Level Wells, Nevada National Security Site. http://nevada.usgs.gov/doe_nv/ntsmap.htm Last accessed on September 13, 2011.

USGS, see U.S. Geological Survey.

Wilder, D. G., and J. L. Yow, Jr., 1984. *Structural Geology Report Spent Fuel Test – Climax Nevada Test Site.* Lawrence Livermore National Laboratory Report UCRL-53381.

APPENDIX A

Site Selection for Source Physics Experiment in Granite at the Nevada Test Site

By

Margaret Townsend, Lance Prothro, and Dawn Haugstad
UGTA/Boreholes Project
National Security Technologies, LLC

March 11, 2010

Site Selection for Source Physics Experiment in Granite at the Nevada Test Site

Margaret Townsend, Lance Prothro, and Dawn Haugstad
National Security Technologies, LLC, UGTA/Boreholes Project
March 11, 2010

Introduction and Preliminary Criteria

Discussions among the National Center for Nuclear Security Source Physics Experiment (SPE) subject matter experts, held at Sandia National Laboratories (SNL) in Albuquerque, New Mexico, on 22–23 February 2010, addressed very preliminary requirements for the experiment site, pending further development of the experiment design. These preliminary requirements included:

- "Homogeneous" granite, with surface weathered zone to be as thin as possible. Preliminary geologic info presented at the meeting suggested that weathering of the granite at Climax generally extends as much as 50 feet (ft) or more from the surface, and is quite variable.
- No obvious faults in area, though it was recognized that there will be fractures, even in the unweathered granite at depth (these will be characterized within the source and gage holes by means of coring and geophysical logging).
- Avoid lithologic contacts, including that between the quartz monzonite (Kqm) and the granodiorite (Kgd) that make up the Climax body.
- Position as close as feasible to existing roads and other infrastructure.
- Keep appropriate distance from the surface ground zeros of the three underground nuclear tests conducted at Climax.
- The group envisioned one source hole (30 inches or less in diameter) with two rings of 6-inch diameter gage holes. A working sketch showed the two semicircular rings of six holes each (12 holes total) centered on the source hole. Distance from source hole to farthest gage hole to be approximately equal to one depth of burial. These specifications are factors in how large a site is needed.
- All holes nominally 100–150 feet deep. Depth might have to be adjusted based on knowledge of depth of weathering at the selected site.
- Depth of weathering to be mapped seismically by SNL at two or three preliminary sites prior to final site selection.

National Security Technologies, LLC, geologists have selected three sites for further study, incorporating the above criteria to the extent possible, and trying to provide a choice of sites in the two granitic rock types. Figures 1 and 2 show the three locations; Figure 1 is on an orthophoto base, and Figure 2 shows the surface geology. The sites are numbered 1, 2, and 3, which reflects our estimation of their ranking, based on our current understanding of the requirements.

Discussion of three Area 15 sites selected for further study

Sites 1 and 2 are both located on Kqm, and Site 3 is located on Kgd. Site 3 is higher in elevation than the other two sites, and in general the terrain on the Kgd surface seems rougher than that on the Kqm. Sites 1 and 2 are on or near existing pads, which could be expanded to suit the needs of the SPE. The pad for Site 3 would have to be constructed on "virgin" ground.

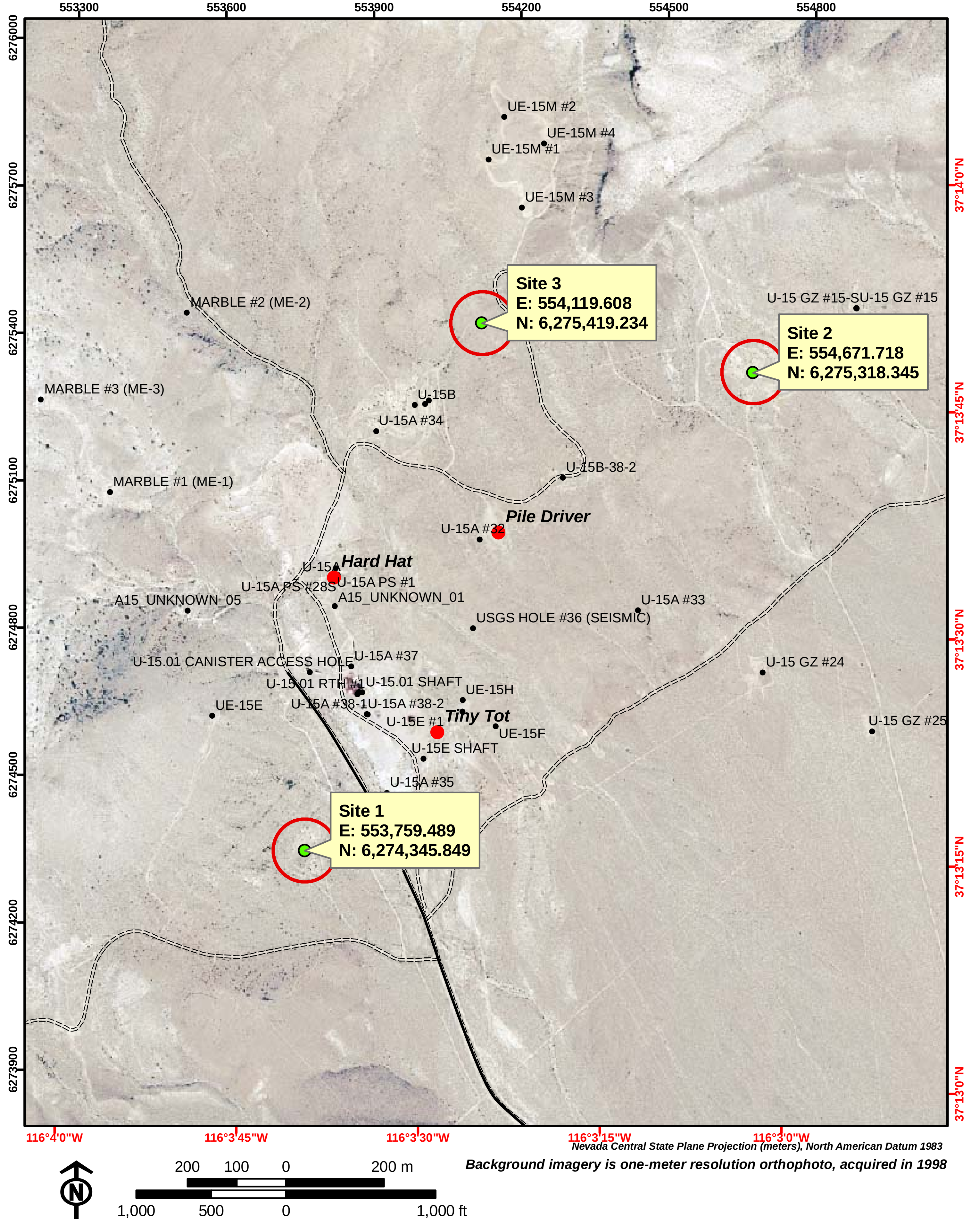


Figure 1. Orthophoto of Climax Stock Area Showing Locations of Three SPE Sites Selected for Further Study

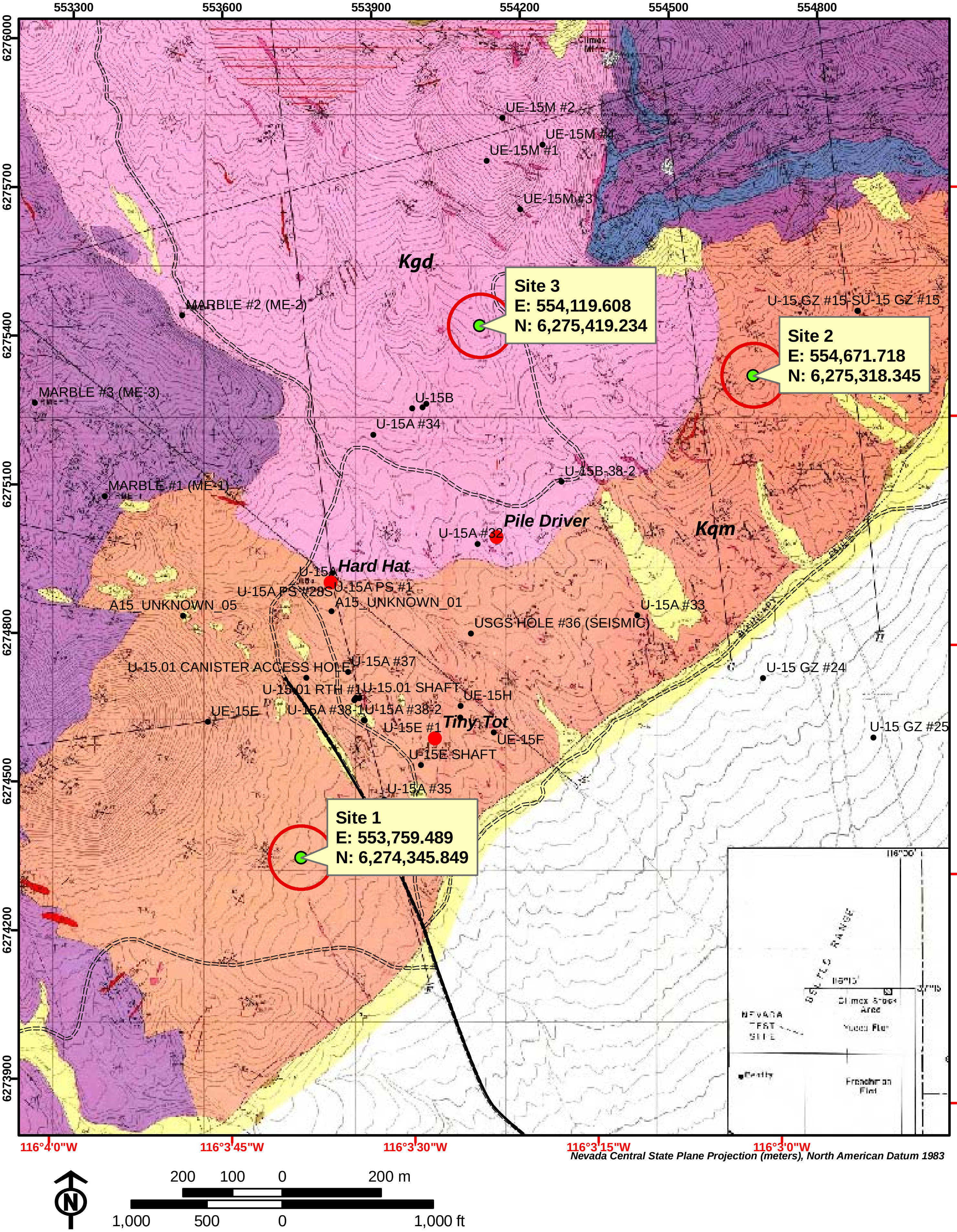


Figure 2. Geologic Map of Climax Stock Area Showing Locations of Three SPE Sites Selected for Further Study

The most difficult aspect is predicting the depth of weathering. There are some core holes in the area, which we will evaluate in more detail in the next week or two. However, for the purpose of siting this test, we should place more weight on the SNL seismic mapping data for final site selection.

Site 1 is easily accessed from the main paved road. There is already a pad at the proposed site, but the purpose of the pad is unclear (no sign or record of a borehole, though there appears to be a mud pit associated with it). The pad would probably have to be expanded. We will continue to try to determine whether there is a borehole there. There are good outcrops of Kqm nearby, suggesting that weathering may be minimal here. This area may be more geologically homogenous than the other two sites, as fewer dikes are shown on geologic maps. The site is approximately 1,000 ft from Boundary fault (closest approach). See Photo #1.

Site 2 is more than 4,000 ft from the main paved road, but the road to it is in relatively good shape. This site may be more geologically heterogeneous than Site 1, as more dikes are mapped. Weathering may be more extensive here as well, based on condition of nearby outcrops. The site is approximately 1,200 ft from the Boundary fault (closest approach). This pad was constructed for the drilling of Hole U-15 GZ#14, and there is a mud pit below the pad. The pad would have to be extended back or scraped down, and the mud pit filled, to increase its size and to avoid the existing borehole. See Photo #2.

Site 3 is located on a narrow ridge between the pads for Holes U-15b and U-15b Ex. #1. Few outcrops are present, making it difficult to assess weathering. Dirt roads pass near the site, but the suggested site itself has not been disturbed, and would require significant dirt-work. See Photo #3.

Photo 1. View of Site #1 looking east. Pad is located in upper center of photo, above berm, below gray muckpile.

Photo 2. View of Site #2 looking south. Two people are standing just to the right of the borehole collar

Photo 3. View of Site #3 (foreground, right of small road) looking northeast from pad for borehole U-15b

APPENDIX B
Drilling Narratives for the U-15n Boreholes

July 2010 through March 2011

Core Hole
36-Inch-Diameter Source Hole
8-Inch-Diameter Instrument Holes

By UGTA/Boreholes Group
National Security Technologies, LLC

APPENDIX B
Drilling Narratives for the U-15n Boreholes
July 2010 through March 2011

B.1.0 Introduction

Eight holes were drilled to construct the test bed in granite for the Source Physics Experiment (SPE): one exploratory core hole at the center of the planned test bed, six 8-inch (in.) diameter instrument holes, and a 36-in. diameter source hole, which was drilled at the location of the collar of the core hole. The planned depth for all holes was 58 meters (m) (190 feet [ft]). The core hole and the first six instrument holes were constructed in the summer of 2010. The source hole was begun in 2010, but not completed till March 2011. A seventh instrument hole was drilled in 2011, prior to the second SPE test, as a replacement for one of the original holes in which instrumentation had failed after the first test. This and other additional instrument holes that are planned but not been completed at the time of this report will be described in a future report.

The core hole and instrument holes were drilled with few problems, but severe difficulties were encountered in drilling the 36-in. Source Hole. This appendix provides detailed narratives of the drilling of the core hole, the source hole, and the first six instrument holes. The daily drilling reports for all drilling activities are provided in Appendix C. Construction information, including deviation plots, is provided in Appendix D.

B.1.1 Site Configuration

The test bed was designed to consist of a 36-in. diameter source hole at the center, surrounded by two rings of three instrument holes each (Figure B-1). The rings are located on radii of 10 and 20 m (33 and 66 ft) from the source hole. The three holes in each ring are positioned 120 degrees apart, and are staggered so that the holes in the inner ring are 60 degrees off the positions of the holes in the outer ring. The placement of the instrument holes was determined from the location of a hole in the outer ring (U-15n#4), whose position was selected to be in line with an azimuth to U16b Tunnel from the U-15n Source Hole.

The drilling plan included an initial core hole at the center of the site that would provide information on the geology of the site and rock samples for later laboratory testing.

B.1.2 Preparations for Drilling

The selected site had once been graded, and included a constructed pit that might have been planned as a mud pit for a drilling project. This graded area is visible on air photos taken in 1964, but the original date of pad construction is unknown. Near the center of the site was found a small depression with a pipe nearby. There was concern that a borehole might have been drilled at this site, which, if cased, could cause a problem for future experiments. The drilling archives of National Security Technologies, LLC (NSTec), and other sources were checked to determine whether a hole had previously been drilled at this location, but nothing was found to indicate this was the case. In addition, the area was checked with a hand-held magnetometer to determine if any buried metal (which could indicate a drill casing) was present. No indication of subsurface metal items was found, so work proceeded to prepare the site.

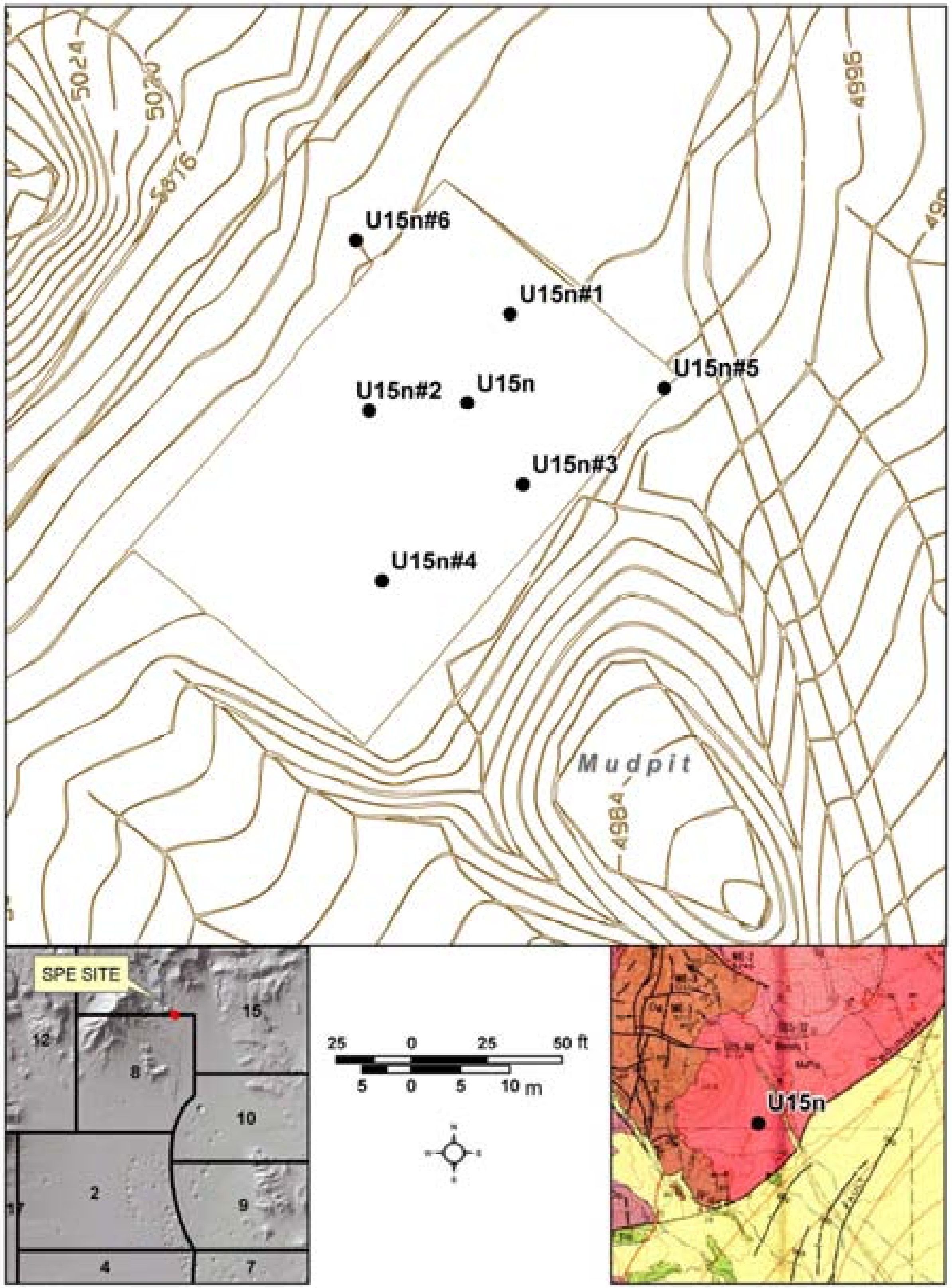


Figure B-1
Map of Source Physics Experiment Site Showing Layout of Holes

Table B-1
Construction Data for Holes Drilled at the U15n Site
(As-built coordinates and elevations as of December 14, 2011)

Hole Name	State Planar Coordinates [a]		UTM Coordinates [b]		Well Coordinates [c]		Ground Elev [d]	Conductor Hole	Conductor Casing	Drilled Depth	TD Date
	Northing feet	Easting feet	Northing meters	Easting meters	Latitude	Longitude	feet	Depth feet	Depth feet	feet	
U-15n (core hole)	900,077.28	676,640.62	4,119,823.7	583,318.7	37.221195	116.060867	5,001.82	7.3 [e]	6.7 [g]	196.5	7/28/2010
U-15n (36-in. hole)	900,077.28	676,640.62	4,119,823.7	583,318.7	37.221195	116.060867	5,001.82	7.5 [f]	7.0 [h]	112 (Temp.) 199 (Final)	Temp. TD, 10/21/2010 Final 3/15/2011
U-15n#1	900,107.01	676,655.17	4,119,832.8	583,323.1	37.221267	116.060816	5,002.00	7 [e]	6.5 [i]	190 [j]	8/25/2010
U-15n#2	900,075.27	676,608.54	4,119,823.1	583,308.9	37.221190	116.060977	5,002.16	10 [e]	9.5 [i]	190 [j]	9/16/2010
U-15n#3	900,050.67	676,659.48	4,119,815.6	583,324.5	37.221121	116.060803	5,001.66	10 [e]	9.5 [i]	190 [j]	8/23/2010
U-15n#4	900,018.48	676,612.53	4,119,805.8	583,310.2	37.221034	116.060965	5,001.59	10 [e]	9.5 [i]	192 [j]	9/18/2010
U-15n#5	900,082.71	676,706.51	4,119,825.5	583,338.8	37.221208	116.060641	5,001.29	10 [e]	9.5 [i]	192 [j]	9/17/2010
U-15n#6	900,131.75	676,603.86	4,119,840.3	583,307.4	37.221345	116.060992	5,005.07	7 [e]	6.5 [i]	190 [j]	8/27/2010

a. Central Nevada State Planar coordinates, in feet, NAD 27

b. Universal Transverse Mercator, zone 11, in meters, NAD 83

c. Lat/Long presented as decimal degrees.

d. National Geodetic Vertical Datum, 1929

e. 12¼-inch hole

f. 48-inch hole

g. 5½-inch casing in core hole only. Removed when 36-inch hole was drilled.

h. 42-inch steel casing

i. 10-inch steel casing

J. 8-inch hole

Township and Range, All Holes			
Qtr Sec	Sec	Town	Range
NW 1/4 of NW1/4	27	8S	53E

The area planned for construction of the SPE test bed was surveyed and graded starting on July 8, 2010. NSTec surveyors then laid out and marked locations for the core hole and six instrument holes, and provided lay-out coordinates and collar elevations for each. The site was designated U15n ("n" was the next sequential alphabetic identifier for construction sites in Area 15), and each hole name includes that identifier. See Table B-1 for construction information for all holes drilled to date.

B.2.0 Drilling Narratives

This section describes the construction of the eight SPE holes drilled in 2010.

B.2.1 Surface Hole Construction

The surface holes for the core hole and all the first six instrument holes were drilled and cased on July 23–24, 2010. The NSTec drill crew used an auger rig to drill a 12¼ -in. diameter surface hole to the depth of 10 ft at each location. The crew installed a 10-in. steel conductor casing to the depth of 9.5 ft in Instrument Holes U-15n#2, #3, #4, and #5. Instrument Holes U-15n#1 and #6 were drilled to 7 ft and the 10-in. casing was set at 6.5 ft. The annulus between the casing and the borehole wall of each instrument hole was sealed with Type 2 cement.

The drillers used the Nevada National Security Site (NNSS) Failing rig to drill a 12¼-in. diameter surface hole for the U-15n Core Hole to the depth of 7.3 ft, and set a string of 5½-in. surface casing to the depth of 6.7 ft. The annulus of the surface casing for the core hole was filled with gravel, rather than cement, to permit removal of the casing for drilling of the 36-in. hole at this location later.

B.2.2 Core Hole

The U-15n Core Hole was cored from the depth of 7.3 ft to a total depth (TD) of 196.5 ft by NSTec drillers using the Failing drill rig on July 26–28, 2010. The core size was 2.5 in. ("HQ"), which produced a borehole 3.8 in. in diameter. Drilling was conducted during the day shift only, and proceeded quickly. No problems were encountered. The total cored length was 189.2 ft, and total core recovery was 187.6 ft (99.2 percent). The daily drilling reports are compiled in Appendix C.

NSTec geologists documented and boxed the core as it was extracted from the hole, recording standard drilling data, such as drilled interval, recovery, drilling time, etc. In addition, the geologists selected samples for preservation (see Section 3.1 of the main document). A total of 37 samples were preserved, equaling 31.2 ft (16.6 percent of the core).

A suite of geophysical logs recommended by the SPE subject matter expert group was run in the borehole by Colog on July 31, 2010. Fill was encountered at the depth of 157 ft during logging. The drill crew ran the drill string back in the hole and cleaned out the sloughed material so that the logging tools could survey all the way to the TD. After cleaning out the hole, they blew the residual drill fluid out using high-pressure air, but the fluid level recovered quickly to the depth of 36 ft. This fluid was too murky to obtain clear images with the camera, but did not cause problems with any of the other planned logs. See the main report for discussions of the logs. A list of samples and other core data are provided in Appendix E.

All core from the U-15n Core Hole was delivered to the U.S. Geological Survey (USGS) Data Center and Core Library in Mercury, Nevada for storage. The geophysical logs were provided to participating organizations in digital and paper format, and are available from the NSTec Underground Test Area (UGTA)/Boreholes Programs and Operations group, Mercury, Nevada. Plots of the geophysical logs are reproduced in Appendix F.

B.2.3 Instrument Holes

All six of the original SPE instrument holes are 8 in. in diameter. NSTec drillers used the Failing rig to drill the first three holes. Due to mechanical problems with the Failing rig, the NSTec drilling subcontractor, United Drilling Incorporated (UDI), was brought in to drill the last three holes, for which they used the UDI GD 2500 rig. The drill dates for the holes are listed below. The order was determined by the logistics of setting the flow line and need to re-position various equipment on the pad. See Appendix C for the daily rig operations reports.

- U-15n#3 (August 21–23, 2010)
- U-15n#1 (August 24–25, 2010)
- U-15n#6 (August 26–27, 2010)
- U-15n#2 (September 15–17, 2010)
- U-15n#5 (September 17, 2010)
- U-15n#4 (September 18, 2010)

The NSTec drill crew started drilling the instrument holes after it was decided to use UDI to finish drilling the partially completed 36-in. hole. NSTec completed three instrument holes while the procurement process for UDI was in progress. The last three holes were drilled by UDI while drilling of the 36-in. hole was shut down to wait for replacement of a damaged bit. See Section B.2.4 for information on the construction of the 36-in. hole.

All the instrument holes were drilled with an air-foam drill fluid. Pairs of one-pint samples (duplicates) of the drill cuttings were collected by NSTec geologists from the three outer instrument holes (U-15n #4, #5, and #6) at 10-ft intervals during drilling.

Following drilling, the fluid levels in the instruments were measured at depths ranging from about 57 to 77 ft. The required suite of geophysical logs was run in all six boreholes by Colog on September 20, 2010. No fill was encountered during logging of any of the holes. See Section 3.2 of the main report for a list of logs run in the boreholes.

The drill cuttings samples collected during drilling of the three outer instrument holes were delivered to the USGS Data Center and Core Library in Mercury, Nevada, where one set was washed and boxed according to standard Core Library procedures and the other set was archived unwashed. The geophysical logs were provided to participating organizations in digital and paper format, and are available from the NSTec UGTA/Boreholes Programs and Operations group, Mercury, Nevada. Plots of the geophysical logs are reproduced in Appendix F.

B.2.4 36-Inch Diameter Source Hole

NSTec drillers began work on the 36-in. diameter Source Hole, centered at the location of the collar of the U-15n Core Hole, on August 5, 2010. They augered a 48-in. diameter hole from the surface to the depth of 5 ft, but encountered difficulty with a ledge of hard rock at the depth of 2.5 ft. The next day they moved the Failing rig onto the hole and drilled a 12¼-in. hole from 5 to 7 ft, though drilling was slow due to very hard rock. Next they picked up a 5-in. hammer bit and drilled several holes to 10 ft, within the footprint of the planned hole, to try to break up the rock. The next day they brought the auger rig back on and used a 48-in. bit to drill from 5 to 7.5 ft. The crew then landed a string of 42-in. case at the depth of 7 ft, and cemented it in place with type HLNCC grout. The next day the annulus was cemented to the surface with HLNCC grout.

It took four days to prepare the collar assembly and flow line, move additional compressors to the site, and set up for drilling the 36-in. hole with the NNSS Cardwell rig. The NSTec drill crew started drilling from the top of the cement in the conductor hole at 5 ft on August 8, 2010, using a 36-in. hammer bit. They drilled to the depth of 21 ft by August 14, 2010 (again very slowly due to hard rock) then spent seven days working on the rig and the hammer bit, and adding more compressors. They still encountered severe drilling difficulties, and on August 19, 2010, the shaft between the king swivel and the power swivel twisted off. A crane was used to remove the power swivel, and drilling operations were suspended.

The drilling subcontractor UDI and their GD 2500 rig were in to complete the 36-in. hole. Drilling resumed on August 31, 2010, but the UDI rig also experienced mechanical problems, including leaks in the flow system and small failures of various components. On September 9, 2010, after 14.5 hours of drilling advanced the hole only 1 ft (to the depth of 94 ft), the decision was made to pull out of the hole and check the hammer bit. Visual inspection of the bit showed that some of the drive pins on the bit spline were broken, and the bit was sent out for repair. While waiting on the bit repair, the UDI crew used their rig with an 8-in. bit to drill the remaining three instrument holes (see Section B.2.3).

After the drill string was removed from the 36-in. diameter hole, NSTec ran a camera in the borehole to check conditions. The borehole appeared to be severely deviated from vertical, with a "corkscrew" path, so it was decided to run a mandrel designed to match the size and shape of the explosives canister to determine whether the hole was straight enough to install the canister.

The mandrel run was conducted on September 24, 2010. The mandrel was blocked due to severe borehole deviation at the depth of 34.5 ft. The decision was made to cement the lower portion of the hole and re-drill it to correct the deviation. The first cement stage consisted of 425 cubic feet (ft^3) of Type 2 cement, which brought the top of the cement to the depth of 48 ft. The second stage of 210 ft^3 of Type 2 cement brought the top of the cement to the depth of 24.7 ft) on September 25, 2010.

On September 27, 2010, the drilling assembly was brought back to the rig site. An additional reamer had been added to stiffen the drill string, which was expected to improve the plumbness of the hole. A crane was used to lower the assembly into the hole, but the assembly was blocked at the depth of 17 ft, so it was removed and returned to the shop for evaluation. The drilling assembly was brought back to the site and lowered into the hole successfully the next day, and the hole was re-drilled through the cement to the depth of 53 ft. The decision was made to add a second reamer to the drill string, so the drilling assembly was again removed and taken to the shop to add the reamer.

During disassembly of the bit at the shop on September 29, 2010, a chain failed and an employee was slightly injured. Drilling operations were suspended while safety assessments were made both at the shop and at the SPE drill site. After minor issues were addressed, the safety suspension was lifted so that operations could resume on October 4, 2010. However, it was found that additional required components had to be obtained to complete assembly of the drill string with the additional reamer, so no drilling took place the week of October 4, 2010. After receipt, installation, and inspection of the additional drilling assembly sections, UDI resumed drilling on October 15, 2010.

Reaming and drilling by the UDI crew and rig had advanced to the depth of 75 ft on October 15, 2010, when the shaft on the rotary table transmission twisted apart. Drilling resumed the next day after the rotary table was replaced; however, the rig continued to suffer various mechanical problems. The bolts that hold the rotating rubber on the drilling assembly were found to be missing when it was pulled to add pipe, so the rotating rubber was replaced and bolted on. The transmission drive train failed and had to be replaced, and a U-joint in the rotary table drive line failed and had to be repaired. At the depth of 112 ft on October 21, 2010, high torque caused the kelly to fail. A new kelly was brought up and installed the next day, but continuing high torque during drilling began to cause similar wear on the new kelly.

The decision was made to suspend drilling and take steps to obtain a more robust drill rig to complete the hole. When the crew attempted to pull the bit assembly from the hole on October 27, 2010, the bit parted from the hammer and was left in the borehole. Over the next few days a pump was run in the hole to lower the water level so that a camera could be used to examine the lost bit. Fishing operations to recover the bit began on November 1, 2010, alternating with pumping and repeated camera runs to help guide placement of the fishing tools. The bit was recovered on November 3, 2010, but one of its retaining rings was found to be missing, presumably left in the hole.

The mandrel was successfully run to the bottom of the borehole at 112 ft on November 4, 2010, indicating that the re-drilled hole was remaining fairly straight.

The UDI rig was demobilized from the site, and equipment left at the site was prepared for winter. There was no drilling activity at the site until the end of January 2011, when preparations began to bring in a leased raise-bore type drill rig, through the UDI subcontract, to complete the hole. The raise-bore rig is capable of approximately four times the rotary torque of the UDI GD 2500 rig, and its hydraulic controls enable better control of rotary speed and torque than a standard rotary rig.

The hammer bit was refurbished and all necessary components checked. An auger rig with a 36-in. bit was brought in to clean out the borehole and clear a tight spot at 89 ft. During the cleaning operation, the hole was periodically dewatered and a camera run to check for the metal ring lost from the bit. In addition, a magnet was run in the hole, but no metal was recovered. The auger rig experienced a mechanical failure and a rented rig was brought in to finish cleaning out the hole. After the final cleaning with the auger, no metal parts were found, but another survey with the metal detector indicated the presence of metal, so the magnet was run again and recovered half of the missing retaining ring from the bit on February 25, 2011.

During this time preparations were underway to build a “strongback” at the hole collar, on which to set the raise-bore rig. Cement was placed in the borehole to the level of 96 ft, to isolate any remaining metal parts that might be stuck in a fracture or void in the borehole wall. Drilling with the raise-bore rig began at the top of the cement on March 3, 2011. Below the depth of 140 ft, the rig experienced very high torque. When the depth of 146 ft was reached, on Thursday, March 10, 2011, the drilling assembly was removed and the reamers were found to be damaged. The reamers were shipped out for repair and returned by the following Monday. The hole was drilled to the final depth of 199 ft on March 15, 2011.

The mandrel was run in the borehole but would not pass the depth of 140 ft. During the week of March 21, 2011, the drilling assembly was rebuilt to add two tungsten-carbide–coated stabilizers (to serve as reamers) and a smaller (26-in.) rotary bit (to increase circulation at the bottom of the hole for removal of cuttings). The hole was reamed to the depth of 195 ft to remove the tight spots that had obstructed the mandrel. The drilling assembly, pipe, and drill rig were then removed and the mandrel was successfully run to the depth of 192 ft on March 25, 2011. All drilling equipment was demobilized from the site the week of March 28, 2011, to allow for final installation of the emplacement canister in the U-15n Source Hole and the rest of the accelerometer packages in the instrument holes.

APPENDIX C

Daily Rig Operations Reports for U15n Source Physics Experiment
National Security Technologies, LLC

Appendix C-1

NSTec Daily Rig Operations Reports for the U-15n Core Hole

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Saturday	07/24/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Set conductor casing	12-1/4	10"/5.5"	N/A	200'

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
N/A	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Saturday 07/24/10 to 0700 Hrs. Sunday 07/25/10

0.50 Hrs	Travel from reporting area to location. Review PTHR and Plan of the Day.
0.50 Hrs	Lunch break
3.50 Hrs	Drill hole #6 with 12-1/4" hammer bit from 3' to 7'. Lay down hammer bit and run 10" casing. Land at 6.5'. Rig down Failing 1500 drill rig.
4.50 Hrs	Rig up Failing 1500 on core hole. Pick up 12-1/4" hammer bit. Drill from 2.5' to 7.3'. Run 5-1/2" casing and land at 6.7' Rig down hammer bit and tools.
1.00 Hrs	Rig up coring tools. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Notes	Hole#1: 12-1/4" at 7' depth with 10" casing set at 6.5'.
	Hole#2: 12-1/4" at 10' depth with 10" casing set at 9.5'.
	Hole#3: 12-1/4" at 10' depth with 10" casing set at 9.5'.
	Hole#4: 12-1/4" at 10' depth with 10" casing set at 9.5'.
	Hole#5: 12-1/4" at 10' depth with 10" casing set at 9.5'.
	Hole#6: 12-1/4" at 7' depth with 10" casing set at 6.5'.
	U15N core hole: 12-1/4" at 7.3' depth with 5-1/2" casing set at 6.7'.

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Monday	07/26/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Coring	3.8125	5.5	6.7	200'

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
37	6.5	30	3.0	10.00	N/A	120

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
N/A	N/A	N/A	N/A	N/A	water/polymer

Time log: Report Period

0700 Hrs. Monday 07/26/10 to 0700 Hrs. Tuesday 07/27/10

1.00 Hrs	Travel from reporting area to location. Pthr and Plan of the day.
4.00 Hrs	Rig up equipment and tools for coring. Set in bean pump, racks and core extractor. Back fill annulus with 3/8" gravel from 6.5' to G.L. Make up core barrel and pick up same.
0.50 Hrs	Lunch break.
1.00 Hrs	Run in hole tag cement at 6.5'. Attempt to core no returns. Lay down inner tube and adjust latch in setting.
3.50 Hrs	Coring 3.8125" hole. Core run #1 from 6.5' to 16.5'.Recovery 7.9'. Core run #2 from 16.5' to 26.5'. Recovery 9.8'. Core run #3 from 26.5' to 36.5'. Not enough time to process core run #3. Leave core in the hole overnight. Pull rods 20' off bottom and secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	07/27/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Coring	3.8125	5.5	6.7	200'

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
137	36.5	100	8.0	12.50	N/A	120/150

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
1	N/A	N/A	250	N/A	water/polymer

Time log: Report Period

0700 Hrs. Tuesday 07/27/10 to 0700 Hrs. Wednesday 07/28/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day.
8.00 Hrs	Pull core run #3- 10' recovery. Core 3.8125" hole from 36.5 to 136.5'.
0.50 Hrs	Lunch break.
0.50 Hrs	Pull off bottom 60' and secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Core run #4 from 36.5' to 46.5'- 10' recovery.
Core run #5 from 46.5' to 56.5'- 10' recovery.
Core run #6 from 56.5' to 66.5'- 10' recovery.
Core run #7 from 66.5' to 76.5'- 10' recovery.
Core run #8 from 76.5' to 86.5'- 10' recovery.
Core run #9 from 86.5' to 96.5'- 10' recovery.
Core run #10 from 96.5' to 106.5'- 10' recovery.
Core run #11 from 106.5' to 116.5'- 10' recovery.
Core run #12 from 116.5' to 126.5'- 10' recovery.
Core run #13 from 126.5' to 136.5'- left core in the hole overnight.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	07/28/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Coring	3.8125	5.5	6.7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
196	136	60	6.0	10.00	N/A	120/150

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
1	N/A	N/A	250	N/A	water/polymer

Time log: Report Period

0700 Hrs. Wednesday 07/28/10 to 0700 Hrs. Thursday 07/29/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day.
6.00 Hrs	Pull core run #13-10' recovery. Core 3.8125" hole from 136'to 196' T.D.
0.50 Hrs	Lunch break.
0.50 Hrs	Pump 30 bbls clean water down hole to clean hole of drilling fluid.
2.00 Hrs	Pull core rods out of hole and lay down same. Lay down core barrel and break down same. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Core run #14 from 136.5 to 146.5' - 10' recovery.
Core run #15 from 146.5 to 156.5' - 9.8' recovery.
Core run #16 from 156.5 to 166.5' - 10' recovery.
Core run #17 from 166.5 to 176.5' - 10' recovery.
Core run #18 from 176.5 to 186.5' - 10' recovery.
Core run #19 from 186.5 to 196' - 10' recovery.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Thursday	07/29/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Mob/Demob	N/A	5.5	6.7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
196 TD	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
1	N/A	N/A	N/A	N/A	water/polymer

Time log: Report Period

0700 Hrs. Thursday 07/29/10 to 0700 Hrs. Friday 07/30/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day.
8.50 Hrs	Mob 3-900CFM compressors from area 6 equipment yard to location. Move core tools,casing,3/8" gravel and misc. equipment to area 1 subdock. Mob 48" auger, Auger rig and tools to locations. Move in 36" hammer bit and tools from subdock. Secure location.
0.50 Hrs	Lunch break.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Notes: Tire truck replace bad tire on Failing 1500.
Mechanic repair mixing tub on bean pump skid.
Fluid in core hole at 47' at 1600 hrs.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	07/30/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Logging	N/A	5.5	6.7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
196 TD	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
1	N/A	N/A	N/A	N/A	water/polymer

Time log: Report Period

0700 Hrs. Friday 07/30/10 to 0700 Hrs. Saturday 07/31/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day.
1.00 Hrs	Wait on Colog. Conduct PTHR with loggers and crew on handling of source.
2.50 Hrs	Rig up Colog. Pick up OBI tool and run in hole. Obtain log from 5' to 157'. Tool stopped at 157', tag fill. Lay down tool and rig down Colog.
5.50 Hrs	Run in hole with 3.8125" bit and core pipe. Tag fill at 168'. Clean out fill from 168' to 196' with water/polymer mix. Pull up 40' and wait 30 minutes. Trip back to bottom, no fill. Blow fluid from hole. Lay down core pipe.
3.00 Hrs	Rig up Colog. Pick up OBI tool and run in hole. Obtain log from 5' to 194.5'. Fluid at 36'. Lay down OBI tool and run video camera in hole to 40'. Fluid not clear enough for camera. Lay down tool and rig down Colog. Secure location.
0.50 Hrs	Travel to reporting area.
10.50 Hrs	No activity.

Colog on location at 0850 Hrs.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Saturday	07/31/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Logging	N/A	5.5	6.7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
196 TD	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	1	1400	N/A	N/A	water/soap

Time log: Report Period

0700 Hrs. Saturday 07/31/10 to 0700 Hrs. Sunday 08/01/10

0.50 Hrs	Crew travel from reporting area to location.
1.50 Hrs	Wait on Colog. Conduct PTHR and Plan of the Day with rig crew and Colog.
2.00 Hrs	Rig up Colog. Pick up ABI tool and run in the hole. TD at 191', fluid at 46'. Obtain log from 191' to 13'. Lay down tool.
2.00 Hrs	Pick up CDL-Cal tool. Tool not working, swap out tools. Run tool in the hole, TD at 188'. Obtain log from 188' to 7'. Repeat run,TD at 188'. Lay down tool.
2.50 Hrs	Pick up Elog, GR,SP tool and run in the hole,TD at 186.7'. Obtain log from 186' to 7'. Lay down tool. Run in hole with 3 arm Caliper,TD 185.9. Obtain log from 185' to 7'. Lay down tool. Run in hole with FWS,GR tool. TD at 185.5'. Obtain log from 185' to 7'. Lay down tool. Rig down Colog.
3.00 Hrs	Rig up 1.9" tubing tools. Run in hole with 1.9" tubing open ended. Tag fill at 181'. Clean fill from 181' to 196' with air/foam. Blow fluid out of hole. Lay down tubing and rig down tools.
1.50 Hrs	Rig up Colog. Run video camera in the hole. TD at 195, fluid at 89'. Lay down camera and rig down Colog. Secure location.
0.50 Hrs	Travel to reporting area.
10.50 Hrs	No activity.

Note: Colog on location at 0845 hrs.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Monday	08/02/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Mob for cementing	N/A	5.5	6.7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
196 TD	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Monday 08/02/10 to 0700 Hrs. Tuesday 08/03/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
9.00 Hrs	Wait on cementing program. Mob pump truck and cementing equipment from area 1 to location. Rig up same. Clean out mixing tub on bean pump skid for cementing. Work on grant head.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Note: Fluid at 51' at 1000 hrs.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	08/03/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
cementing	N/A	5.5	6.7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
196 TD	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	1	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Tuesday 08/03/10 to 0700 Hrs. Wednesday 08/04/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
3.00 Hrs	Run in hole with 1.9" tubing and stinger (mule shoe and slotted) for cementing. Tag fill at 186'. Clean fill from 186' to 190'. Stinger plugged with sand. Trip out of hole and lay down stinger. Run in hole with 1.9" tubing open ended. Clean fill from 190' to 196'.
2.00 Hrs	Rig up to pump cement. Attempt to pump HLGCCAR-1 cement mixture with the bean pump. Pump sanding up. Clean out pump and attempt to pump mixture again. Bean pump can not pump this mixture. Rig down cement tools.
4.00 Hrs	Lay down tubing. Clean out bean pump,mixing tub, and hoses. NSTec cement crew go to well 3 and blend new mixture (HLNCC).
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	08/04/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
cementing	N/A	5.5	6.7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
196 TD	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	1	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Wednesday 08/04/10 to 0700 Hrs. Thursday 08/05/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
1.00 Hrs	Run in hole with 1.9" tubing and stinger. Tag fill at 192'. Clean fill from 192' to 196'.
1.00 Hrs	Rig up cementers. Pump stage #1 with 8cu/ft of HLNCC cement with NSTec pump truck. CIP at 0945 hrs. Lay down tubing.
2.00 Hrs	WOC. Run in hole with tubing and tag top of cement at 170'(26' rise). Lay down 3 joints tubing and rig up cementers.
0.50 Hrs	Pump stage #2 with 9cu/ft of HLNCC cement, CIP at 1210 hrs. Lay down 1.9 tubing.
2.00 Hrs	WOC. Run in hole with tubing and tag top of cement at 80'(90' rise). Rig up cementers.
0.50 Hrs	Pump stage #3 with 5cu/ft of Type 2 cement, CIP at 1445 hrs. Lay down tubing.
2.00 Hrs	WOC. Run in hole and tag top of cement at 45'(35' rise). Lay down tubing. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Appendix C-2

NSTec Daily Rig Operations Reports for the U-15n 36-inch Diameter Source Hole

Includes excerpts from weekly reports by the SPE Project Manager covering periods without daily rig operations reports.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Thursday	08/05/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Auger Rig	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Auger 48" hole	48	5.5	6.7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
5	0	5	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Thursday 08/05/10 to 0700 Hrs. Friday 08/06/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
2.00 Hrs	Rig down cementing equipment. Pull 5.5" casing. Rig down and move Failing 1500. Move 1.9" tubing and tools. Move bean pump.
1.00 Hrs	Move in Auger Rig and equipment. Rig up same.
0.50 Hrs	Lunch break.
4.50 Hrs	Auger 48" hole from surface to 5'. Hard rock at 2.5". Auger 2.5' of hard rock. Rock ledge at 2.5'. Bolts sheared on kelly ring. Repair same.
1.00 Hrs	Move in Failing 1500 to pick up hammer bit to try and break up rock. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	08/06/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Auger Rig/Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Hammer drill	12-1/4"/5"	N/A	N/A	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	1	N/A	N/A	N/A	water

Time log: Report Period

0700 Hrs. Friday 08/06/10 to 0700 Hrs. Saturday 08/07/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
8.50 Hrs	Rig up Failing 1500. Make up 3" drill pipe and 12-1/4" hammer bit. Drill 12-1/4" hole from 5' to 7'. Lay down 12-1/4" hammer and make up 5" hammer. Drill 2-5" holes from 5' to 10'. Rig down Failing and move to drill more holes to try and break up rock. Rig up and pick up 5" hammer. Drill 2-5" holes from 5' to 10'. Rig down move and rig up Failing. Drill 2-5" holes from 5' to 10'. Rig down and secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Saturday	08/07/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Auger Rig	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Auger	48"	N/A	N/A	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
7.5'	5'	2.5'	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Saturday 08/07/10 to 0700 Hrs. Sunday 08/08/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
0.50 Hrs	Move Failing Rig and tools off location.
4.00 Hrs	Pick up 48" auger bit. Auger hole from 5' to 7.5'.
0.50 Hrs	Lunch break.
1.00 Hrs	Pick up 9' of 42" casing. Run in hole and land at 7' G.L. Mechanic weld gussets on casing and land on beams.
3.00 Hrs	Rig up cementers. Pump plug inside 42" casing with 12cu/ft of HLN cement. Fill annulus between 10" casing and 12-1/4" hole in holes 1 through 6 with type 2 cement.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Monday	08/09/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	N/A	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Rig up	N/A	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Monday 08/09/10 to 0700 Hrs. Tuesday 08/10/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
3.00 Hrs	Rig up cementers. Pump 50cu/ft of HLNCC cement around annulus of 42" casing (fill to surface, CIP at 0930 Hrs). Rig down cementers.
0.50 Hrs	Lunch break.
5.50 Hrs	Rig down Auger Rig and take to area 6 equipment yard. Move in 3-900 CFM compressors and rig up same. Move flow line from area 1 Subdock to site. Mechanic work on plate for top of 42" casing. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	08/10/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	N/A	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Rig up	N/A	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Tuesday 08/10/10 to 0700 Hrs. Wednesday 08/11/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
2.00 Hrs	Crew go to equipment yard and lay down mast on Cardwell 100. Prepare rig to move. Mechanics conducting PM on rig.
2.00 Hrs	Move fuel tanker from equipment yard to location. Remove landing beams from 42" casing. Set in rig beams.
0.50 Hrs	Lunch break.
4.50 Hrs	Mechanics found bad area on drilling line on Cardwell 100 during PM. Crew travel to equipment yard. Change out 7/8" drilling line.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Thursday	08/12/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	N/A	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Rig up	36"	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Thursday 08/12/10 to 0700 Hrs. Friday 08/13/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
2.50 Hrs	Pick up 8" bottom hole drill collar. Make up x over subs and shock sub on 8" collar. Set 36" hammer bit in hole. Pressure test air system to 350psi (found 2 leaks). Replace 1-2" hose and 1-3" hose. Test again and no leaks found.
3.00 Hrs	Wait on NSTec welders.
3.50 Hrs	Weld flange onto 42" casing and bolt on plate for rotating head. Work on flow line. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Note: NSTec welders on location at 1330 hrs.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	08/13/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Cardwell 100	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Drilling	36"	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
14	5	9	4.5	2.00	4K	20

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	3	27020	150	N/A	water/foam

Time log: Report Period

0700 Hrs. Friday 08/13/10 to 0700 Hrs. Saturday 08/14/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
4.00 Hrs	NSTec welders install 10-3/4" flow line (need 9' more to reach sump).
	Replace fuel lines on compressors.
2.00 Hrs	Drill 36" hole with hammer bit from 5' to 10' (drill 2' cement).
0.50 Hrs	Install 9' section 10-3/4" flow line.
2.50 Hrs	Drill 36" hole with hammer bit from 10' to 14'. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Saturday	08/14/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Cardwell 100	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
Drilling	36"	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
21	14	7	7.0	1.00	4K	20

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
5	4	3600	150	10/bbls/hr	water/foam

Time log: Report Period

0700 Hrs. Saturday 08/14/10 to 0700 Hrs. Sunday 08/15/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
1.50 Hrs	Set in 4th 900 CFM compressor and rig up same.
7.50 Hrs	Drill 36" hole with hammer bit. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Monday	08/16/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Cardwell 100	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36"	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	4	3600	150	10/bbls/hr	water/foam

Time log: Report Period

0700 Hrs. Monday 08/16/10 to 0700 Hrs. Tuesday 08/17/10

1.00 Hrs	Crew attend Security Briefing in area 6.
1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
1.00 Hrs	Tighten packing on King Swivel and 3" nipple.
1.00 Hrs	Drill 36" hole with hammer bit.
6.00 Hrs	Shock sub came apart while drilling. Land hammer bit in cellar and break x-over sub from 8" collar. Break shock sub and lay down collar. Travel to sub dock and locate another shock sub. Break down King swivel to replace packing. Shaft in power swivel twisted off inside swivel housing. Lay down King Swivel. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	08/17/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Cardwell 100	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36"	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
4	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Tuesday 08/17/10 to 0700 Hrs. Wednesday 08/18/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
8.50 Hrs	Mechanics work on shaft in power swivel (weld together). Break off x-over subs off shock sub. Make up x-over subs to new shock sub. Rig down and move air compressor to make room for more compressors. Repack King Swivel with new packing. Secure location.
0.50 Hrs	Lunch break.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	08/18/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Cardwell 100	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36"	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
6	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Wednesday 08/18/10 to 0700 Hrs. Thursday 08/19/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
8.50 Hrs	Make up shock sub and x-over subs on power swivel. Attach King Swivel on top of power swivel. Pick up and make up 8" drill collar to hammer bit. Check King Swivel for leaks, still leaking at packing. Break off and lay down Swivel. Mechanic make spacers and install in swivel packing. Make up swivel. Hook up two more 900cfm compressors. Secure location.
0.50 Hrs	Lunch break
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Thursday	08/19/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Cardwell 100	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36"	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
23	21	2	2.5	0.80	4K	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
6	6	5400	250	10bbls/hr	water/soap

Time log: Report Period

0700 Hrs. Thursday 08/19/10 to 0700 Hrs. Friday 08/20/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
1.50 Hrs	Change hoses and fittings on new compressors. Pressure test same to 350psi.
2.00 Hrs	Drill 36" hole with hammer bit. Packing in King Swivel leaking.
1.00 Hrs	Two sulair compressors down, work on same.
0.50 Hrs	Drill 36" hole with hammer bit.
2.00 Hrs	Four compressors down (fuel filters). Mechanic change filters.
4.50 Hrs	Shaft between King Swivel and power swivel twisted off. Break off hammer bit and land in cellar. Break off shock sub and lay down 8" collar. Lay down King Swivel. Mechanics remove power swivel with crane and take to area 6 equipment yard. Secure location.
0.50 Hrs	Travel to reporting area.
11.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Monday	08/30/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Monday 08/30/10 to 0700 Hrs. Tuesday 08/31/10

2.00 Hrs	Travel from reporting area to location. UDI on location at 0900 hrs. PTHR and Plan of the Day with UDI personnel.
9.50 Hrs	UDI mob ramp and beam to location. Travel to Mercury and mob GD 2500 Rig to location. Set in beam and ramp. Spot rig on ramp and level same. Hyd. hose on front jack ruptured.Rig engine battery down. Charge battery and raise mast. Set in 7th compressor and NSTec mechanic hook up fuel lines. Receive 3 light plants.
0.50 Hrs	Travel to reporting area.
12.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	08/31/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
30	23	7	5.5	1.27	kelly	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	7	6300	150/200	10bbl/hr	water/foam

Time log: Report Period

0700 Hrs. Tuesday 08/31/10 to 0700 Hrs. Wednesday 09/01/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
9.00 Hrs	UDI rigging up GD 2500 rig and equipment. Hook up air lines from comp. to stand pipe. Complete install of fuel lines for compressors. Install flow line to 42" casing.
1.00 Hrs	Pick up and make up shock sub. Attempt to drill, not enough weight to use shock sub. Lay down shock sub.
5.50 Hrs	Drill 36" hole with hammer from 23' to 30'.
0.50 Hrs	Pull kelly high, shut off air and secure location.
7.00 hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	09/01/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
50	30	20	8.5	2.35	2/3K	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	7	6300	150/200	10bbl/hr	water/foam

Time log: Report Period

0700 Hrs. Wednesday 09/01/10 to 0700 Hrs. Thursday 09/02/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
4.00 Hrs	UDI replace alternator and batteries on rig engine. Repair pin on swivel bail. Work on drawworks clutch. NSTec mechanic repair oil leak on Sulair compressor. Replace stripping rubber on diverter.
3.00 Hrs	Break off hammer and land in cellar. Pick up short 10" collar and two xo subs, make up same.
8.50 Hrs	Drill 36" hole from 30' to 50'.
0.50 Hrs	Pull kelly high. Secure location.
7.00 hrs	No activity.

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Thursday	09/02/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
68	49	19	5.0	3.80	3/4K	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	7	6300	150/200	10bbl/hr	water/foam

Time log: Report Period

0700 Hrs. Thursday 09/02/10 to 0700 Hrs. Friday 09/03/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
7.00 Hrs	Break down short collar and xo subs, lay down same. Lay down kelly and repair repair broken braces on gooseneck on swivel. Pick up kelly and one 8" collar and make up on hammer. Mechanic replace broken studs on diveter head. Install Grant rotating head.
5.00 Hrs	Drill 36" hole from 49' to 68'.
4.00 Hrs	Developed leak on swivel gooseneck. Lay down kelly and pull tools into casing. Secure location.
7.00 hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	09/03/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
85	68	17	10.0	1.70	10K	20/25

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	7	6300	150/250	10bbl/hr	water/foam

Time log: Report Period

0700 Hrs. Friday 09/03/10 to 0700 Hrs. Saturday 09/04/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
5.50 Hrs	Repair leaks on swivel gooseneck with NSTec welder. Replace swivel packing and washpipe. Pick up kelly. Lay down 8" drill collar and pick up shock sub. Pick 8" collar back up and make up tools. Start air and bean pump, gooseneck still leaking. Repair same.
10.00 Hrs	Drill 36" hole from 68' to 85'.
0.50 Hrs	Break off kelly and pull tools high. Secure location.
7.00 hrs	No activity.

Note: Put 7 gallons AWF fluid in compressors #08-614 & 08-615 (14 gals total).

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Saturday	09/04/10	0700	MOP/PKO

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
88	85	3	8.0	0.38	10K	8/16

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	6/7	6300	325/350	N/A	water/foam

Time log: Report Period

0700 Hrs. Saturday 09/04/10 to 0700 Hrs. Sunday 09/05/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
7.50 Hrs	Lay down 8" collar. Make up kelly and run in hole. Break off swivel and kelly hose. Lay down 75 ton swivel and pick up 125 ton swivel. Make up swivel and kelly hose. Pick up 2-8" collars and run in hole.
8.00 Hrs	Drill 36" hole with hammer bit.
0.50 Hrs	Break out kelly and set aside. Pull string one collar high. Secure site.
7.00 hrs	No activity.

Note	Compressors running hot and unable to put all seven on line (on high).

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	09/07/10	0700	MOP/PKO

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
93	88	5	12.0	0.42	10/14K	8/16

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	6/7	6300	325/350	N/A	water/foam

Time log: Report Period

0700 Hrs. Tuesday 09/07/10 to 0700 Hrs. Wednesday 09/08/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
3.50 Hrs	Change out clutch and throw out bearing on rig drawworks. Lay down kelly and tighten hammer union on goose neck. Run in hole and make up kelly.
12.00 Hrs	Drill 36" hole with hammer bit.
0.50 Hrs	Break kelly off and pull string high. Secure location.
7.00 hrs	No activity.

Notes	1730 hrs made total of 3' in 6 hrs (1/2'/hr avg).
	1830 hrs made 1'/hr.
	1930 hrs made 0.75'/hr.
	2030 hrs made only 2-3"/hr.
	2230 hrs made only 2-3" in 2 hrs.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	09/08/10	0700	MOP/PKO

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
94	93	1	14.5	0.06	10/14K	8/16

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	6	5400	300/325	N/A	water/foam

Time log: Report Period

0700 Hrs. Wednesday 09/08/10 to 0700 Hrs. Thursday 09/09/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
1.00 Hrs	Run in the hole. Make up kelly.
14.50 Hrs	Drill 36" hole.
0.50 Hrs	Break off kelly. Pull string high. Secure location.
7.00 hrs	No activity.

Notes	Install pressure gage on rig standpipe, 325psi at comp.and 200psi at rig.
	Install new pressure gage, 325psi at comp and 275psi at rig standpipe.
	Pressure test system to 350psi and no leaks.
	Run light weight on bit and speed up rpm to 35, no change in drilling.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Thursday	09/09/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Thursday 09/09/10 to 0700 Hrs. Friday 09/10/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
6.50 Hrs	Trip out of the hole to check hammer and bit. Lay down 2-8" collars and remove rotating head. Land hammer on 42" casing and remove diverter plate. Lay down shock sub. Lower mast and move rig off ramp. Lay down hammer and bit with fork lift.
2.50 Hrs	Rig up NSTec to run camera in the hole. Run camera to top of fluid at 89'. Rig down camera crew.
0.50 Hrs	Secure location.
13.50 Hrs	No activity.
Note	Take hammer to area 1 Subdock to break down. Visual inspection of hammer seems to reveal broken drive pins on bit spline.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	09/24/10	0700	MOP

Station:	Rig:	User:
Area 15 INF U15N	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Friday 09/24/10 to 0700 Hrs. Saturday 09/25/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
5.50 Hrs	Mob crane to location. Haul 30" mandrel and 2-3/8" tubing tools from area 1 subdock to location. Spot crane and pick up mandrel. Run in hole and land on casing. Spot rig and raise mast. Make up kelly onto mandrel and run in the hole. Mandrel started dragging at 24',stopped at 34.5'. Pull out of the hole and land mandrel on casing. Lay down mast and move rig. Lay down mandrel. Spot rig and raise mast. Rig up tubing tools.
3.50 Hrs	Run in the hole with 2-3/8" tubing. Tag bottom at 93'. Rig up cementers. Pump 425cu/ft typeII cement, CIP @ 1615 hrs. Lay down 2 joints tubing and pull 2 high. Secure location.
14.00 Hrs	No activity.

Notes: Bail 1-1/2 barrels water out of hole#6.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Saturday	09/25/10	0700	MOP

Station:	Rig:	User:
Area 15 INF U15N	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Saturday 09/25/10 to 0700 Hrs. Sunday 09/26/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
1.50 Hrs	Run in hole with 2-3/8" tubing. Tag cement at 48'. Lay down 1 joint of tubing and pick up 2-5' pups. Rig up to cement. Pump 210 cu/ft of typeII cement. CIP at 0930 hrs. Lay down tubing.
3.00 Hrs	Wait on cement. Run in hole and tag at 42'. Cement not set up.
3.00 Hrs	Wait on cement. Run in hole and tag at 24.7'. Lay down tubing.
1.50 Hrs	Rig down cementers. Lay down mast and move rig off ramp. Secure location.
14.00 Hrs	No activity.

Notes	Bail 20 barrels water out of hole #6.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Monday	09/27/10	0700	MOP

Station:	Rig:	User:
Area 15 INF U15N	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Monday 09/27/10 to 0700 Hrs. Tuesday 09/28/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
12.00 Hrs	Load hammer bit,short collars and x-over subs and take to area 1 subdock. Break x-over subs off collar. Make up float sub and 36" stabilizer onto hammer bit. Make up 1- 10" short collar onto bit assembly. Tighten all connections with hydraulic wrench. Load assembly and take back to area 15. Pick up bit assembly and run in hole with crane. Bit stopped at 17'. Try to work down hole will not go past 17'. Pull out of hole and take to subdock. Move in compressors and hook up hoses. Rig up bean pump. Set in flow line and weld to diverter. Secure location.
11.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	09/28/10	0700	MOP

Station:	Rig:	User:
Area 15 INF U15N	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
53	25	28	5.0	5.60	Kelly	10/12

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	4/5	3600/4500	250/325	N/A	water/foam

Time log: Report Period

0700 Hrs. Tuesday 09/28/10 to 0700 Hrs. Wednesday 09/29/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
7.00 Hrs	Go to subdock and remove short collar from bit assembly. Load on truck and take back to location. Pick up bit assembly with crane and land onto 42" casing. Spot rig and raise derrick. Strip plate and Grant head over BHA. Make up kelly and rotating rubber.
5.00 Hrs	Tag cement at 25'. Drill 36" hole with hammer.
1.00 Hrs	Clean and condition hole. Pull kelly high. Secure location.
10.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	09/29/10	0700	MOP

Station:	Rig:	User:
Area 15 INF U15N	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Wednesday 09/29/10 to 0700 Hrs. Thursday 09/30/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
4.00 Hrs	Land BHA on 42" casing. Break off kelly. Lay down mast and move rig. Strip off Grant head and plate. Lay down BHA with crane. Load on truck and take to subdock. Rig up to break off x-over sub with chain wrench and vise. Chain on vise broke while trying to break connection striking employee in chest. All work ceased (stand down).
19.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	10/13/10	0700	MOP

Station:	Rig:	User:
Area 15 Hole #2	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	N/A	10"	9.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Wednesday 10/13/10 to 0700 Hrs. Thursday 10/14/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
4.00 Hrs	Rig down Failing 1500 and move back to hole #2. Rig up and raise mast. Pull instrument package back out of hole.
0.50 Hrs	Lunch break.
5.00 Hrs	Travel to subdock. Break out x-over subs from bit assembly with Atlas Copco hydraulic wrench. Make up short 10" collar and second 36" stabilizer onto BHA. Load BHA onto truck.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	10/15/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
75	53	22	4.0	5.50	12/15K	8/12

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	5	4500	250/300	N/A	water/foam

Time log: Report Period

0700 Hrs. Friday 10/15/10 to 0700 Hrs. Saturday 10/16/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
4.00 Hrs	Pick up bit assembly with crane and run in the hole. Land on 42" casing. Set Grant head on. Spot rig on ramp and raise mast. Make up 10" collar and kelly. Tight hole at 46'.
1.50 Hrs	Ream hole from 46' to 53'.
4.00 Hrs	Drill 36" hole. Ream tight hole from 71' to 75'. Shaft on rotary table transmission twisted apart.
0.50 Hrs	Clean hole and pull kelly high.
2.50 Hrs	Pull rotary table transmission. Secure location.
10.50 Hrs	No activity.

Notes	Pre start meeting with UDI and NSTec personnel. Inspect all cables, drilling line, tugger line, snub lines, slings, blocks, crown and cat head on UDI equipment before start up.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Saturday	10/16/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	5	4500	250/300	N/A	water/foam

Time log: Report Period

0700 Hrs. Saturday 10/16/10 to 0700 Hrs. Sunday 10/17/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
6.00 Hrs	Change out rotary table transmission.
1.00 Hrs	Ream and clean hole from 70' to 75'.
3.00 Hrs	Pull rotating rubber to make connection. Bolts holding rubber onto head missing. Go to subdock and get new bolts. Break off kelly and pick up 8" collar. Put new rubber and bolts on.
2.00 Hrs	Wait on welder.
1.50 Hrs	Tack weld bolts on rotating rubber. Strip rubber onto kelly. Secure site.
9.50 Hrs	No activity.

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Thursday	10/21/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
112	110	2	2.5	0.80	12/14K	8/10

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	5/6	4500/5400	250/300	N/A	water/foam

Time log: Report Period

0700 Hrs. Thursday 10/21/10 to 0700 Hrs. Friday 10/22/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
2.00 Hrs	Replace rotary table U joint.
1.00 Hrs	Drill 36" hole from 110' to 111'. High torque.
1.00 Hrs	Hydraulic hose for tugger busted. Bypass tugger and plug hose. Change out 2" air hose on compressor.
1.50 Hrs	Drill 36" hole from 111' to 112'. High torque. Kelly stock rounded off(4' section) slipping inside kelly bushing. Can not rotate drill string.
4.50 Hrs	Break off kelly and pull 6" collar. Lay down collar. Break swivel and xo subs on kelly and lay down same. Secure location.
13.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	10/22/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Friday 10/22/10 to 0700 Hrs. Saturday 10/23/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
6.00 Hrs	Install new 1" hydraulic hoses for rig tugger. Pick up new kelly. Make up swivel,kelly hose,xo subs and rotary bushing onto kelly. Pick up 6" collar and make up same. Run in the hole and install rotating rubber. Make up kelly and prepare to drill on Monday. Secure location.
17.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	10/26/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
112	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Tuesday 10/26/10 to 0700 Hrs. Wednesday 10/27/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
6.00 Hrs	Break off kelly and set back. Pull out of hole. Heat and break 6" collar and xo sub. Lay down collar. Heat and break 8" collar at xo to 10" collar. Lay down collar. Land bit assembly on 42" casing. Lower mast on rig and prepare to move. Drain bean pump and hoses. Secure location.
2.50 Hrs	Travel to subdock. Load 30" mandrel and 4 1/2" pipe on truck.
14.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	10/27/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Wednesday 10/27/10 to 0700 Hrs. Thursday 10/28/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
2.50 Hrs	Set up 75 ton crane. Pull rig off ramp. Pull bit assembly out of the hole. Bit (36") left in the hole, parted from inside the hammer. Load assembly on truck and take to subdock.
3.00 Hrs	Wait on electric pump and pipe to dewater hole.
2.00 Hrs	Pick up pump and run in hole on 1-1/2" pipe. Set on top of bit.
2.50 Hrs	Start pump to dewater hole. Rig up and run camera in the hole. Lower water to +/- 110'. Able to see top of bit shank in bottom of the hole. Shut off pump and pull camera out of hole. Secure location.
13.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Monday	11/01/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Monday 11/01/10 to 0700 Hrs. Tuesday 11/02/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
2.00 Hrs	Wait on electrician.
3.00 Hrs	Pick up 1 joint of 1-1/2" pipe and run pump to bottom. Electrician hook up pump and start pumping water. Run pump for 1-1/2 hours to lower water below bit shank. Lay down pipe and pump.
6.00 Hrs	Pick up overshot,bumper sub and jars. Make all connections on tools. Run in hole with 6" collars. Make up kelly. Run camera in the hole. Attempt to latch onto fish with overshot. Unable to get over fish. Pull camera out of hole. Trip out with tools to redress tools. Secure location.
12.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	11/02/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Tuesday 11/02/10 to 0700 Hrs. Wednesday 11/03/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
7.00 Hrs	Work on fishing tools. Weld guide skirt onto bottom of overshot. Welder make 18" stabilizer and weld onto short collar 6' above overshot. Make up tools and trip in the hole.
2.50 Hrs	Attempt to latch onto 36" bit (unsuccessful). Pull tools high and prepare to run pump. Secure location.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	11/03/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Wednesday 11/03/10 to 0700 Hrs. Thursday 11/04/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
2.50 Hrs	Pick up electric pump and run in the hole. Dewater hole for 1 hour. Lay down pump.
3.00 Hrs	Run camera in the hole. Fish for bit with overshot and stabilizer. Broke stabilizer off pipe (retrieve same with hook and cable). Unable to get over bit. Pull camera out of hole. Trip out of hole with tools.
5.00 Hrs	Break off overshot and lay down short collar. Bend joint of 4 1/2" drill pipe to approx. 8 degrees. Pick up jars and bumper sub. Make up overshot on bent joint and trip in hole. Latch onto bit and pull free with jars. Trip out of hole with fish. Land on plate on top of casing. Secure location
12.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Thursday	11/04/10	0700	MOP

Station:	Rig:	User:
Area 15 U15N	GD 2500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42	7	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Thursday 11/04/10 to 0700 Hrs. Friday 11/05/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
2.50 Hrs	Release 36" bit from overshot. Break down jars,bumper sub and cross over subs. Lay down tools.
2.00 Hrs	Lay mast down and move rig off ramp. Rig up crane. Pick up 30" mandrel and set in hole. Land on plate on top of casing. Rig down crane. Back rig on ramp and raise mast.
0.50 Hrs	Lunch break.
3.50 Hrs	Run mandrel in hole on 4 1/2" pipe using kelly to lower each joint. Tag bottom at 112'. Trip out of hole. Land mandrel. Lay down mast and move rig. Rig up crane and pull mandrel out of hole. Cover hole with plate. Rig down crane. Secure location.
14.50 Hrs	No activity.

Note: Release UDI at 1530 Hrs.

National Security Technologies, LLC, Daily Operations Reports for drilling of the U-15n 36-inch diameter Source Hole end with the report dated 11/04/10. However, the weekly reports prepared by Dennis Barker, Source Physics Experiment Project Manager, cover the period from November 8, 2010, through April 1, 2011, and provide information regarding the completion of the Source Hole. Relevant drilling information has been extracted from these reports and compiled on the following pages.

November 8–10, 2010

- Demobilized United Drilling, Incorporated (UDI) drill rig.

November 15–24, 2010

- One company has been found that expressed an interest in supporting our drilling with a capable rig. Negotiations will commence via the procurement department with assistance from our drilling engineer.

December 6–10, 2010

- Procurement has an Acquisition Strategy and Plan to acquire the drill rig required to complete the 36-inch bore hole on the proposed SPE schedule.

December 13–17, 2010

- Procurement has issued a task order to UDI under their existing contract to provide an appropriate drill rig to complete the 36-inch bore hole for SPE. The acquisition schedule is intended to place this rig on SPE site by mid-February.

December 20–23, 2010

- Procurement of a drill rig and related equipment is proceeding as planned.

December 26, 2010–January 7, 2011

- A purchase requisition for drilling the explosives canister emplacement bore hole has been signed. The contract award is expected early next week. The drill rig will have 158,000 foot-pounds of rotary torque.
- The regeneration of work packages required to restart drilling operations at the SPE site in Area 15 has been initiated.

January 10–13, 1011

- A Task Order has been awarded to UDI to provide a raise-bore drill rig to complete the 36-inch canister bore hole for the SPE. The drill rig will have a working rotary torque rating of 127,000 foot-pounds and a maximum torque rating of 182,000 foot-pounds, or approximately four times the rotary torque of the previously used drill rig. In addition, the new rig is hydraulic and capable of much finer control of the rotary speed and applied torque. The drill rig will be on location Monday, February 14, 2011.
- The reamers have been sent to the vendor for refurbishing and are on schedule to arrive prior to the mobilization of the drill rig.
- The GearWrench assemblies that require refurbishing are packed and ready for an expected pickup January 13 for shipment to the vendor. They are on schedule to return prior to the mobilization of the drill rig.
- The hammer drill repair parts are ordered; they are in stock and expected to be delivered next week, so work on the hammer drill can be completed before the drill rig is mobilized. A list of spares is under development to hold at Nevada National Security Site (NNSS) to shorten repair time in case of a hammer drill failure.
- The rotary head is in the maintenance shop for refurbishing and is on schedule to be completed prior to the mobilization of the drill rig.

January 18–21, 2011

- The leased drill rig is expected to be on the SPE site on February 14, 2011. Preparations are being made to have all required support equipment on the site and ready to work during the week of February 7.
- The hammer drill repair parts have been received, and the repair will be conducted on schedule to make the drill available prior to the arrival of the rig.

January 24–28, 2011

- The leased drill rig is expected to be on the SPE site on February 14. Preparations are being made to have all required support equipment on the site and ready to work during the week of February 7.

January 31–February 4, 2011

- The leased drill rig is expected to be on the SPE site on February 14. Preparations are being made to have all required support equipment on the site and ready to work during the week of February 7.
- Work packages have been revised as required to resume drilling operations at SPE site.
- The GearWrench tool has been rebuilt and certified by a factory technician.
- Procurements have been placed for equipment, materials, and supplies required to resume drilling operations, and delivery will occur the week of February 7.
- Two highly experienced drillers travelled to Denver, Colorado, to measure and study the drill rig so we can be sure the base platform we build will fit the rig.

February 7–11, 2011

- A management walk-through was conducted on February 8. The SPE drilling location was found to be neat and well maintained with proper work procedures being followed and safety equipment present, in good condition, and being used by the drillers preparing the 36-inch bore hole for resumption of drilling.
- The leased drill rig is expected to be on the SPE site on February 14. Preparations are being made to have all required support equipment on the site and ready to work during the week of February 7, so drilling can commence the week of February 14.
- The hammer drill has been refurbished and additional spare parts ordered against future issues.
- The reamers have arrived and been coupled to the hammer, completing the bottom hole assembly.
- A magnet has been run to capture any metal in the bottom of the 36-inch bore hole from the previous hammer drill failure. An auger bit has been run in the 36-inch bore hole to clean out the muck at the bottom and clear a tight spot at 89 feet. No metal was recovered with either the auger or the magnet, but a chunk of plastic from the hammer failure was recovered.
- A camera run was made after cleaning and dewatering the hole. No metal was observed. There is no obvious place where water is entering the bore hole in any large quantity.

February 14–18, 2011

- The leased drill rig arrived on February 14, 2011. The strong-back support for the rig has been constructed and the anchors set on location. Equipment is ready to commence drilling as soon as the hole can be cleaned and the remaining metal fished out or isolated in the side wall.
- The NSTec auger rig suffered a transmission/gearbox failure while cleaning muck from the bottom of the 36-inch bore hole. The rig is in the mechanic shop where repairs are being expedited. The NSTec auger rig is estimated to be available no earlier than February 28, even with expedited service. To

mitigate this, a local auger rig has been leased and will be on location February 22 to finish cleaning the muck from the bore hole. At that time the hole will be dewatered, a magnet will be run, and a camera run will be made to ascertain whether the lost metal rings from the damaged hammer drill are at the bottom of the bore hole. If so, they will be fished out with the magnet and/or the auger. If they are not found, approximately 10 feet of cement will be pumped in the bore hole to stabilize the lost metal away from the bottom of the hole, and drilling will commence.

February 22–25, 2011

- The rented auger rig completed the task of cleaning the muck from the bottom of the 36-inch hole and recovered some plastic parts that were lost when the hammer drill was damaged.
- A camera run was made, and all indications are that the 36-inch bore hole is stable. There was no visual evidence of the missing steel ring parts in the sidewall or at the bottom of the hole.
- A metal detector was run to the bottom of the hole, and a slight indication was noted.
- Fishing operations with a magnet and compressed air recovered half of the missing hardened-steel retaining ring on Thursday, February 24. Operations will be continued on Friday, in an attempt to recover the second half, if it is on the bottom of the hole.
- On Friday, February 24, cement will be poured to cover the top of the washout at the bottom of the hole (about 10 feet of cement) and isolate any metal fragments that may be in the sidewall of the hole.

February 28–March 4, 2011

- A safety walkdown was conducted this week at the SPE drill site prior to commencing drilling operations with the raise-bore machine. No issues were found.
- The rented raise-bore rig was set in place over the 36-inch bore hole on a custom-made strong-back, and anchored securely in place. The required generator, compressor, and auxiliary equipment were also installed on the SPE drill pad.
- Drilling commenced at 12:15 pm on Thursday, March 3, at 96 feet, the top of the emplaced cement, and continued to 106 feet.
- Drilling resumed on Friday and is proceeding at the expected rate of approximately 2 to 3 feet per hour. The total depth at the end of the day Friday, March 4, is 122 feet.
- The drilling operation suffered two instances of king swivel connection failure. NNSS craft promptly repaired the king swivel connection parts and returned them to service early Friday morning, March 4.

March 7–10, 2011

- Drilling reached the depth of 146 feet.
- The drilling operation incurred very high torque readings (90,000 foot-pounds) while drilling the last few feet. The bottom hole assembly was pulled from the hole and examined. The reamers were found to be damaged and will be sent to Bakersfield, California, for repairs over the weekend. No parts were lost in the hole. Drilling operations are expected to resume on Monday, March 14, using only one reamer to reduce the stress on the drill string and bottom hole assembly.

March 14–18, 2011

- Installed the new drill stem stabilizer and rebuilt the bottom hole assembly (BHA) at the subdock and transported it to the SPE site.
- Lowered the BHA into the hole with a crane and replaced the raise-bore rig over the hole.

- Drilled the 36-inch bore hole to 199 feet. This allows 10 feet of extra hole in case there is some filling in after drilling as has commonly occurred in the recent past.
- Ran the 30-inch diameter test mandrel. The mandrel will not pass 140 feet. The path forward is to obtain an additional reamer/stabilizer, install both reamer/stabilizers about 15 feet apart with a small rotary bit on the bottom of the drill string, and use the assembly to smooth off the corners in the deviated portion of the hole. The purpose of the small bit is to allow circulation to remove cuttings from the hole.

<u>March 21–24, 2011</u>

- The federal facility manager did a safety walkdown of the SPE site and reported there were no issues found.
- The bottom hole assembly was rebuilt with two tungsten carbide coated stabilizers (functioning as reamers) and a 26-inch rotary bit to allow circulation to be established to remove cuttings.
- The BHA was lowered into the hole with a crane, and the raise-bore rig was moved over the hole.
- The emplacement hole was reamed to 195 feet, with special attention to the locations that were tight on the previous mandrel run.
- On Friday, March 25, we plan to pull the pipe, remove the drill rig, remove the bottom hole assembly, place the mandrel in the hole, replace the drill rig, and run the mandrel to total depth to verify the hole is ready to receive the explosive canister.

<u>March 28–April 1, 2011</u>

- The test mandrel was run to 192 feet with no problem, and the 36-inch canister emplacement hole is now able to receive the explosive canister at the required 180-foot depth.
- A caliper log, deviation survey, and camera were run in the 36-inch bore hole. They show the hole is suitable to proceed with the experiment.
- The drilling equipment for the 36-inch bore hole has been removed from the SPE site and transported to the Area 1 drilling yard, where it will remain on standby for use later.

Appendix C-3

NSTec Daily Rig Operations Reports for the 8-Inch-Diameter Instrument Holes (U-15n #1 through U-15n#6)

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	08/20/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	8"	10"	9.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
20	8	12	1.0	12.00	N/A	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
6	1	900	200	10bbls/hr	water/soap

Time log: Report Period

0700 Hrs. Friday 08/20/10 to 0700 Hrs. Saturday 08/21/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
8.00 Hrs	Mob Failing 1500 from equipment yard to location. Mob 3 1/2" drill pipe and 6" flow line from subdock to location. Rig up Failing on hole #3. Set in pipe and racks. Change out 1" hoses on stand pipe and swivel with 2" hoses. Mechanic build diverter head and install 6" flow line. Pick up 8" hammer bit and x over subs. Pick 1 joint 3 1/2" drill pipe.
1.00 Hrs	Drill 8" hole with hammer bit. Tag cement at 8'. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Daily Rig Operations Report

Day:		Date:		Time:		Initials:
Saturday		08/21/10		0700		MOP
Station: Area 15 INF Hole #3			Rig: Failing 1500		User: NNSA/NSO	
Present activity: no activity		Bit size:(inches) 8"	Last csg. Size 10"	Casing Depth: 9.5'	Hole Program Total Depth: 190	
Total Depth:(feet) 150	Drilled from:(feet) 20	Footage Drilled: 130	Rotate Hrs: 8.0	ROP: (ft./hr) 16.25	Wt. on Bit: N/A	RPM: 20/30
Comps. on loc.: 6	Using: 1	CFM: 900	PSI: 200	GPM in/GPM out 10bbls/hr	Type fluid: water/soap	

Time log: Report Period

0700 Hrs. Saturday 08/21/10 to 0700 Hrs. Sunday 08/22/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
8.00 Hrs	Drilling 8" hole with hammer bit.
1.00 Hrs	Trip out of hole, pull bit into casing. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Monday	08/23/10	0700	MOP

Station:	Rig:	User:
Area 15 INF Hole #3	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	8"	10"	9.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
190	150	40	3.0	13.33	N/A	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
6	1	900	200	10bbls/hr	water/soap

Time log: Report Period

0700 Hrs. Monday 08/23/10 to 0700 Hrs. Tuesday 08/24/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
1.50 Hrs	Replace stripping rubber on diverter. Trip in hole with 8" hammer bit. 1" fill.
3.00 Hrs	Drilling 8" hole with hammer bit. TD at 190' on hole #3.
1.50 Hrs	Blow hole dry. Lay down 3-1/2" drill pipe and hammer bit.
3.00 Hrs	Rig down Cardwell 100 and move off 36" hole. Rig down Failing 1500 and move to hole #1. Remove flow line and diverter head from hole #3. Rig up Failing on hole #1. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Tuesday	08/24/10	0700	MOP

Station:	Rig:	User:
Area 15 INF Hole #1	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	8"	10"	6.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
89	6.5	83	6.0	13.75	N/A	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
6	1	900	200	10bbls/hr	water/soap

Time log: Report Period

0700 Hrs. Tuesday 08/24/10 to 0700 Hrs. Wednesday 08/25/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
3.00 Hrs	Finish rigging up Failing 1500. Install flowline and air lines. Pick up and make up hammer bit on 3-1/2" pipe.
6.00 Hrs	Drilling 8" hole with hammer bit and connections.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	08/25/10	0700	MOP

Station:	Rig:	User:
Area 15 INF Hole #1	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	8"	10"	6.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
190	89	101	5.0	20.20	N/A	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
6	1	900	200	10bbls/hr	water/soap

Time log: Report Period

0700 Hrs. Wednesday 08/25/10 to 0700 Hrs. Thursday 08/26/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
0.50 Hrs	Trip in hole, no fill.
5.00 Hrs	Drilling 8" hole with hammer bit and connections. TD hole #1 at 190'.
1.50 Hrs	Blow hole dry. Lay down 3-1/2" drill pipe and hammer bit.
2.00 Hrs	Rig down Failing 1500 and equipment. Move and rig up on hole #6. Move one compressor and bean pump. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Thursday	08/26/10	0700	MOP

Station:	Rig:	User:
Area 15 INF Hole #6	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	8"	10"	6.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
50	7	43	4.0	10.75	N/A	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
6	1	900	200	10bbls/hr	water/soap

Time log: Report Period

0700 Hrs. Thursday 08/26/10 to 0700 Hrs. Friday 08/27/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
4.00 Hrs	Finish rigging up Failing 1500 on hole #6. Install diverter head and flow line. Install sample catcher on flow line. Pick up hammer bit.
0.50 Hrs	Lunch break.
0.50 Hrs	Stand down because of lightning.
4.00 Hrs	Drilling 8" hole with hammer bit and connections. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	08/27/10	0700	MOP

Station:	Rig:	User:
Area 15 INF Hole #6	Failing 1500	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	8"	10"	6.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
190	50	140	7.0	20.00	N/A	20/30

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
6	1	900	200	10bbls/hr	water/soap

Time log: Report Period

0700 Hrs. Friday 08/27/10 to 0700 Hrs. Saturday 08/28/10

1.00 Hrs	Travel from reporting area to location. PTHR and Plan of the Day
0.50 Hrs	Trip in hole, no fill.
7.00 Hrs	Drilling 8" hole and connections. TD at 190' on hole #6.
1.50 Hrs	Blow hole dry. Lay down 3-1/2" pipe and hammer bit. Secure location.
0.50 Hrs	Travel to reporting area.
13.50 Hrs	No activity.

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Wednesday	09/15/10	0700	MOP/CO

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	8	10"	9.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
47	9	38	9.0	4.22	Kelly	10/15

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	1	900	150/325	N/A	water/foam

Time log: Report Period

0700 Hrs. Wednesday 09/15/10 to 0700 Hrs. Thursday 09/16/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
6.50 Hrs	Cut off and move 10" flow line from 42" casing. Move rig and ramp from U15N to hole#2. Nipple up Grant head and diverter. Raise mast and set in equipment. Hook up flow line and air lines. Pick up 6" hammer with 8" bit. Make up tools. Run in hole and tag at 9'.
9.00 Hrs	Drill 8" hole and connections.
0.50 Hrs	Pull kelly high and secure location.
7.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Friday	09/17/10	0700	MOP/MWW

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	8	10"	9.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
192	10	182	6.5	28.00	5/10K	10/15

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	1	900	150/325	N/A	water/foam

Time log: Report Period

0700 Hrs. Friday 09/17/10 to 0700 Hrs. Saturday 09/18/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
6.50 Hrs	Lay down mast on rig. Move rig and ramp from hole #2 to hole #5 and spot same. Remove Grant Head from Hole #2 and nipple up on hole #5. Raise mast and rig up equipment. Install flow line. Set in 2 compressors, manifold, and bean pump. Pick up new 6" hammer and 8" bit.
6.50 Hrs	Drill 8" hole and connections.
2.00 Hrs	Clean and blow water from hole.
1.00 Hrs	Trip out of hole and lay down collars. Secure locations.
7.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Saturday	09/18/10	0700	MOP/MWW

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	8	10"	9.5'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
192	9	183	5.5	33.27	5/10K	10/15

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	1	900	150/325	N/A	water/foam

Time log: Report Period

0700 Hrs. Saturday 09/18/10 to 0700 Hrs. Sunday 09/19/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
5.50 Hrs	Lower mast and rig down equipment. Move compressor from in front of hole #4. Disconnect fuel lines and move fuel tanker. Move and spot ramp on hole #4. Nipple up Grant Head. Spot rig and raise mast. Hook up air lines and flow line. Make up hammer bit. Set in collars.
5.50 Hrs	Drill 8" hole and connections.
1.00 Hrs	Clean hole and blow dry.
1.00 Hrs	Lay down collars and hammer. Secure location.
10.00 Hrs	No activity.

National Security Technologies LLC
Vision • Service • Partnership

Daily Rig Operations Report

Day:	Date:	Time:	Initials:
Monday	09/20/10	0700	MOP

Station:	Rig:	User:
Area 15 INF	GD 2500 UDI	NNSA/NSO

Present activity:	Bit size:(inches)	Last csg. Size	Casing Depth:	Hole Program Total Depth:
no activity	36	42"	7'	190

Total Depth:(feet)	Drilled from:(feet)	Footage Drilled:	Rotate Hrs:	ROP: (ft./hr)	Wt. on Bit:	RPM:
N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comps. on loc.:	Using:	CFM:	PSI:	GPM in/GPM out	Type fluid:
7	N/A	N/A	N/A	N/A	N/A

Time log: Report Period

0700 Hrs. Monday 09/20/10 to 0700 Hrs. Tuesday 09/21/10

1.00 Hrs	Travel to location. PTHR and Plan of the Day.
10.00 Hrs	Lay mast down. Rig down compressors and bean pump. Move fuel tanker and compressors. Move and spot rig and ramp onto hole U15N. Remove Grant Head and flow line from hole #4.Set in air manifold. Move equipment and tools away from holes for loggers. Colog logging holes #1-#6.
13.00 Hrs	No activity.

Notes	Colog on location at 0900 Hrs.
	Hole #1 Fluid at 58.3'. TD at 187.1.
	Hole #2 Fluid at 77'. TD at 191.2.
	Hole #3 Fluid at 58'. TD at 179.2.
	Hole #4 Fluid at 61'. TD at 188.5.
	Hole #5 Fluid at 57.3'. TD at 192.2.
	Hole #6 Fluid at 61.5'. TD at 188.2.

APPENDIX D

Survey Data and Borehole Deviation Data for Source Physics Experiment Holes

Notes for U-15n Borehole Deviation Coordinates

Surface coordinates provided by NSTec Survey Department.

Borehole deviation surveys performed by Colog, a Division of Layne Christensen Company

A/B	As-Built Coordinates (final)
ags	above ground surface
CL	Centerline of casing
Dia	Diameter
ft	feet
GEO	Geographic Coordinate System
GS	Ground Surface
in	inches
L/O	Lay-Out Coordinates (preliminary)
NAD	North American Datum
NAVD	North American Vertical Datum
NGVD	National Geodetic Vertical Datum
SPC	State Plane Coordinate System
TD	Total Depth
TOC	Top of Casing (stickup distance above ground surface)

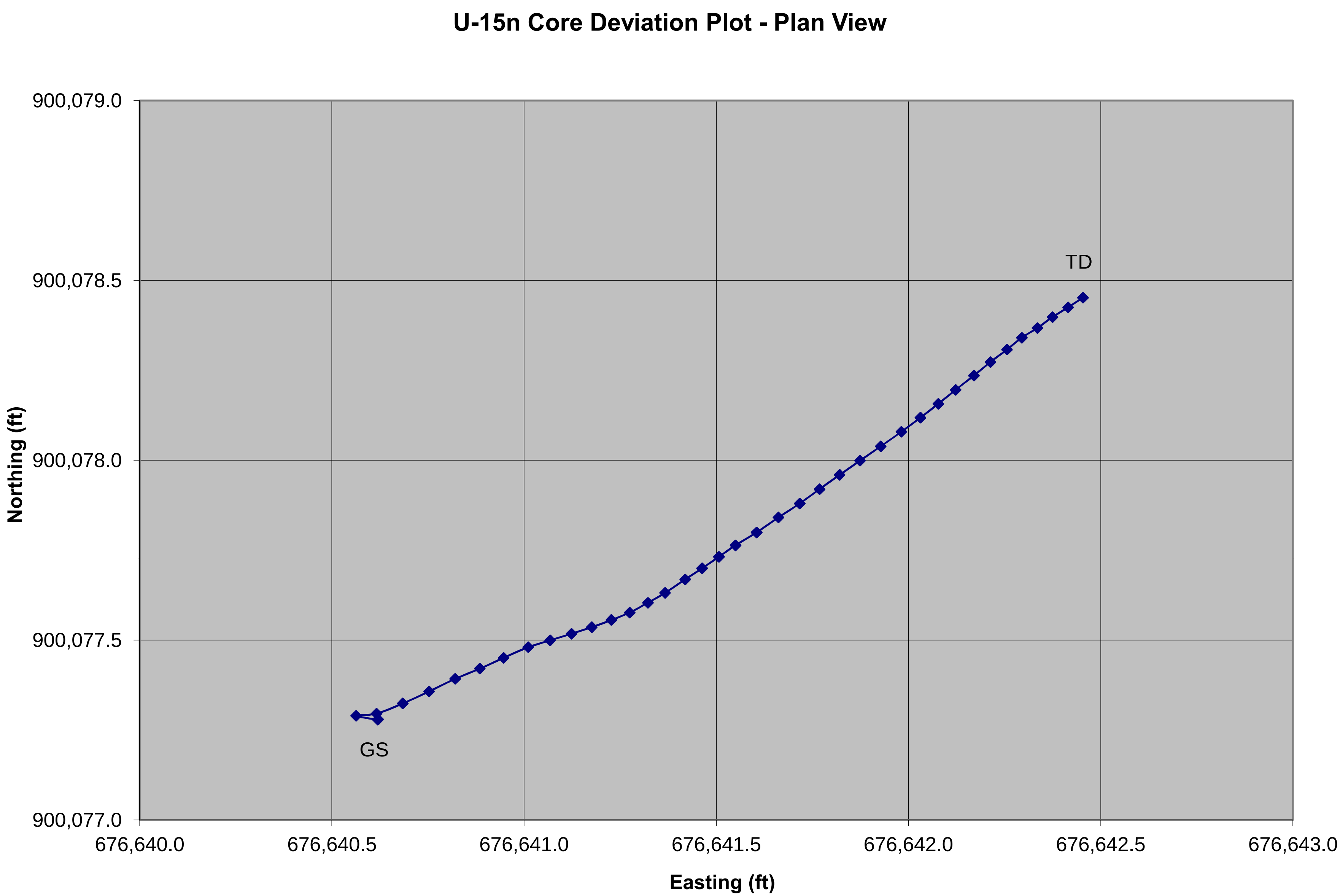
Summary Of U-15n Borehole Surface Coordinates

Hole Name	Survey Report Date	Survey Type	Reference Point	Northing feet	Easting feet	Elevation feet
				Nevada SPC NAD27		NGVD29
U-15n	6/23/2010	L/O	GS	900,077.65	676,640.92	5,003.12
U-15n	5/26/2011	A/B	TOC CL	900,077.22	676,640.60	5,002.37
U-15n	8/18/2011	A/B	TOC CL	900,077.22	676,640.60	5,002.37
U-15n	11/29/2011	A/B	TOC CL	900,077.28	676,640.62	5,002.42
U-15n	12/14/2011	A/B	TOC CL	900,077.28	676,640.62	5,002.42
U-15n#1	6/23/2010	L/O	GS	900,107.23	676,655.11	5,003.19
U-15n#1	5/26/2011	A/B	TOC CL	900,106.97	676,655.15	5,002.60
U-15n#1	8/18/2011	A/B	TOC CL	900,106.97	676,655.15	5,002.60
U-15n#1	12/14/2011	A/B	TOC CL	900,107.01	676,655.17	5,002.60
U-15n#1A	8/18/2011	L/O	GS	900,109.95	676,645.65	-
U-15n#1A	12/14/2011	A/B	TOC CL	900,109.89	676,645.66	5,002.60
U-15n#2	6/23/2010	L/O	GS	900,075.16	676,608.20	5,003.28
U-15n#2	5/26/2011	A/B	TOC CL	900,075.28	676,608.56	5,002.81
U-15n#2	8/18/2011	A/B	TOC CL	900,075.28	676,608.56	5,002.81
U-15n#2	12/14/2011	A/B	TOC CL	900,075.27	676,608.54	5,002.81
U-15n#3	6/23/2010	L/O	GS	900,050.57	676,659.44	5,002.85
U-15n#3	5/26/2011	A/B	TOC CL	900,050.70	676,659.44	5,002.18
U-15n#3	8/18/2011	A/B	TOC CL	900,050.70	676,659.44	5,002.18
U-15n#3	12/14/2011	A/B	TOC CL	900,050.67	676,659.48	5,002.26
U-15n#4	6/23/2010	L/O	GS	900,018.49	676,612.53	5,002.79
U-15n#4	5/26/2011	A/B	TOC CL	900,018.53	676,612.52	5,002.29
U-15n#4	8/18/2011	A/B	TOC CL	900,018.53	676,612.52	5,002.29
U-15n#4	12/14/2011	A/B	TOC CL	900,018.48	676,612.53	5,002.34
U-15n#5	6/23/2010	L/O	GS	900,082.65	676,706.35	5,001.27
U-15n#5	5/26/2011	A/B	TOC CL	900,082.68	676,706.48	5,001.94
U-15n#5	8/18/2011	A/B	TOC CL	900,082.68	676,706.48	5,001.94
U-15n#5	12/14/2011	A/B	TOC CL	900,082.71	676,706.51	5,001.94
U-15n#6	6/23/2010	L/O	GS	900,131.82	676,603.88	5,005.10
U-15n#6	5/26/2011	A/B	TOC CL	900,131.71	676,603.87	5,005.72
U-15n#6	8/18/2011	A/B	TOC CL	900,131.71	676,603.87	5,005.72
U-15n#6	12/14/2011	A/B	TOC CL	900,131.75	676,603.86	5,005.69

U-15n Core

Spud: 7/26/2010	BH Dia: 3.8125 in	Data: s-Built 11/29/11 (source ho
Completion: 7/28/2010	TD: 196 ft	TOC: 0.60 ft ags

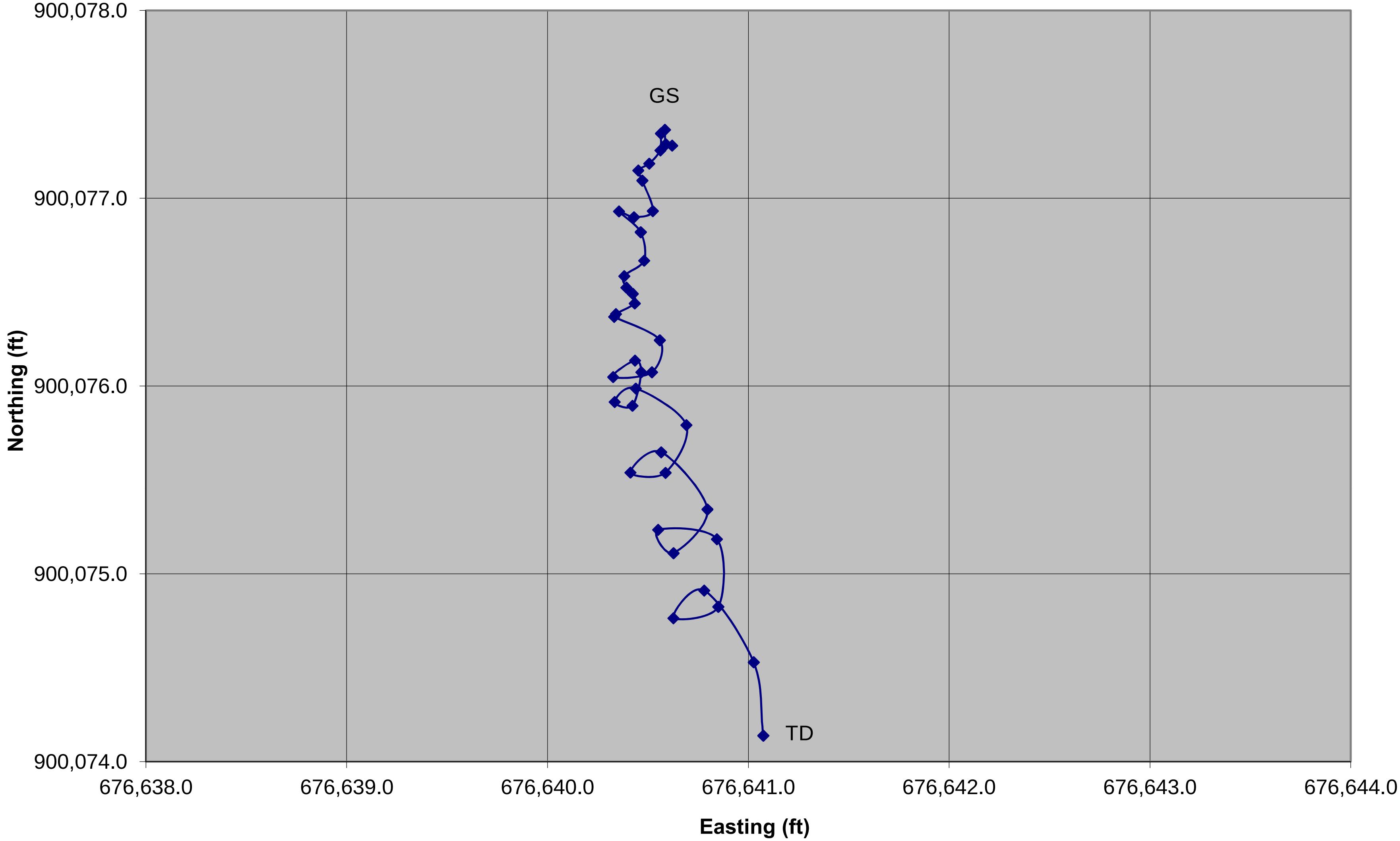
Vertical Depth	Northing	Easting	Elevation	Latitude	Longitude	Elevation
	SPC NAD27 ft		NGVD29 ft	GEO NAD83 deg		NAVD88 ft
0.00	900,077.28	676,640.62	5,001.82	37.221195	116.060867	5005.13
5.20	900,077.28	676,640.62	4,996.62	37.221195	116.060867	4999.93
10.00	900,077.29	676,640.56	4,991.82	37.221195	116.060867	4995.13
15.00	900,077.30	676,640.62	4,986.82	37.221195	116.060867	4990.13
20.00	900,077.32	676,640.68	4,981.82	37.221195	116.060867	4985.13
25.00	900,077.36	676,640.75	4,976.82	37.221195	116.060867	4980.13
30.00	900,077.39	676,640.82	4,971.82	37.221195	116.060866	4975.13
35.00	900,077.42	676,640.88	4,966.82	37.221195	116.060866	4970.13
40.00	900,077.45	676,640.95	4,961.82	37.221195	116.060866	4965.13
45.00	900,077.48	676,641.01	4,956.82	37.221195	116.060866	4960.13
50.00	900,077.50	676,641.07	4,951.82	37.221195	116.060866	4955.13
54.99	900,077.52	676,641.12	4,946.83	37.221195	116.060865	4950.13
59.99	900,077.54	676,641.18	4,941.83	37.221195	116.060865	4945.13
64.99	900,077.56	676,641.23	4,936.83	37.221195	116.060865	4940.13
69.99	900,077.58	676,641.27	4,931.83	37.221195	116.060865	4935.13
74.99	900,077.60	676,641.32	4,926.83	37.221196	116.060865	4930.13
79.99	900,077.63	676,641.37	4,921.83	37.221196	116.060864	4925.13
84.99	900,077.67	676,641.42	4,916.83	37.221196	116.060864	4920.13
89.99	900,077.70	676,641.46	4,911.83	37.221196	116.060864	4915.13
94.99	900,077.73	676,641.51	4,906.83	37.221196	116.060864	4910.14
99.99	900,077.76	676,641.55	4,901.83	37.221196	116.060864	4905.14
104.99	900,077.80	676,641.60	4,896.83	37.221196	116.060864	4900.14
109.99	900,077.84	676,641.66	4,891.83	37.221196	116.060863	4895.14
114.99	900,077.88	676,641.72	4,886.83	37.221196	116.060863	4890.14
119.99	900,077.92	676,641.77	4,881.83	37.221196	116.060863	4885.14
124.99	900,077.96	676,641.82	4,876.83	37.221196	116.060863	4880.14
129.99	900,078.00	676,641.87	4,871.83	37.221197	116.060863	4875.14
134.99	900,078.04	676,641.93	4,866.83	37.221197	116.060863	4870.14
139.99	900,078.08	676,641.98	4,861.83	37.221197	116.060862	4865.14
144.99	900,078.12	676,642.03	4,856.83	37.221197	116.060862	4860.14
149.99	900,078.16	676,642.08	4,851.83	37.221197	116.060862	4855.14
154.99	900,078.20	676,642.12	4,846.83	37.221197	116.060862	4850.14
159.99	900,078.24	676,642.17	4,841.83	37.221197	116.060862	4845.14
164.99	900,078.27	676,642.21	4,836.83	37.221197	116.060862	4840.14
169.99	900,078.31	676,642.26	4,831.83	37.221197	116.060861	4835.14
174.99	900,078.34	676,642.29	4,826.83	37.221198	116.060861	4830.14
179.99	900,078.37	676,642.34	4,821.83	37.221198	116.060861	4825.14
184.99	900,078.40	676,642.37	4,816.83	37.221198	116.060861	4820.14
189.99	900,078.43	676,642.42	4,811.84	37.221198	116.060861	4815.14
194.59	900,078.45	676,642.45	4,807.24	37.221198	116.060861	4810.54


U-15n Core Deviation Plot - Plan View
900,079.0
900,078.5
900,078.0
900,077.5
900,077.0
Northing (ft)
676,640.0
676,640.5
676,641.0
676,641.5
676,642.0
676,642.5
676,643.0
Easting (ft)
TD
GS

U-15n Source

Spud: 8/5/2010 Compl: 3/17/2011		BH Dia: 36 in TD: 199 ft		Data: TOC:	As-Built 12/14/11 0.60 ft ags	
Vertical Depth	Northing	Easting	Elevation	Latitude	Longitude	Elevation
	SPC NAD27 ft		NGVD29 ft	GEO NAD83 deg		NAVD88 ft
0.00	900,077.28	676,640.62	5,001.82	37.221195	116.060867	5005.13
5.00	900,077.29	676,640.59	4,996.82	37.221195	116.060867	5000.13
9.99	900,077.36	676,640.58	4,991.83	37.221195	116.060867	4995.14
14.99	900,077.34	676,640.56	4,986.83	37.221195	116.060867	4990.14
19.98	900,077.26	676,640.56	4,981.84	37.221195	116.060867	4985.15
24.97	900,077.18	676,640.51	4,976.85	37.221194	116.060867	4980.15
29.97	900,077.15	676,640.45	4,971.85	37.221194	116.060868	4975.16
34.96	900,077.09	676,640.47	4,966.86	37.221194	116.060868	4970.16
39.95	900,076.93	676,640.52	4,961.87	37.221194	116.060867	4965.17
44.95	900,076.90	676,640.43	4,956.87	37.221194	116.060868	4960.18
49.94	900,076.93	676,640.36	4,951.88	37.221194	116.060868	4955.19
54.93	900,076.82	676,640.46	4,946.89	37.221193	116.060868	4950.19
59.93	900,076.67	676,640.48	4,941.89	37.221193	116.060868	4945.20
64.92	900,076.59	676,640.38	4,936.90	37.221193	116.060868	4940.21
69.91	900,076.52	676,640.39	4,931.91	37.221193	116.060868	4935.21
74.91	900,076.49	676,640.42	4,926.91	37.221192	116.060868	4930.22
79.90	900,076.44	676,640.43	4,921.92	37.221192	116.060868	4925.22
84.90	900,076.38	676,640.34	4,916.92	37.221192	116.060868	4920.23
89.89	900,076.37	676,640.33	4,911.93	37.221192	116.060868	4915.24
94.88	900,076.24	676,640.56	4,906.94	37.221192	116.060867	4910.25
99.87	900,076.07	676,640.52	4,901.95	37.221191	116.060867	4905.26
104.86	900,076.05	676,640.33	4,896.96	37.221191	116.060868	4900.27
109.85	900,076.14	676,640.44	4,891.97	37.221192	116.060868	4895.28
114.85	900,076.07	676,640.47	4,886.98	37.221191	116.060868	4890.28
119.84	900,075.89	676,640.42	4,881.98	37.221191	116.060868	4885.29
124.83	900,075.92	676,640.33	4,876.99	37.221191	116.060868	4880.30
129.82	900,075.99	676,640.44	4,872.00	37.221191	116.060868	4875.31
134.81	900,075.79	676,640.69	4,867.01	37.221191	116.060867	4870.32
139.79	900,075.54	676,640.59	4,862.03	37.221190	116.060867	4865.34
144.78	900,075.54	676,640.41	4,857.04	37.221190	116.060868	4860.34
149.77	900,075.65	676,640.57	4,852.05	37.221190	116.060867	4855.35
154.75	900,075.34	676,640.80	4,847.07	37.221189	116.060866	4850.38
159.74	900,075.11	676,640.63	4,842.09	37.221189	116.060867	4845.39
164.73	900,075.23	676,640.55	4,837.09	37.221189	116.060867	4840.40
169.71	900,075.18	676,640.84	4,832.11	37.221189	116.060866	4835.42
174.69	900,074.82	676,640.85	4,827.13	37.221188	116.060866	4830.44
179.68	900,074.76	676,640.63	4,822.14	37.221188	116.060867	4825.45
184.67	900,074.91	676,640.78	4,817.15	37.221188	116.060867	4820.46
189.64	900,074.53	676,641.03	4,812.18	37.221187	116.060866	4815.49
192.61	900,074.14	676,641.07	4,809.21	37.221186	116.060866	4812.52

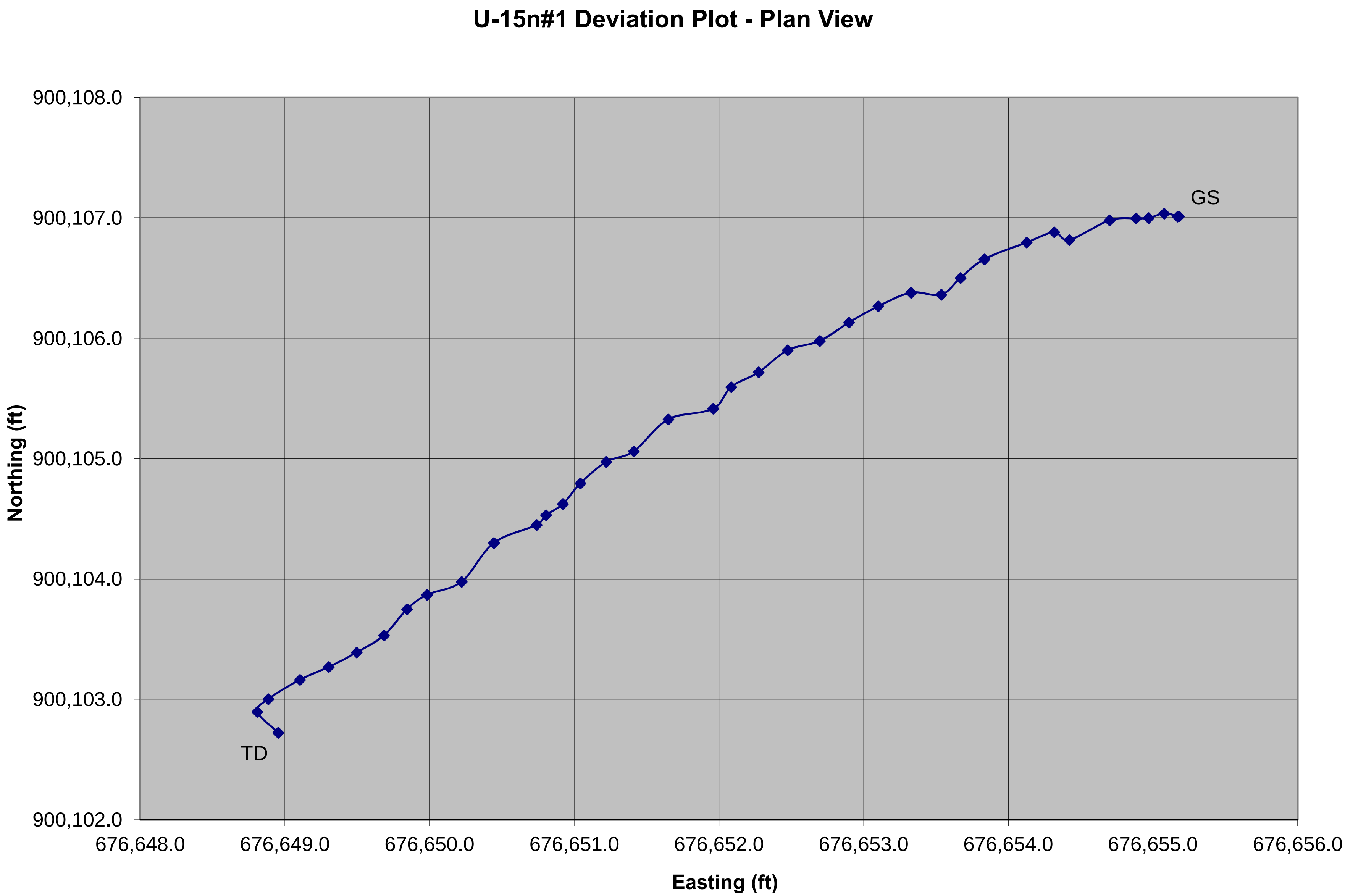
U-15n Source Deviation Plot - Plan View



U-15n#1

Spud: 8/24/2010	BH Dia: 8 in	Data: As-Built 12/14/11
Compl: 8/25/2010	TD: 190 ft	TOC: 0.60 ft ags

Vertical Depth	Northing	Easting	Elevation	Latitude	Longitude	Elevation
	SPC NAD27 ft		NGVD29 ft	GEO NAD83 deg		NAVD88 ft
0.00	900,107.01	676,655.17	5,002.00	37.221276	116.060816	5005.31
5.00	900,107.01	676,655.18	4,997.00	37.221276	116.060816	5000.31
10.00	900,107.04	676,655.08	4,992.00	37.221276	116.060817	4995.31
15.00	900,107.00	676,654.97	4,987.00	37.221276	116.060817	4990.31
20.00	900,107.00	676,654.88	4,982.00	37.221276	116.060817	4985.31
24.99	900,106.98	676,654.70	4,977.01	37.221276	116.060818	4980.31
29.98	900,106.82	676,654.42	4,972.02	37.221276	116.060819	4975.32
34.98	900,106.88	676,654.32	4,967.02	37.221276	116.060819	4970.33
39.98	900,106.79	676,654.13	4,962.02	37.221275	116.060820	4965.33
44.97	900,106.66	676,653.83	4,957.03	37.221275	116.060821	4960.34
49.96	900,106.50	676,653.67	4,952.04	37.221275	116.060822	4955.35
54.96	900,106.36	676,653.54	4,947.04	37.221274	116.060822	4950.35
59.95	900,106.38	676,653.33	4,942.05	37.221274	116.060823	4945.35
64.95	900,106.27	676,653.10	4,937.05	37.221274	116.060824	4940.36
69.94	900,106.13	676,652.90	4,932.06	37.221274	116.060824	4935.37
74.93	900,105.98	676,652.70	4,927.07	37.221273	116.060825	4930.37
79.93	900,105.90	676,652.47	4,922.07	37.221273	116.060826	4925.38
84.92	900,105.72	676,652.27	4,917.08	37.221273	116.060826	4920.39
89.92	900,105.59	676,652.08	4,912.08	37.221272	116.060827	4915.39
94.91	900,105.41	676,651.96	4,907.09	37.221272	116.060827	4910.40
99.90	900,105.33	676,651.65	4,902.10	37.221271	116.060829	4905.41
104.89	900,105.06	676,651.41	4,897.11	37.221271	116.060829	4900.42
109.88	900,104.97	676,651.22	4,892.12	37.221271	116.060830	4895.42
114.88	900,104.79	676,651.04	4,887.12	37.221270	116.060831	4890.43
119.87	900,104.62	676,650.92	4,882.13	37.221270	116.060831	4885.43
124.87	900,104.53	676,650.80	4,877.13	37.221269	116.060831	4880.44
129.87	900,104.45	676,650.74	4,872.13	37.221269	116.060832	4875.44
134.86	900,104.30	676,650.44	4,867.14	37.221269	116.060833	4870.45
139.84	900,103.98	676,650.22	4,862.16	37.221268	116.060833	4865.46
144.84	900,103.87	676,649.98	4,857.16	37.221268	116.060834	4860.47
149.83	900,103.75	676,649.84	4,852.17	37.221267	116.060835	4855.47
154.83	900,103.53	676,649.68	4,847.17	37.221267	116.060835	4850.48
159.82	900,103.39	676,649.50	4,842.18	37.221266	116.060836	4845.49
164.82	900,103.27	676,649.30	4,837.18	37.221266	116.060837	4840.49
169.81	900,103.16	676,649.10	4,832.19	37.221266	116.060837	4835.50
174.80	900,103.00	676,648.89	4,827.20	37.221265	116.060838	4830.50
179.80	900,102.90	676,648.81	4,822.20	37.221265	116.060838	4825.51
184.80	900,102.72	676,648.95	4,817.20	37.221264	116.060838	4820.51



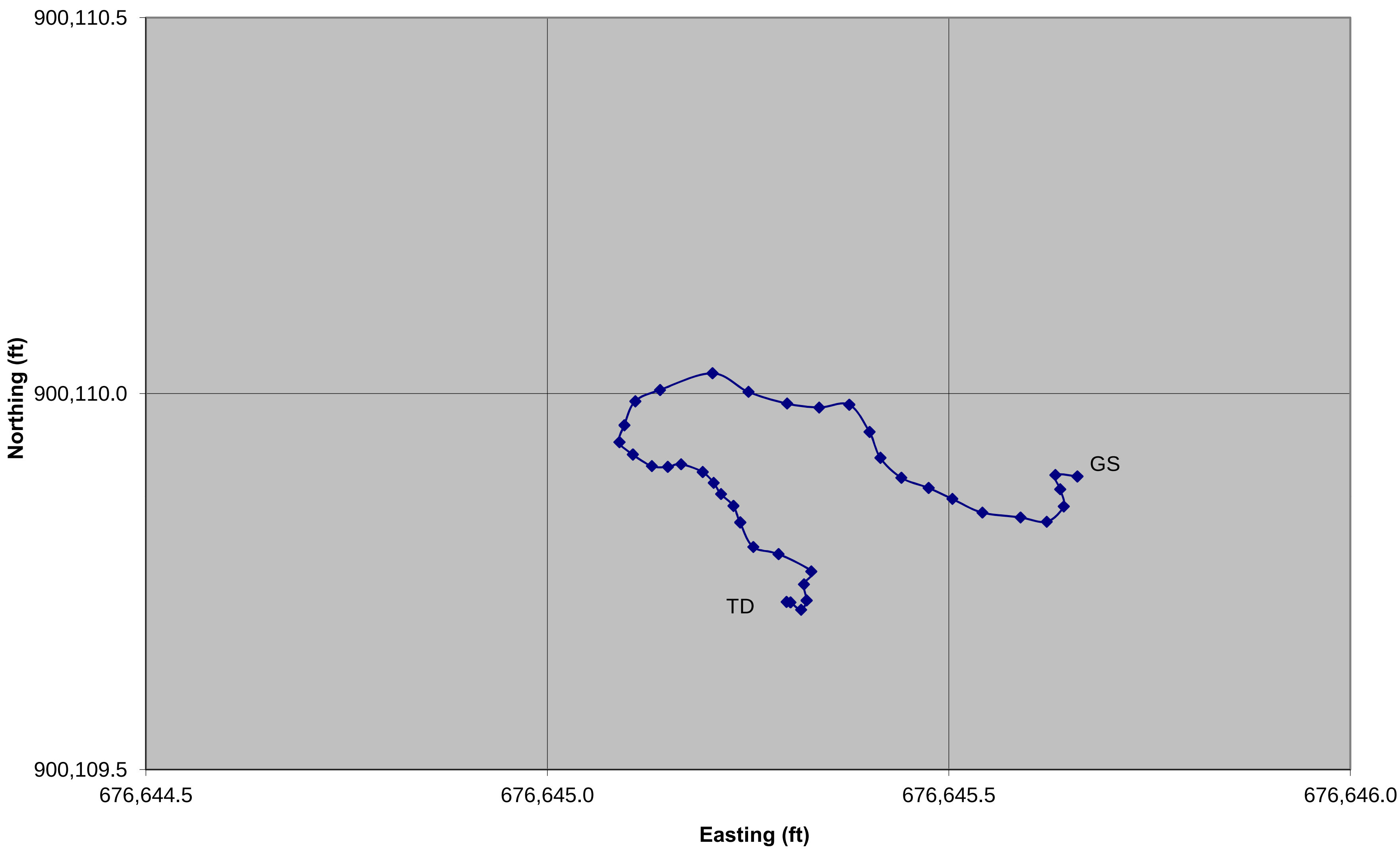
U-15n#1 Deviation Plot - Plan View
900,108.0
900,107.0
900,106.0
900,105.0
900,104.0
900,103.0
900,102.0
Northing (ft)
676,648.0
676,649.0
676,650.0
676,651.0
676,652.0
676,653.0
676,654.0
676,655.0
676,656.0
Easting (ft)
GS
TD

U-15n#1A

Spud: 8/25/2011	BH Dia: 8 in	Data: As-Built 12/14/11
Compl: 8/27/2011	TD: 194 ft	TOC: 0.49 ft ags

Vertical Depth	Northing SPC NAD27 ft	Easting SPC NAD27 ft	Elevation NGVD29 ft	Latitude GEO NAD83 deg	Longitude GEO NAD83 deg	Elevation NAVD88 ft
0.00	900,109.89	676,645.66	5,002.11	37.221284	116.060849	5005.42
5.50	900,109.89	676,645.66	4,996.61	37.221284	116.060849	4999.92
10.50	900,109.89	676,645.63	4,991.61	37.221284	116.060849	4994.92
15.50	900,109.87	676,645.64	4,986.61	37.221284	116.060849	4989.92
20.50	900,109.85	676,645.64	4,981.61	37.221284	116.060849	4984.92
25.50	900,109.83	676,645.62	4,976.61	37.221284	116.060849	4979.92
30.50	900,109.84	676,645.59	4,971.61	37.221284	116.060849	4974.92
35.50	900,109.84	676,645.54	4,966.61	37.221284	116.060849	4969.92
40.50	900,109.86	676,645.50	4,961.61	37.221284	116.060850	4964.92
45.50	900,109.87	676,645.47	4,956.61	37.221284	116.060850	4959.92
50.50	900,109.89	676,645.44	4,951.61	37.221284	116.060850	4954.92
55.50	900,109.91	676,645.41	4,946.61	37.221284	116.060850	4949.92
60.50	900,109.95	676,645.40	4,941.61	37.221284	116.060850	4944.92
65.50	900,109.99	676,645.38	4,936.61	37.221284	116.060850	4939.92
70.50	900,109.98	676,645.34	4,931.61	37.221284	116.060850	4934.92
75.50	900,109.99	676,645.30	4,926.61	37.221284	116.060850	4929.92
80.50	900,110.00	676,645.25	4,921.61	37.221284	116.060850	4924.92
85.50	900,110.03	676,645.21	4,916.61	37.221285	116.060851	4919.92
90.50	900,110.00	676,645.14	4,911.61	37.221284	116.060851	4914.92
95.50	900,109.99	676,645.11	4,906.61	37.221284	116.060851	4909.92
100.50	900,109.96	676,645.10	4,901.61	37.221284	116.060851	4904.92
105.50	900,109.94	676,645.09	4,896.61	37.221284	116.060851	4899.92
110.50	900,109.92	676,645.11	4,891.61	37.221284	116.060851	4894.92
115.50	900,109.90	676,645.13	4,886.61	37.221284	116.060851	4889.92
120.50	900,109.90	676,645.15	4,881.61	37.221284	116.060851	4884.92
125.50	900,109.91	676,645.17	4,876.61	37.221284	116.060851	4879.92
130.50	900,109.90	676,645.19	4,871.61	37.221284	116.060851	4874.92
135.50	900,109.88	676,645.21	4,866.61	37.221284	116.060851	4869.92
140.50	900,109.87	676,645.22	4,861.61	37.221284	116.060851	4864.92
145.50	900,109.85	676,645.23	4,856.61	37.221284	116.060851	4859.92
150.50	900,109.83	676,645.24	4,851.61	37.221284	116.060850	4854.92
160.50	900,109.80	676,645.26	4,841.61	37.221284	116.060850	4844.92
165.50	900,109.79	676,645.29	4,836.62	37.221284	116.060850	4839.92
170.50	900,109.76	676,645.33	4,831.62	37.221284	116.060850	4834.92
175.50	900,109.75	676,645.32	4,826.62	37.221284	116.060850	4829.92
180.50	900,109.72	676,645.32	4,821.62	37.221284	116.060850	4824.92
185.50	900,109.71	676,645.32	4,816.62	37.221284	116.060850	4819.92
190.50	900,109.72	676,645.30	4,811.62	37.221284	116.060850	4814.92
192.50	900,109.72	676,645.30	4,809.62	37.221284	116.060850	4812.92

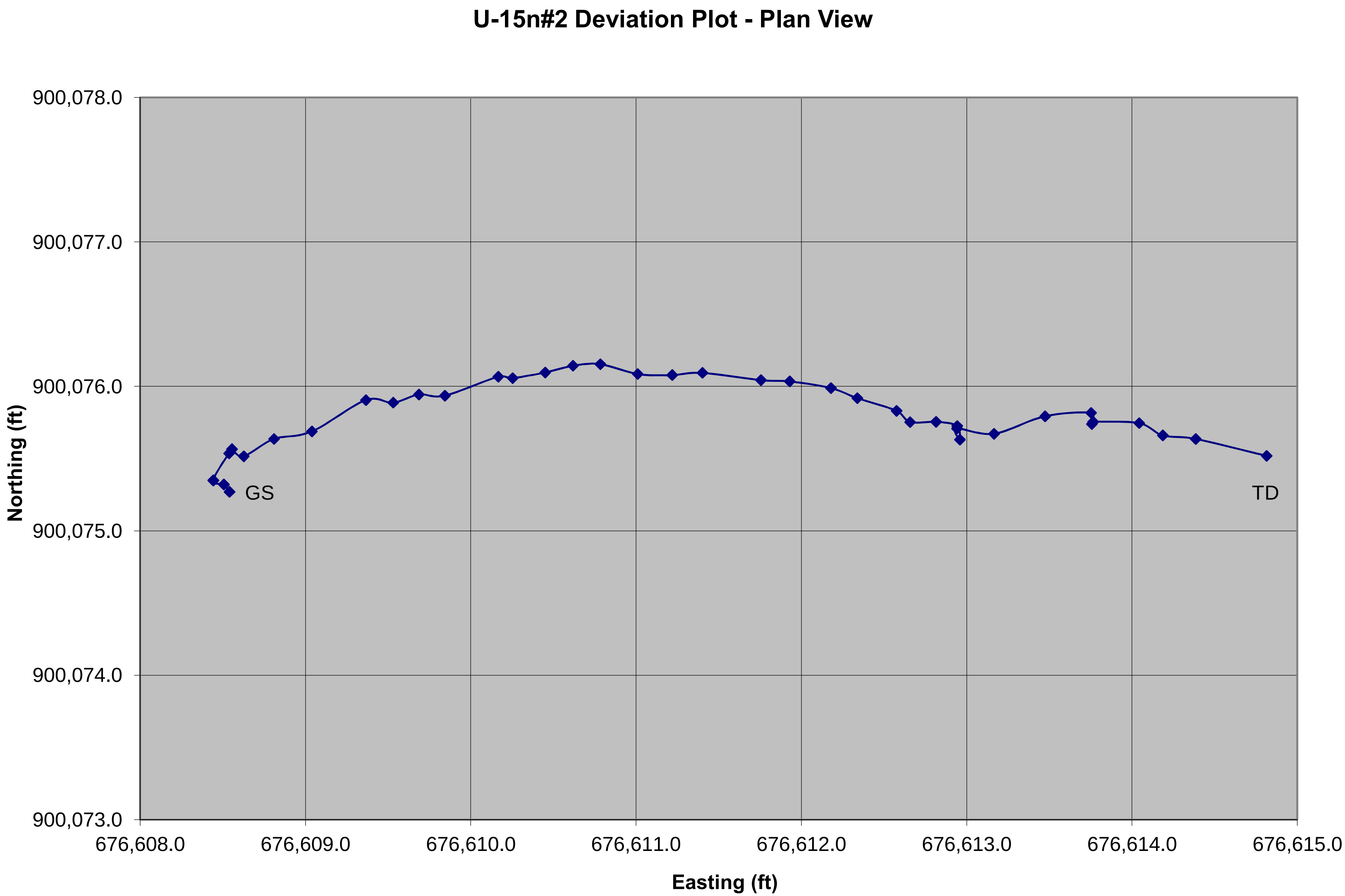
U-15n#1A Core Deviation Plot - Plan View



U-15n#2

Spud: 9/15/2010	BH Dia: 8 in	Data: As-Built 12/14/11
Compl: 9/16/2010	TD: 191.2 ft	TOC: 0.65 ft ags

Vertical Depth	Northing SPC NAD27 ft	Easting SPC NAD27 ft	Elevation NGVD29 ft	Latitude GEO NAD83 deg	Longitude GEO NAD83 deg	Elevation NAVD88 ft
0.00	900,075.27	676,608.54	5,002.16	37.221190	116.060977	5005.47
5.00	900,075.32	676,608.51	4,997.16	37.221190	116.060977	5000.47
10.00	900,075.35	676,608.44	4,992.16	37.221190	116.060978	4995.47
14.99	900,075.54	676,608.54	4,987.17	37.221190	116.060977	4990.47
19.99	900,075.57	676,608.55	4,982.17	37.221191	116.060977	4985.47
24.99	900,075.52	676,608.63	4,977.17	37.221190	116.060977	4980.47
29.99	900,075.64	676,608.81	4,972.17	37.221191	116.060976	4975.48
34.98	900,075.69	676,609.04	4,967.18	37.221191	116.060976	4970.48
39.97	900,075.91	676,609.37	4,962.19	37.221191	116.060974	4965.50
44.97	900,075.89	676,609.53	4,957.19	37.221191	116.060974	4960.50
49.96	900,075.94	676,609.69	4,952.20	37.221192	116.060973	4955.50
54.96	900,075.94	676,609.84	4,947.20	37.221191	116.060973	4950.51
59.95	900,076.07	676,610.17	4,942.21	37.221192	116.060972	4945.52
64.95	900,076.06	676,610.25	4,937.21	37.221192	116.060971	4940.52
69.94	900,076.10	676,610.45	4,932.22	37.221192	116.060971	4935.52
74.94	900,076.14	676,610.62	4,927.22	37.221192	116.060970	4930.53
79.94	900,076.15	676,610.78	4,922.22	37.221192	116.060970	4925.53
84.93	900,076.09	676,611.01	4,917.23	37.221192	116.060969	4920.54
89.93	900,076.08	676,611.22	4,912.23	37.221192	116.060968	4915.54
94.92	900,076.09	676,611.40	4,907.24	37.221192	116.060967	4910.54
99.91	900,076.04	676,611.75	4,902.25	37.221192	116.060966	4905.56
104.91	900,076.03	676,611.93	4,897.25	37.221192	116.060966	4900.56
109.90	900,075.99	676,612.18	4,892.26	37.221192	116.060965	4895.57
114.90	900,075.92	676,612.34	4,887.26	37.221191	116.060964	4890.57
119.89	900,075.83	676,612.58	4,882.27	37.221191	116.060963	4885.58
124.89	900,075.75	676,612.66	4,877.27	37.221191	116.060963	4880.58
129.89	900,075.76	676,612.81	4,872.27	37.221191	116.060963	4875.58
134.89	900,075.73	676,612.94	4,867.27	37.221191	116.060962	4870.58
139.89	900,075.63	676,612.96	4,862.27	37.221191	116.060962	4865.58
144.89	900,075.71	676,612.94	4,857.27	37.221191	116.060962	4860.58
149.88	900,075.67	676,613.16	4,852.28	37.221191	116.060961	4855.59
154.87	900,075.79	676,613.47	4,847.29	37.221191	116.060960	4850.60
159.86	900,075.82	676,613.75	4,842.30	37.221191	116.060959	4845.61
164.86	900,075.74	676,613.76	4,837.30	37.221191	116.060959	4840.61
169.86	900,075.75	676,613.76	4,832.30	37.221191	116.060959	4835.61
174.85	900,075.75	676,614.04	4,827.31	37.221191	116.060958	4830.61
179.85	900,075.66	676,614.19	4,822.31	37.221191	116.060958	4825.62
184.85	900,075.64	676,614.38	4,817.31	37.221191	116.060957	4820.62
189.83	900,075.52	676,614.81	4,812.33	37.221190	116.060956	4815.64



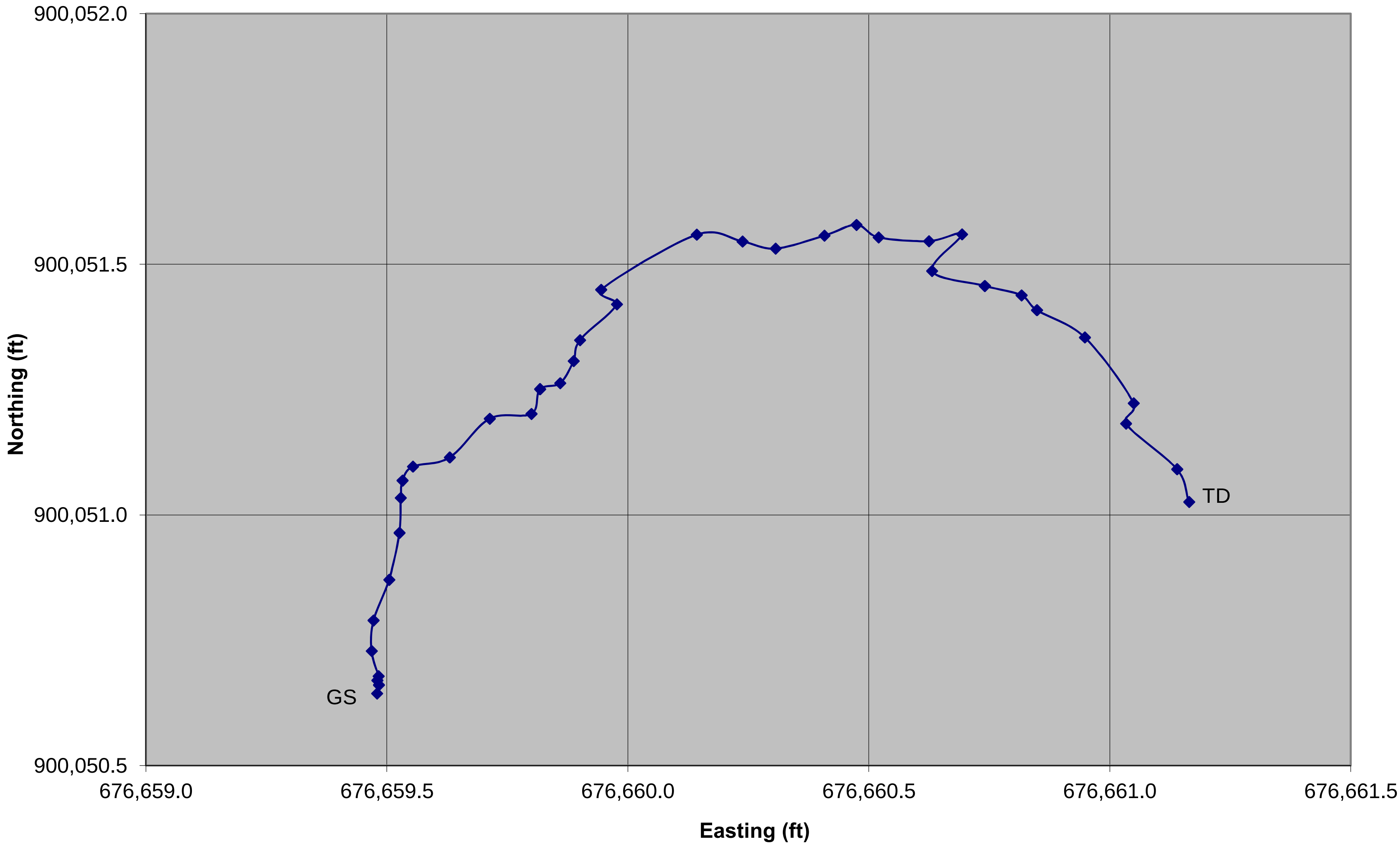
U-15n#2 Deviation Plot - Plan View
900,078.0
900,077.0
900,076.0
900,075.0
900,074.0
900,073.0
Northing (ft)
676,608.0
676,609.0
676,610.0
676,611.0
676,612.0
676,613.0
676,614.0
676,615.0
Easting (ft)
GS
TD

U-15n#3

Spud: 8/21/2010	BH Dia: 8 in	Data: As-Built 12/14/11
Compl: 8/23/2010	TD: 190 ft	TOC: 0.60 ft ags

Vertical Depth	Northing	Easting	Elevation	Latitude	Longitude	Elevation
	SPC NAD27 ft		NGVD29 ft	GEO NAD83 deg		NAVD88 ft
0.00	900,050.67	676,659.48	5,001.66	37.221121	116.060803	5004.97
5.00	900,050.64	676,659.48	4,996.66	37.221121	116.060803	4999.97
10.00	900,050.66	676,659.48	4,991.66	37.221121	116.060803	4994.97
15.00	900,050.68	676,659.48	4,986.66	37.221121	116.060803	4989.97
20.00	900,050.73	676,659.47	4,981.66	37.221121	116.060803	4984.97
25.00	900,050.79	676,659.47	4,976.66	37.221122	116.060803	4979.97
30.00	900,050.87	676,659.50	4,971.66	37.221122	116.060803	4974.97
35.00	900,050.96	676,659.53	4,966.66	37.221122	116.060803	4969.97
40.00	900,051.03	676,659.53	4,961.66	37.221122	116.060803	4964.97
45.00	900,051.07	676,659.53	4,956.66	37.221122	116.060803	4959.97
50.00	900,051.10	676,659.55	4,951.66	37.221122	116.060803	4954.97
55.00	900,051.11	676,659.63	4,946.66	37.221122	116.060802	4949.97
59.99	900,051.19	676,659.71	4,941.67	37.221123	116.060802	4944.97
64.99	900,051.20	676,659.80	4,936.67	37.221123	116.060802	4939.97
69.99	900,051.25	676,659.82	4,931.67	37.221123	116.060802	4934.97
74.99	900,051.26	676,659.86	4,926.67	37.221123	116.060802	4929.97
79.99	900,051.31	676,659.89	4,921.67	37.221123	116.060801	4924.97
84.99	900,051.35	676,659.90	4,916.67	37.221123	116.060801	4919.97
89.99	900,051.42	676,659.98	4,911.67	37.221123	116.060801	4914.98
94.99	900,051.45	676,659.94	4,906.67	37.221123	116.060801	4909.98
99.99	900,051.56	676,660.14	4,901.67	37.221124	116.060801	4904.98
104.99	900,051.55	676,660.24	4,896.67	37.221124	116.060800	4899.98
109.99	900,051.53	676,660.31	4,891.67	37.221124	116.060800	4894.98
114.98	900,051.56	676,660.41	4,886.68	37.221124	116.060800	4889.98
119.98	900,051.58	676,660.47	4,881.68	37.221124	116.060799	4884.98
124.98	900,051.55	676,660.52	4,876.68	37.221124	116.060799	4879.98
129.98	900,051.55	676,660.62	4,871.68	37.221124	116.060799	4874.99
134.98	900,051.56	676,660.69	4,866.68	37.221124	116.060799	4869.99
139.98	900,051.49	676,660.63	4,861.68	37.221123	116.060799	4864.99
144.98	900,051.46	676,660.74	4,856.68	37.221123	116.060799	4859.99
149.98	900,051.44	676,660.82	4,851.68	37.221123	116.060798	4854.99
154.98	900,051.41	676,660.85	4,846.68	37.221123	116.060798	4849.99
159.98	900,051.35	676,660.95	4,841.68	37.221123	116.060798	4844.99
164.97	900,051.22	676,661.05	4,836.69	37.221123	116.060797	4839.99
169.97	900,051.18	676,661.03	4,831.69	37.221123	116.060798	4834.99
174.97	900,051.09	676,661.14	4,826.69	37.221122	116.060797	4829.99
179.97	900,051.03	676,661.16	4,821.69	37.221122	116.060797	4825.00

U-15n#3 Deviation Plot - Plan View

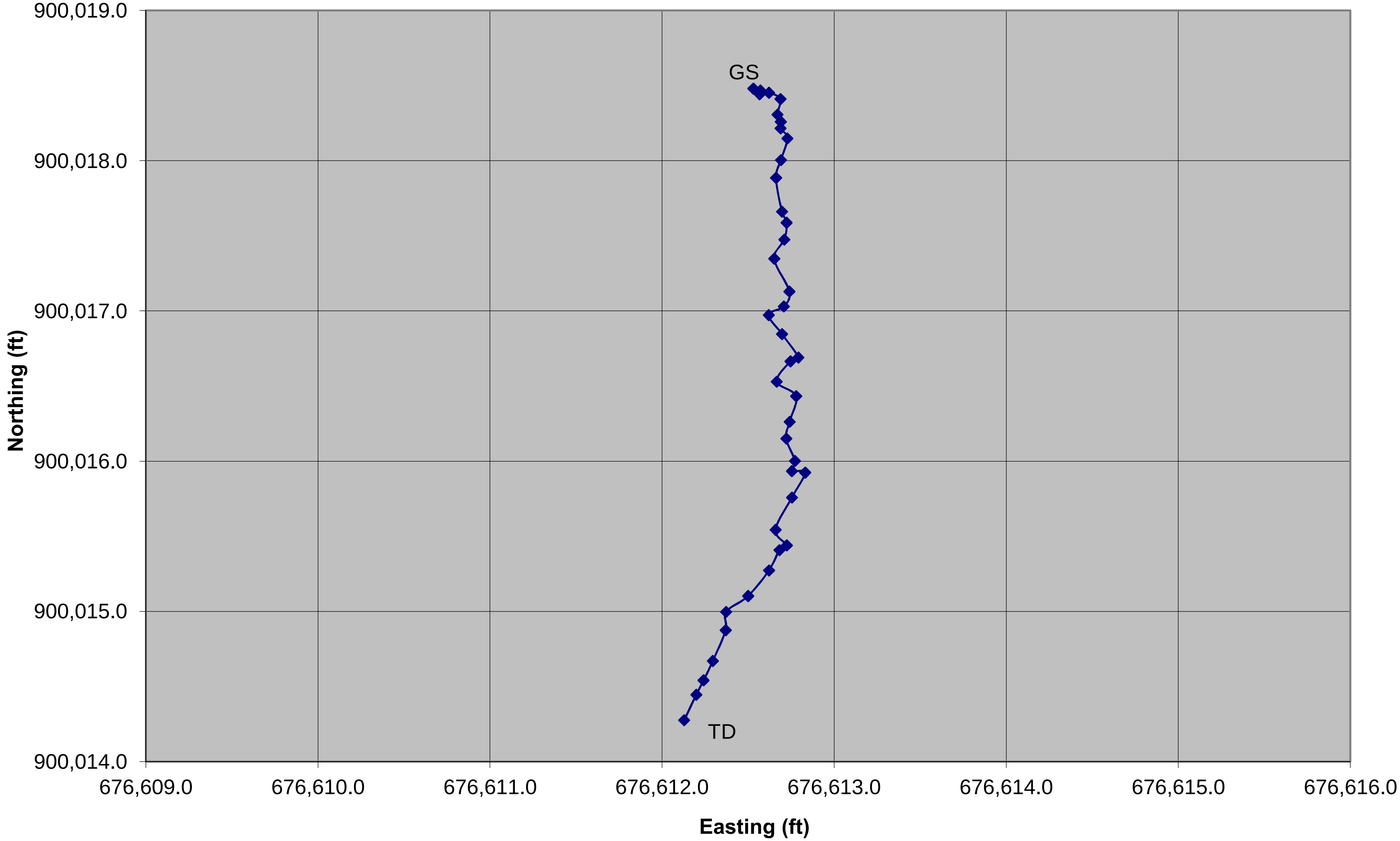


U-15n#4

Spud: 9/18/2010	BH Dia: 8 in	Data: As-Built 12/14/11
Compl: 9/18/2010	TD: 192 ft	TOC: 0.75 ft ags

Vertical Depth	Northing	Easting	Elevation	Latitude	Longitude	Elevation
	SPC NAD27 ft		NGVD29 ft	GEO NAD83 deg		NAVD88 ft
0.00	900,018.48	676,612.53	5,001.59	37.221034	116.060965	5004.90
5.00	900,018.44	676,612.57	4,996.59	37.221034	116.060965	4999.90
10.00	900,018.47	676,612.57	4,991.59	37.221034	116.060965	4994.90
15.00	900,018.45	676,612.62	4,986.59	37.221034	116.060965	4989.90
20.00	900,018.41	676,612.69	4,981.59	37.221033	116.060964	4984.90
25.00	900,018.31	676,612.67	4,976.59	37.221033	116.060964	4979.90
30.00	900,018.26	676,612.69	4,971.59	37.221033	116.060964	4974.90
35.00	900,018.22	676,612.69	4,966.59	37.221033	116.060964	4969.90
40.00	900,018.15	676,612.73	4,961.59	37.221033	116.060964	4964.90
44.99	900,018.00	676,612.69	4,956.60	37.221032	116.060964	4959.90
49.99	900,017.89	676,612.66	4,951.60	37.221032	116.060964	4954.90
54.99	900,017.66	676,612.70	4,946.60	37.221031	116.060964	4949.91
59.99	900,017.59	676,612.72	4,941.60	37.221031	116.060964	4944.91
64.99	900,017.47	676,612.71	4,936.60	37.221031	116.060964	4939.91
69.98	900,017.35	676,612.65	4,931.61	37.221031	116.060964	4934.91
74.98	900,017.13	676,612.74	4,926.61	37.221030	116.060964	4929.92
79.98	900,017.03	676,612.71	4,921.61	37.221030	116.060964	4924.92
84.98	900,016.97	676,612.62	4,916.61	37.221029	116.060965	4919.92
89.97	900,016.85	676,612.70	4,911.62	37.221029	116.060964	4914.92
94.97	900,016.69	676,612.79	4,906.62	37.221029	116.060964	4909.93
99.97	900,016.66	676,612.75	4,901.62	37.221029	116.060964	4904.93
104.97	900,016.53	676,612.67	4,896.62	37.221028	116.060964	4899.93
109.97	900,016.43	676,612.78	4,891.62	37.221028	116.060964	4894.93
114.96	900,016.26	676,612.74	4,886.63	37.221028	116.060964	4889.93
119.96	900,016.15	676,612.72	4,881.63	37.221027	116.060964	4884.94
124.96	900,016.00	676,612.77	4,876.63	37.221027	116.060964	4879.94
129.96	900,015.93	676,612.75	4,871.63	37.221027	116.060964	4874.94
134.96	900,015.92	676,612.83	4,866.63	37.221027	116.060964	4869.94
139.95	900,015.76	676,612.75	4,861.64	37.221026	116.060964	4864.94
144.95	900,015.54	676,612.66	4,856.64	37.221026	116.060964	4859.95
149.95	900,015.44	676,612.72	4,851.64	37.221025	116.060964	4854.95
154.95	900,015.41	676,612.68	4,846.64	37.221025	116.060964	4849.95
159.94	900,015.27	676,612.62	4,841.65	37.221025	116.060965	4844.95
164.94	900,015.10	676,612.50	4,836.65	37.221024	116.060965	4839.96
169.94	900,015.00	676,612.37	4,831.65	37.221024	116.060965	4834.96
174.94	900,014.88	676,612.37	4,826.65	37.221024	116.060965	4829.96
179.93	900,014.67	676,612.29	4,821.66	37.221023	116.060966	4824.97
184.93	900,014.54	676,612.24	4,816.66	37.221023	116.060966	4819.97
189.93	900,014.45	676,612.20	4,811.66	37.221023	116.060966	4814.97
194.93	900,014.28	676,612.13	4,806.66	37.221022	116.060966	4809.97

U-15n#4 Deviation Plot - Plan View

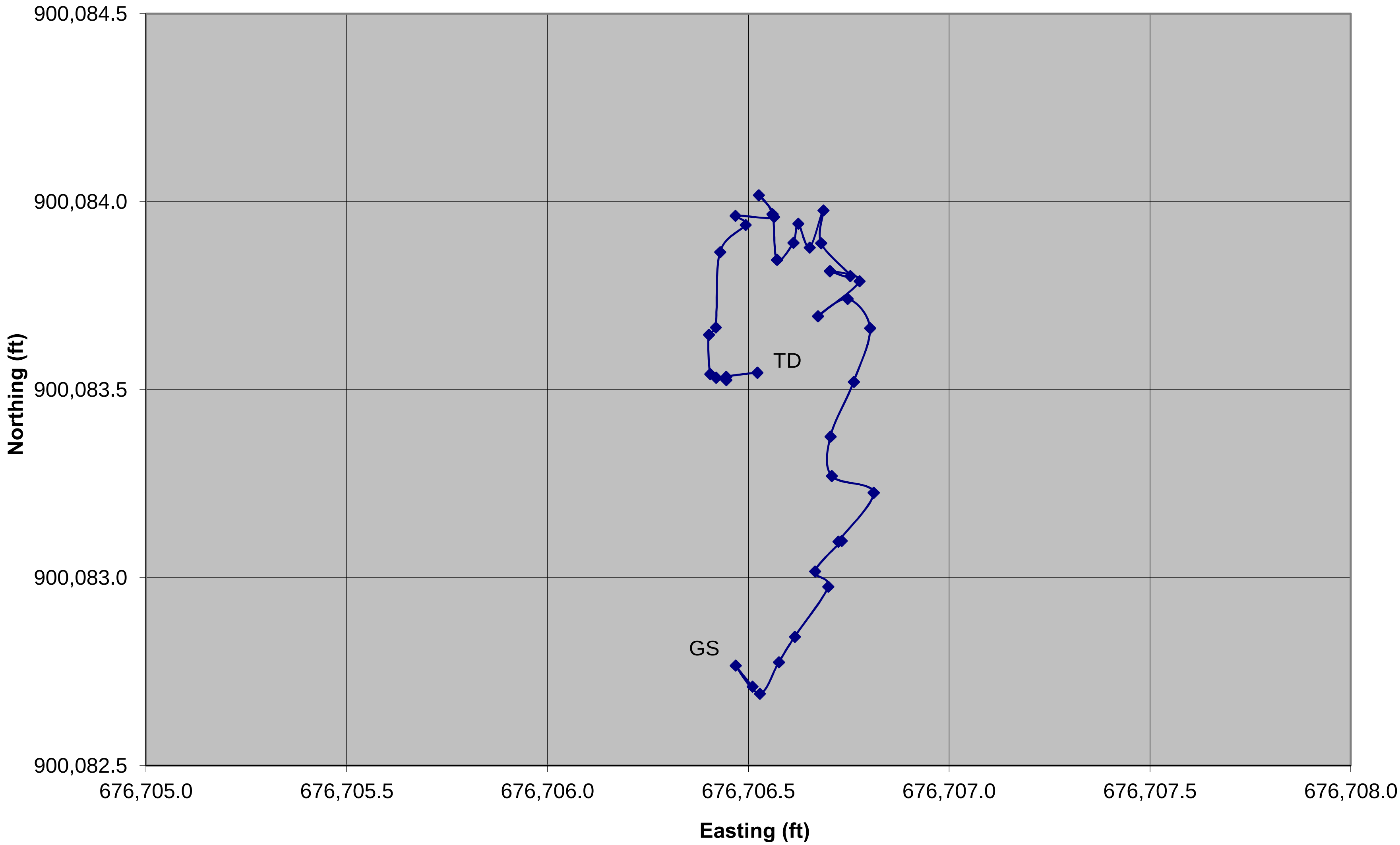


U-15n#5

Spud: 9/17/2010	BH Dia: 8 in	Data: As-Built 12/14/11
Compl: 9/17/2010	TD: 192 ft	TOC: 0.65 ft ags

Vertical Depth	Northing	Easting	Elevation	Latitude	Longitude	Elevation
	SPC NAD27 ft		NGVD29 ft	GEO NAD83 deg		NAVD88 ft
0.00	900,082.71	676,706.51	5,001.29	37.221208	116.060641	5004.60
5.00	900,082.77	676,706.47	4,996.29	37.221209	116.060641	4999.60
10.00	900,082.69	676,706.53	4,991.29	37.221208	116.060641	4994.60
15.00	900,082.77	676,706.58	4,986.29	37.221209	116.060640	4989.60
20.00	900,082.84	676,706.62	4,981.29	37.221209	116.060640	4984.60
24.99	900,082.98	676,706.70	4,976.30	37.221209	116.060640	4979.60
29.99	900,083.02	676,706.67	4,971.30	37.221209	116.060640	4974.60
34.99	900,083.10	676,706.73	4,966.30	37.221209	116.060640	4969.60
39.99	900,083.10	676,706.72	4,961.30	37.221209	116.060640	4964.60
44.99	900,083.23	676,706.81	4,956.30	37.221210	116.060640	4959.61
49.99	900,083.27	676,706.71	4,951.30	37.221210	116.060640	4954.61
54.99	900,083.37	676,706.70	4,946.30	37.221210	116.060640	4949.61
59.99	900,083.52	676,706.76	4,941.30	37.221211	116.060640	4944.61
64.98	900,083.66	676,706.80	4,936.31	37.221211	116.060640	4939.61
69.98	900,083.74	676,706.75	4,931.31	37.221211	116.060640	4934.61
74.98	900,083.69	676,706.67	4,926.31	37.221211	116.060640	4929.62
79.98	900,083.79	676,706.78	4,921.31	37.221211	116.060640	4924.62
84.98	900,083.82	676,706.70	4,916.31	37.221211	116.060640	4919.62
89.98	900,083.80	676,706.75	4,911.31	37.221211	116.060640	4914.62
94.98	900,083.89	676,706.68	4,906.31	37.221212	116.060640	4909.62
99.98	900,083.98	676,706.69	4,901.31	37.221212	116.060640	4904.62
104.98	900,083.88	676,706.65	4,896.31	37.221212	116.060640	4899.62
109.98	900,083.94	676,706.62	4,891.31	37.221212	116.060640	4894.62
114.98	900,083.89	676,706.61	4,886.31	37.221212	116.060640	4889.62
119.97	900,083.84	676,706.57	4,881.32	37.221212	116.060640	4884.62
124.97	900,083.97	676,706.56	4,876.32	37.221212	116.060640	4879.62
129.97	900,084.02	676,706.53	4,871.32	37.221212	116.060641	4874.62
134.97	900,083.96	676,706.56	4,866.32	37.221212	116.060640	4869.63
139.97	900,083.96	676,706.47	4,861.32	37.221212	116.060641	4864.63
144.97	900,083.94	676,706.49	4,856.32	37.221212	116.060641	4859.63
149.97	900,083.87	676,706.43	4,851.32	37.221212	116.060641	4854.63
154.97	900,083.67	676,706.42	4,846.32	37.221211	116.060641	4849.63
159.97	900,083.65	676,706.40	4,841.32	37.221211	116.060641	4844.63
164.97	900,083.54	676,706.40	4,836.32	37.221211	116.060641	4839.63
169.97	900,083.53	676,706.42	4,831.32	37.221211	116.060641	4834.63
174.97	900,083.53	676,706.44	4,826.32	37.221211	116.060641	4829.63
179.97	900,083.53	676,706.44	4,821.32	37.221211	116.060641	4824.63
184.96	900,083.54	676,706.52	4,816.33	37.221211	116.060641	4819.63
189.96	900,083.54	676,706.52	4,811.33	37.221211	116.060641	4814.63

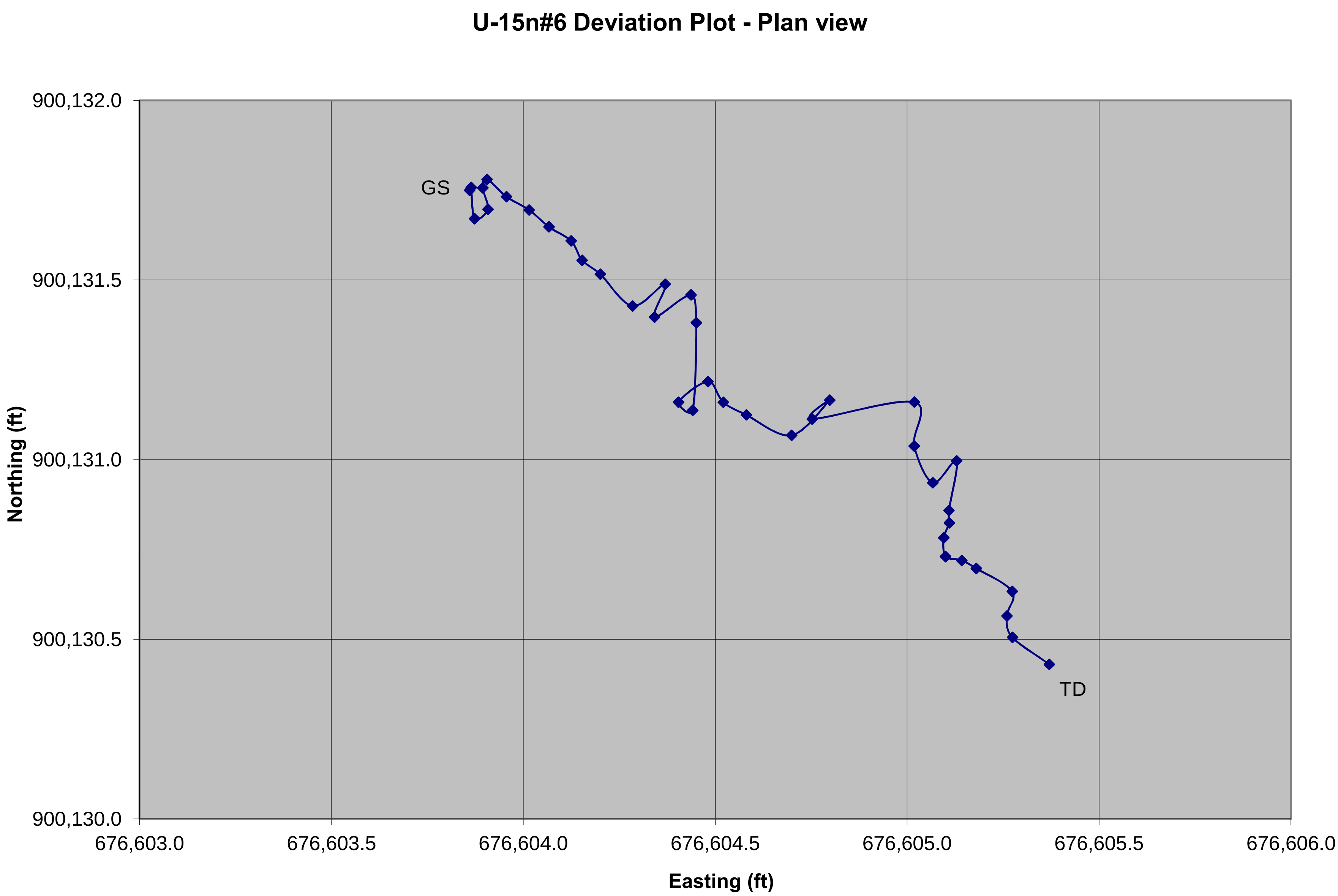
U-15n#5 Deviation Plot - Plan View



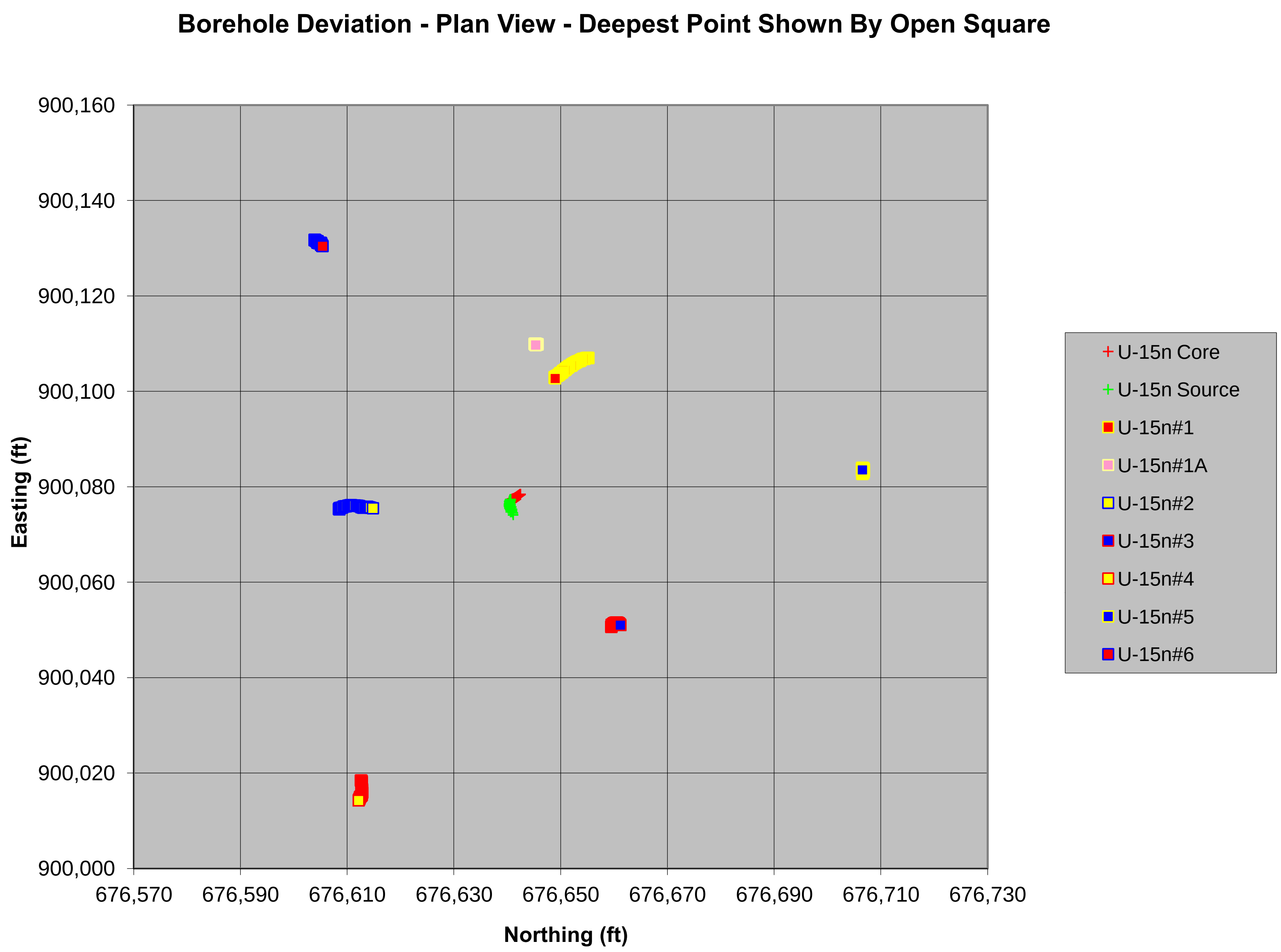
U-15n#6

Spud: 8/26/2010		BH Dia: 8 in		Data: As-Built 12/14/11		
Compl: 8/27/2010		TD: 190 ft		TOC: 0.62 ft ags		

Vertical Depth	Northing	Easting	Elevation	Latitude	Longitude	Elevation
	SPC NAD27 ft		NGVD29 ft	GEO NAD83 deg		NAVD88 ft
0.00	900,131.75	676,603.86	5,005.07	37.221345	116.060992	5008.38
5.00	900,131.76	676,603.86	5,000.07	37.221345	116.060992	5003.38
10.00	900,131.67	676,603.87	4,995.07	37.221345	116.060992	4998.38
15.00	900,131.70	676,603.91	4,990.07	37.221345	116.060992	4993.38
20.00	900,131.76	676,603.89	4,985.07	37.221345	116.060992	4988.38
25.00	900,131.78	676,603.91	4,980.07	37.221345	116.060992	4983.38
30.00	900,131.73	676,603.96	4,975.07	37.221345	116.060992	4978.38
35.00	900,131.70	676,604.02	4,970.07	37.221345	116.060992	4973.38
40.00	900,131.65	676,604.07	4,965.07	37.221345	116.060991	4968.38
45.00	900,131.61	676,604.12	4,960.07	37.221345	116.060991	4963.38
50.00	900,131.56	676,604.15	4,955.07	37.221344	116.060991	4958.38
55.00	900,131.52	676,604.20	4,950.07	37.221344	116.060991	4953.38
59.99	900,131.43	676,604.28	4,945.08	37.221344	116.060991	4948.38
64.99	900,131.49	676,604.37	4,940.08	37.221344	116.060990	4943.38
69.99	900,131.40	676,604.34	4,935.08	37.221344	116.060990	4938.39
74.99	900,131.46	676,604.44	4,930.08	37.221344	116.060990	4933.39
79.99	900,131.38	676,604.45	4,925.08	37.221344	116.060990	4928.39
84.98	900,131.14	676,604.44	4,920.09	37.221343	116.060990	4923.39
89.98	900,131.16	676,604.40	4,915.09	37.221343	116.060990	4918.39
94.98	900,131.22	676,604.48	4,910.09	37.221343	116.060990	4913.39
99.98	900,131.16	676,604.52	4,905.09	37.221343	116.060990	4908.39
104.98	900,131.12	676,604.58	4,900.09	37.221343	116.060990	4903.40
109.98	900,131.07	676,604.70	4,895.09	37.221343	116.060989	4898.40
114.98	900,131.17	676,604.80	4,890.09	37.221343	116.060989	4893.40
119.98	900,131.11	676,604.75	4,885.09	37.221343	116.060989	4888.40
124.97	900,131.16	676,605.02	4,880.10	37.221343	116.060988	4883.41
129.97	900,131.04	676,605.02	4,875.10	37.221343	116.060988	4878.41
134.97	900,130.94	676,605.07	4,870.10	37.221343	116.060988	4873.41
139.97	900,131.00	676,605.13	4,865.10	37.221343	116.060988	4868.41
144.97	900,130.86	676,605.11	4,860.10	37.221342	116.060988	4863.41
149.97	900,130.82	676,605.11	4,855.10	37.221342	116.060988	4858.41
154.97	900,130.78	676,605.10	4,850.10	37.221342	116.060988	4853.41
159.96	900,130.73	676,605.10	4,845.11	37.221342	116.060988	4848.41
164.96	900,130.72	676,605.14	4,840.11	37.221342	116.060988	4843.41
169.96	900,130.70	676,605.18	4,835.11	37.221342	116.060988	4838.41
174.96	900,130.63	676,605.27	4,830.11	37.221342	116.060987	4833.41
179.96	900,130.57	676,605.26	4,825.11	37.221342	116.060987	4828.41
184.96	900,130.51	676,605.27	4,820.11	37.221341	116.060987	4823.42
189.96	900,130.43	676,605.37	4,815.11	37.221341	116.060987	4818.42



U-15n#6 Deviation Plot - Plan view
Northing (ft)
900,132.0
900,131.5
900,131.0
900,130.5
900,130.0
Easting (ft)
676,603.0
676,603.5
676,604.0
676,604.5
676,605.0
676,605.5
676,606.0
GS
TD



Borehole Deviation - Plan View - Deepest Point Shown By Open Square
900,160
900,140
900,120
900,100
900,080
900,060
900,040
900,020
900,000
Easting (ft)
676,570
676,590
676,610
676,630
676,650
676,670
676,690
676,710
676,730
Northing (ft)
U-15n Core
U-15n Source
U-15n#1
U-15n#1A
U-15n#2
U-15n#3
U-15n#4
U-15n#5
U-15n#6

APPENDIX E
Data for U-15n Core Hole:

Appendix E-1: RQD Data

Appendix E-2: List of Preserved Samples

Appendix E-3: Fracture Log (from visual evaluation)

Appendix E-1
Rock Quality Designation (RQD) Data for the U-15n Core Hole
(Including RQD Procedure Information)

U-15n Core Hole

Run#	Run Top	Run Bottom	Amount Drilled	Loss	Sound	Run Top	RQD
1	7.3	16.5	9.2	1.3	6.7	7.3	73
2	16.5	26.5	10.0	0.2	5.2	16.5	52
3	26.5	36.5	10.0	0.0	8.1	26.5	81
4	36.5	46.5	10.0	0.0	8.1	36.5	81
5	46.5	56.5	10.0	0.0	9.3	46.5	93
6	56.5	66.5	10.0	0.0	8.0	56.5	80
7	66.5	76.5	10.0	0.0	9.6	66.5	96
8	76.5	86.5	10.0	0.0	7.1	76.5	71
9	86.5	96.5	10.0	0.1	8.7	86.5	87
10	96.5	106.5	10.0	0.0	8.0	96.5	80
11	106.5	116.5	10.0	0.0	9.5	106.5	95
12	116.5	126.5	10.0	0.0	7.9	116.5	79
13	126.5	136.5	10.0	0.0	9.6	126.5	96
14	136.5	146.5	10.0	0.0	10.0	136.5	100
15	146.5	156.5	10.0	0.2	9.3	146.5	93
16	156.5	166.5	10.0	0.0	7.7	156.5	77
17	166.5	176.5	10.0	0.0	7.9	166.5	79
18	176.5	186.5	10.0	+0.2	9.9	176.5	99
19	186.5	196.5	10.0	0.0	9.2	186.5	92

Rock Quality Designation (RQD) logging of core is a standard, internationally accepted means of estimating rock quality for engineering purposes. The technique has been used for more than 40 years, and a large database of experience has been built (Deere and Deere, 1988; 1989). The RQD is modified core-recovery percentage in which all sound core pieces more than 4 inches (100 millimeters) long are summed and divided by the length of the core run (see Figure D-6 in the following excerpt). Thus, RQD logging is basically a measurement of the percentage of "good" rock recovered from an interval of a borehole.

The following pages are an excerpt from NSTec Organization Procedure OP-2152.203, "Rock Descriptions," describing the method for RQD logging.

References:

Deere, D. U., and D. W. Deere, 1988. "The Rock Quality Designation (RQD) Index in Practice." In *Proceedings of Symposium on Rock Classification Systems for Engineering Purposes.* ASTM Special Technical Publications 984, Philadelphia, pp. 91–101.

Deere, D. U., and D. W. Deere, 1989. *Rock Quality Designation (RQD) after Twenty Years.* U.S. Army Corps of Engineers Report No. GL-89-1, 92 p.

APPENDIX D (continued)
Guidelines for Measurements to Support Rock Mass Classification

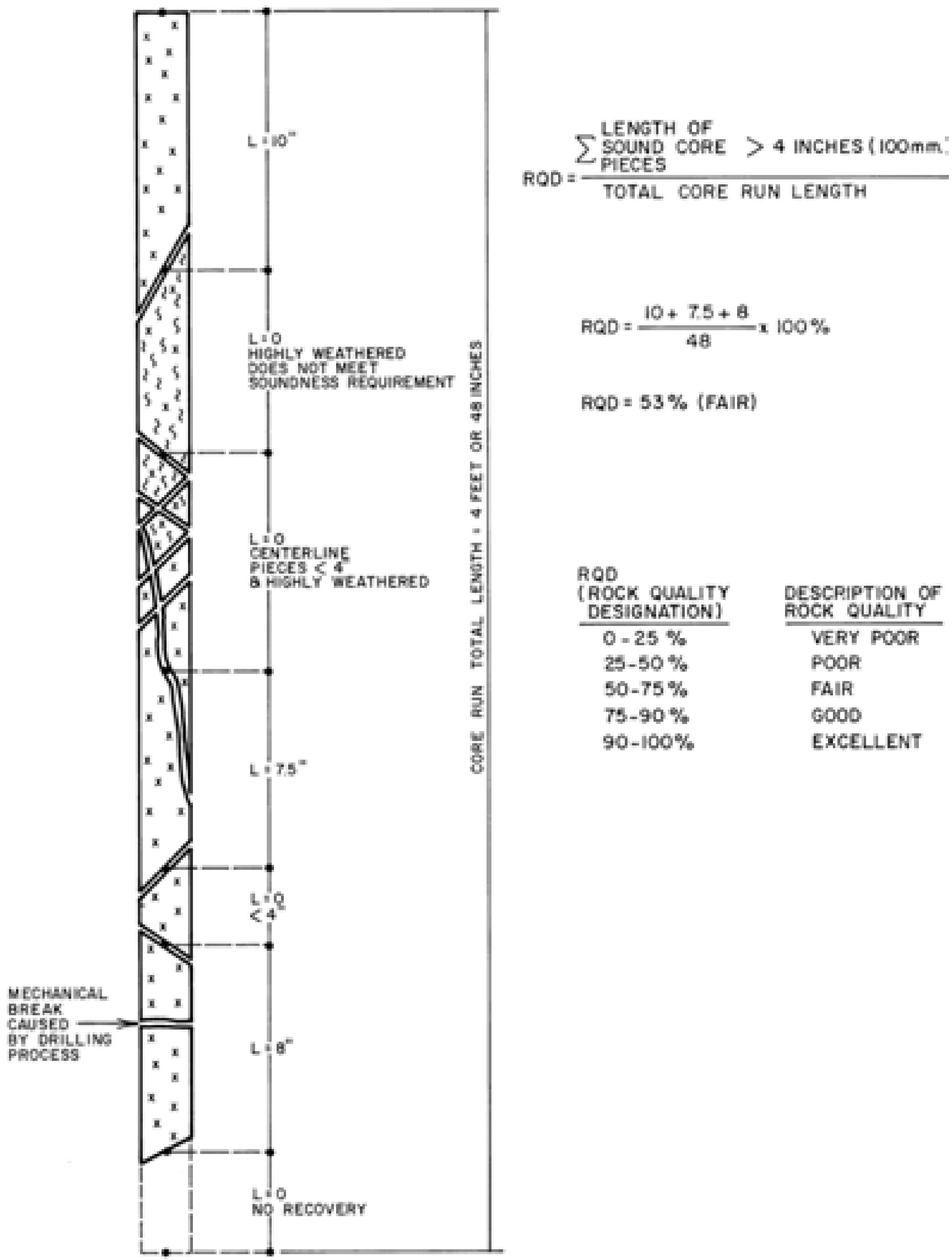


Figure D-6. Example of How to Measure Core Pieces to Determine RQD
(from Deere and Deere, 1989)

APPENDIX D (continued)
Guidelines for Measurements to Support Rock Mass Classification
Section D-5: RQD Logging (continued)

2.0 METHOD

2.1 RQD can be measured on a range of core sizes, but its use on the very smallest diameter cores (i.e., “BQ” and “BX”) is discouraged. Core segment lengths should be measured as shown in Figure D-8. Core pieces either side of a break caused by the drilling process should be fitted together and counted as one piece. Determination of whether a break is natural or due to drilling may be difficult, but generally natural joints and fractures can be recognized by the presence of slickensides, polished surfaces, or mineral coatings. Drilling-induced breaks typically have a rougher, more jagged, fresh-looking appearance (Figure D-7).

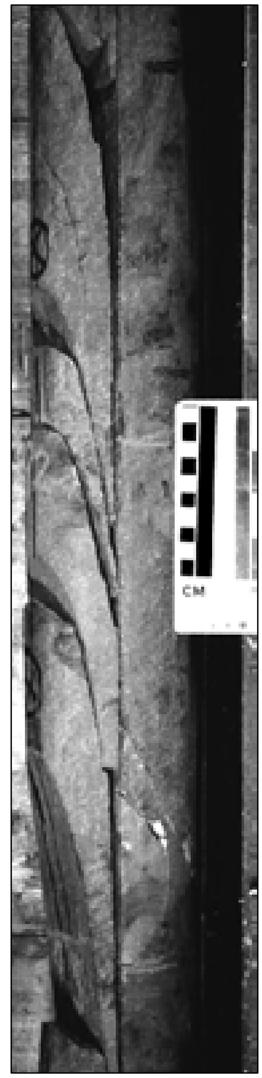


Figure D-7. Photo of Drilling-Induced Break in Core
(petal centerline fracture)

2.2 Because some clay-rich rocks such as shales or claystones may break into smaller pieces with time or due to drying, the RQD should be done at the drill site while the core is fresh. If break-up of the core with time is observed, this should be noted on the core log.

2.3 Data required to determine RQD on core should be recorded on Form FRM-1078, “Core Data Sheet” (this sheet may also be used for recording Core Index (CI) data [see Appendix E]). For both applications, the following data must be recorded on each form:

- Hole name
- Project
- Geologist’s name
- Total depth of hole

2.3.1 Similar data are recorded for these two types of core quality measurements (RQD and CI), including those listed below. Refer to Appendix E of this procedure for more information on collection of these data.

- Core run number
- Amount drilled
- Drilled interval
- Amount recovered

2.4 The RQD determination requires measurement in each run of the total amount “sound” core. Sound core pieces are those 4 in. or longer that have not been weakened by weathering or other alteration. For each run, the RQD is calculated by dividing the length of sound core by the total length of core drilled, to derive a percentage of sound rock for that run. For core on which CI is not required, the “Joints” and “CI” columns on FRM-1078 can be crossed out.

APPENDIX D (continued)
Guidelines for Measurements to Support Rock Mass Classification

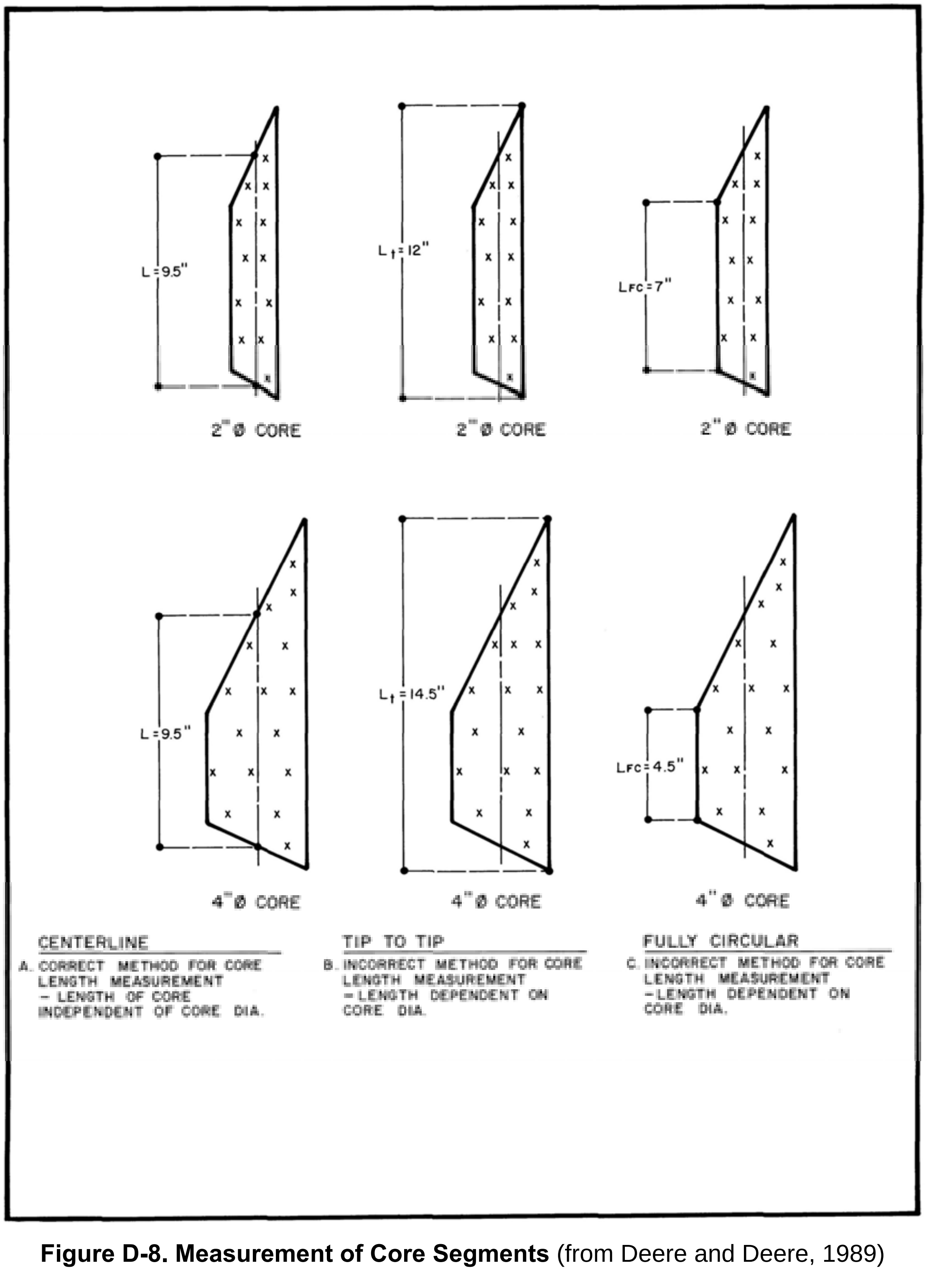


Figure D-8. Measurement of Core Segments (from Deere and Deere, 1989)

Appendix E-2

List of Preserved Samples from the U-15n Core Hole

U-15n
Preserved Core Samples

Top	Bottom	Length	Notes
(feet)	(feet)	(feet)	
10.1	11.3	1.2	
19.9	21.0	1.1	
22.3	23.7	1.4	
33.7	34.4	0.7	
35.6	36.5	0.9	
40.1	41.1	1.0	
45.2	46.1	0.9	
49.3	50.2	0.9	
55.6	56.5	0.9	
60.1	60.8	0.7	
65.5	66.1	0.6	
66.1	66.5	0.4	
68.3	69.1	0.8	
73.5	74.4	0.9	
76.5	77.7	1.2	
85.8	86.5	0.7	
91.2	91.9	0.7	
95.3	96.4	1.1	
98.4	99.1	0.7	
102.0	102.9	0.9	
108.8	109.5	0.7	
113.3	114.2	0.9	
117.7	118.6	0.9	
120.7	121.5	0.8	
127.9	128.5	0.6	
130.7	131.5	0.8	
138.1	139.0	0.9	
143.3	144.0	0.7	
148.1	148.8	0.7	
152.4	153.1	0.7	
156.5	157.5	1.0	healed frac
163.9	164.5	0.6	
169.2	169.9	0.7	healed frac
175.9	176.5	0.6	
181.2	181.9	0.7	healed frac
185.9	186.5	0.7	
187.7	188.6	0.9	healed frac
194.2	194.8	0.6	

All core is stored at USGS Core Library in Mercury, NV

Appendix E-3

NSTec Fracture Log for the U-15n Core Hole (from visual evaluation)

Feature (dip not corrected for hole deviation)								Discontinuity Characteristics																			Comments
Disc. No.	Run No.	Depth (dist. along core)	Type				Dip	Apert.	Infill Thick.	Infill Type									Roughness and Planarity								
		(feet)	joint	fault	break w/joint characs	rubble	degrees	(mm)	(mm)	calcite	Fe oxide	Mn oxide	kaolinized feldspar	breccia	clayey gouge	thin clayey film	pyrite	other (comments)	very rough	rough	slightly rough	smooth	slickensided	planar	wavy	stepped	*representative discontinuity described
0																											
1	1	7.3			x		6		<1							x					x			x			top of core run
2	1	8.0	x				3		<1									x			x						
3	1	11.3	x				9		1-3			x									x			x			other end waxed
4	1	12.9	x				5		<1			x									x			x			
5	1	13.4	x				7		1-3			x									x			x			
6	1	15.1	x				13		<1			x									x			x			
7	1	15.9	x				11		<1			x						x			x			x			Intersects #8; limonite
8	1	16.0			x		70		<1			x									x					x	~1 ft long
9	1	16.0	x				5		<1			x						x			x			x			Intersects #8; limonite
10	1	16.1	x				21		<1			x						x			x			x			Intersects #8; limonite
11	2	17.5	x				85		<1			x						x			x				x		16.5 to 19.5; limonite
12	2	19.7	x				25		<1			x						x			x			x			limonite
13	2	21.0	x				15		<1			x				x				x				x			
14	2	21.3	x				16		<1			x								x				x			
15	2	21.9	x				2		<1							x				x				x			
16	2	22.3	x				9		<1			x						x		x				x			limonite (yellow)
17	2	23.7	x				12		<1			x									x			x			
18	2	25.3	x				68		<1			x					x	x			x			x			limonite
19	2	25.4	x				68		<1			x					x	x			x			x			limonite
20	2	25.5	x				68		<1			x					x	x			x			x			limonite, muscovite
21	2	25.9	x				3		1-3						x						x			x			muscovite
22	2	26.3	x				3		<1						x						x			x			
23	2	26.4	x				4		<1						x						x			x			muscovite
24	3	28.3	x				6		<1									x				x		x			limonite
25	3	28.3	x				86		<1			x									x			x		x	limonite; steps off #20; terminates at #33
26	3	28.5	x				6		<1			x									x					x	cuts half the core; stops at #21
27	3	28.5	x				6		1-3			x										x	x	x			

Feature (dip not corrected for hole deviation): Disc. No.	Run No.	Depth (dist. along core) (feet)	Type: joint	fault	break w/joint characs	rubble	Dip (degrees)	Discontinuity Characteristics: Apert. (mm)	Infill Thick. (mm)	Infill Type: calcite	Fe oxide	Mn oxide	kaolinized feldspar	breccia	clayey gouge	thin clayey film	pyrite	other (comments)	Roughness and Planarity: very rough	rough	slightly rough	smooth	slickensided	planar	wavy	stepped	Comments: *representative discontinuity described
28	3	30.2	x				24		<1		x										x					x	
29	3	30.8	x				65		<1									x			x			x			thin gouge?
30	3	31.3	x				63		<1									x			x			x			thin gouge?
31	3	31.5	x				5		<1			x									x			x			
32	3	31.6	x				12		<1			x								x				x			
33	3	31.8	x				70		<1									x		x				x			very thin gouge
34	3	32.4	x				3		<1									x		x				x			very thin gouge
35	3	32.7	x				65		<1									x						x			very thin gouge
36	3	33.2	x				12		<1			x									x			x			
37	3	33.5	x				6		<1			x						x				x		x			muscovite
38	3	33.7	x				9		<1			x						x			x			x			very thin gouge
39	3	34.4	x				4		<1			x						x			x			x			limonite
40	3	35.4	x				12		<1			x									x			x			
41	3	35.6	x				6		<1			x						x									muscovite
42	4	36.5	x				8		<1									x			x			x			thin gouge
43	4	36.7	x				16		<1			x						x			x			x			limonite
44	4	37.1	x				9		<1			x										x		x			
45	4	37.2	x				8		<1			x										x		x			
46	4	38.1	x				12		<1			x									x			x			
47	4	38.7	x				9		<1									x		x				x			very little, thin gouge
48	4	39.0	x				6		<1			x						x			x			x			limonite
49	4	40.1	x				12		<1			x						x			x			x			limonite
50	4	41.1	x				7		<1			x									x			x			
51	4	41.1	x				62		<1			x						x				x		x			half of joint is waxed
52	4	42.1	x				12		<1			x									x			x			
53	4	42.4	x			x	4		<1			x						x			x			x			thin gouge, rubble
54	4	42.4	x			x	43		<1			x									x					x	part of rubble area
55	4	43.9	x				6		<1			x								x				x			

Feature (dip not corrected for hole deviation)								Discontinuity Characteristics																			Comments
Disc. No.	Run No.	Depth (dist. along core)	Type				Dip	Apert.	Infill Thick.	Infill Type									Roughness and Planarity								
		(feet)	joint	fault	break w/joint characs	rubble	degrees	(mm)	(mm)	calcite	Fe oxide	Mn oxide	kaolinized feldspar	breccia	clayey gouge	thin clayey film	pyrite	other (comments)	very rough	rough	slightly rough	smooth	slickensided	planar	wavy	stepped	*representative discontinuity described
56	4	44.0	x				9		<1			x						x			x			x			limonite
57	4	44.1	x				8		<1									x		x				x			very thin gouge
58	4	44.5	x				15		<1			x									x			x			
59	4	44.8	x				11		<1			x									x			x			
60	4	44.9	x				5		<1			x						x				x		x			limonite
61	5	46.5	x				3		<1						x							x				x	
62	5	46.7	x				11		<1			x										x		x			
63	5	47.2	x				18		<1			x						x						x			limonite
64	5	49.3	x				22		<1			x						x		x				x			limonite
65	5	50.2	x				6		<1			x												x			
66	5	52.2	x				11		<1			x												x			
67	5	52.3	x				11		<1			x												x			
68	5	53.4	x				2		<1										x					x			almost no coating
69	5	53.5	x				22		<1			x						x		x				x			limonite
70	5	55.0	x				75		<1			x						x			x			x			limonite
71	5	55.0	x				15		<1			x									x			x			cuts off #70
72	5	55.6	x				22		<1			x						x			x			x			muscovite
73	6	57.1	x				10		<1			x						x			x			x			muscovite
74	6	57.5	x				10		<1			x						x			x			x			
75	6	59.5	x				72		<1			x						x			x			x			limonite
76	6	60.0	x				31		<1			x						x		x				x			limonite
77	6	60.4	x				3		<1			x						x		x				x			limonite
78	6	62.3	x				80		<1			x									x				x		61.8-62.8
79	6	63.7	x				88		<1			x									x				x		61.8-65.0
80	7	66.5			x		2		<1									x		x					x		could be drilling-induced (clay?)
81	7	67.2	x				10		<1									x		x				x			limonite
82	7	67.4	x				7		<1									x				x		x			muscovite?
83	7	68.3	x				8		<1			x								x				x			

Feature (dip not corrected for hole deviation)								Discontinuity Characteristics																			Comments
Disc. No.	Run No.	Depth (dist. along core)	Type				Dip	Apert.	Infill Thick.	Infill Type									Roughness and Planarity								
		(feet)	joint	fault	break w/joint characs	rubble	degrees	(mm)	(mm)	calcite	Fe oxide	Mn oxide	kaolinized feldspar	breccia	clayey gouge	thin clayey film	pyrite	other (comments)	very rough	rough	slightly rough	smooth	slickensided	planar	wavy	stepped	*representative discontinuity described
84	7	71.0	x				3		<1			x								x				x			
85	7	72.7	x				9		<1			x									x			x			
86	7	75.1	x				2		<1									x				x		x			thin gouge
87	8	78.1	x		x		75		<1										x						x		fault zone starts at 77.7
88	8	79.2	x		x		80		<1									x		x					x		thin gouge; "fault zone"
89	8	79.5	x		x		80		<1									x		x					x		thin gouge; "fault zone"
90	8	81.0	x		x		70		<1			x											x				part of "fault zone"
91	8	81.4	x		x		82		<1			x											x		x		part of "fault zone"
92	8	83.0	x		x		80		<1			x											x		x		part of "fault zone"
93	8	83.3	x		x		60		<1			x									x		x				part of "fault zone"
94	8	84.2	x		x		65		<1									x			x						fault zone ends wtih this joint
95	8	85.6	x				65		<1			x								x				x			
96	9	87.4	x				14		<1			x								x				x			
97	9	88.5	x				80		<1			x									x			x			possibly 2 slip surfaces
98	9	89.3	x				8		<1					x								x		x			
99	9	91.3	x				8		<1			x								x				x			
100	9	91.9	x				9		<1					x							x			x			
101	9	93.1	x				13		<1			x									x			x			
102	10	100.3	x				12		<1			x								x				x			
103	10	102.0	x				8		1.0			x						x	x					x			Ilimonite; quartz crystals
104	10	102.9	x				10		<1									x				x		x			Ilimonite
105	10	104.7	x	x			80		<1			x									x			x			fault zone starts at 104.0
106	10	105.2	x	x			80		<1									x				x					thin gouge; part of fault zone
107	106.0-106.5					x																					rubble zone
108	11	106.6	x	x			84		<1									x			x			x			thin gouge
109	11	106.8	x	x			7		<1									x			x			x			limonite
110	11	107.2	x	x			76		<1									x			x			x			part of fault zone
111	11	107.6	x	x			73		<1									x			x			x			thin gouge; part of fault zone

Feature (dip not corrected for hole deviation)								**Discontinuity Characteristics**																						**Comments**
Disc. No.	Run No.	Depth (dist. along core)	Type				Dip	Apert.	Infill Thick.	Infill Type									Roughness and Planarity											
		(feet)	joint	fault	break w/joint characs	rubble	degrees	(mm)	(mm)	calcite	Fe oxide	Mn oxide	kaolinized feldspar	breccia	clayey gouge	thin clayey film	pyrite	other (comments)	very rough	rough	slightly rough	smooth	slickensided	planar	wavy	stepped				*representative discontinuity described
112	11	108.1	x	x			74		<1									x			x			x						thin gouge; end of fault zone
113	11	108.8	x				8		<1			x								x				x						
114	11	111.8	x				76		<1			x						x				x			x					thin gouge
115	11	114.9	x				17		<1			x						x		x				x						thin gouge
116	12	117.0	x				70		<1			x						x			x			x						thin gouge
117	12	117.7	x				4		<1									x				x		x						limonite
118	12	121.5	x				7		<1			x								x						x				
119	12	121.9	x				11		<1			x									x			x						
120	12	122.2	x				14		1-3			x						x	x					x						quartz lined
121	12	123.7	x				12		<1									x					x	x						limonite
122	12	123.9	x				18		<1			x						x				x								limonite
123	12	124.4	x				12		<1			x						x			x			x						limonite
124	12	124.7	x				14		<1			x									x			x						
125	12	124.3	x				86		<1			x									x			x						
126	12	124.5	x				12		<1			x										x		x						
127	12	125.5	x				11		<1			x						x			x			x						thin yellow coating
128	12	125.8	x				5		1.0			x									x					x				thin yellow coating
129	12	126.3	x				7		<1											x				x						almost no infill
130	13	127.4	x				11		1-3			x						x				x		x						intersected by long high-angle frac (#131)
131	13	127.5	x				66		<1									x							x					limonite (yellowish)
132	13	127.9	x				11		<1			x						x				x		x						limonite
133	13	131.5	x				13		<1									x			x			x						limonite
134	13	132.7	x				15		<1			x						x				x		x						limonite
135	13	133.6	x				56		1.0			x						x			x			x						limonite
136	13	134.2	x				54		<1									x		x				x						limonite
137	13	134.9	x				22		<1			x							x					x						
138	13	133.9	x				8		<1			x									x					x				
139	13	135.7	x				22		<1			x								x				x						

Feature (dip not corrected for hole deviation)								Discontinuity Characteristics																			Comments
Disc. No.	Run No.	Depth (dist. along core)	Type				Dip	Apert.	Infill Thick.	Infill Type									Roughness and Planarity								
		(feet)	joint	fault	break w/joint characs	rubble	degrees	(mm)	(mm)	calcite	Fe oxide	Mn oxide	kaolinized feldspar	breccia	clayey gouge	thin clayey film	pyrite	other (comments)	very rough	rough	slightly rough	smooth	slickensided	planar	wavy	stepped	*representative discontinuity described
140	13	136.1	x				11		<1			x					x	x		x							pyrite crystals
141	14	137.3	x				58		<1			x						x			x			x			light colored gouge
142	14	138.1	x				15		<1			x								x				x			very little gouge
143	14	139.0	x				19		<1									x			x			x			light colored gouge
144	14	139.4	x				19		<1			x								x				x			slightly wavy
145	14	140.8	x				15		<1			x					x	x		x							limonite
146	14	143.3	x				23		<1		x						x				x			x			
147	14	144.0	x				5		<1		x						x				x			x			
148	15	148.0	x				41		<1		x	x									x			x			
149	15	148.8	x				38		<1			x									x			x			
150	15	149.0	x				55		1.0						x						x			x			light colored gouge
151	15	149.1	x				70		1.0			x									x			x			terminates at #150
152	15	150.6	x				51		1.0									x			x			x			limonite
153	15	152.4	x				19		<1			x			x			x			x			x			
154	15	154.9	x				54		<1						x						x			x			light colored gouge
155	15	155.5	x				50		<1						x						x			x			brown gouge
156	15	155.6	x				63		<1			x			x						x			x			very little gouge
157	15	156.5	x				11		<1			x			x							x					light colored gouge
158	16	157.5	x				50		<1			x			x						x			x			
159	16	157.5	x				73		<1			x			x						x			x			terminates at #158
160	16	158.0	x				13		<1			x					x				x			x			
161	16	159.6	x				55		<1			x			x						x			x			
162	16	159.7	x				57		<1			x			x						x			x			
163	16	160.0	x				8		<1						x						x			x			yellowish gouge
164	16	160.6	x				52		<1			x			x						x			x			yellowish gouge
165	16	161.0	x				75		<1			x									x			x			terminates at #164
166	16	161.4	x				9		<1						x							x		x			light colored gouge
167	16	163.0	x				9		<1			x								x				x			

Feature (dip not corrected for hole deviation)								Discontinuity Characteristics																			Comments
Disc. No.	Run No.	Depth (dist. along core)	Type				Dip	Apert.	Infill Thick.	Infill Type									Roughness and Planarity								
		(feet)	joint	fault	break w/joint characs	rubble	degrees	(mm)	(mm)	calcite	Fe oxide	Mn oxide	kaolinized feldspar	breccia	clayey gouge	thin clayey film	pyrite	other (comments)	very rough	rough	slightly rough	smooth	slickensided	planar	wavy	stepped	*representative discontinuity described
168	16	163.3	x				4		1.0			x			x					x				x			
169	16	163.7	x				58		<1			x									x			x			
170	16	165.4	x				6		<1						x						x			x			light colored gouge
171	16	166.5	x				7		<1										x					x			light colored gouge
172	17	167.8	x				28		<1						x						x			x			limonite
173	17	167.9	x				25		<1						x						x			x			limonite
174	17	168.0	x				67		<1			x			x						x			x			
175	17	168.6	x				69		<1						x					x				x			#175 and #176 intersect
176	17	169.9	x				82		<1						x					x				x			almost no gouge
177	17	170.8	x				67		<1			x			x						x			x			
178	17	171.9	x				20		<1			x			x						x			x			
179	17	172.8	x				80		<1			x									x			x			#179 cuts #180
180	17	173.2	x				8		1-3						x						x			x			yellowish gouge
181	17	174.3	x				25		<1			x									x			x			
182	17	174.6	x				15		1.0			x									x			x			
183	17	174.7	x				11		<1						x					x				x			yellowish soft gouge
184	17	175.5	x				75		<1			x									x					x	
185	17	175.9	x				14		<1			x			x					x				x			#185 and #186 intersect
186	17	176.0	x				70		<1			x								x				x			almost no fill
187	18	179.2	x				11		<1									x		x				x			light colored gouge
188	18	179.6	x				3		<1			x					x				x			x			
189	18	179.9	x				44		<1									x			x			x			limonite
190	18	181.2	x				10		<1			x						x		x				x			limonite
191	18	182.0	x				33		<1									x			x			x			limonite
192	18	183.4	x				12		<1			x						x			x			x			limonite
193	18	185.5	x				13		<1						x						x			x			light colored gouge
194	19	186.5	x				10		<1						x		x				x					x	light colored gouge (light gray)
195	19	187.7	x				19		<1									x			x						limonite

Feature (dip not corrected for hole deviation)								Discontinuity Characteristics																			Comments
Disc. No.	Run No.	Depth (dist. along core)	Type				Dip	Apert.	Infill Thick.	Infill Type									Roughness and Planarity								
		(feet)	joint	fault	break w/joint characs	rubble	degrees	(mm)	(mm)	calcite	Fe oxide	Mn oxide	kaolinized feldspar	breccia	clayey gouge	thin clayey film	pyrite	other (comments)	very rough	rough	slightly rough	smooth	slickensided	planar	wavy	stepped	*representative discontinuity described
196	19	188.6	x				9		<1						x						x			x			light colored gouge
197	19	188.8	x				59		<1			x			x						x			x			
198	19	190.9	x				2		<1						x		x				x			x			light colored, very soft gouge
199	19	192.9	x				28		<1											x				x			almost no gouge
200	19	195.9	x				80		<1			x				x					x				x		light colored gouge
201	19	196.2	x				75		<1			x				x										x	light colored gouge
																											(jt ends at core break at 196.2 ft)
TD = 196.5 ft																											

APPENDIX F

Borehole Geophysical Log Plots by Colog, Inc., Source Physics Experiment Holes:

Appendix F-1: U-15n Core Hole

Appendix F-2: Instrument Hole U-15n#1

Appendix F-3: Instrument Hole U-15n#2

Appendix F-4: Instrument Hole U-15n#3

Appendix F-5: Instrument Hole U-15n#4

Appendix F-6: Instrument Hole U-15n#5

Appendix F-7: Instrument Hole U-15n#6

Appendix F-1

Borehole Geophysical Log Plots for the U-15n Core Hole

COLOG — Borehole Geophysics & Hydrophysics — A Division of Layne Christensen Company

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Far Density
Near Density
Natural Gamma Ray
Caliper

Company	NNSA/NSO
Well	U-15n
Field	Nevada Test Site
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15n
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900077.65'
E: 676640.92'

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Normal Resisitivities
SP, SPR
Full-Wave Sonic

PERMANENT DATUM G.L. **ELEVATION** 5003.12

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM G.L.

DATE ACQUIRED	31 July 2010			
RUN NUMBER	3			
LOG TYPE	Long Space Density	Short Space Density	Natural Gamma Ray	Caliper
DEPTH-DRILLER	196.5			
DEPTH-LOGGER	194.8'			
BTM LOG INTERVAL	182'	187'	187'	186'
TOP LOG INTERVAL	9'	9'	9'	9'
RECORDED BY	A. Caster			
WITNESSED BY	G. Juniel			
PROBE TYPE, S/N	FDGS, 5924			
LOGGING SPEED	15 ft/min			
A.S.D.E.	0.0'			
SAMPLE INTERVAL	0.2'			

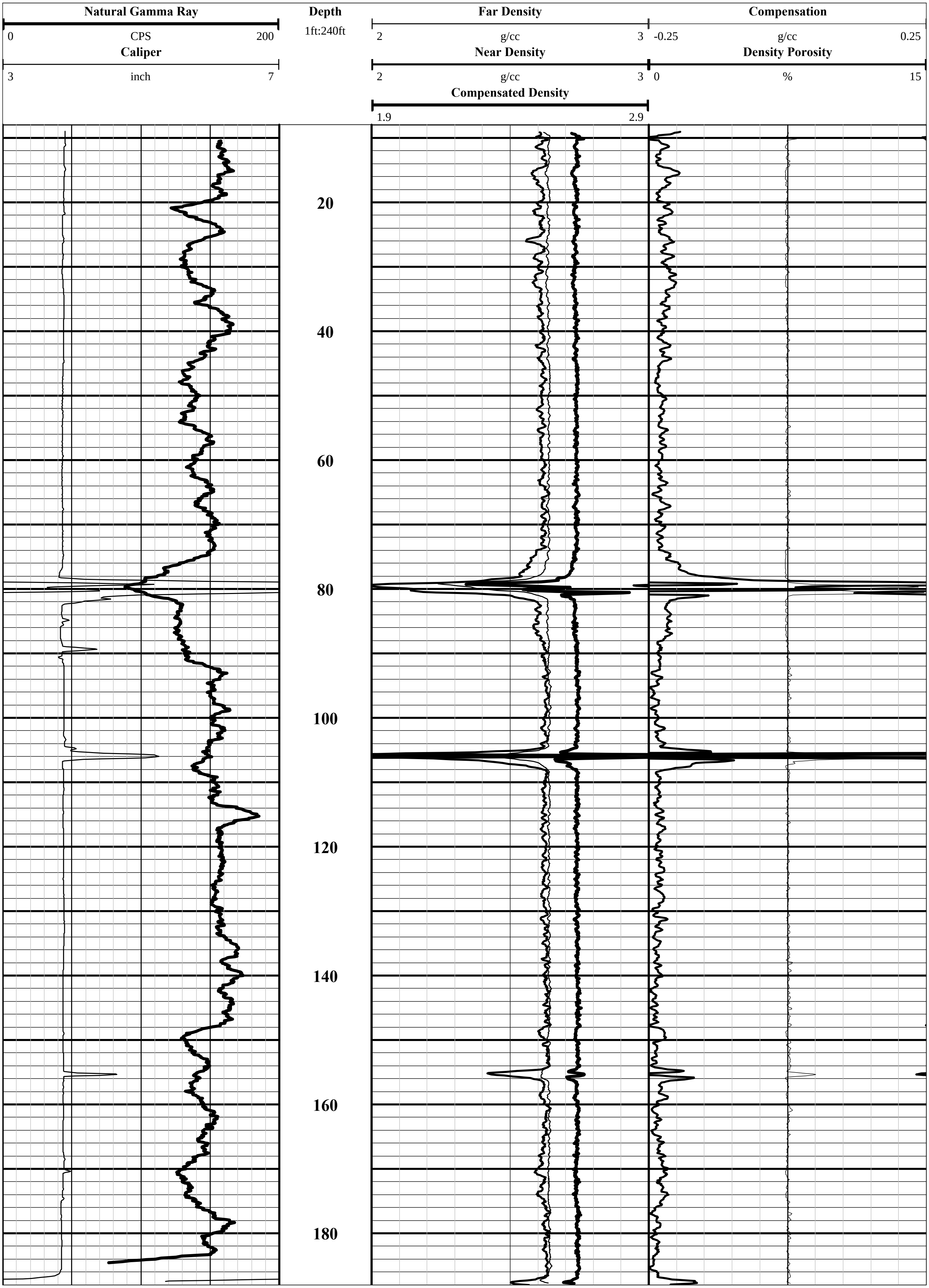
BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	3.81"	6.7'	196.	5.5"		0.83'	6.7'

COMMENTS

NA - Not Available, N/A - Not Applicable

Matrix Density or 2.64 used to calculate Density Porosity

Could not reach driller's TD, due to fill.


Natural Gamma Ray
0 CPS 200
Caliper
3 inch 7
Depth
1ft:240ft
Far Density
2 g/cc 3
Near Density
2 g/cc 3
Compensated Density
1.9 2.9
Compensation
-0.25 g/cc 0.25
Density Porosity
0 % 15
20
40
60
80
100
120
140
160
180

COLOG
BOREHOLE GEOPHYSICS & HYDROPHYSICS
A DIVISION OF LAYNE CHRISTENSEN COMPANY

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Natural Gamma Ray
Spontaneous Potential
Single Point Resistance
16"& 64" Resistivity

Company NNSA/NSO
Well U-15n
Field Nevada Test Site
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15n
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900077.65'
E: 676640.92'

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Dual-Spaced Density
Caliper
Full-Wave Sonic

PERMANENT DATUM G.L. **ELEVATION** 5003.12

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

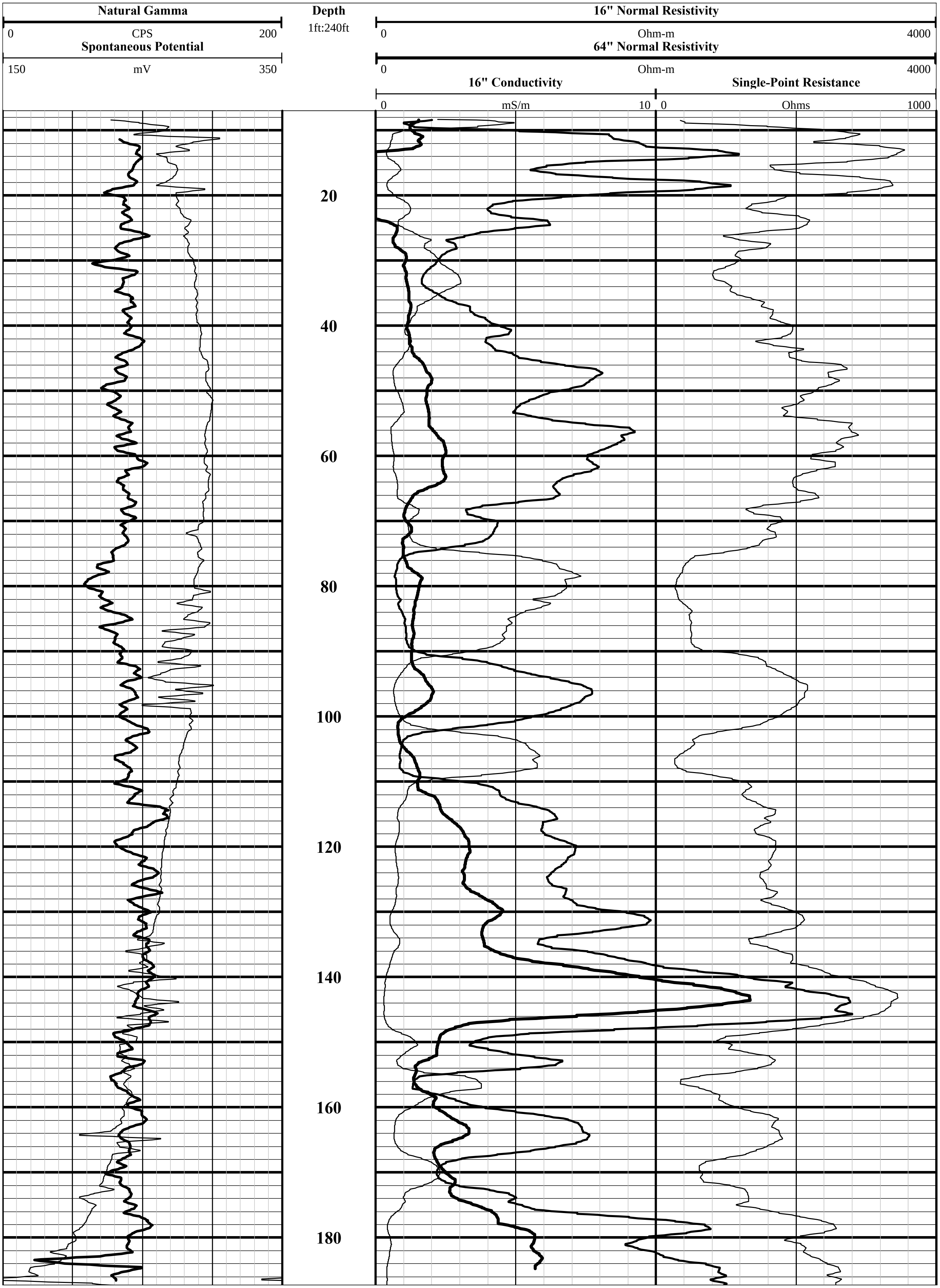
DRILLING MEAS. FROM G.L.

DATE ACQUIRED	31 July 2010			
RUN NUMBER	4			
LOG TYPE	Natural Gamma Ray	Resistivities	SP	
DEPTH-DRILLER	196.5'			
DEPTH-LOGGER	194.8'			
BTM LOG INTERVAL	185'	187'	187'	
TOP LOG INTERVAL	10'	7'	7'	
RECORDED BY	A. Caster			
WITNESSED BY	G. Juniel			
PROBE TYPE, S/N	ELXG, 5875			
LOGGING SPEED	25 ft/min			
A.S.D.E.	0.0'			
SAMPLE INTERVAL	0.2'			

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	3.81	6.7	196.5	5.5"		+0.83'	6.7'

COMMENTS

NA - Not Available, N/A - Not Applicable


Natural Gamma
0 CPS 200
Spontaneous Potential
150 mV 350
Depth
1ft:240ft
16" Normal Resistivity
0 Ohm-m 4000
64" Normal Resistivity
0 Ohm-m 4000
16" Conductivity
0 mS/m 10
Single-Point Resistance
0 Ohms 1000
20
40
60
80
100
120
140
160
180

COLOG — Borehole Geophysics & Hydrophysics — A Division of Layne Christensen Company
810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Acoustic Televiewer

Company	NNSA/NSO
Well	U-15n
Field	Nevada Test Site
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15n
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900077.65'
E: 676640.92'

OTHER SERVICES
Optical Televiewer
Normal Resistivities
SP, SPR
Full-Wave Sonic
Dual-Spaced Density
Caliper
Natural Gamma Ray

QTR **SEC** **TWP** **RGE**

PERMANENT DATUM G.L. **ELEVATION** 5003.12
LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**
DRILLING MEAS. FROM G.L.

DATE ACQUIRED	31 July 2010		
RUN NUMBER	1		
LOG TYPE	Acoustic Televiewer		
DEPTH-DRILLER	196.5		
DEPTH-LOGGER	194.8'		
BTM LOG INTERVAL	189'		
TOP LOG INTERVAL	12'		
RECORDED BY	A. Caster		
WITNESSED BY	G. Juniel		
PROBE TYPE, S/N	FAC 40, 983303		
LOGGING SPEED	3 ft/min		
A.S.D.E.	2.0'		
SAMPLE INTERVAL	0.008'		

BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	3.81	6.7	196.5	5.5"		+0.83'	6.7'

COMMENTS

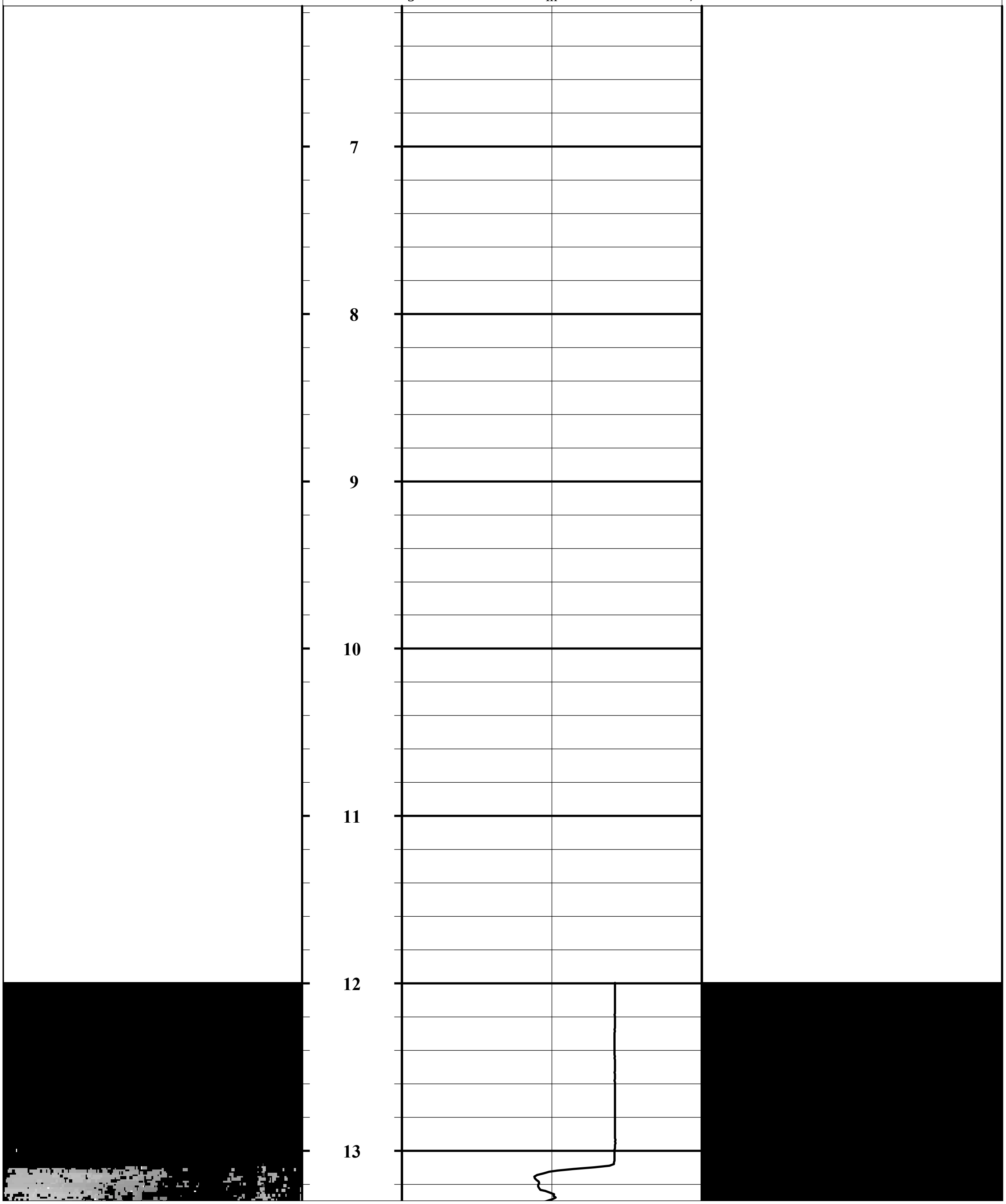
NA - Not Available, N/A - Not Applicable

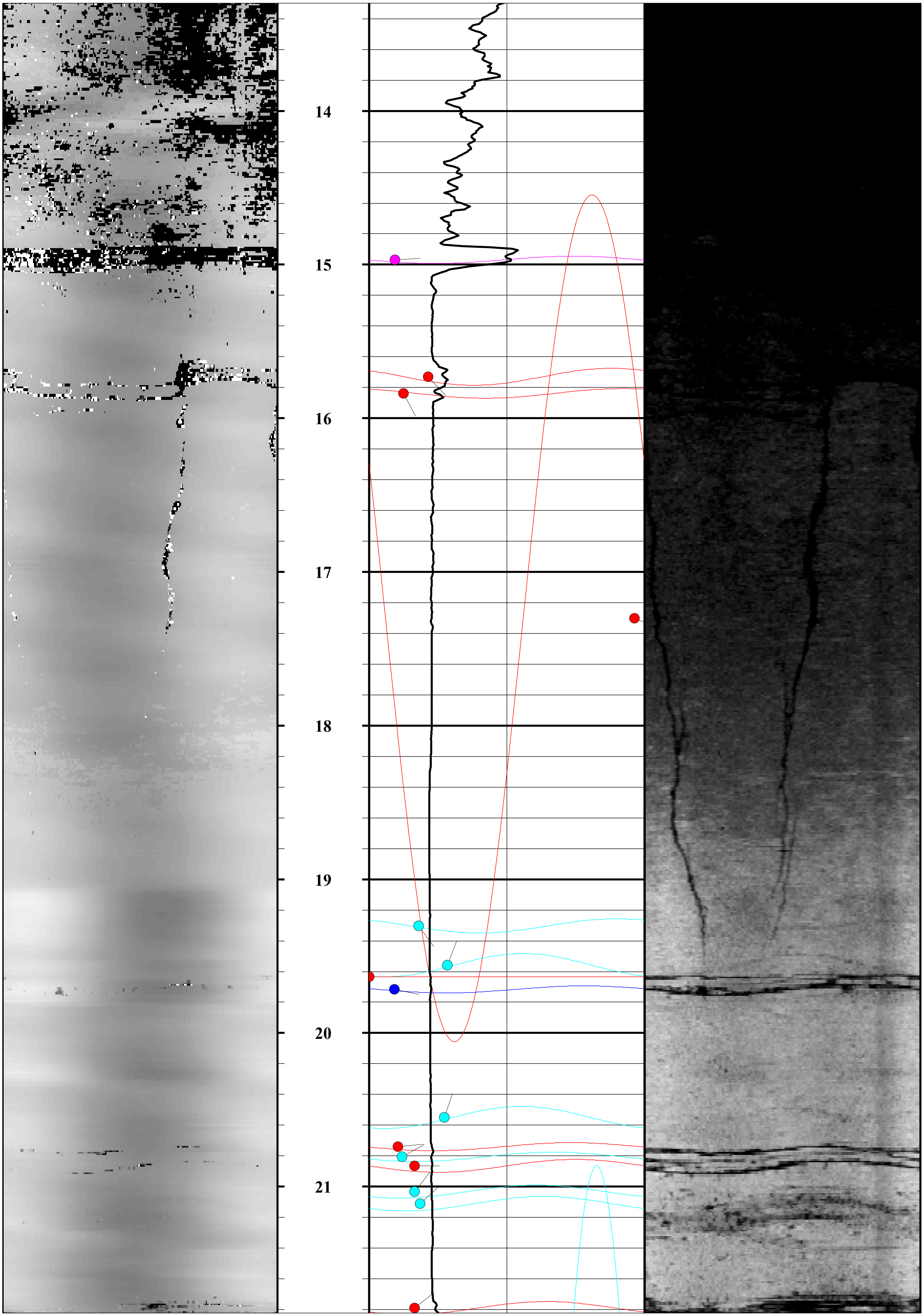
Images, Projections, and Tadpoles are relative to Magnetic North.

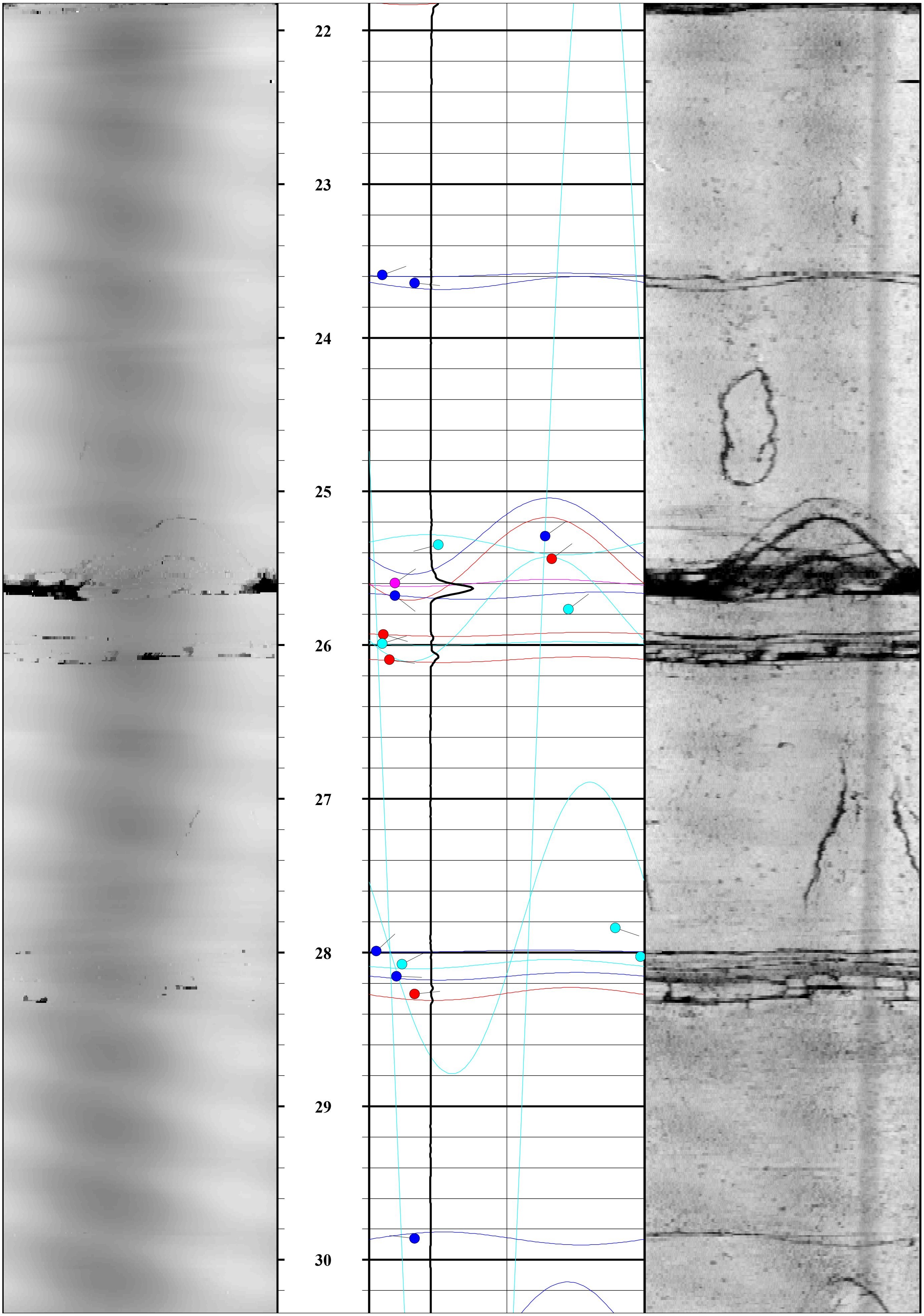
Magnetic declination of 12.85 degrees East added to all directions so that all Stereonets and Rose Diagrams are with respect to True North.

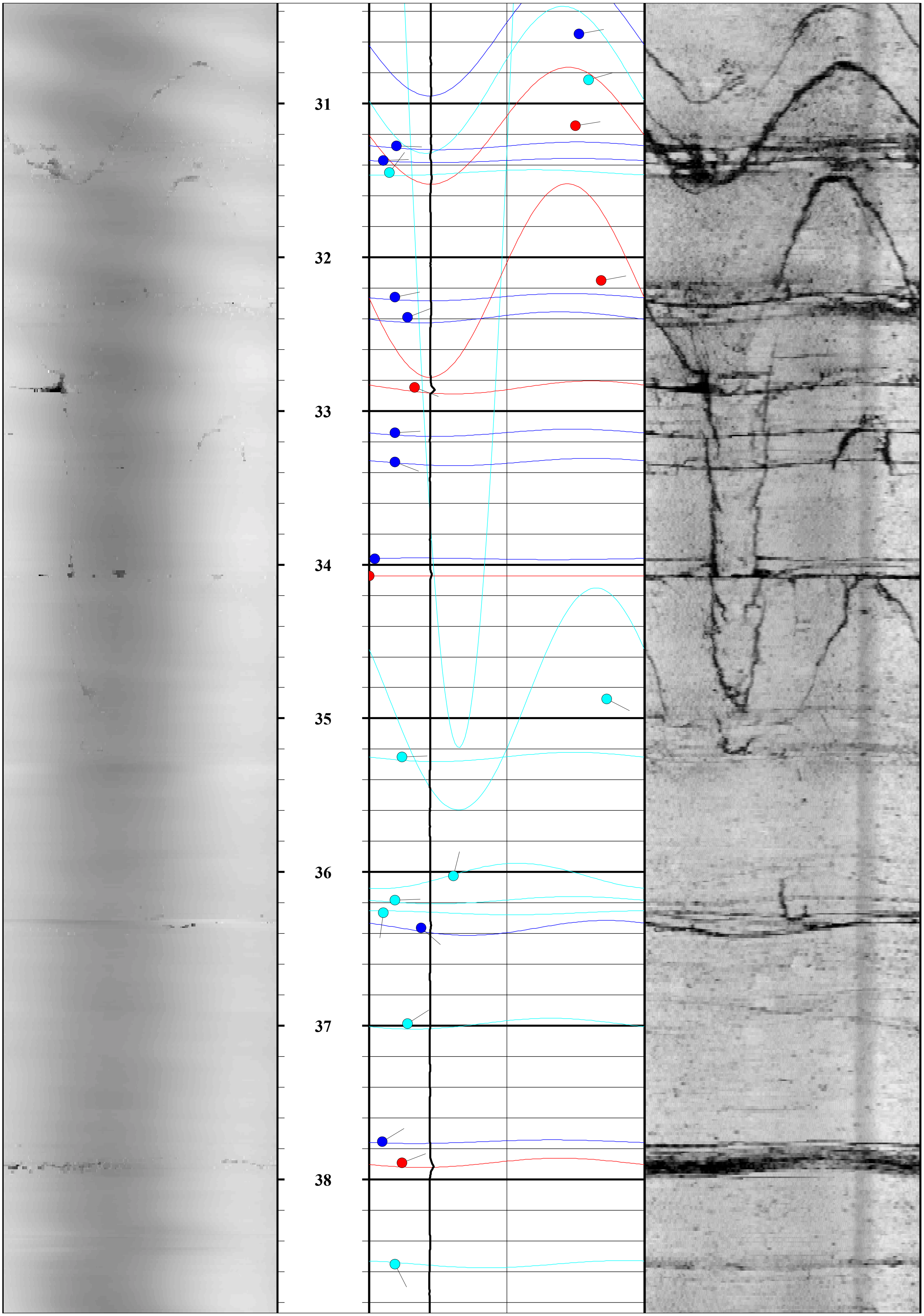
Could not reach driller's TD, due to fill.

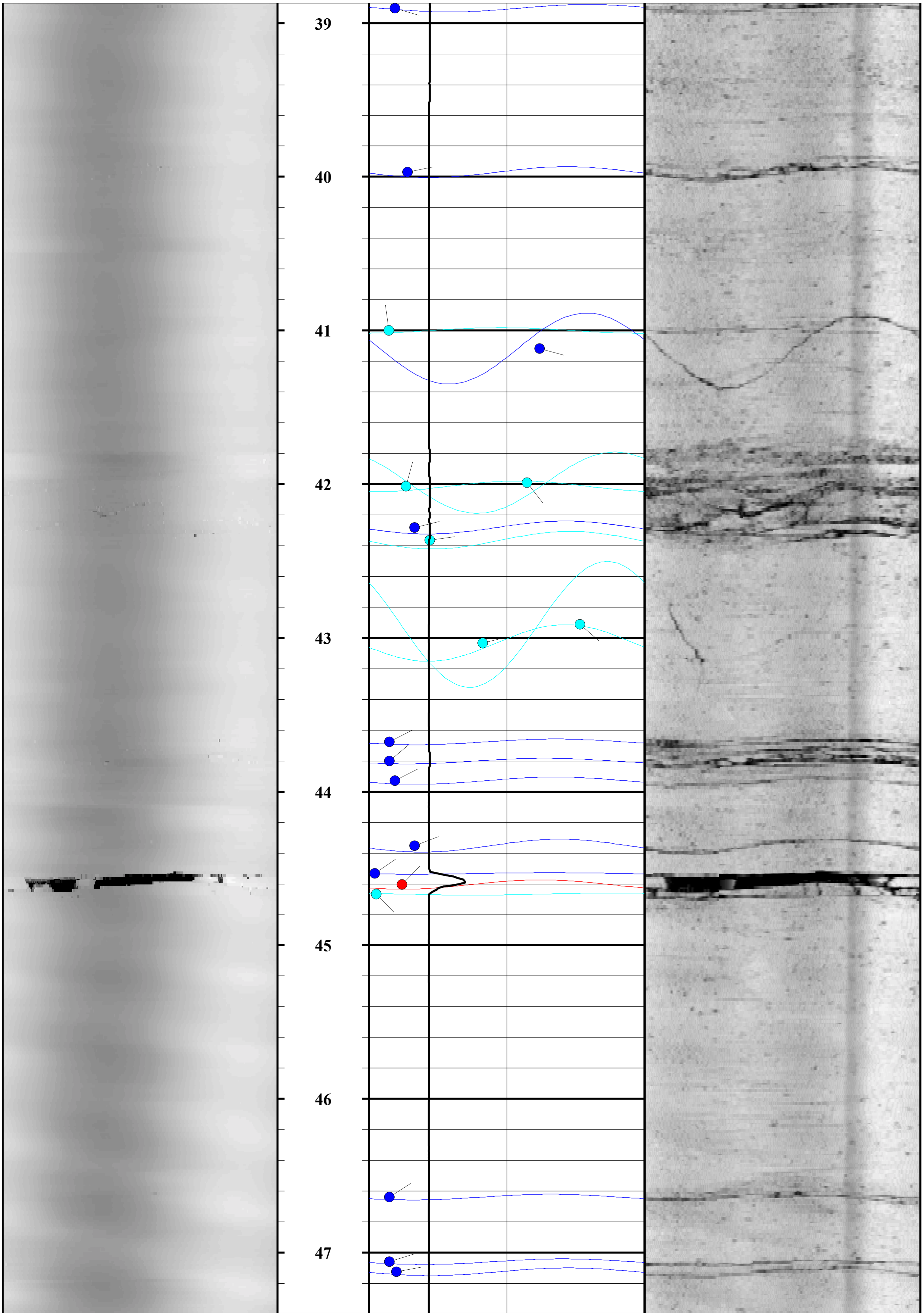
Acoustic Travel Time	Depth	Projections / Tadpoles / Acoustic Caliper	Acoustic Amplitude
0° 90° 180° 270° 0°	1ft:10ft	Projections: 0° 90° 180° 270° 0°	0° 90° 180° 270° 0°
		Tadpoles: 0 90	
		Acoustic Caliper: 3 in 7	

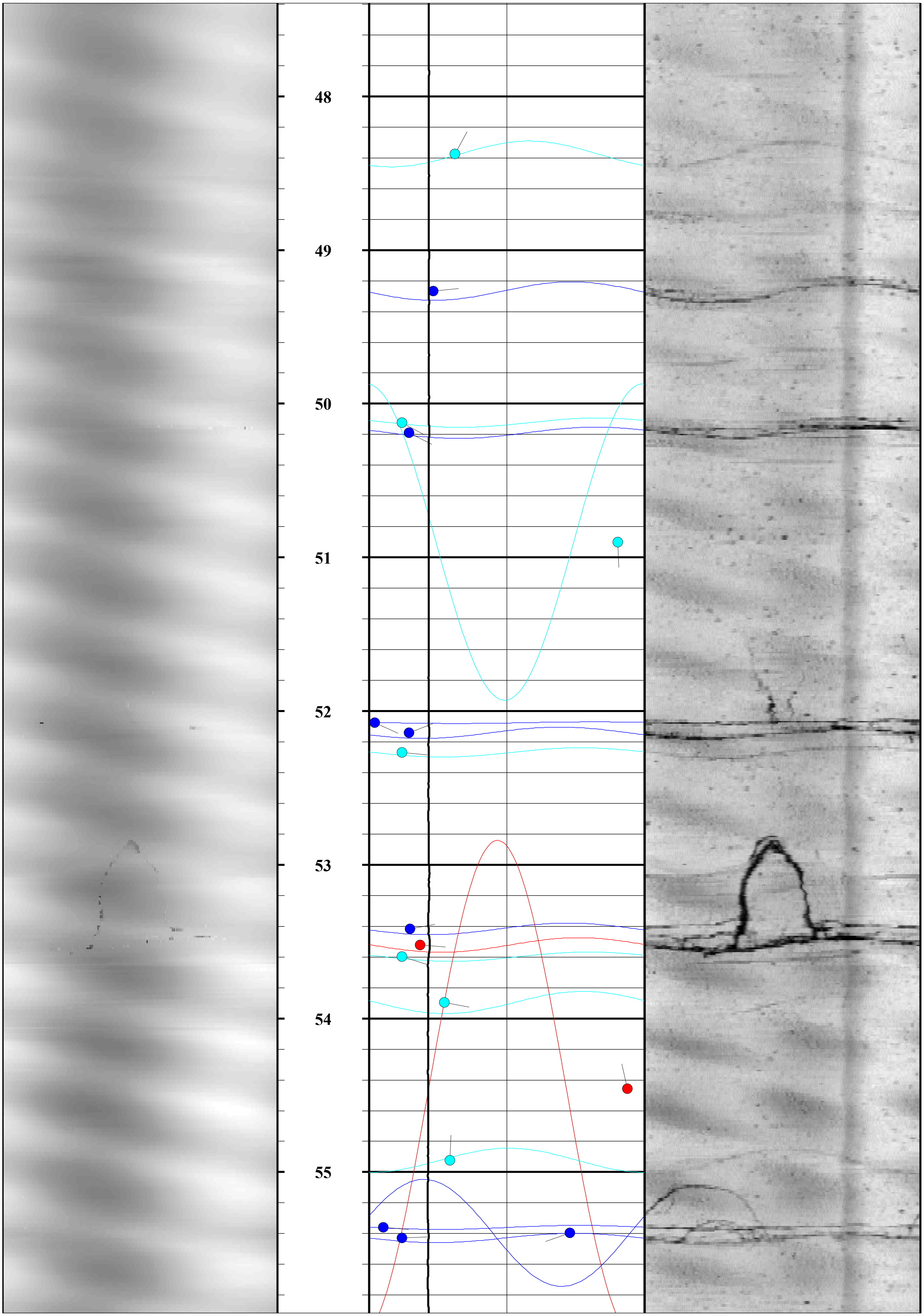


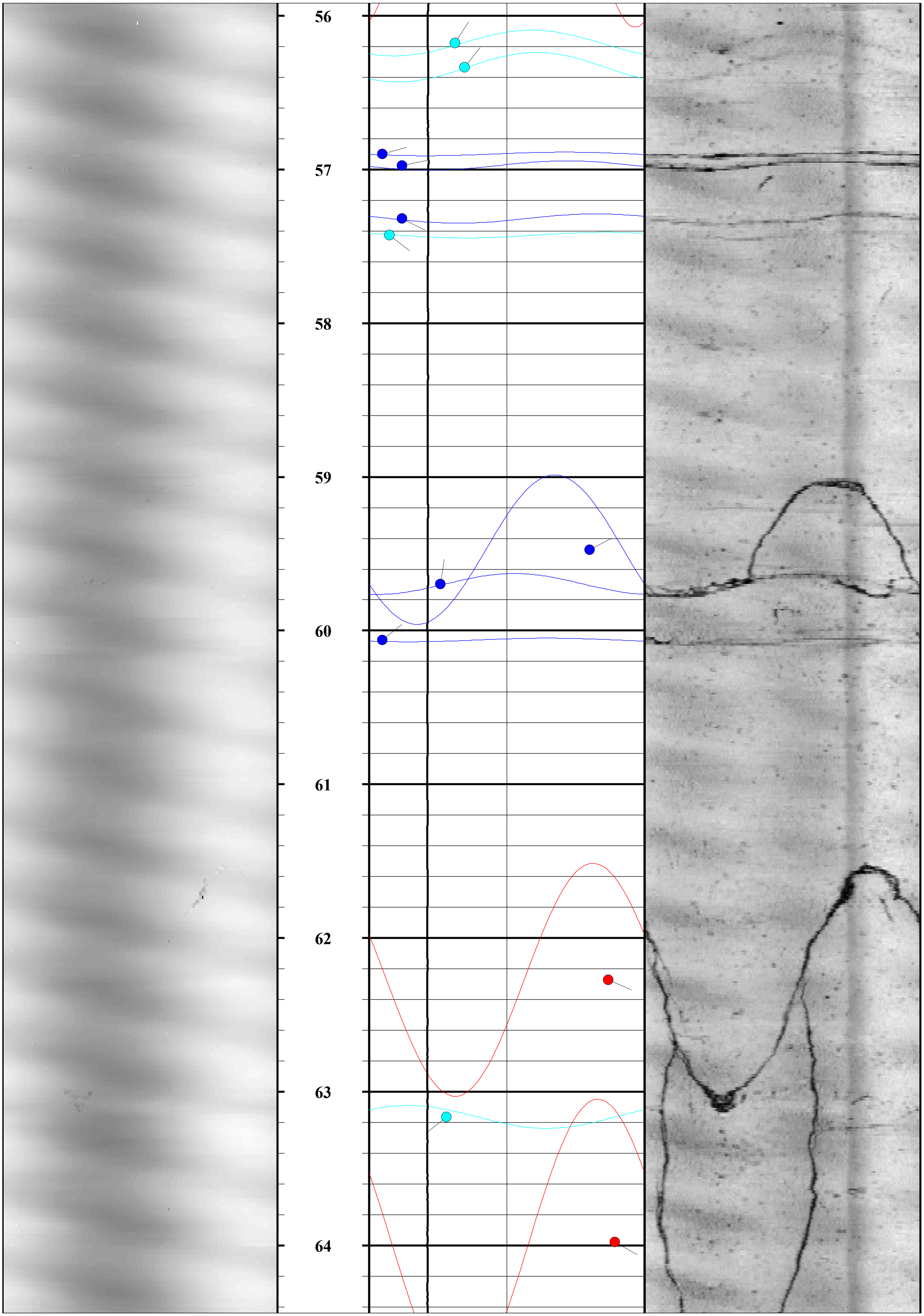

14
15
16
17
18
19
20
21

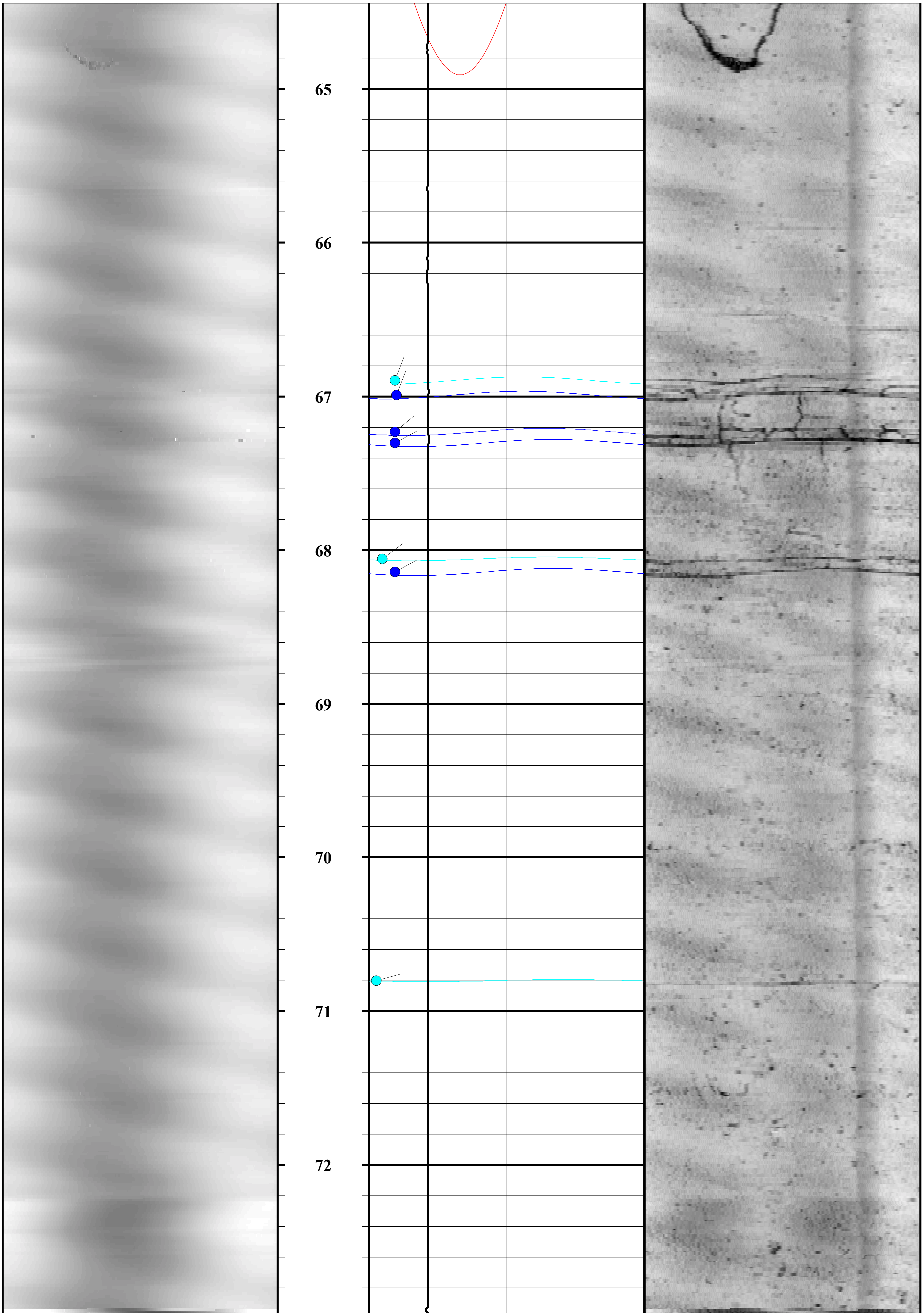

22
23
24
25
26
27
28
29
30

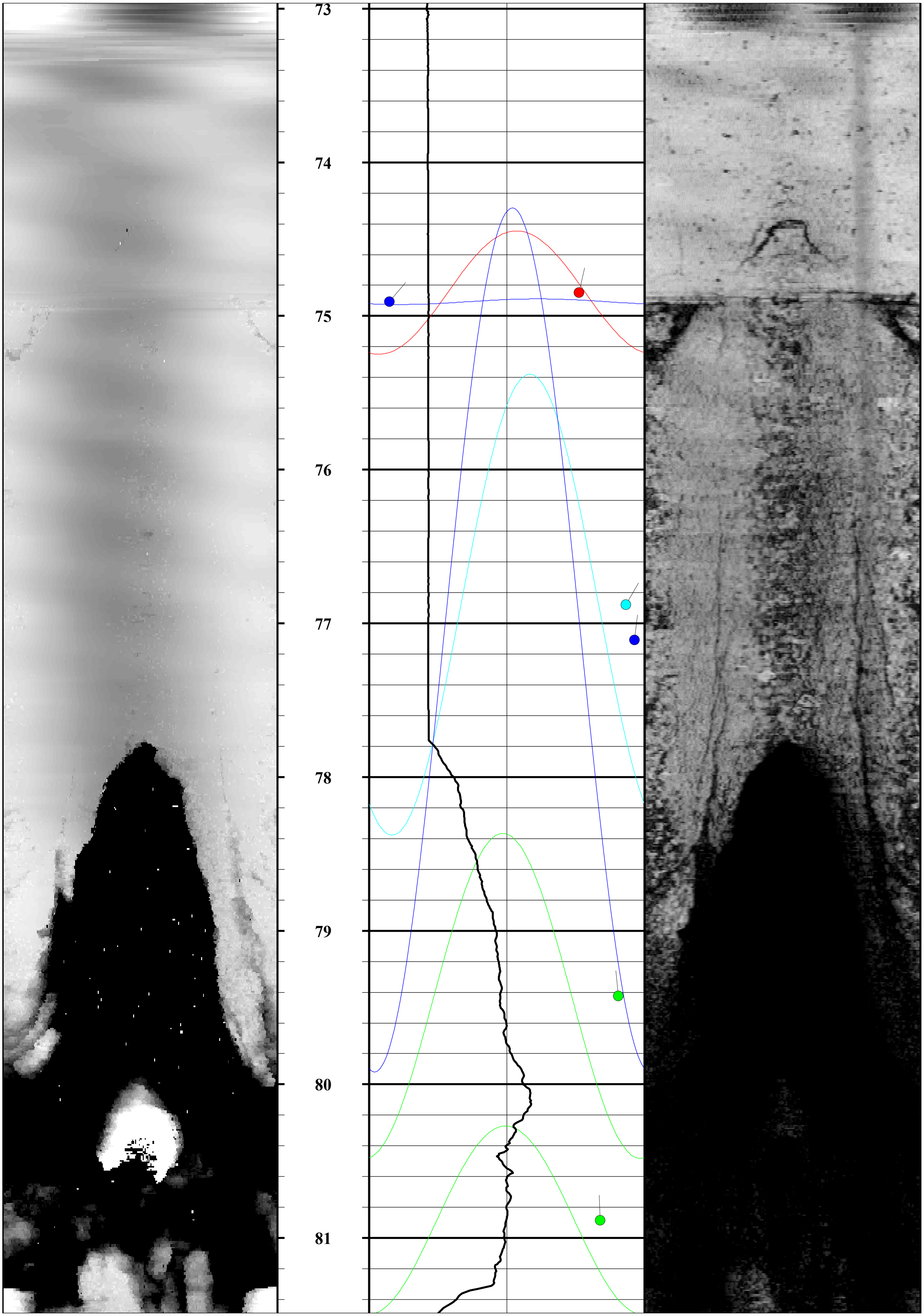

31
32
33
34
35
36
37
38

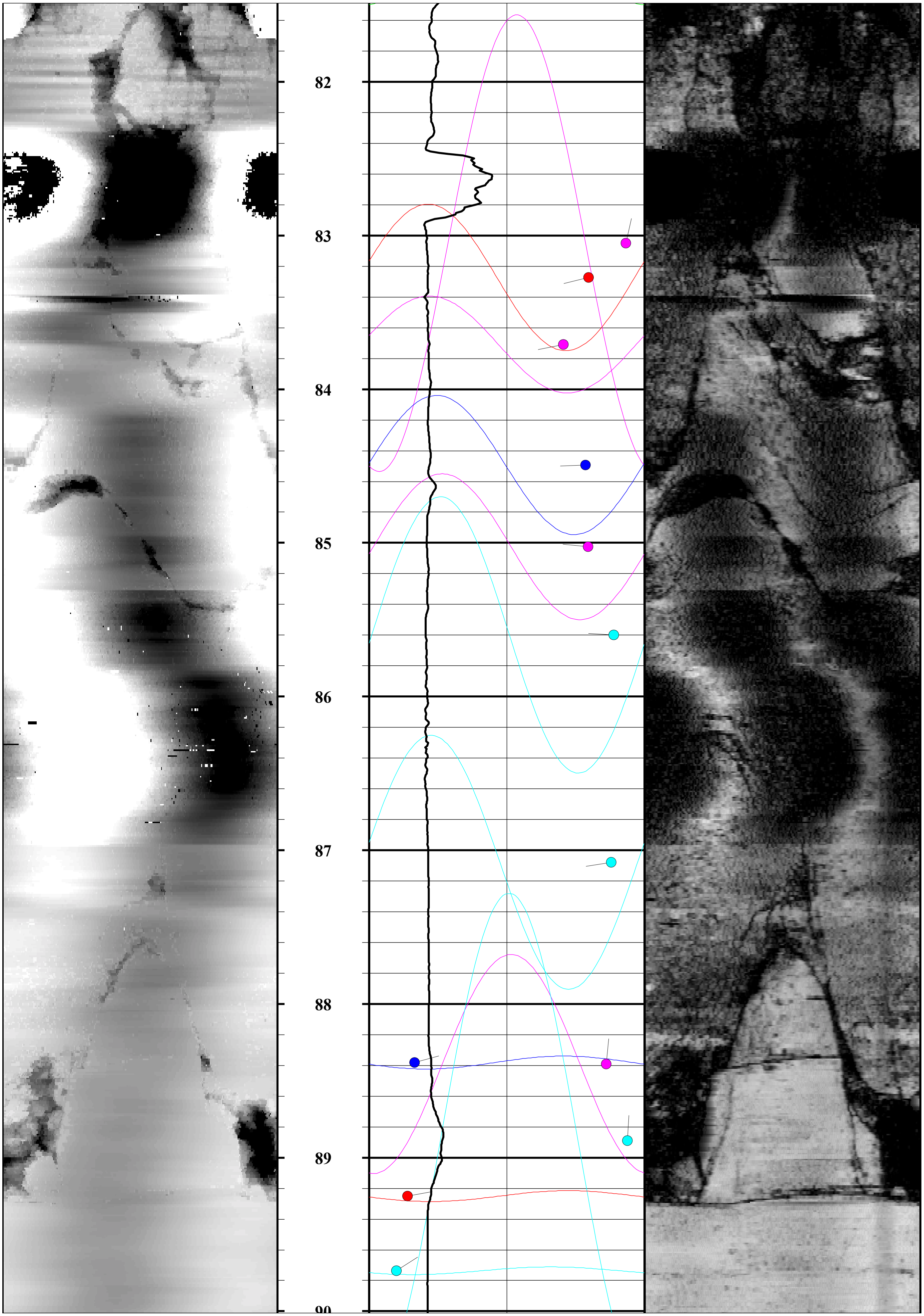

39
40
41
42
43
44
45
46
47

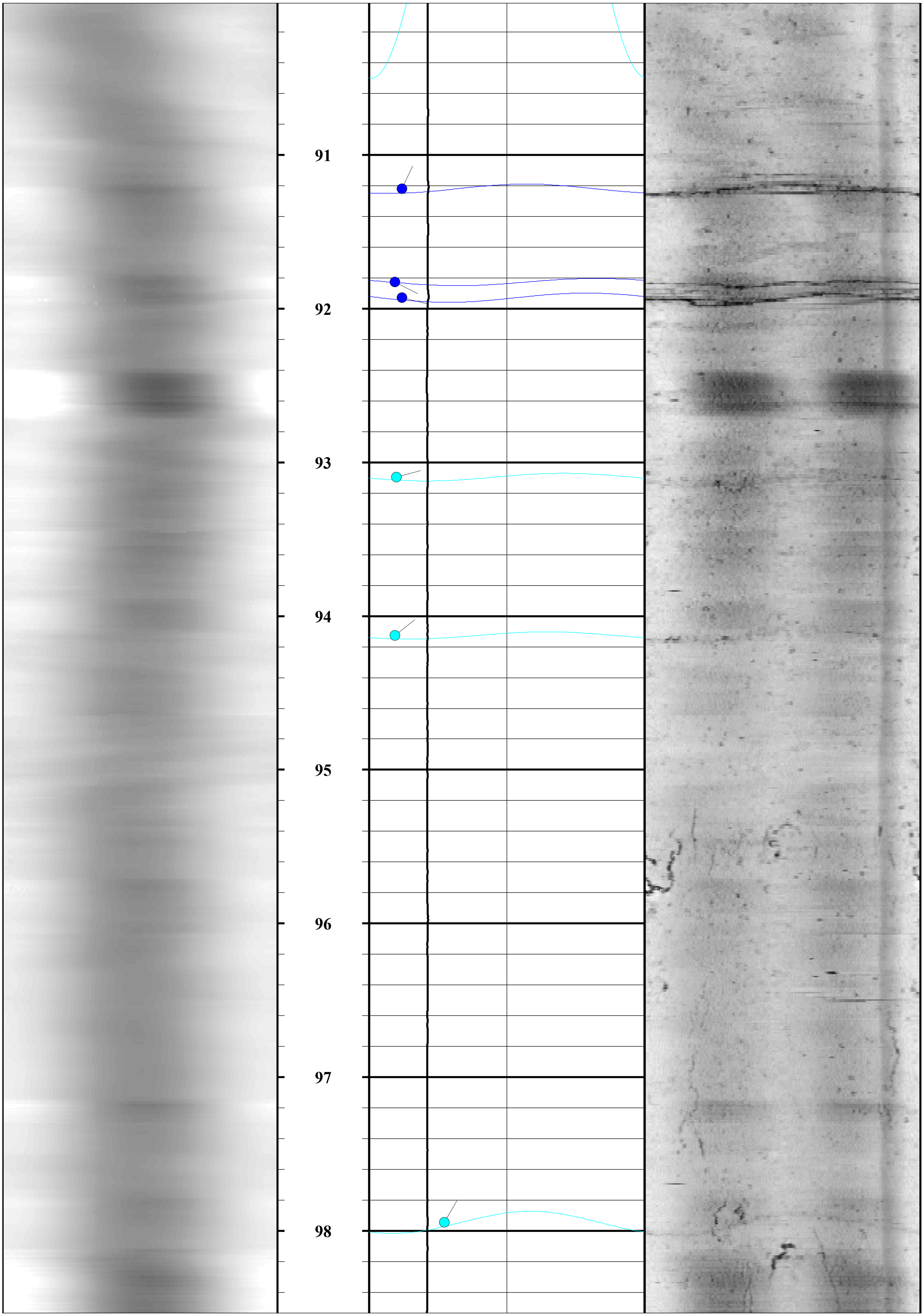

48
49
50
51
52
53
54
55


56
57
58
59
60
61
62
63
64

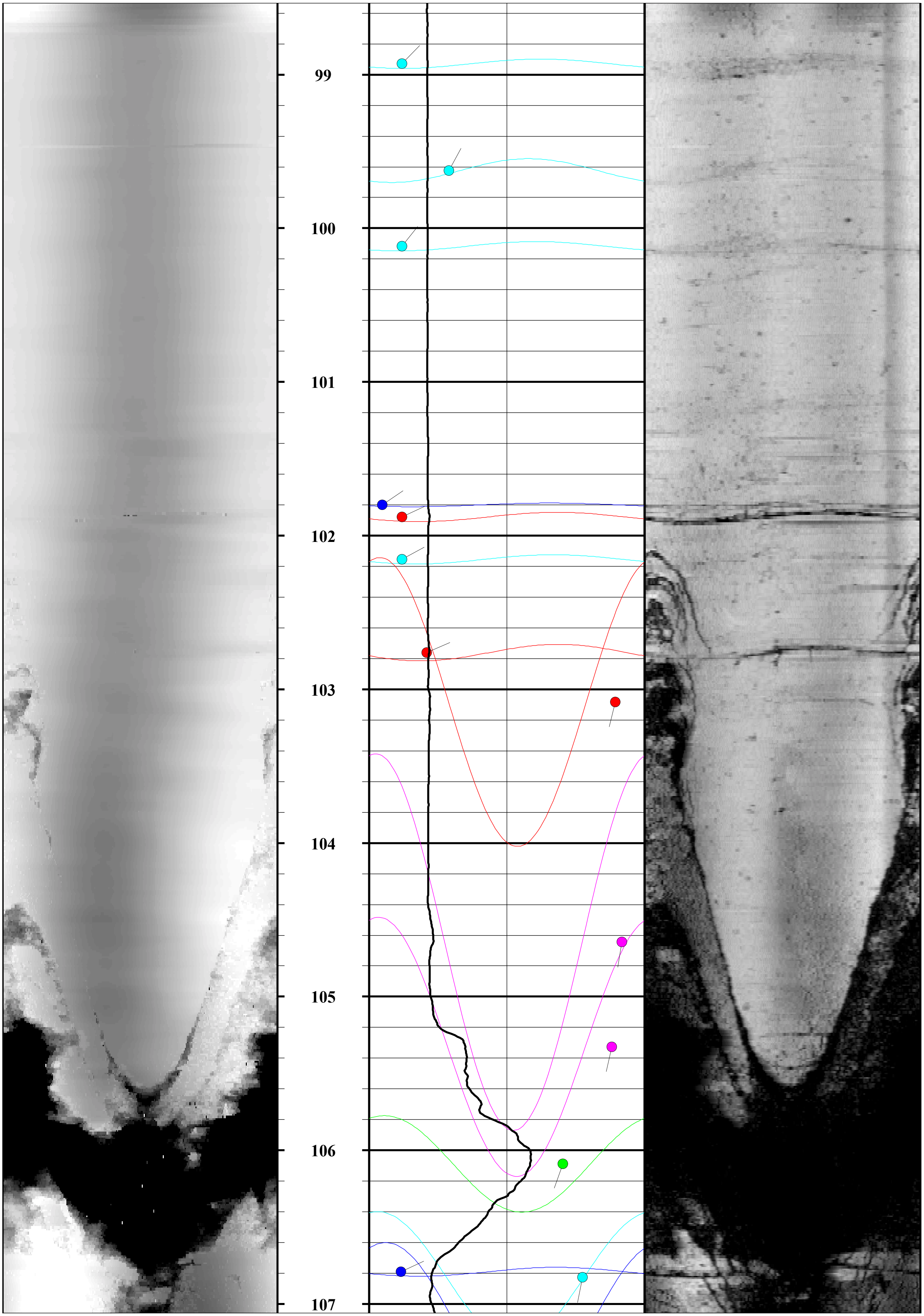

65
66
67
68
69
70
71
72


73
74
75
76
77
78
79
80
81

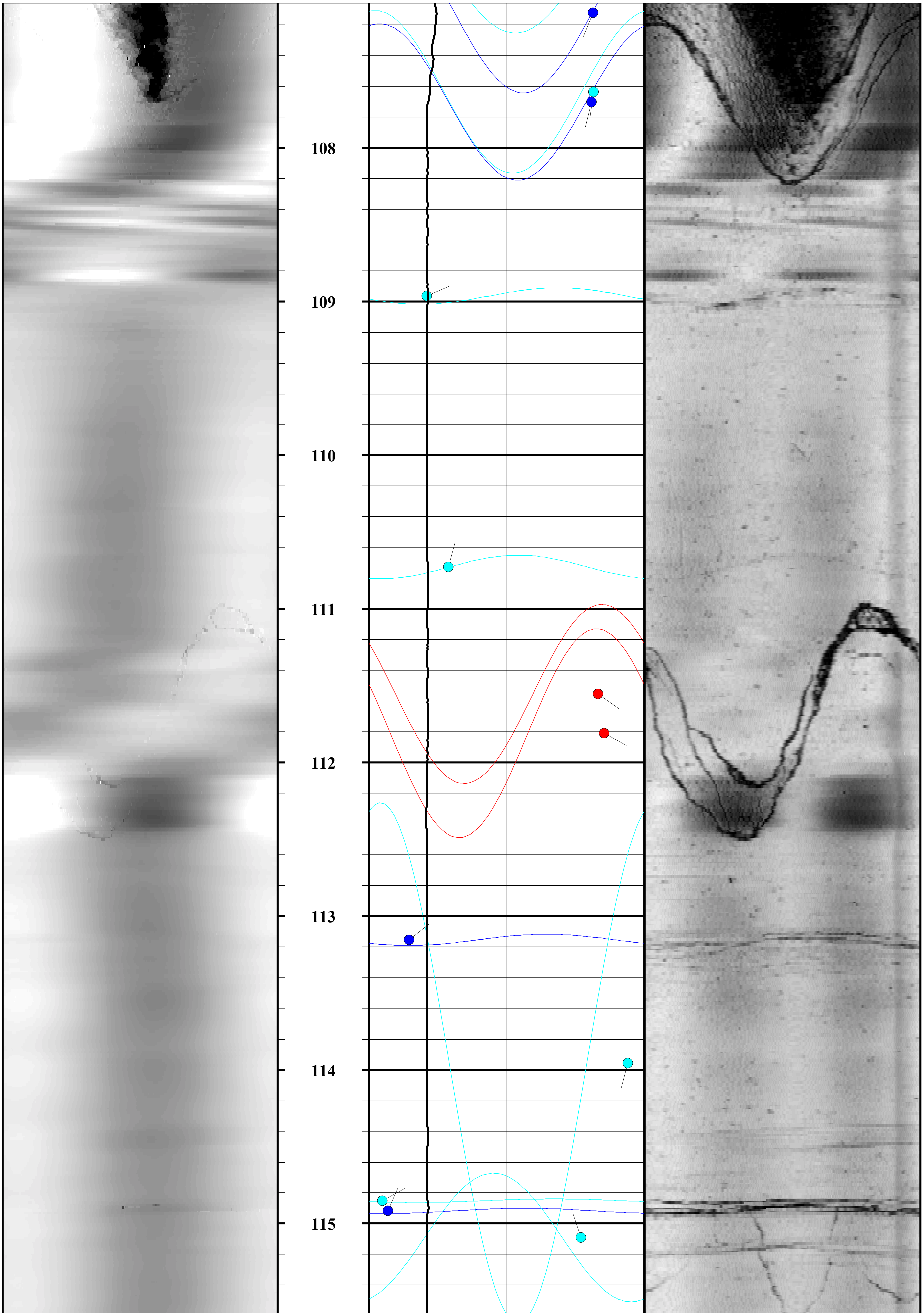

82
83
84
85
86
87
88
89
90

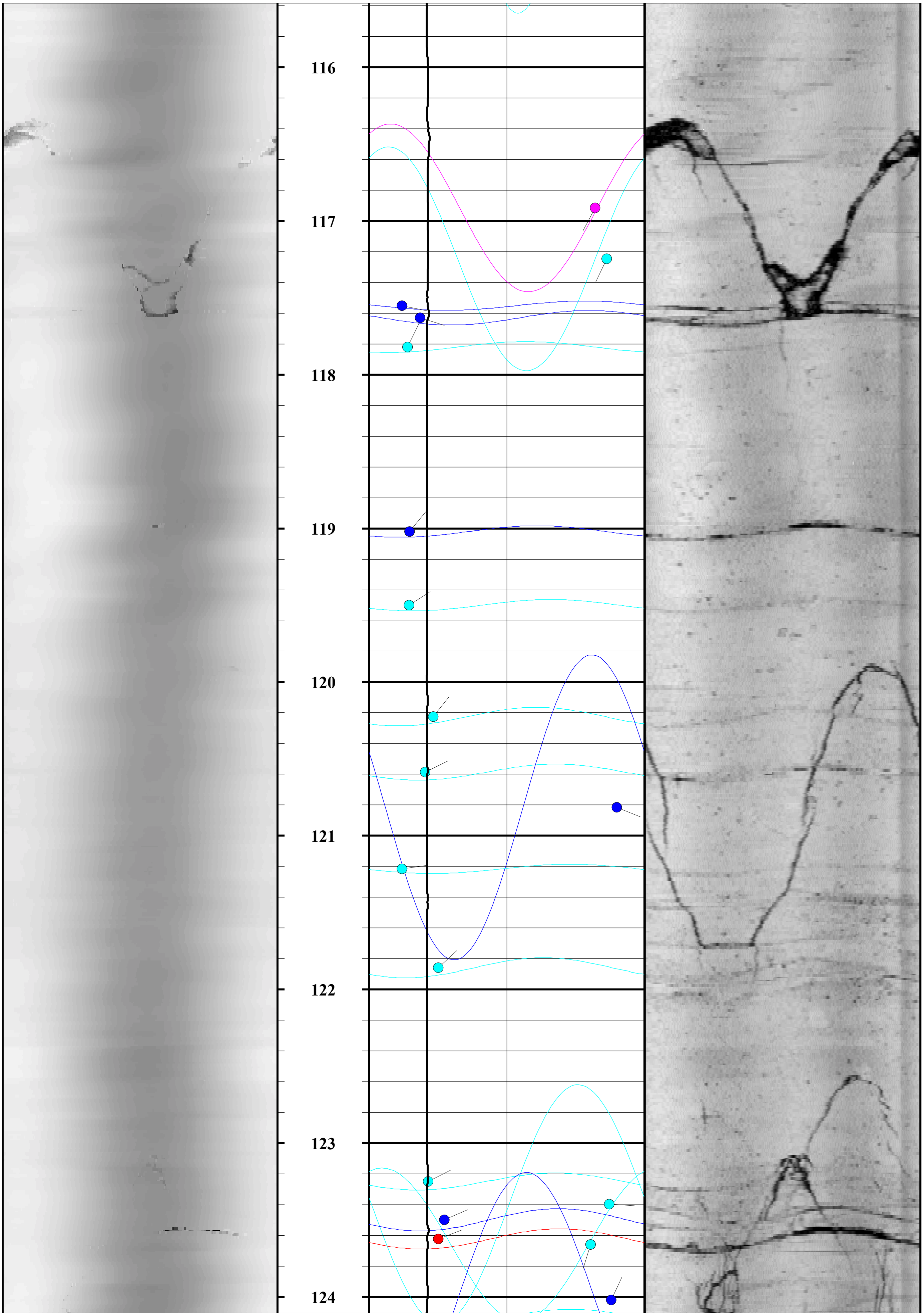


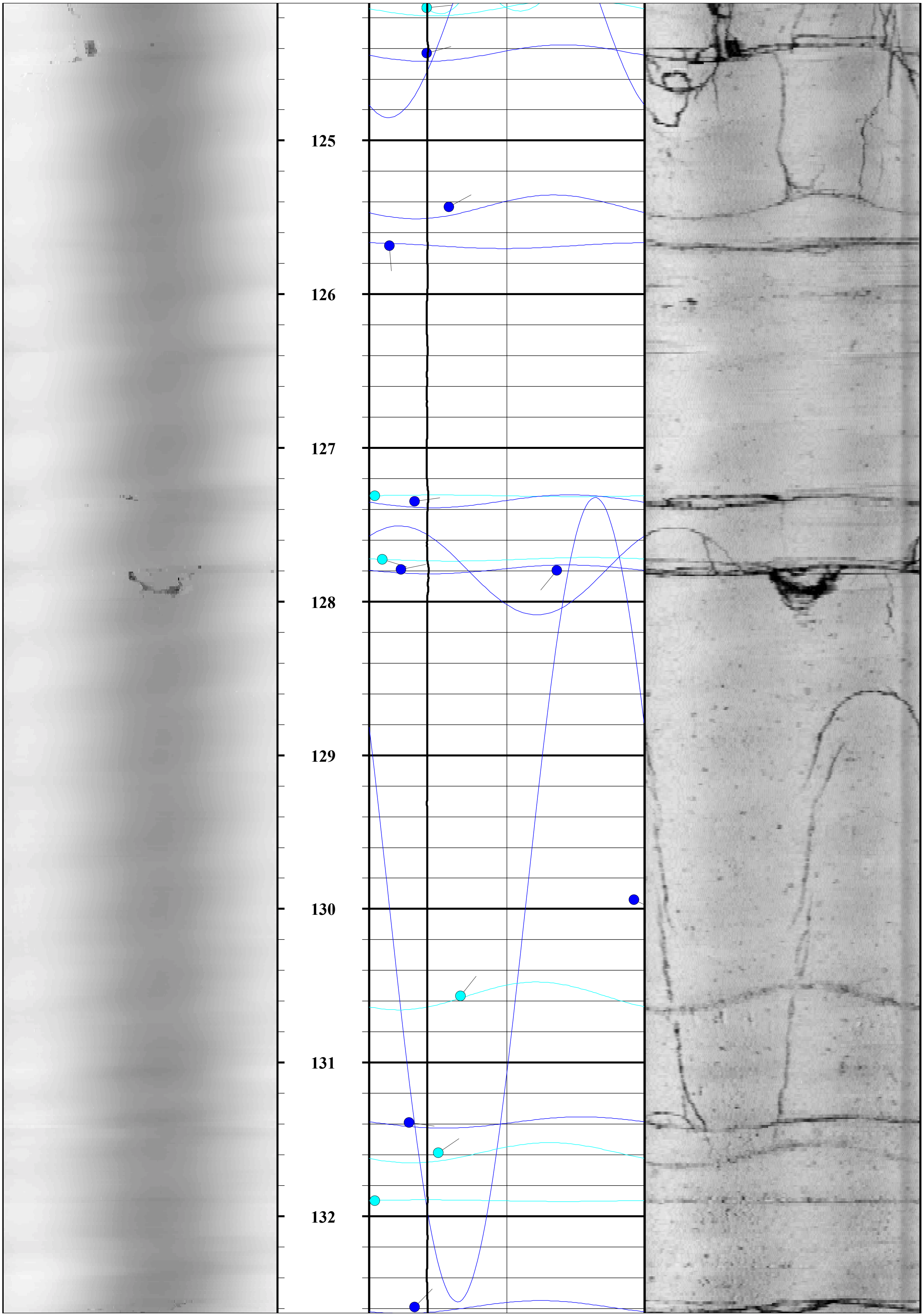
91
92
93
94
95
96
97
98

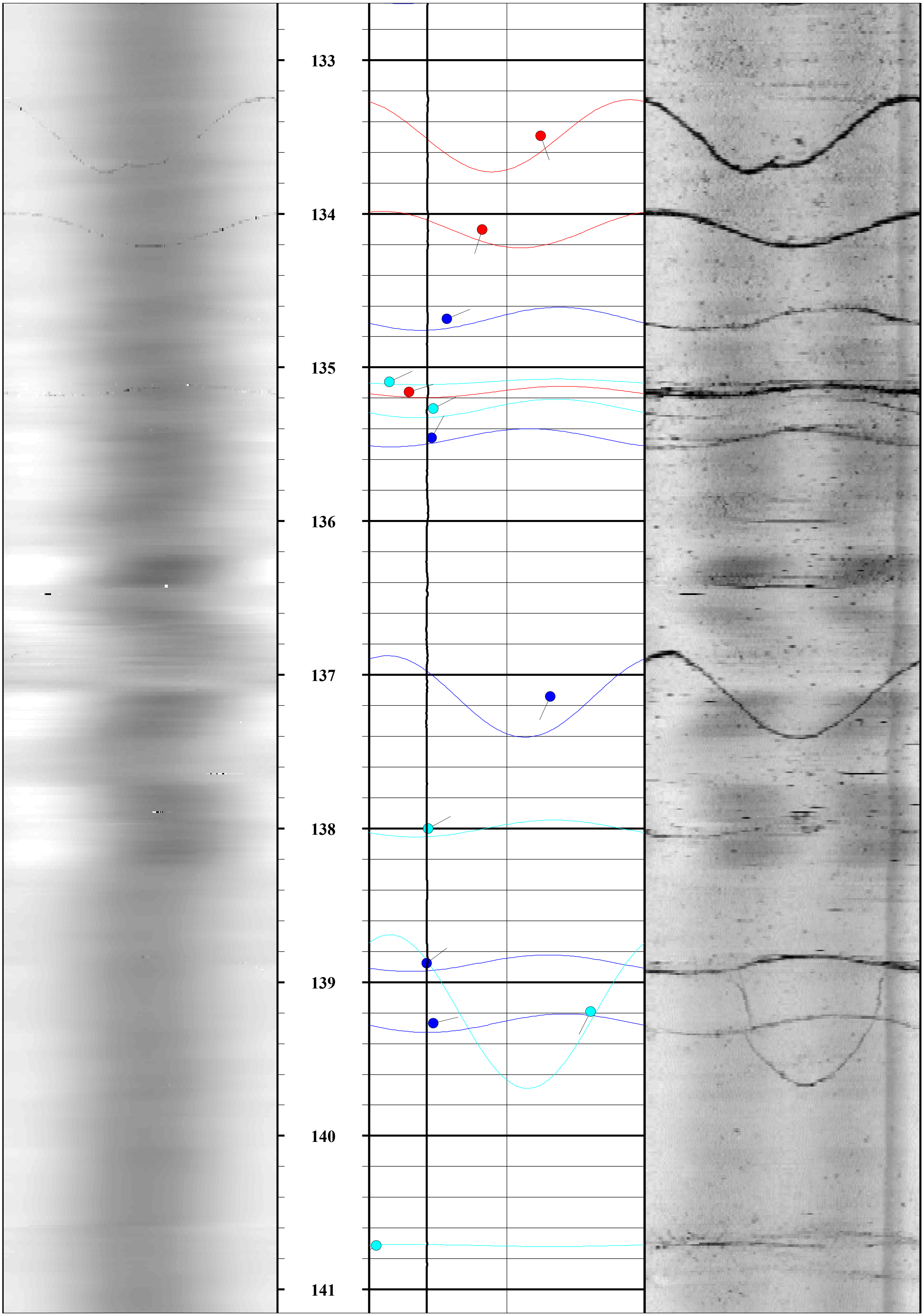


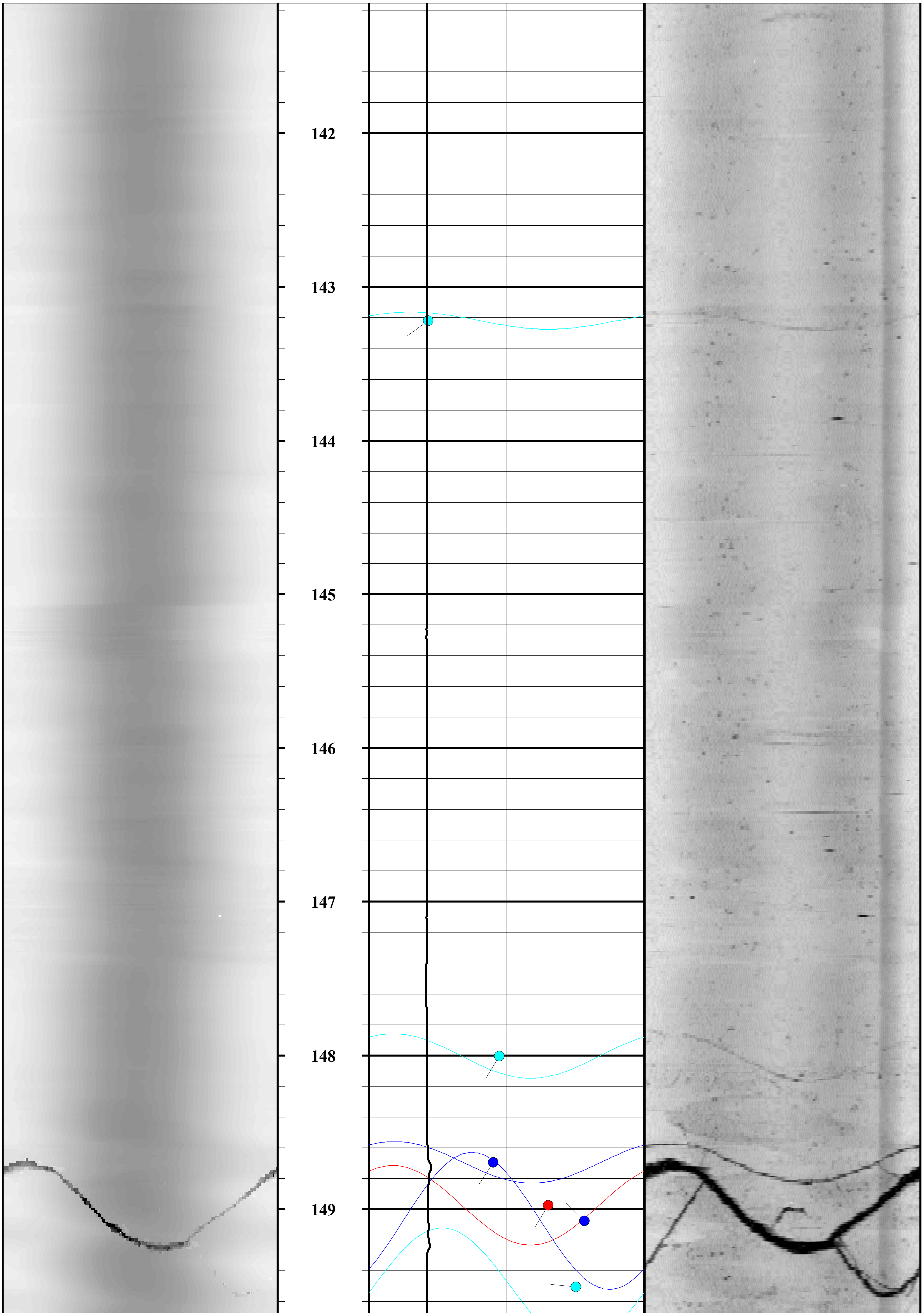
99
100
101
102
103
104
105
106
107

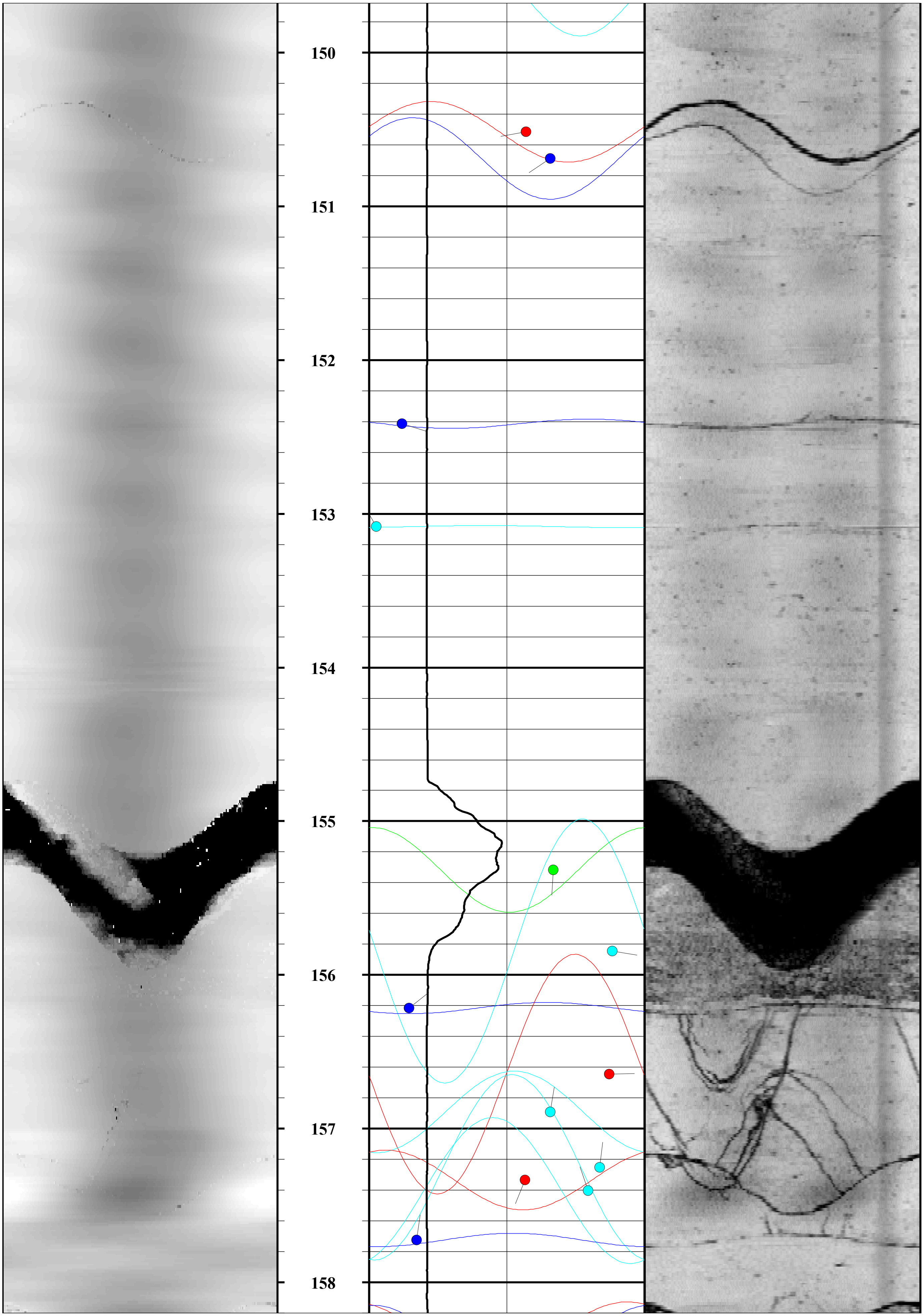

108
109
110
111
112
113
114
115

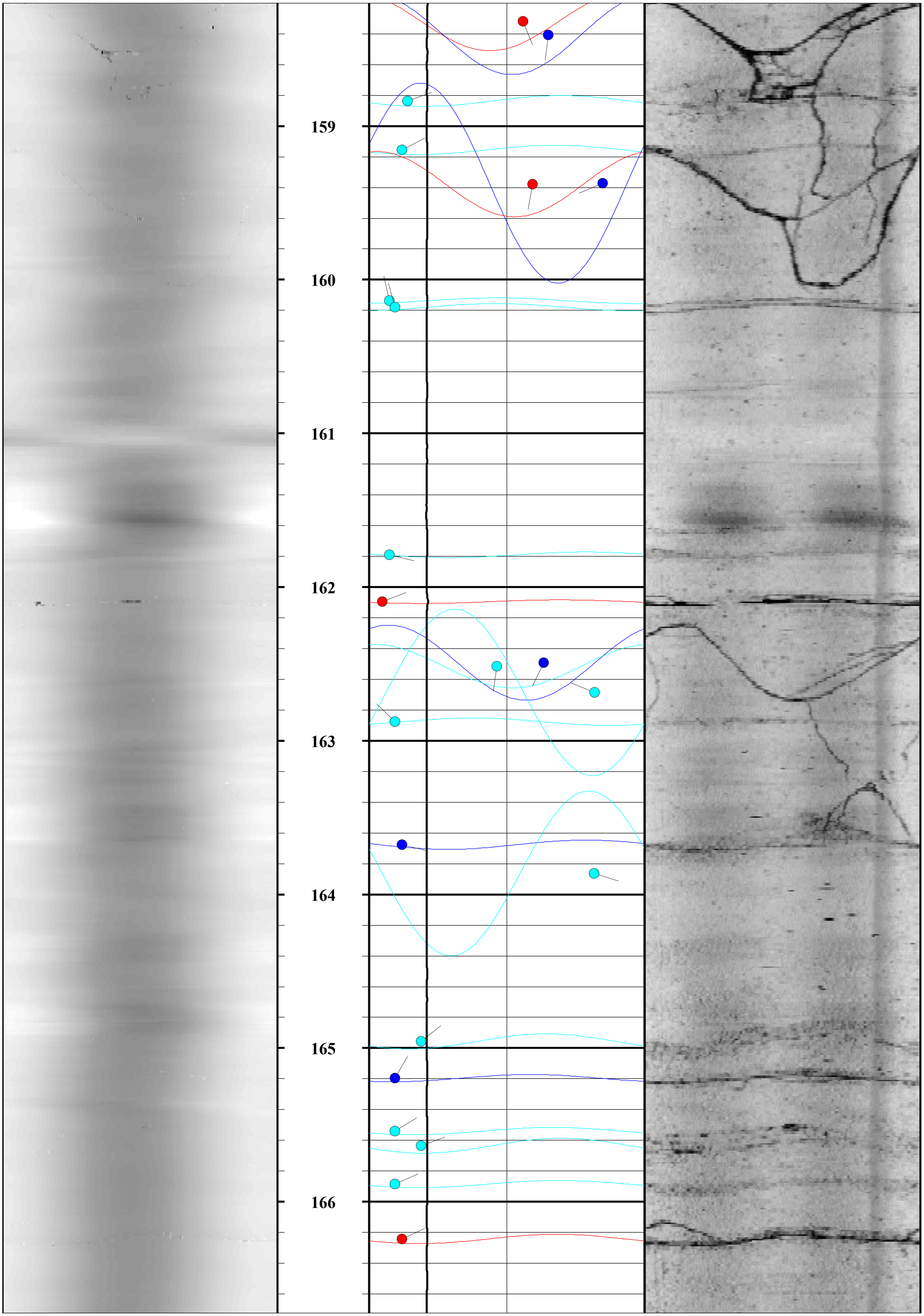

116
117
118
119
120
121
122
123
124

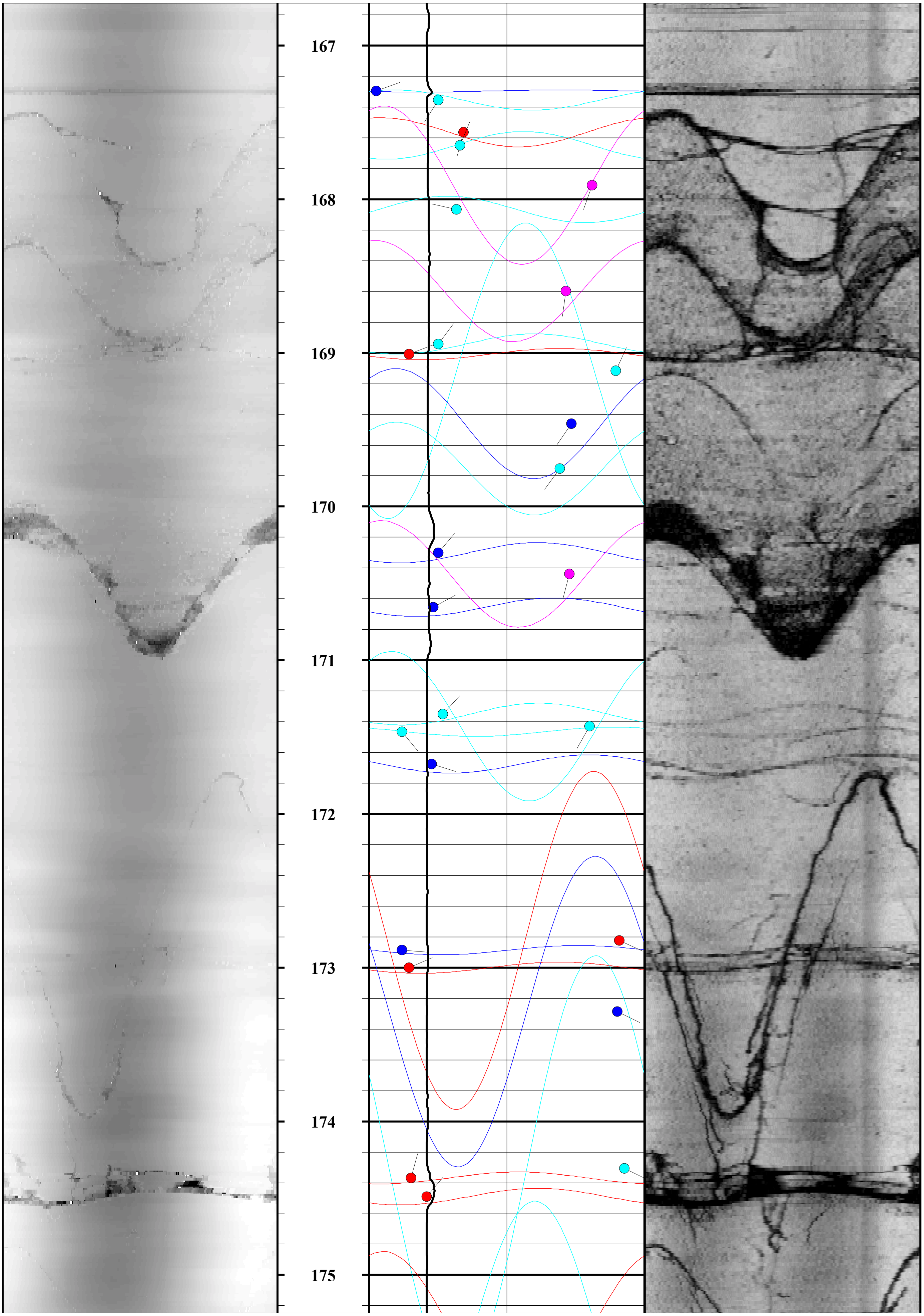

125
126
127
128
129
130
131
132

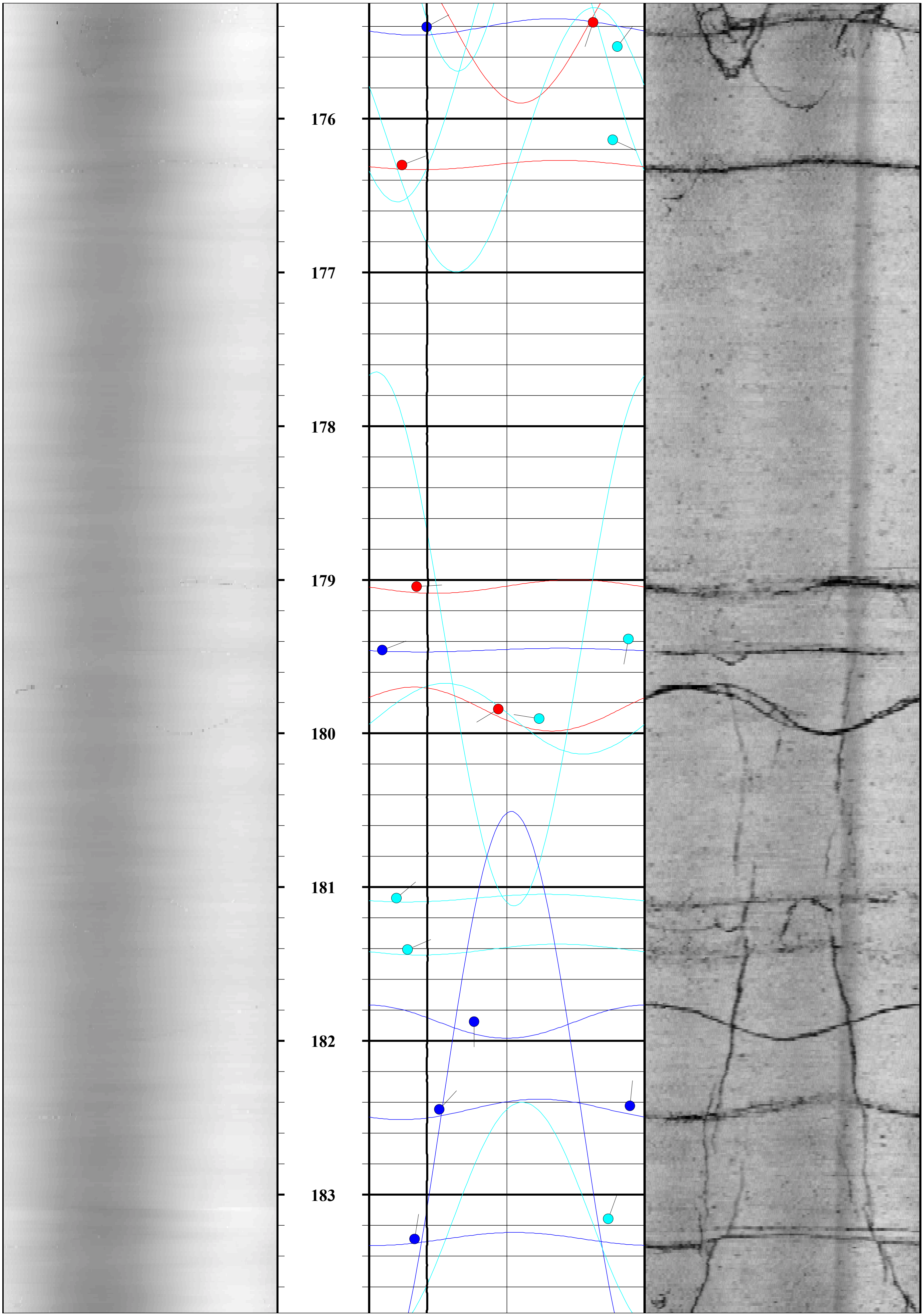

133
134
135
136
137
138
139
140
141

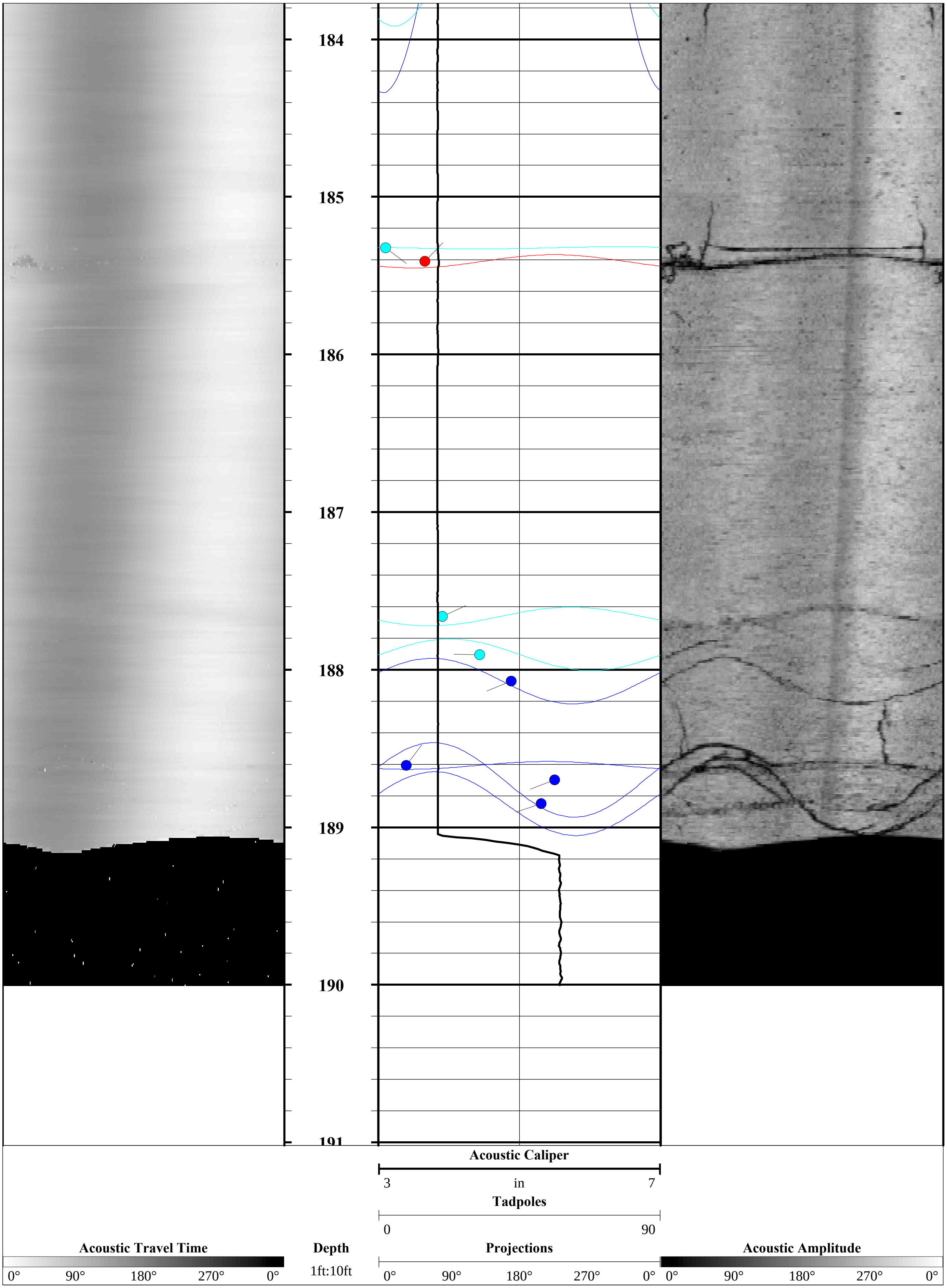

142
143
144
145
146
147
148
149


150
151
152
153
154
155
156
157
158


159
160
161
162
163
164
165
166


167
168
169
170
171
172
173
174
175


176
177
178
179
180
181
182
183



184
185
186
187
188
189
190
191
Acoustic Caliper
3
in
7
Tadpoles
0
90
Acoustic Travel Time
0° 90° 180° 270° 0°
Depth
1ft:10ft
Projections
0° 90° 180° 270° 0°
Acoustic Amplitude
0° 90° 180° 270° 0°

Full-Waveform Sonic

BOREHOLE GEOPHYSICS & HYDROPHYSICS
COLOG
A DIVISION OF LAYNE CHRISTENSEN COMPANY

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Company NNSA/NSO
Well U-15n
Field Nevada Test Site
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15n
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900077.65'
E: 676640.92'

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Normal Resistivities
SP, SPR
Dual-Spaced Density
Caliper
Natural Gamma Ray

PERMANENT DATUM G.L. **ELEVATION** 5003.12

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM G.L.

DATE ACQUIRED	31 July 2010			
RUN NUMBER	6			
LOG TYPE	Full-Waveform Sonic			
DEPTH-DRILLER	196.5'			
DEPTH-LOGGER	194.8'			
BTM LOG INTERVAL	182'			
TOP LOG INTERVAL	0'			
RECORDED BY	A. Caster			
WITNESSED BY	G. Juniel			
PROBE TYPE, S/N	2SAA-F			
LOGGING SPEED	5 ft/min			
A.S.D.E.	0.0'			
SAMPLE INTERVAL	0.2'			

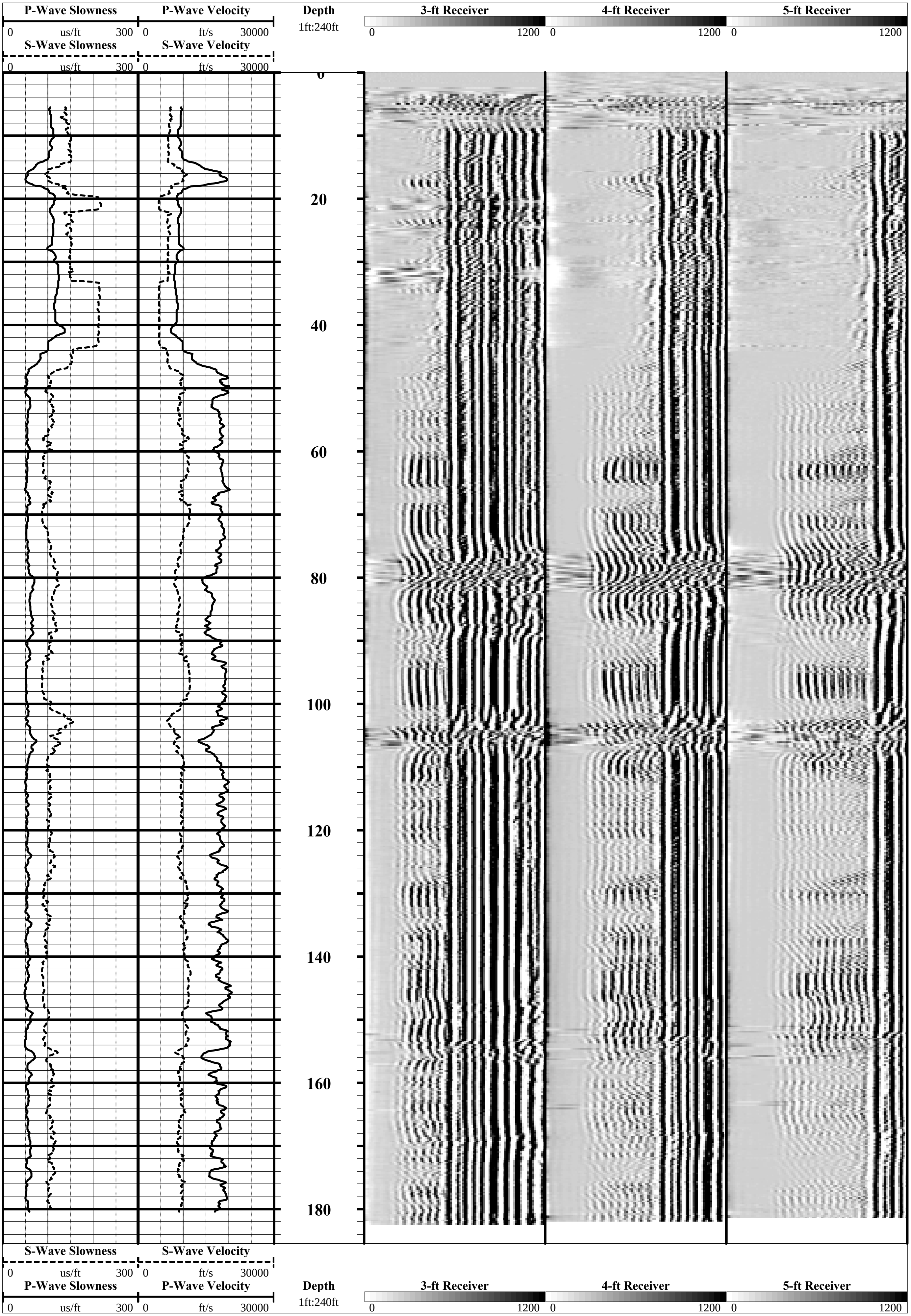
BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	3.81	6.7	196.5	5.5"		+0.83'	6.7'

COMMENTS

NA - Not Available, N/A - Not Applicable

Could not reach driller's TD, due to fill.

P-wave and S-wave Slowness and Velocity calculated from all three receivers, using a semblance algorythm.


P-Wave Slowness
0 us/ft 300
S-Wave Slowness
0 us/ft 300
P-Wave Velocity
0 ft/s 30000
S-Wave Velocity
0 ft/s 30000
Depth
1ft:240ft
3-ft Receiver
0 1200
4-ft Receiver
0 1200
5-ft Receiver
0 1200
0
20
40
60
80
100
120
140
160
180

Borehole Deviation

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Company NNSA/NSO
Well U-15n
Field Nevada Test Site
County Nye
State Nevada

COMPANY	NNSA/NSO
WELL	U-15n
FIELD	Nevada Test Site
COUNTY	Nye
STATE	Nevada

LOCATION
Area 15 (L/O)
N: 900077.65'
E: 676640.92'

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Normal Resistivities
SP, SPR
Full-Wave Sonic
Dual-Spaced Density
Caliper
Natural GAmma Ray

PERMANENT DATUM G.L. **ELEVATION** 5003.12

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM G.L.

DATE ACQUIRED	30 July 2010			
RUN NUMBER	1			
LOG TYPE	Borehole Deviation			
DEPTH-DRILLER	196.5'			
DEPTH-LOGGER	194.8'			
BTM LOG INTERVAL	194'			
TOP LOG INTERVAL	5'			
RECORDED BY	A. Caster			
WITNESSED BY	G. Juniel			
PROBE TYPE, S/N	OBI40, 030601			
LOGGING SPEED	3 ft/min			
A.S.D.E.	0.12'			
SAMPLE INTERVAL	0.008'			

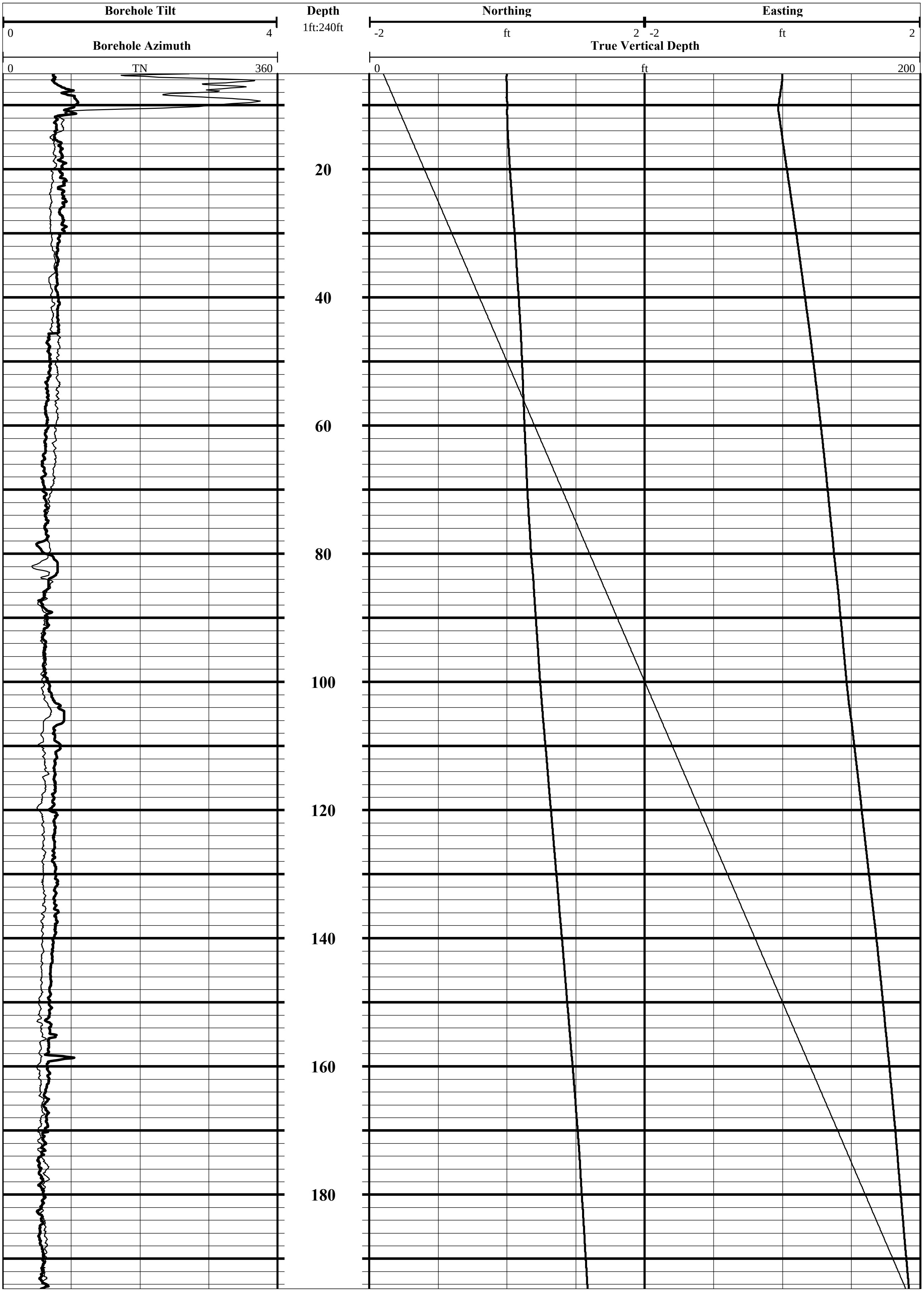
BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	3.81	6.7	196.5	5.5"		+0.83'	6.7'

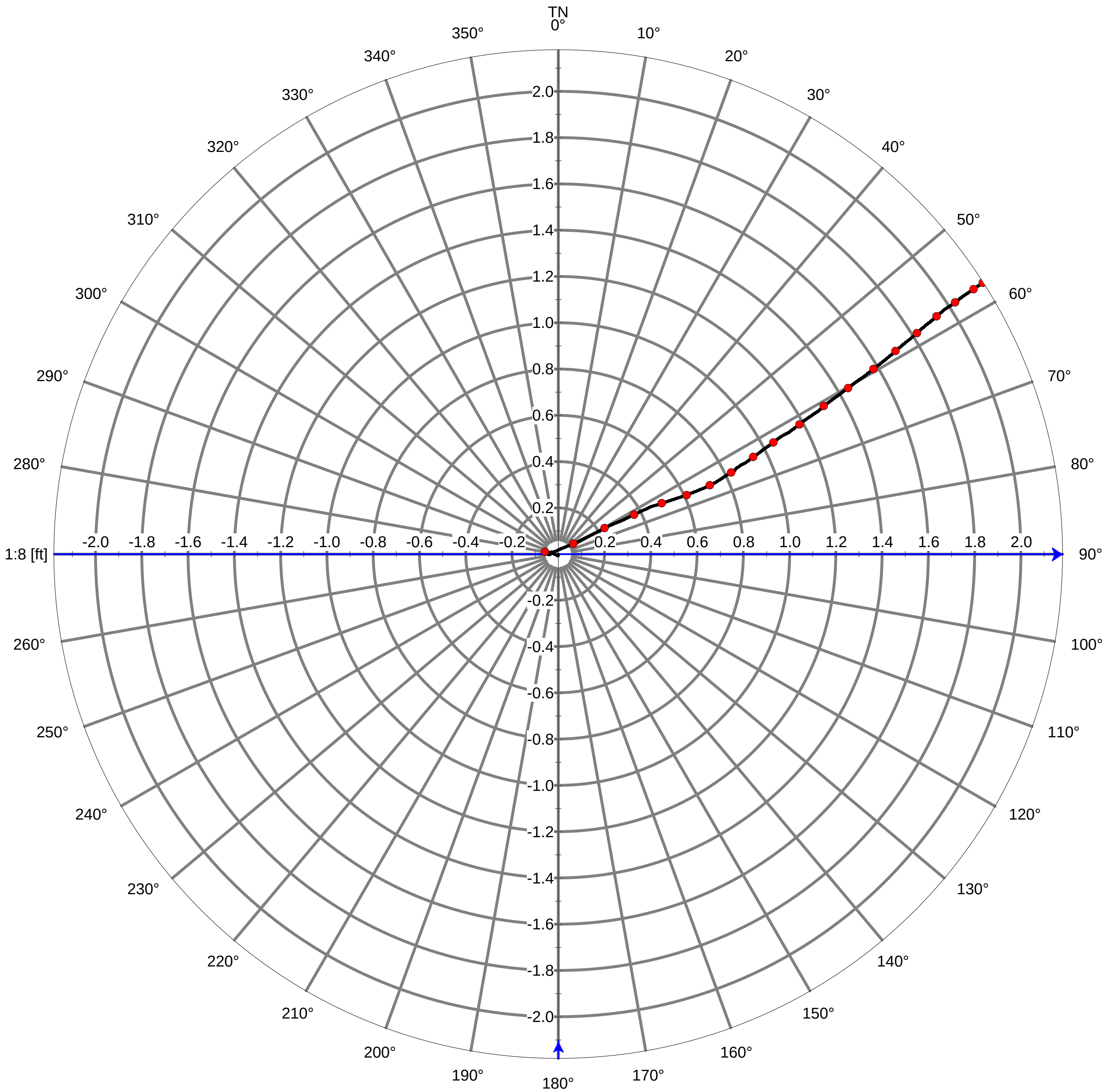
COMMENTS

NA - Not Available, N/A - Not Applicable

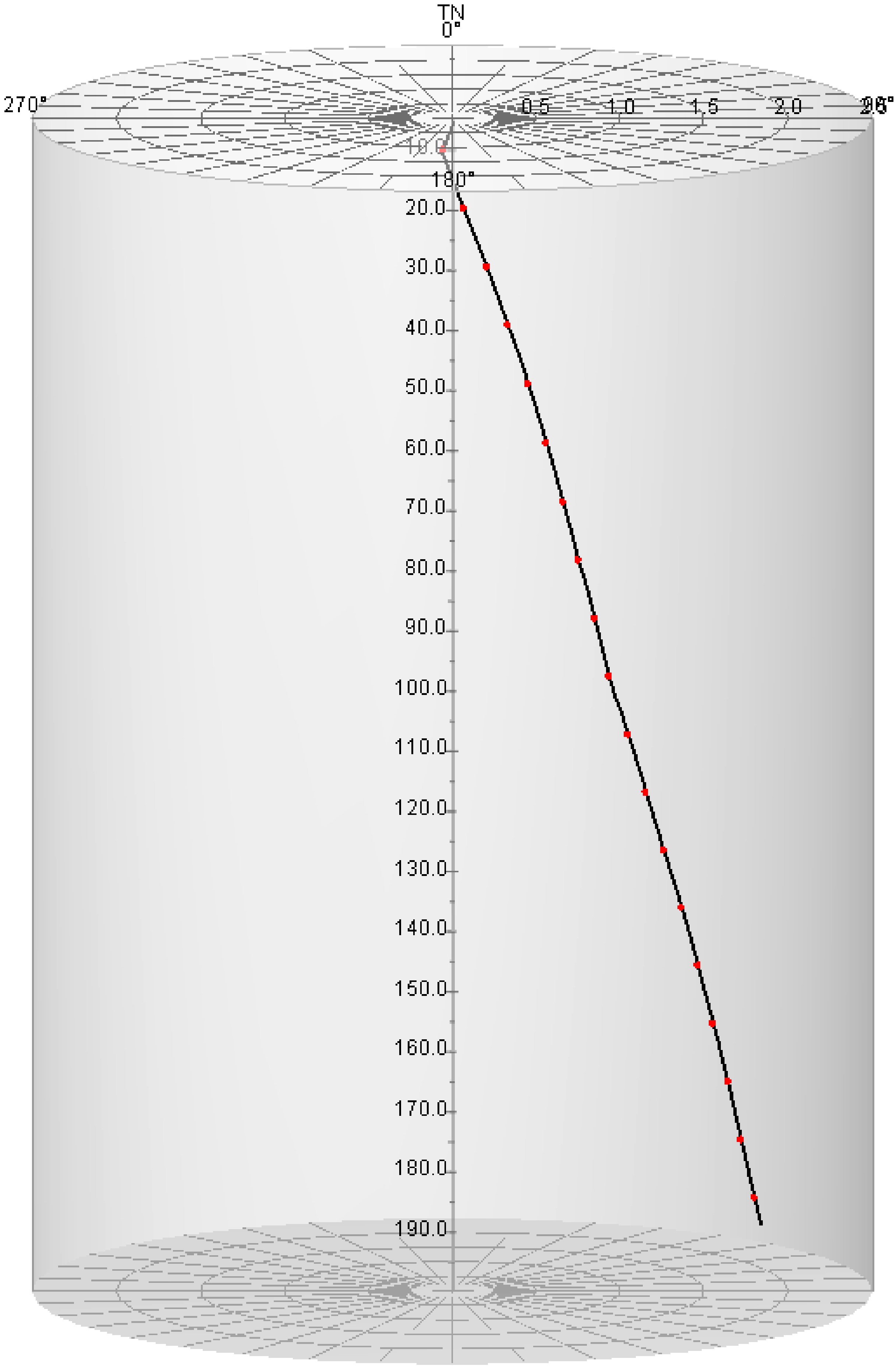
Could not reach driller's TD, due to fill.

Magnetic declination of 12.85 degrees East added to correct magnetic azimuth to True North.


Borehole Tilt
0
4
Borehole Azimuth
0
TN
360
Depth
1ft:240ft
20
40
60
80
100
120
140
160
180
Northing
-2
ft
2
Easting
-2
ft
2
True Vertical Depth
0
ft
200



TN
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
1:8 [ft]
-2.0 -1.8 -1.6 -1.4 -1.2 -1.0 -0.8 -0.6 -0.4 -0.2 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 -0.2 -0.4 -0.6 -0.8 -1.0 -1.2 -1.4 -1.6 -1.8 -2.0



TN
0°
270°
0.5
1.0
1.5
2.0
180°
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
180.0
190.0

Appendix F-2
Borehole Geophysical Log Plots for Instrument Hole U-15n#1

COLOG — Borehole Geophysics & Hydrophysics — A Division of Layne Christensen Company
810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Far Density
Near Density
Natural Gamma Ray
Caliper

Company	NNSA/NSO
Well	U-15N#1
Field	NNSS
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15N#1
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900107.23
E: 676655.11

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Full-Wave Sonic
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5003.19
LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**
DRILLING MEAS. FROM G.L.

DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Far Density	Near Density	Natural Gamma Ray	Caliper
DEPTH-DRILLER	190'			
DEPTH-LOGGER	188.3'			
BTM LOG INTERVAL	187.2'	187.5'	182.7'	186.2'
TOP LOG INTERVAL	7.7'	8.0'	3.2'	6.7'
RECORDED BY	A. Caster			
WITNESSED BY	C. Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	10 ft/min			
A.S.D.E.	0.1'			
SAMPLE INTERVAL	0.1'			

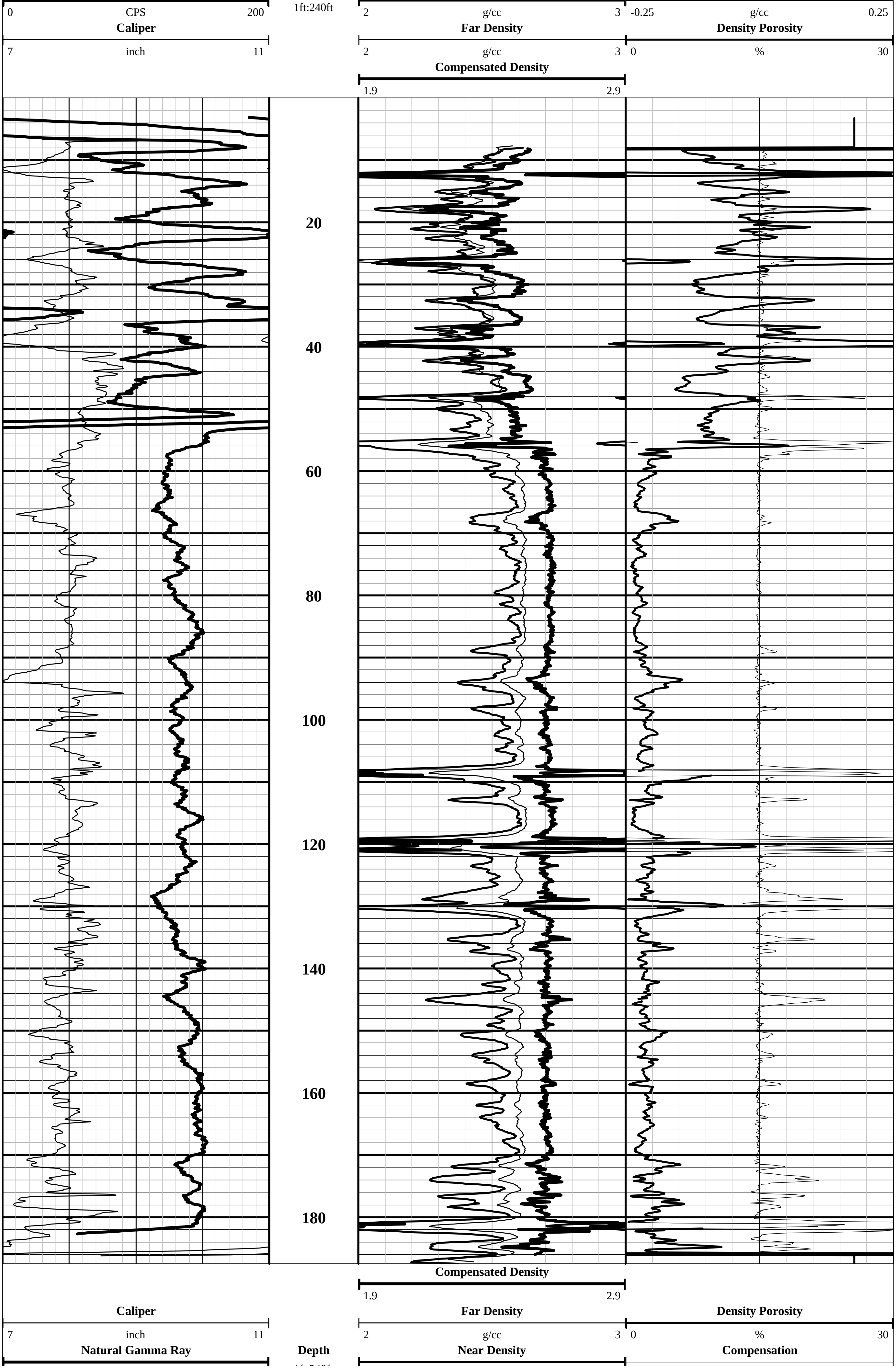
BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	7'	10"		-1.0	6.5'
2	8"	7'	190'				

COMMENTS

NA - Not Available, N/A - Not Applicable

Matrix Density of 2.64 used to calculate Density Porosity

Natural Gamma Ray	Depth	Near Density	Compensation


0 CPS 200
Caliper
7 inch 11
1ft:240ft
2 g/cc 3
Far Density
2 g/cc 3
Compensated Density
1.9 2.9
-0.25 g/cc 0.25
Density Porosity
0 % 30
20
40
60
80
100
120
140
160
180
Compensated Density
1.9 2.9
Far Density
2 g/cc 3
Near Density
Caliper
7 inch 11
Natural Gamma Ray
Depth
Density Porosity
0 % 30
Compensation

0	CPS	200	1ft:240ft	2	g/cc	3	-0.25	g/cc	0.25

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Acoustic Televiewer
Optical Televiewer

Company NNSA/NSO
Well U-15N#1
Field Nevada Test Site
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15N#1
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900107.23
E: 676655.11

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Optical Televiewer
Dual Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5003.19

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM

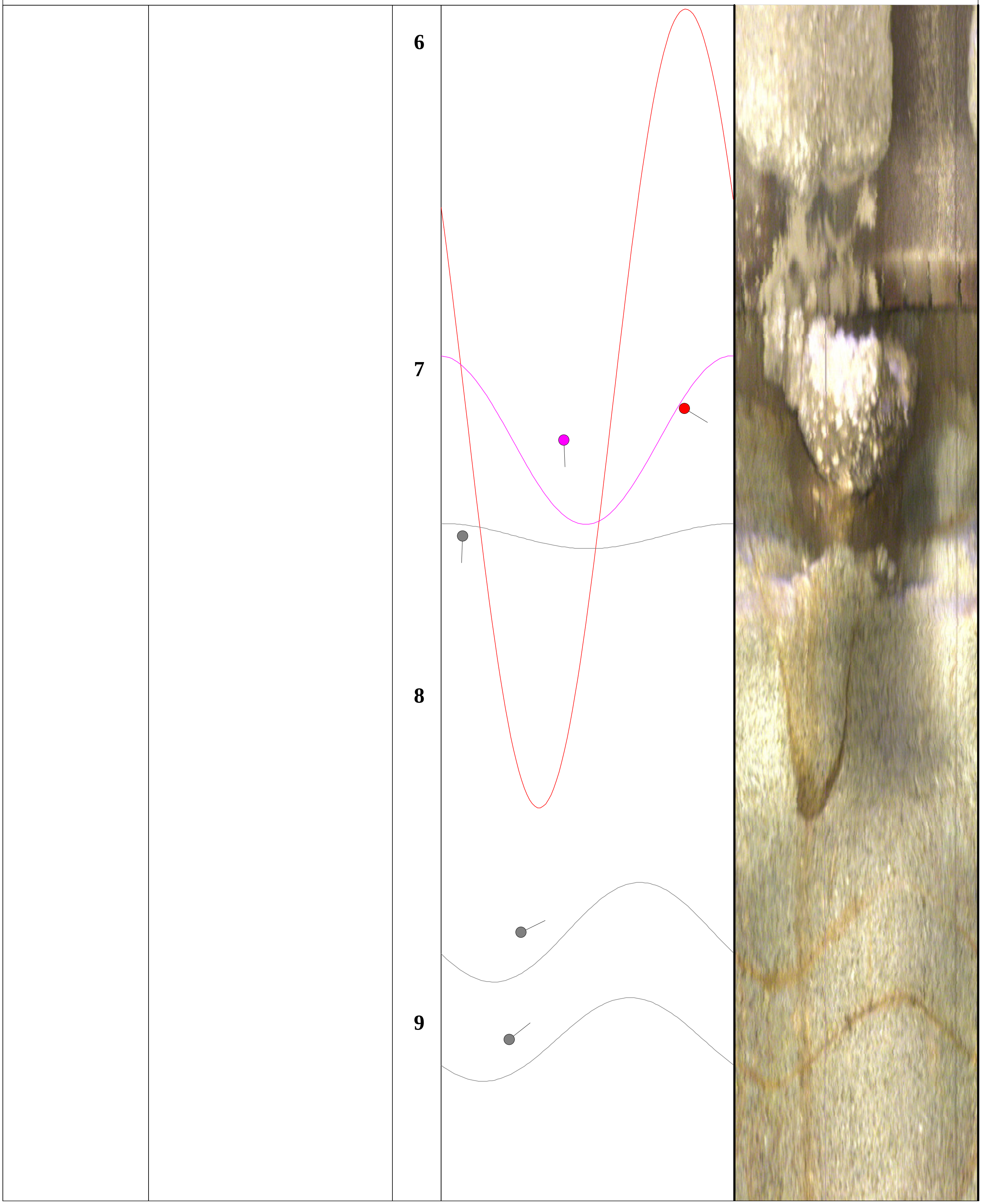
DATE ACQUIRED	21 Sept 2010	21 Sept 2010		
RUN NUMBER	THREE	TWO		
LOG TYPE	ABI	OBI		
DEPTH-DRILLER	190	190		
DEPTH-LOGGER	187	187		
BTM LOG INTERVAL	187	187		
TOP LOG INTERVAL	58	4		
RECORDED BY	E Eaton	E Eaton		
WITNESSED BY	G Juniel	G Juniel		
PROBE TYPE, S/N	ABI-062605	OBI-023902		
LOGGING SPEED	5.5 ft/min	3.5 ft/min		
A.S.D.E.	0.55'	0.59 ft		
SAMPLE INTERVAL	0.0068'	0.0041 ft		

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25"	Surface	7	10"		-1	6.5
	8"	7	190				

COMMENTS

NA - Not Available, N/A - Not Applicable

Travel Time	Acoustic Image	Depth	Projections	Optical Image
0° 90° 180° 270° 0°	0° 90° 180° 270° 0°	1ft:5ft	0° 90° 180° 270° 0°	0° 90° 180° 270° 0°
			Tadpoles	
			0 90	

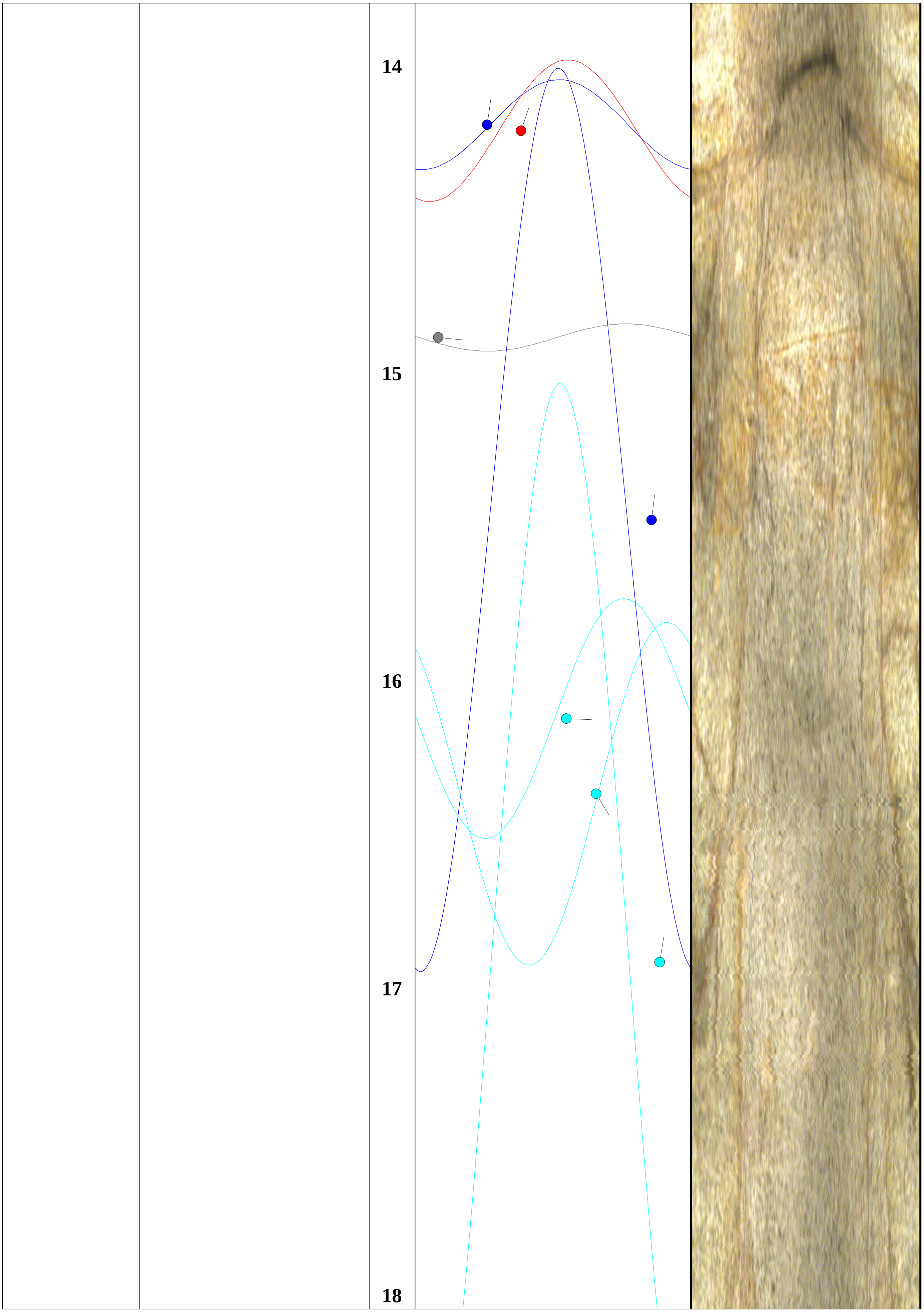


10

11

12

13


14
15
16
17
18

19

20

21

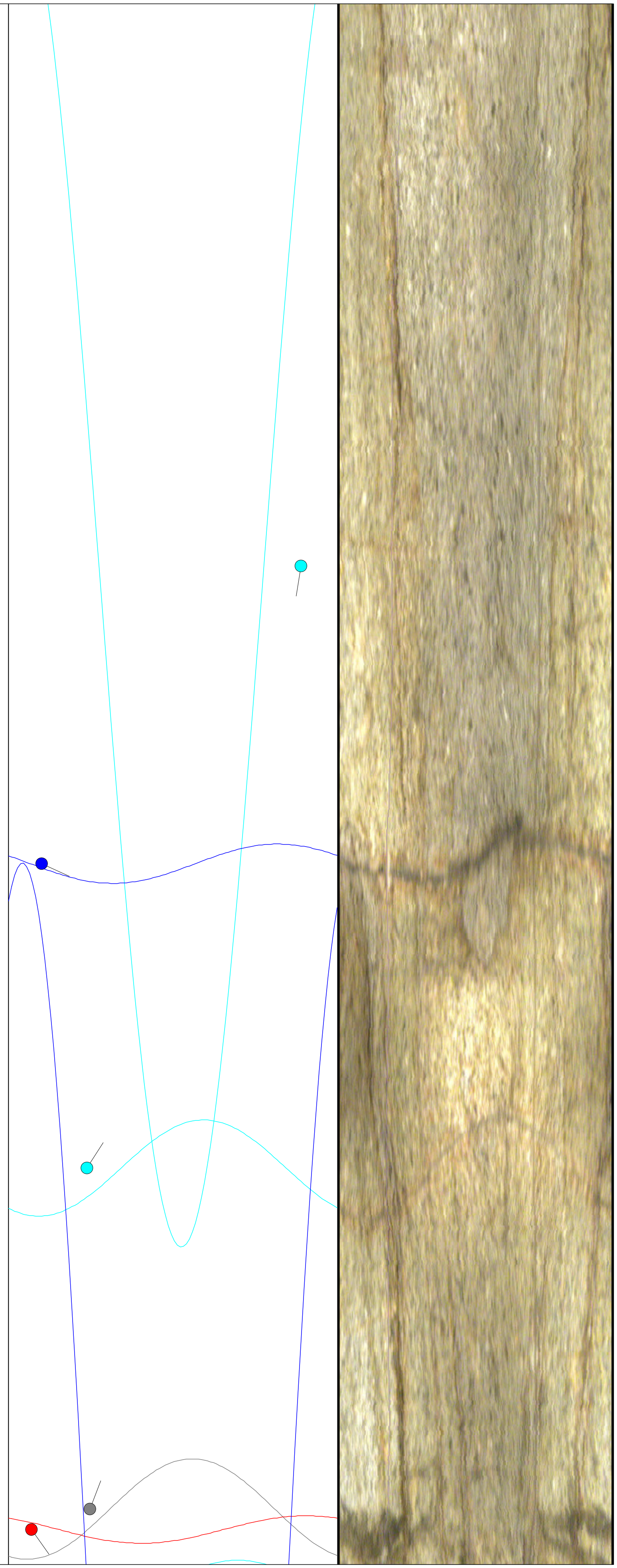
22

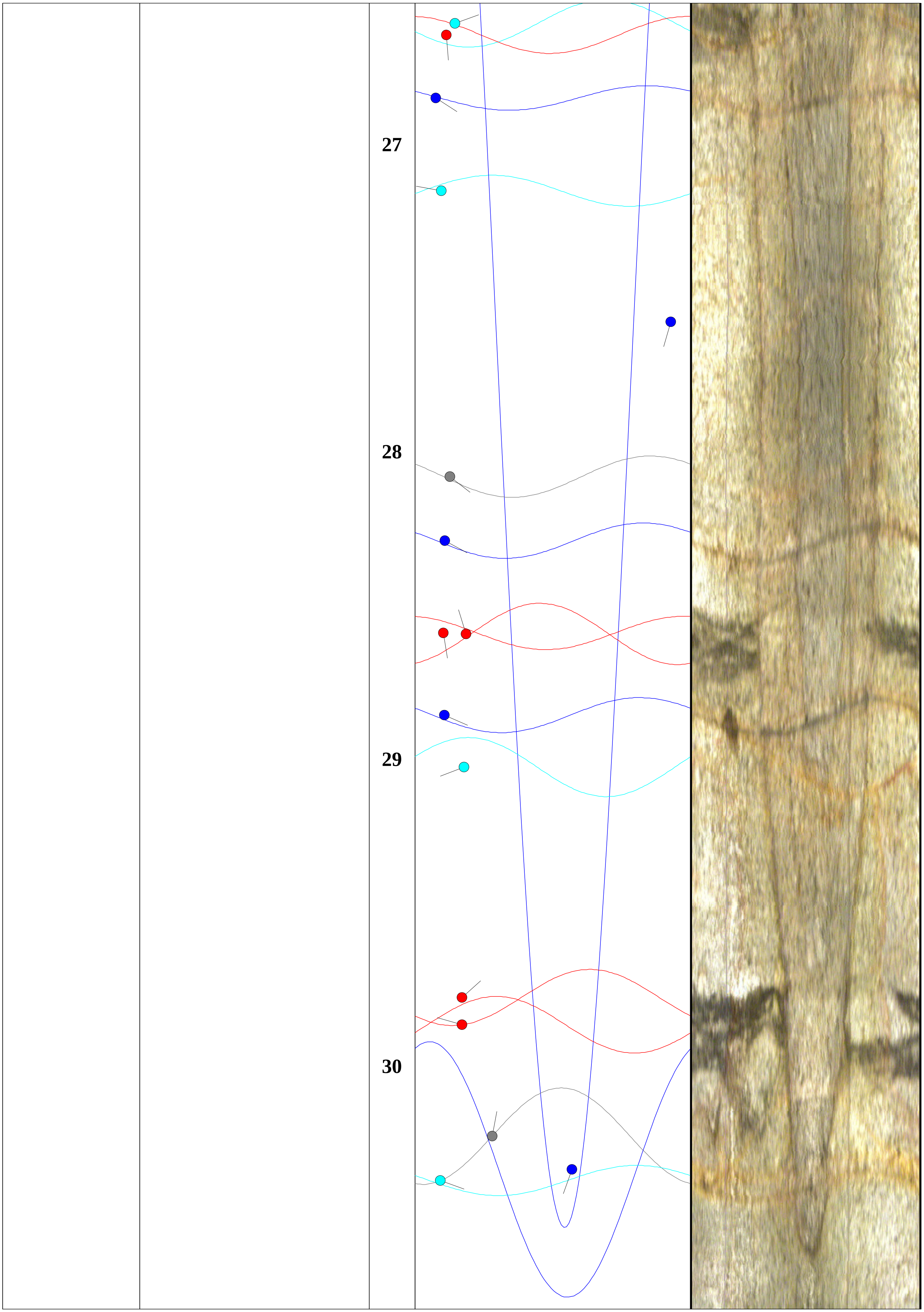
23

24

25

26




27
28
29
30

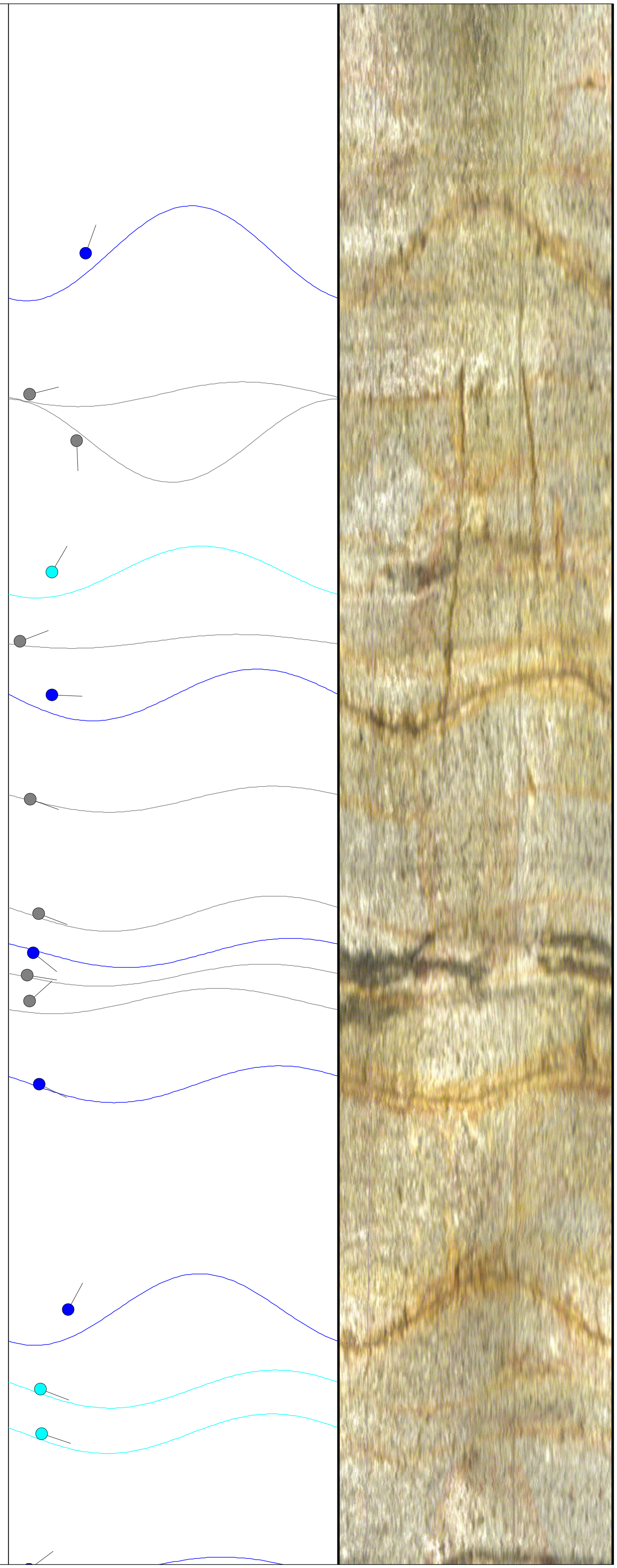
31

32

33

34

35

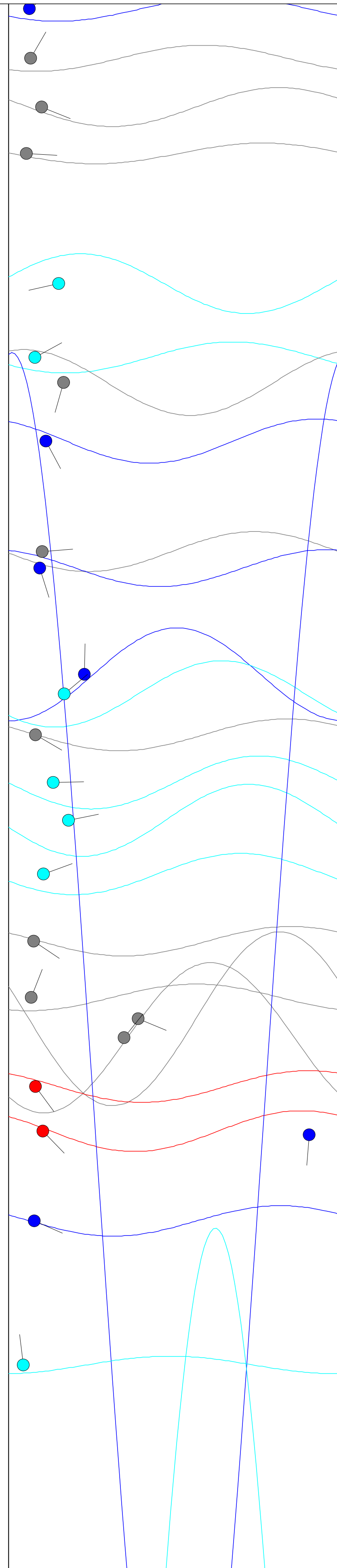


36

37

38

39

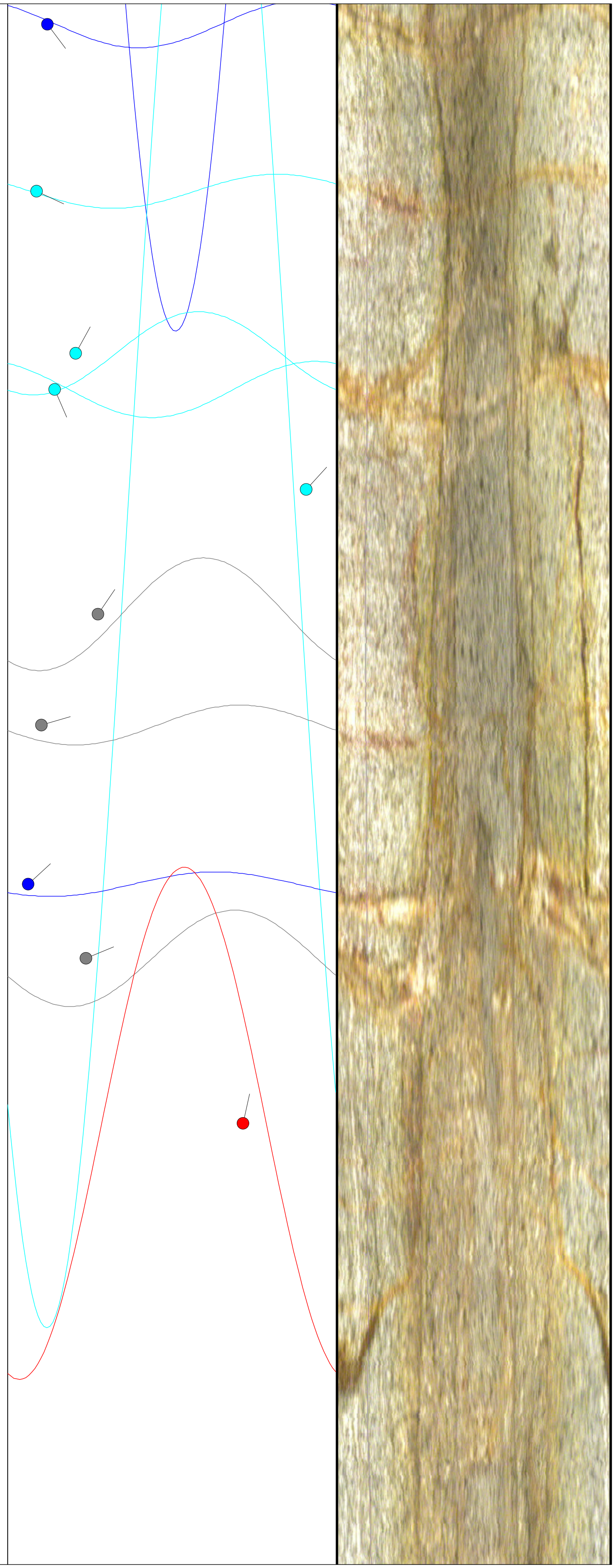


40

41

42

43

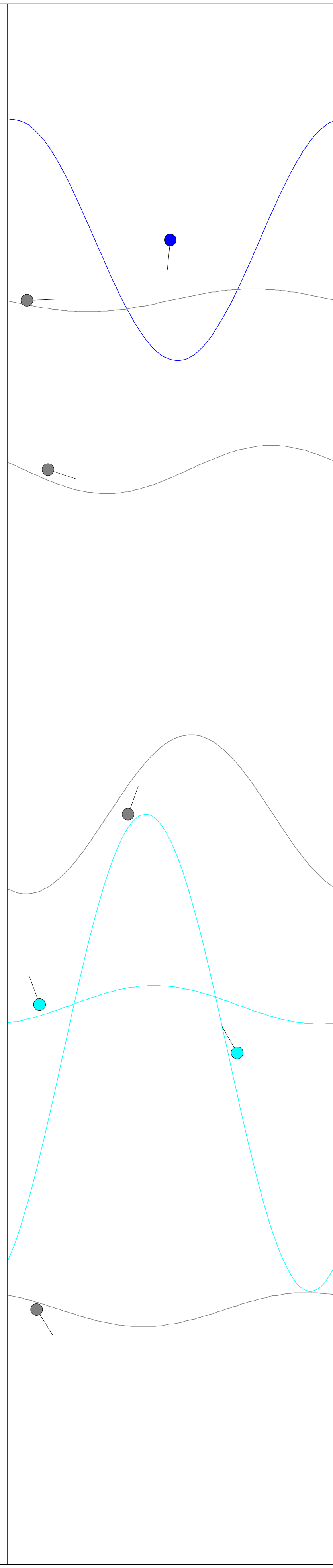


44

45

46

47



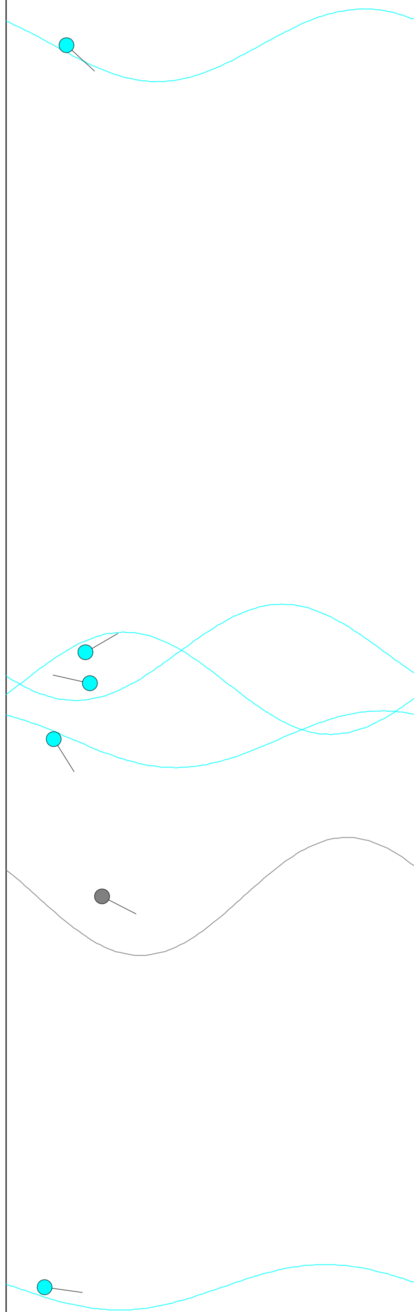
48

49

50

51

52

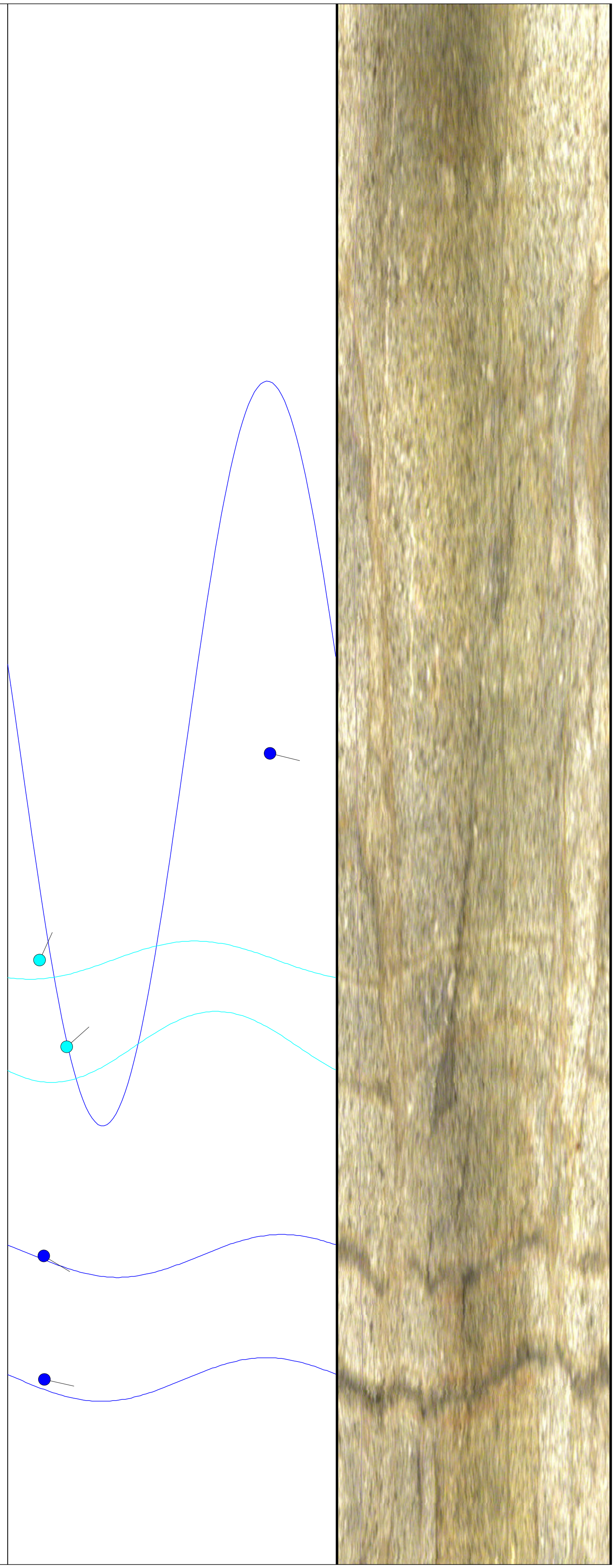


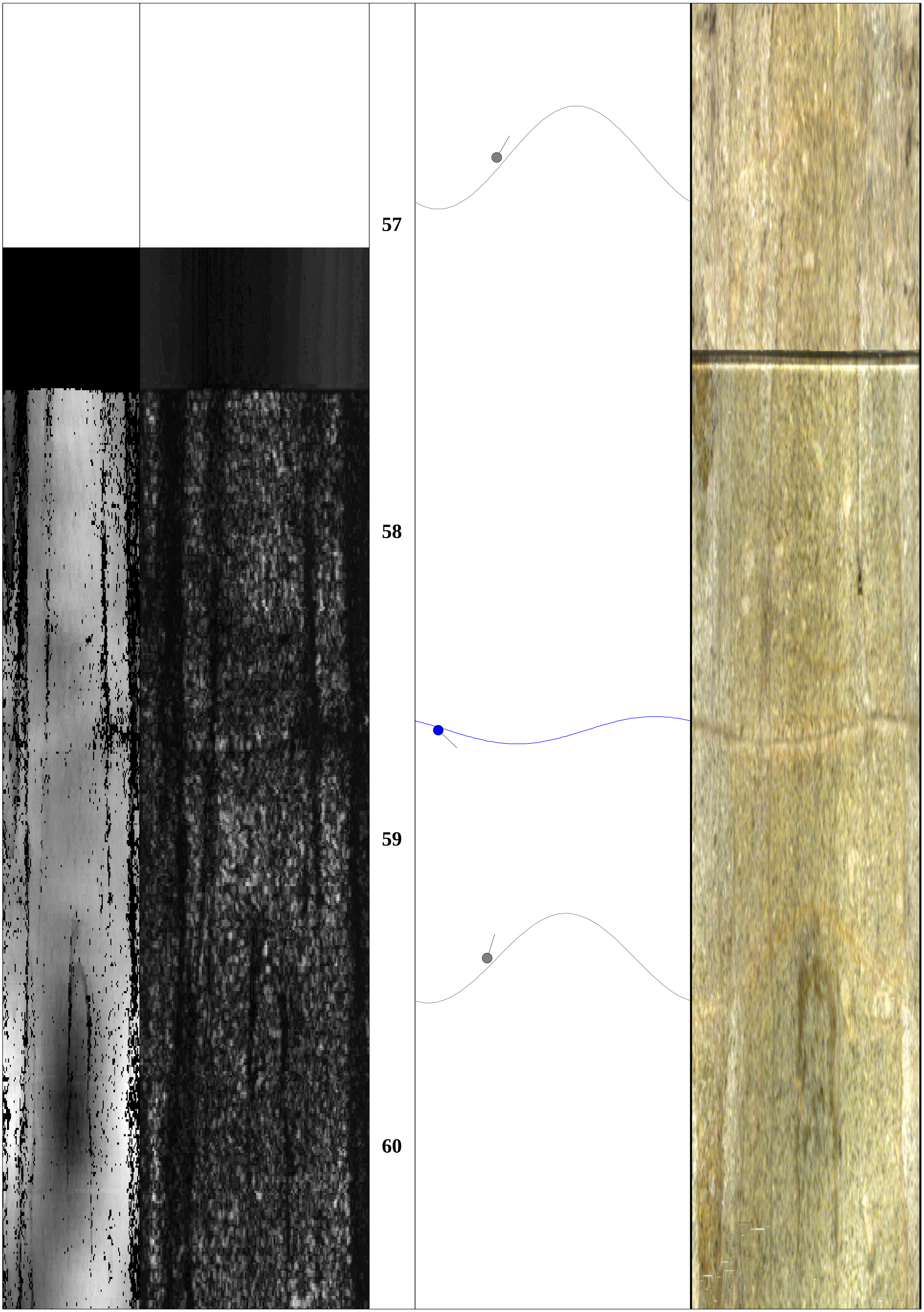
53

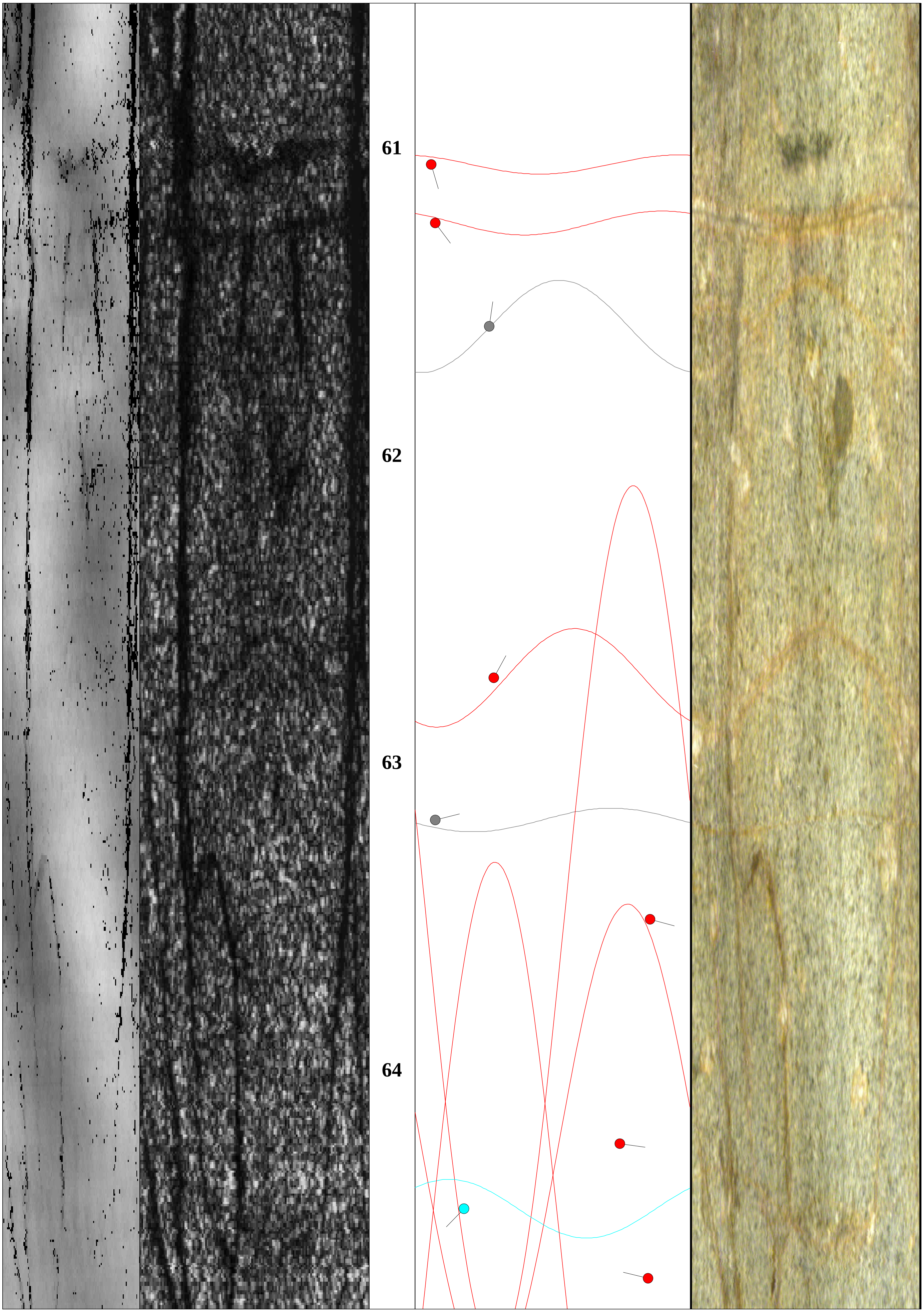
54

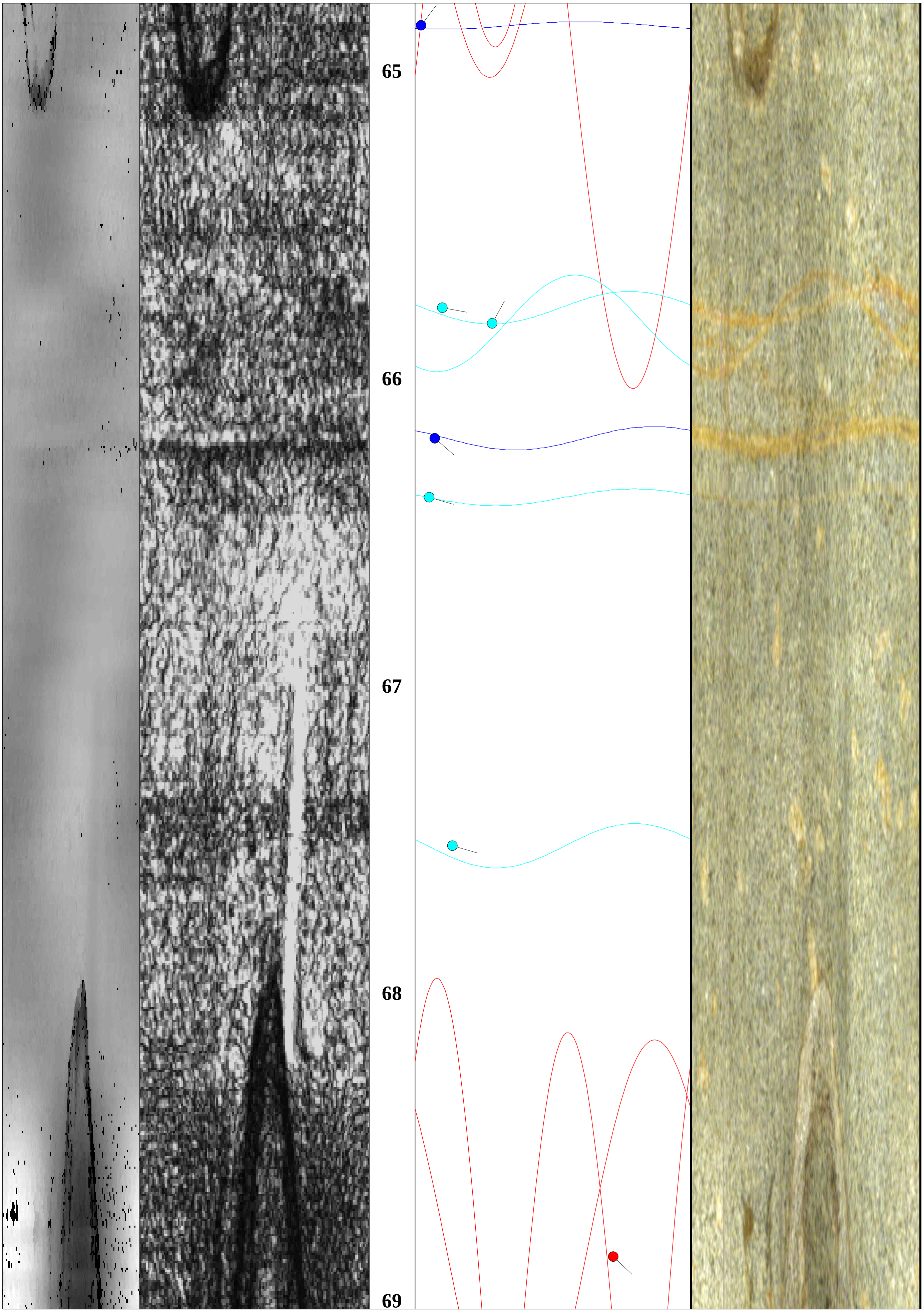
55

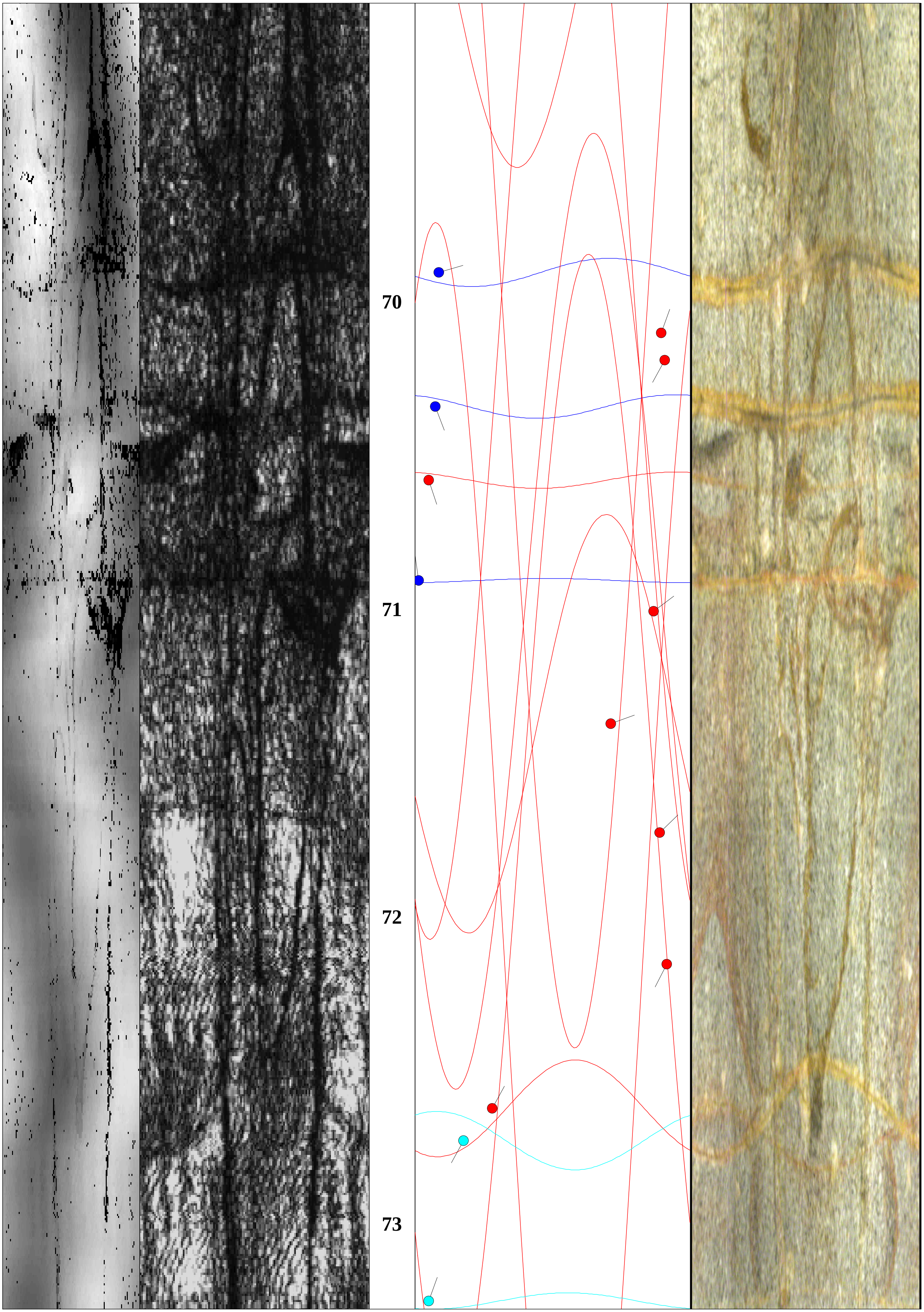
56

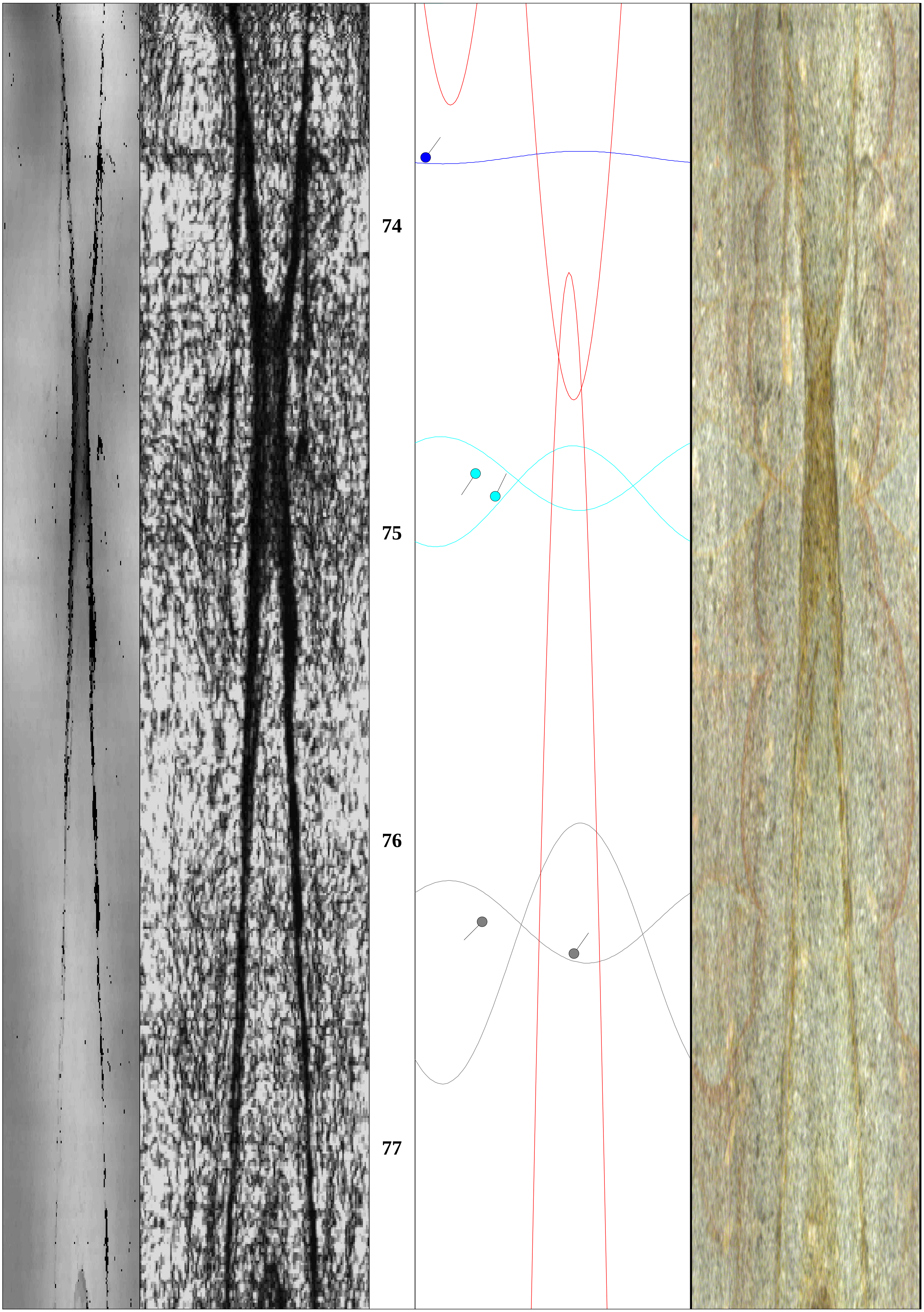


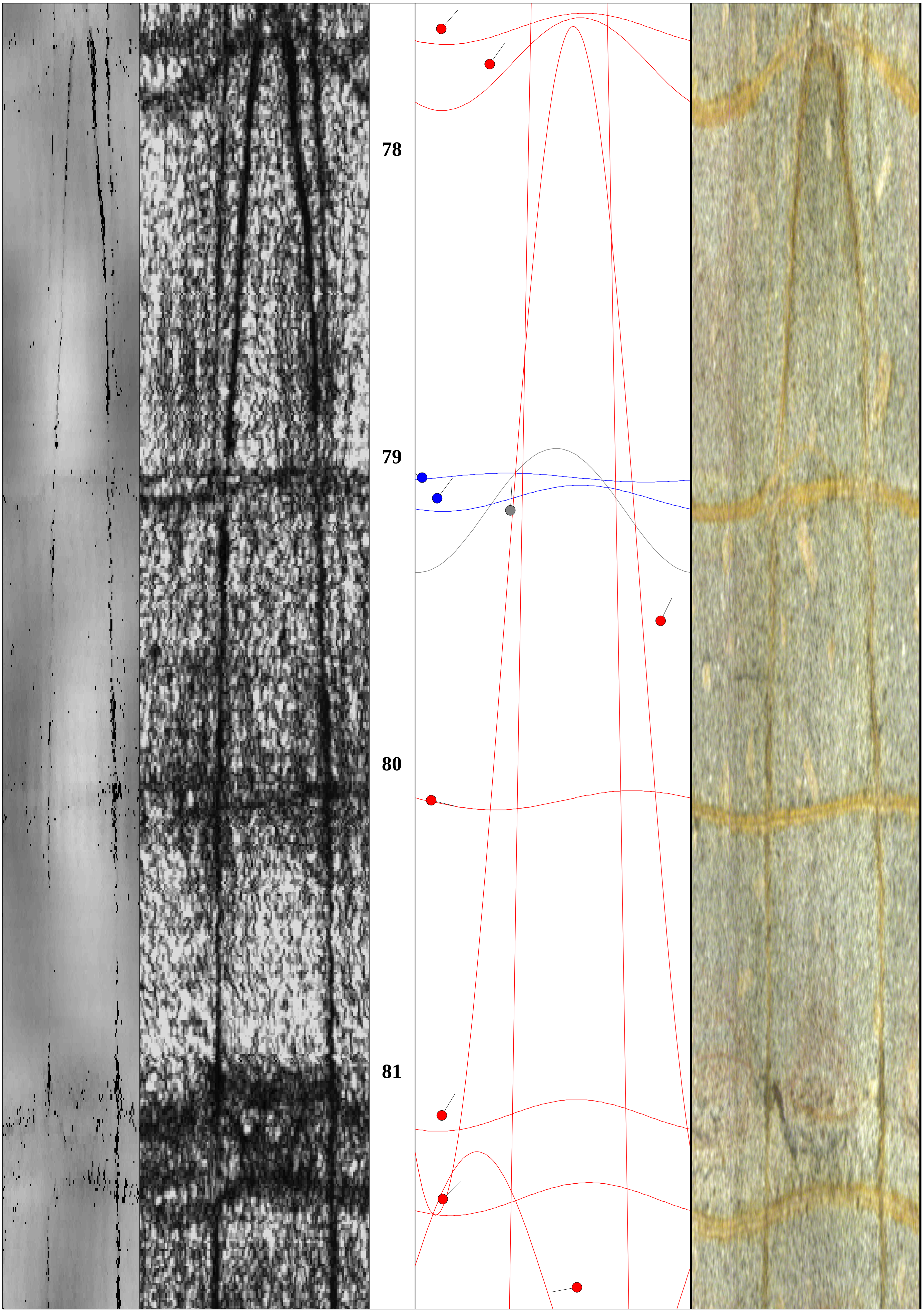

57
58
59
60

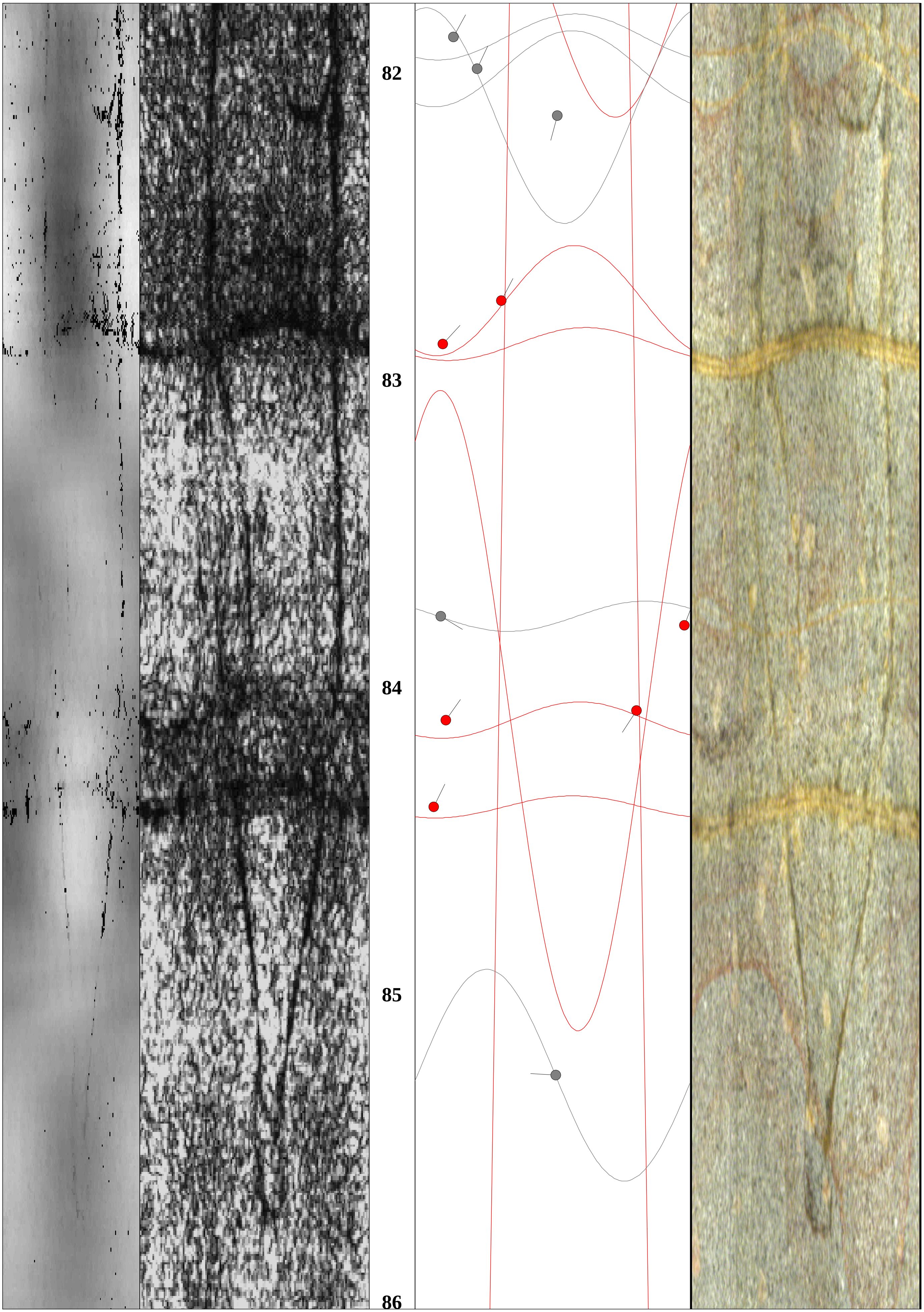

61
62
63
64

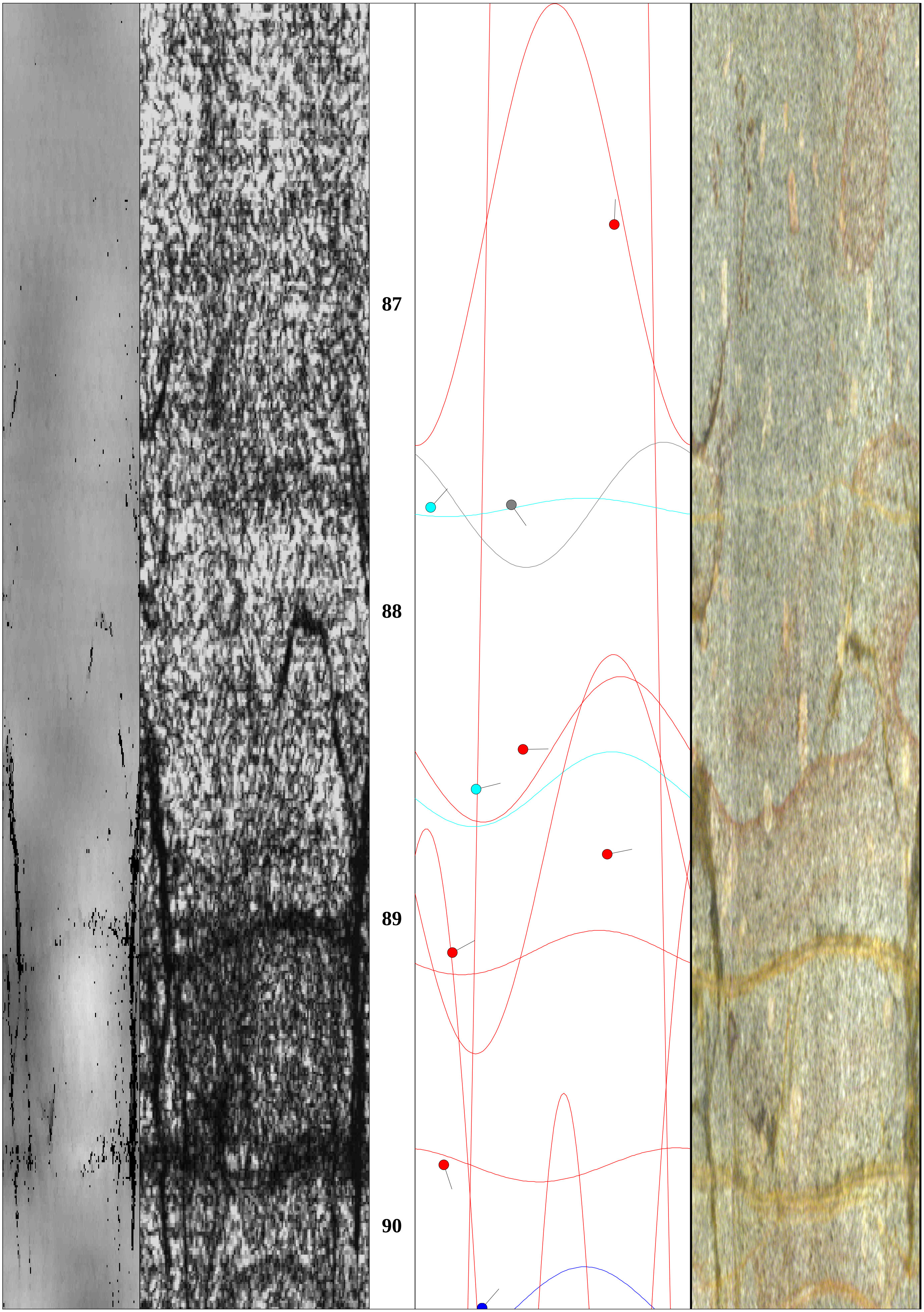

65
66
67
68
69

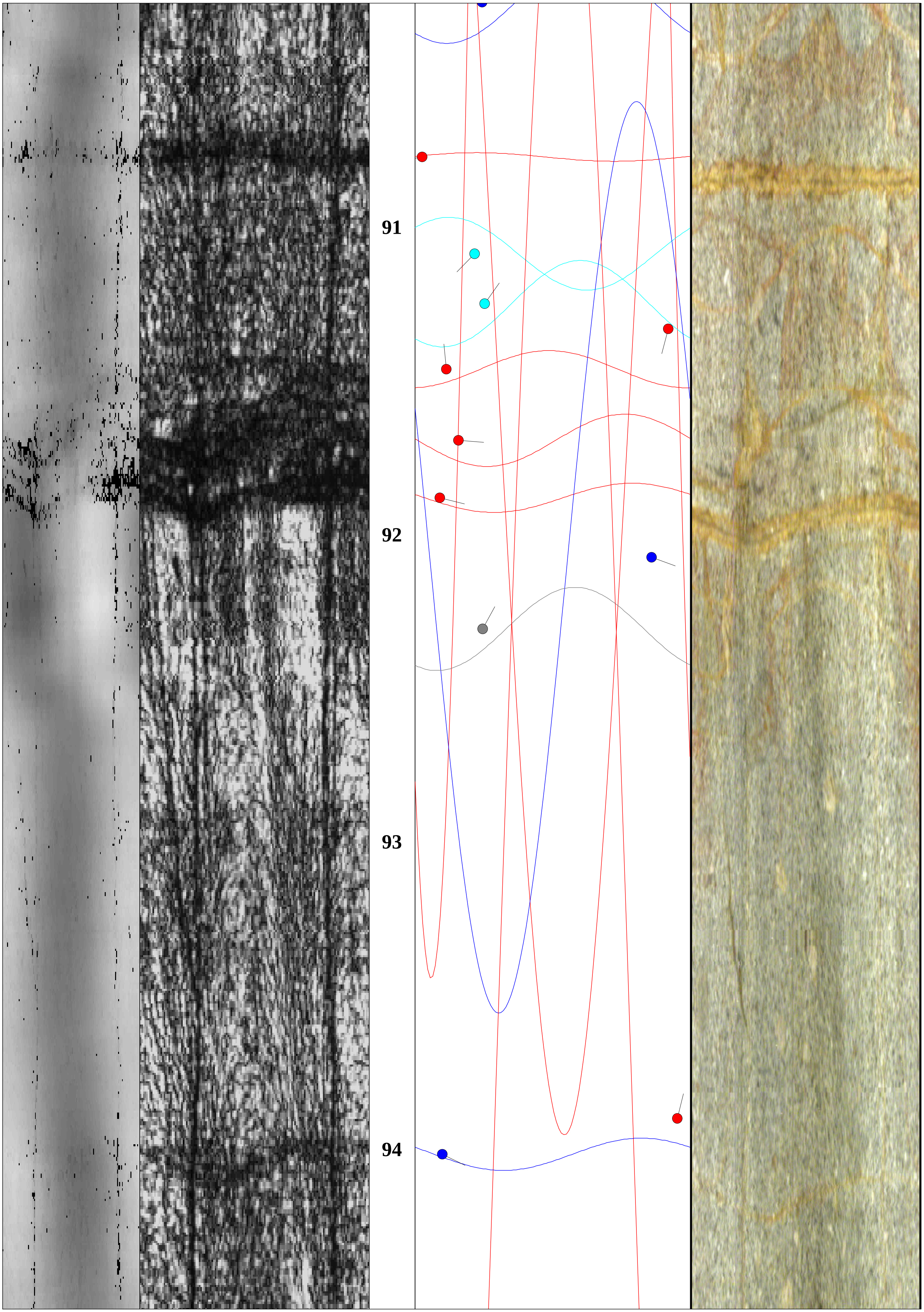

70
71
72
73

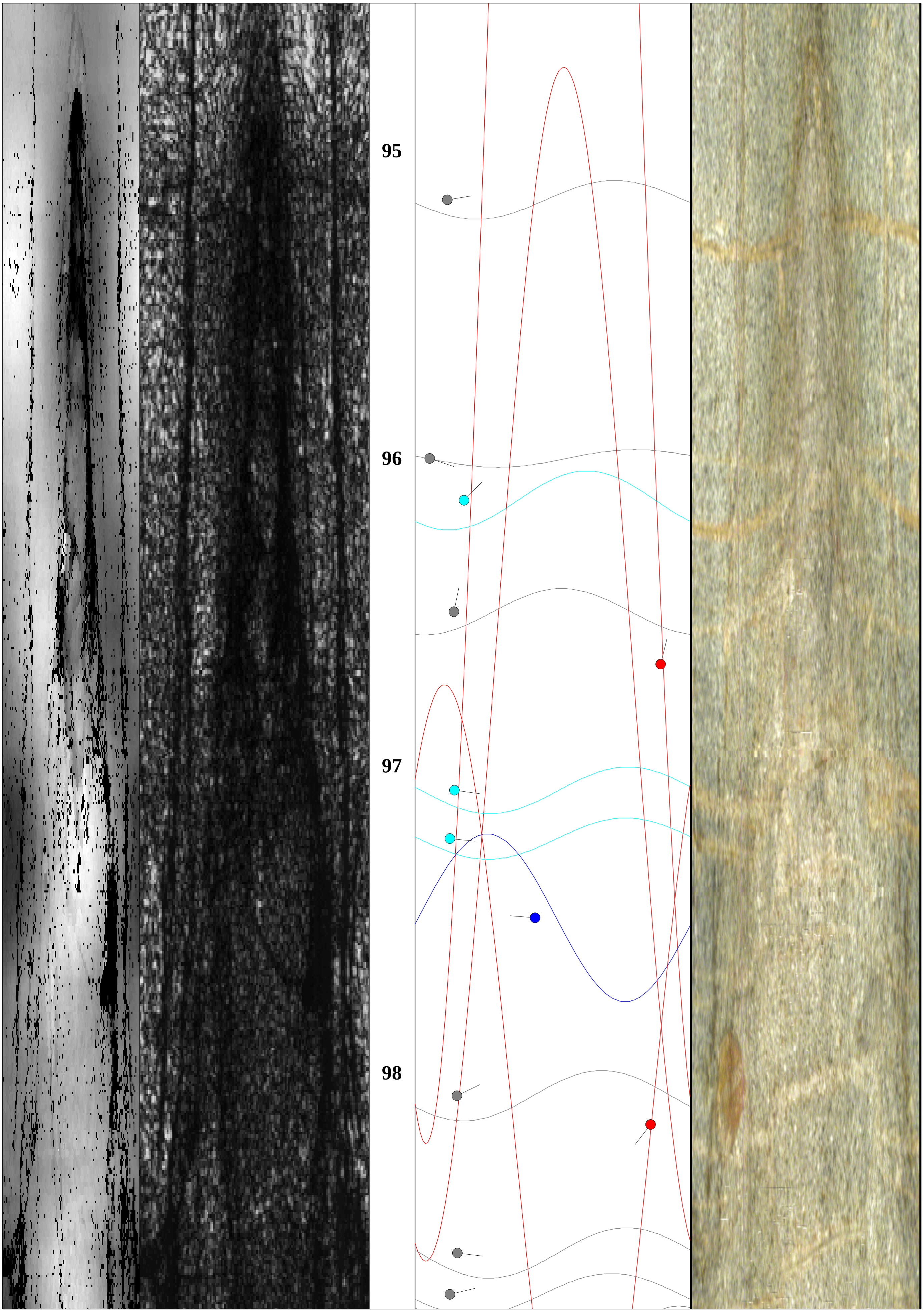

74
75
76
77

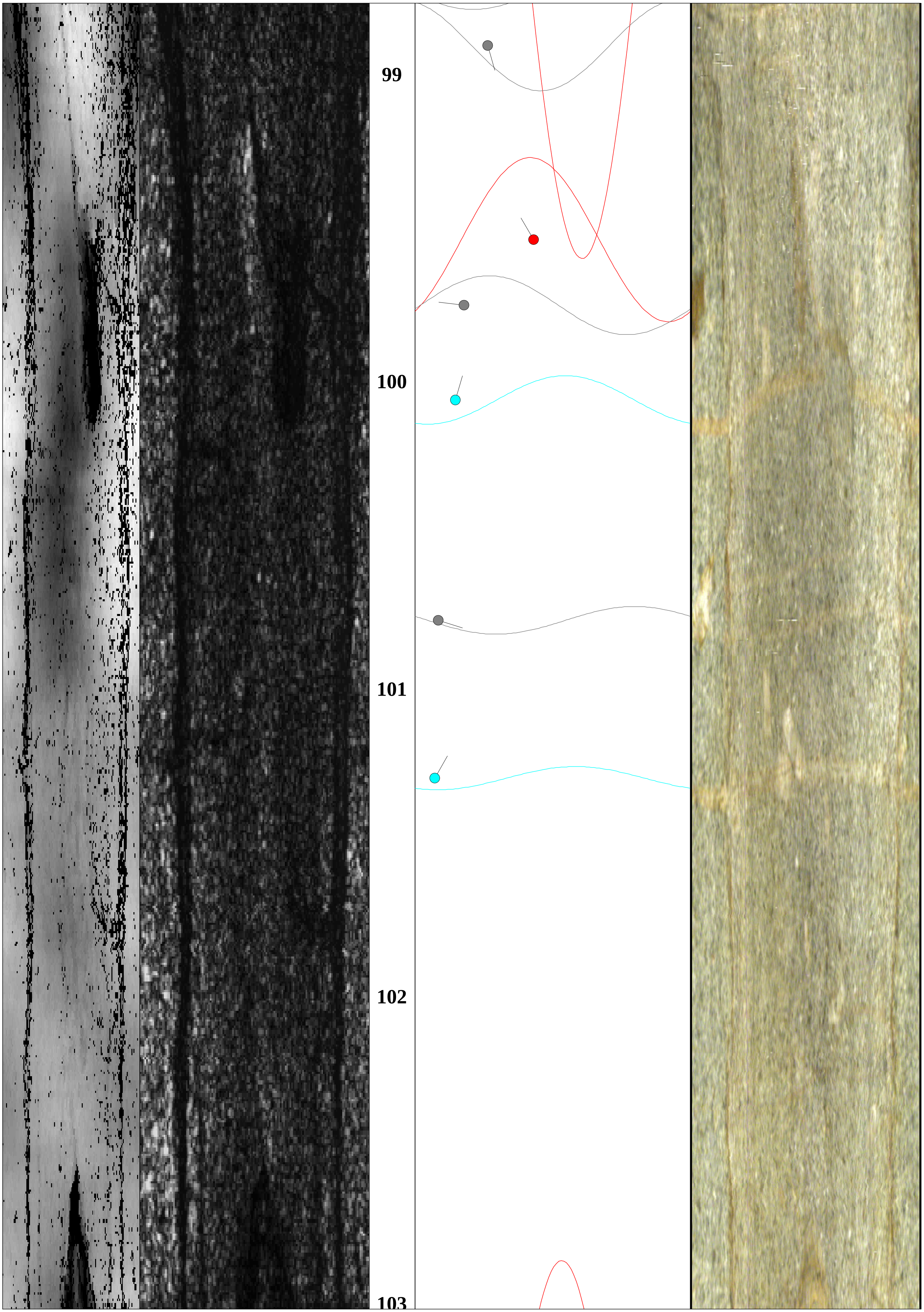

78
79
80
81

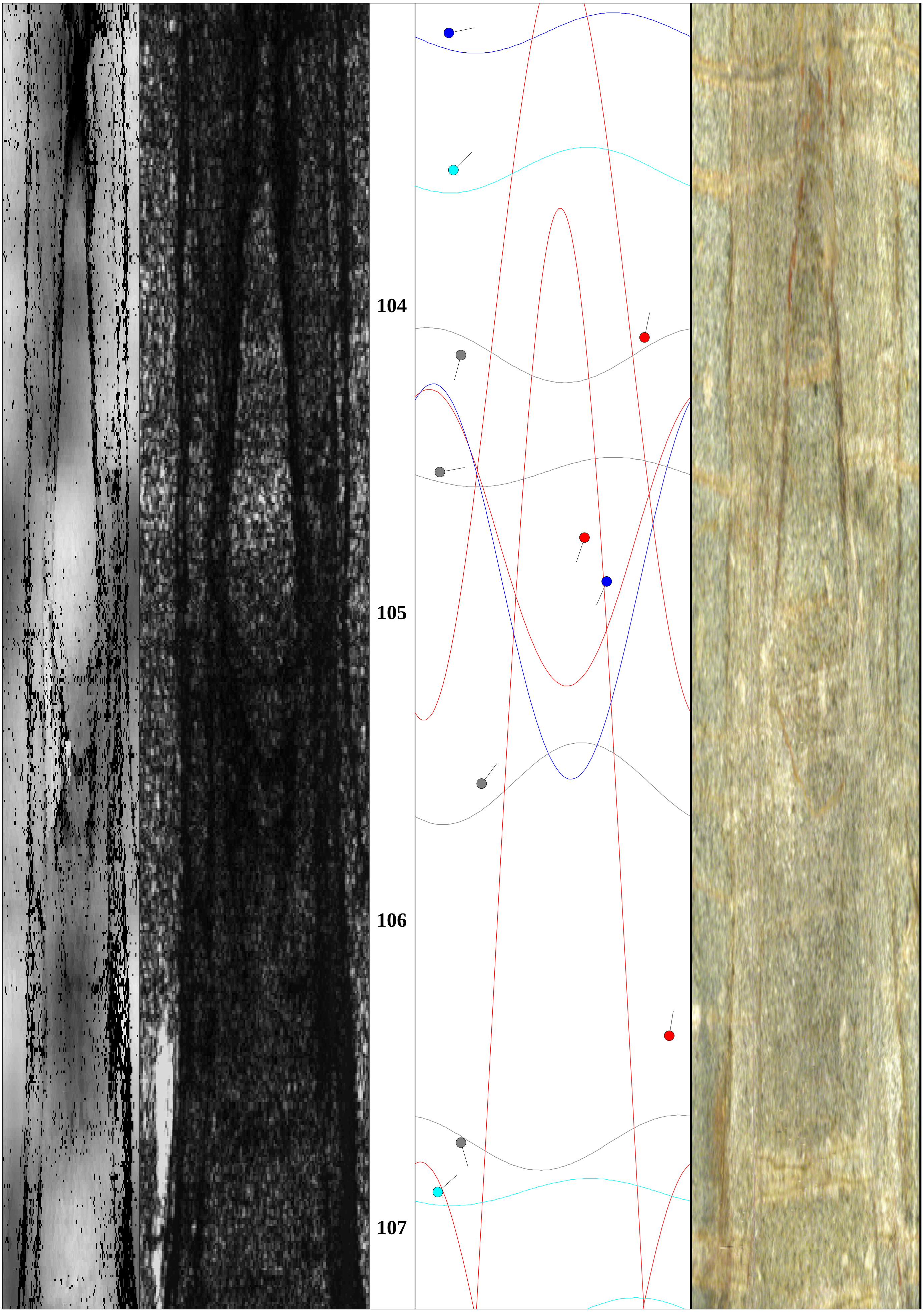

82
83
84
85
86

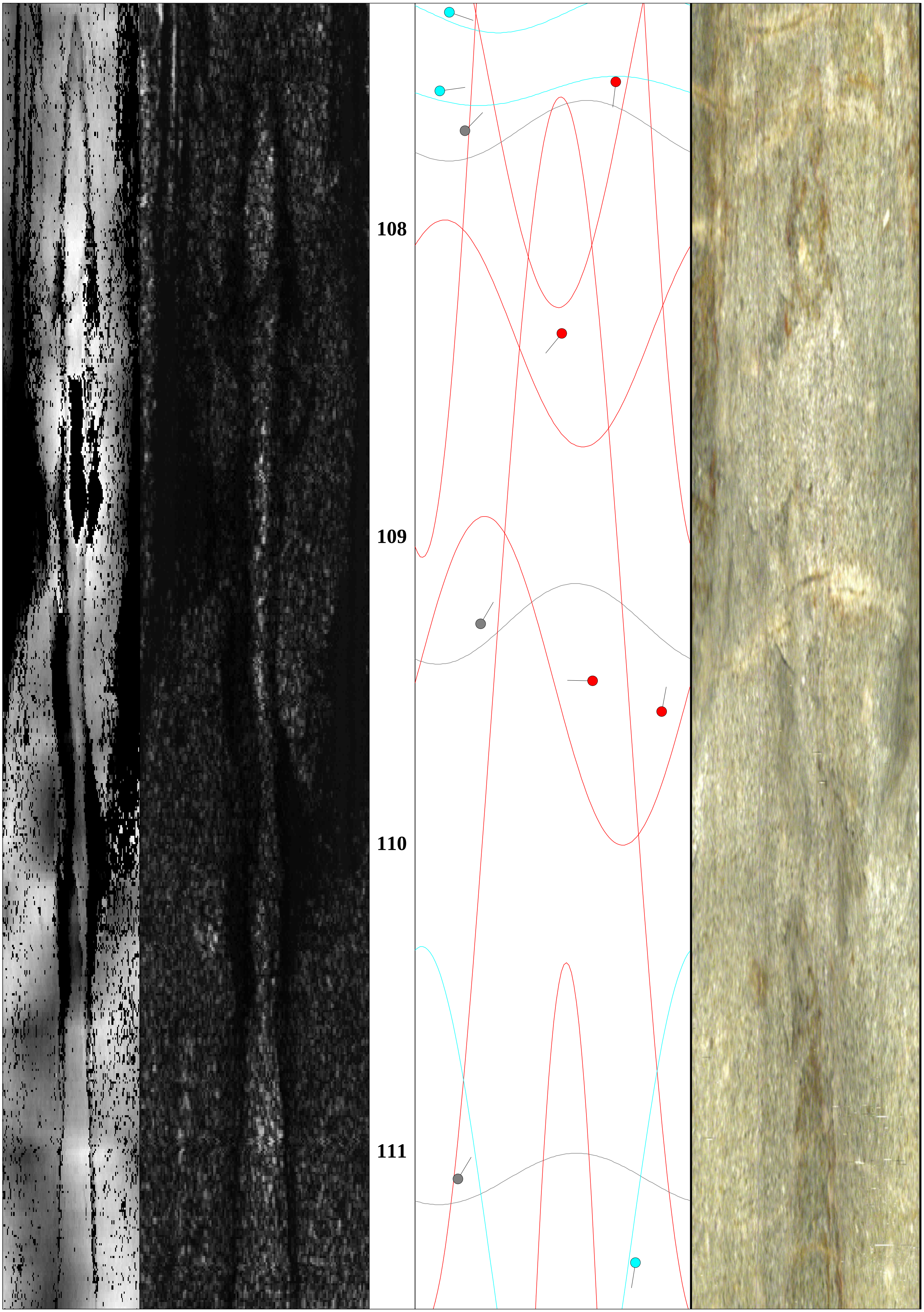

87
88
89
90

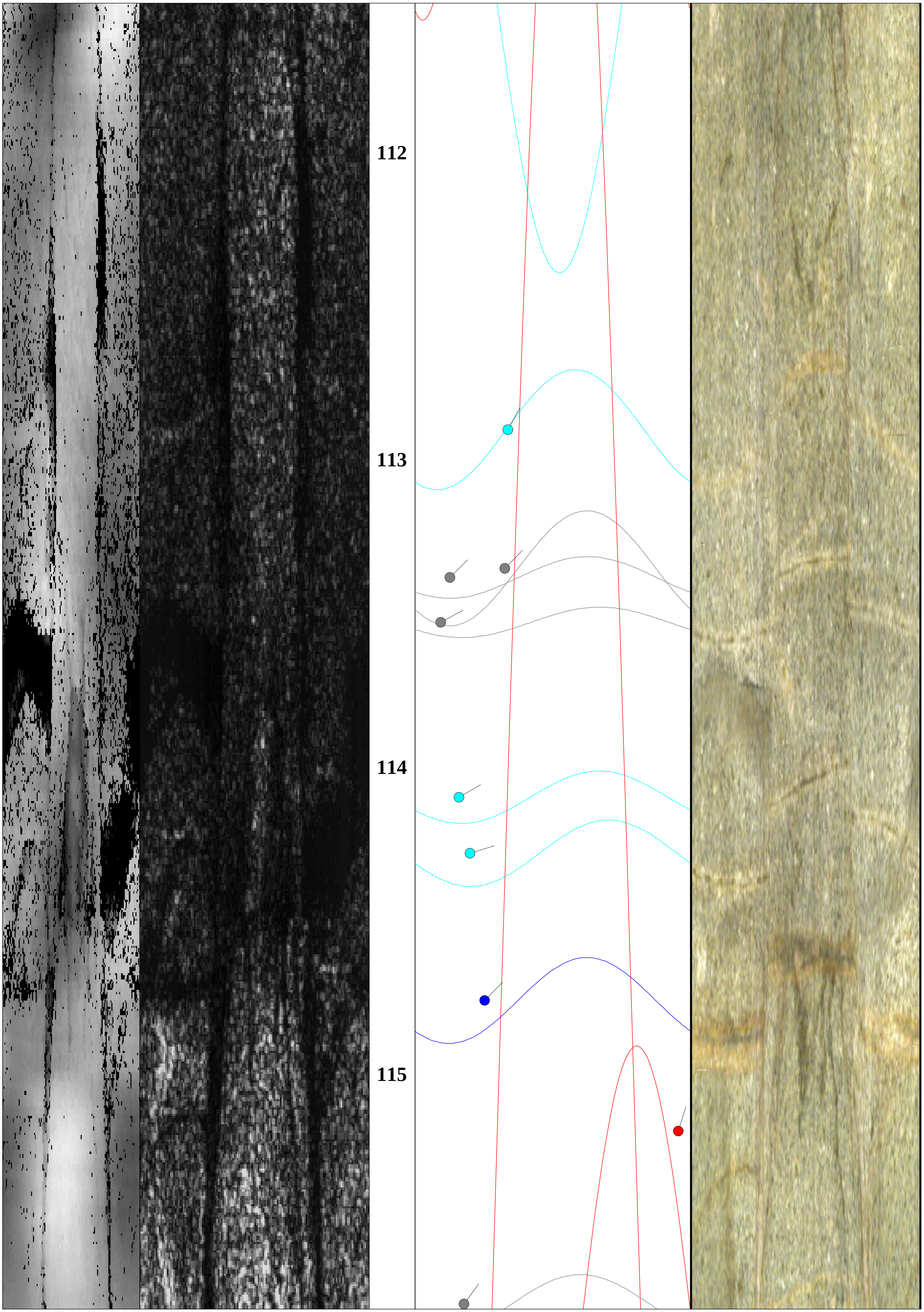

91
92
93
94

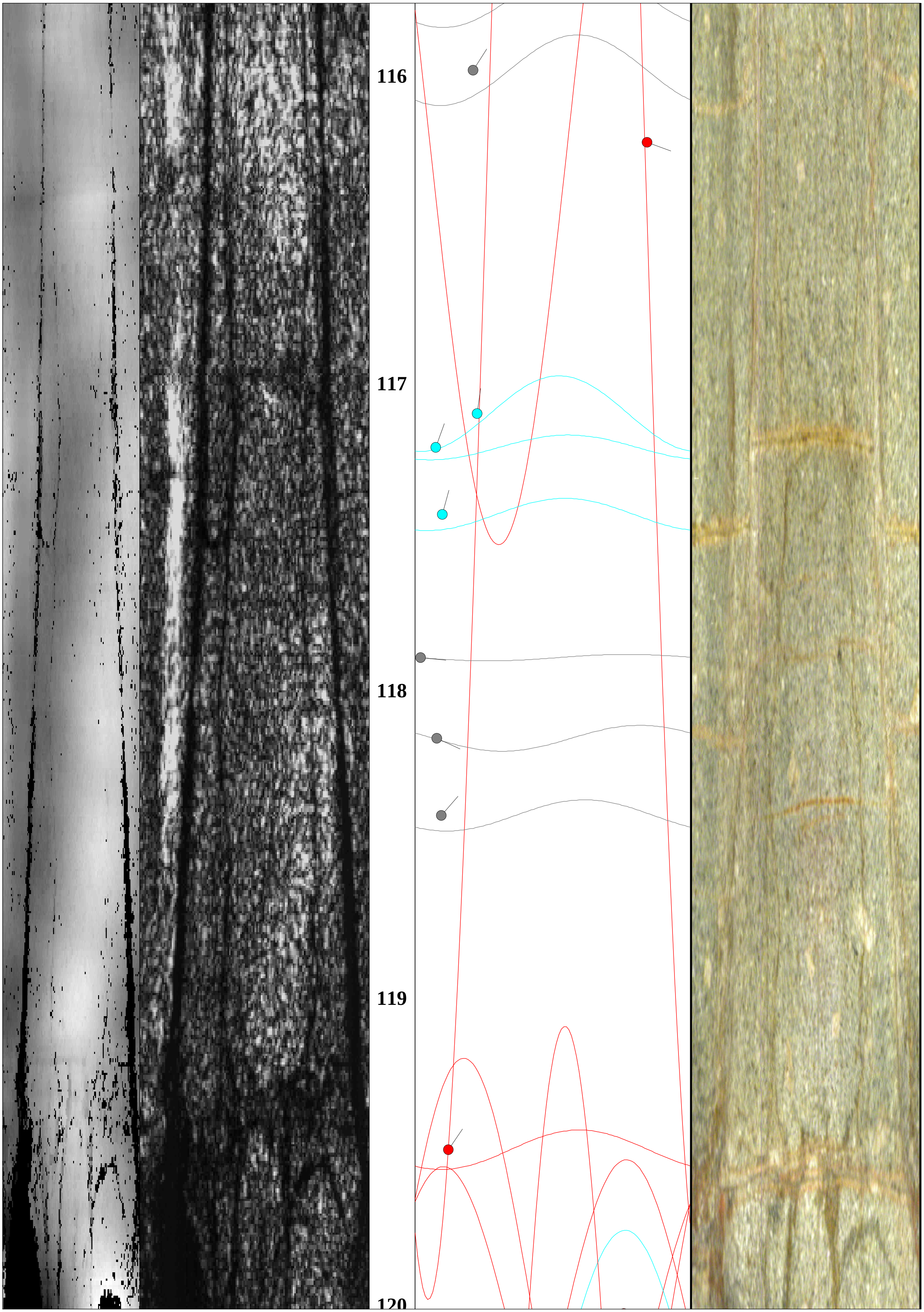

95
96
97
98

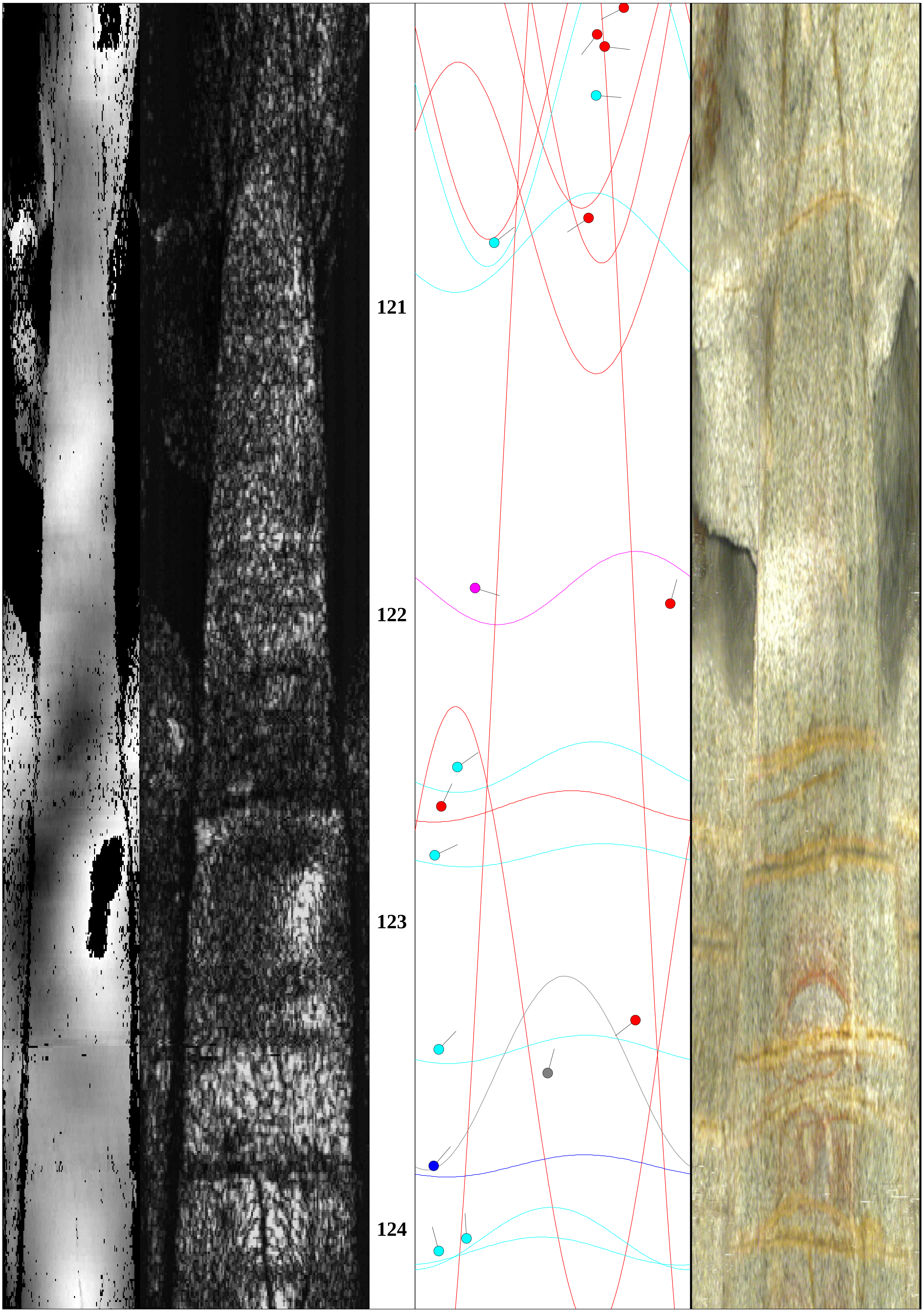

99
100
101
102
103

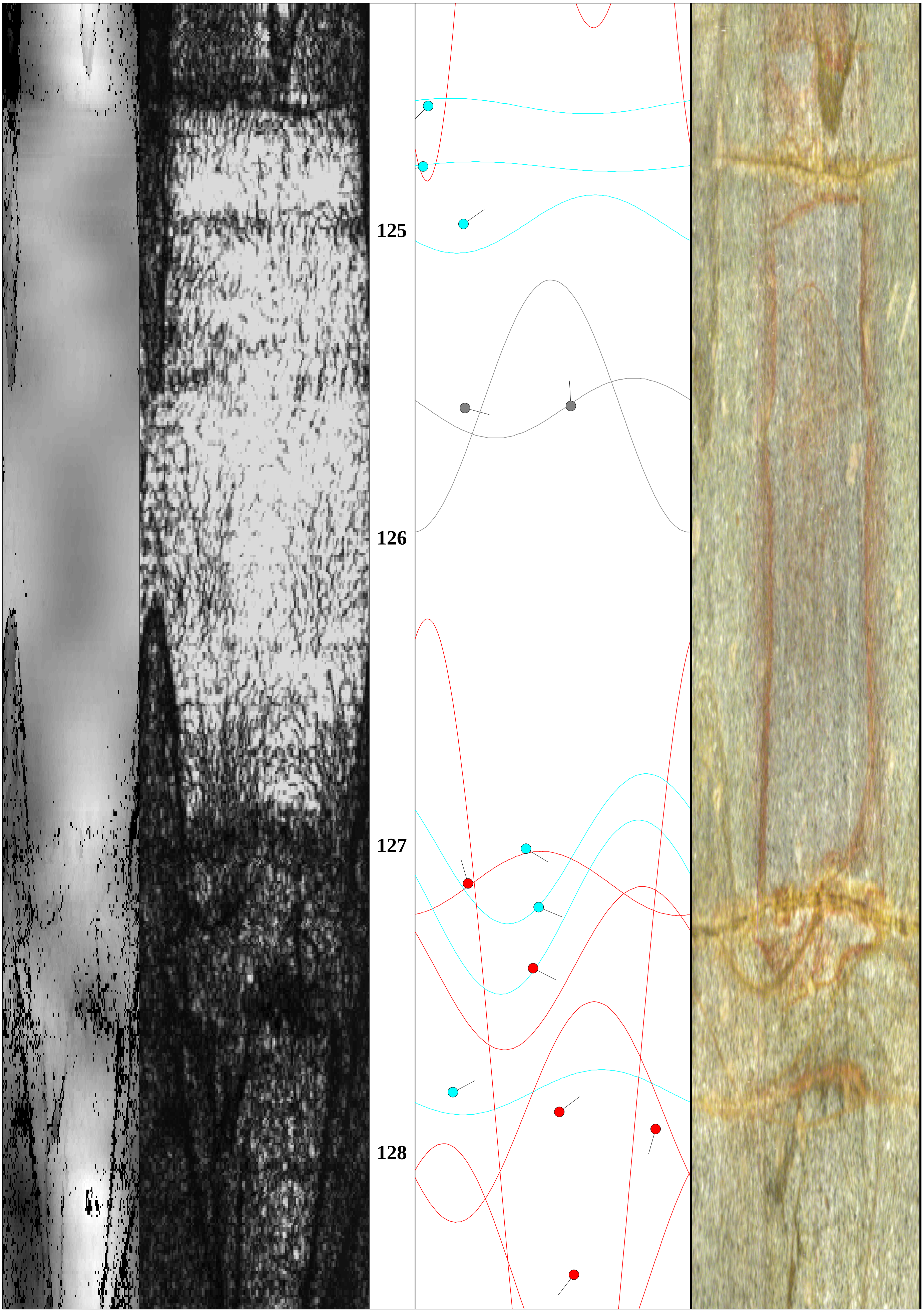

104
105
106
107

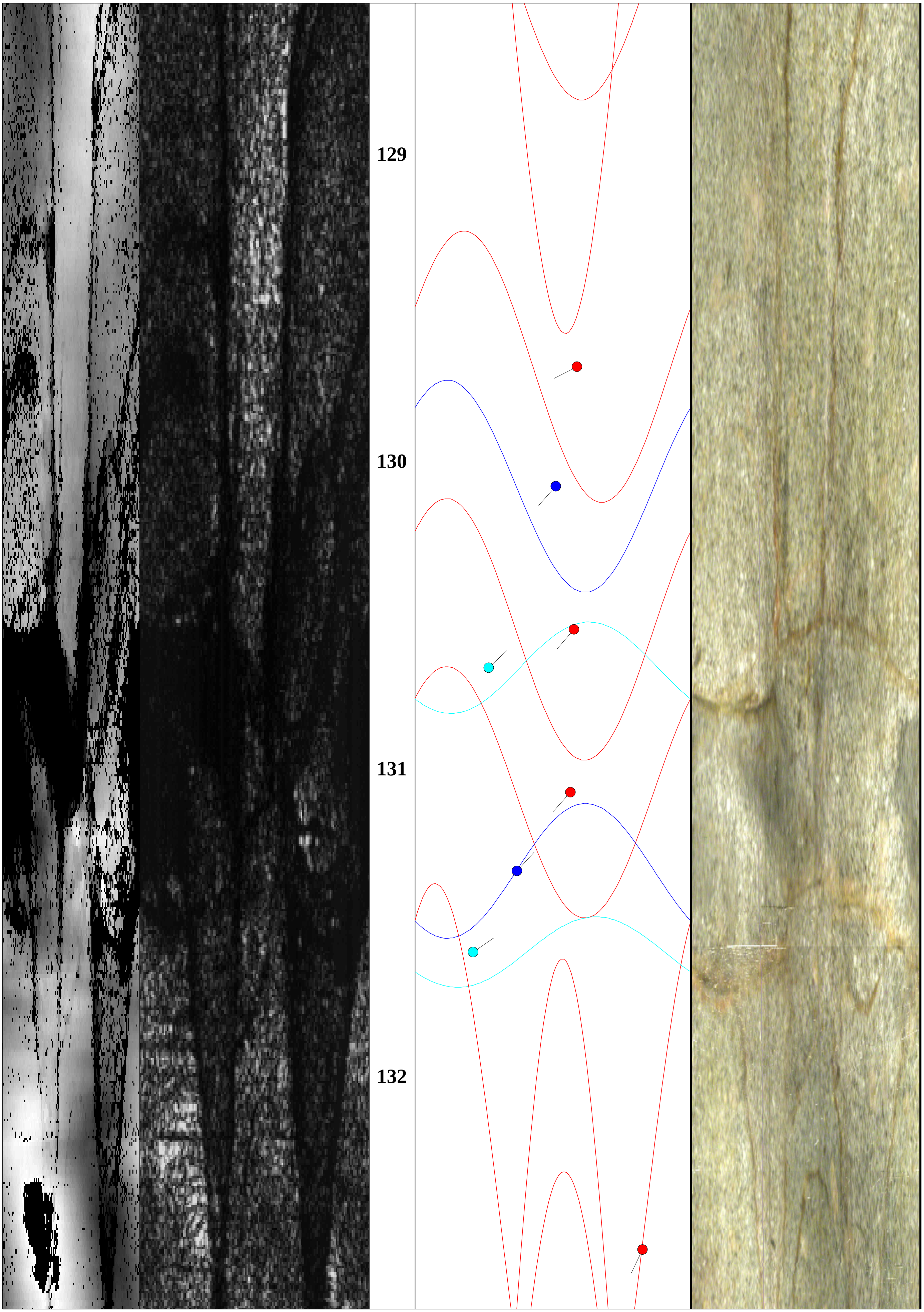

108
109
110
111

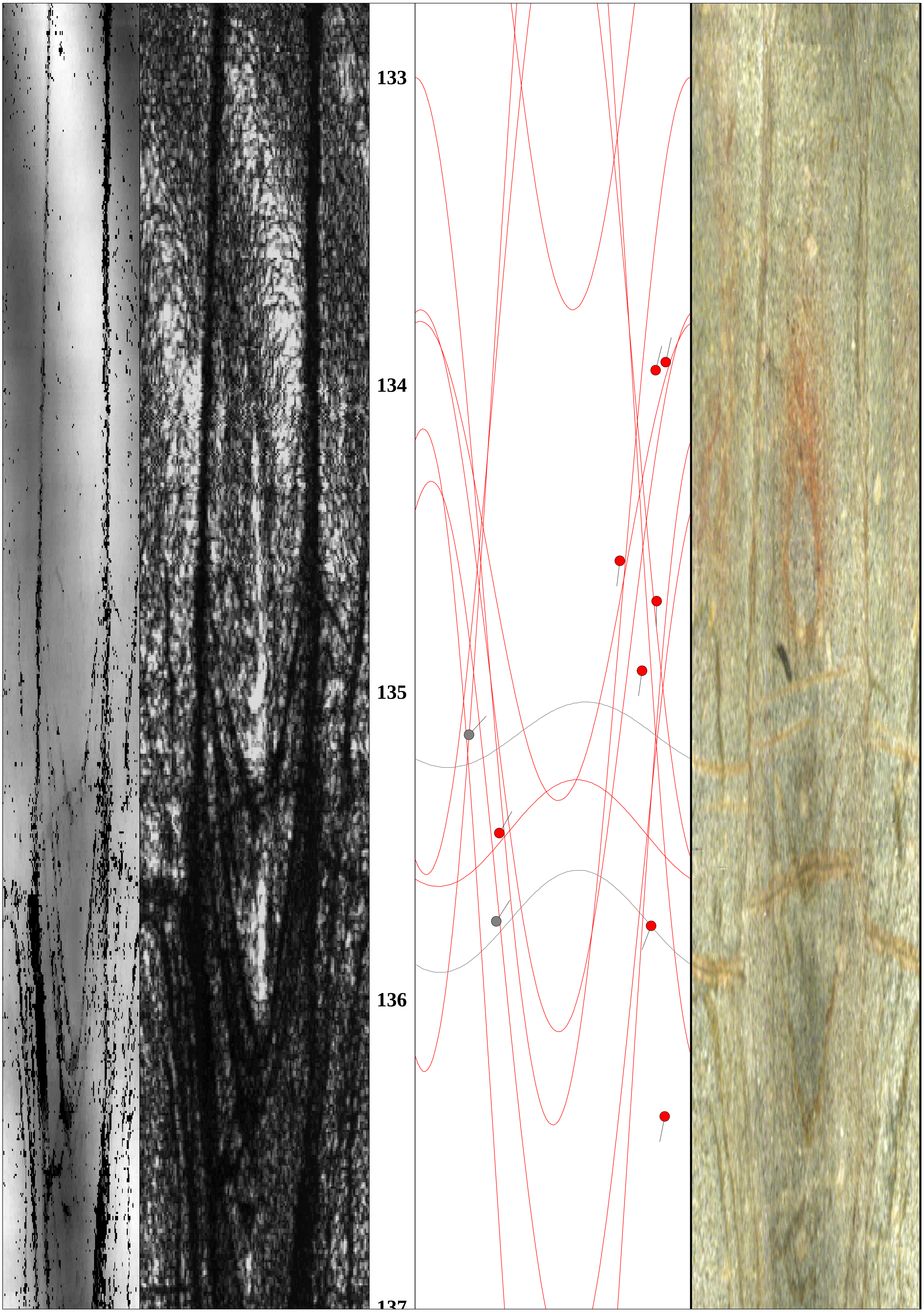

112
113
114
115

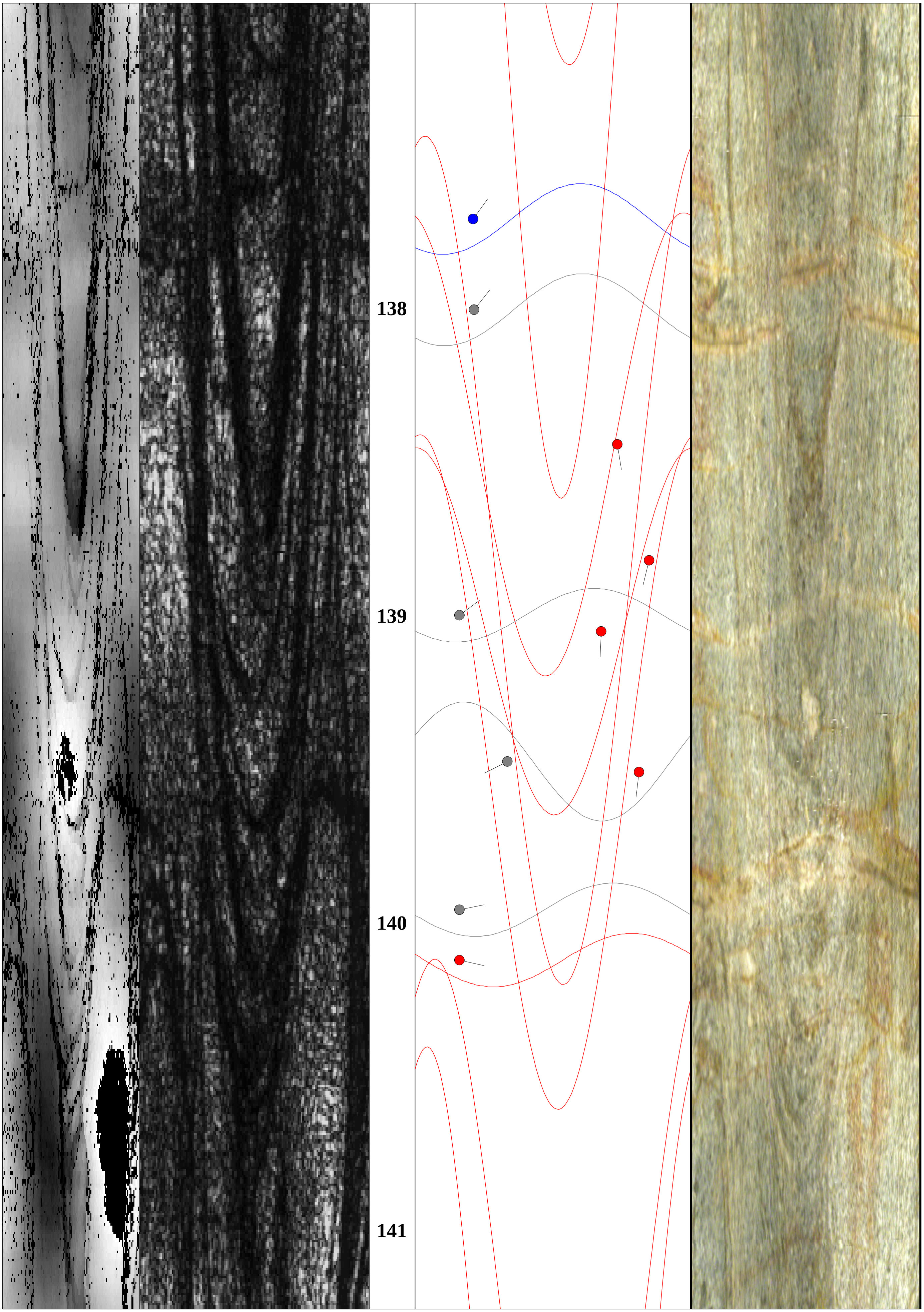

116
117
118
119
120

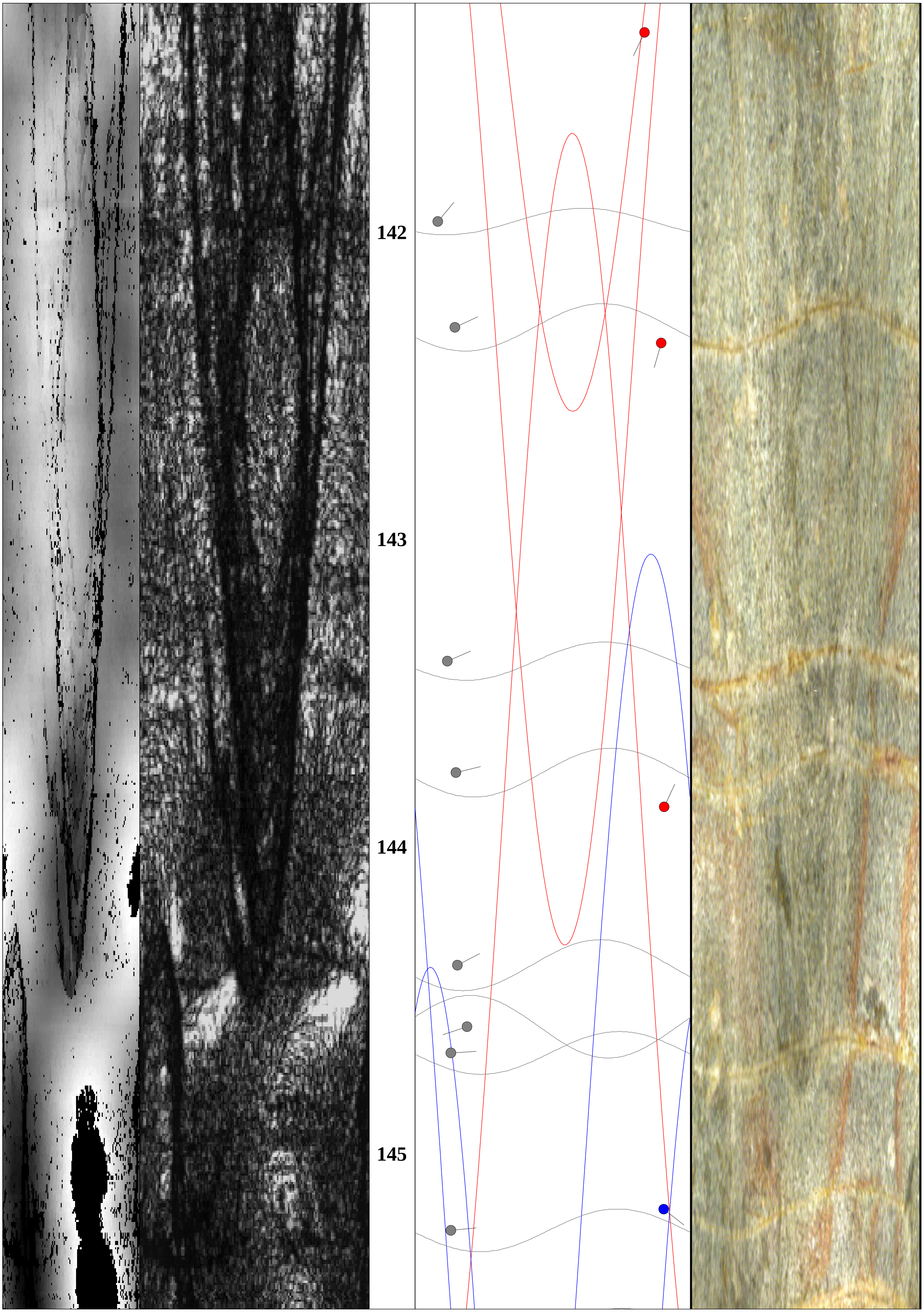

121
122
123
124

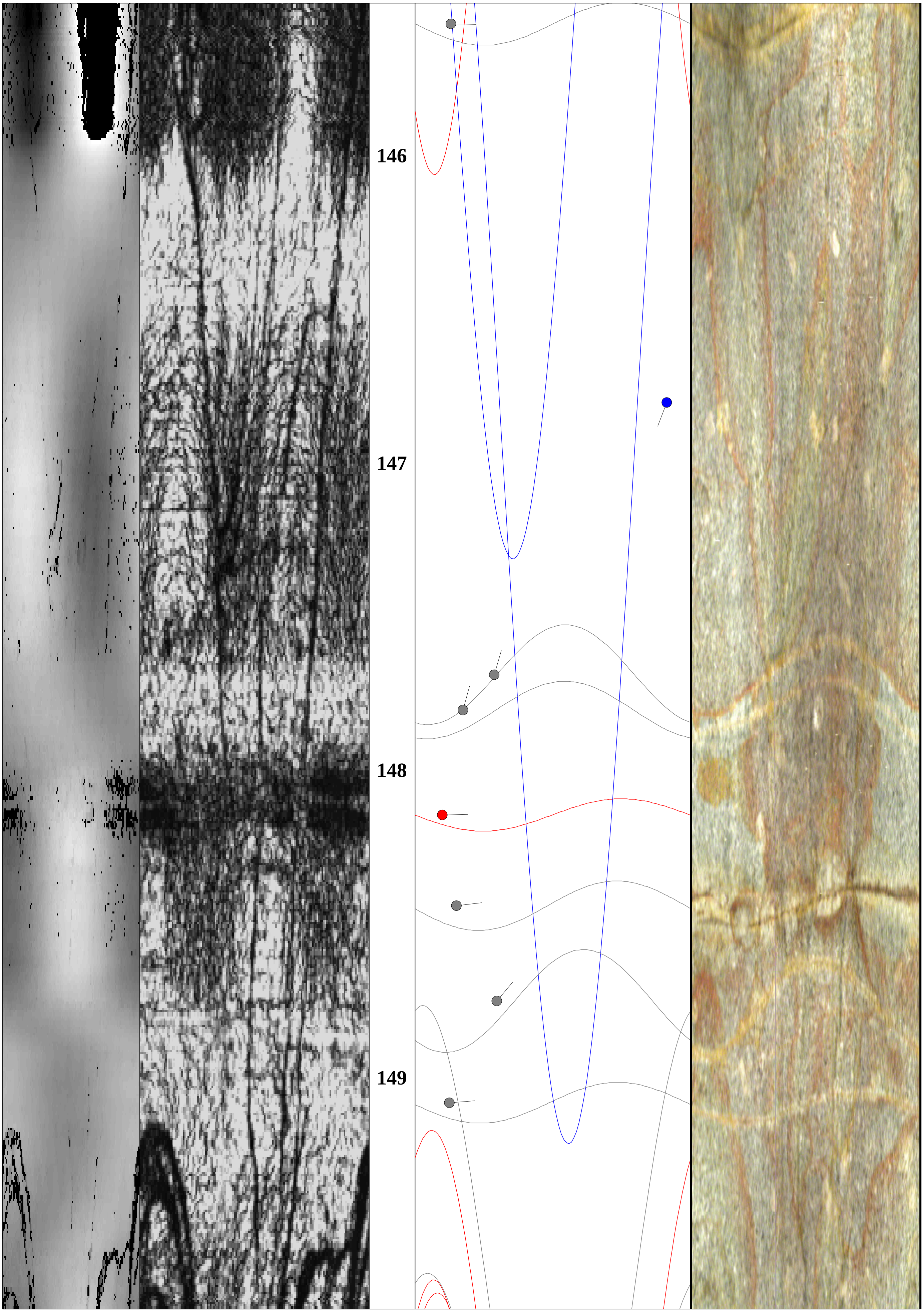

125
126
127
128

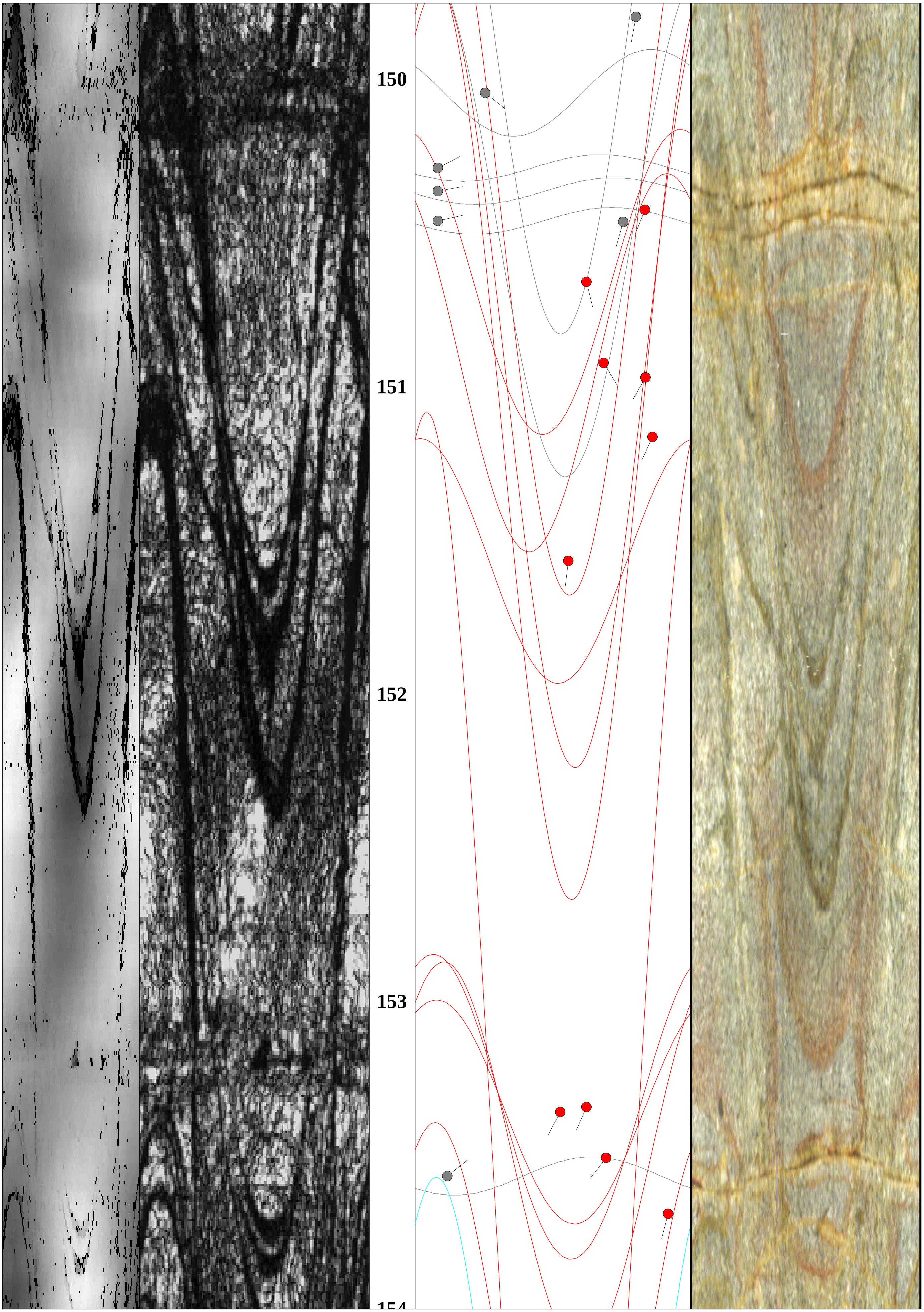

129
130
131
132

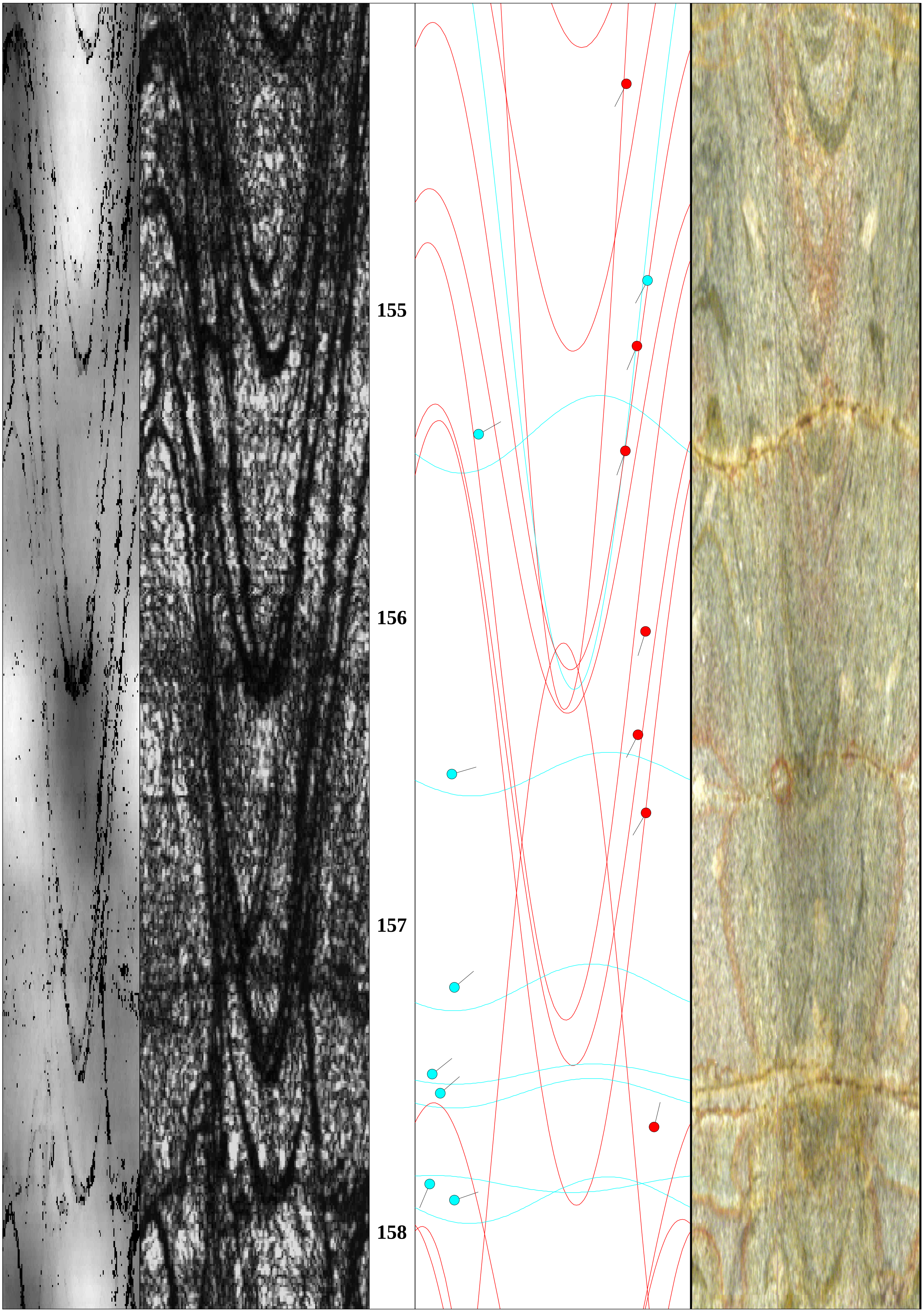

133
134
135
136
137

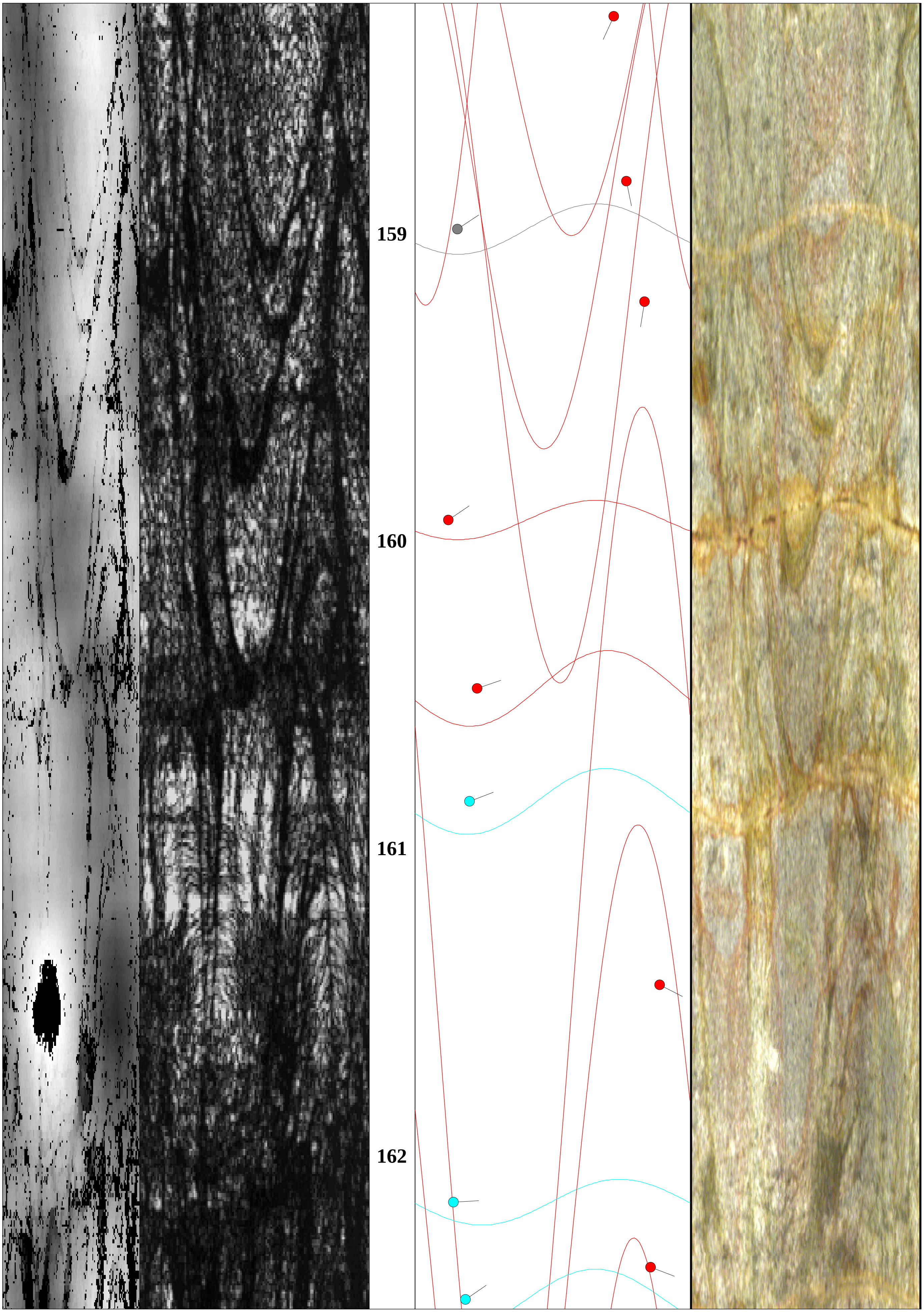

138
139
140
141

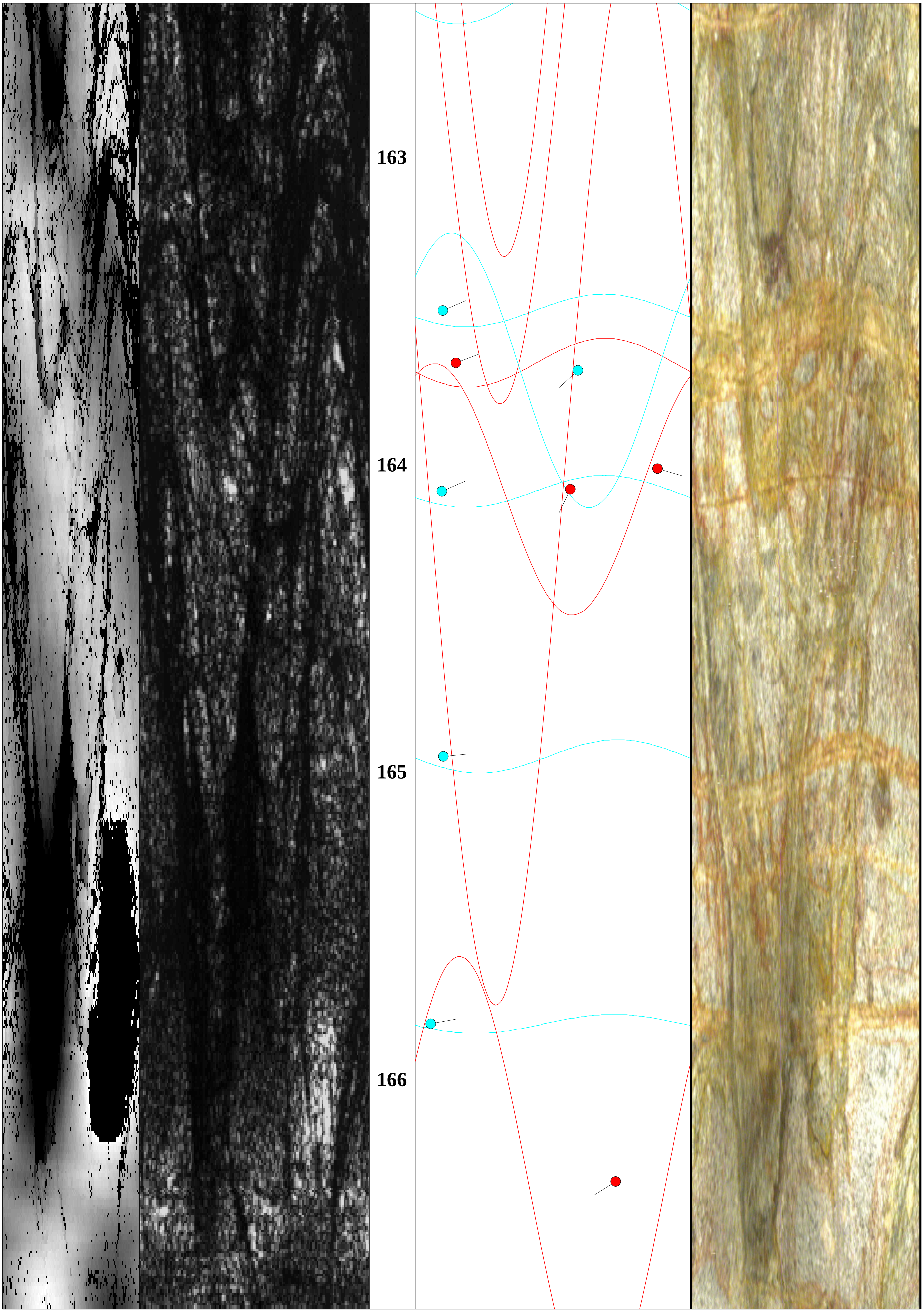

142
143
144
145

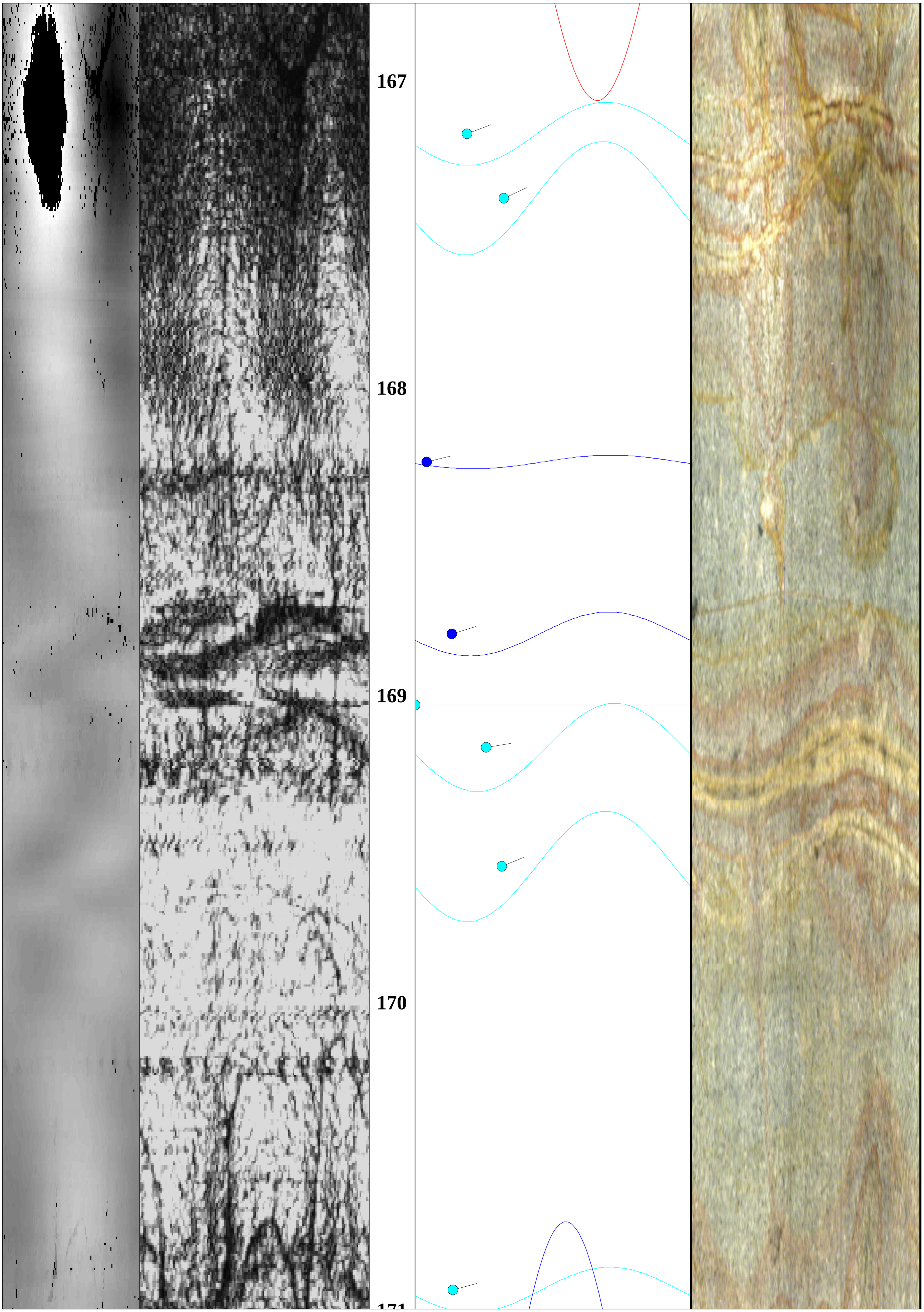

146
147
148
149

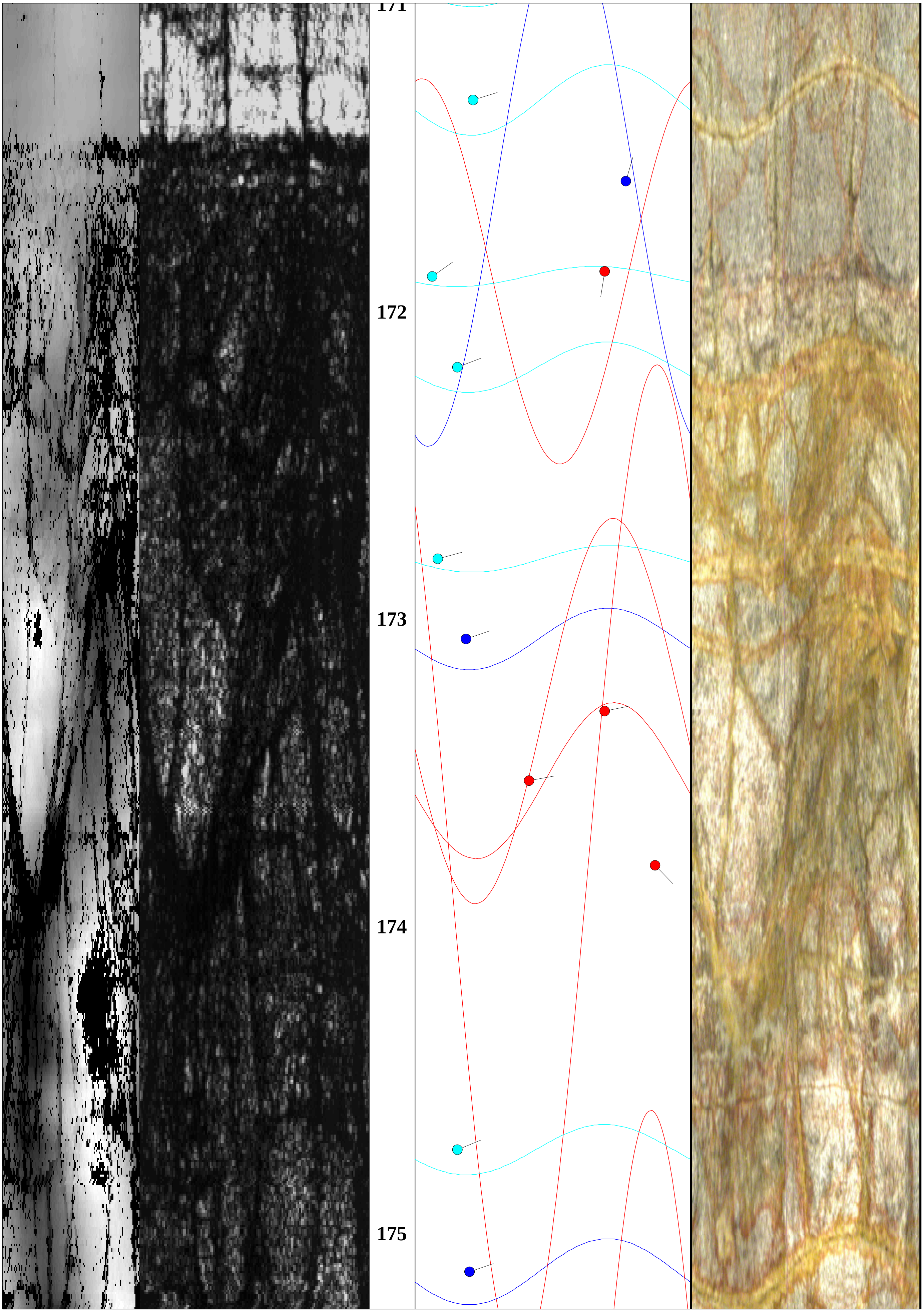

150
151
152
153
154

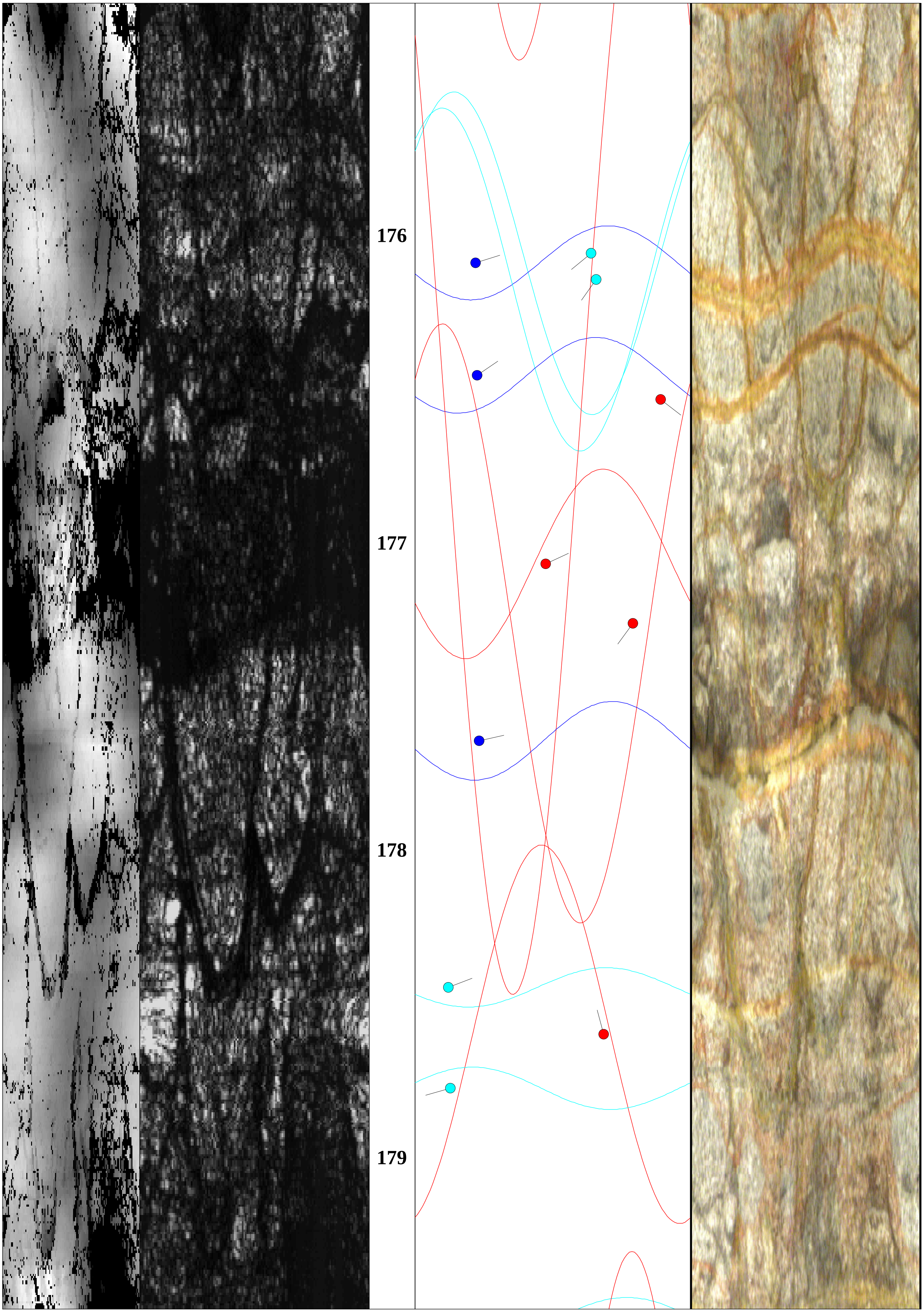

155
156
157
158

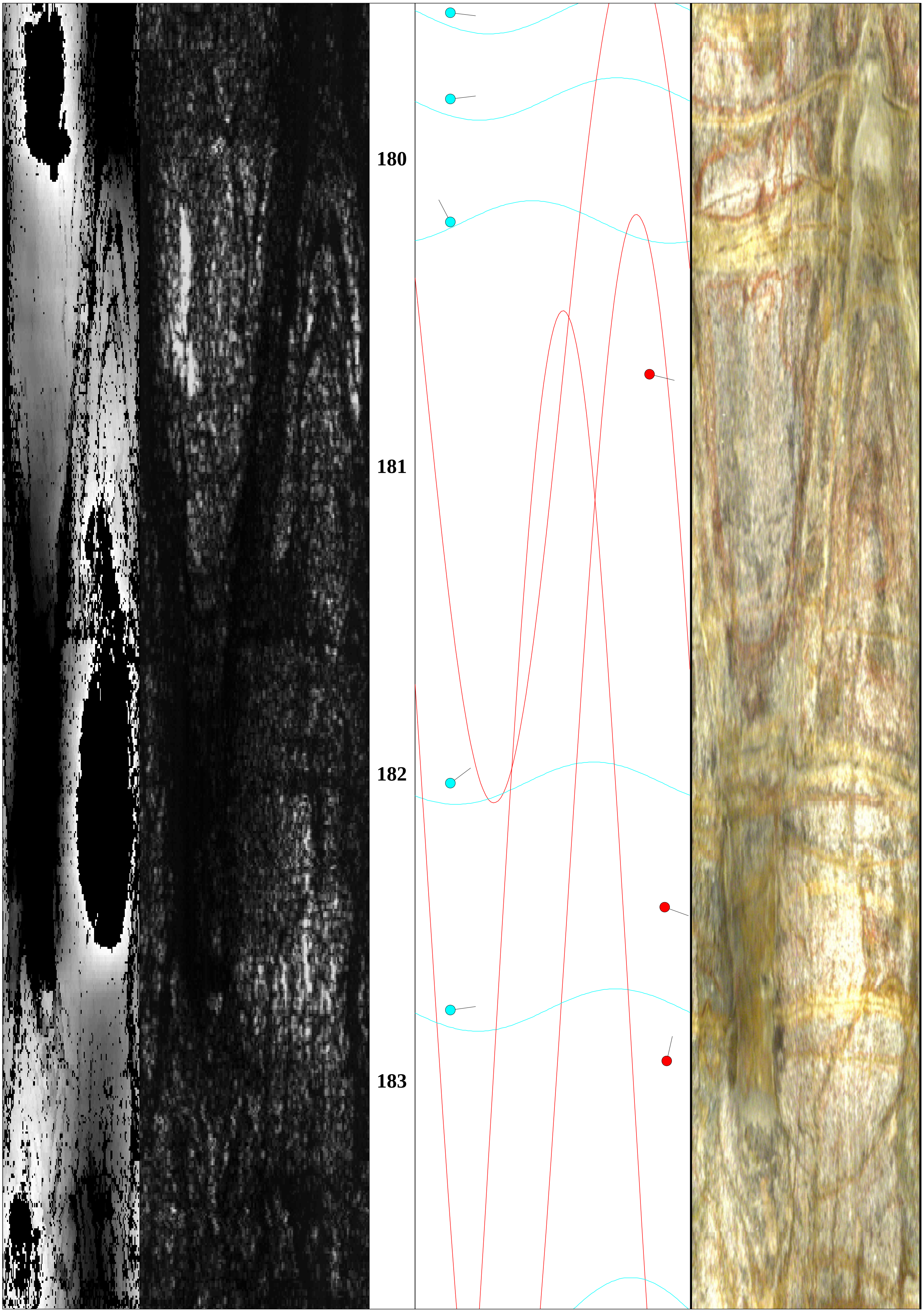

159
160
161
162

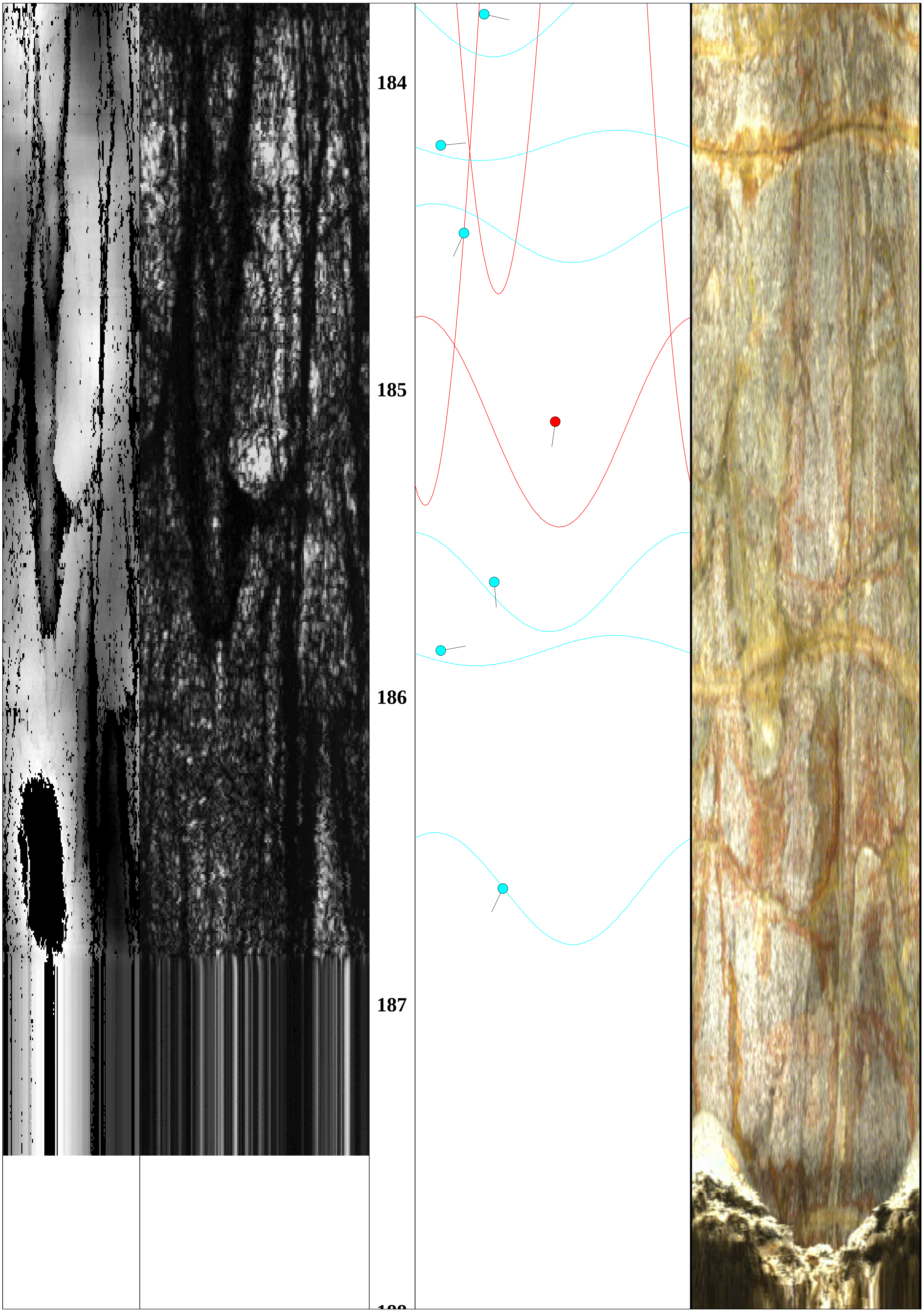

163
164
165
166


167
168
169
170

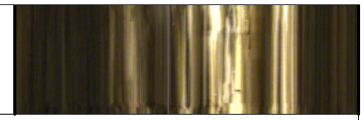

171
172
173
174
175


176
177
178
179


180
181
182
183


184
185
186
187

188

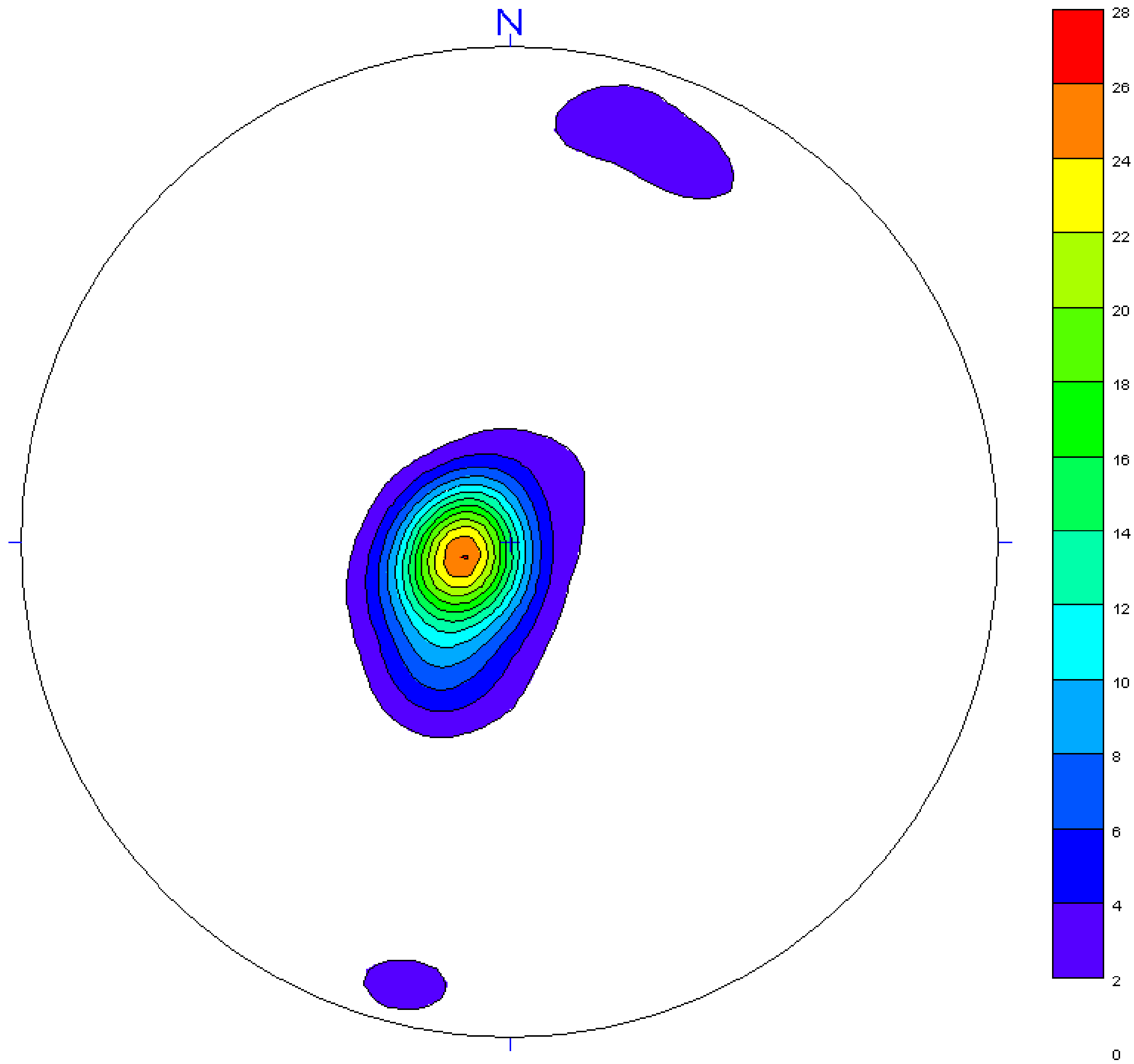


Tadpoles

0 90

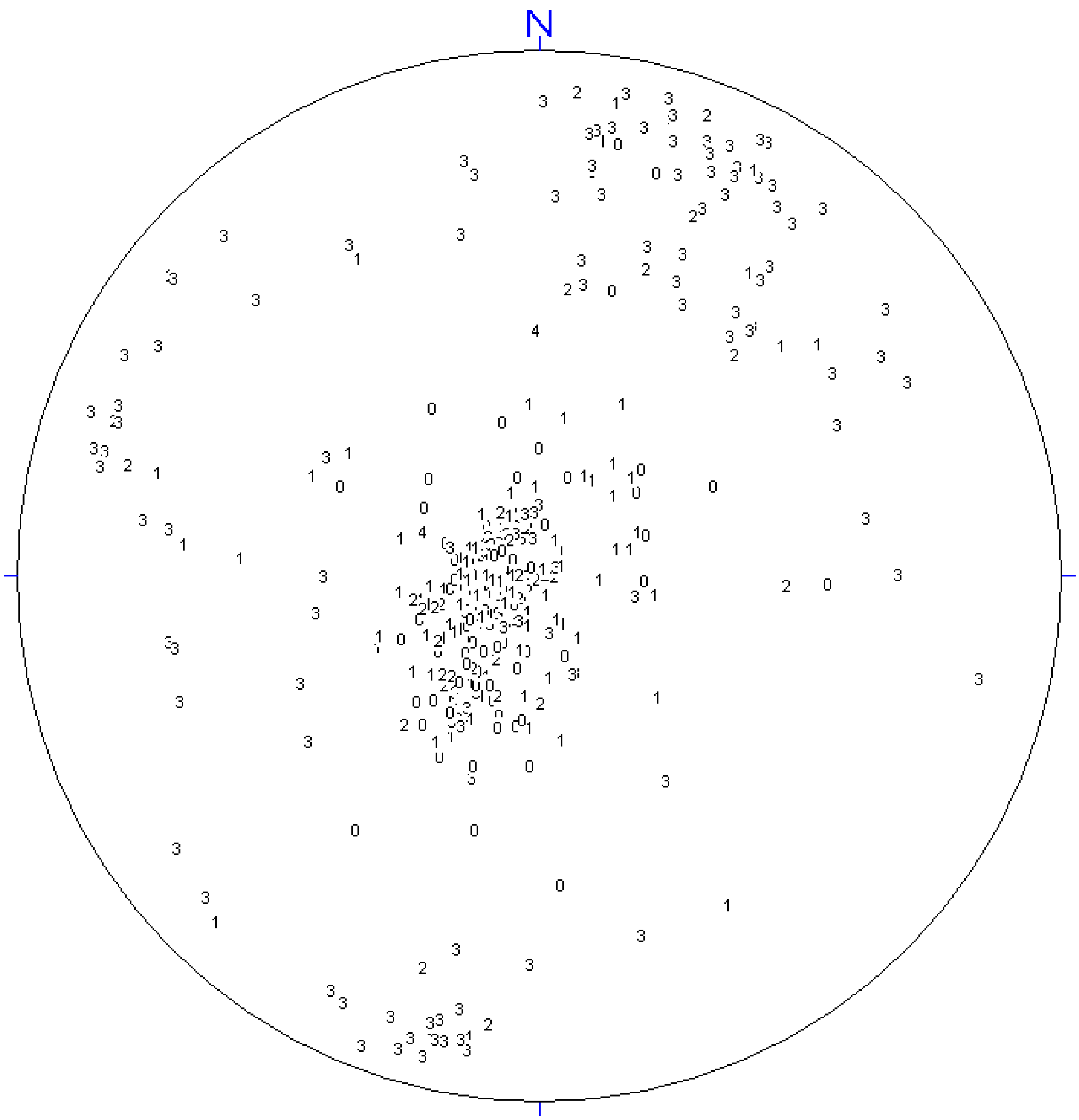
Travel Time	Acoustic Image	Depth	Projections	Optical Image
0° 90° 180° 270° 0°	0° 90° 180° 270° 0°	1ft:5ft	0° 90° 180° 270° 0°	0° 90° 180° 270° 0°

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n1
NNSA/NSO
21 Sept 2010



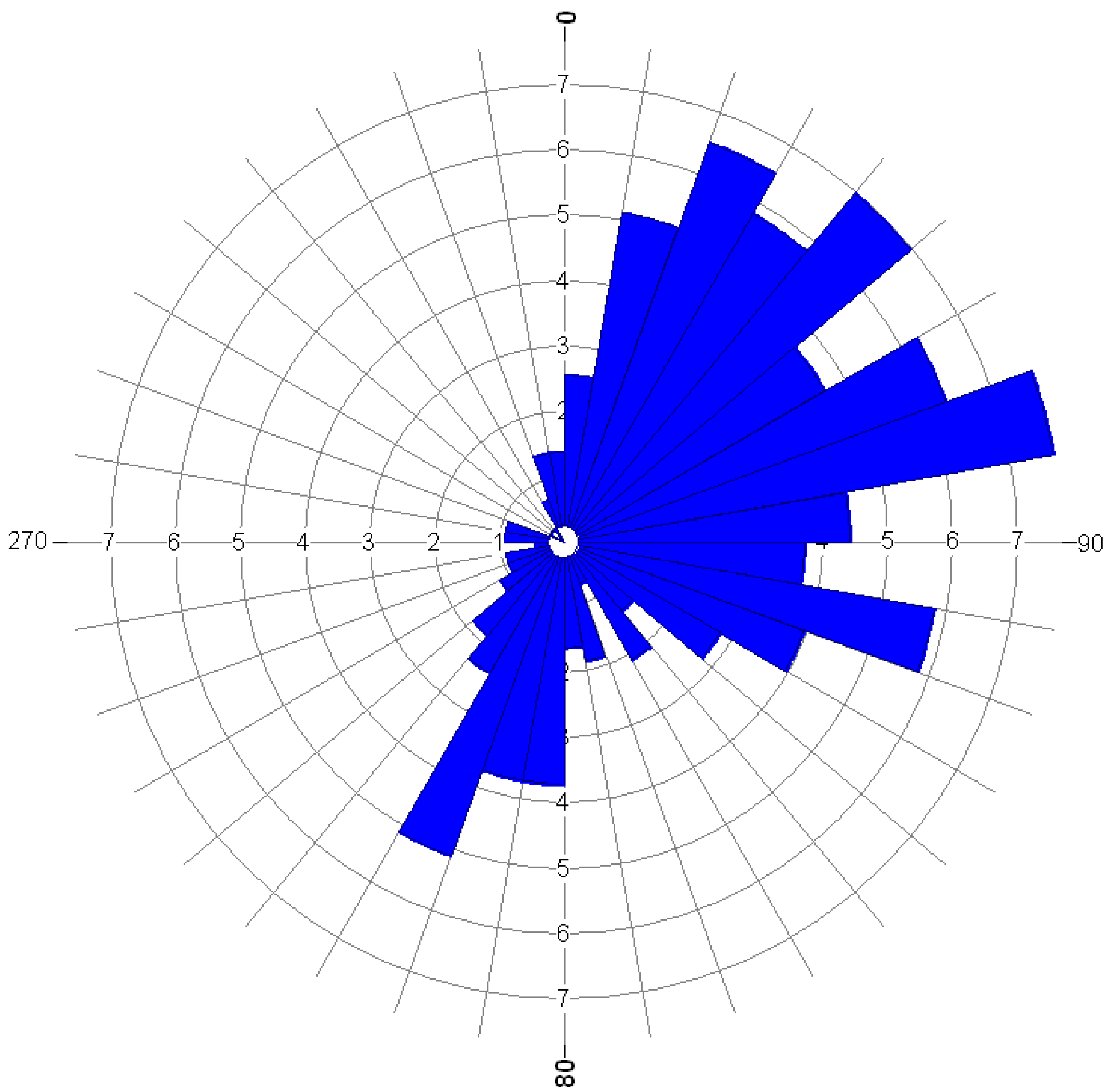
All directions are with respect to True North.

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n1
NNSA/NSO
21 Sept 2010



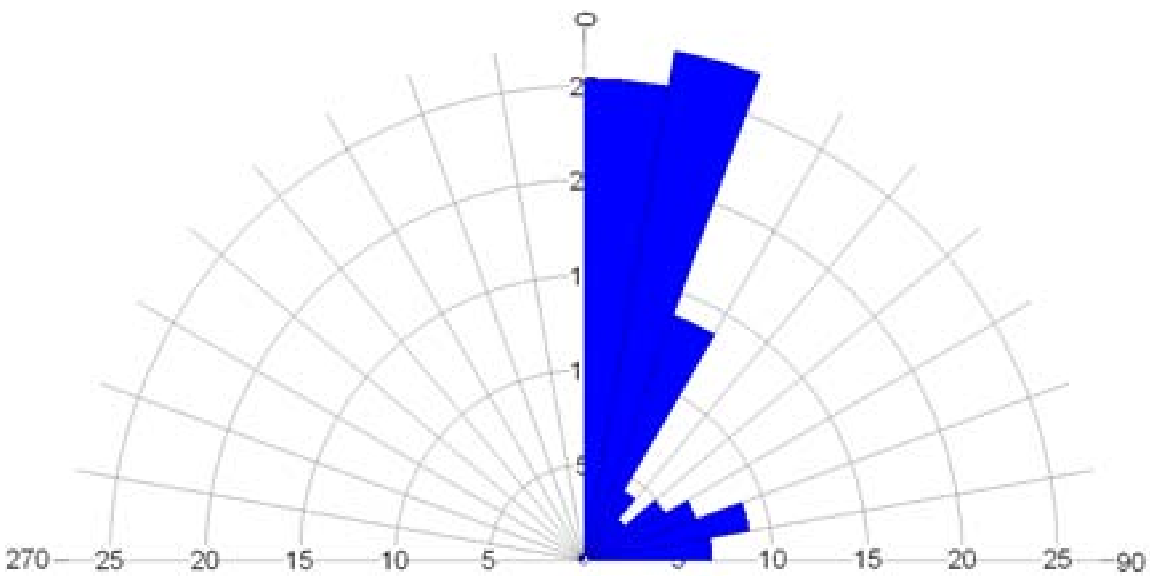
All directions are with respect to True North.

Rose Diagram – Dip Directions
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n1
NNSA/NSO
21 Sept 2010



All directions are with respect to True North.

Rose Diagram – Dip Angles
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n1
NNSA/NSO
21 Sept 2010



All directions are with respect to True North.

Full-Waveform Sonic

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Company NNSA/NSO
Well U-15N#1
Field NNSS
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15N#1
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900107.23
E: 676655.11

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Dual-Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5003.19

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

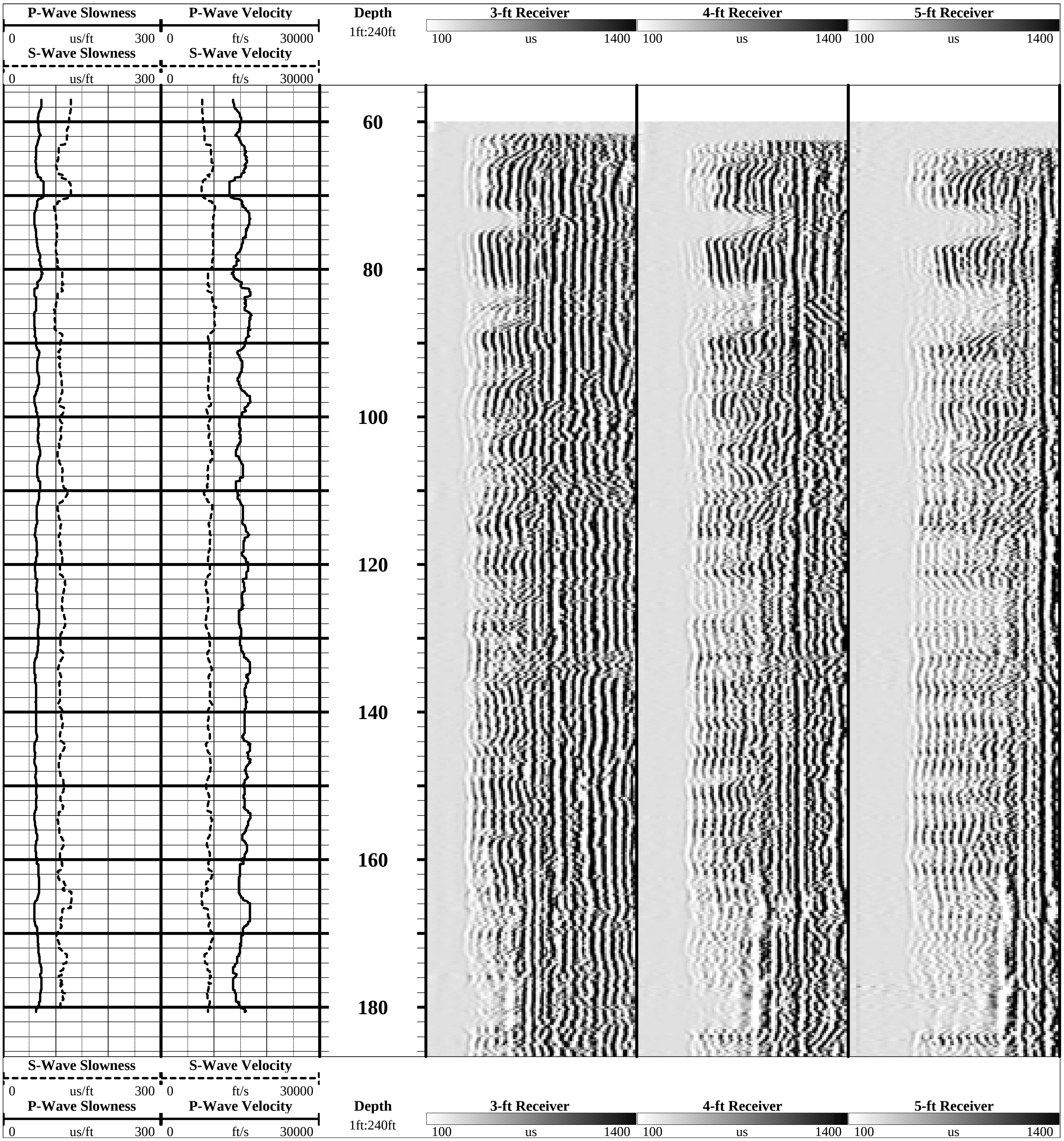
DRILLING MEAS. FROM

DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Full Waveform Sonic			
DEPTH-DRILLER	190'			
DEPTH-LOGGER	187.1'			
BTM LOG INTERVAL	187.1'			
TOP LOG INTERVAL	60.0'			
RECORDED BY	ALC			
WITNESSED BY	C.Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	5 ft/min			
A.S.D.E.	0.1'			
SAMPLE INTERVAL	0.1'			

BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	7'	10"		Surf	6.5'
2	8"	7'	190'				

COMMENTS

NA - Not Available, N/A - Not Applicable


P-Wave Slowness
0 us/ft 300
S-Wave Slowness
0 us/ft 300
P-Wave Velocity
0 ft/s 30000
S-Wave Velocity
0 ft/s 30000
Depth
1ft:240ft
3-ft Receiver
100 us 1400
4-ft Receiver
100 us 1400
5-ft Receiver
100 us 1400
60
80
100
120
140
160
180
S-Wave Slowness
0 us/ft 300
P-Wave Slowness
0 us/ft 300
S-Wave Velocity
0 ft/s 30000
P-Wave Velocity
0 ft/s 30000
Depth
1ft:240ft
3-ft Receiver
100 us 1400
4-ft Receiver
100 us 1400
5-ft Receiver
100 us 1400

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Borehole Deviation

Company	NNSA/NSO
Well	U-15n#1
Field	NNSS
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15N#1
FIELD Nevad National Securities Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N:900107.23
E: 676655.11

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Optical Televiewer
Acoustic Televiewer
Dual-Spaced Density
Caliper
Natural Gamma
Full Wave form Sonic
Video

PERMANENT DATUM Ground Level **ELEVATION** 5003.19

LOG MEAS. FROM Ground Level 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM

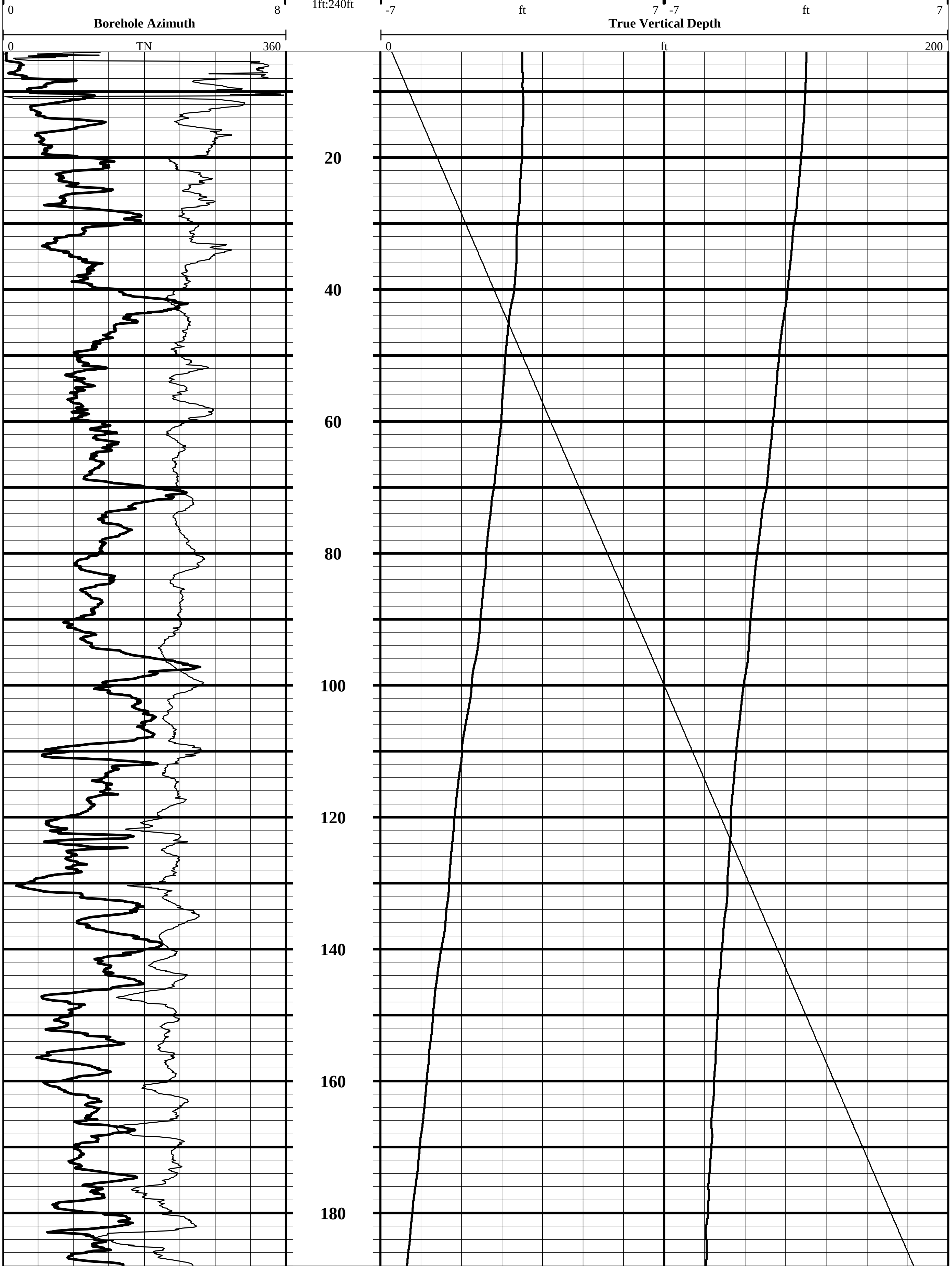
DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	TWO			
LOG TYPE	Borehole Deviation			
DEPTH-DRILLER	190'			
DEPTH-LOGGER	187'			
BTM LOG INTERVAL	187'			
TOP LOG INTERVAL	5			
RECORDED BY	E.Eaton			
WITNESSED BY	G.Juniel			
PROBE TYPE, S/N	OBI-023902			
LOGGING SPEED	3.5 ft/min			
A.S.D.E.	0.59ft			
SAMPLE INTERVAL	0.0041 ft			

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25	Surface	7	10"		-1	6.5
	8"	7	180				

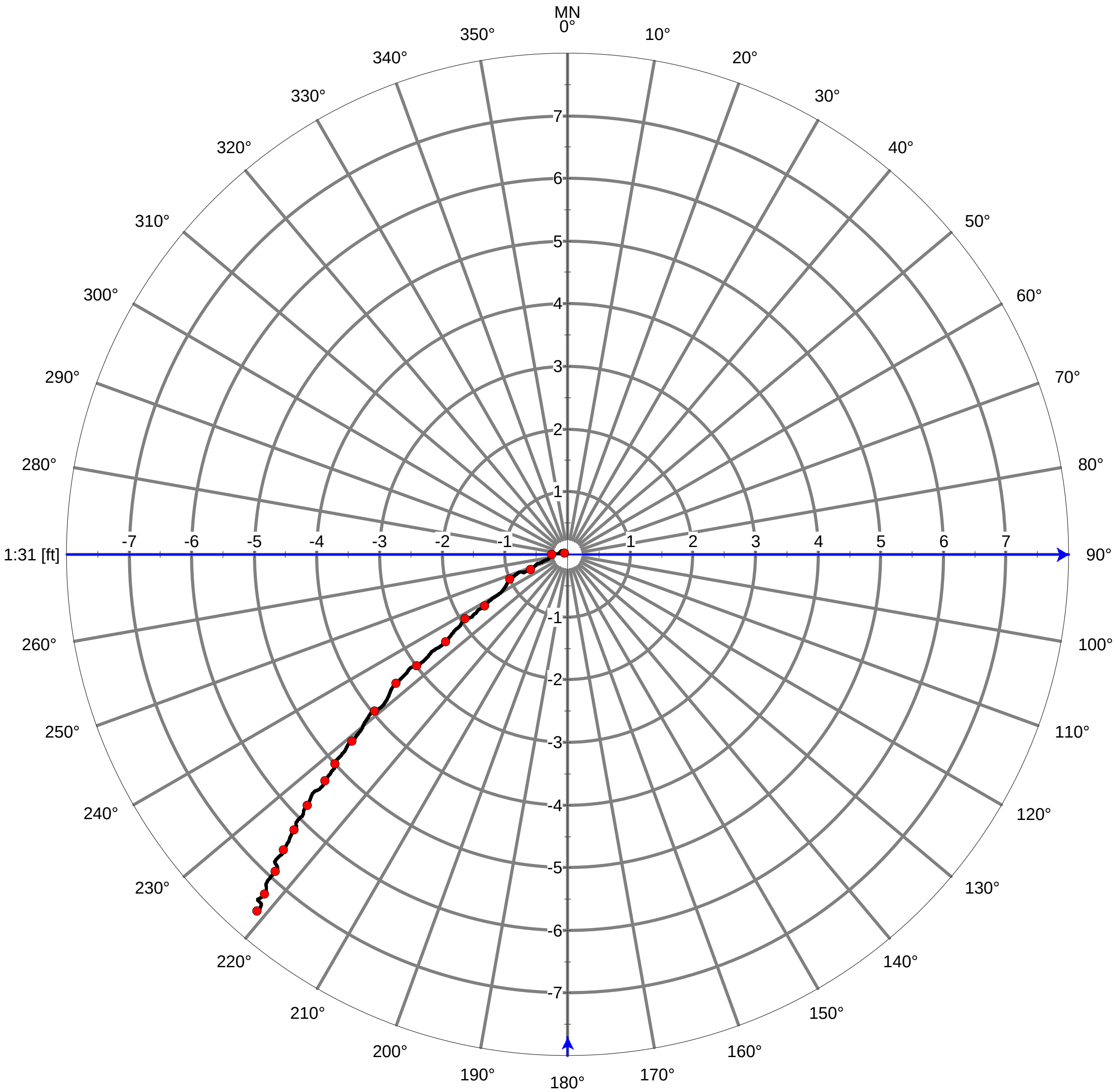
COMMENTS

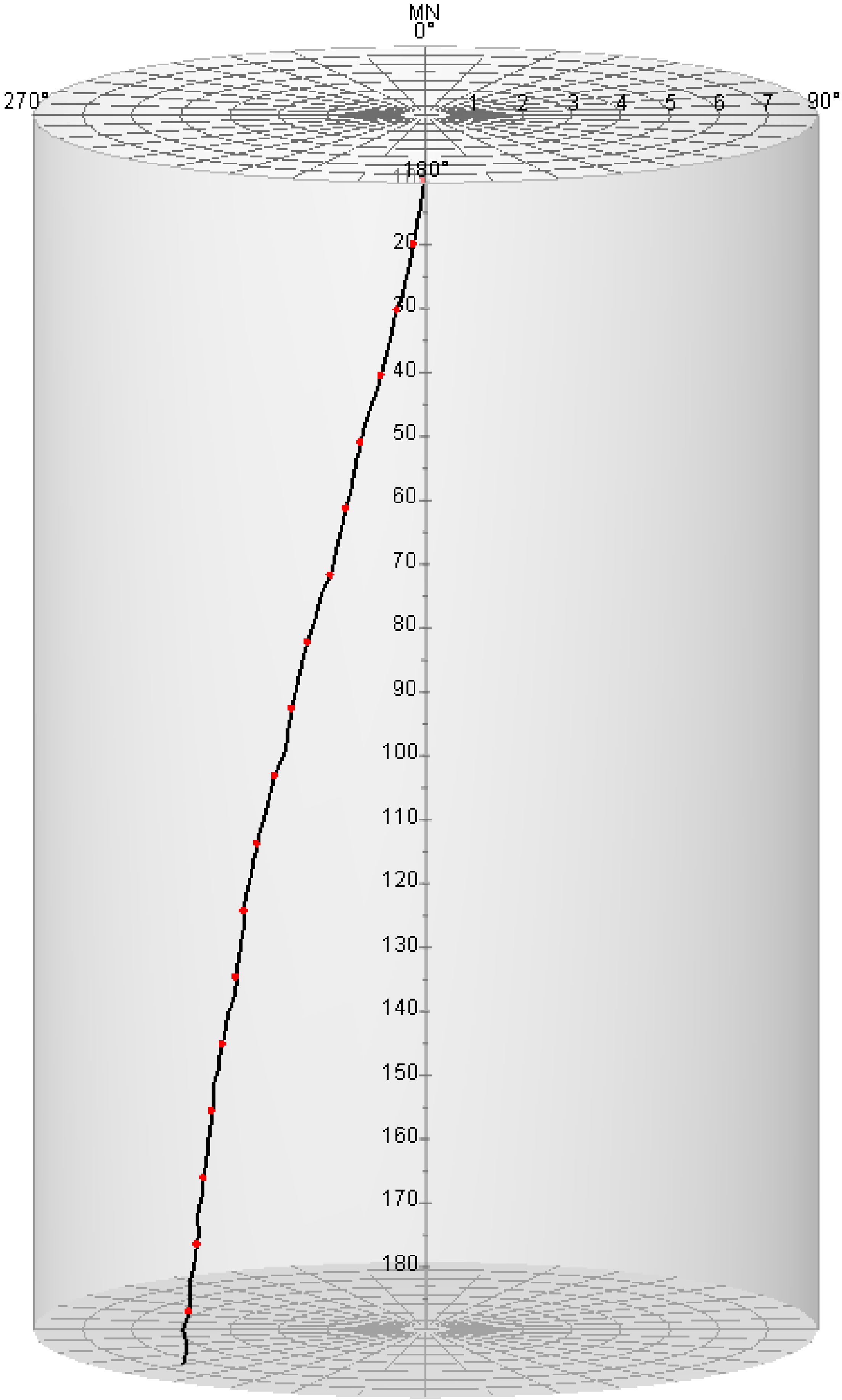
NA - Not Available, N/A - Not Applicable

Borehole Tilt	Depth	Northing	Easting



0
8
Borehole Azimuth
0
TN
360
1ft:240ft
-7
ft
7
-7
ft
7
True Vertical Depth
0
ft
200
20
40
60
80
100
120
140
160
180


MN
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
1:31 [ft]
-7
-6
-5
-4
-3
-2
-1
1
2
3
4
5
6
7



MN
0°
270°
90°
180°
1
2
3
4
5
6
7
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

Appendix F-3

Borehole Geophysical Log Plots for Instrument Hole U-15n#2

COLOG
BOREHOLE GEOPHYSICS & HYDROPHYSICS
A DIVISION OF LAYNE CHRISTENSEN COMPANY
810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Far Density
Near Density
Natural Gamma Ray
Caliper

Company NNSA/NSO
Well U-15N#2
Field NNSS
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15N#2
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900075.16
E: 676608.20

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Full-Wave Sonic
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5003.28
LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**
DRILLING MEAS. FROM G.L.

DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Far Density	Near Density	Natural Gamma Ray	Caliper
DEPTH-DRILLER	192'			
DEPTH-LOGGER	192.8'			
BTM LOG INTERVAL	191.7'	192.0'	187.2'	190.7'
TOP LOG INTERVAL	6.4'	6.7'	1.9'	5.4'
RECORDED BY	A. Caster			
WITNESSED BY	C. Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	10 ft/min			
A.S.D.E.	0.0'			
SAMPLE INTERVAL	0.1'			

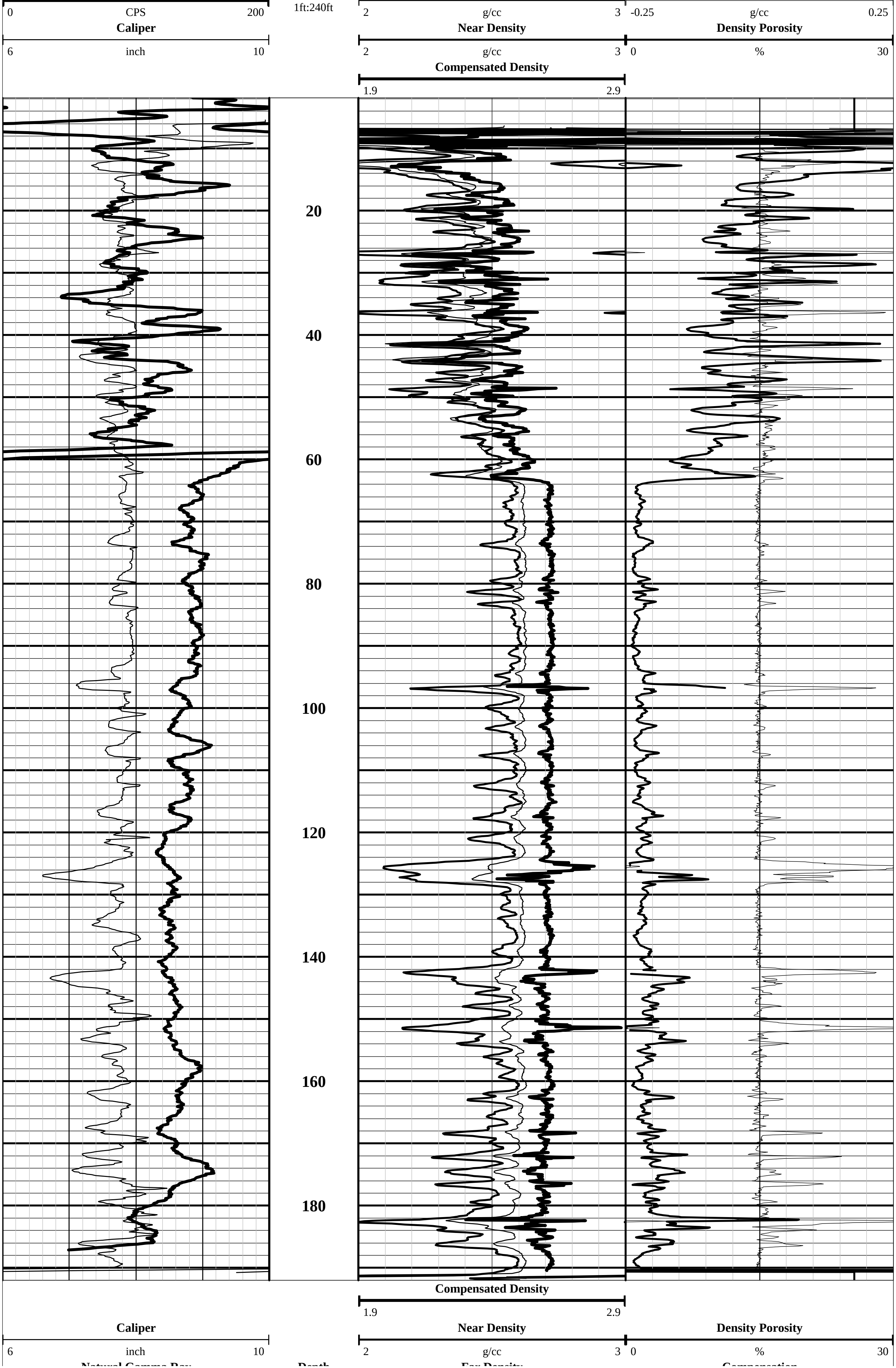
BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	10'	1		-1.0'	9.5'
2	8"	10'	192'				

COMMENTS

NA - Not Available, N/A - Not Applicable

Matrix Density of 2.64 used to calculate Density Porosity

Natural Gamma Ray	Depth	Far Density	Compensation



0 CPS 200
Caliper
6 inch 10
1ft:240ft
2 g/cc 3
Near Density
2 g/cc 3
Compensated Density
1.9 2.9
-0.25 g/cc 0.25
Density Porosity
0 % 30
20
40
60
80
100
120
140
160
180
Compensated Density
1.9 2.9
Caliper
6 inch 10
Near Density
2 g/cc 3
Density Porosity
0 % 30

Natural Gamma Ray			Depth	Far Density			Compensation		
0	CPS	200	1ft:240ft	2	g/cc	3	-0.25	g/cc	0.25

Company NNDA/NSO
Well U-15N#2
Field Nevada Test Site
County Nye
State Nevada

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Acoustic Televiewer
Optical Televiewer

COMPANY NNSA/NSO
WELL U-15N#2
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900075.16
E: 676608.20

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Dual Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5003.28

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM

DATE ACQUIRED	21 Sept 2010	21 Sept 2010		
RUN NUMBER	THREE	TWO		
LOG TYPE	ABI	OBI		
DEPTH-DRILLER	192	192		
DEPTH-LOGGER	192	193		
BTM LOG INTERVAL	192	193		
TOP LOG INTERVAL	4	4		
RECORDED BY	E Eaton	E Eaton		
WITNESSED BY	C Obi	C Obi		
PROBE TYPE, S/N	ABI-062605	OBI-023902		
LOGGING SPEED	5.5 ft/min	3.5 ft/min		
A.S.D.E.	0.52 ft	0.65 ft		
SAMPLE INTERVAL	0.16 ft	0.0041 ft		

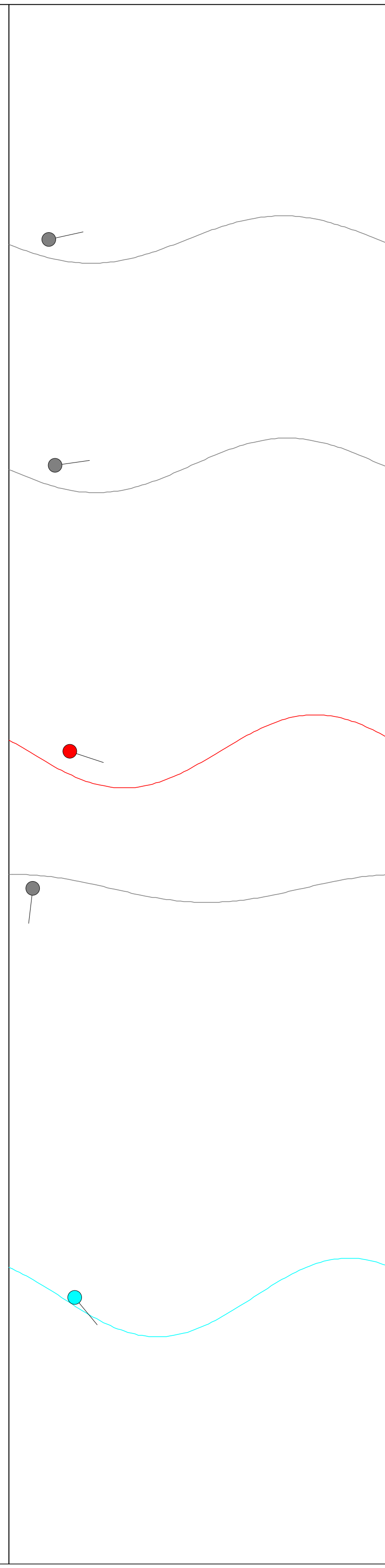
BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25"	Surface	10	10"		-1	9.5
	8"	10	192				

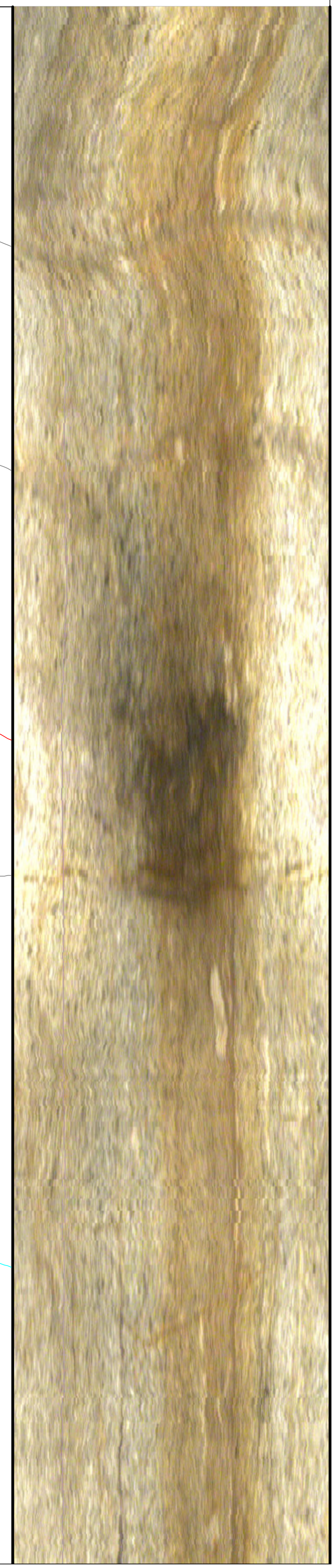
COMMENTS

NA - Not Available, N/A - Not Applicable

Travel Time	Acoustic Image	Depth	Projections	Optical Image
0° 90° 180° 270° 0°	0° 90° 180° 270° 0°	1ft:5ft	0° 90° 180° 270° 0°	0° 90° 180° 270° 0°
			Tadpoles	
			0 90	

Depth: 13, 14, 15, 16



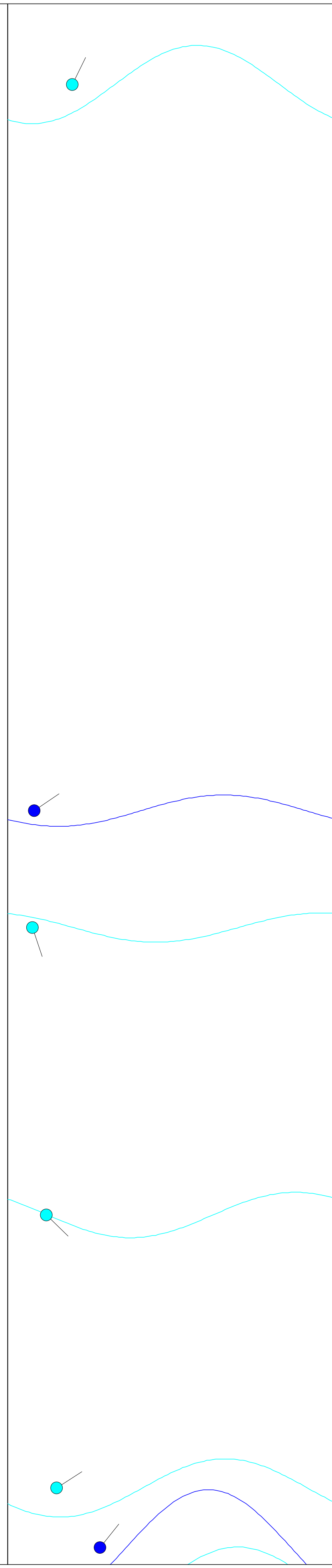


17

18

19

20

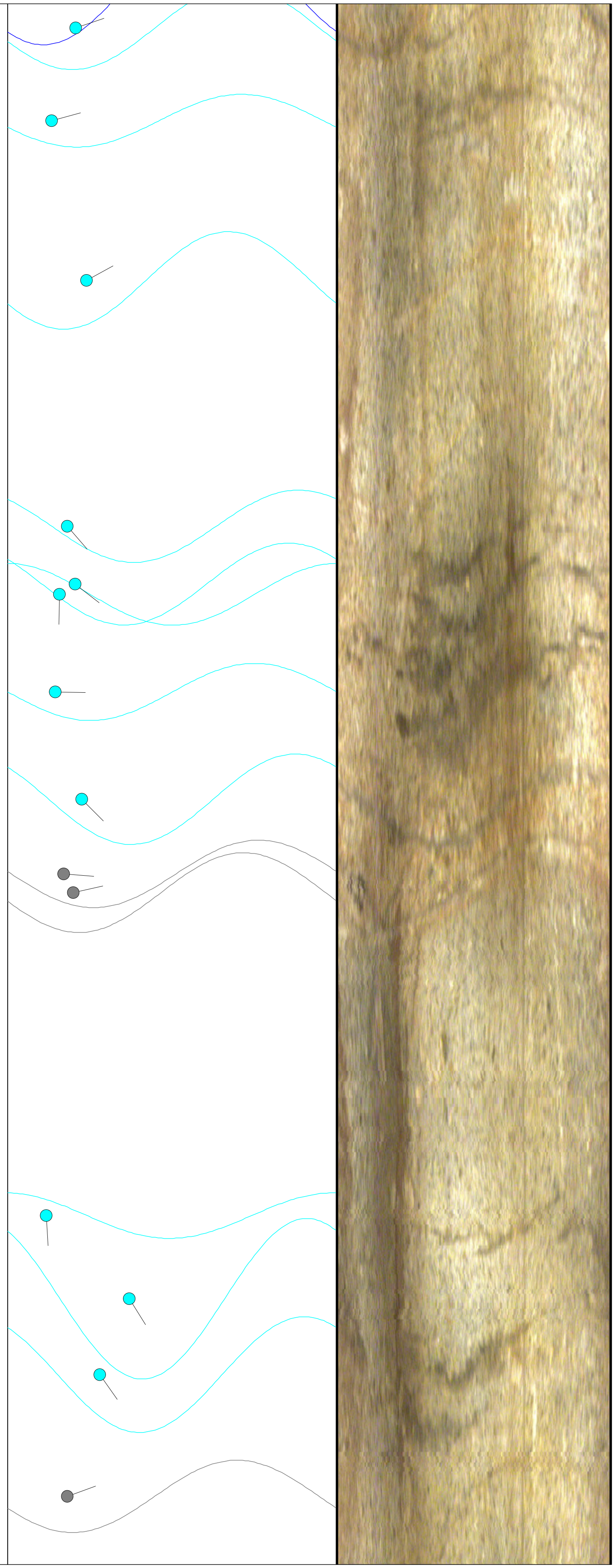


21

22

23

24



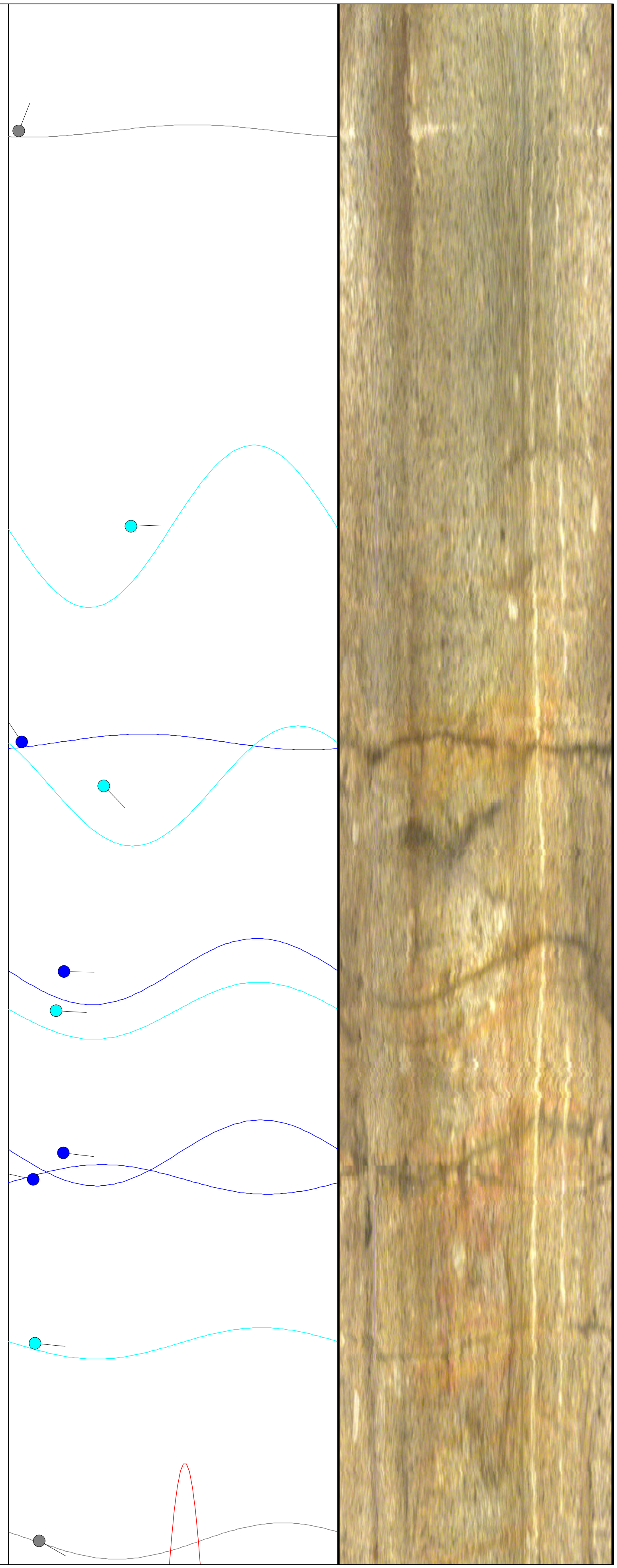
25

26

27

28

29

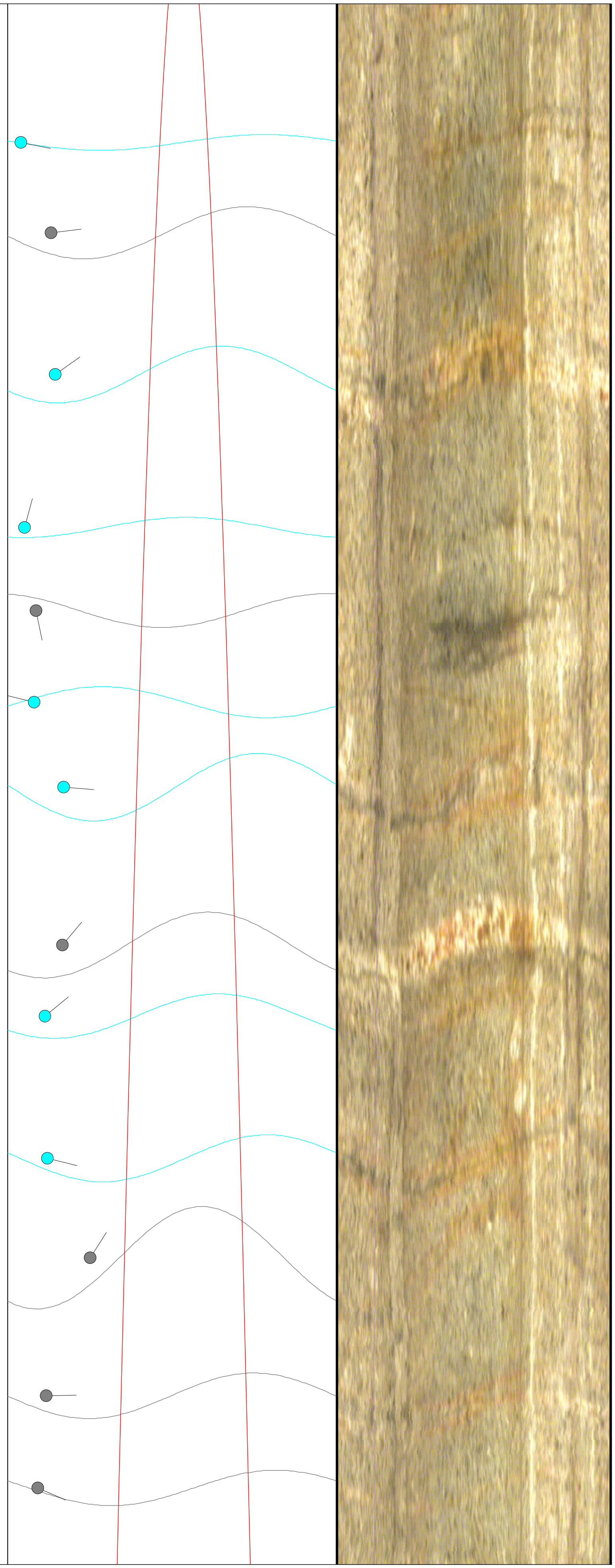


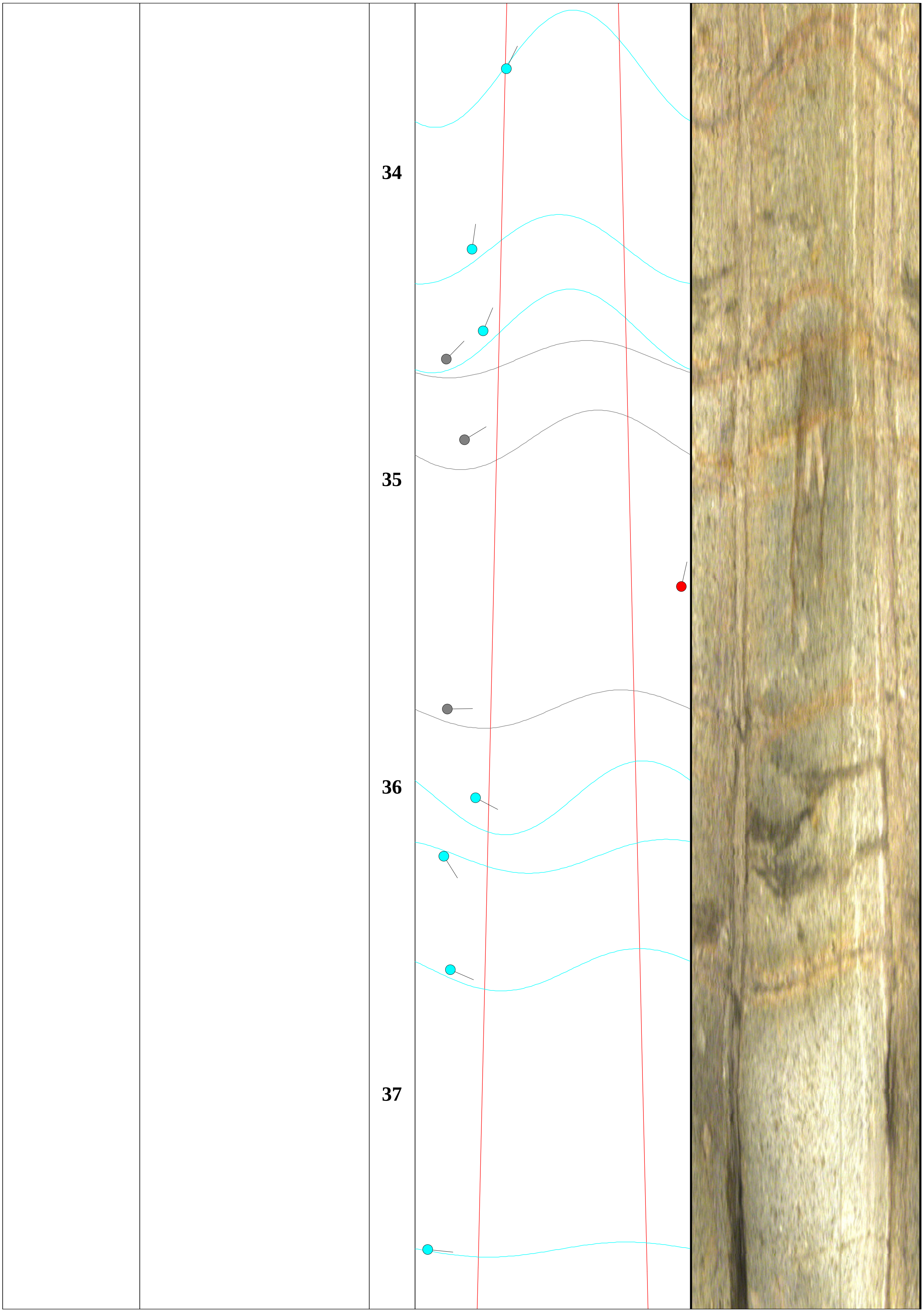
30

31

32

33



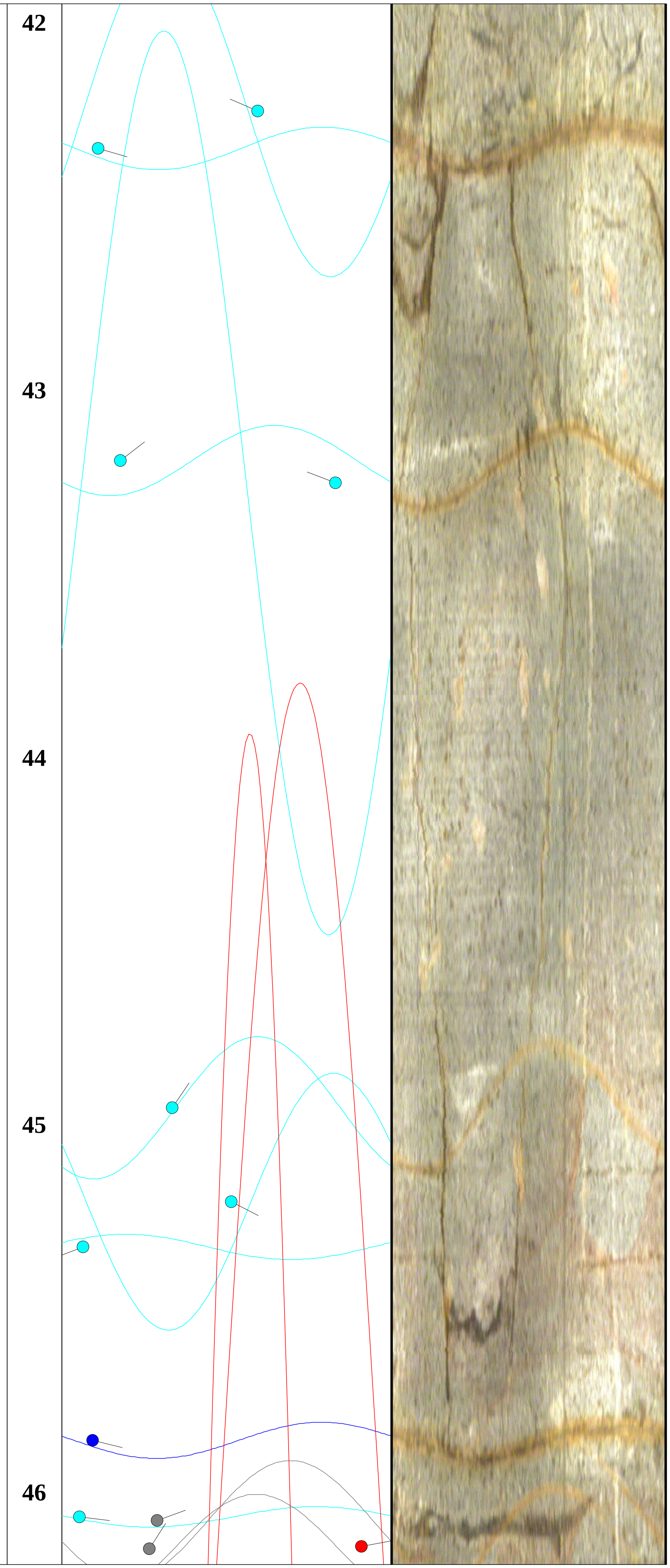

34
35
36
37

38

39

40

41

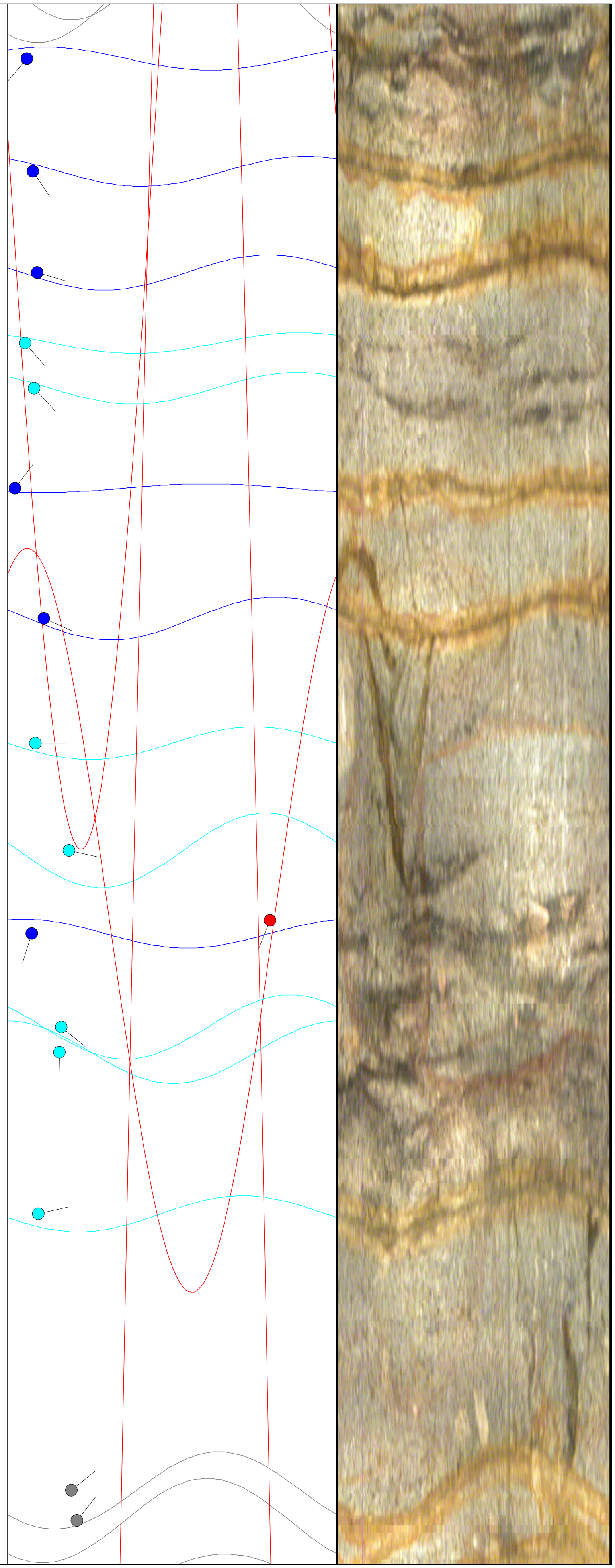

42
43
44
45
46

47

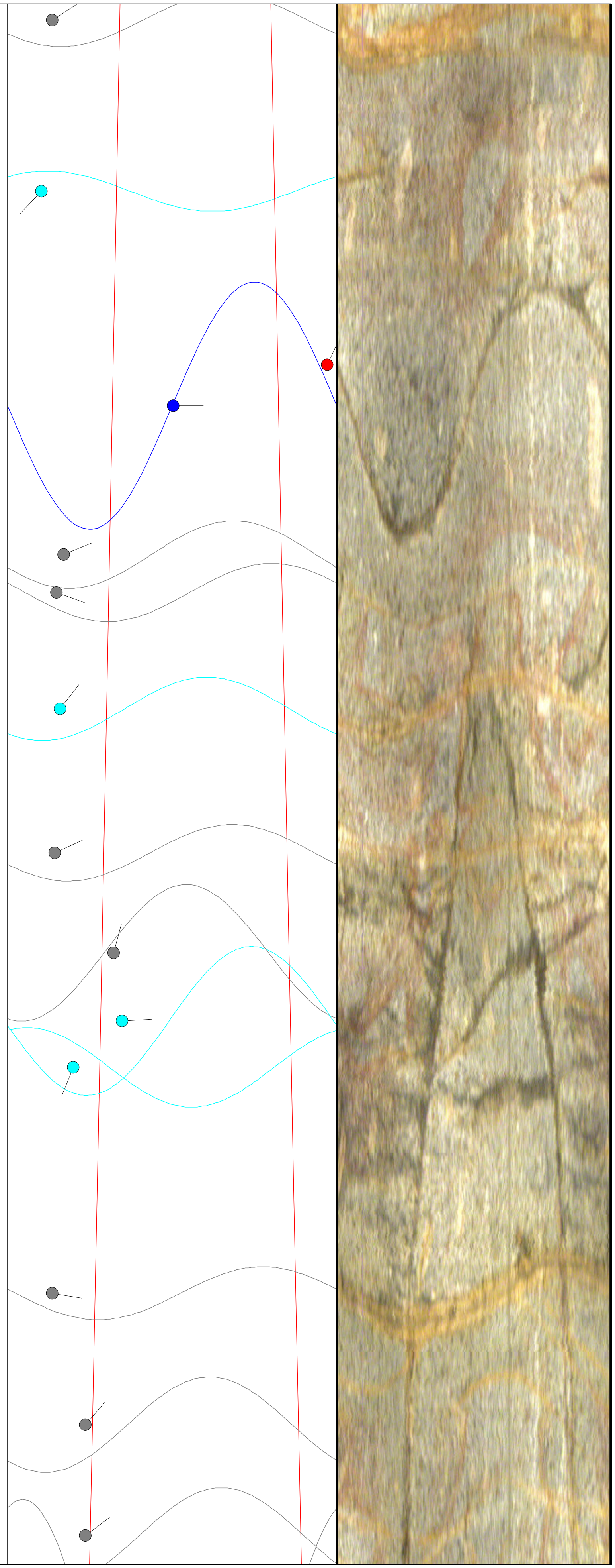
48

49

50



		51
		52
		53
		54



55

56

57

58

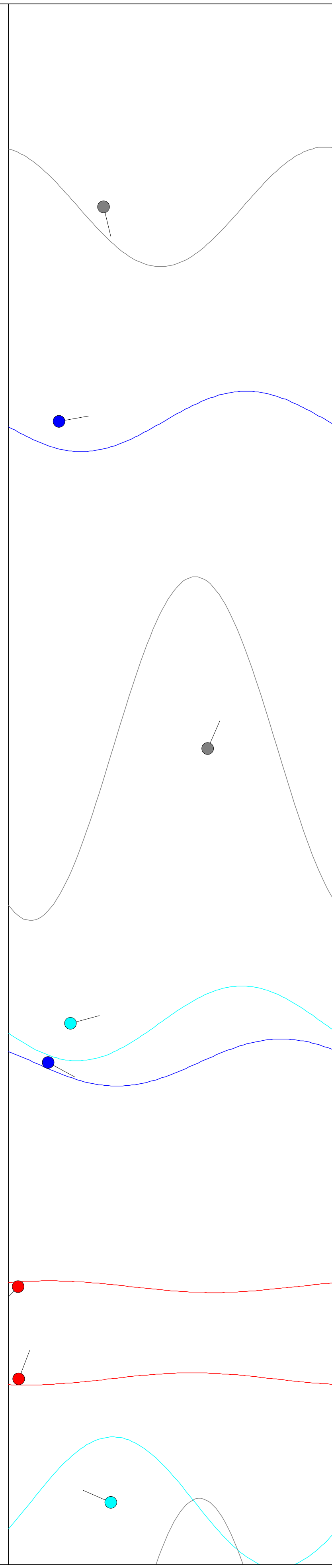
59

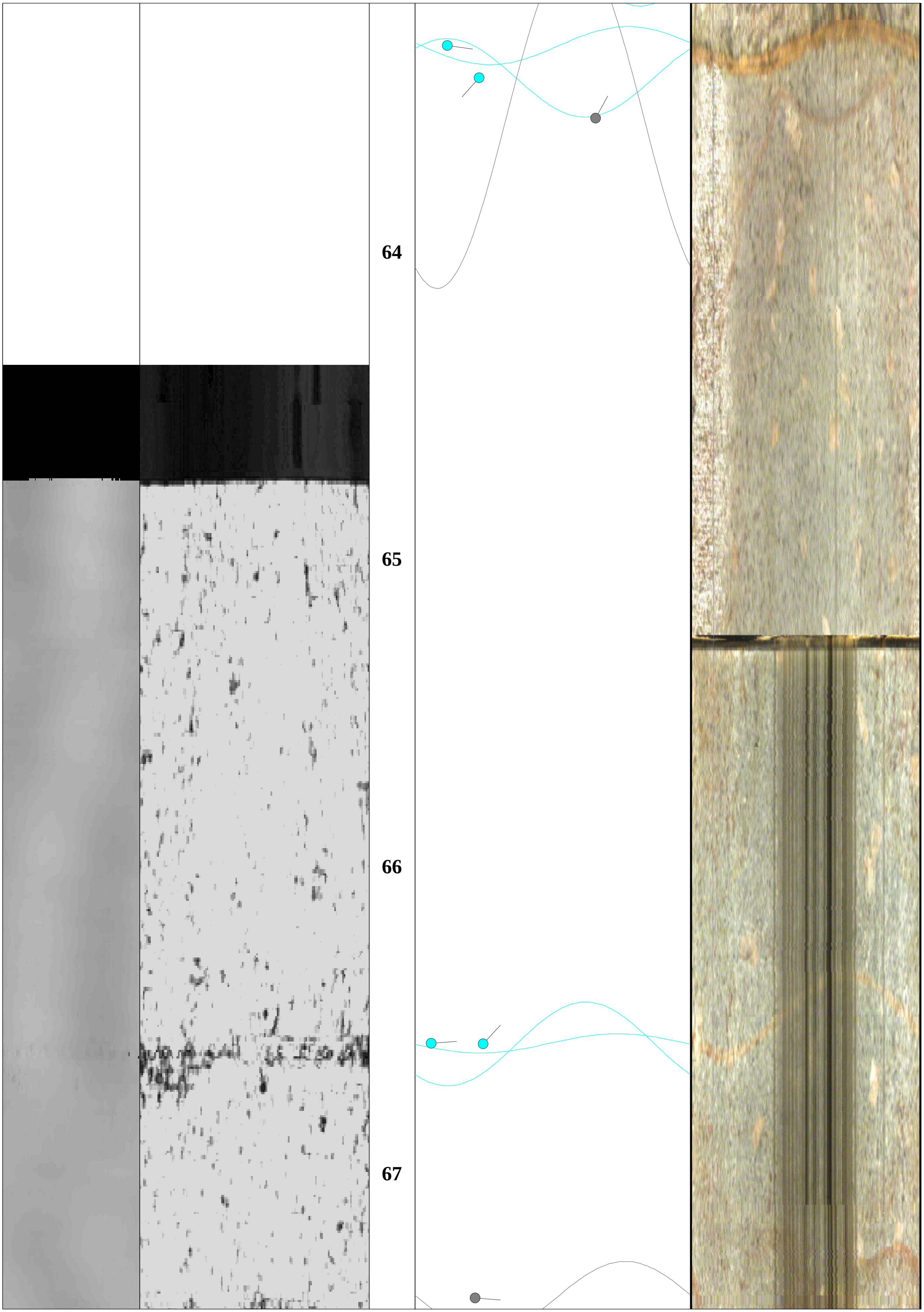
60

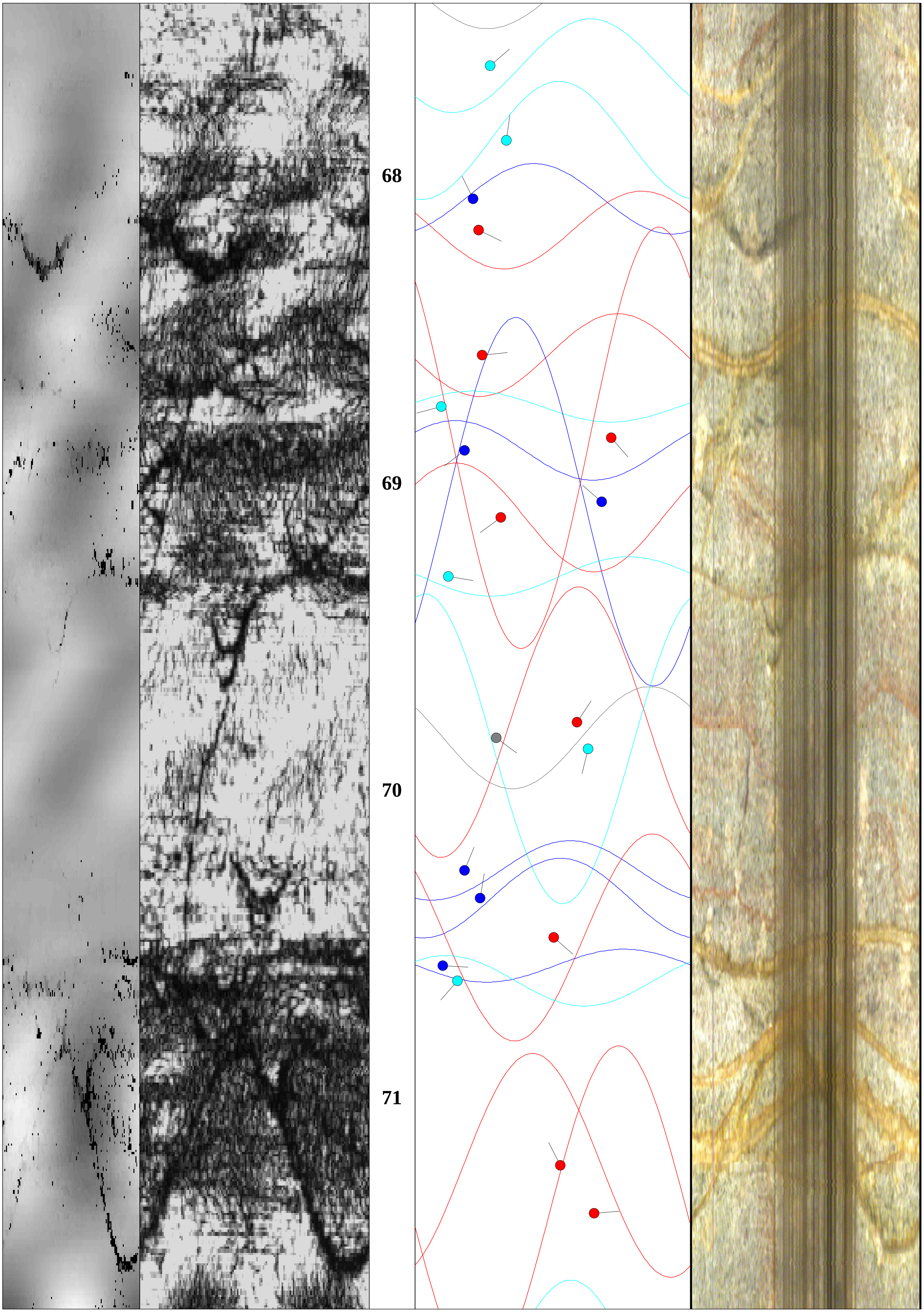
61

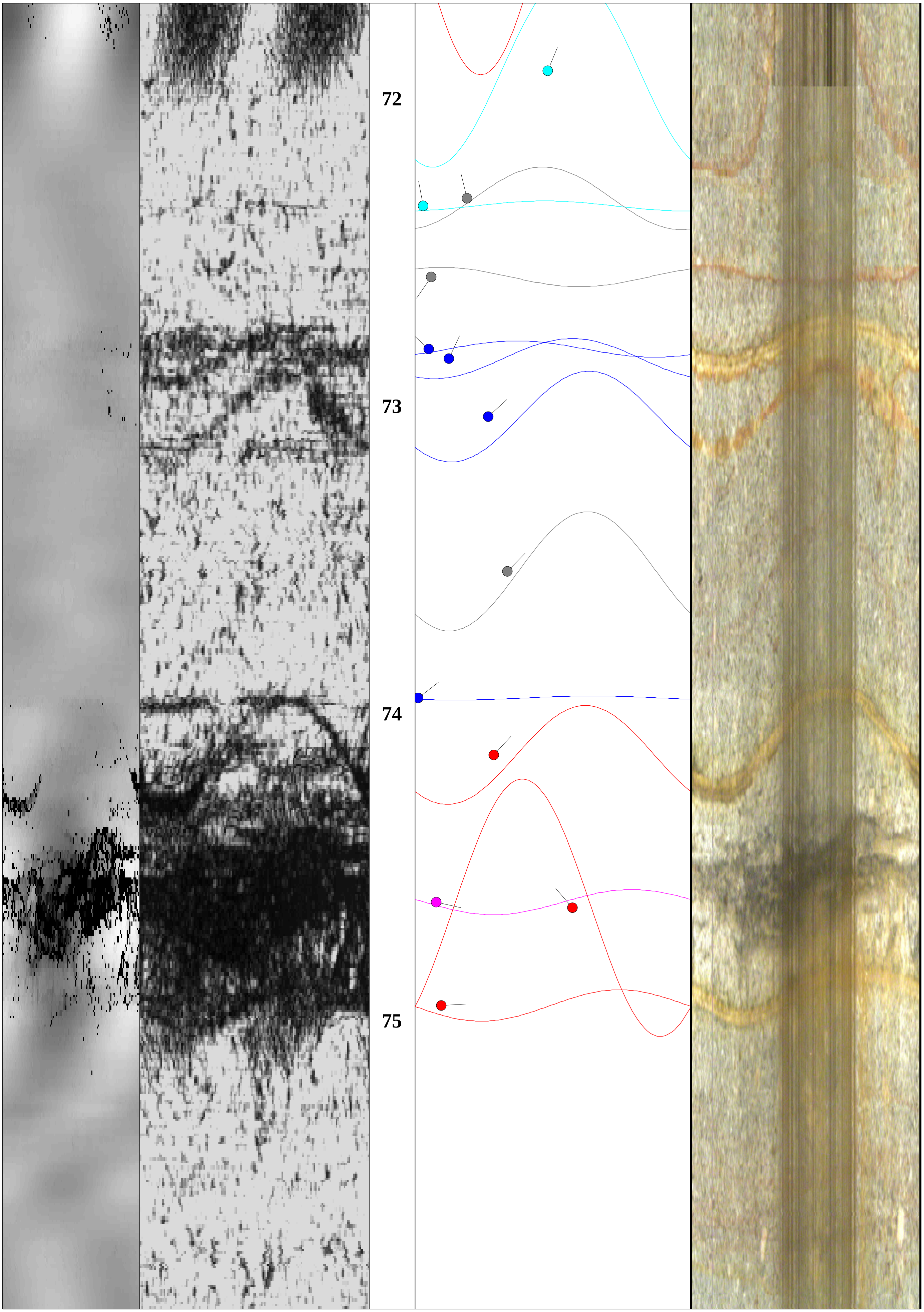
62

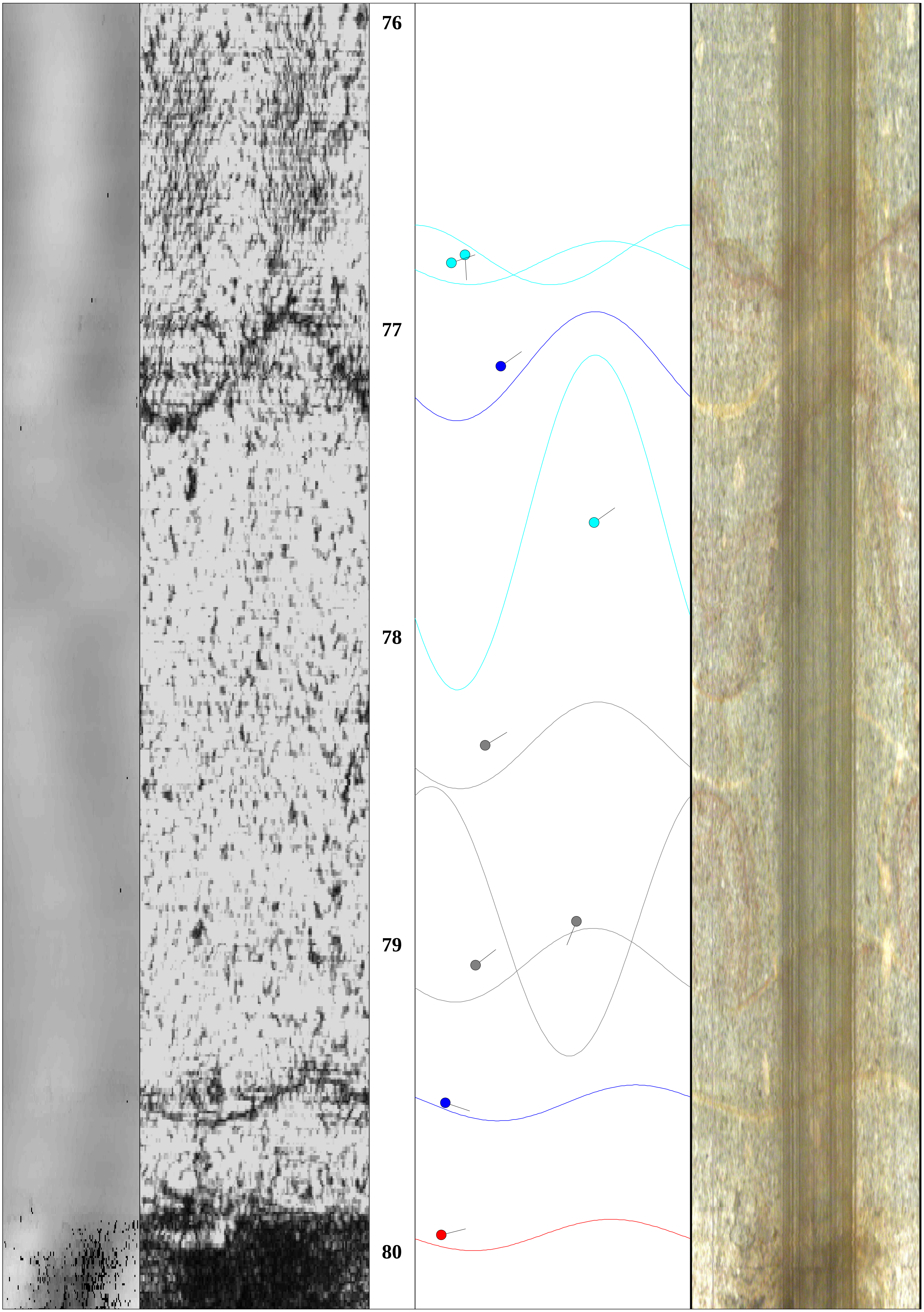
63

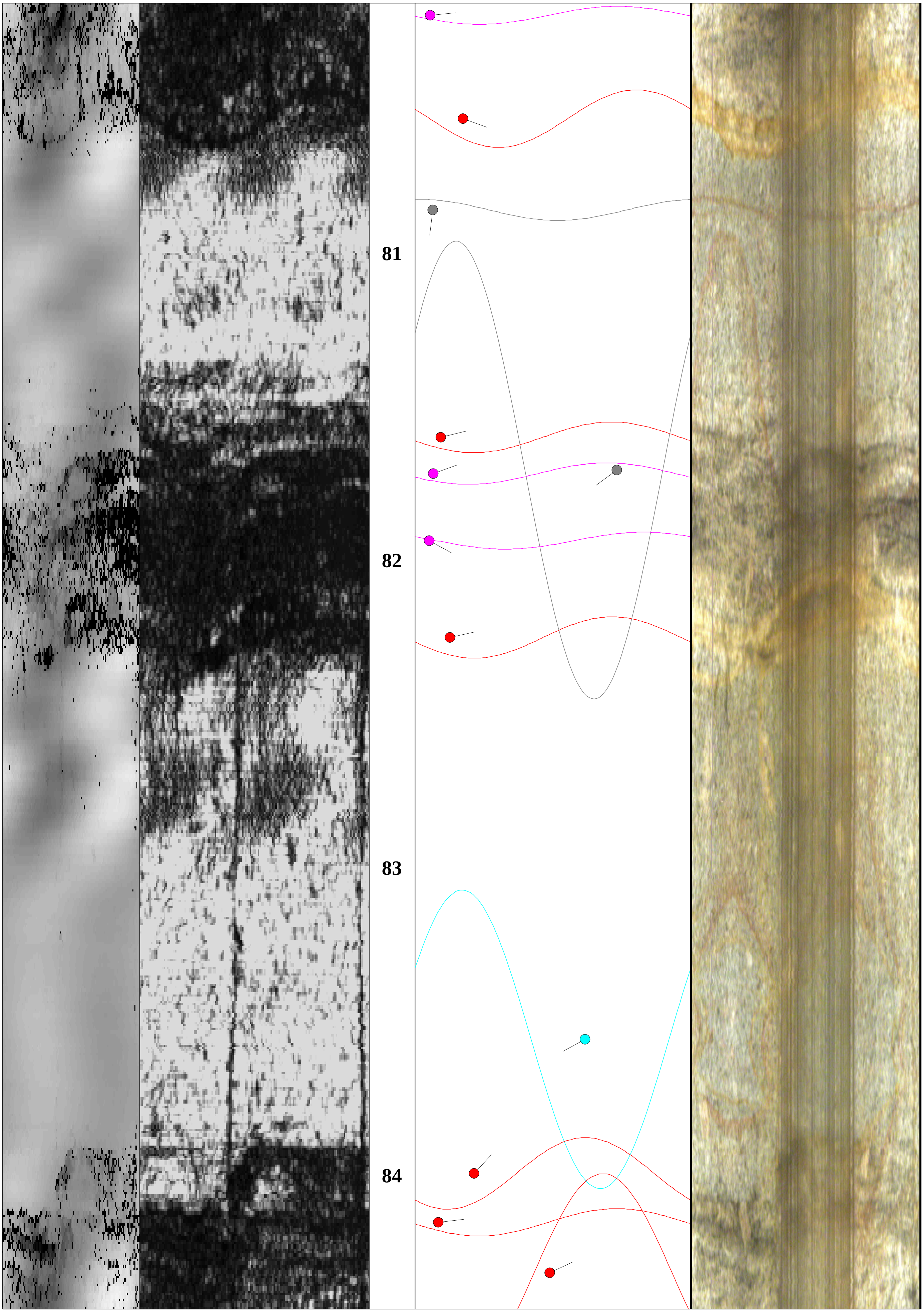



64
65
66
67

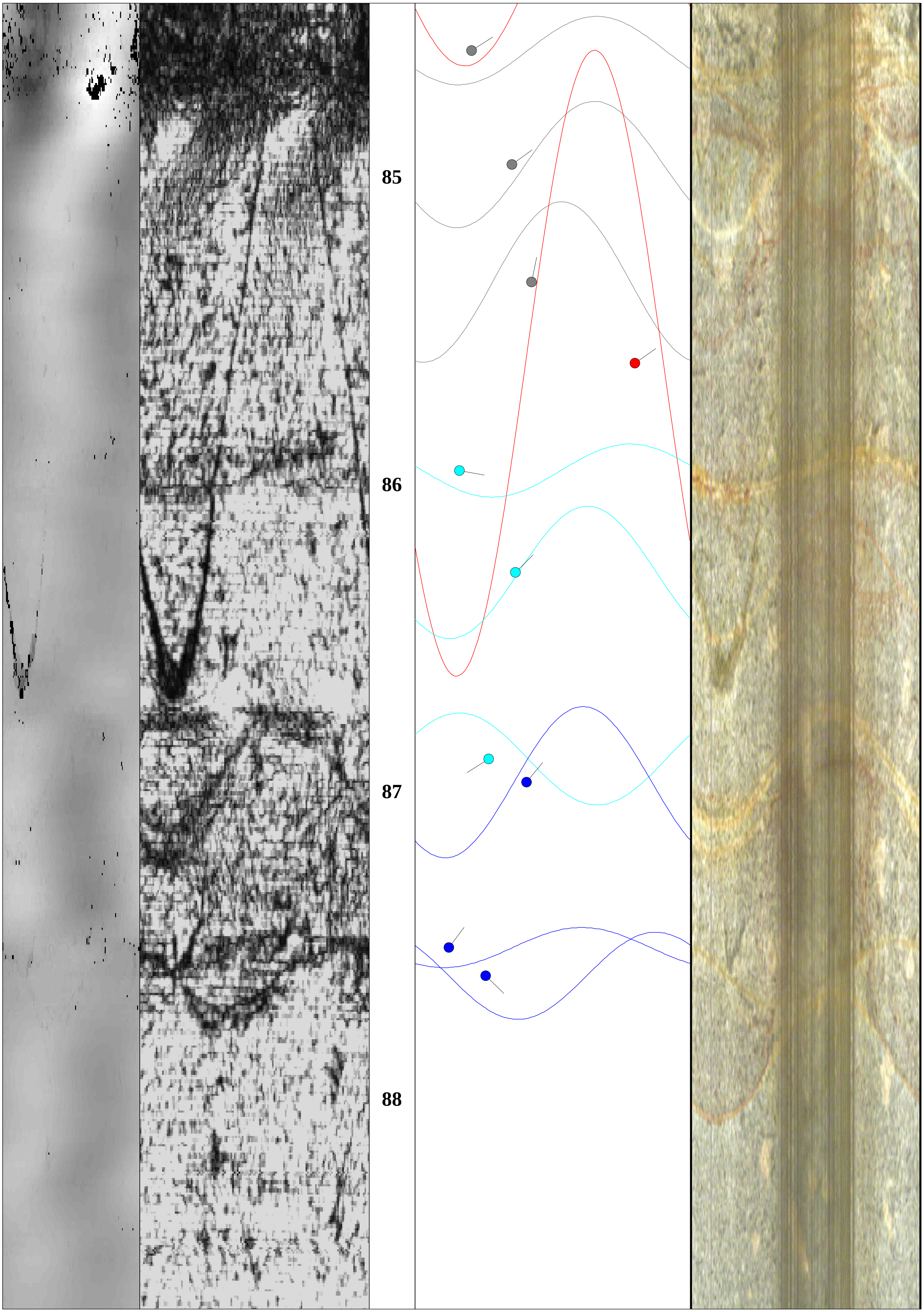

68
69
70
71

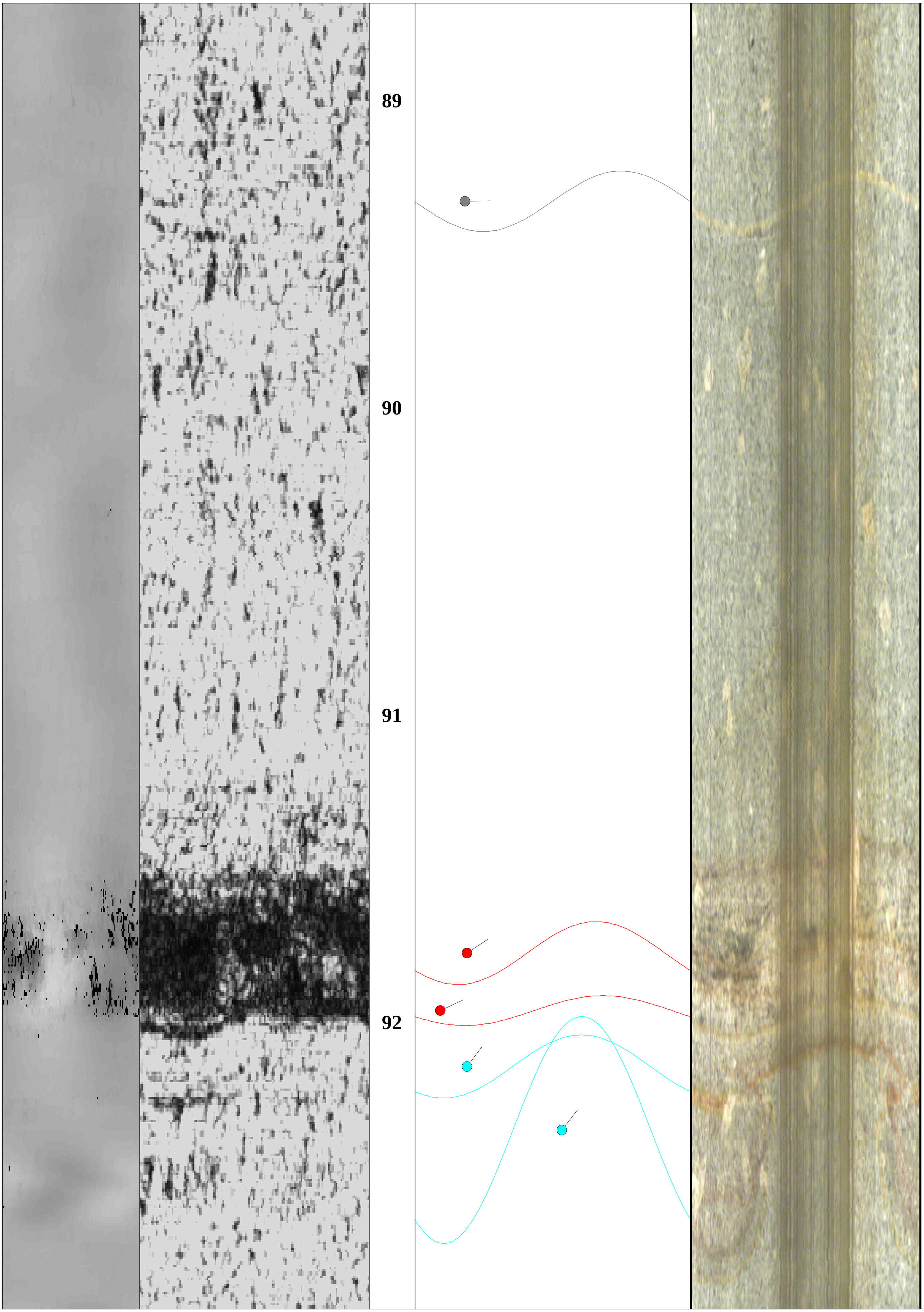

72
73
74
75

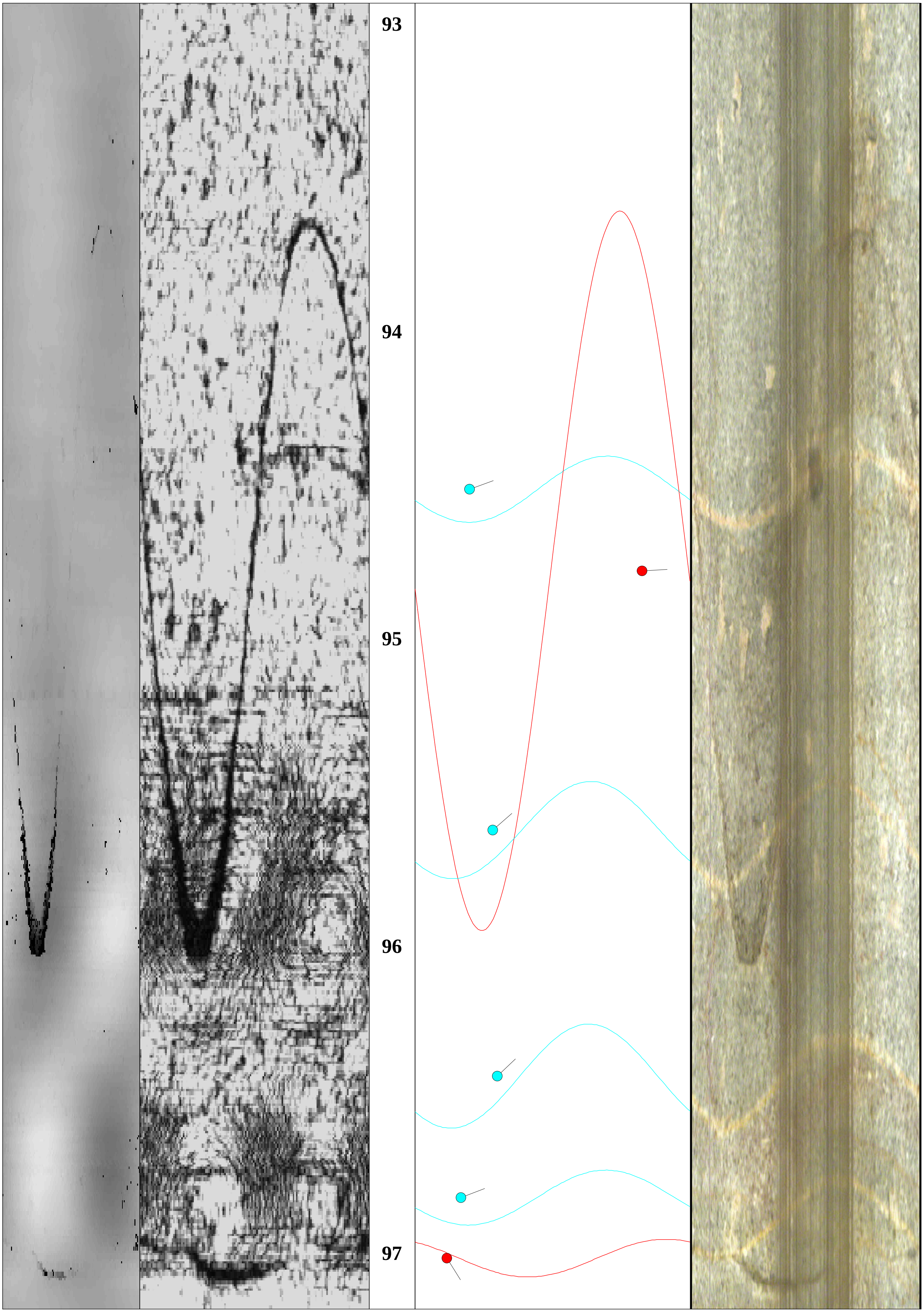

76
77
78
79
80

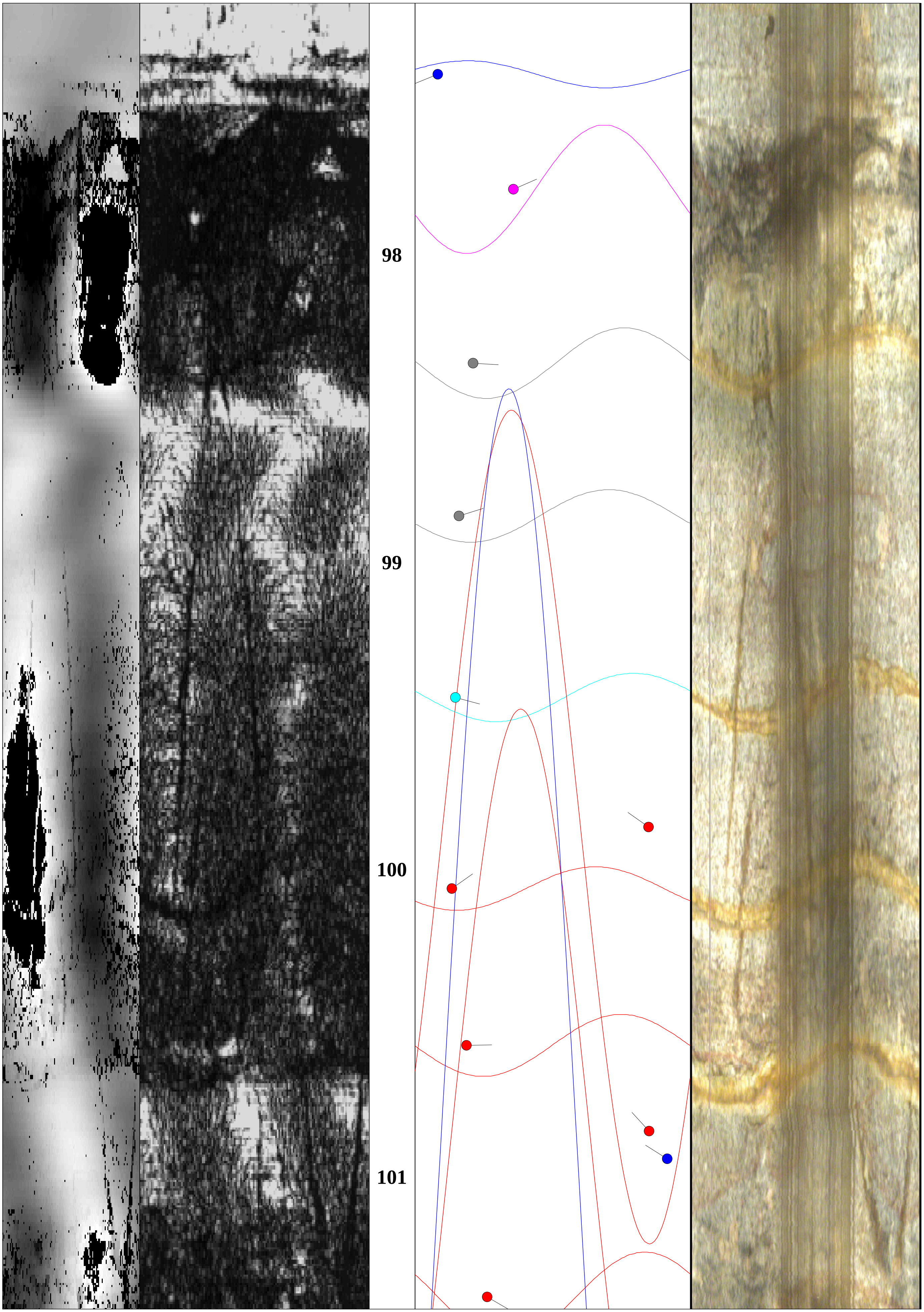


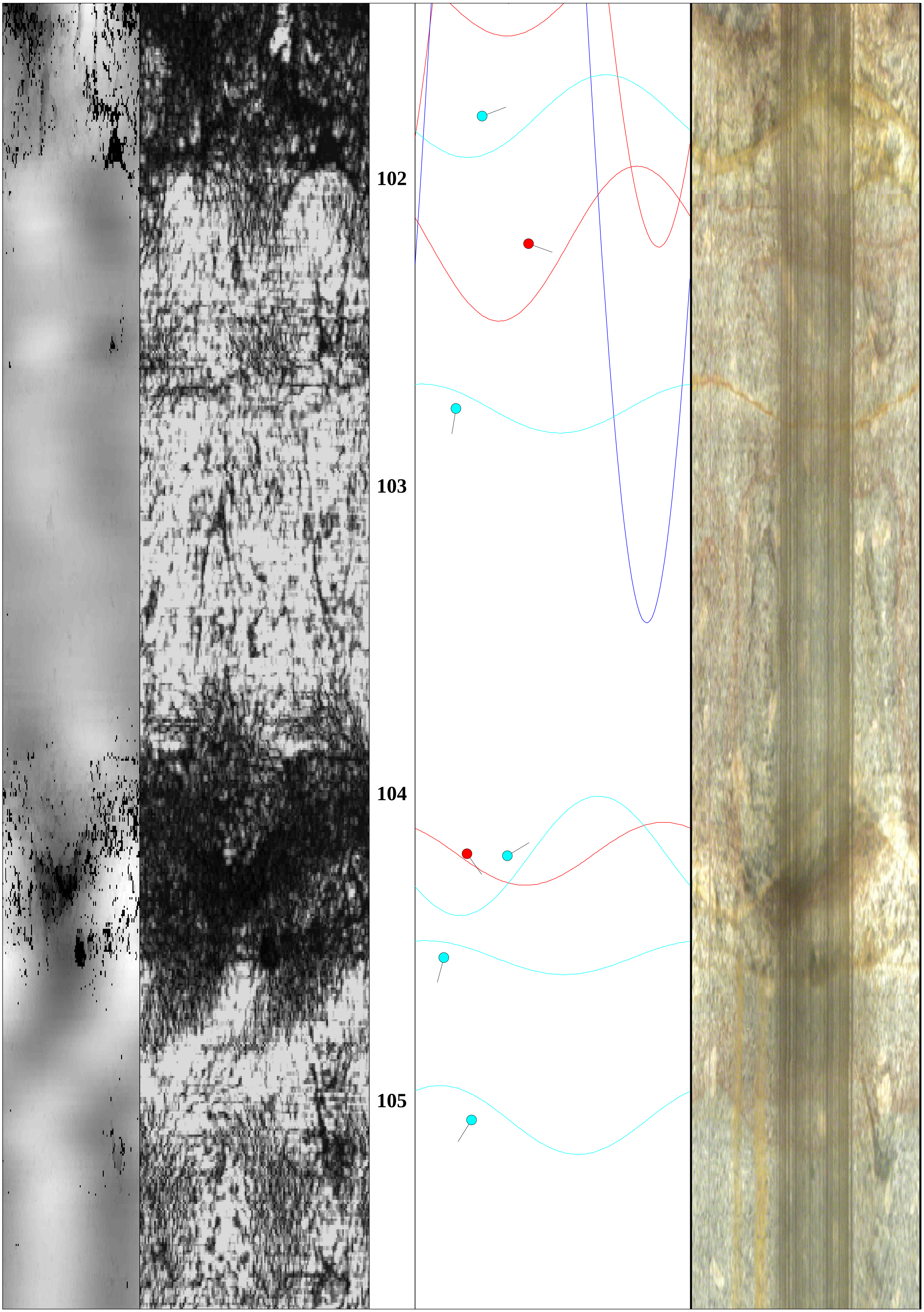
81
82
83
84

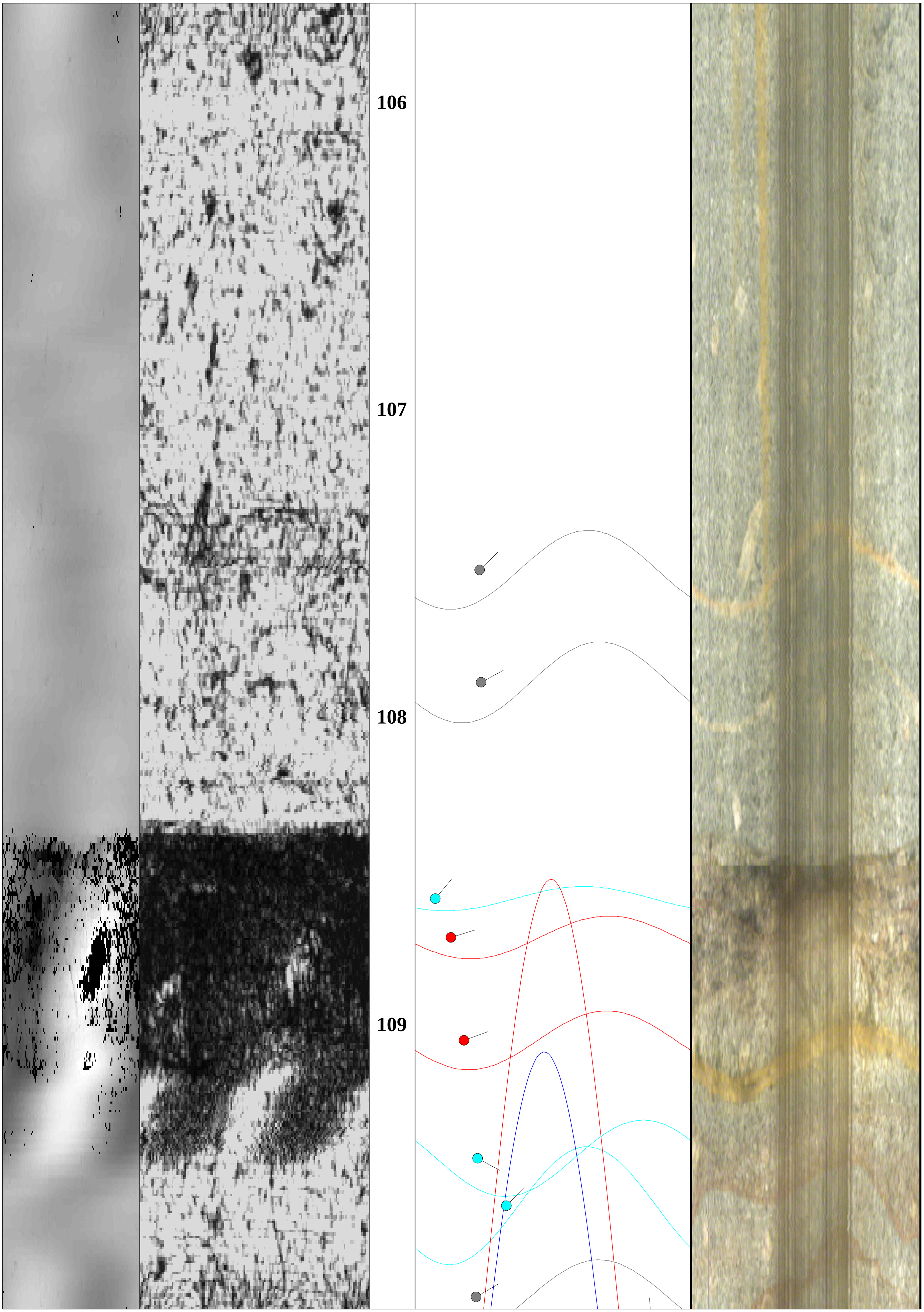

85
86
87
88

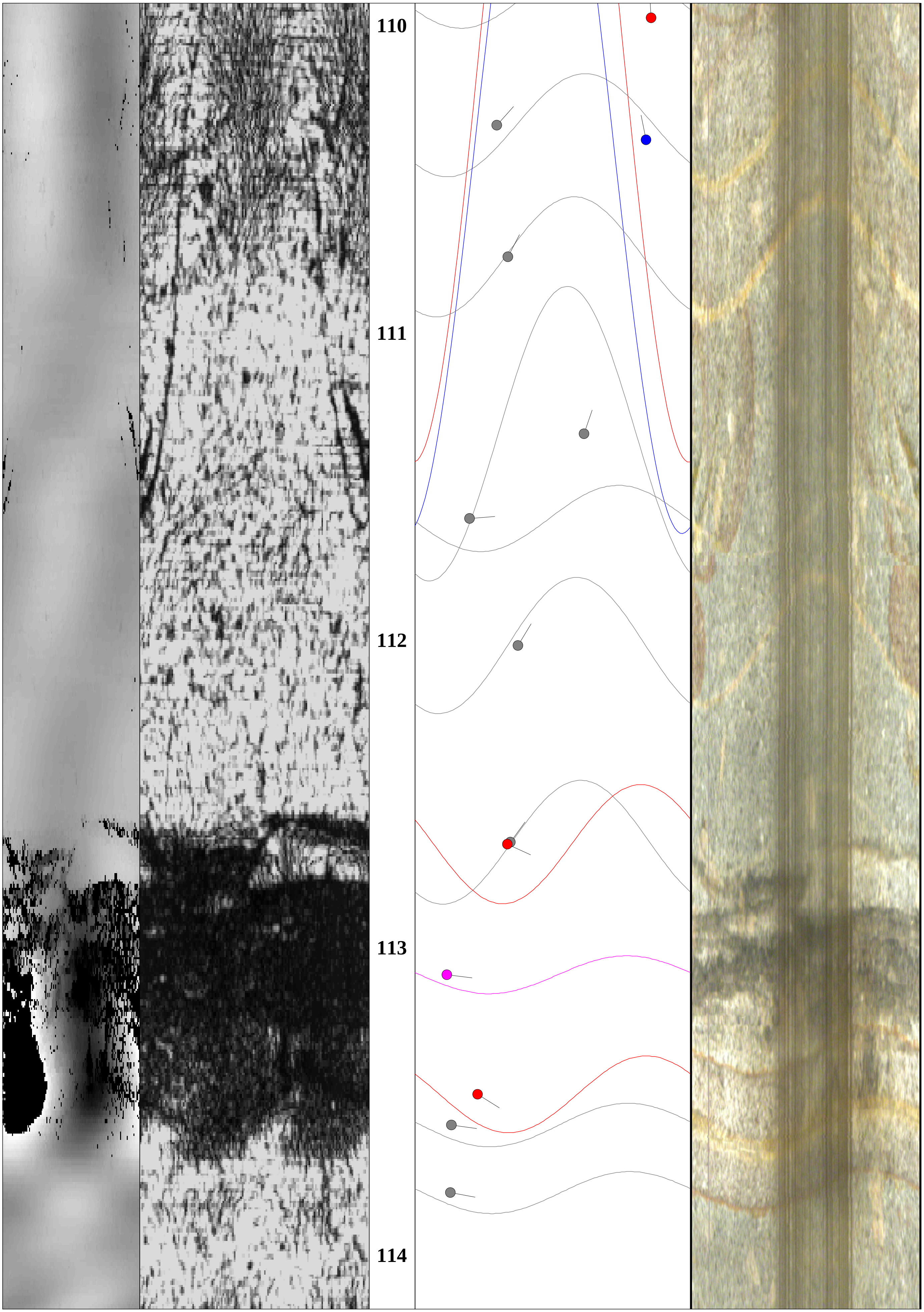

89
90
91
92

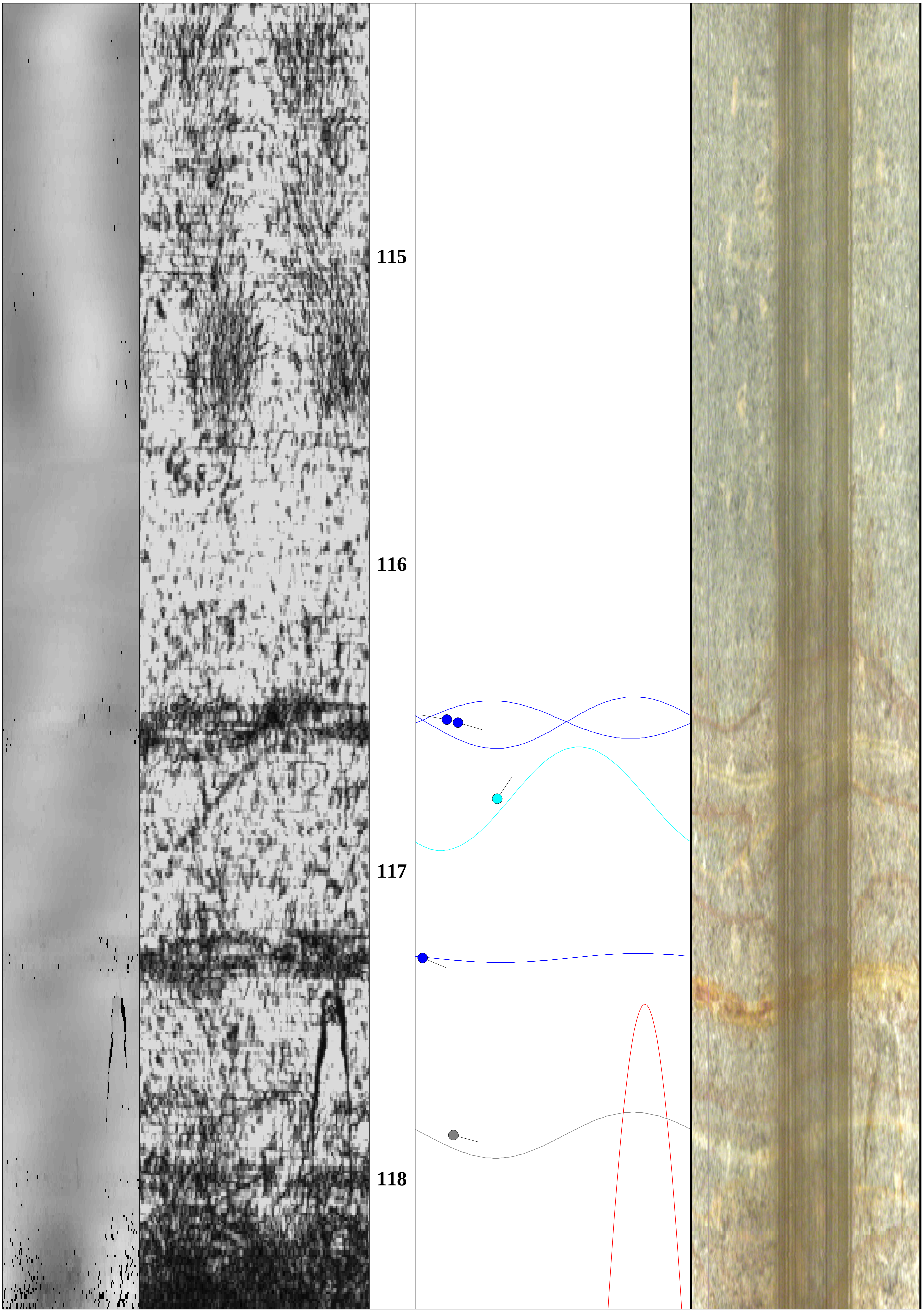

93
94
95
96
97

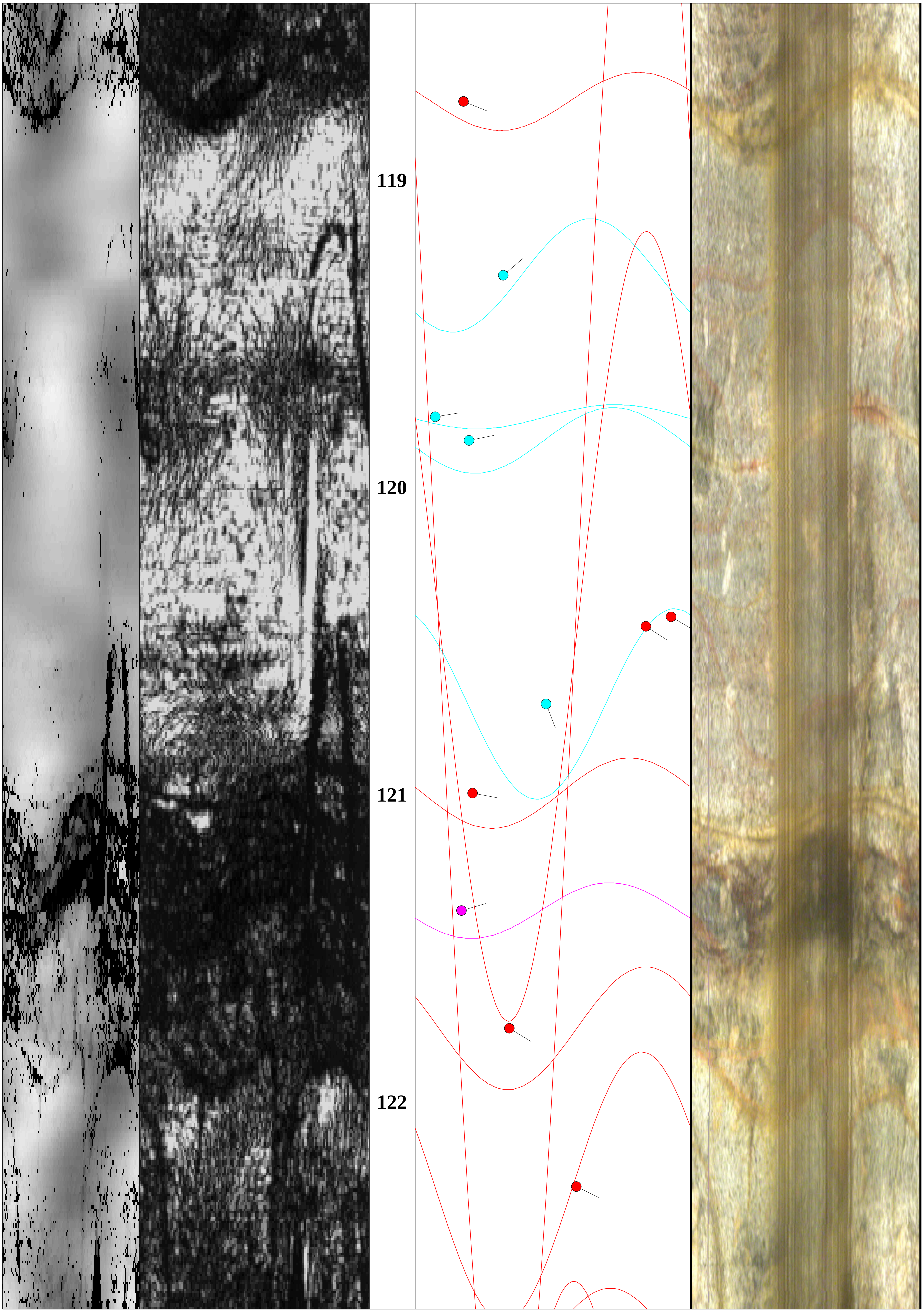

98
99
100
101

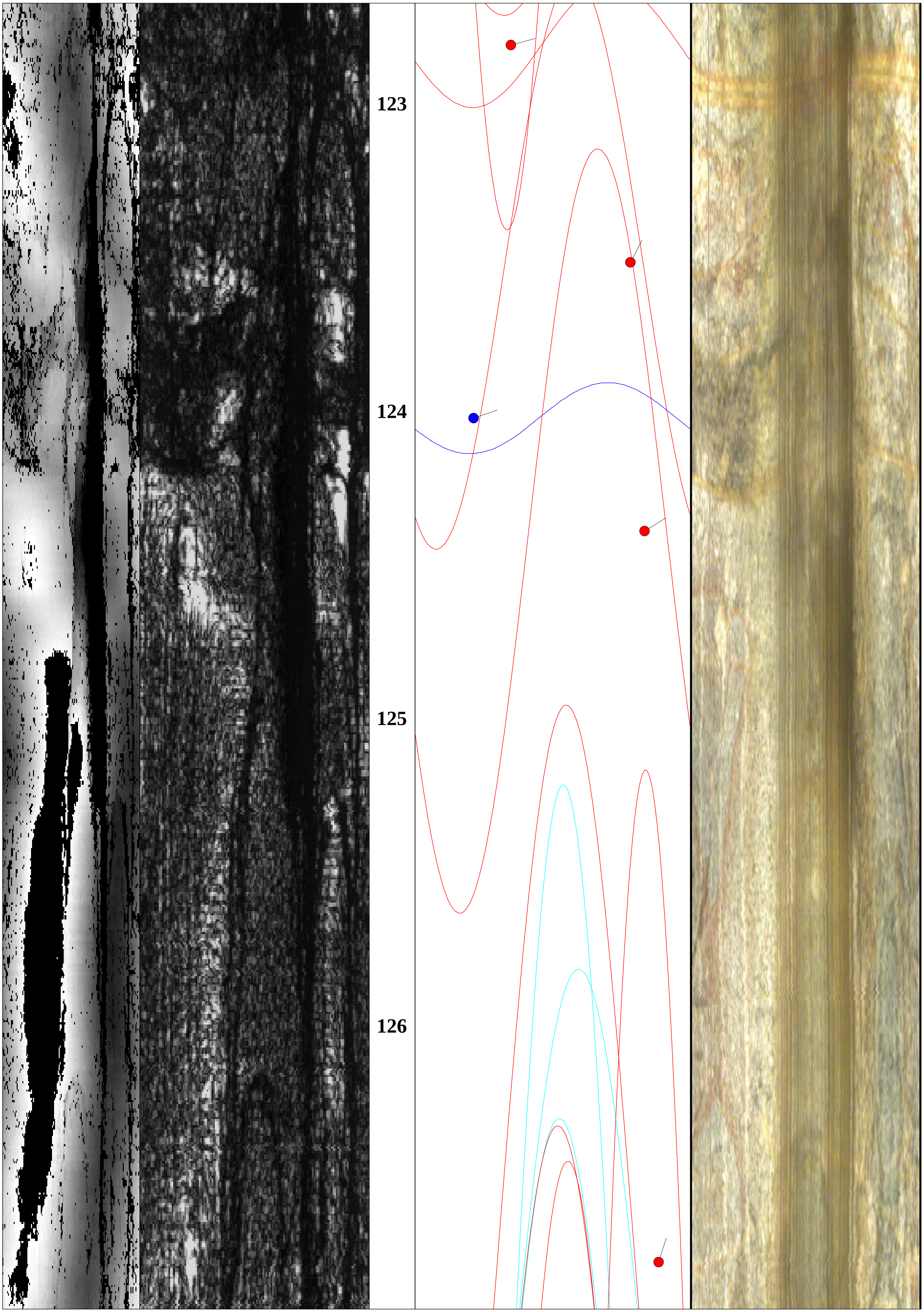

102
103
104
105

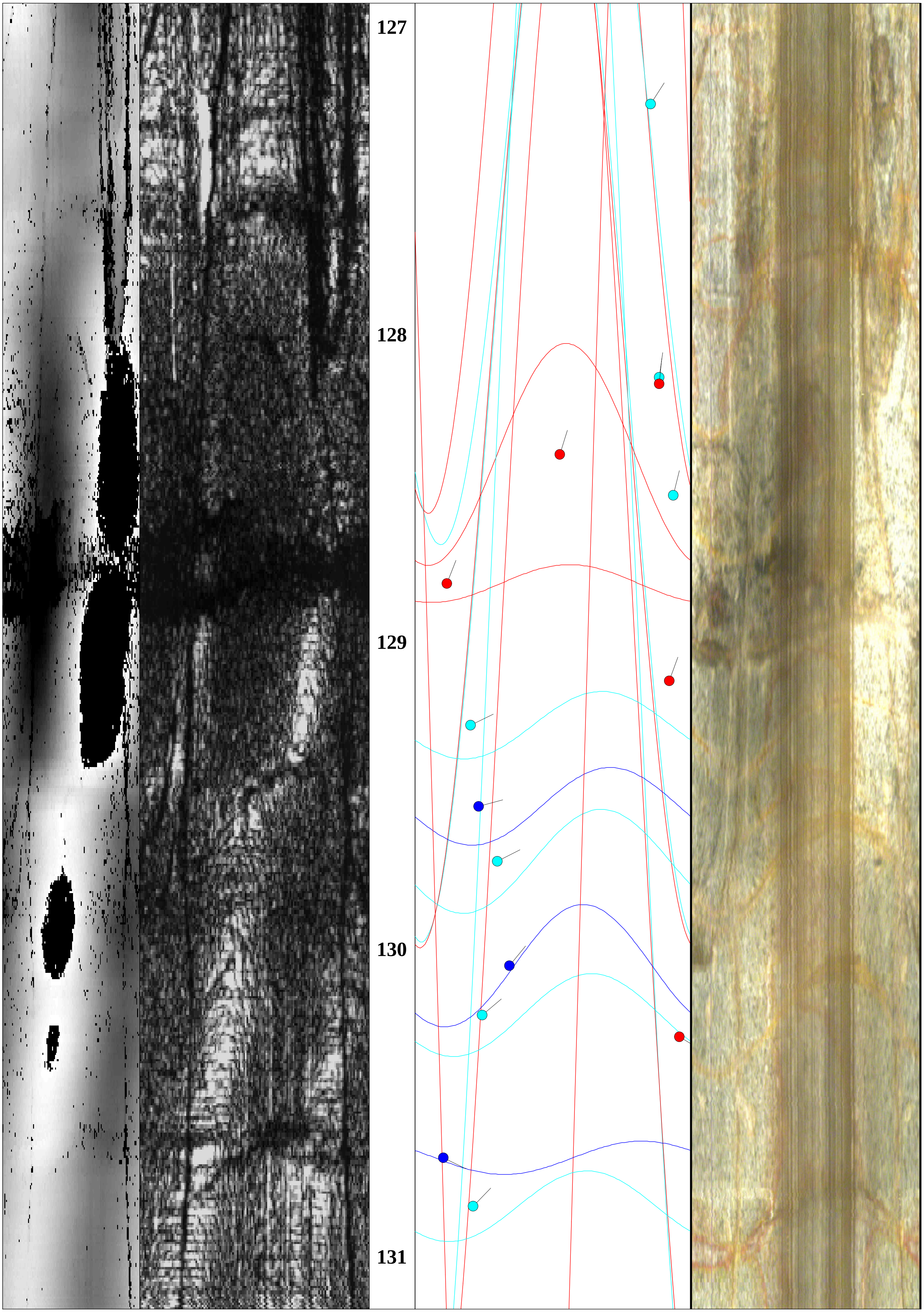

106
107
108
109

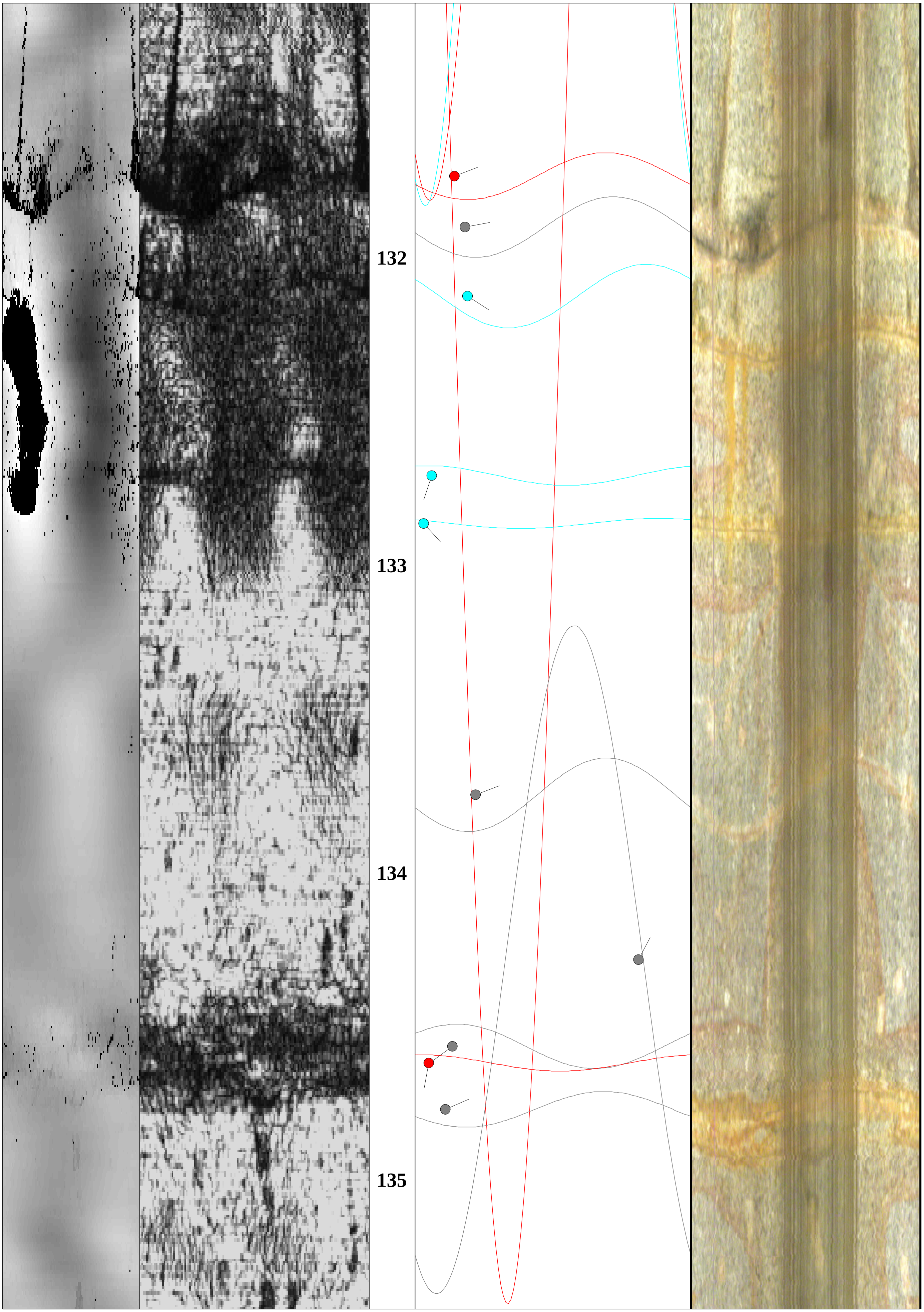

110
111
112
113
114

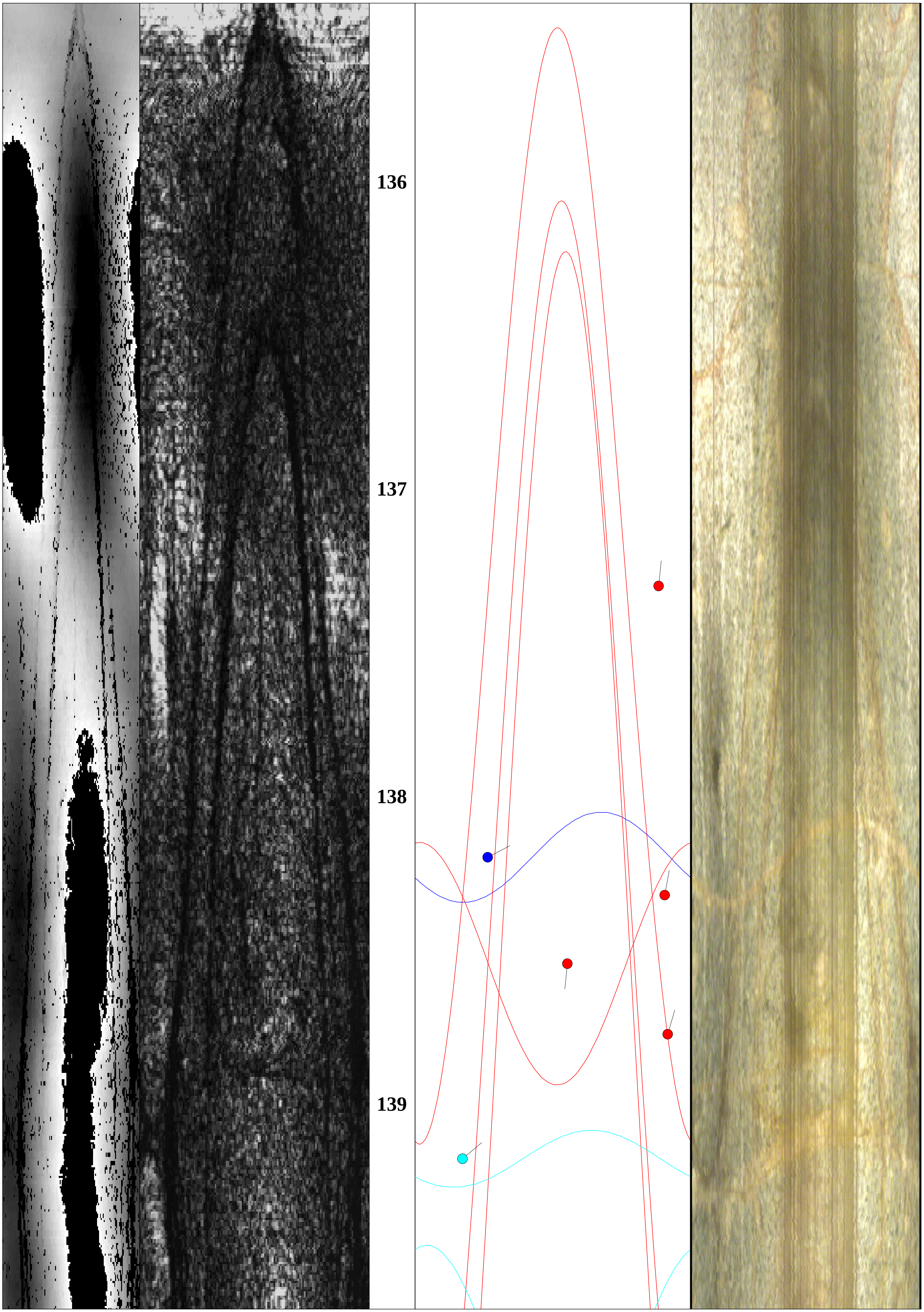

115
116
117
118

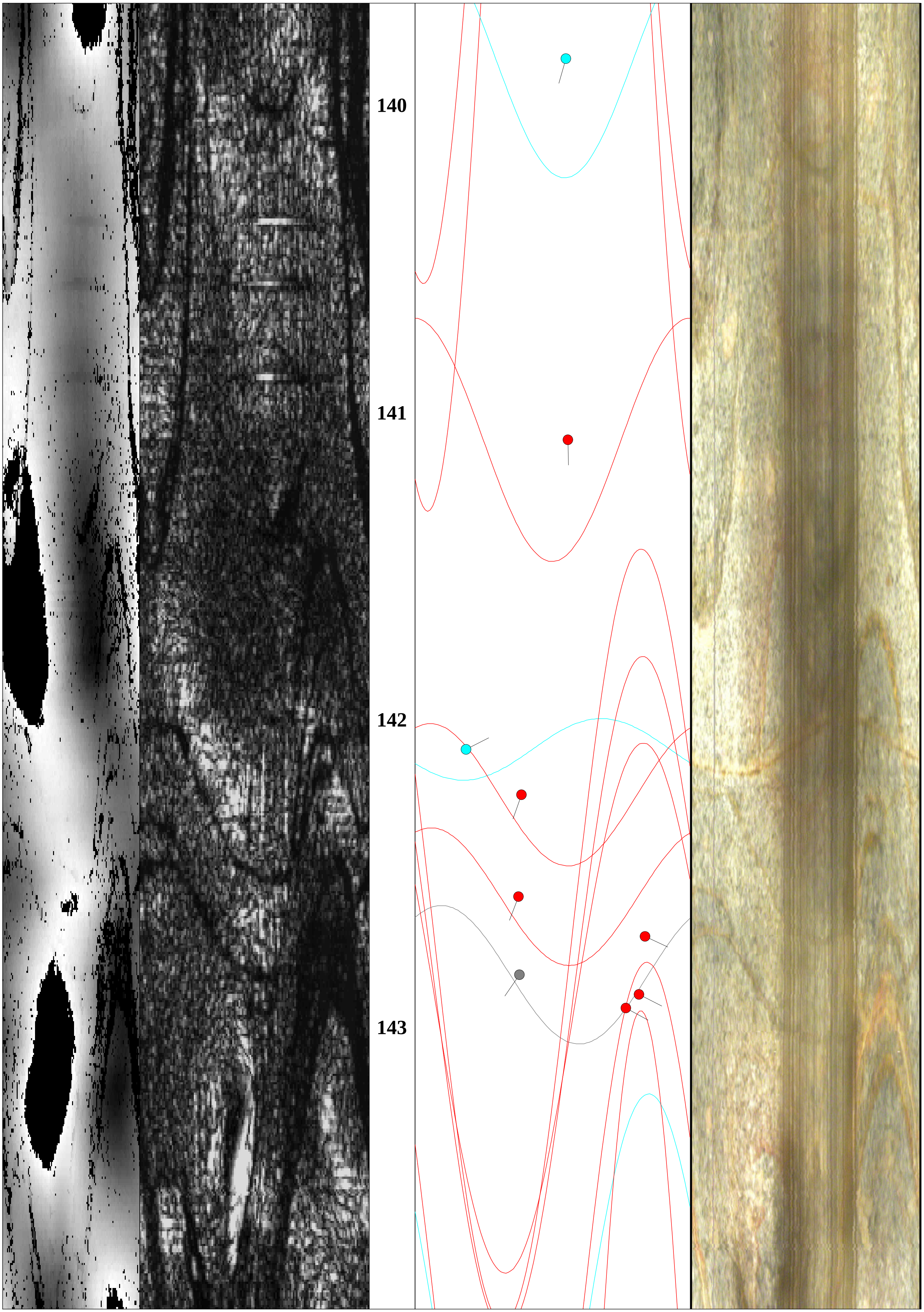

119
120
121
122

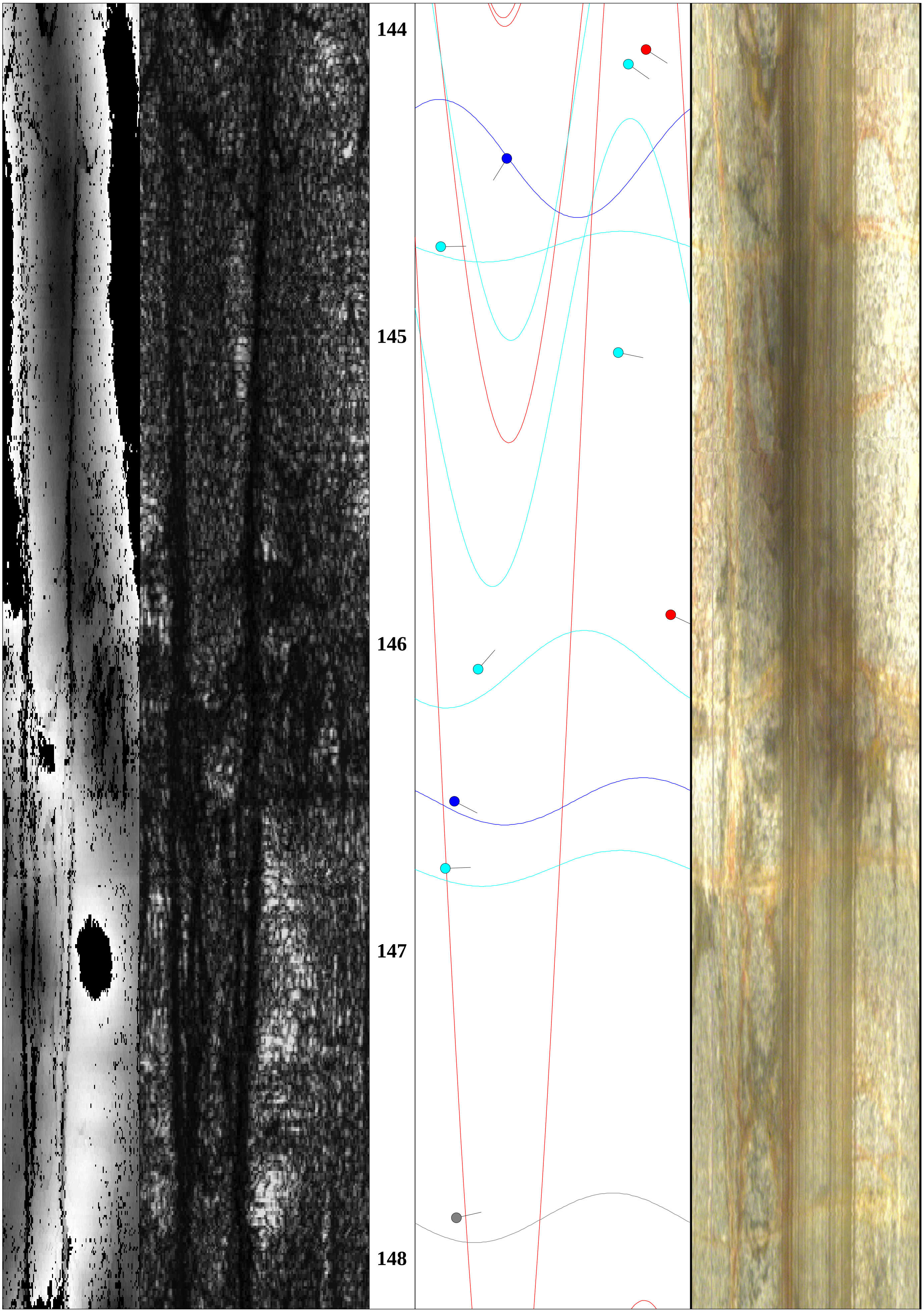

123
124
125
126

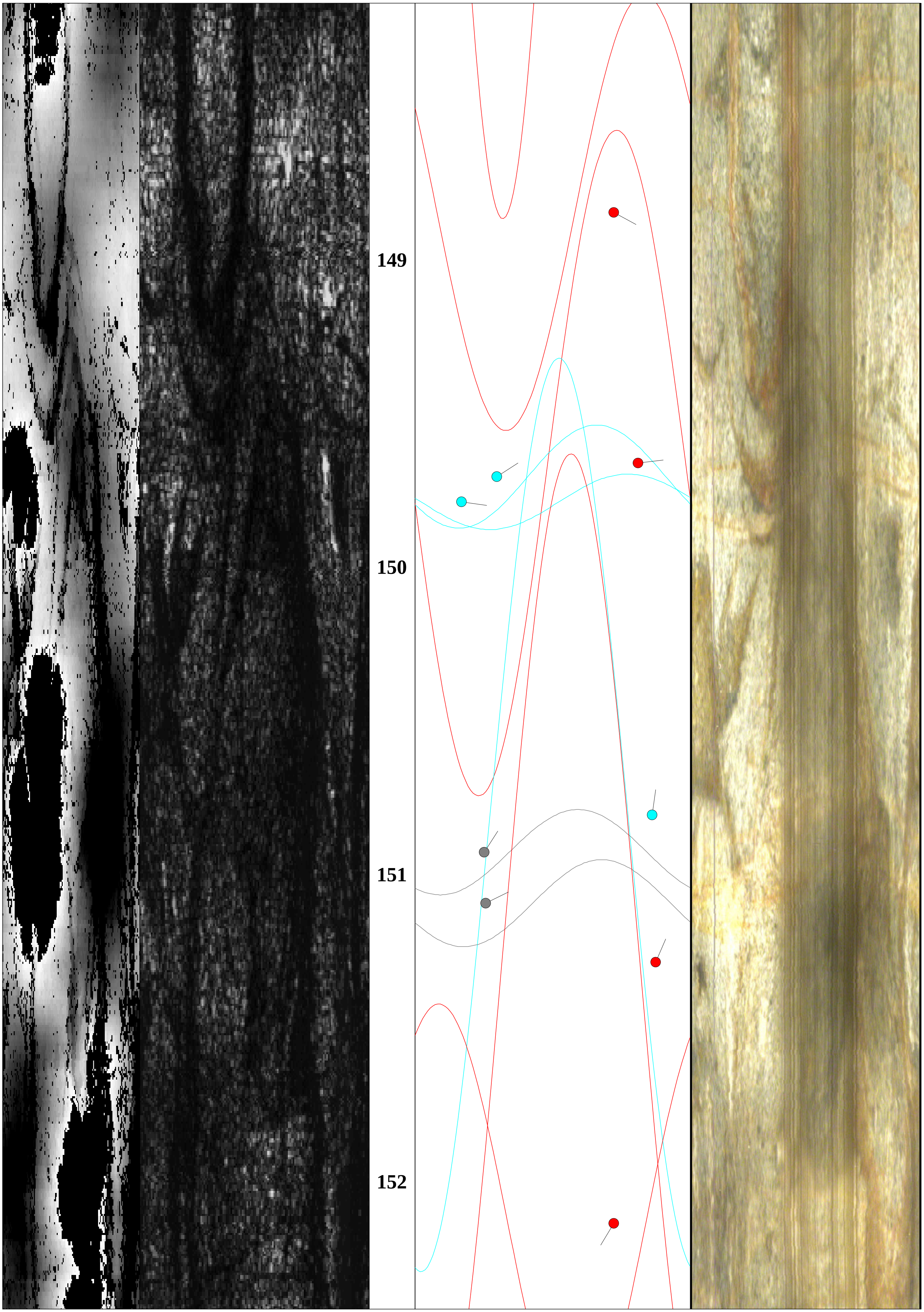

127
128
129
130
131


132
133
134
135

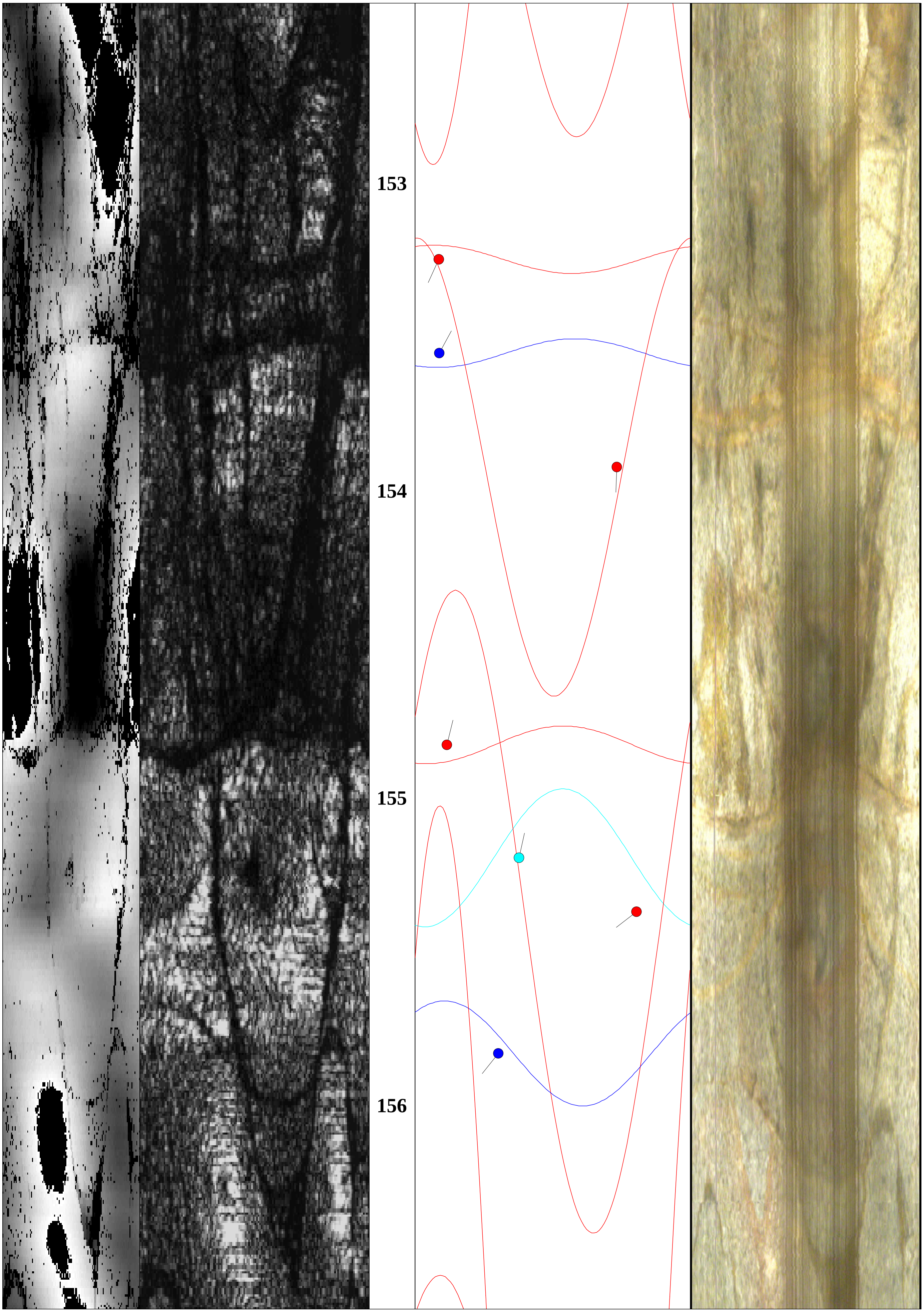

136
137
138
139

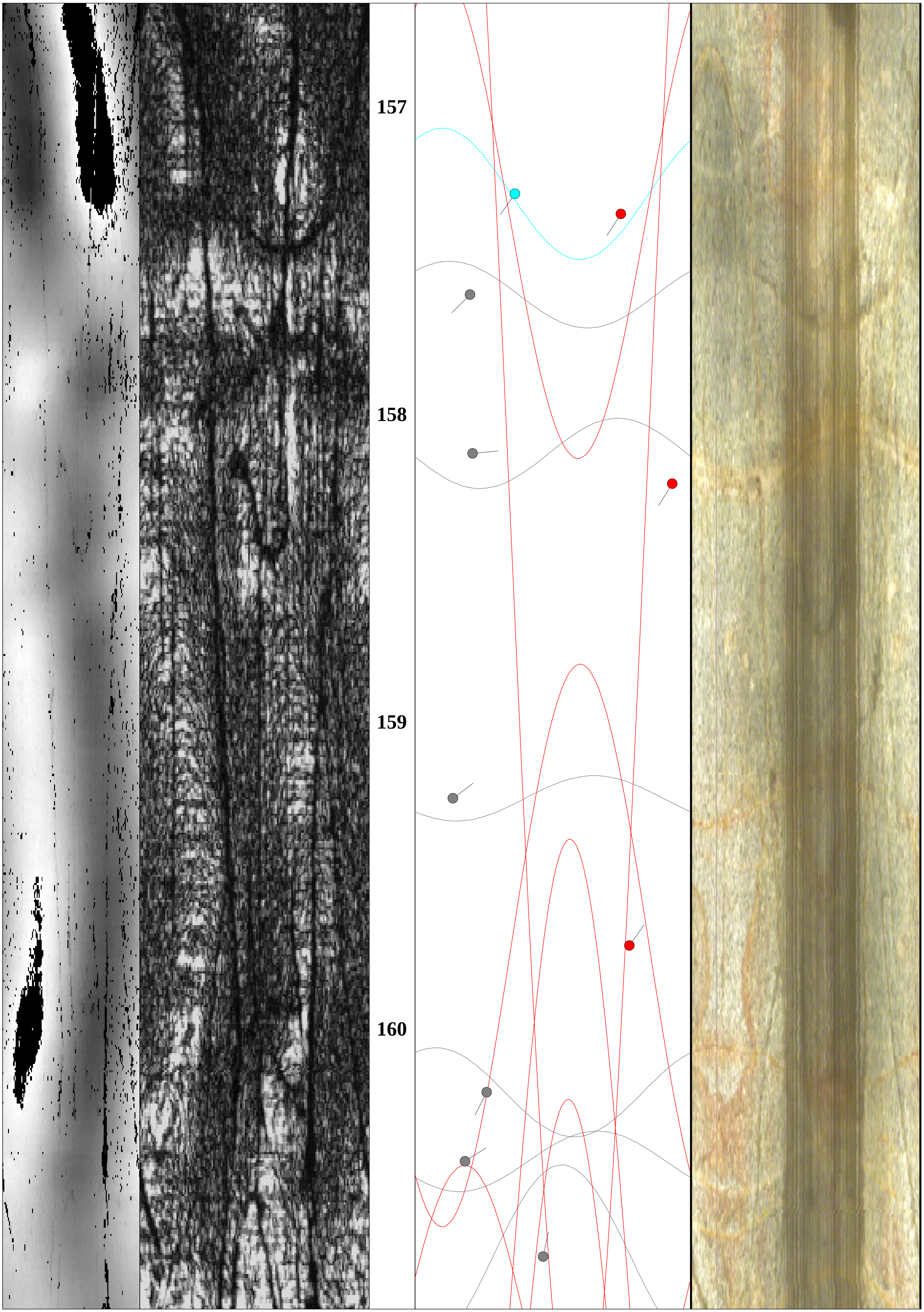

140
141
142
143

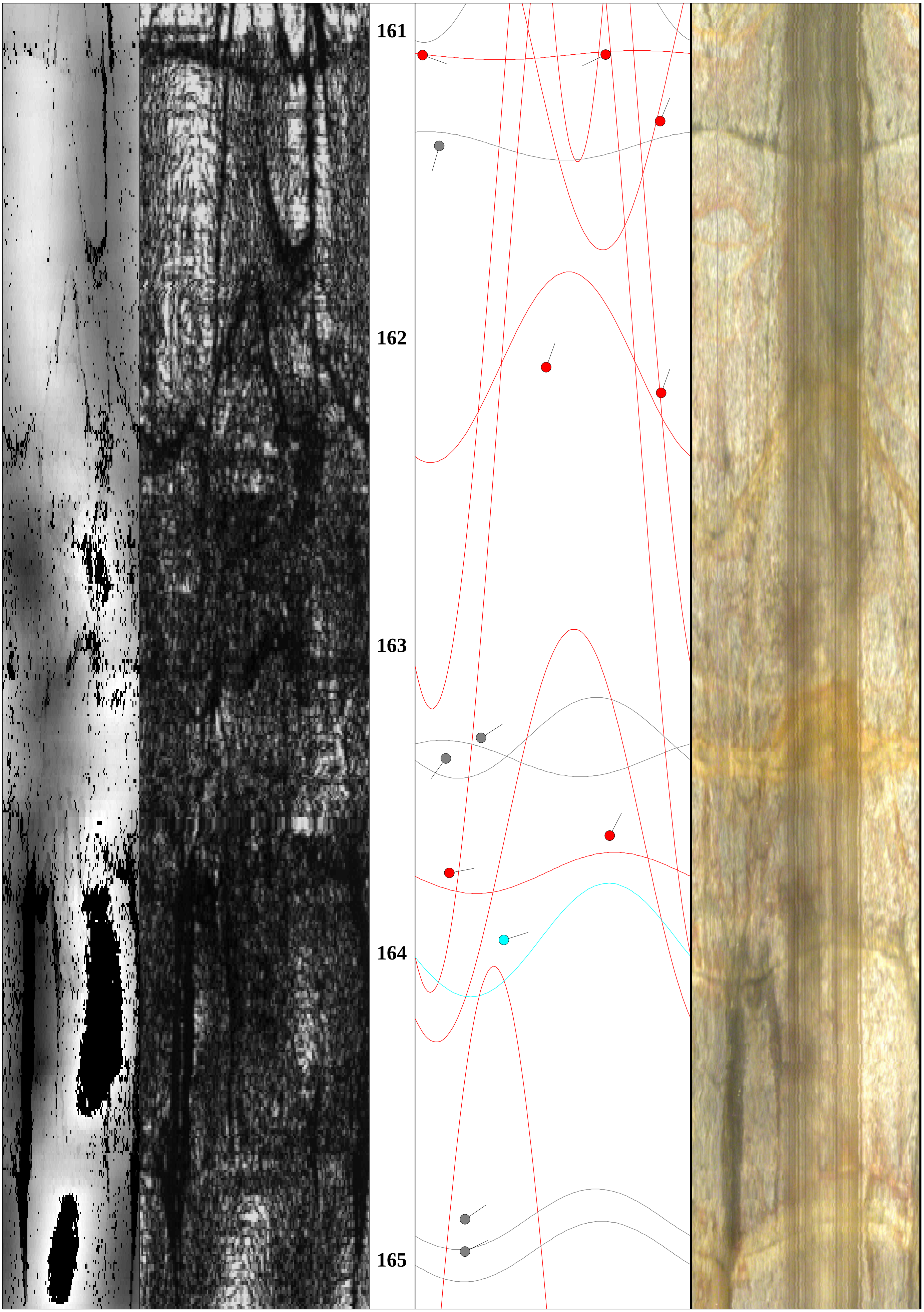

144
145
146
147
148

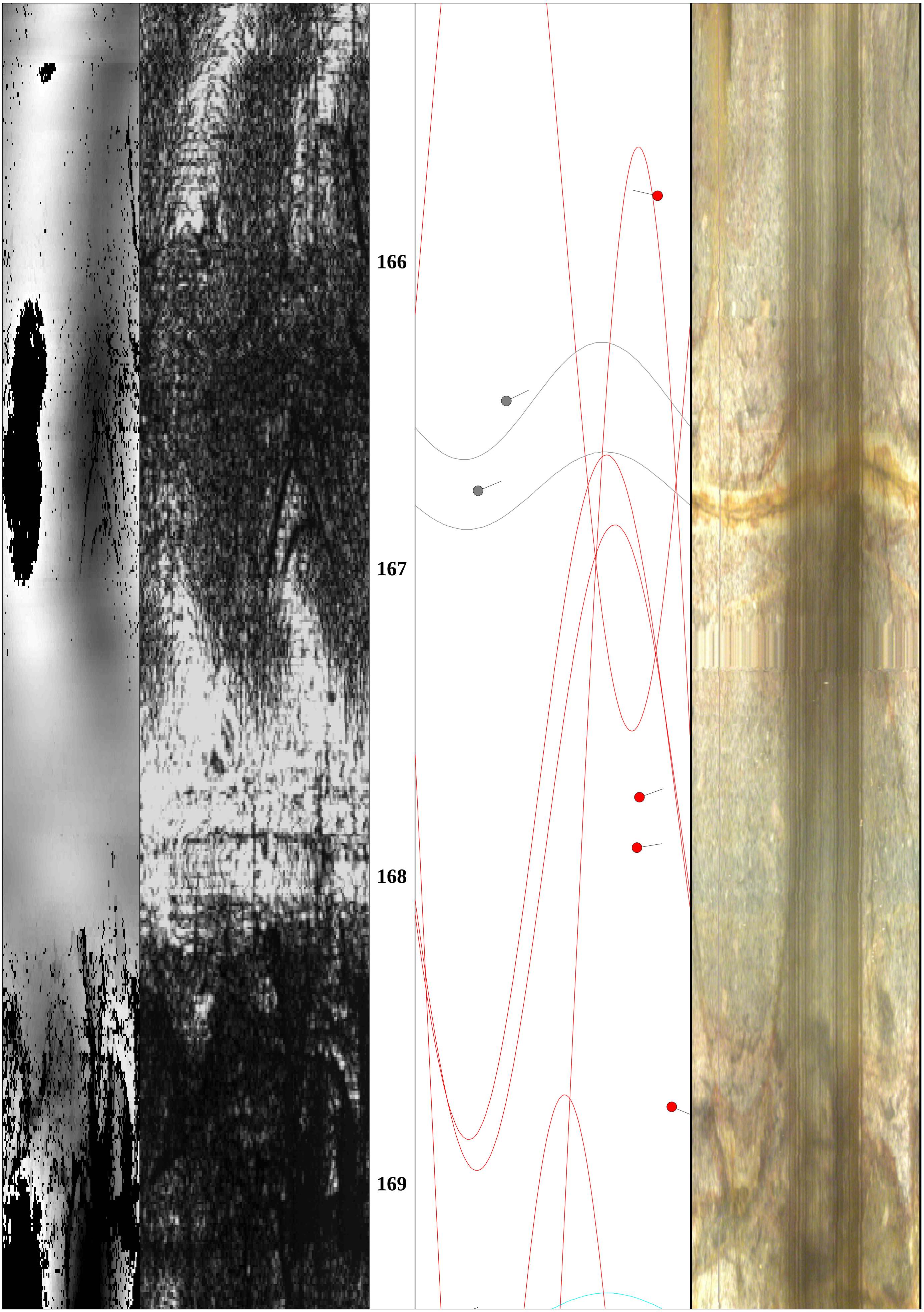


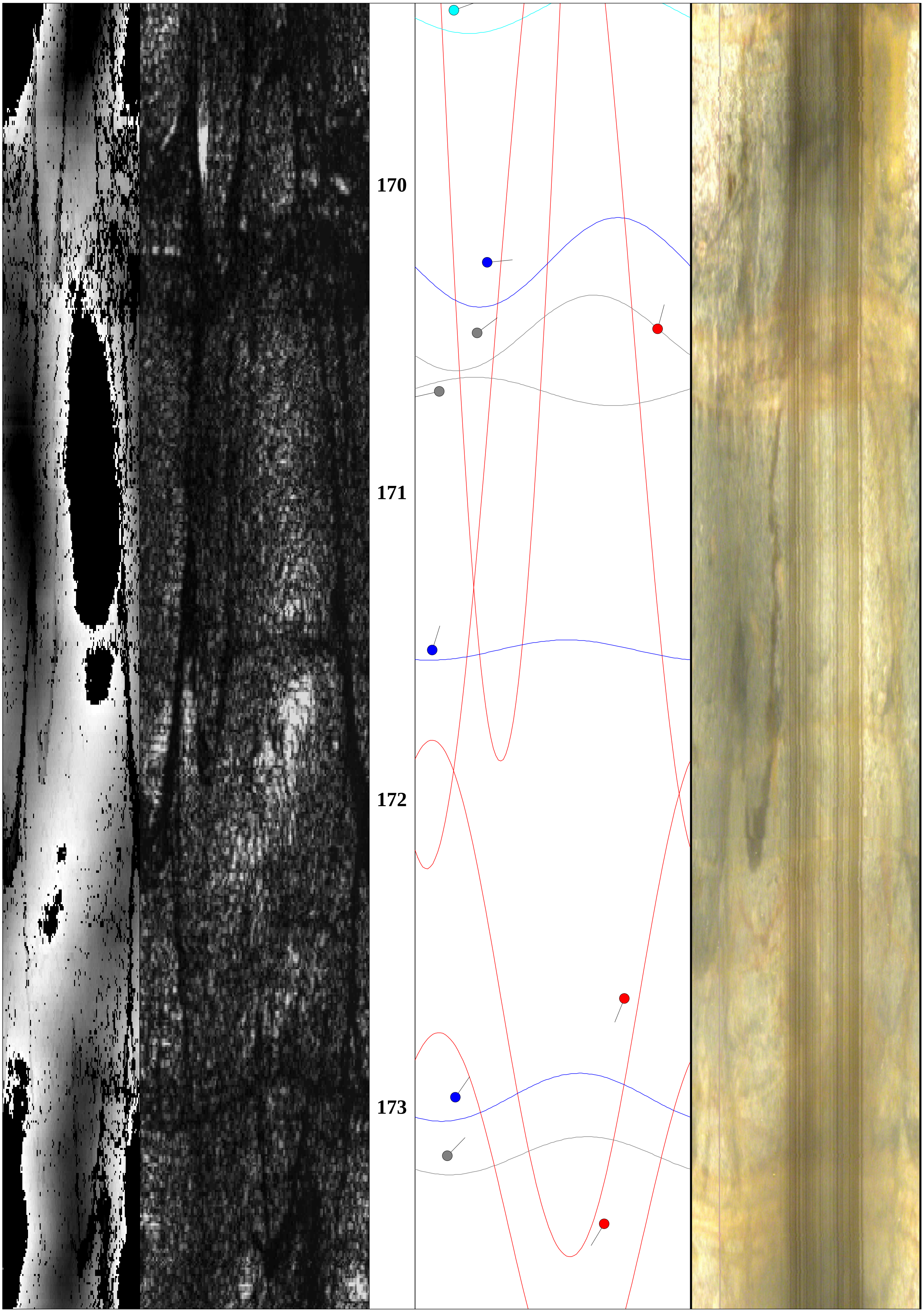
149
150
151
152

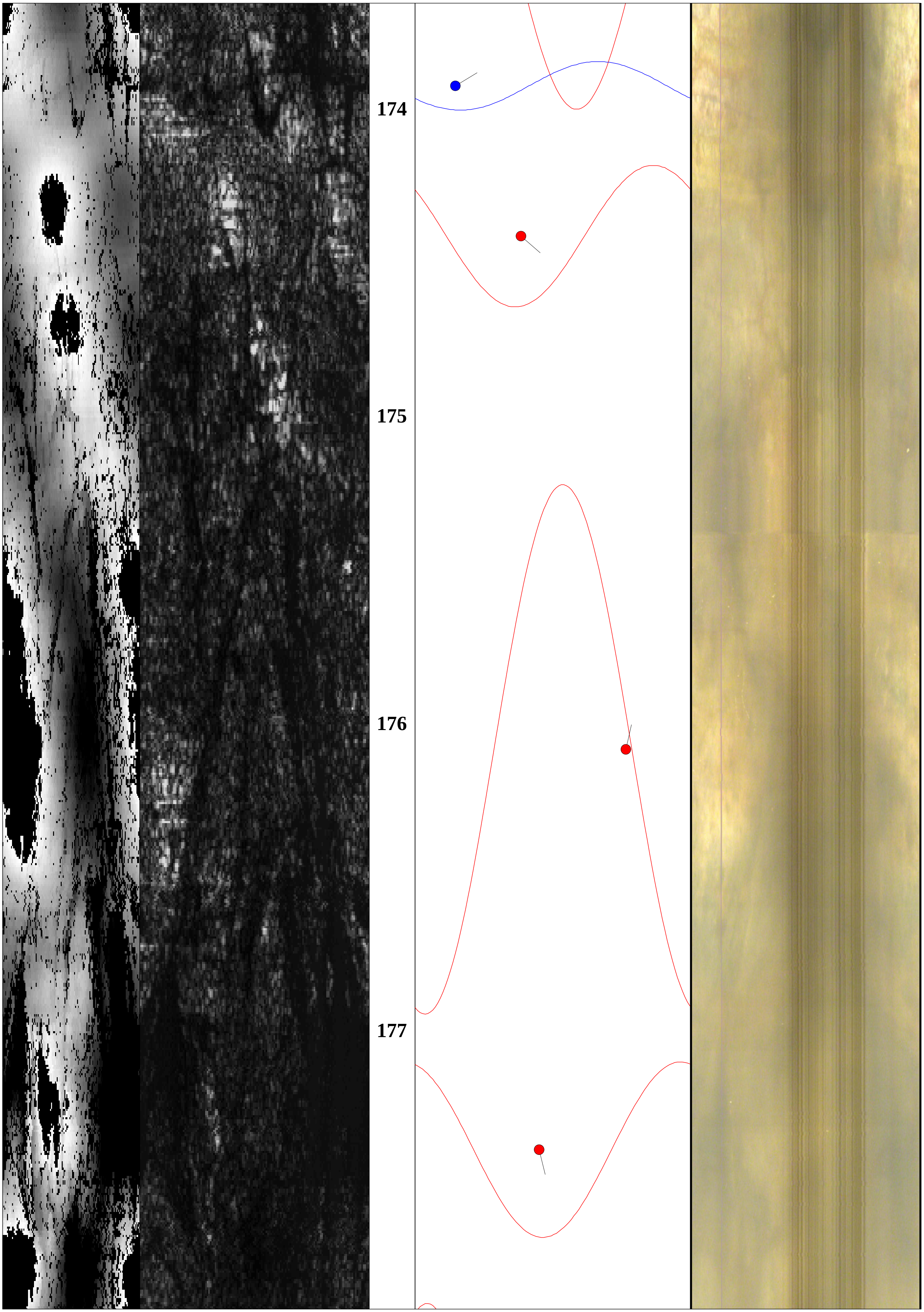

153
154
155
156

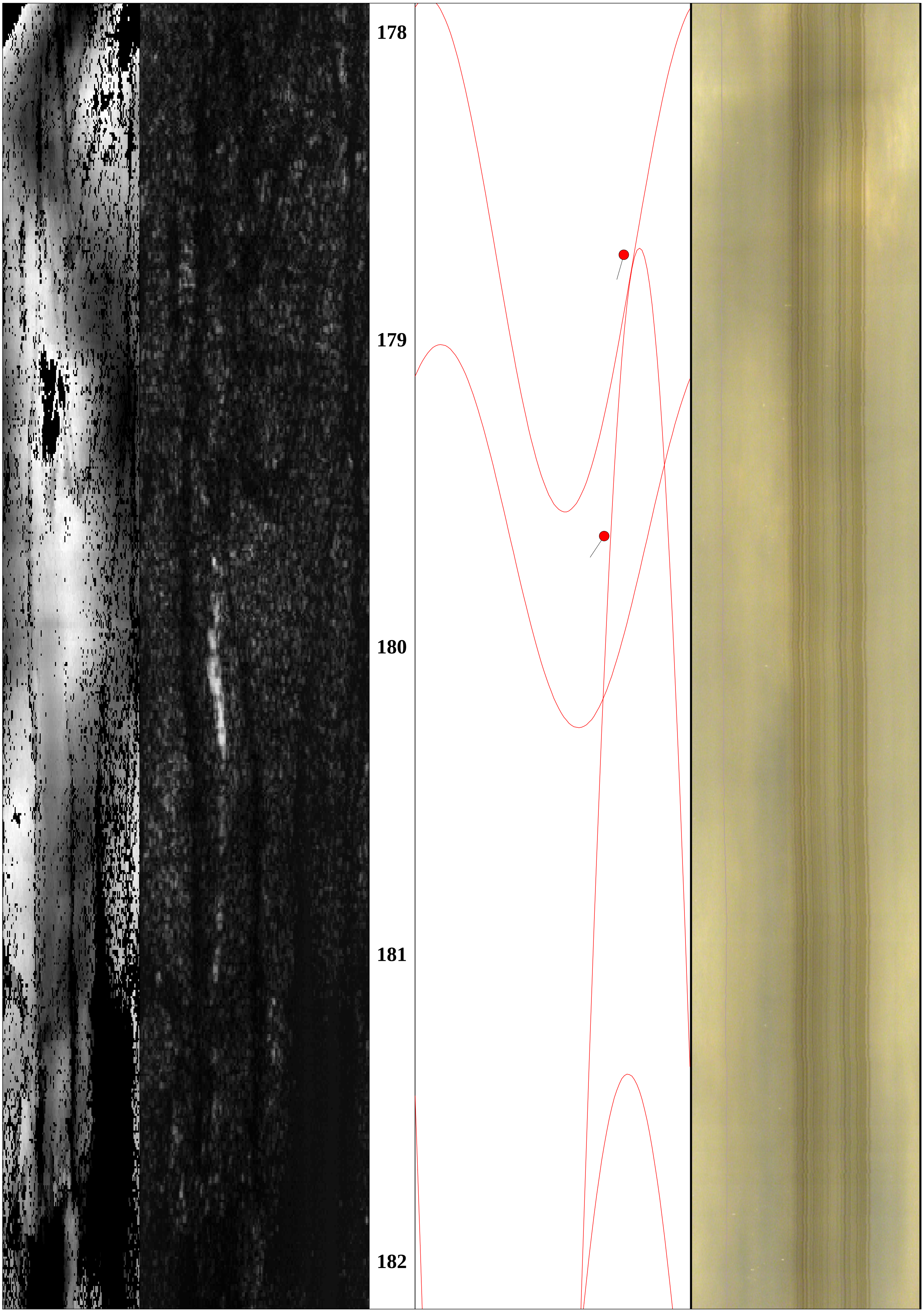

157
158
159
160

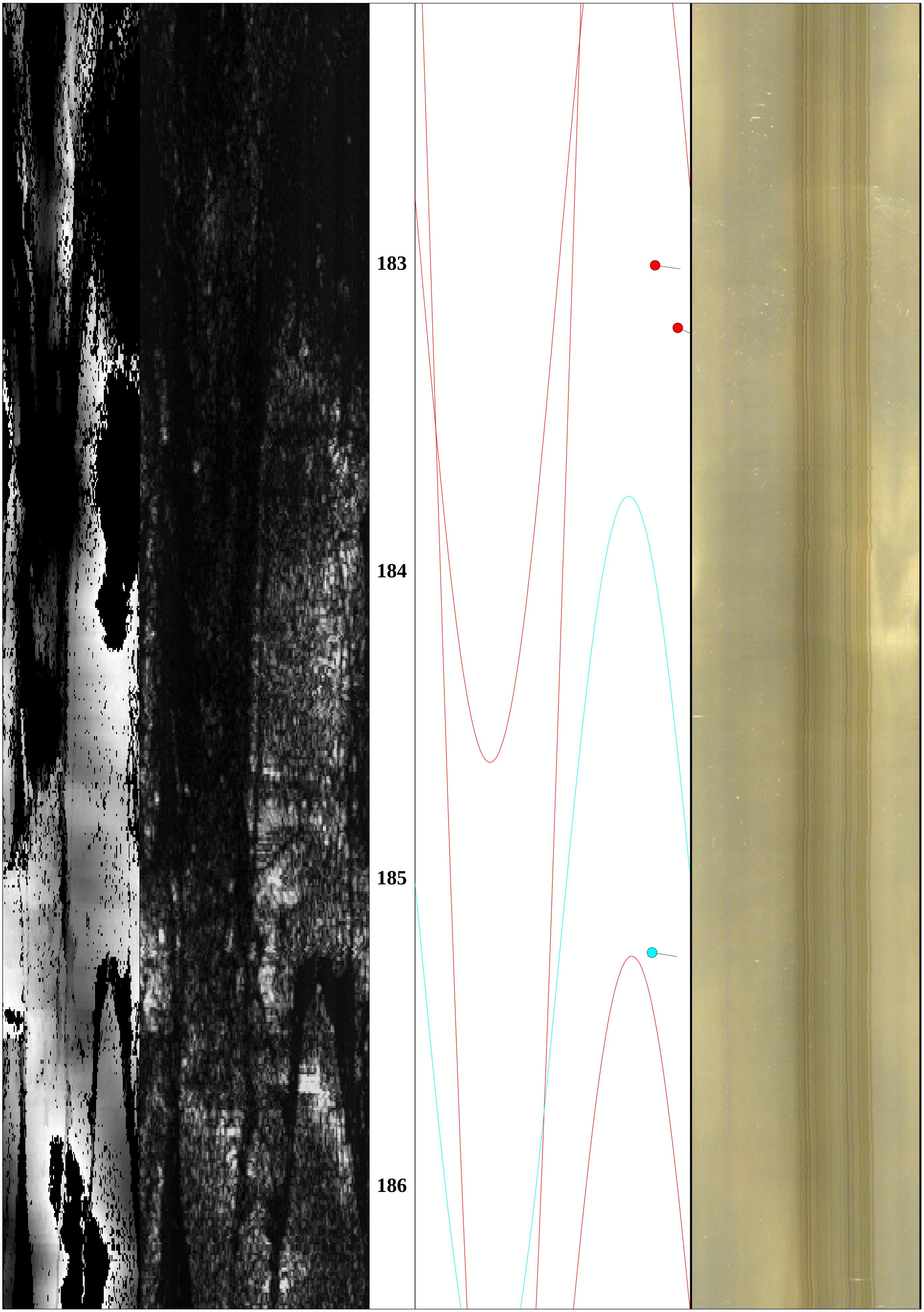

161
162
163
164
165


166
167
168
169

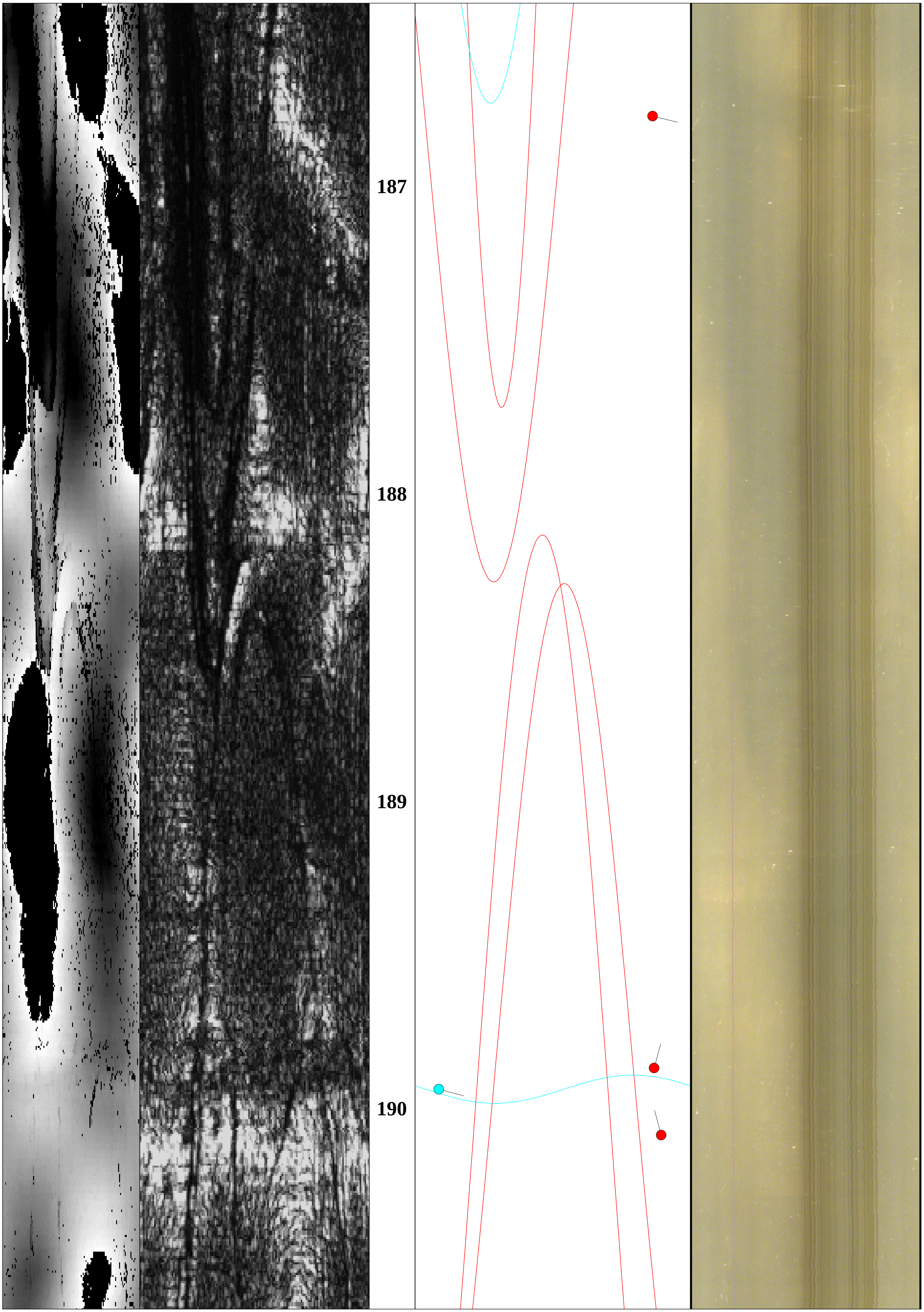

170
171
172
173

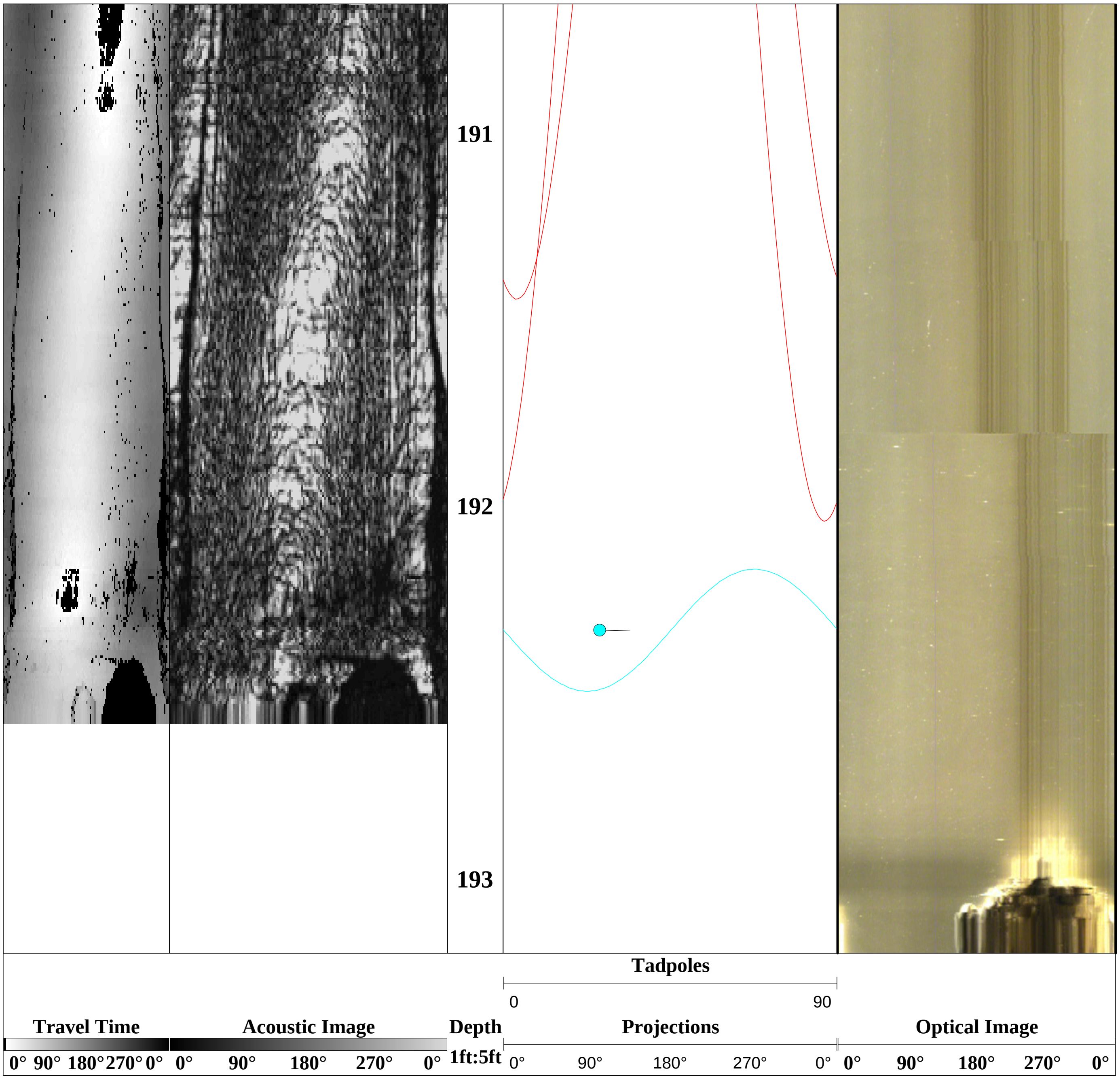

174
175
176
177


178
179
180
181
182

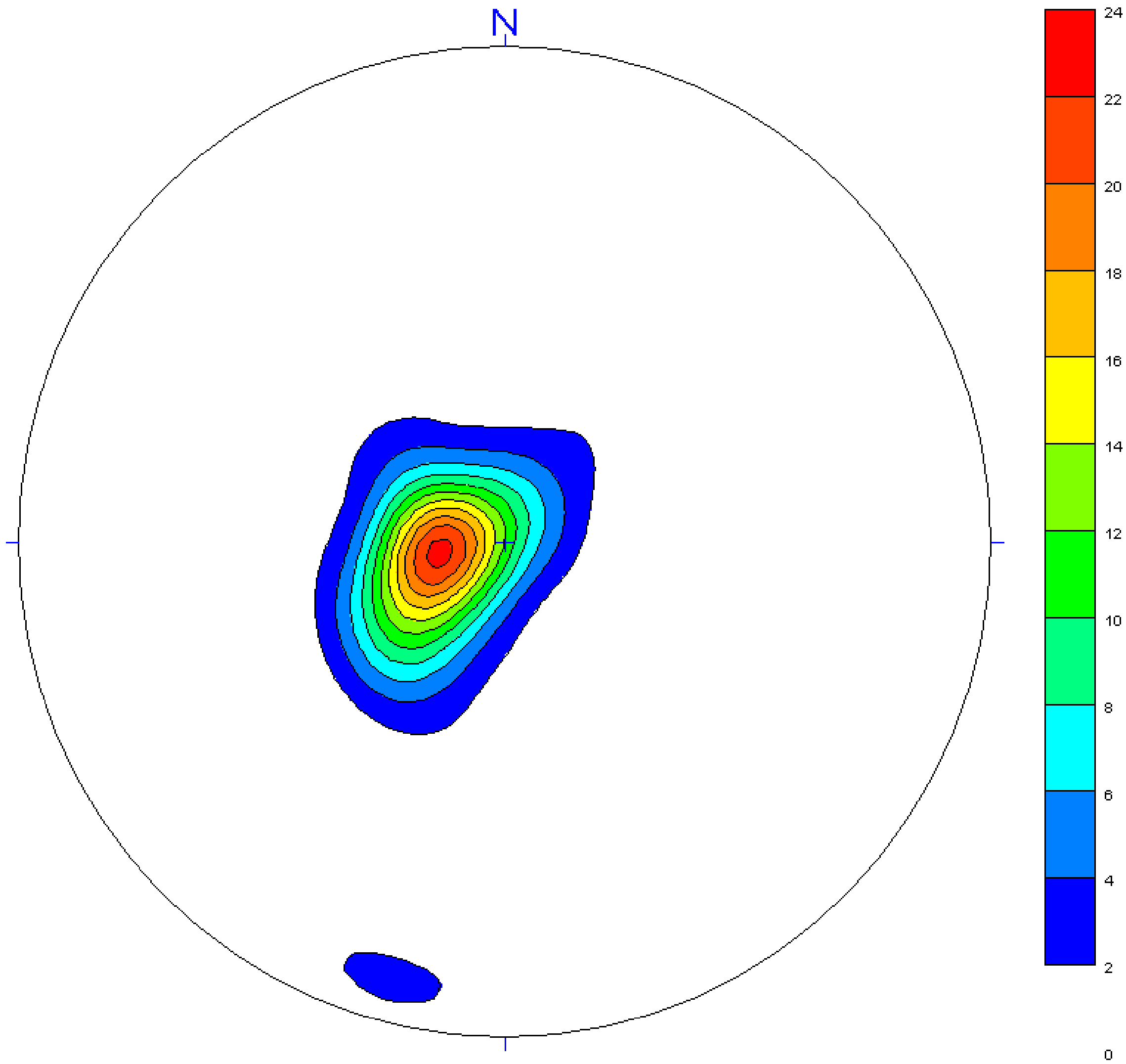


183
184
185
186


187
188
189
190

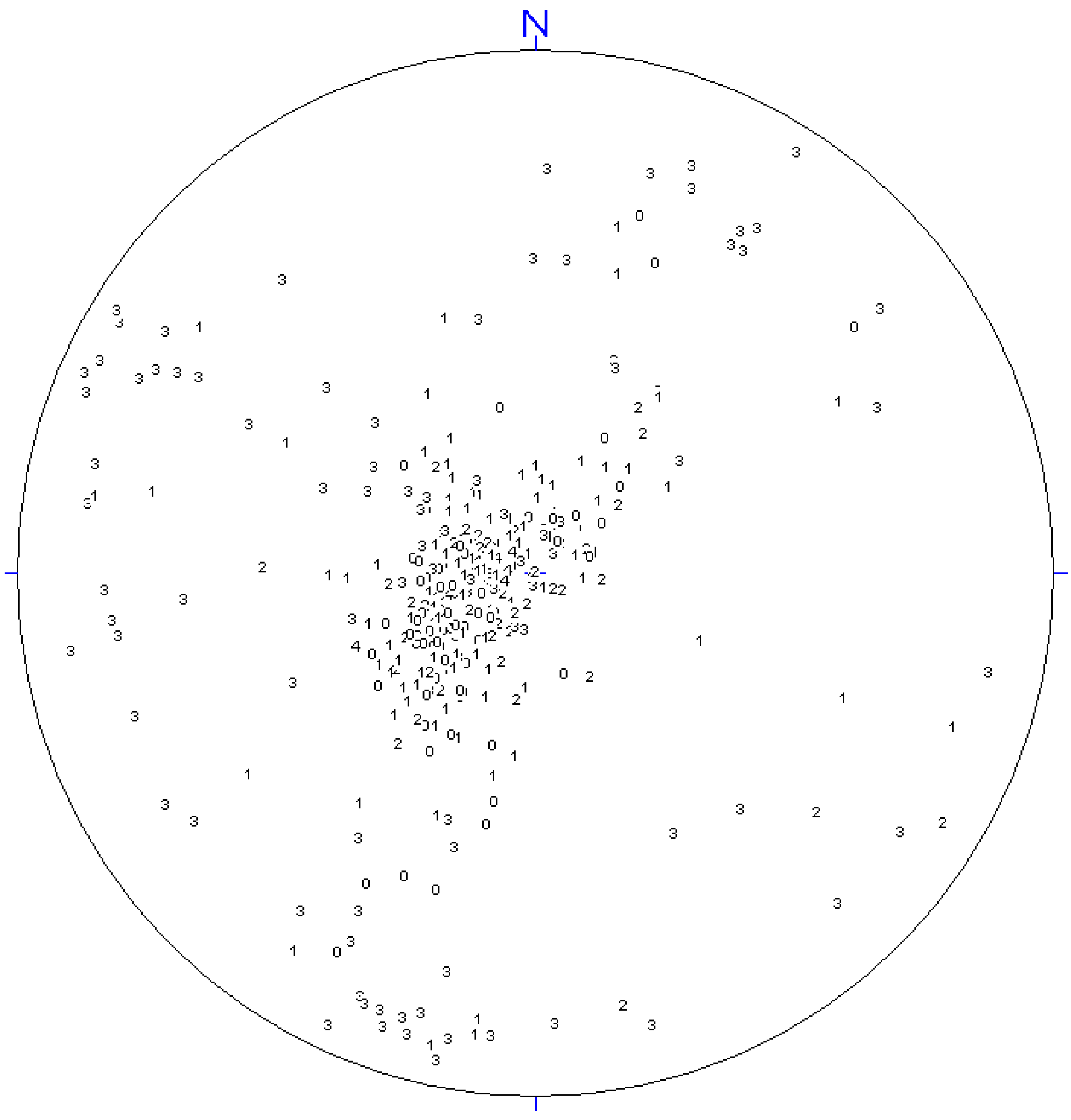

191
192
193
Tadpoles
0
90
Travel Time
Acoustic Image
Depth
Projections
Optical Image
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°
1ft:5ft
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n2
NNSA/NSO
21 Sept 2010



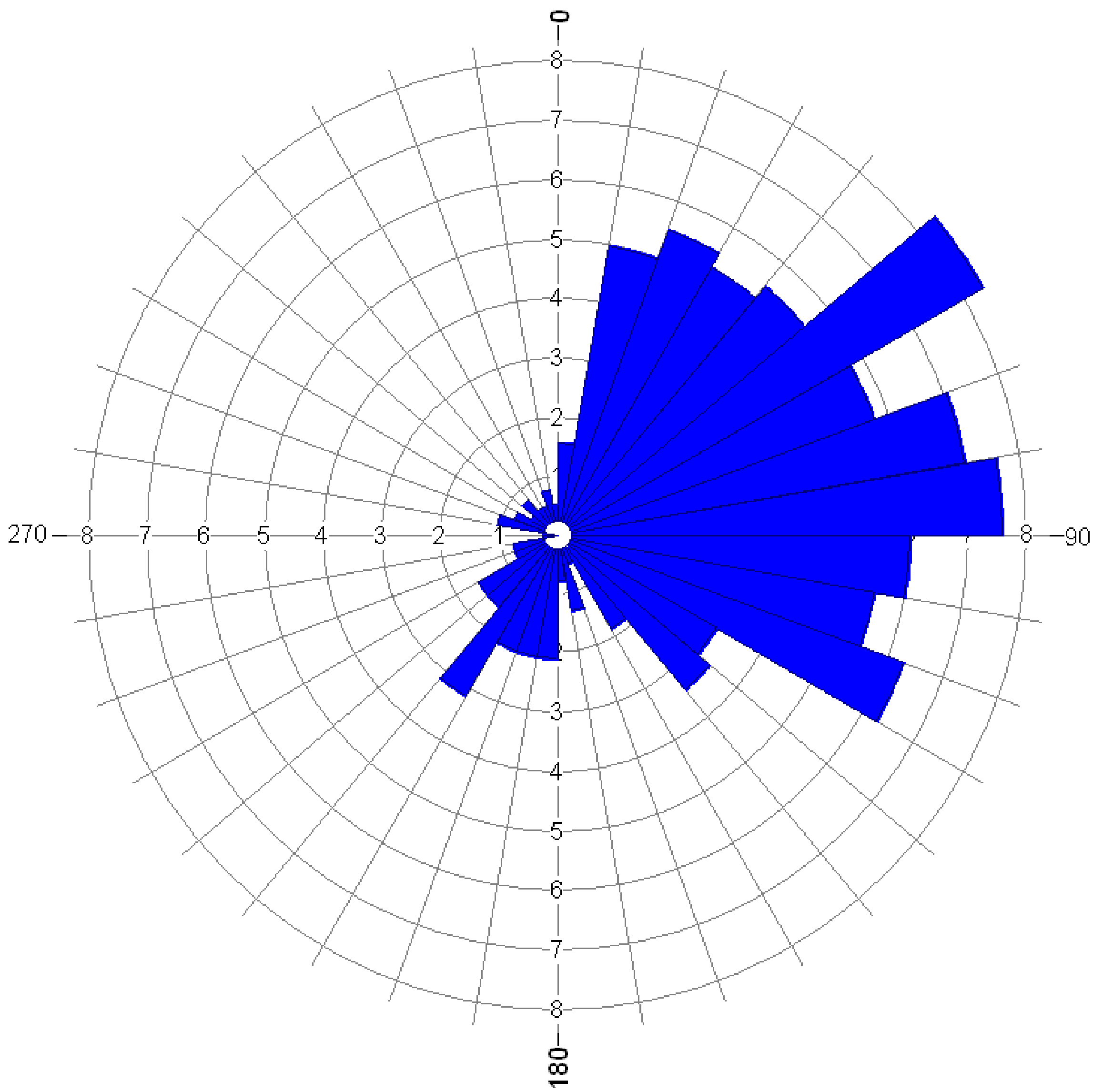
All directions are with respect to True North.

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n2
NNSA/NSO
21 Sept 2010



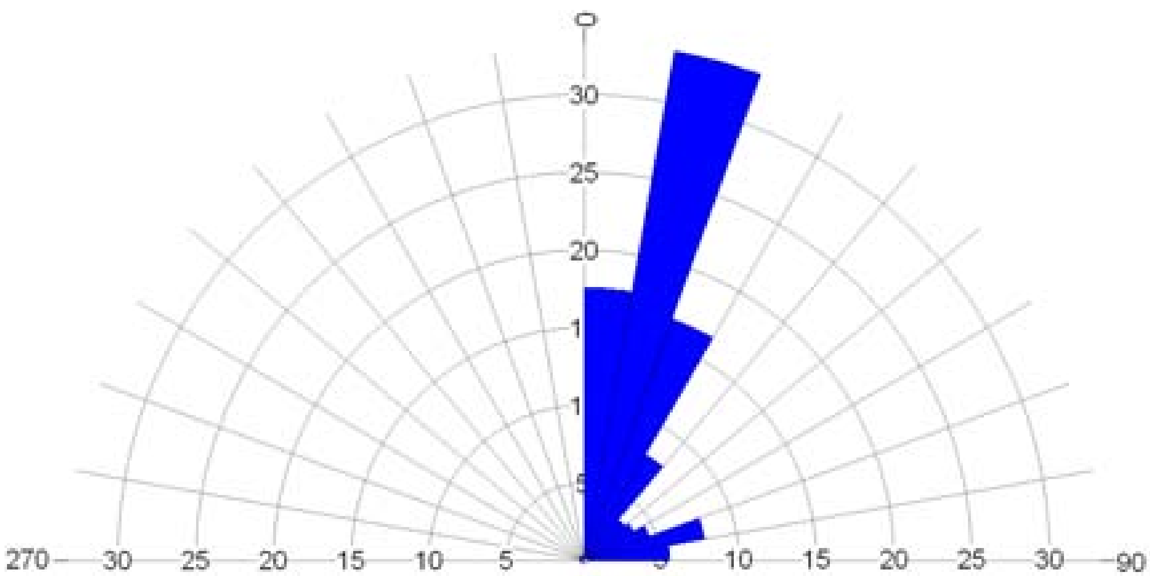
All directions are with respect to True North.

Rose Diagram – Dip Directions
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n2
NNSA/NSO
21 Sept 2010



All directions are with respect to True North.

Rose Diagram – Dip Angles
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n2
NNSA/NSO
21 Sept 2010



All directions are with respect to True North.

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Full-Waveform Sonic

Company	NNSA/NSO
Well	U-15N#2
Field	NNSS
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15N#2
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900075.16
E: 676608.20

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Dual-Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5003.28

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

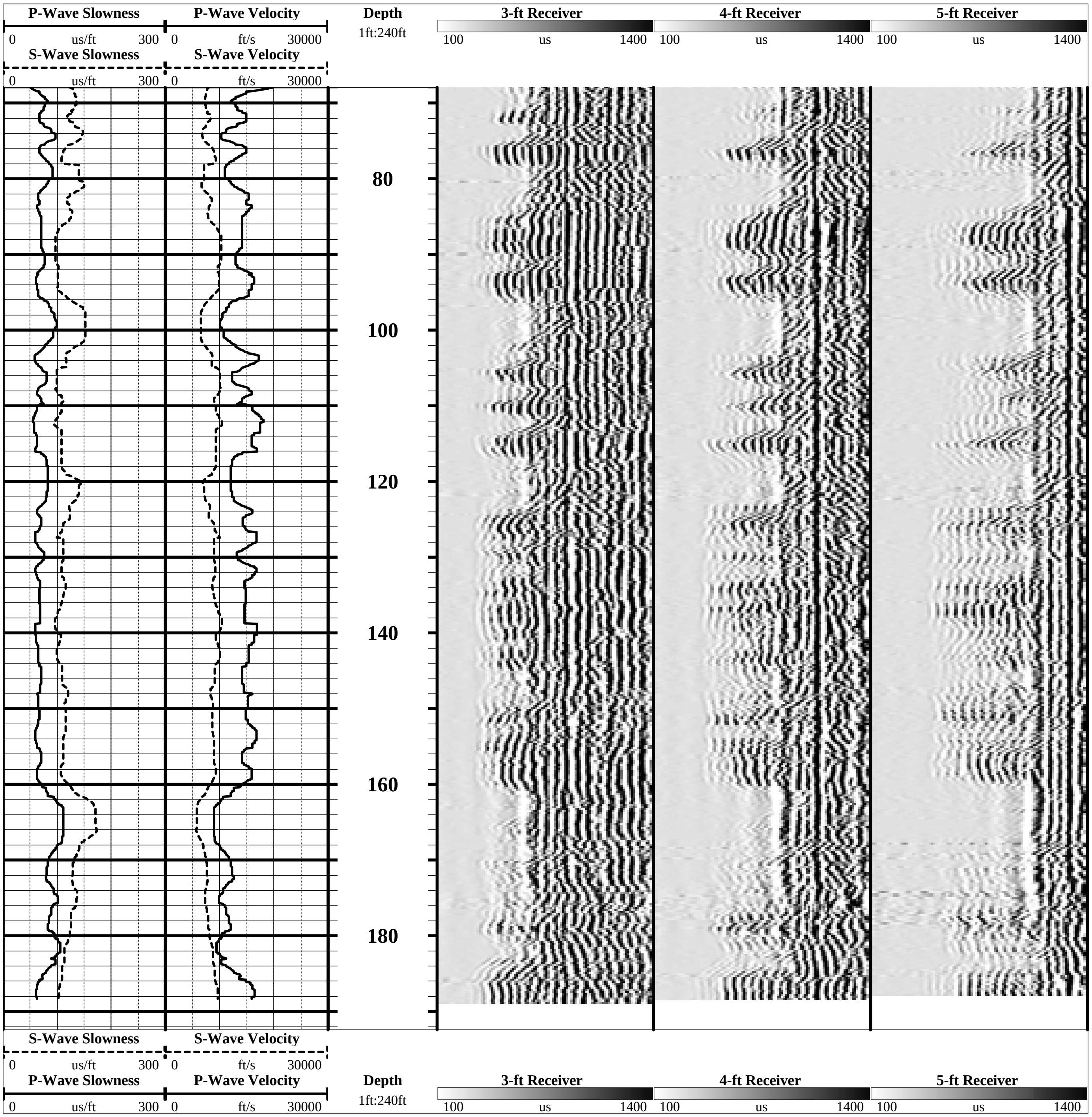
DRILLING MEAS. FROM

DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Full Waveform Sonic			
DEPTH-DRILLER	192'			
DEPTH-LOGGER	192.6'			
BTM LOG INTERVAL	192.6'			
TOP LOG INTERVAL	67.8'			
RECORDED BY	A. Caster			
WITNESSED BY	C.Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	5 ft/min			
A.S.D.E.	0.1'			
SAMPLE INTERVAL	0.1'			

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	10'	10"		-1.0'	9.5'
2	8"	10'	192'				

COMMENTS

NA - Not Available, N/A - Not Applicable


P-Wave Slowness
0 us/ft 300
S-Wave Slowness
0 us/ft 300
P-Wave Velocity
0 ft/s 30000
S-Wave Velocity
0 ft/s 30000
Depth
1ft:240ft
3-ft Receiver
100 us 1400
4-ft Receiver
100 us 1400
5-ft Receiver
100 us 1400
80
100
120
140
160
180
S-Wave Slowness
0 us/ft 300
P-Wave Slowness
0 us/ft 300
S-Wave Velocity
0 ft/s 30000
P-Wave Velocity
0 ft/s 30000
Depth
1ft:240ft
3-ft Receiver
100 us 1400
4-ft Receiver
100 us 1400
5-ft Receiver
100 us 1400

Borehole Deviation

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Company	NNSA/NSO
Well	U-15n#2
Field	NNSS
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15N#2
FIELD Nevada National Securities Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N:900075.16
E:676608.20

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Optical Televiewer
Acoustic Televiewer
Dual Spaced Density
Caliper
Natural Gamma
Full Waveform Sonic
Video

PERMANENT DATUM Ground Level **ELEVATION** 5003.28

LOG MEAS. FROM Ground Level 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM

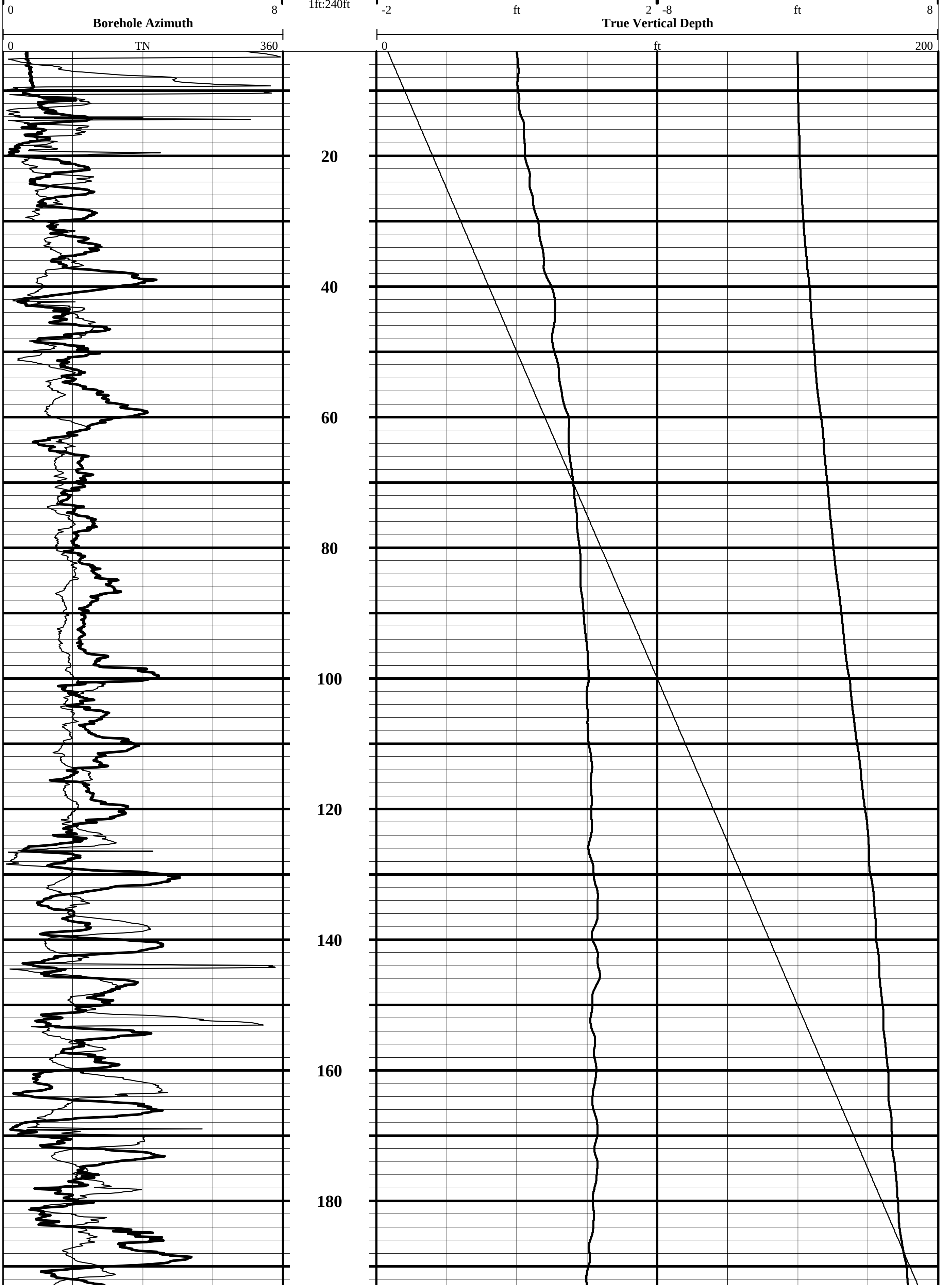
DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	TWO			
LOG TYPE	Borehole Deviation			
DEPTH-DRILLER	192'			
DEPTH-LOGGER	193'			
BTM LOG INTERVAL	193'			
TOP LOG INTERVAL	4'			
RECORDED BY	E.Eaton			
WITNESSED BY	C.Obi			
PROBE TYPE, S/N	OBI40, 023902			
LOGGING SPEED	3.5 ft/min			
A.S.D.E.	.065 ft			
SAMPLE INTERVAL	0.0041 ft			

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25"	Surface	10	10		-1	9.5
	8"	10	192				

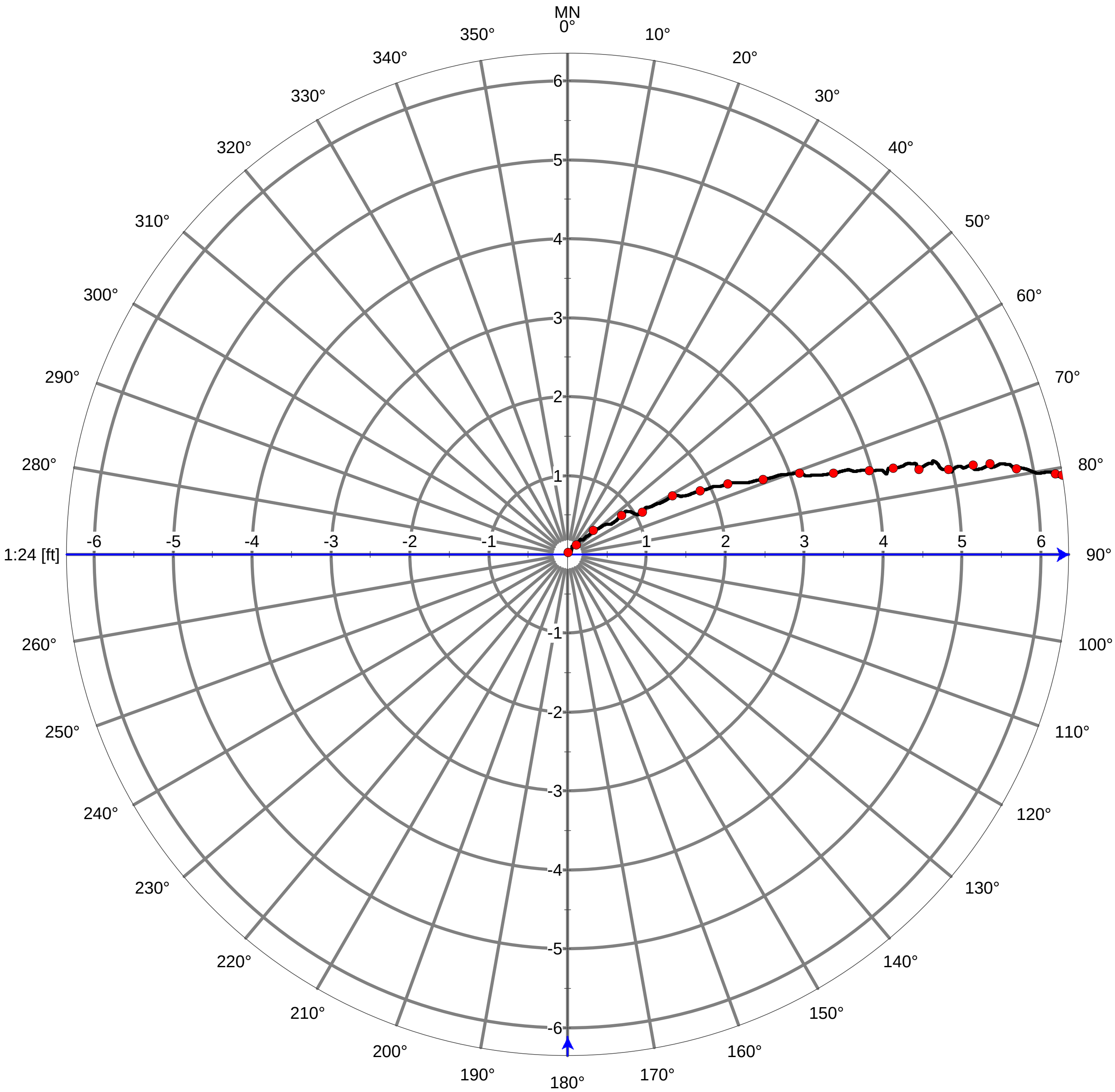
COMMENTS

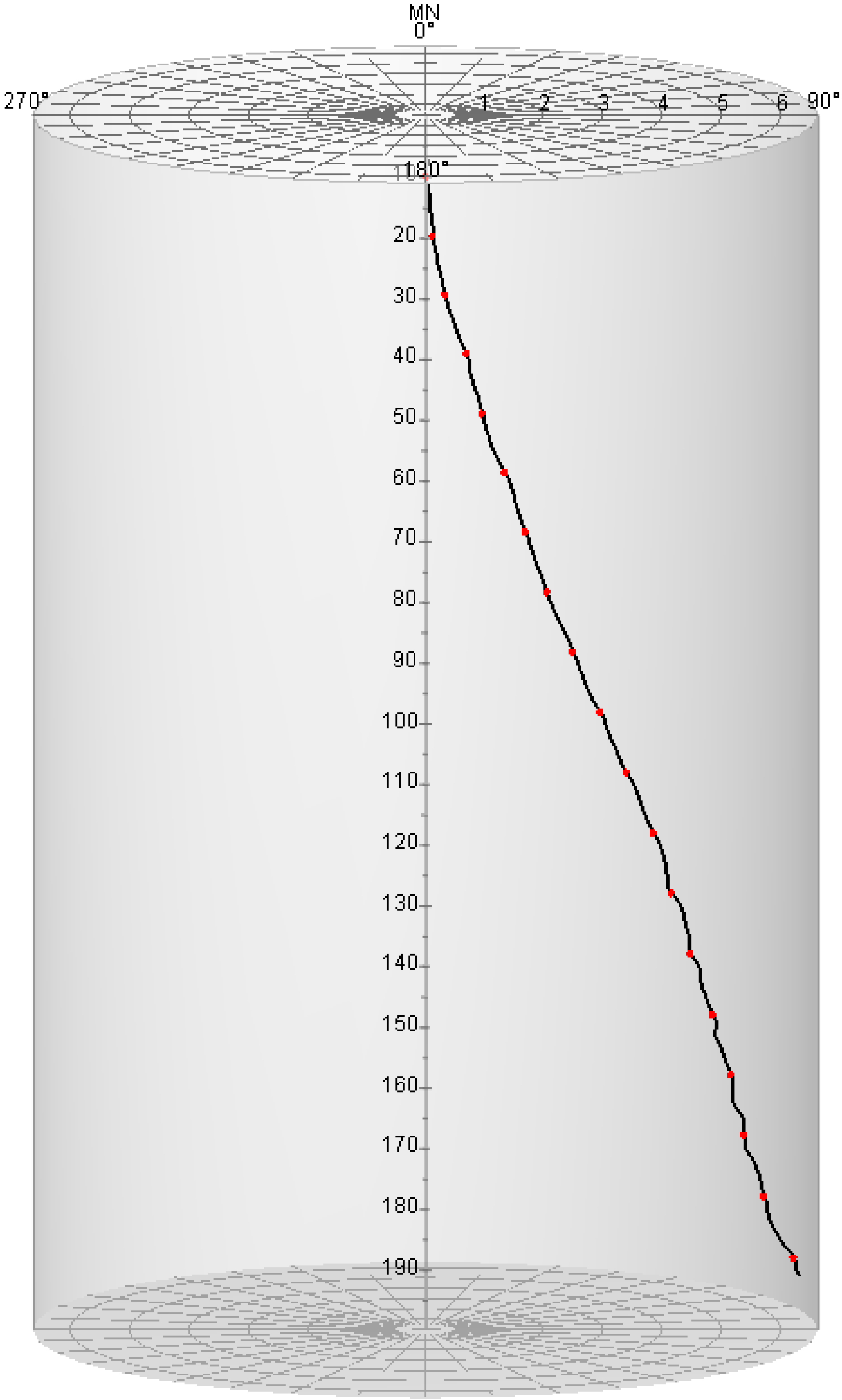
NA - Not Available, N/A - Not Applicable

Borehole Tilt	Depth	Northing	Easting



0
8
Borehole Azimuth
0
TN
360
1ft:240ft
-2
ft
2
-8
ft
8
True Vertical Depth
0
ft
200
20
40
60
80
100
120
140
160
180


MN
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
1:24 [ft]
280°
290°
300°
310°
320°
330°
340°
350°
-6 -5 -4 -3 -2 -1 1 2 3 4 5 6
6 5 4 3 2 1 -1 -2 -3 -4 -5 -6


MN
0°
270°
90°
180°
1
2
3
4
5
6
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

Appendix F-4

Borehole Geophysical Log Plots for Instrument Hole U-15n#3

COLOG
BOREHOLE GEOPHYSICS & HYDROPHYSICS
A DIVISION OF LAYNE CHRISTENSEN COMPANY

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Far Density
Near Density
Natural Gamma Ray
Caliper

Company	NNSA/NSO
Well	U-15N#3
Field	NNSS
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15N#3
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900050.57
E: 676659.44

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Full-Wave Sonic
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5002.85

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM G.L.

DATE ACQUIRED	22 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Far Density	Near Density	Natural Gamma Ray	Caliper
DEPTH-DRILLER	190'			
DEPTH-LOGGER	178.9'			
BTM LOG INTERVAL	177.8'	178.1'	173.3'	176.8'
TOP LOG INTERVAL	7.9'	8.2'	3.4'	6.9'
RECORDED BY	A. Caster			
WITNESSED BY	C. Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	10 ft/min			
A.S.D.E.	0.0'			
SAMPLE INTERVAL	0.1'			

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	10'	10"		-1.0	9.5'
2	8"	10'	190'				

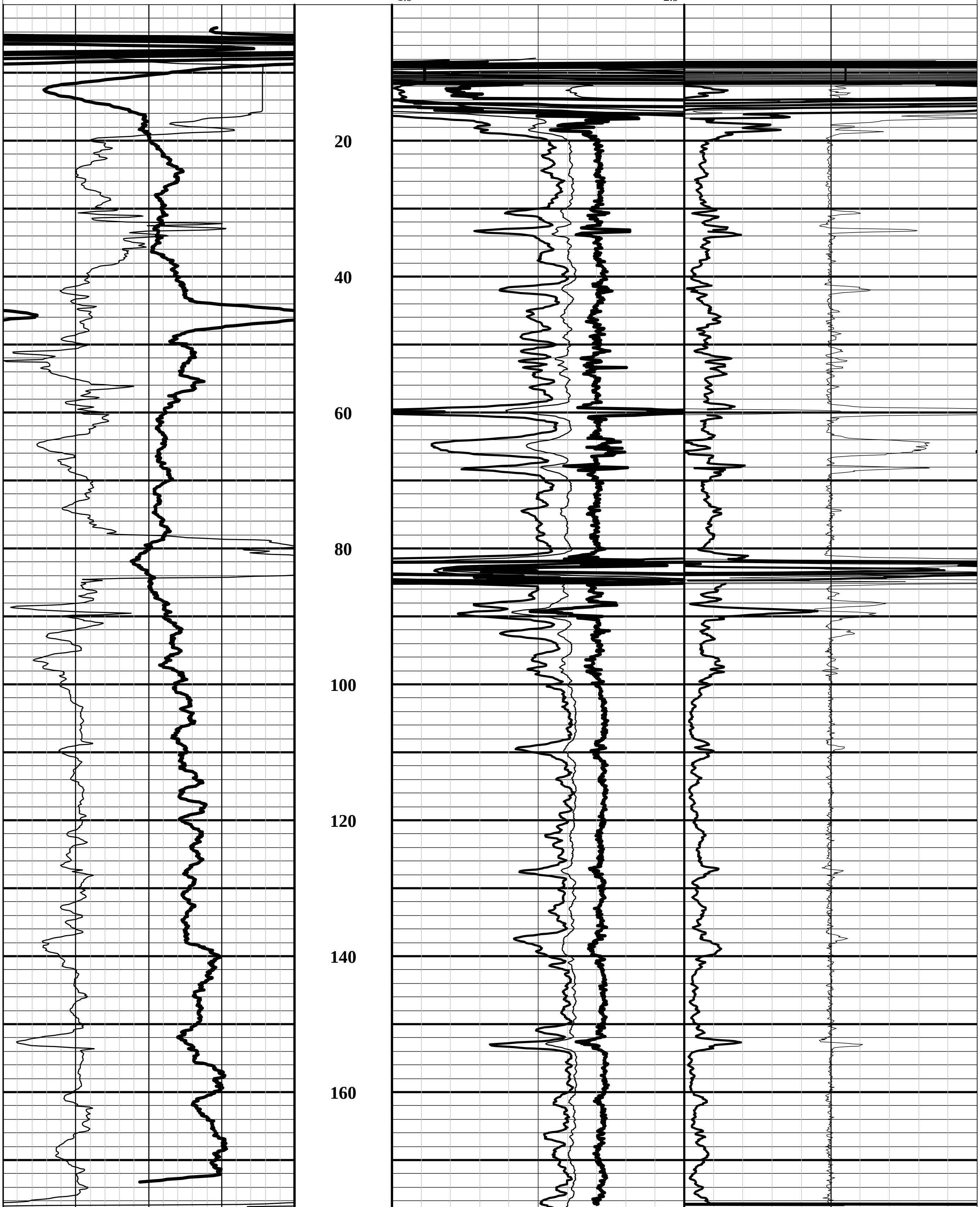
COMMENTS

NA - Not Available, N/A - Not Applicable

Matrix Density of 2.64 used to calculate Density Porosity

Natural Gamma Ray	Depth	Far Density	Compensation

Caliper / Natural Gamma Ray	Depth	Near Density / Far Density / Compensated Density	Density Porosity / Compensation
0 CPS 200	1ft:240ft	2 g/cc 3	-0.25 g/cc 0.25
Caliper		**Near Density**	**Density Porosity**
7 inch 11		2 g/cc 3	0 % 30
		Compensated Density	
		1.9 2.9	



Caliper / Natural Gamma Ray	Depth	Near Density / Far Density / Compensated Density	Density Porosity / Compensation
		Compensated Density	
		1.9 2.9	
Caliper		**Near Density**	**Density Porosity**
7 inch 11		2 g/cc 3	0 % 30
Natural Gamma Ray	**Depth**	**Far Density**	**Compensation**
0 CPS 200	1ft:240ft	2 g/cc 3	-0.25 g/cc 0.25

Company	NNSA/NSO
Well	U-15N#3
Field	Nevada Test Site
County	Nye
State	Nevada

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Acoustic Televiewer
Optical Televiewer

COMPANY NNSA/NSO
WELL U-15N#3
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900050.57
E: 676659.44

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Dual Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5002.85

LOG MEAS. FROM G.L. **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM

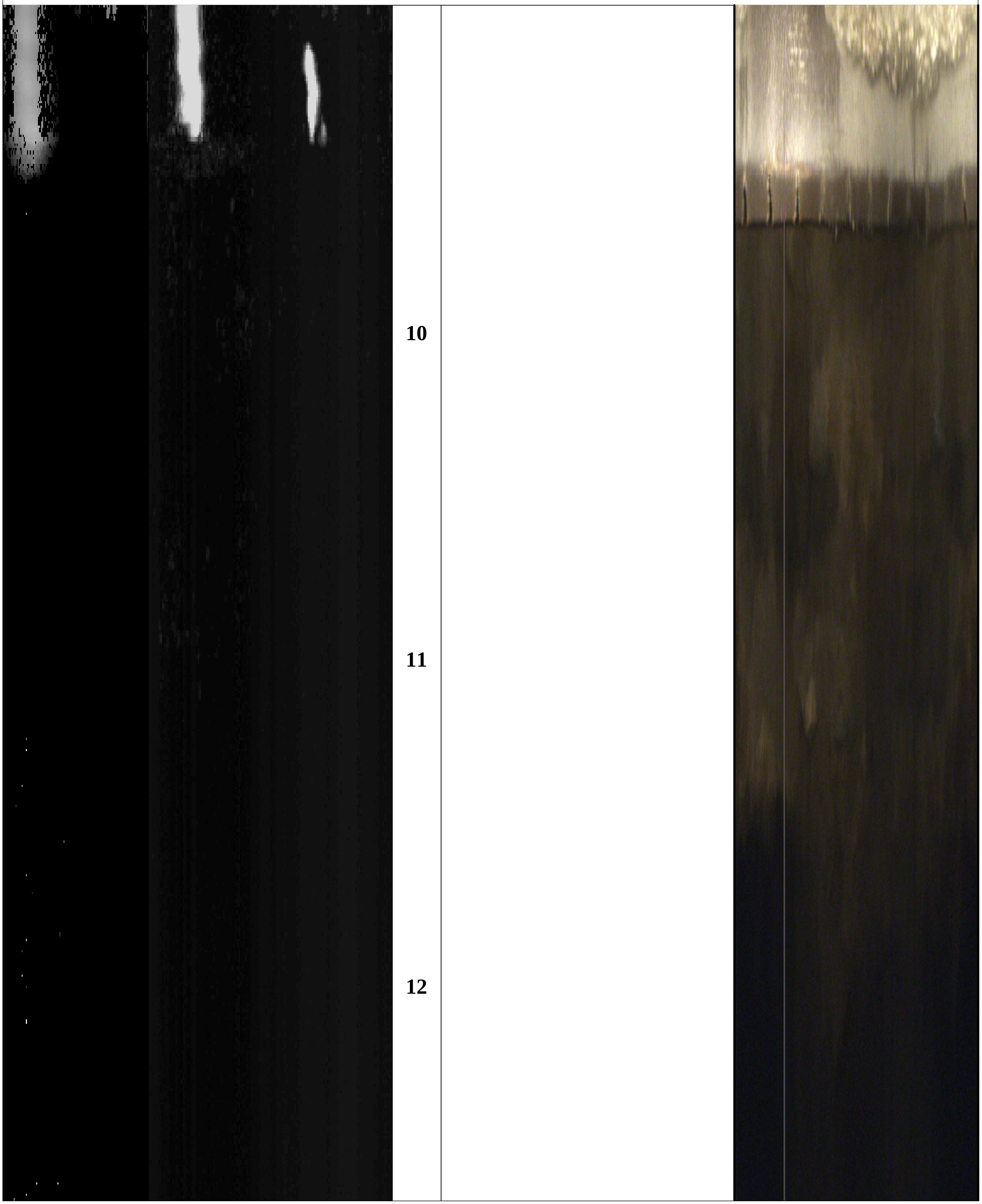
DATE ACQUIRED	22 Sept 2010	21 Sept 2010		
RUN NUMBER	THREE	TWO		
LOG TYPE	ABI	OBI		
DEPTH-DRILLER	190	190		
DEPTH-LOGGER	180	180		
BTM LOG INTERVAL	180	180		
TOP LOG INTERVAL	57	4		
RECORDED BY	E Eaton	E Eaton		
WITNESSED BY	C Obi	C Obi		
PROBE TYPE, S/N	ABI-062605	OBI-023901		
LOGGING SPEED	5.5 ft/sec	3.5 ft/min		
A.S.D.E.	0.50 ft	0.52 ft		
SAMPLE INTERVAL	0.0068 ft	0.0041 ft		

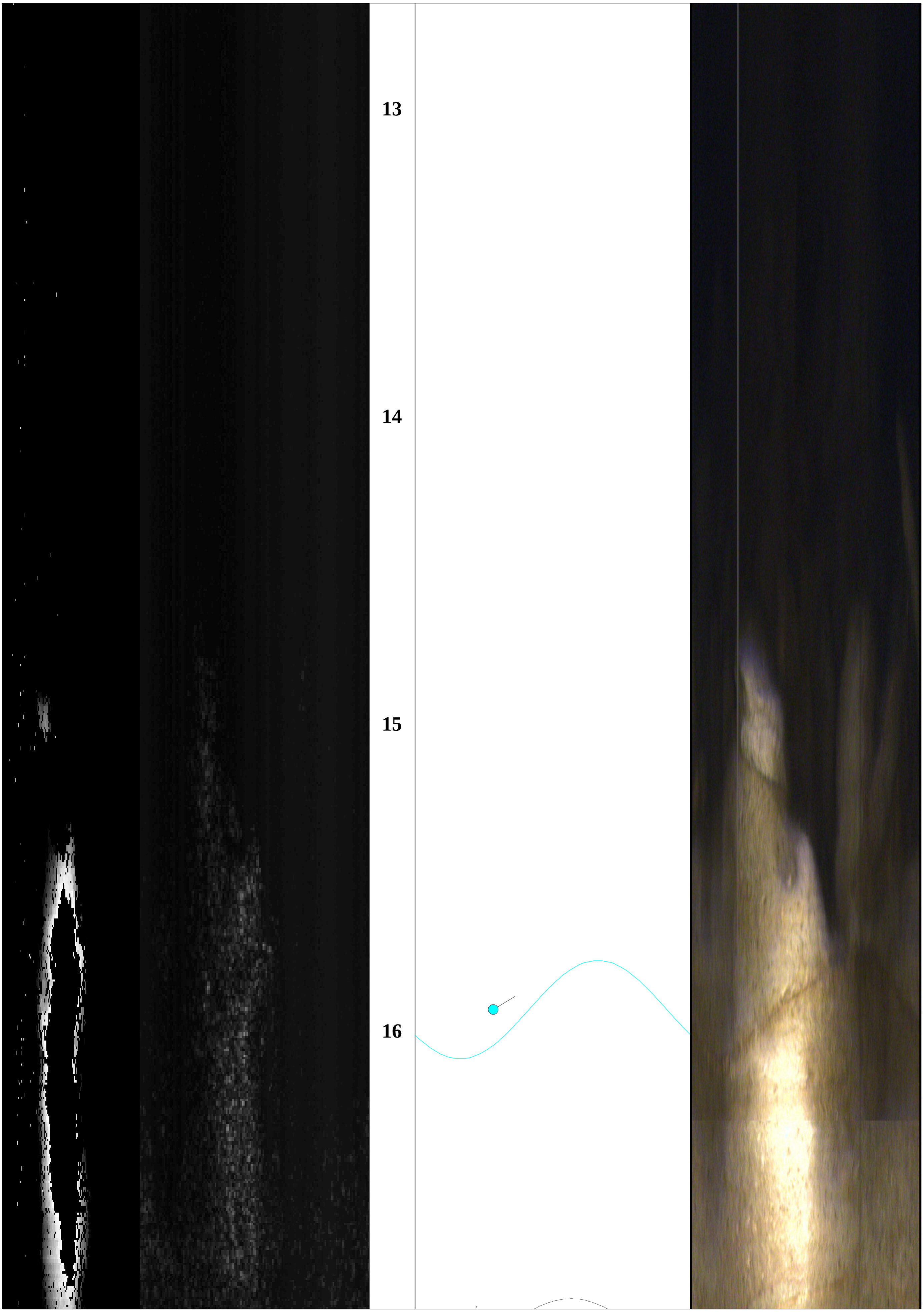
BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25"	Surface	10	10"		-1	9.5
	8"	10	190				

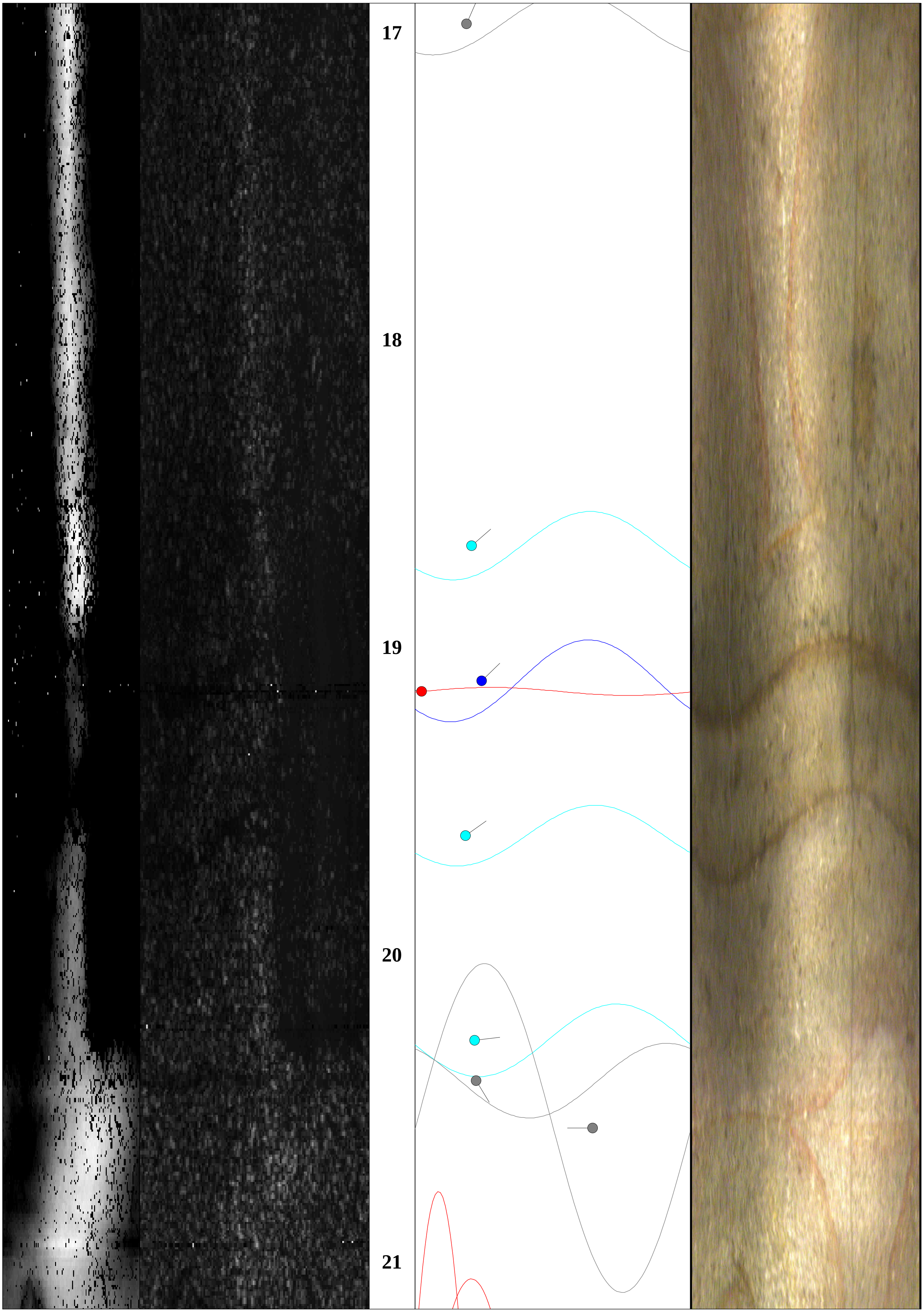
COMMENTS

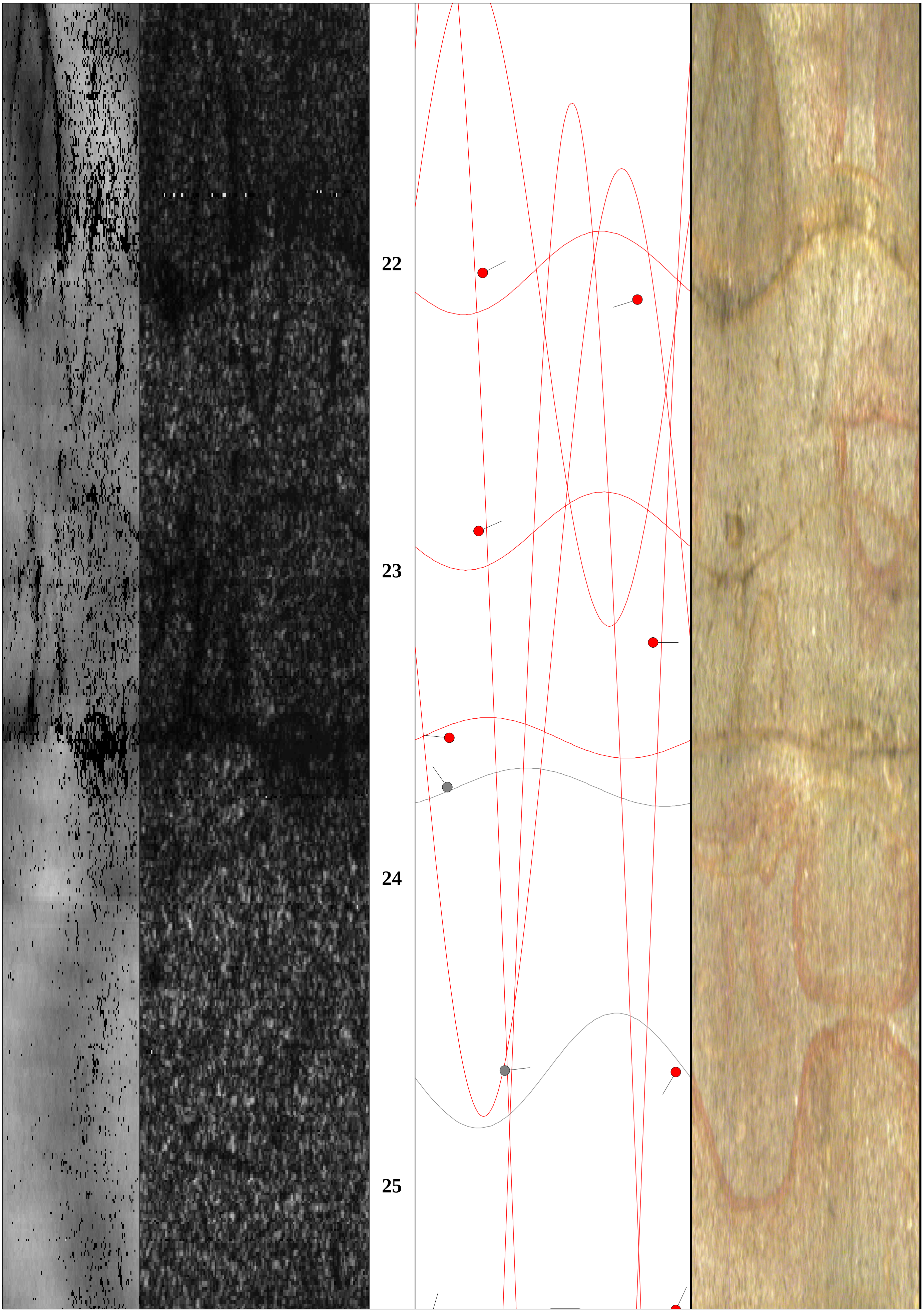
NA - Not Available, N/A - Not Applicable

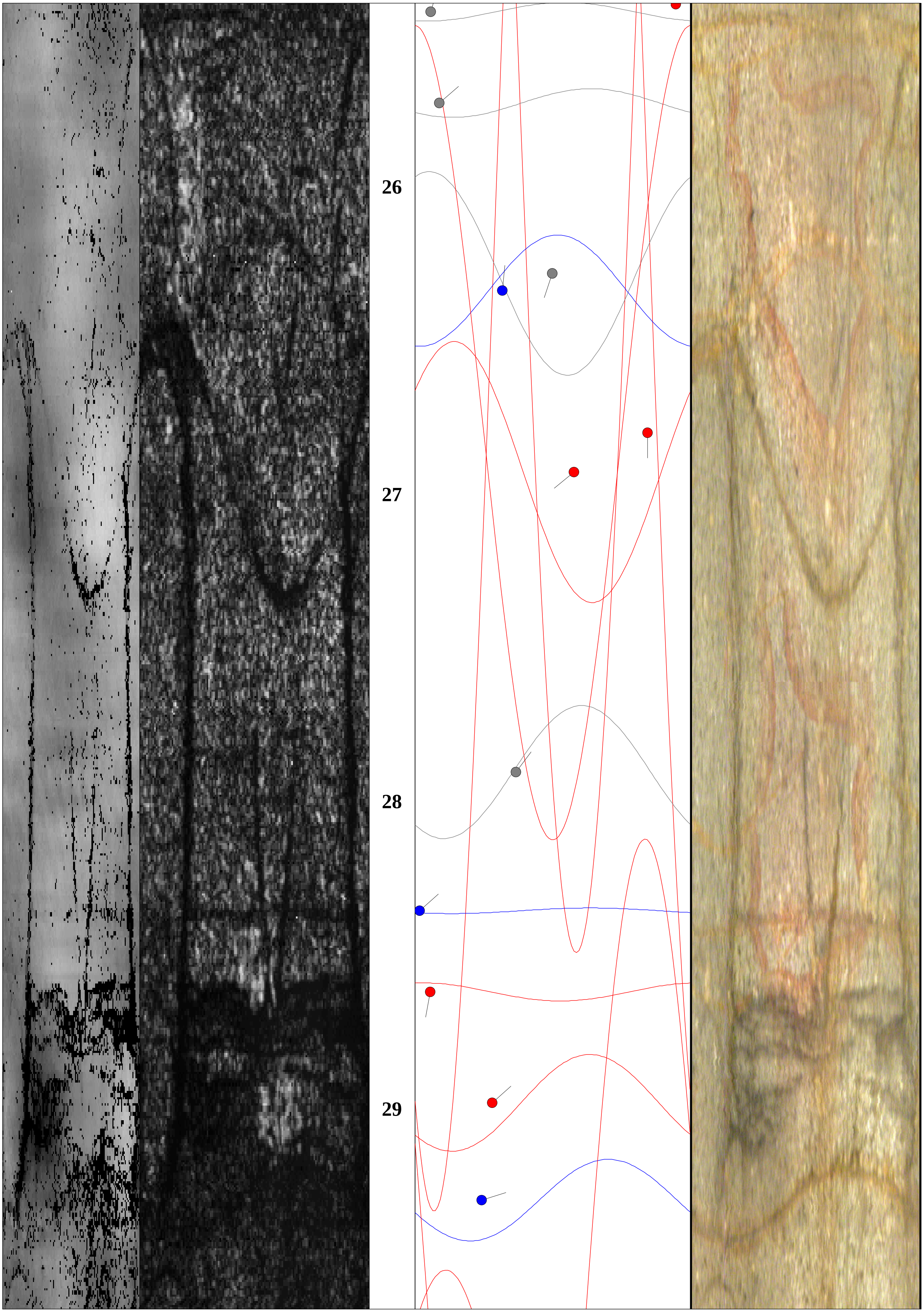
Travel Time	Acoustic Image	Depth	Projections	Optical Image
0° 90° 180° 270° 0°	0° 90° 180° 270° 0°	1ft:5ft	0° 90° 180° 270° 0°	0° 90° 180° 270° 0°
			Tadpoles	
			0 90	

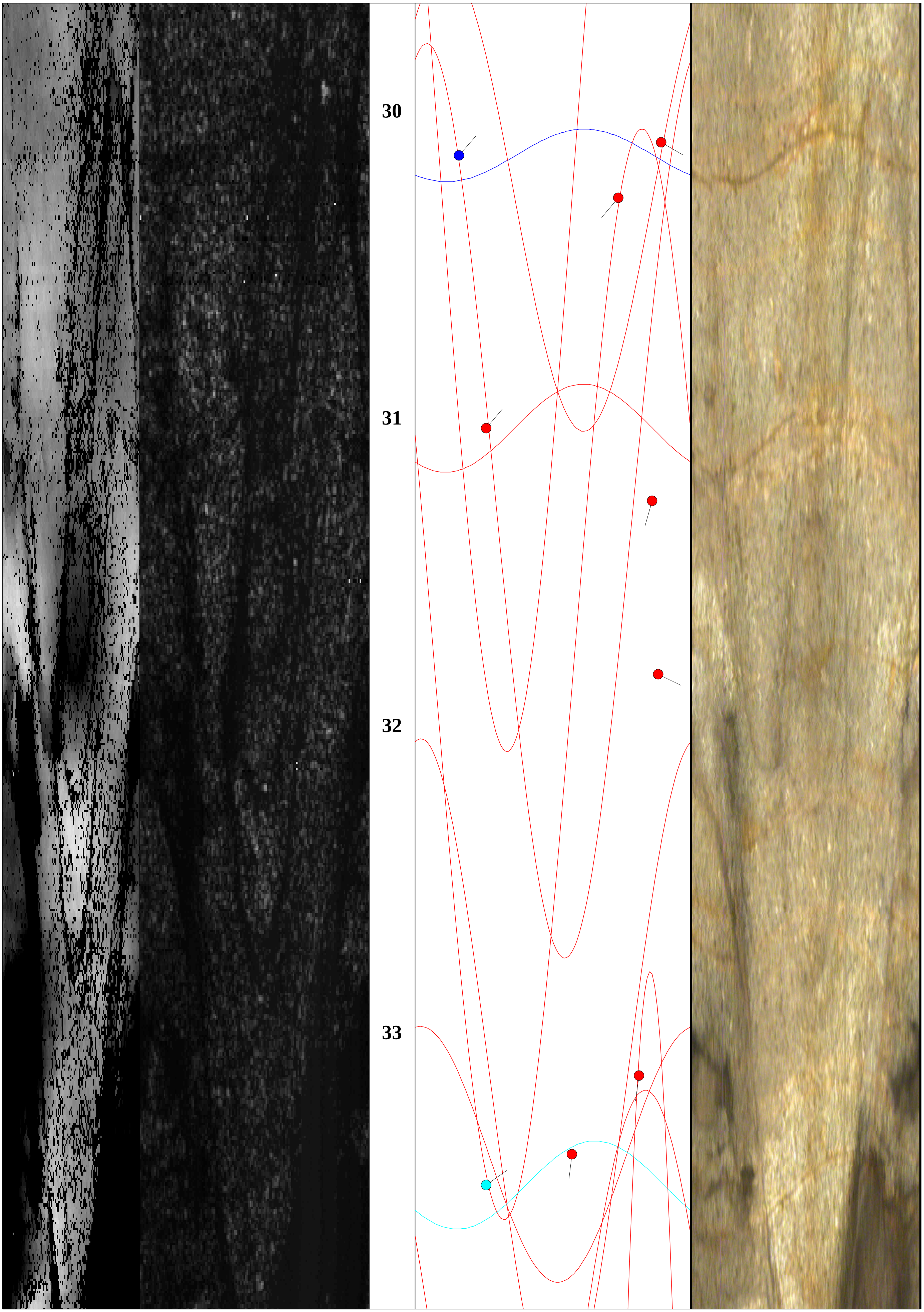


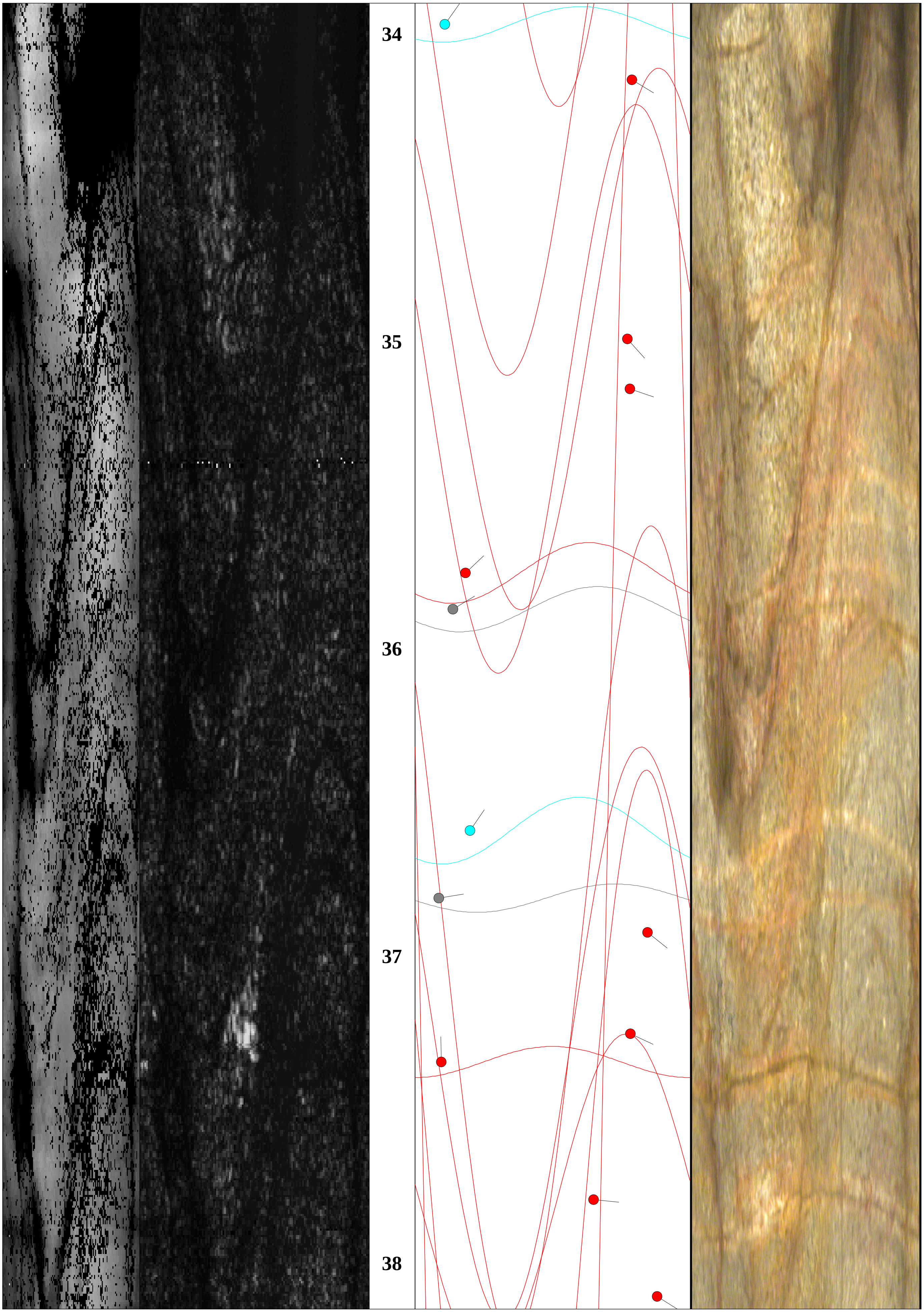

13
14
15
16

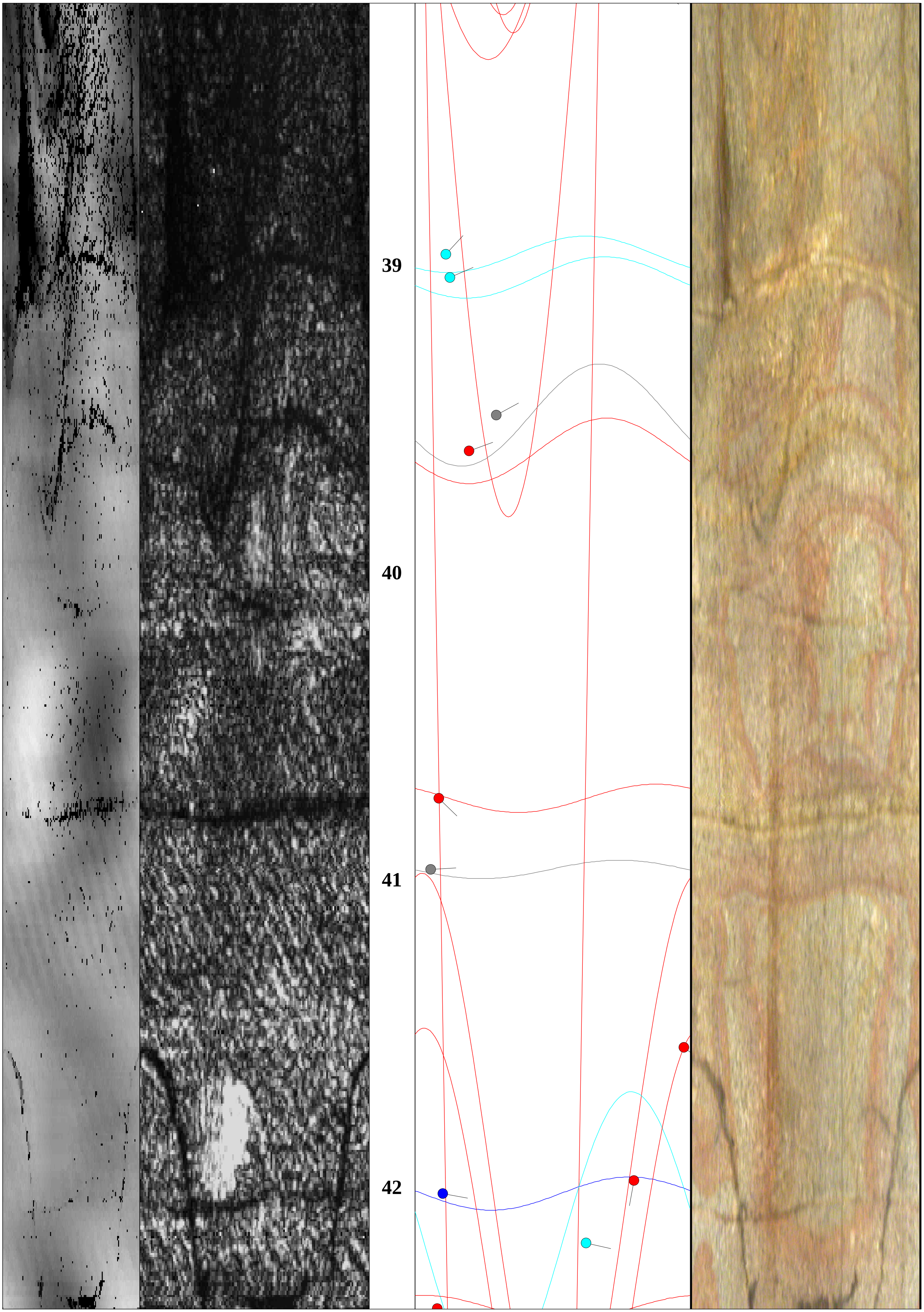

17
18
19
20
21

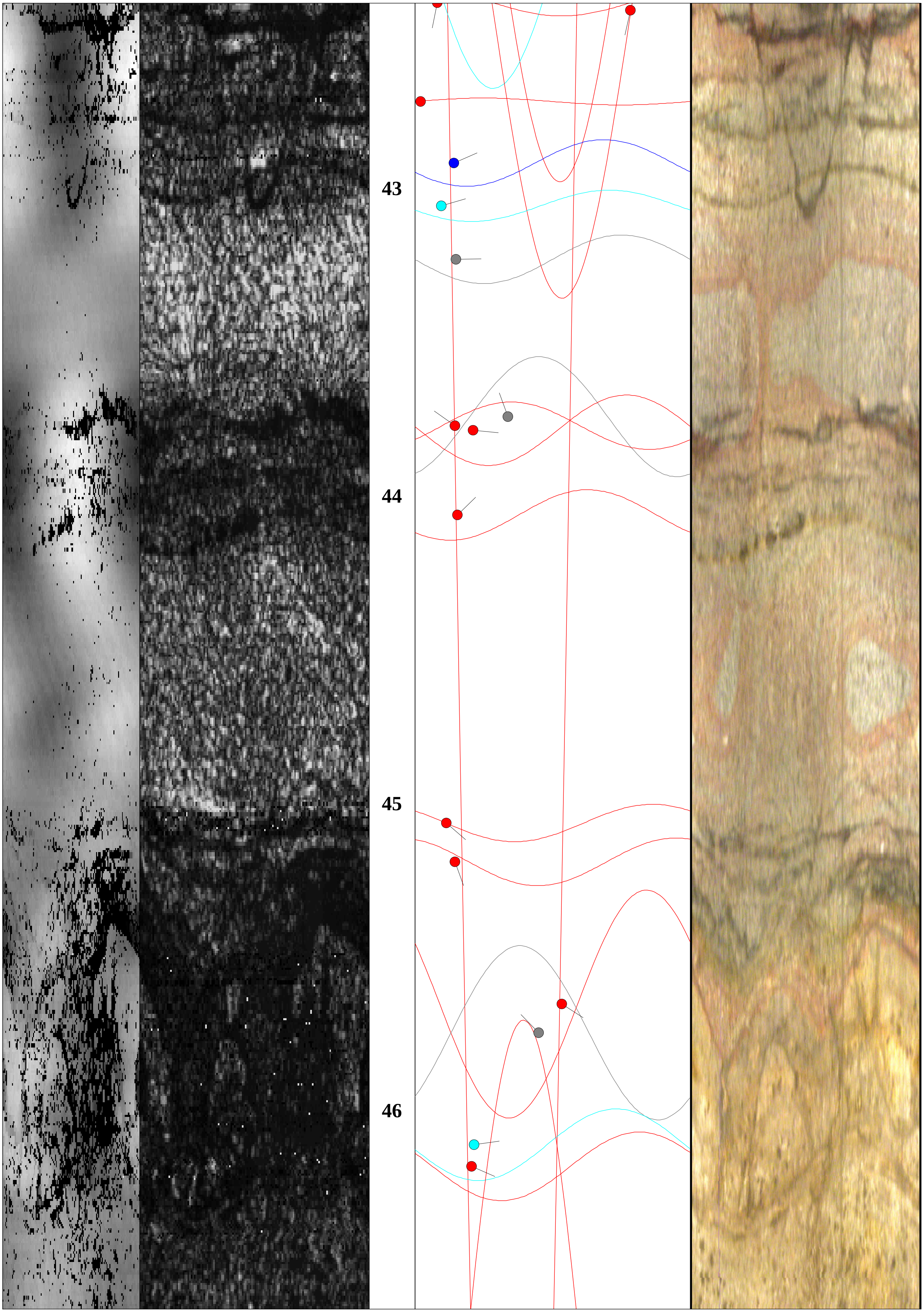

22
23
24
25

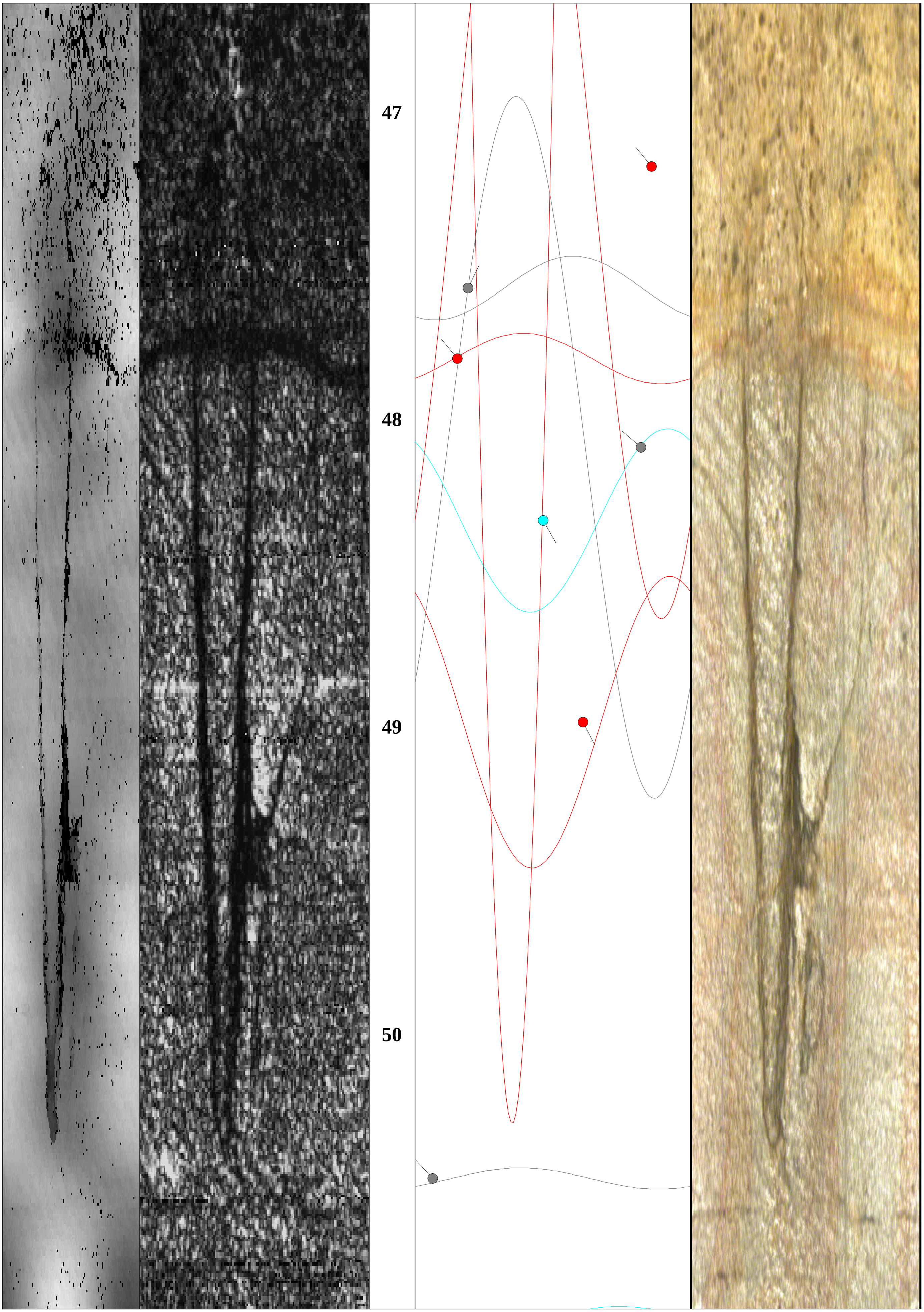

26
27
28
29

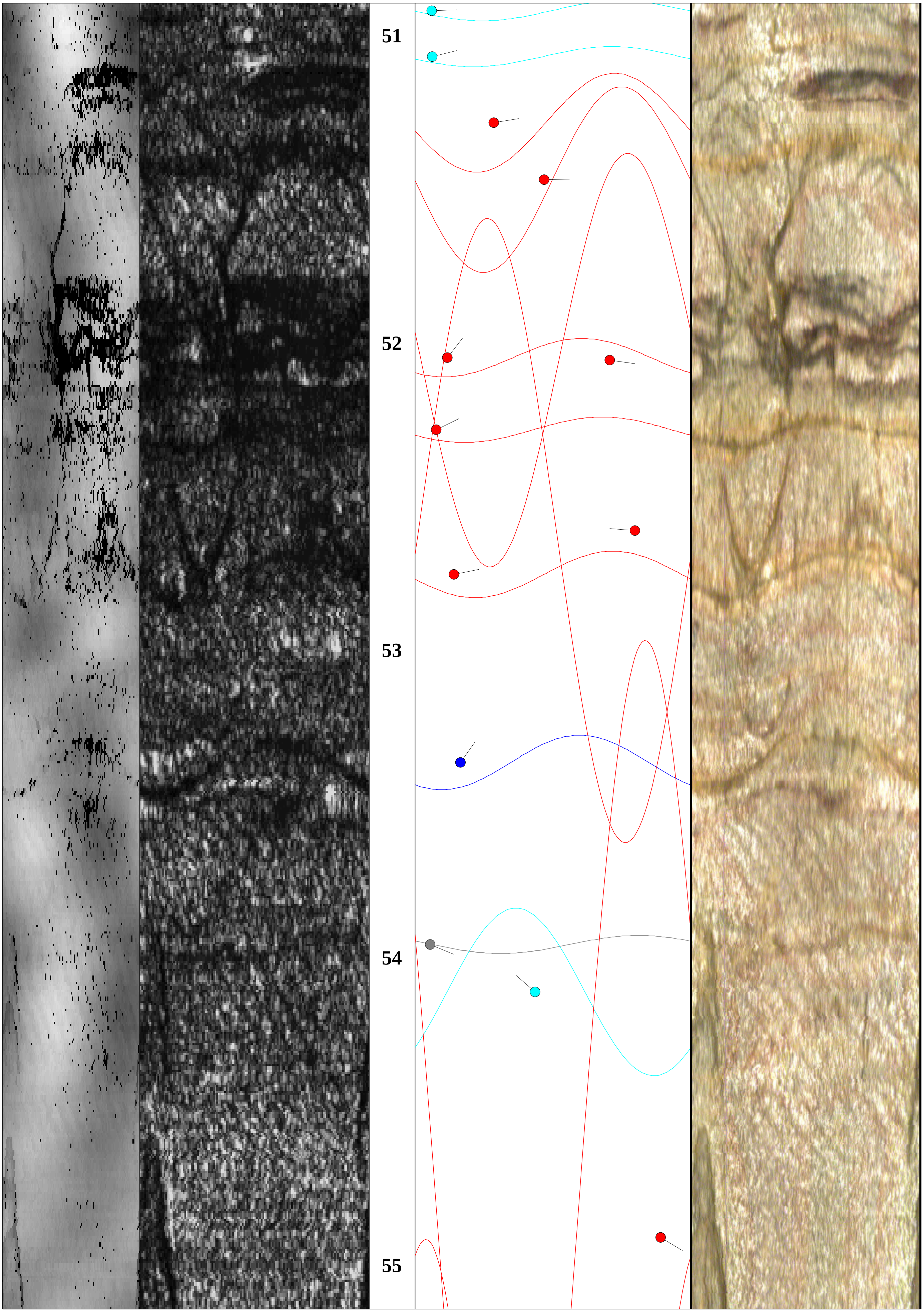

30
31
32
33

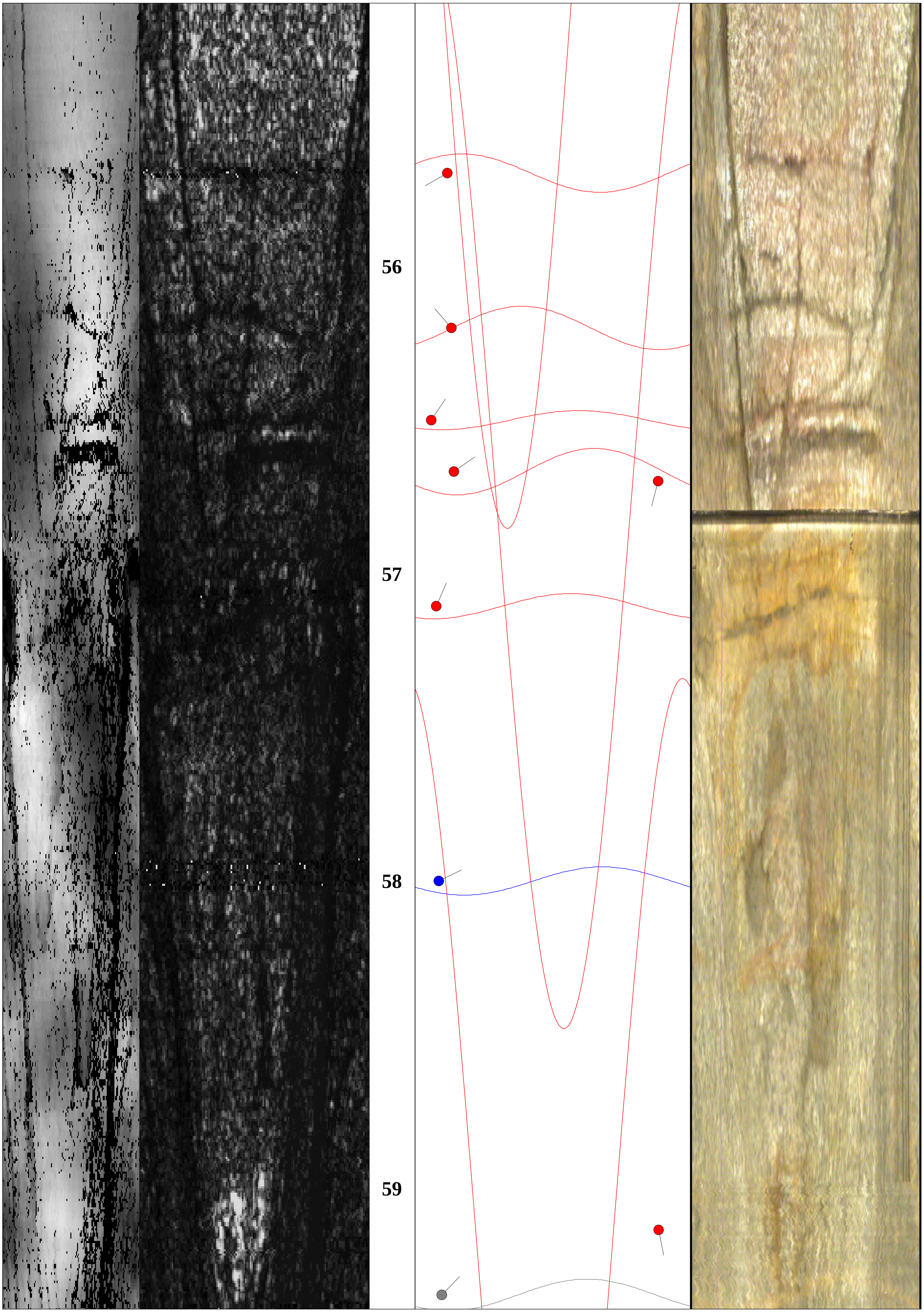

34
35
36
37
38

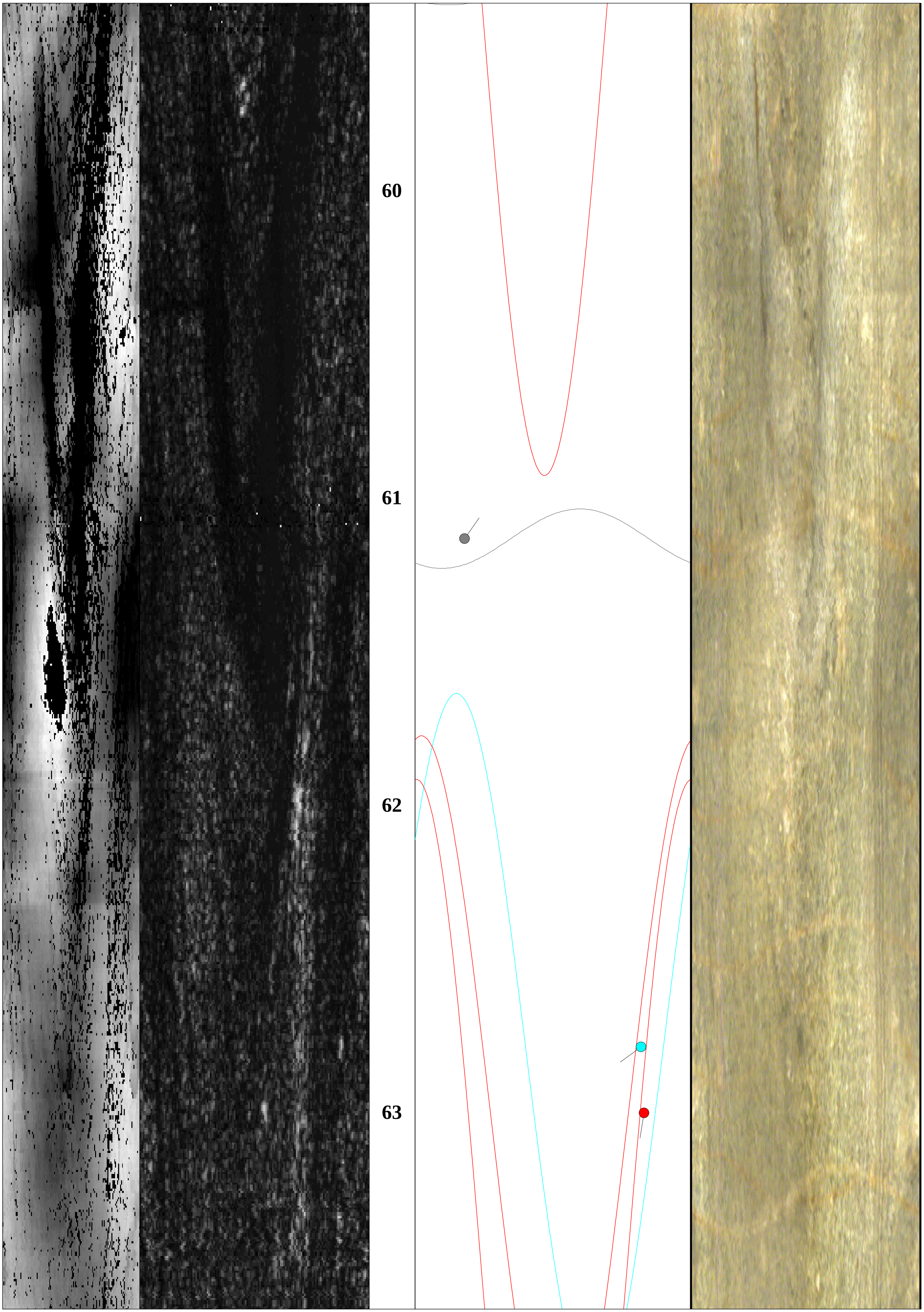

39
40
41
42

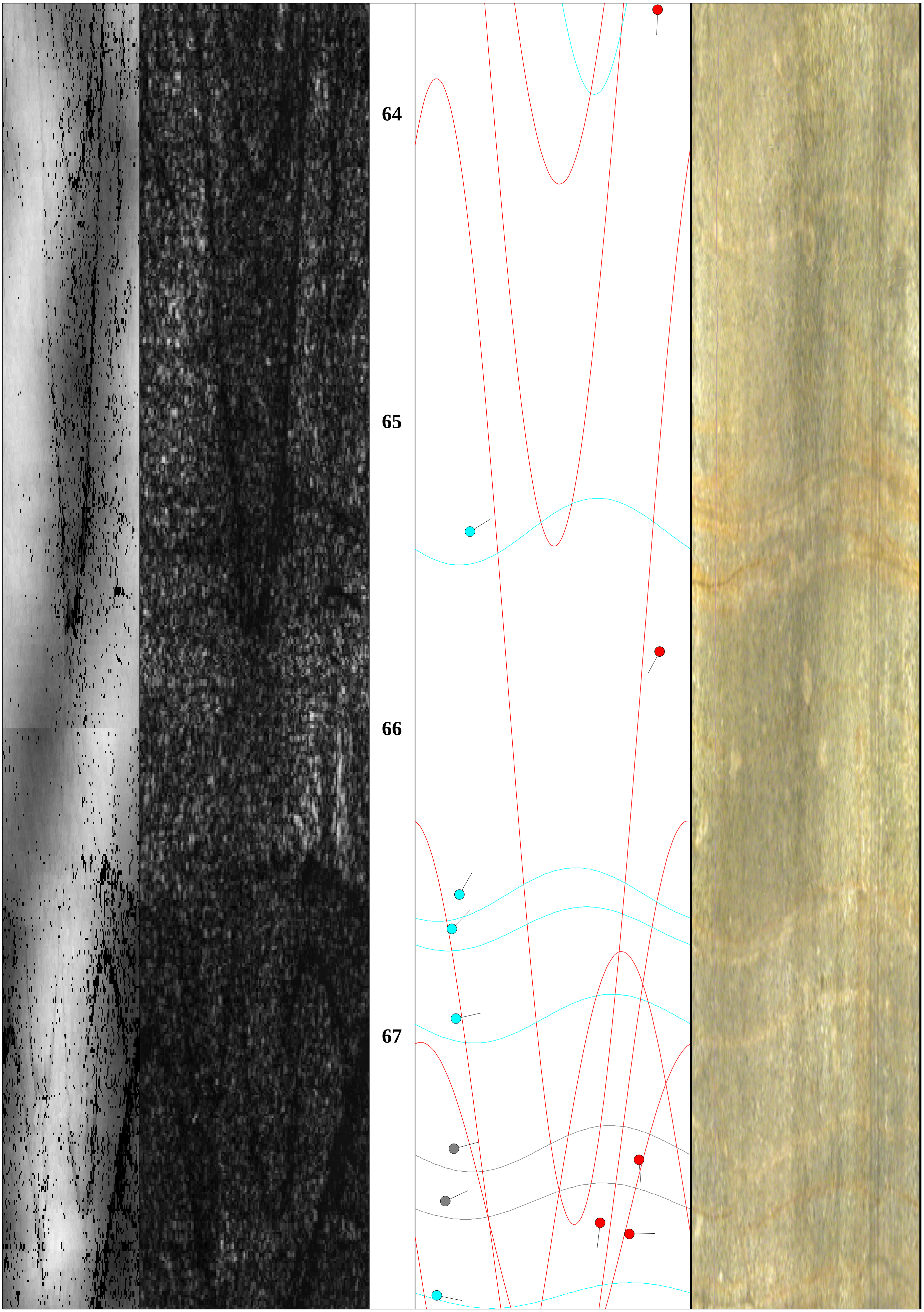

43
44
45
46

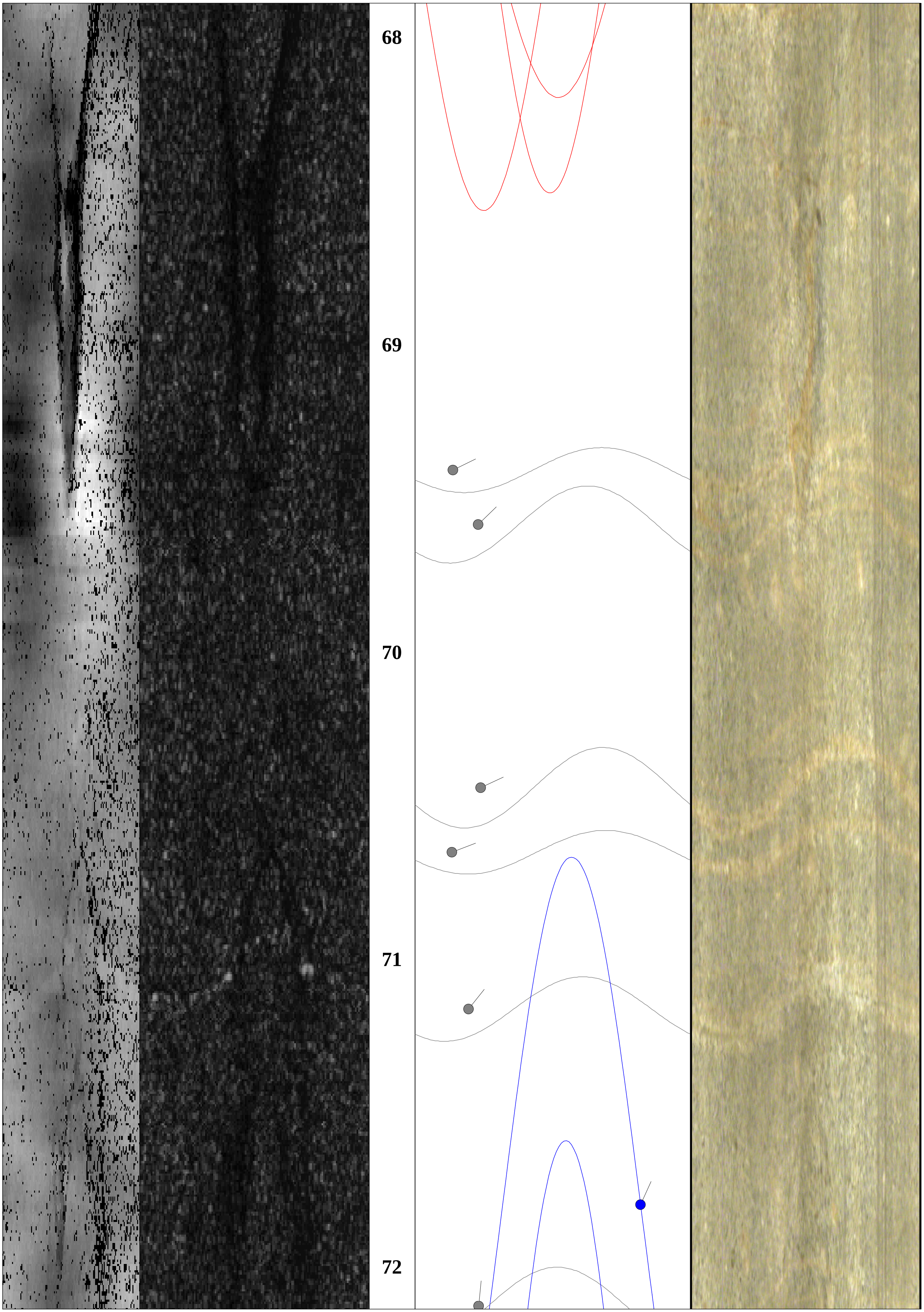

47
48
49
50

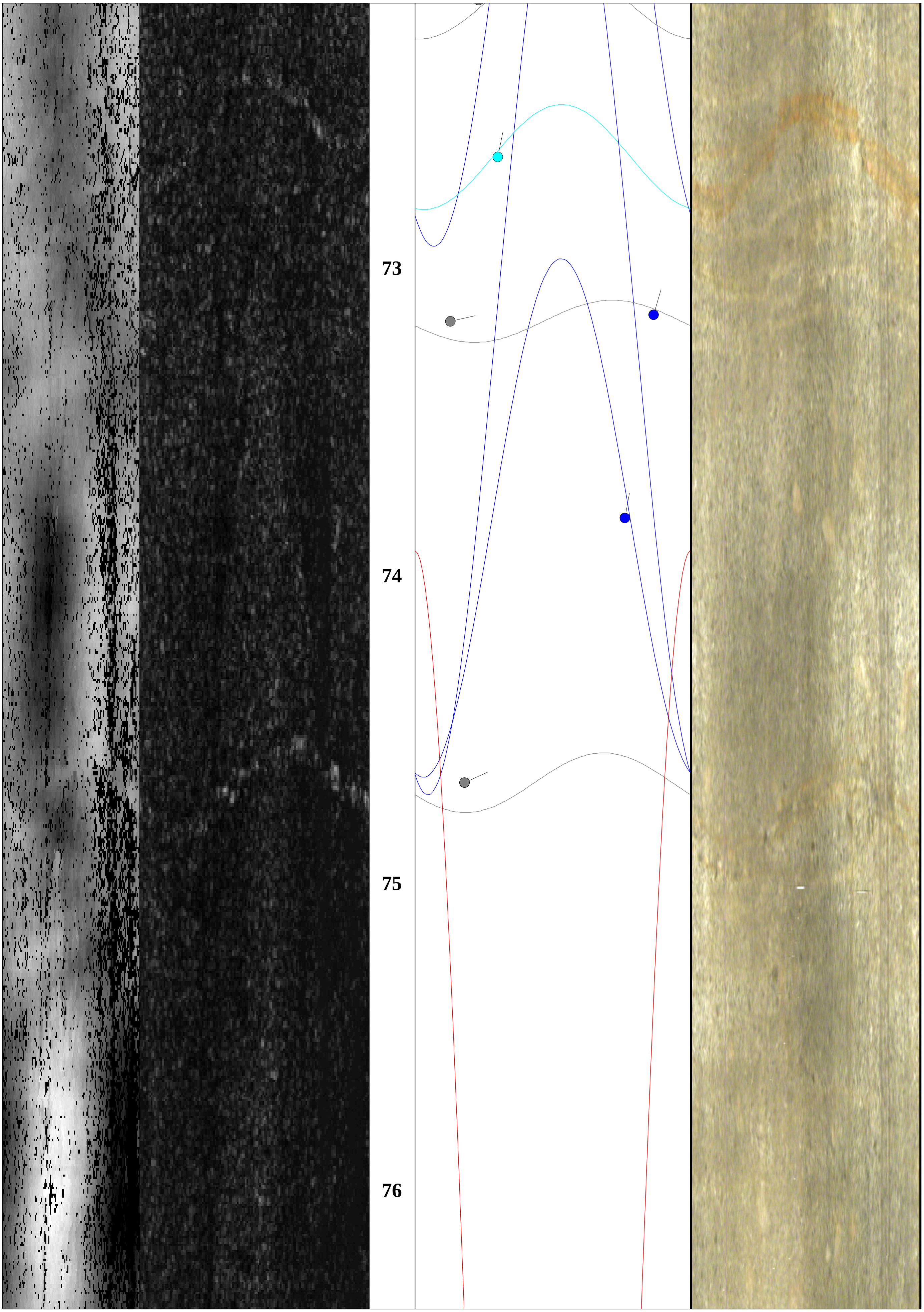

51
52
53
54
55

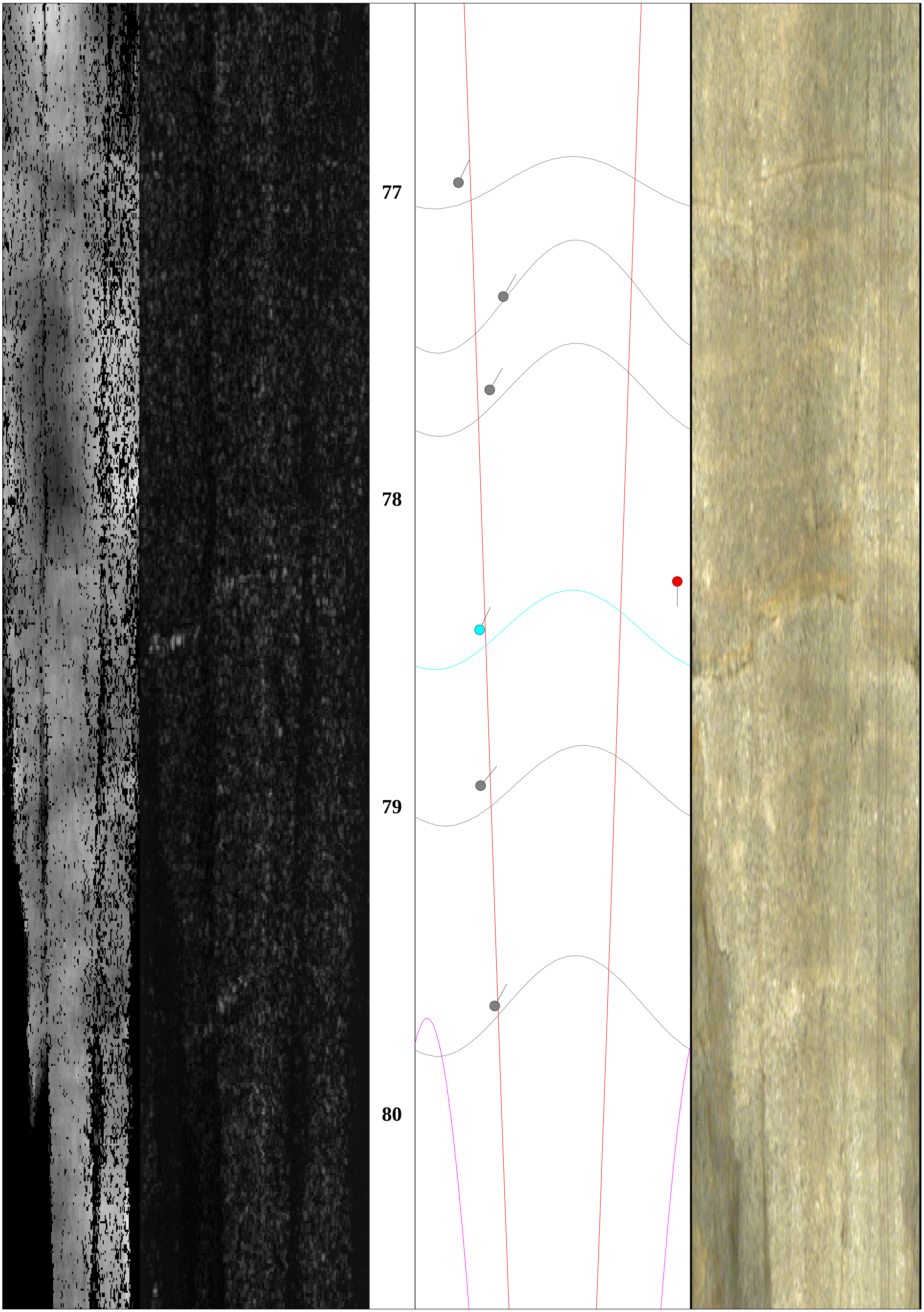

56
57
58
59

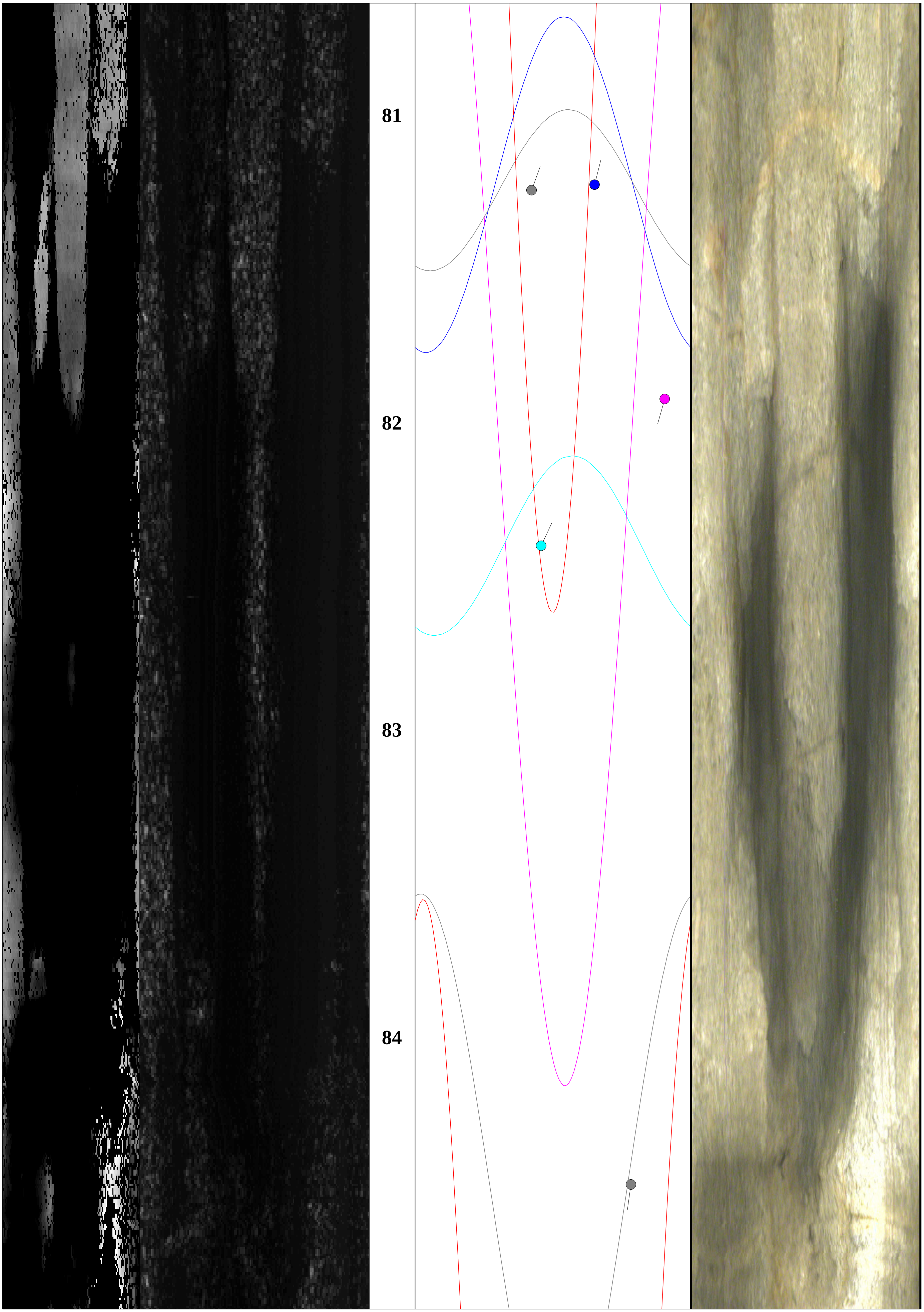

60
61
62
63

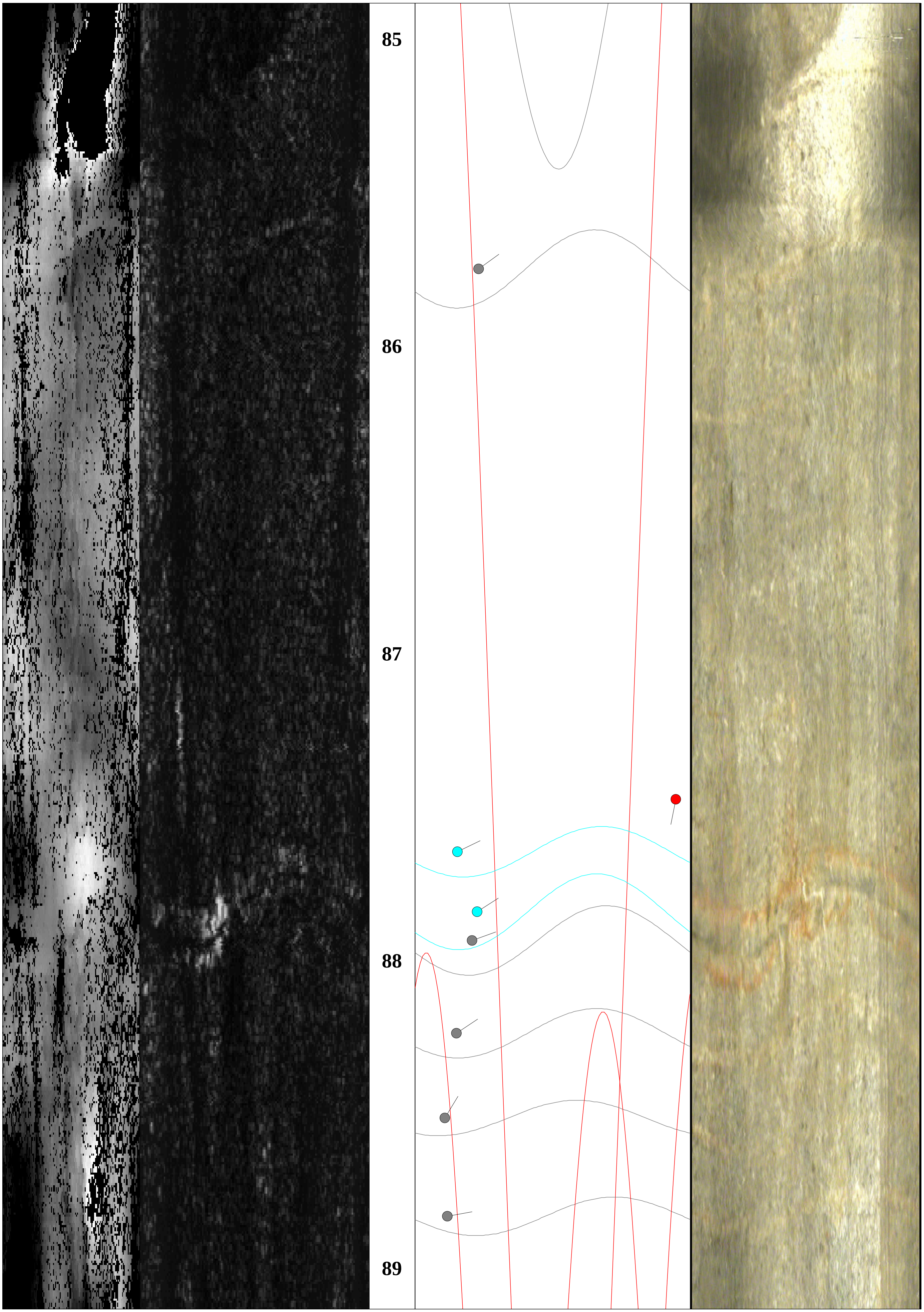

64
65
66
67

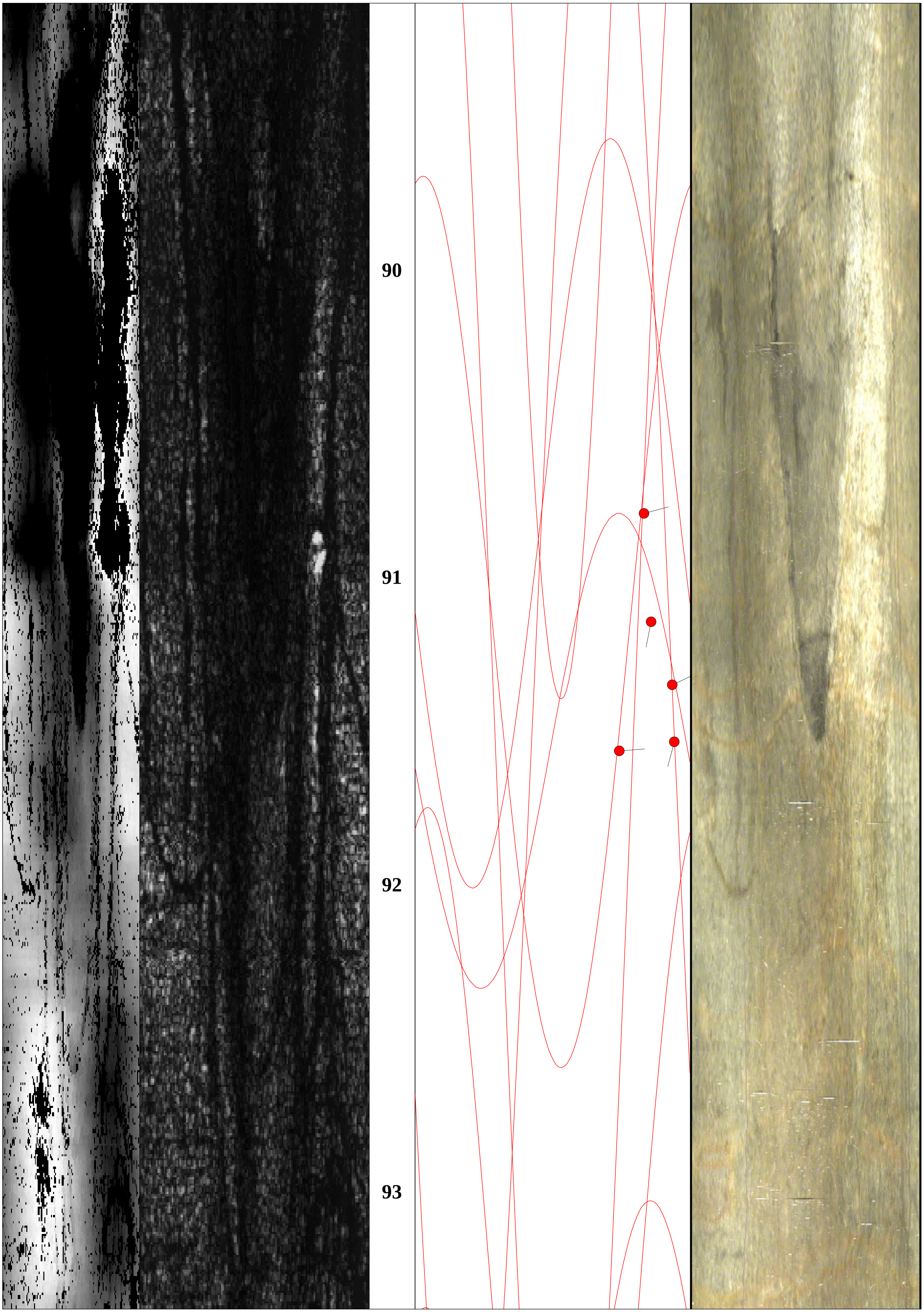

68
69
70
71
72

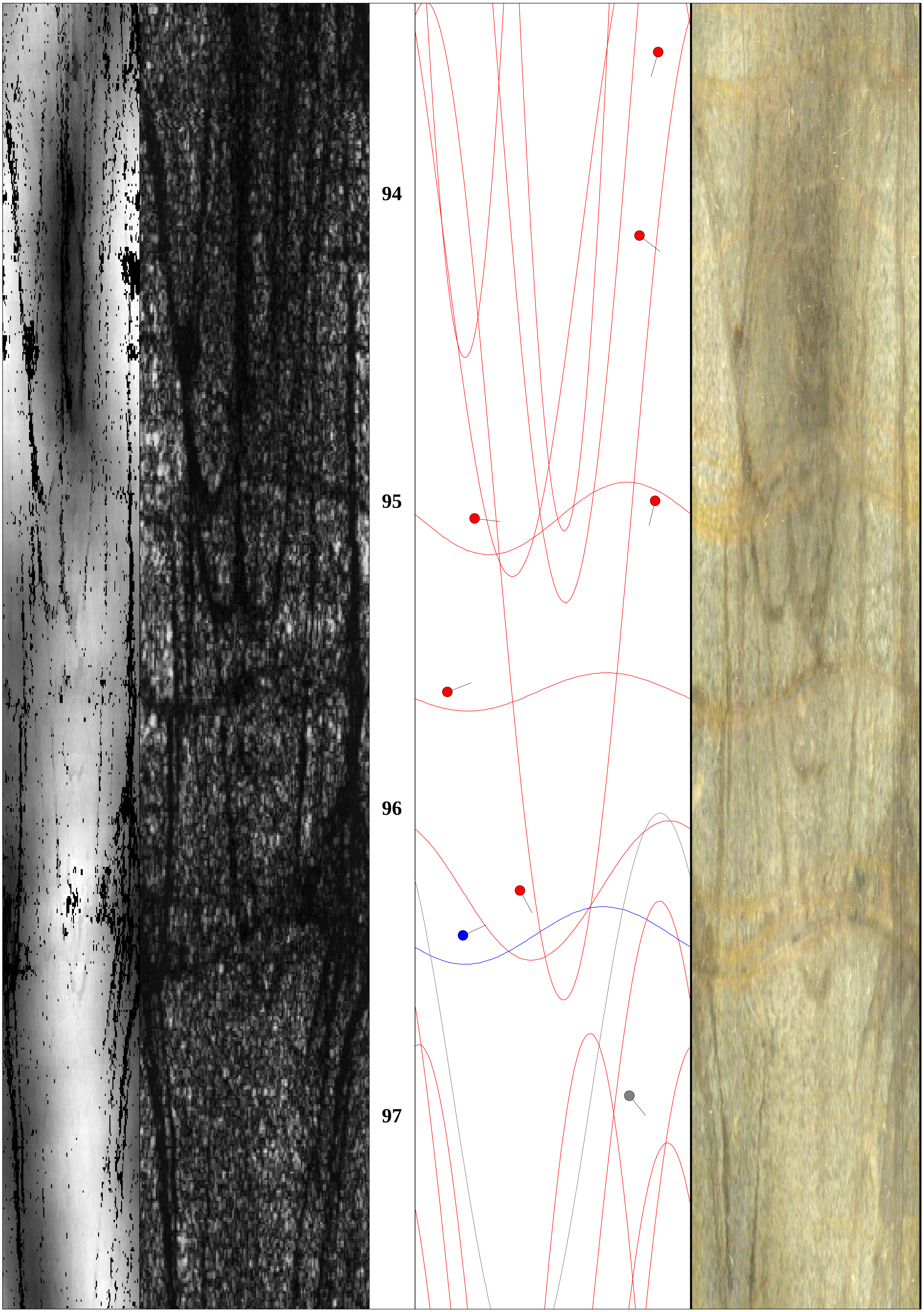

73
74
75
76

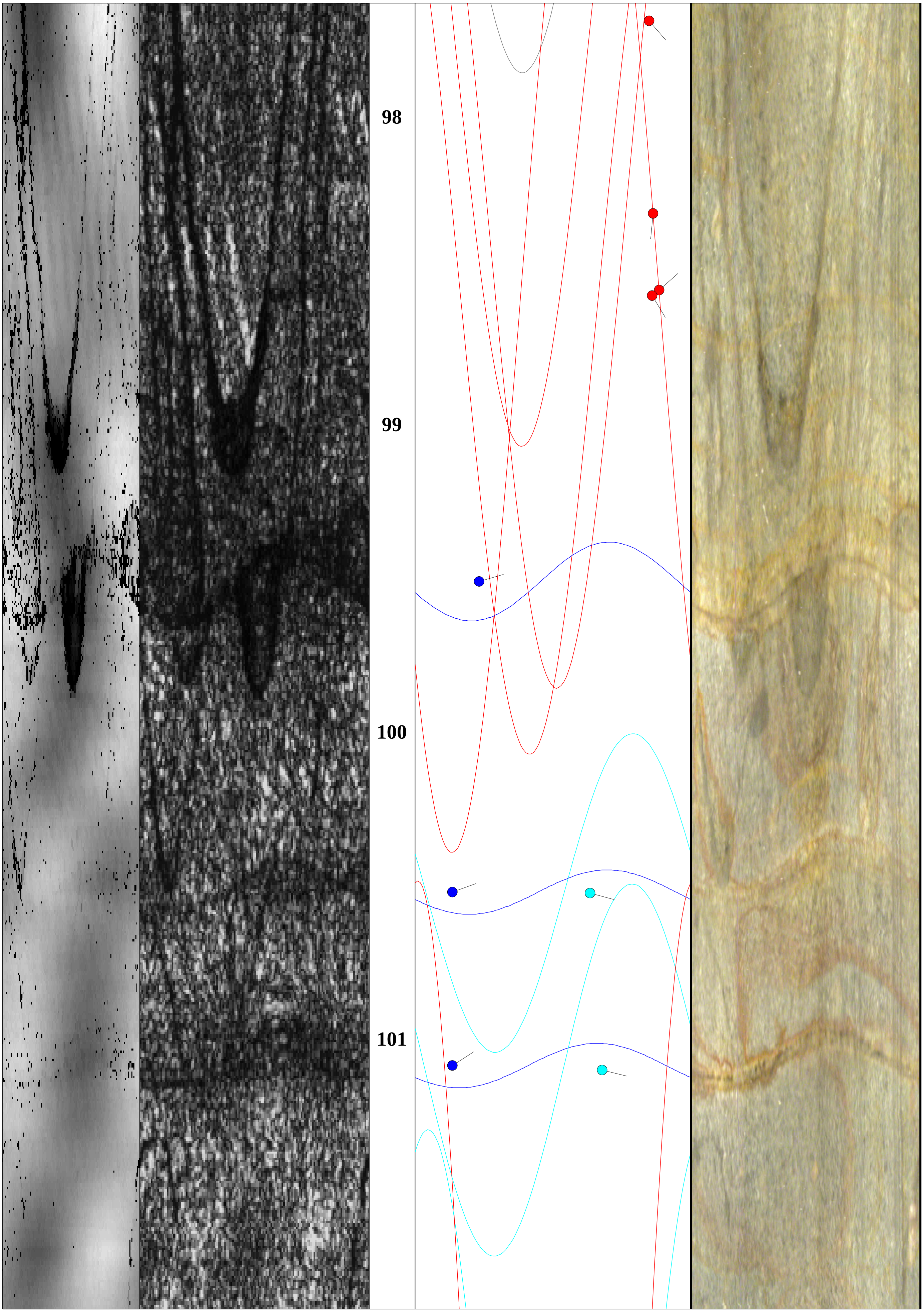

77
78
79
80

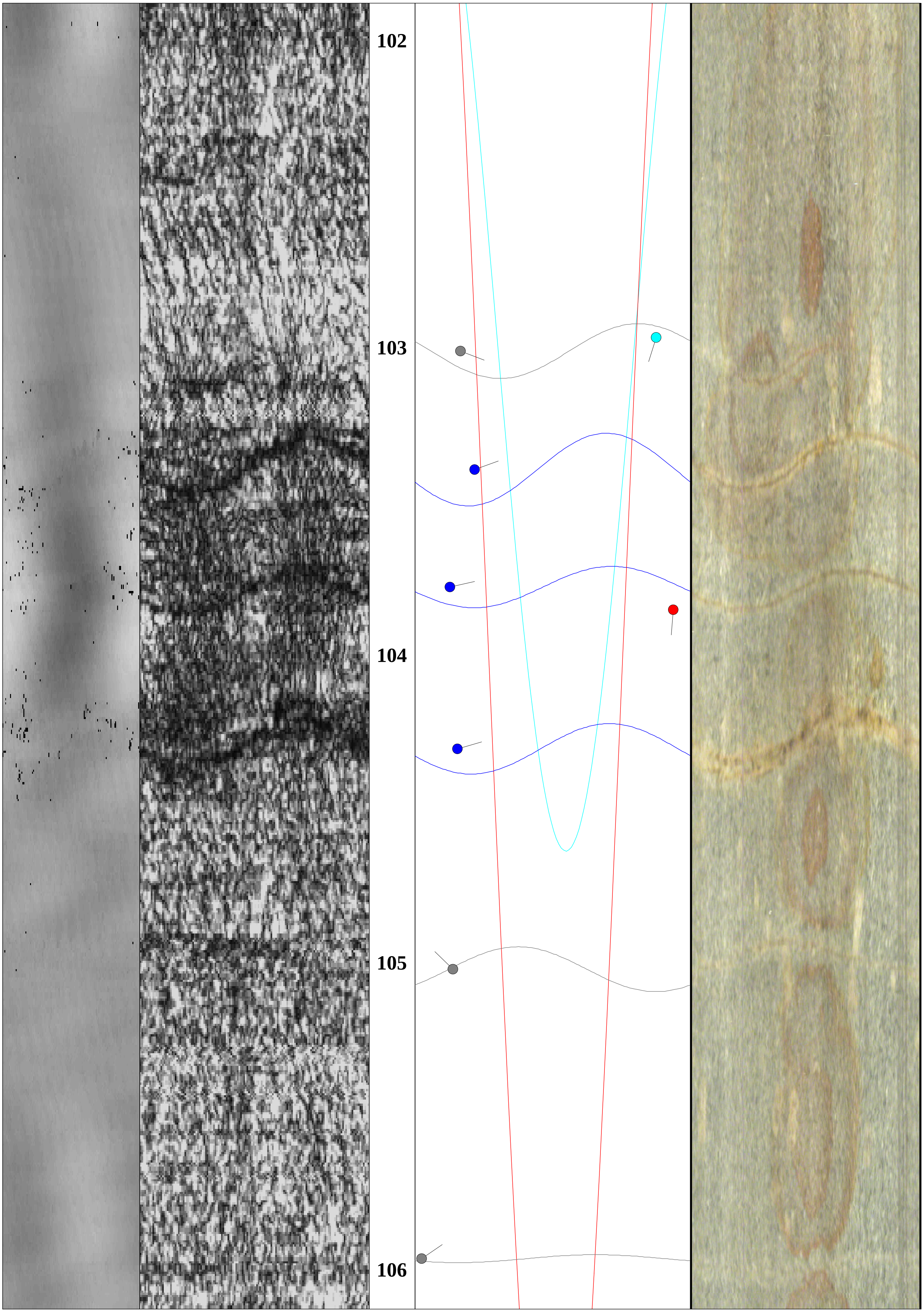

81
82
83
84

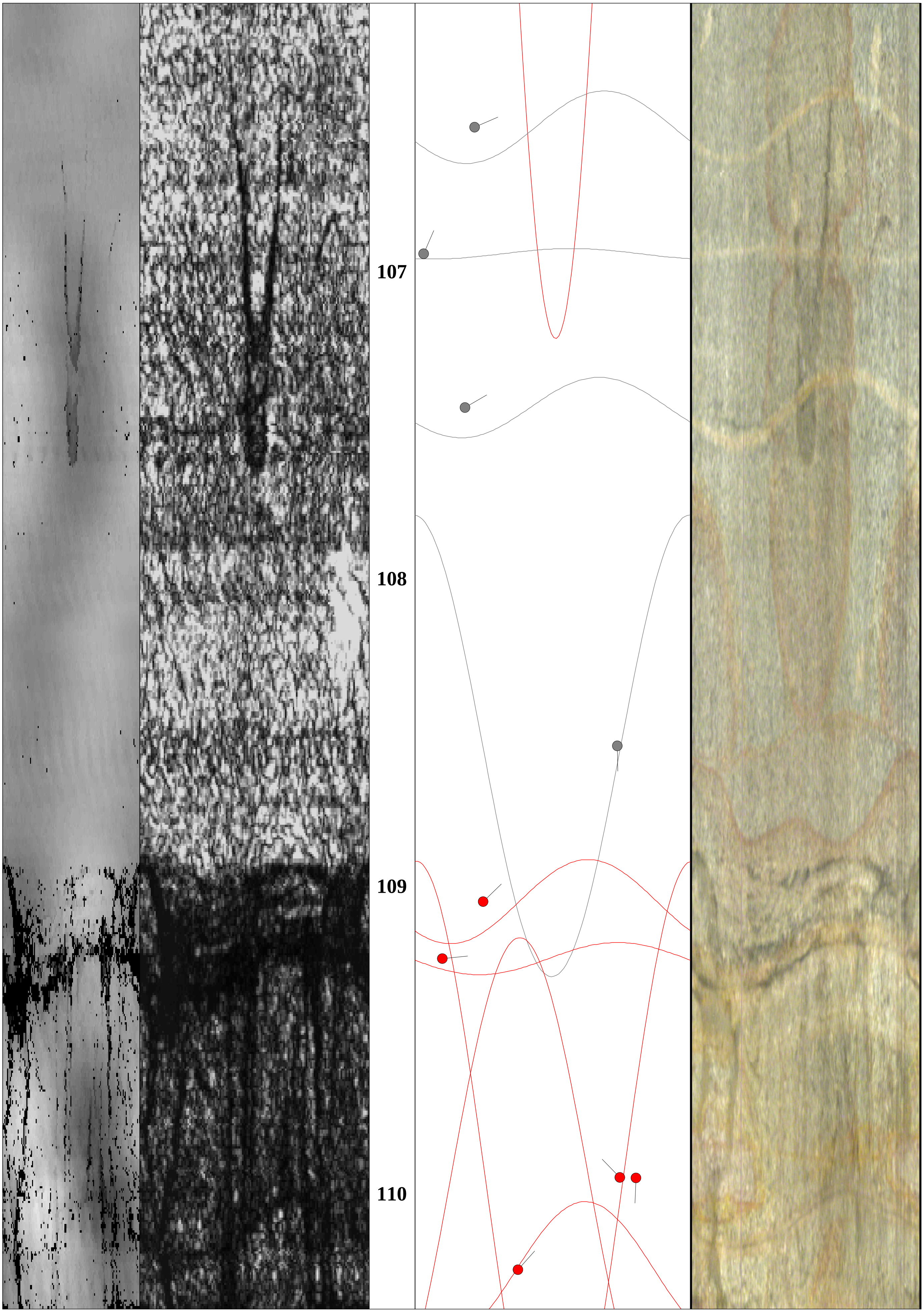

85
86
87
88
89

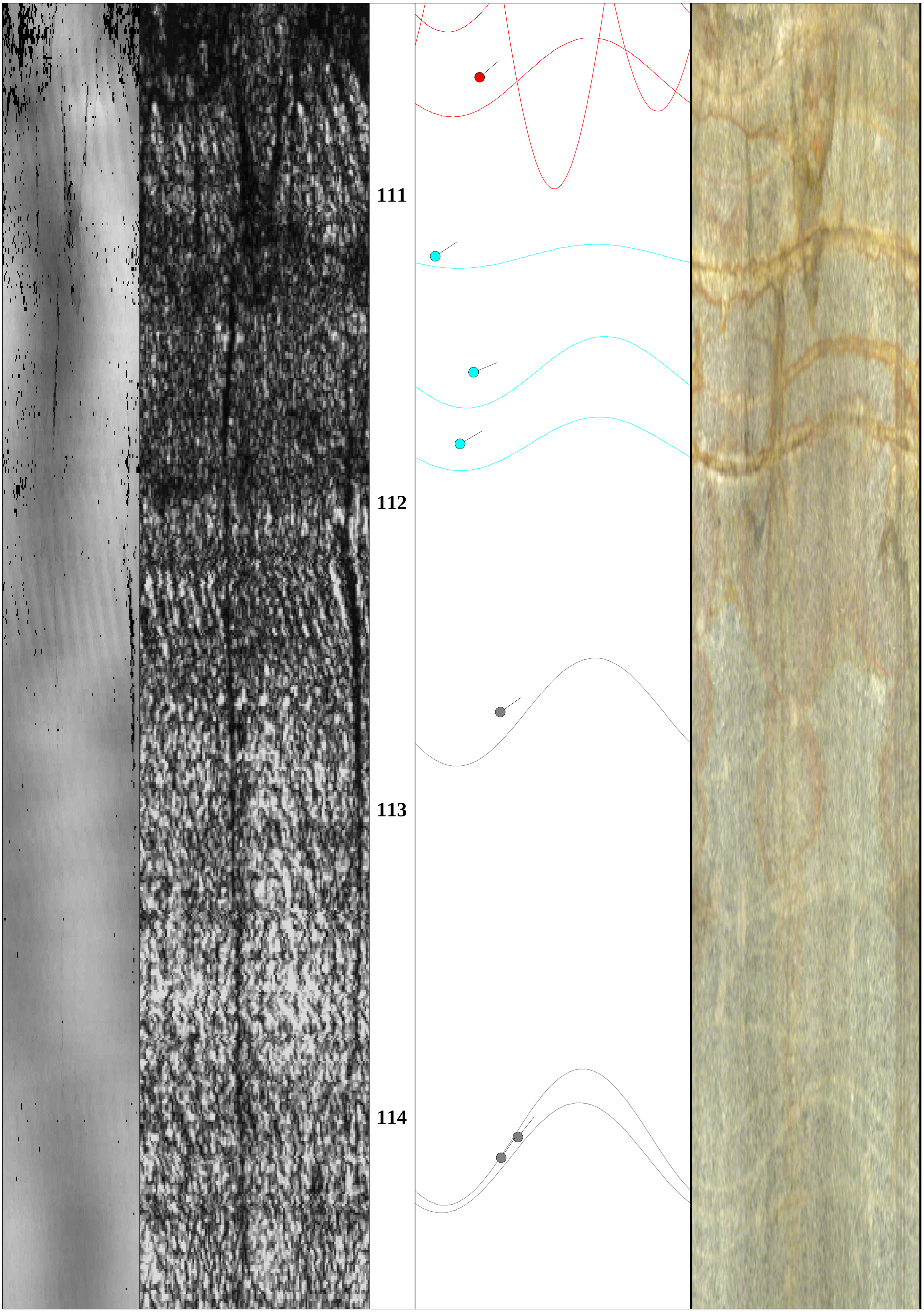

90
91
92
93

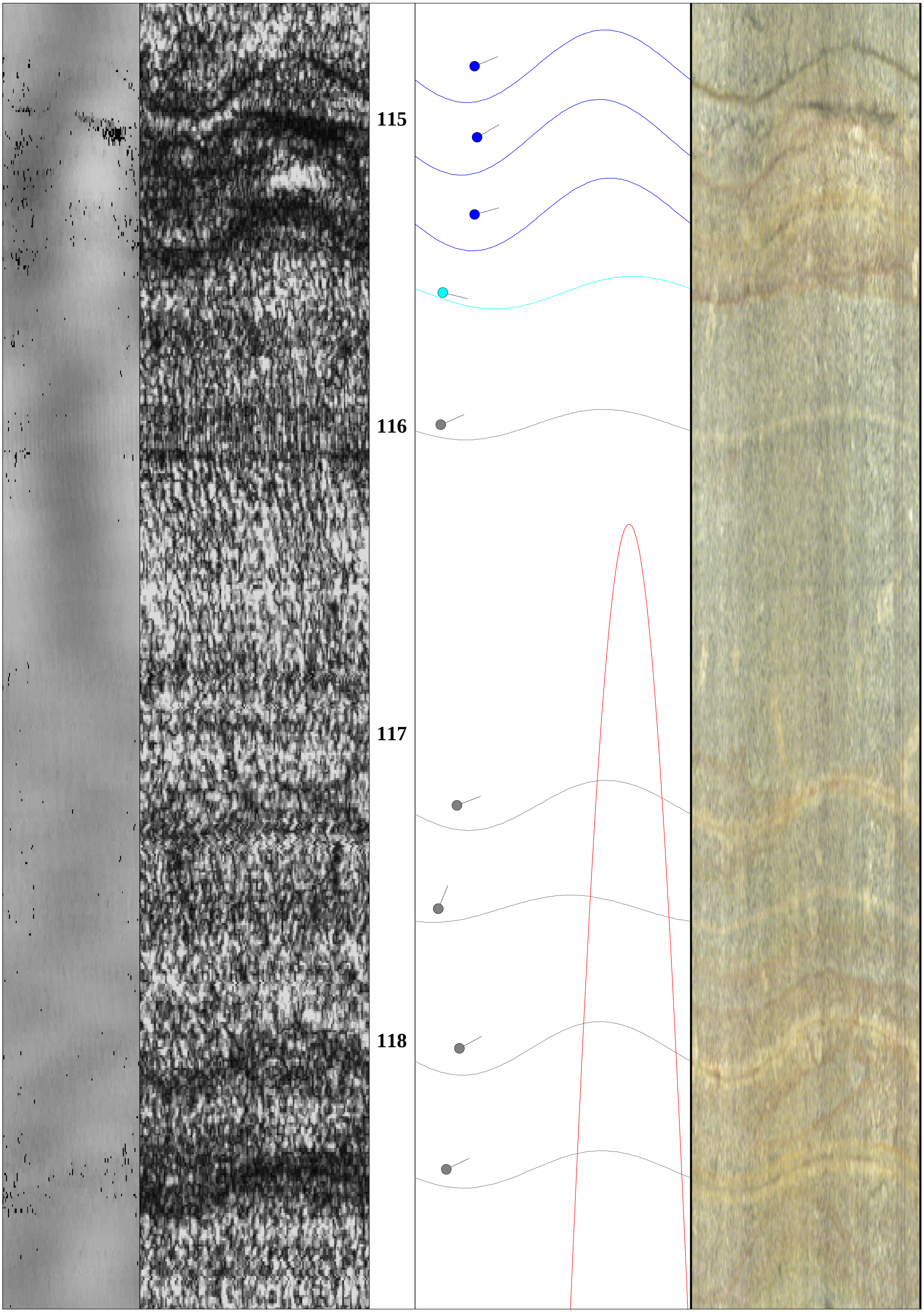

94
95
96
97

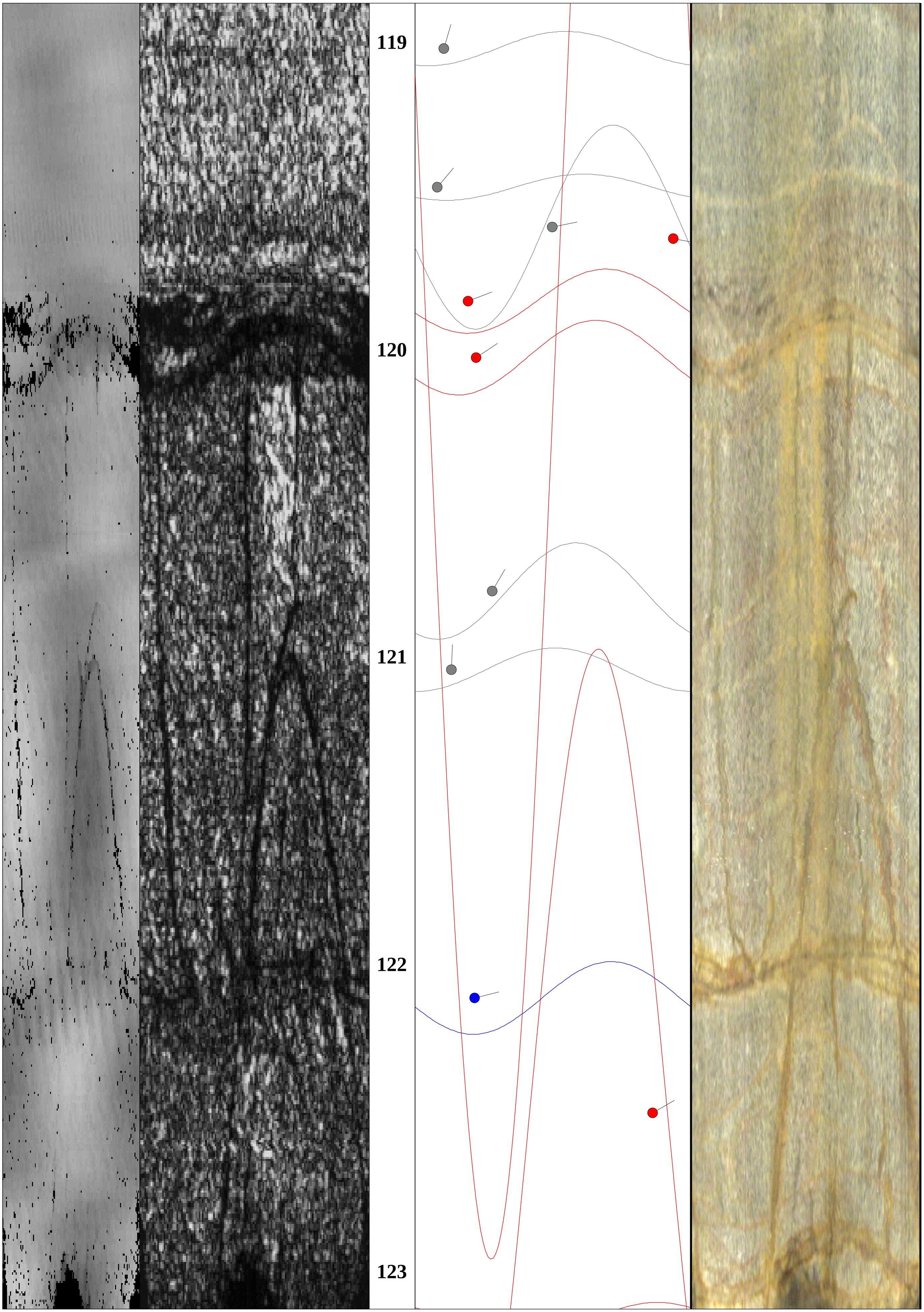

98
99
100
101

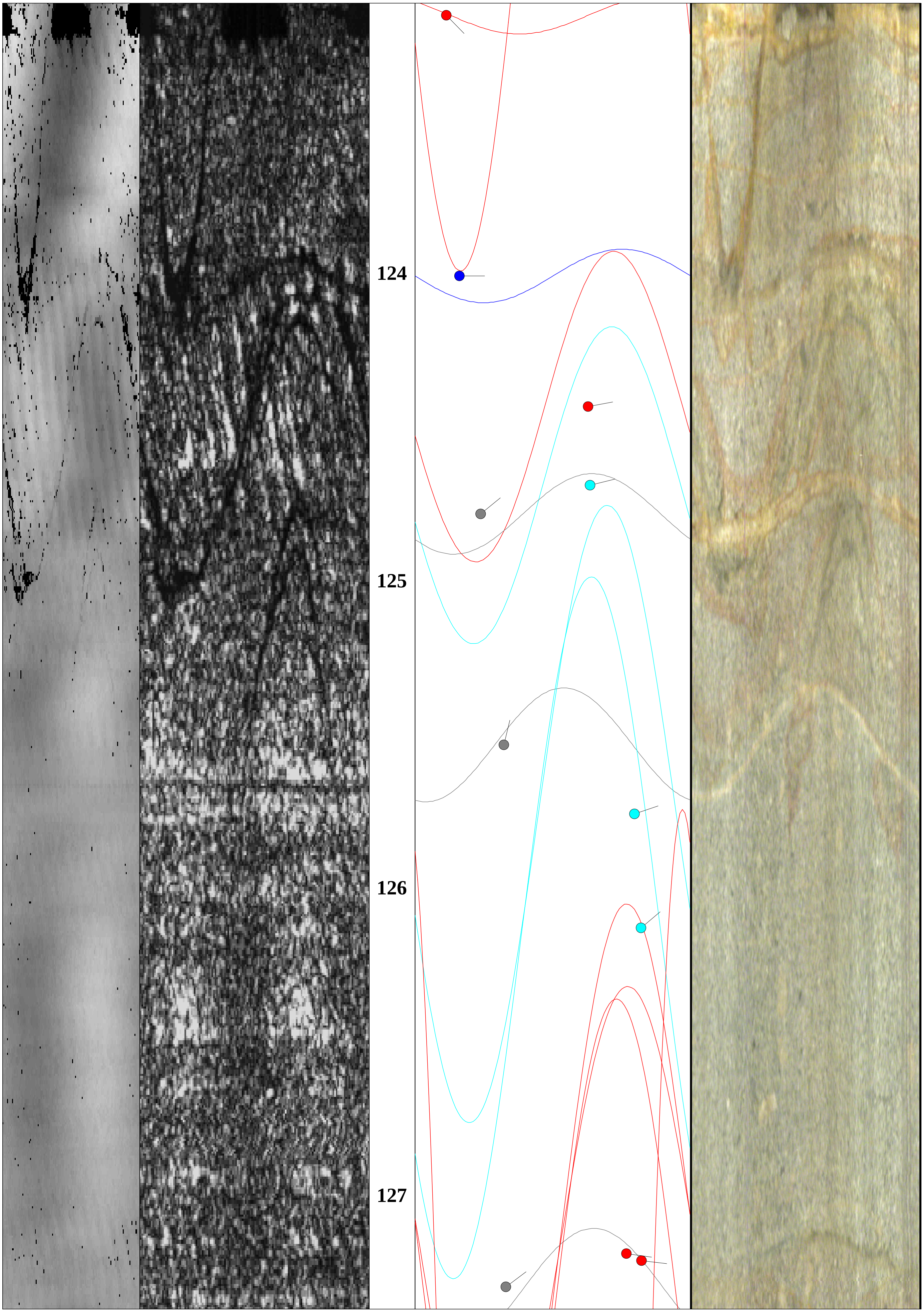

102
103
104
105
106

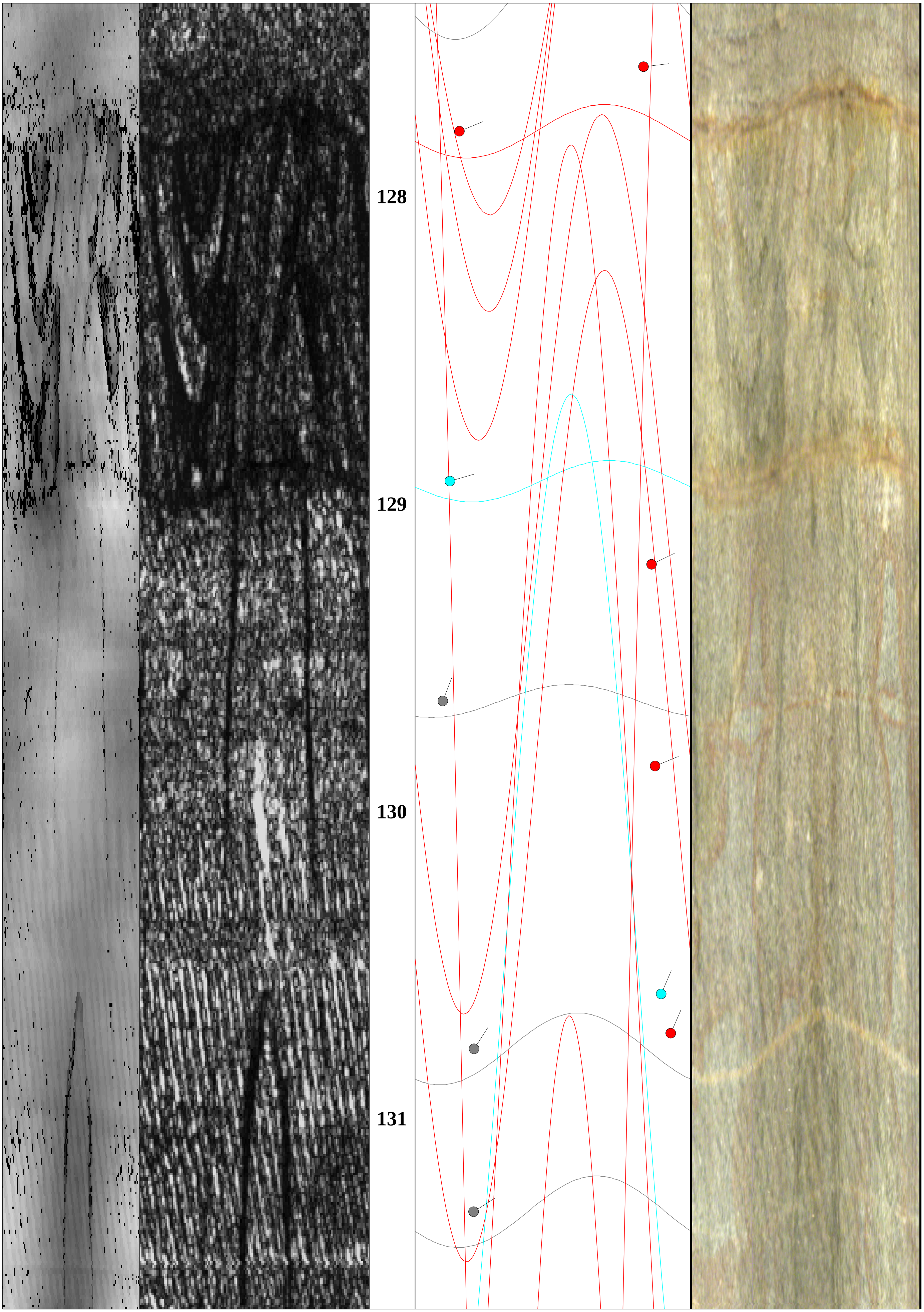

107
108
109
110


111
112
113
114

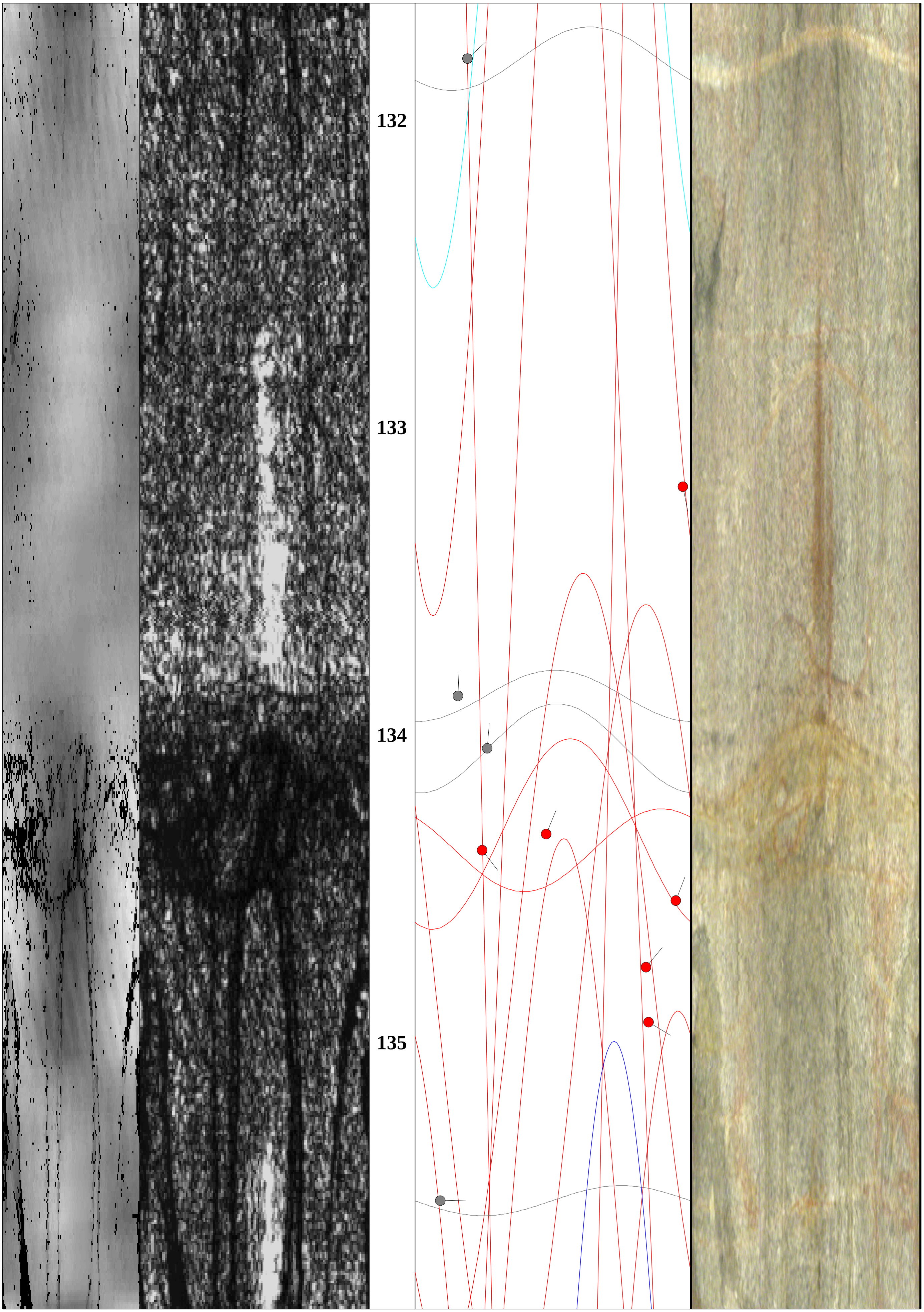

115
116
117
118

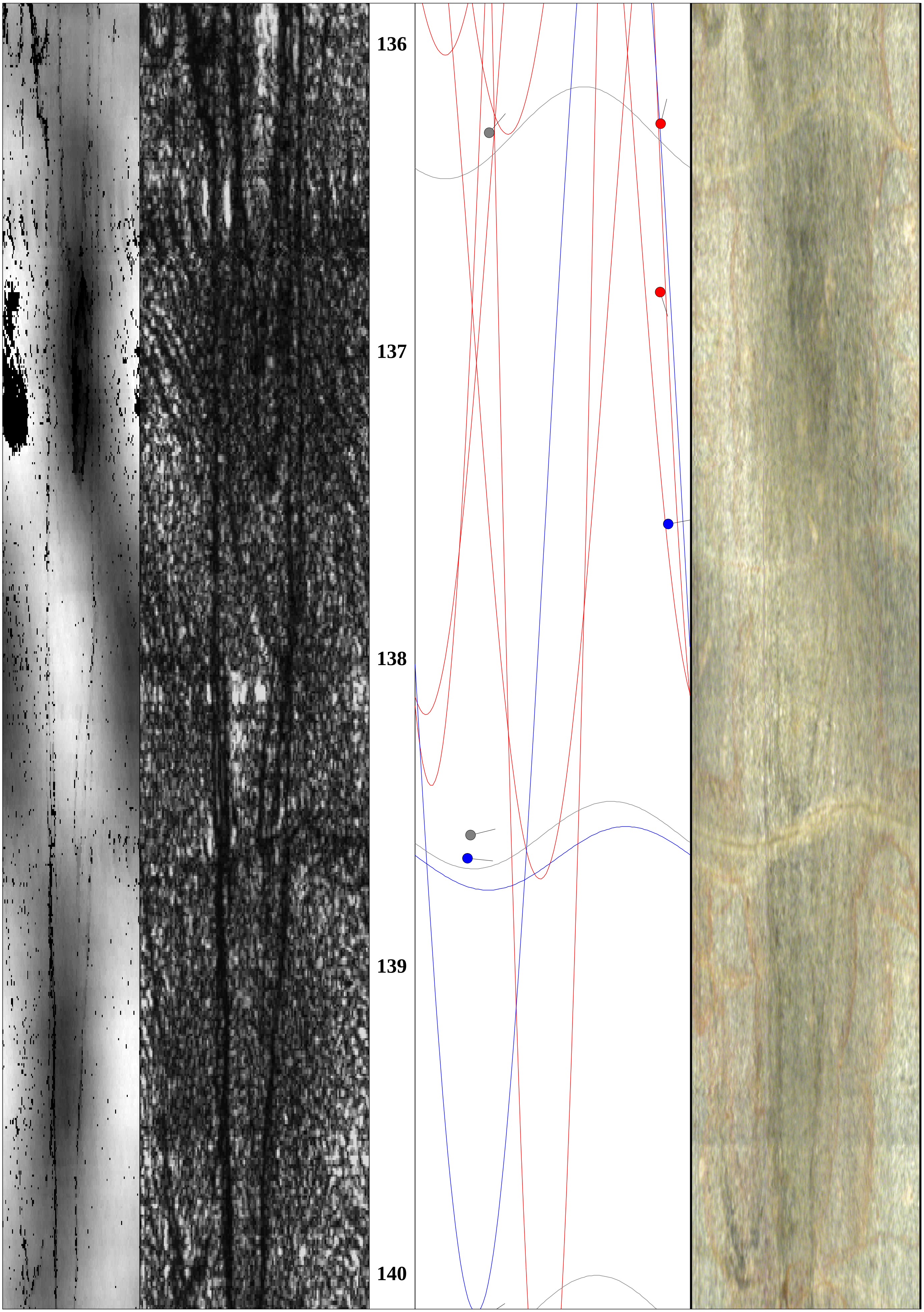

119
120
121
122
123

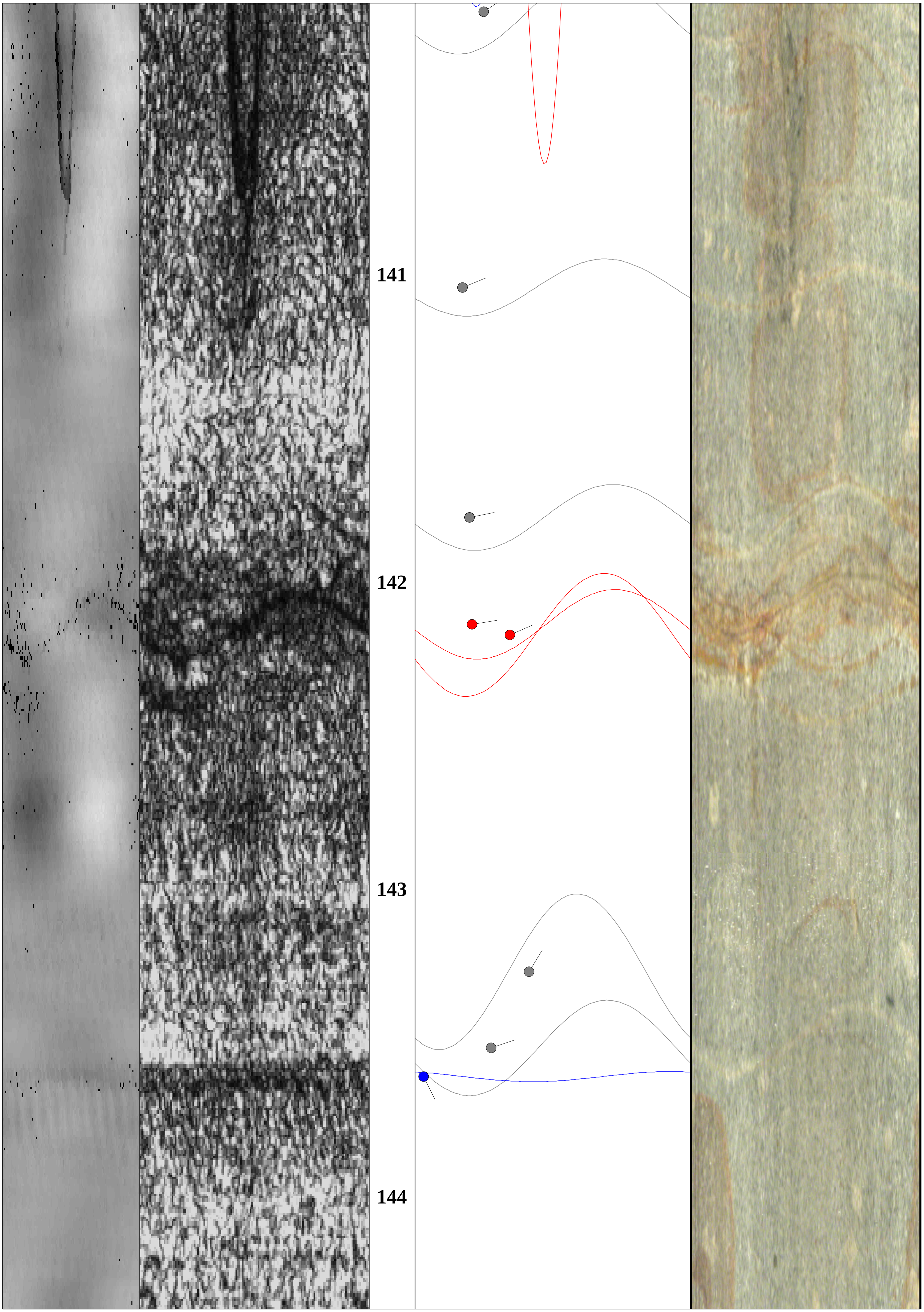

124
125
126
127

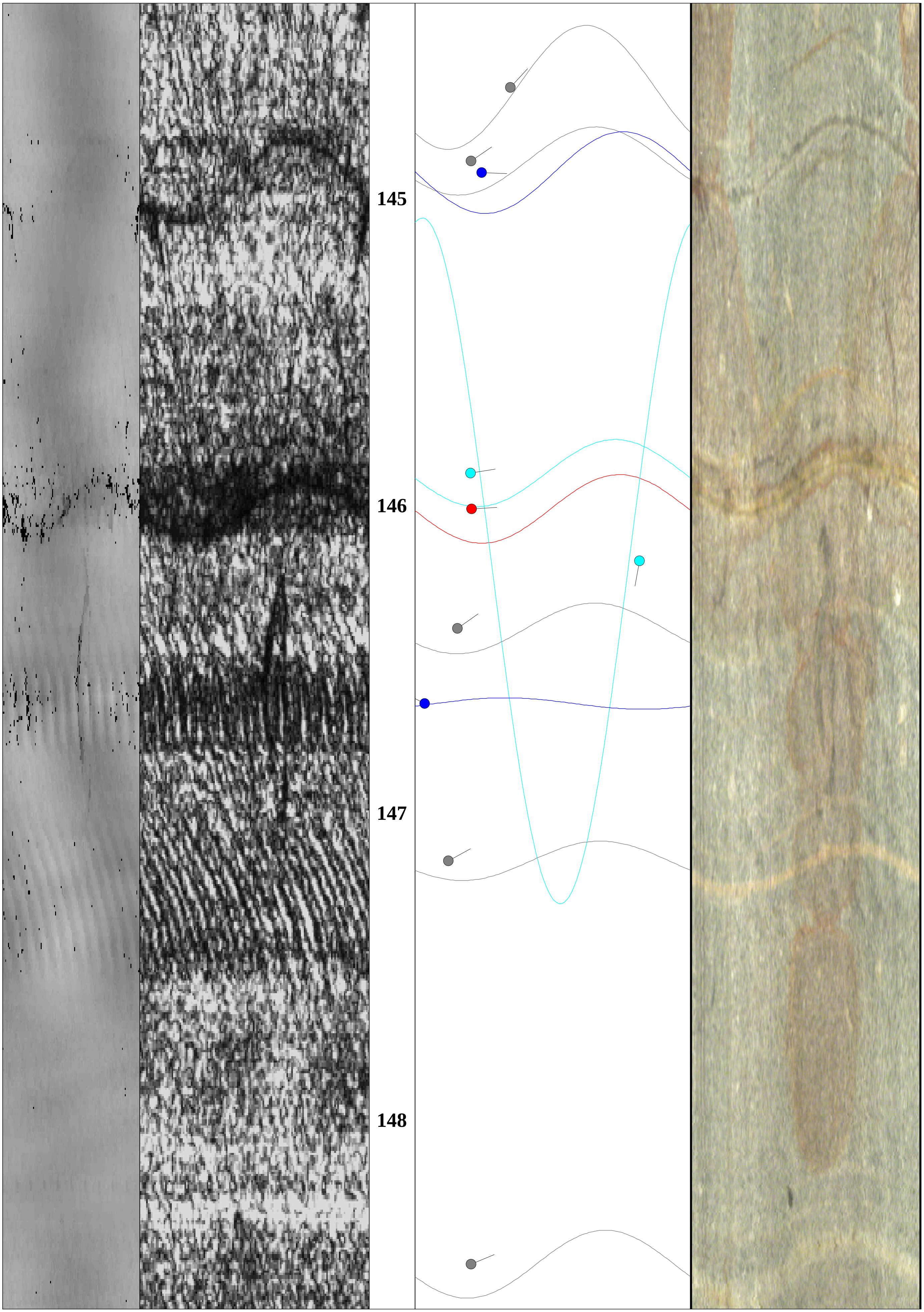


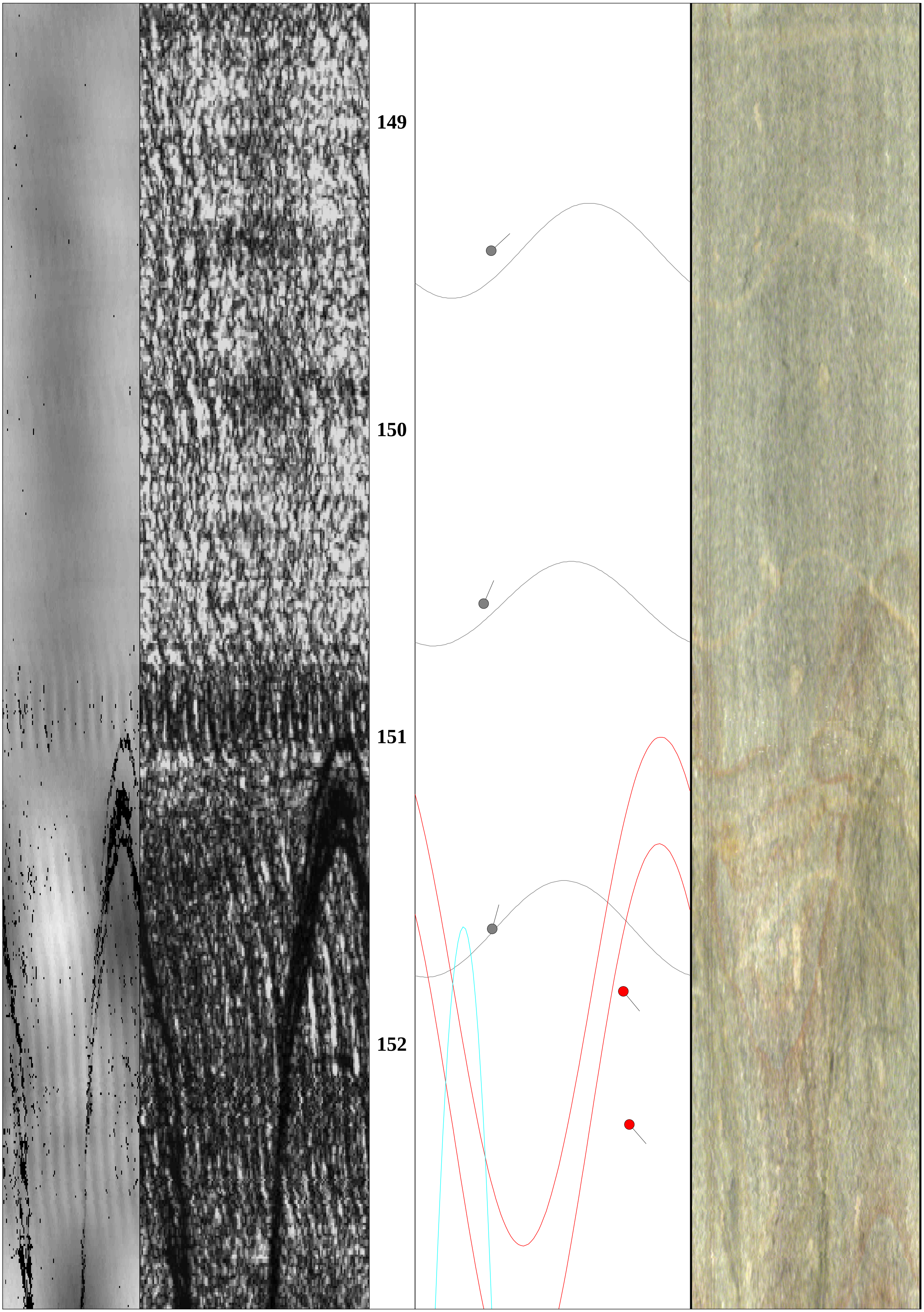
128
129
130
131

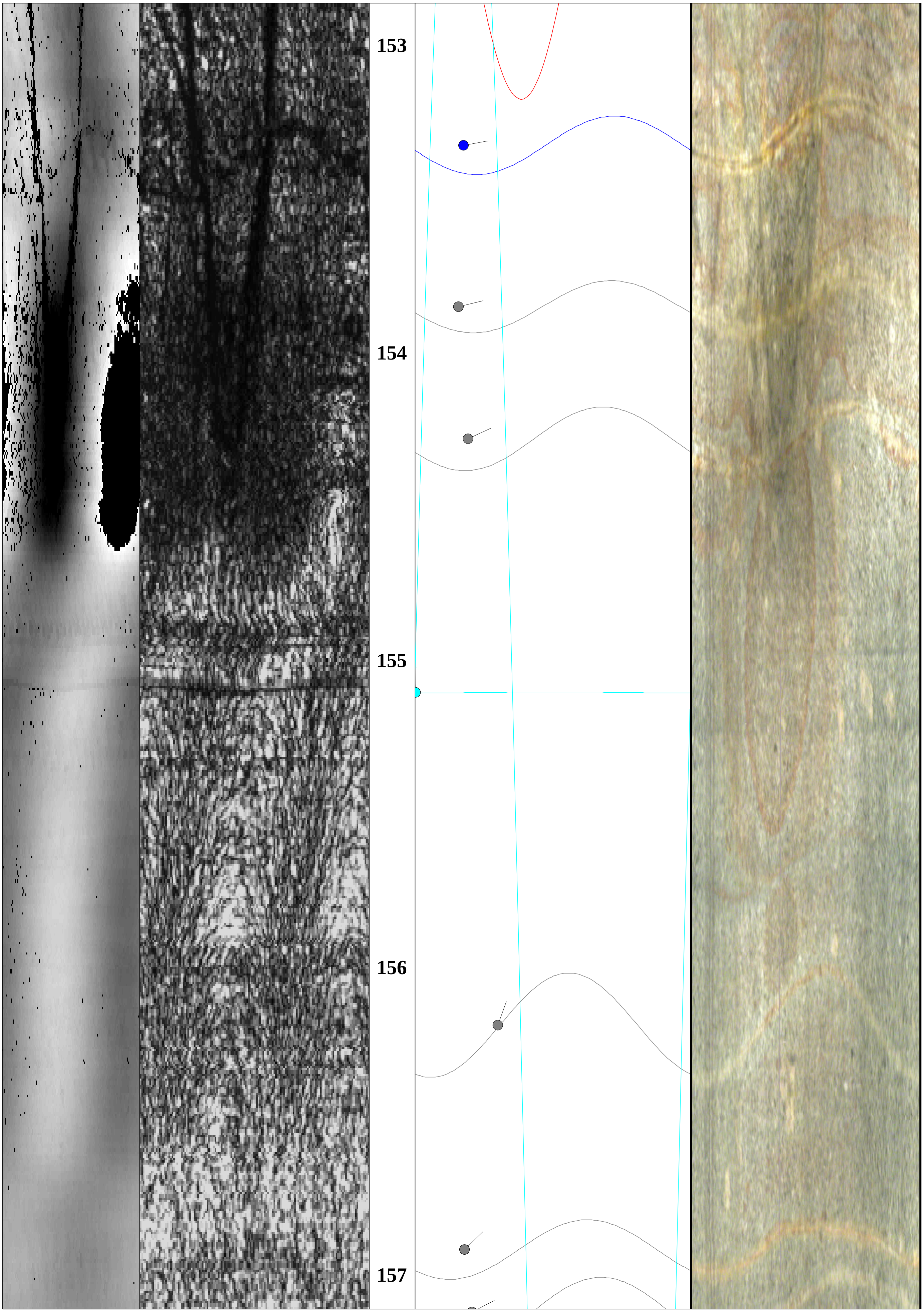

132
133
134
135

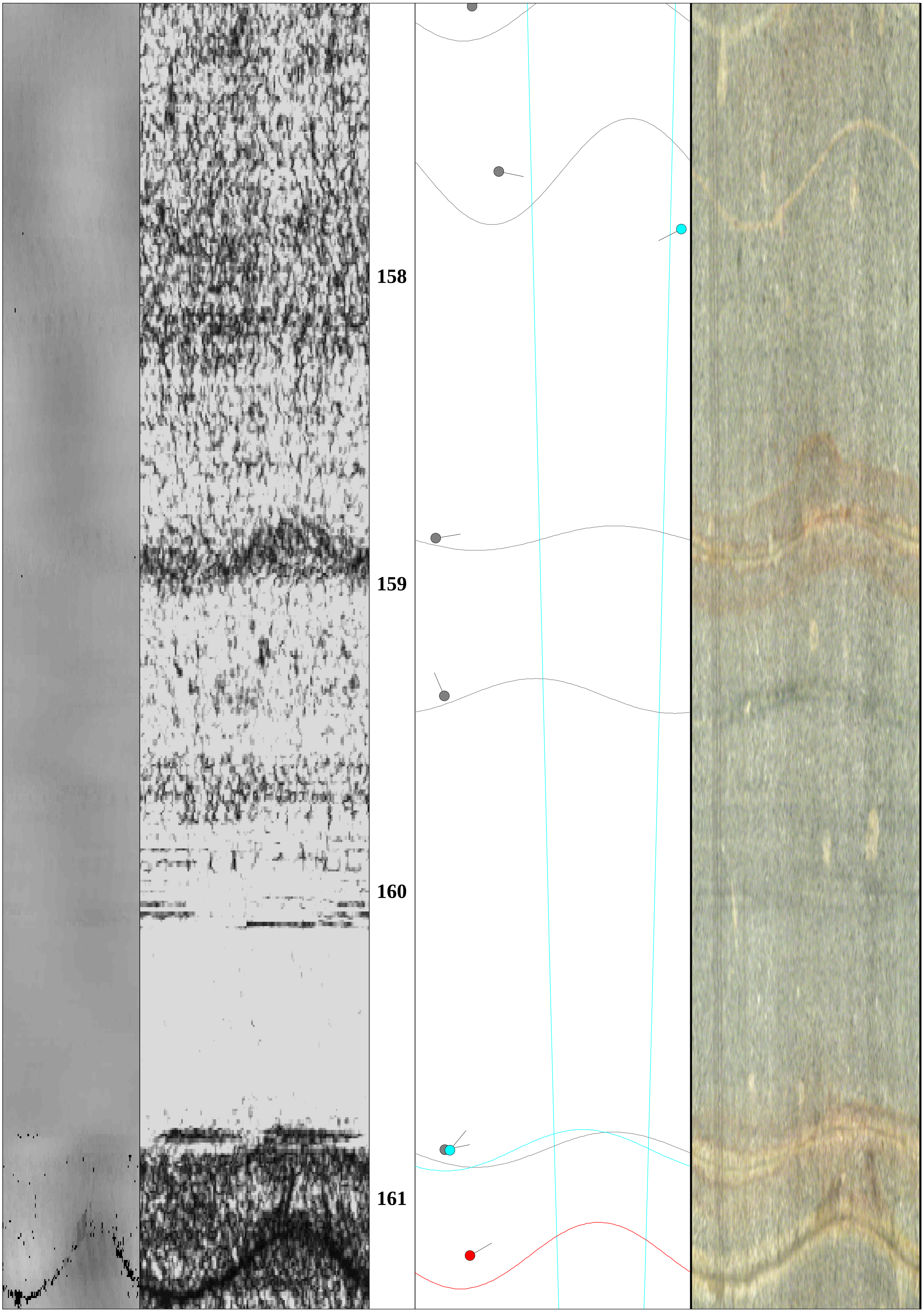

136
137
138
139
140

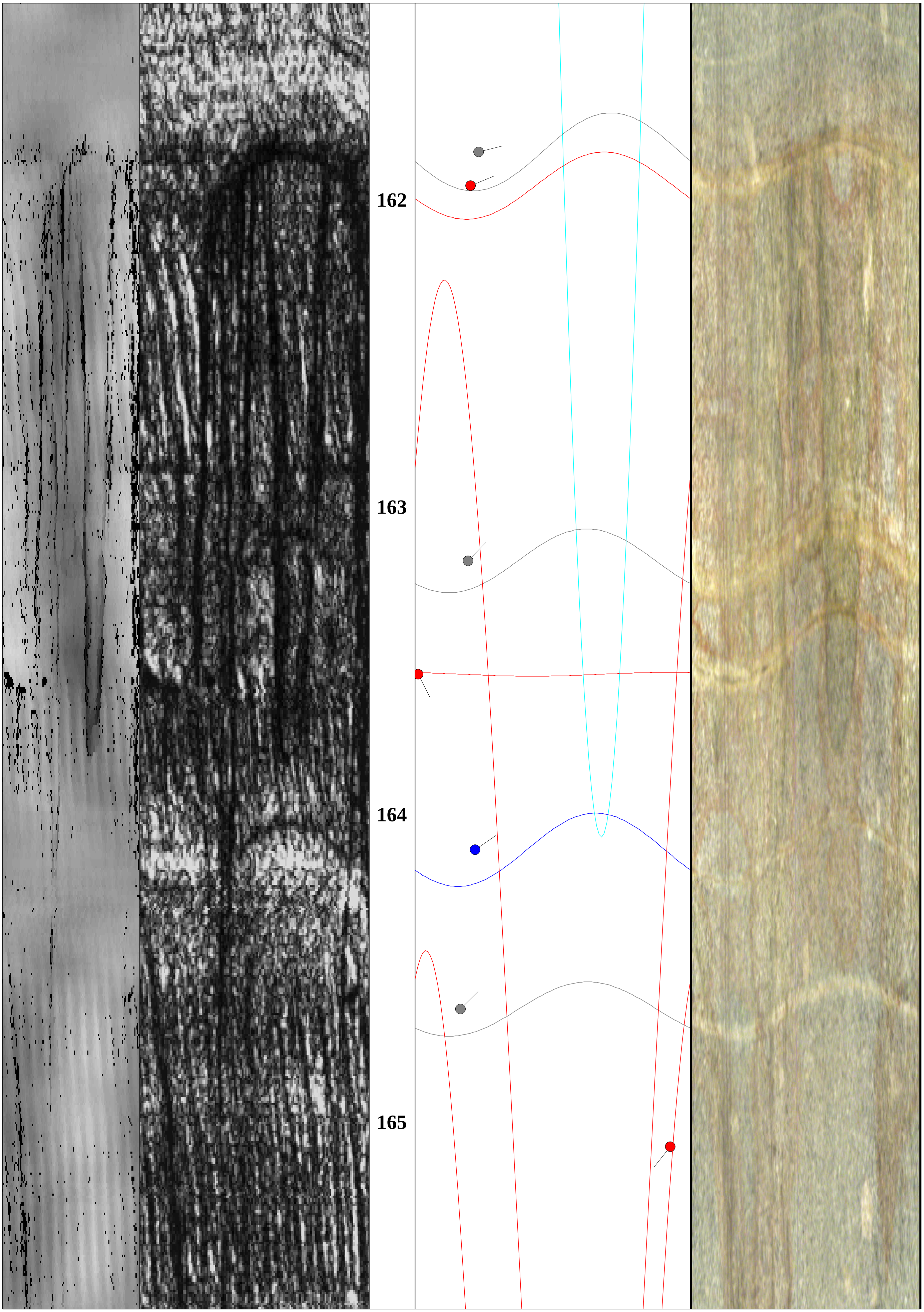

141
142
143
144

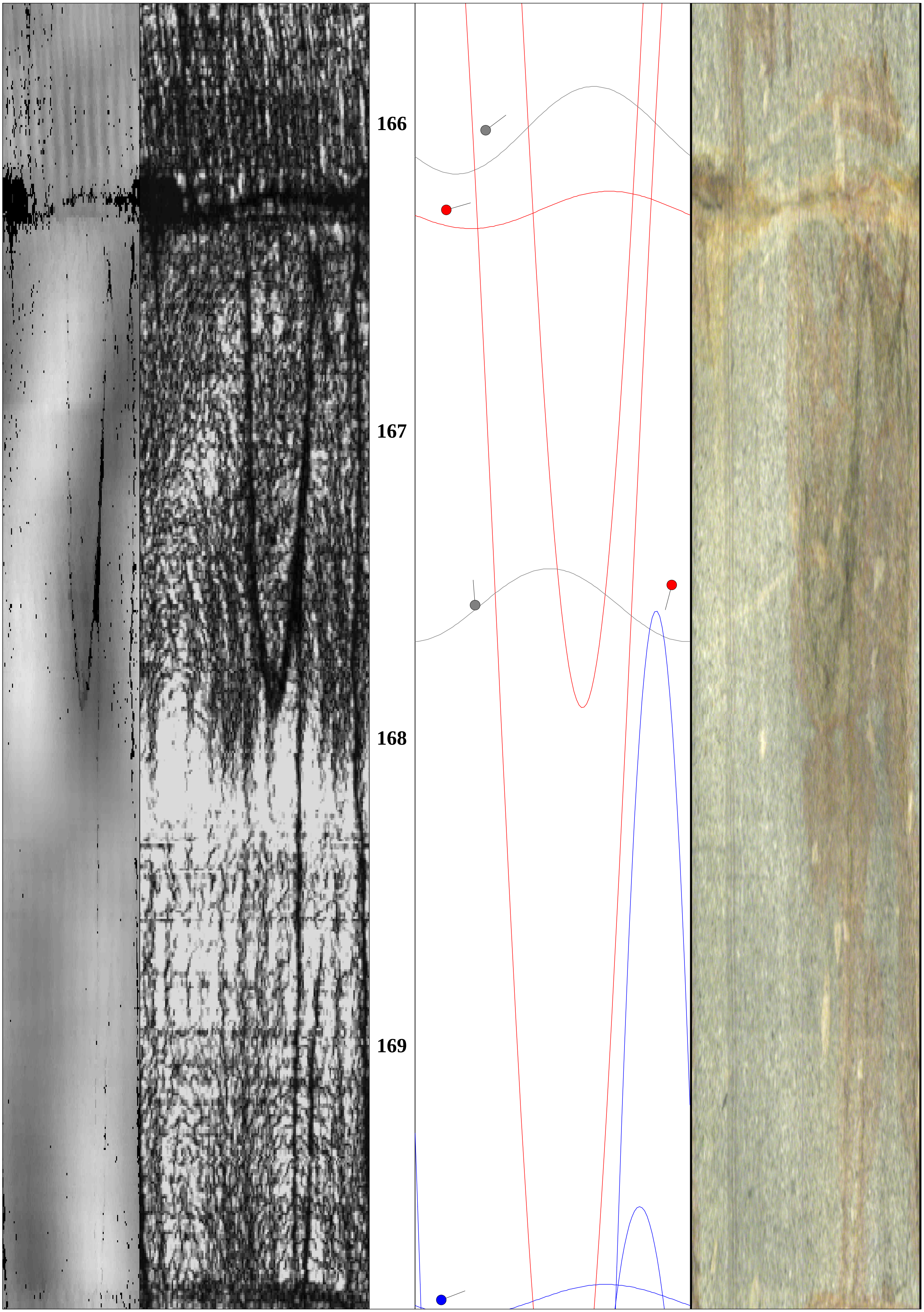

145
146
147
148

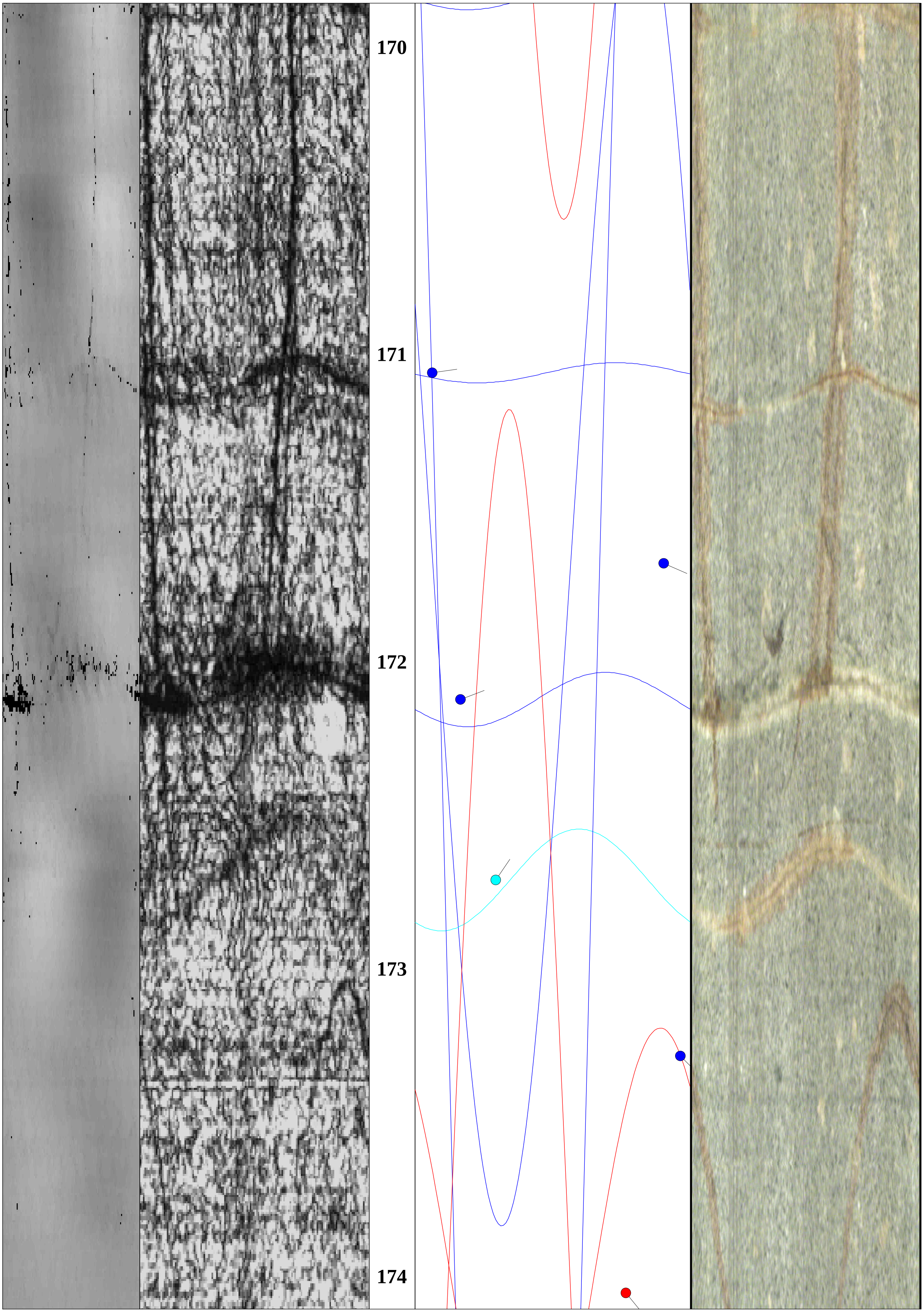

149
150
151
152

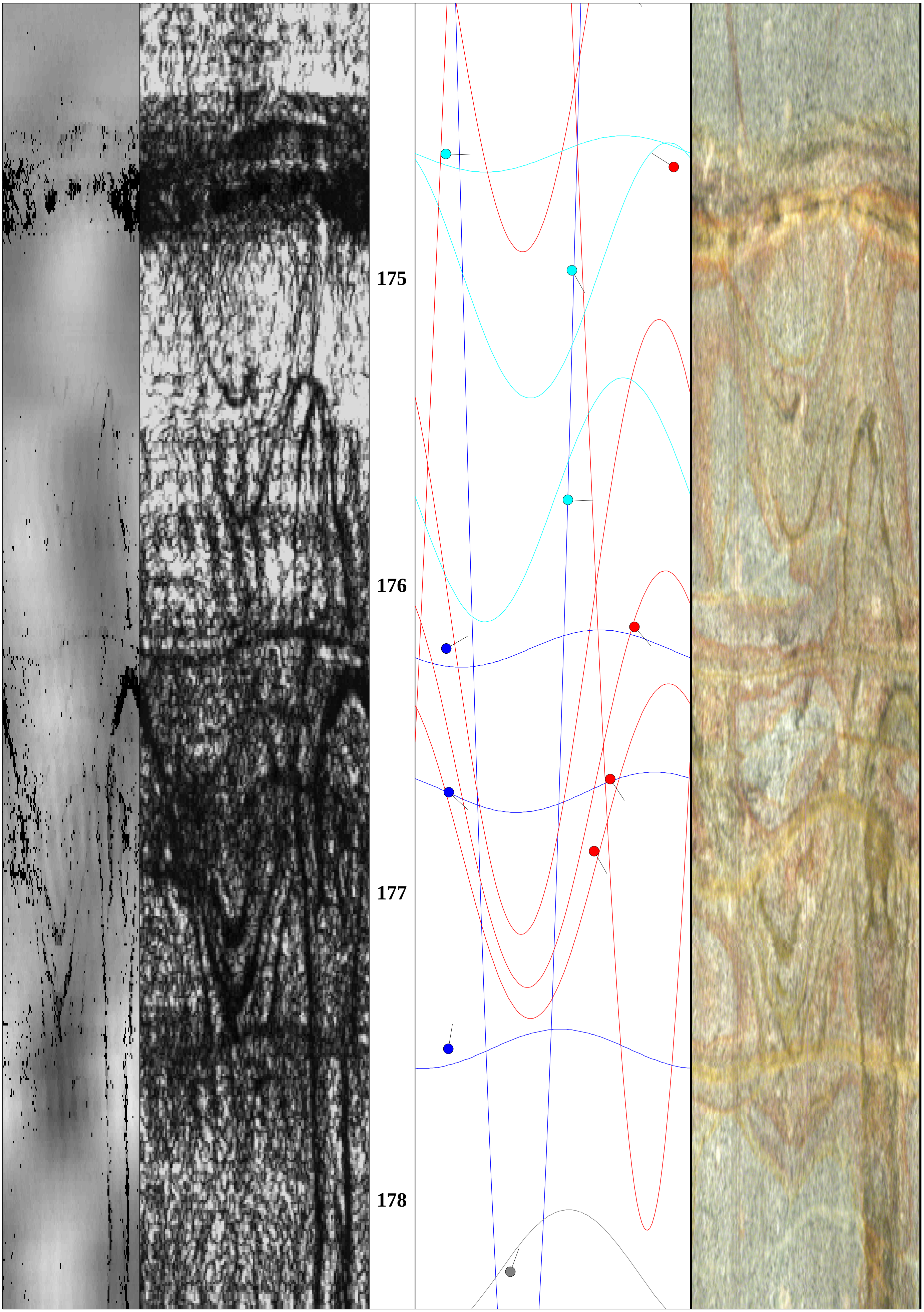

153
154
155
156
157

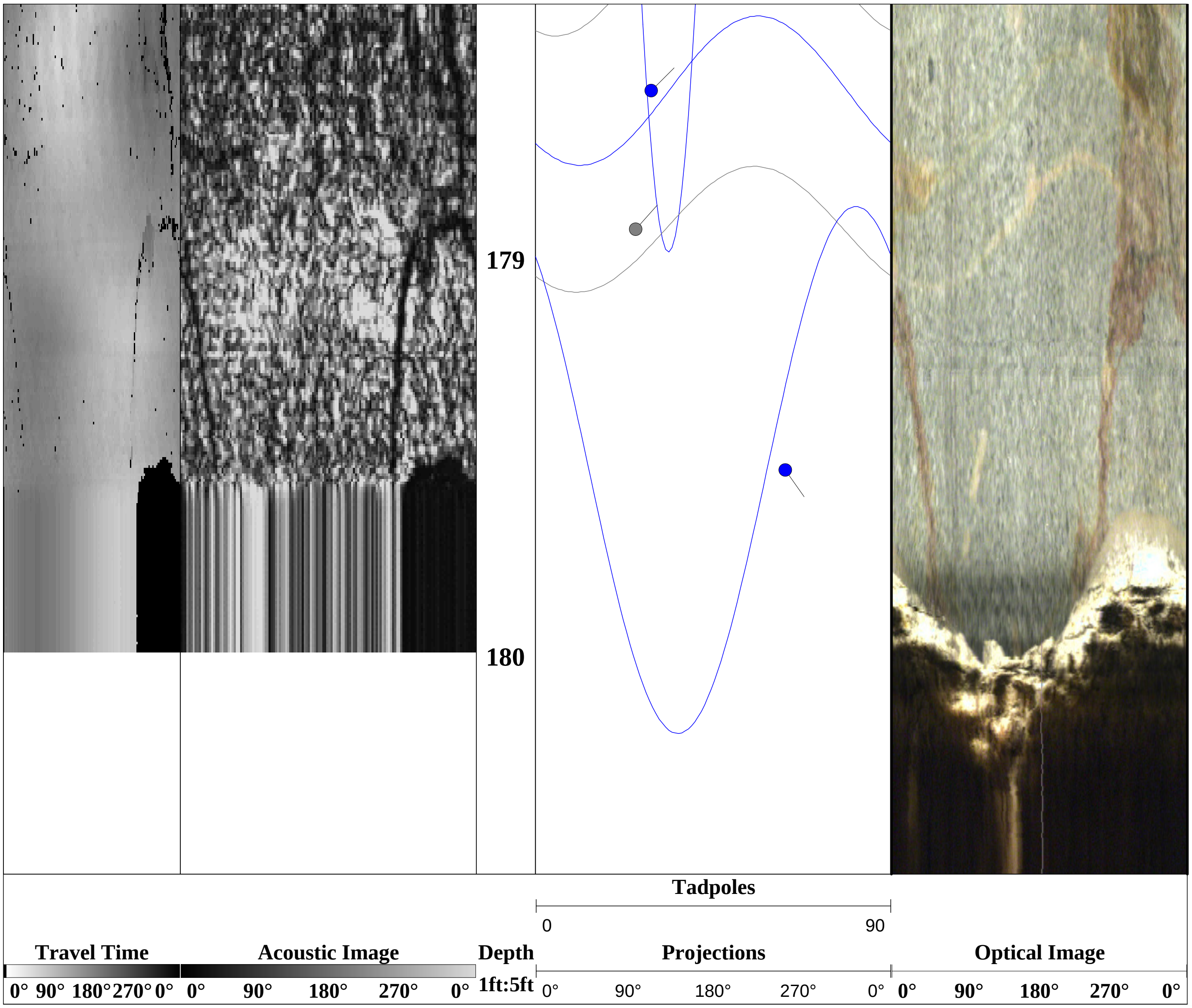

158
159
160
161


162
163
164
165

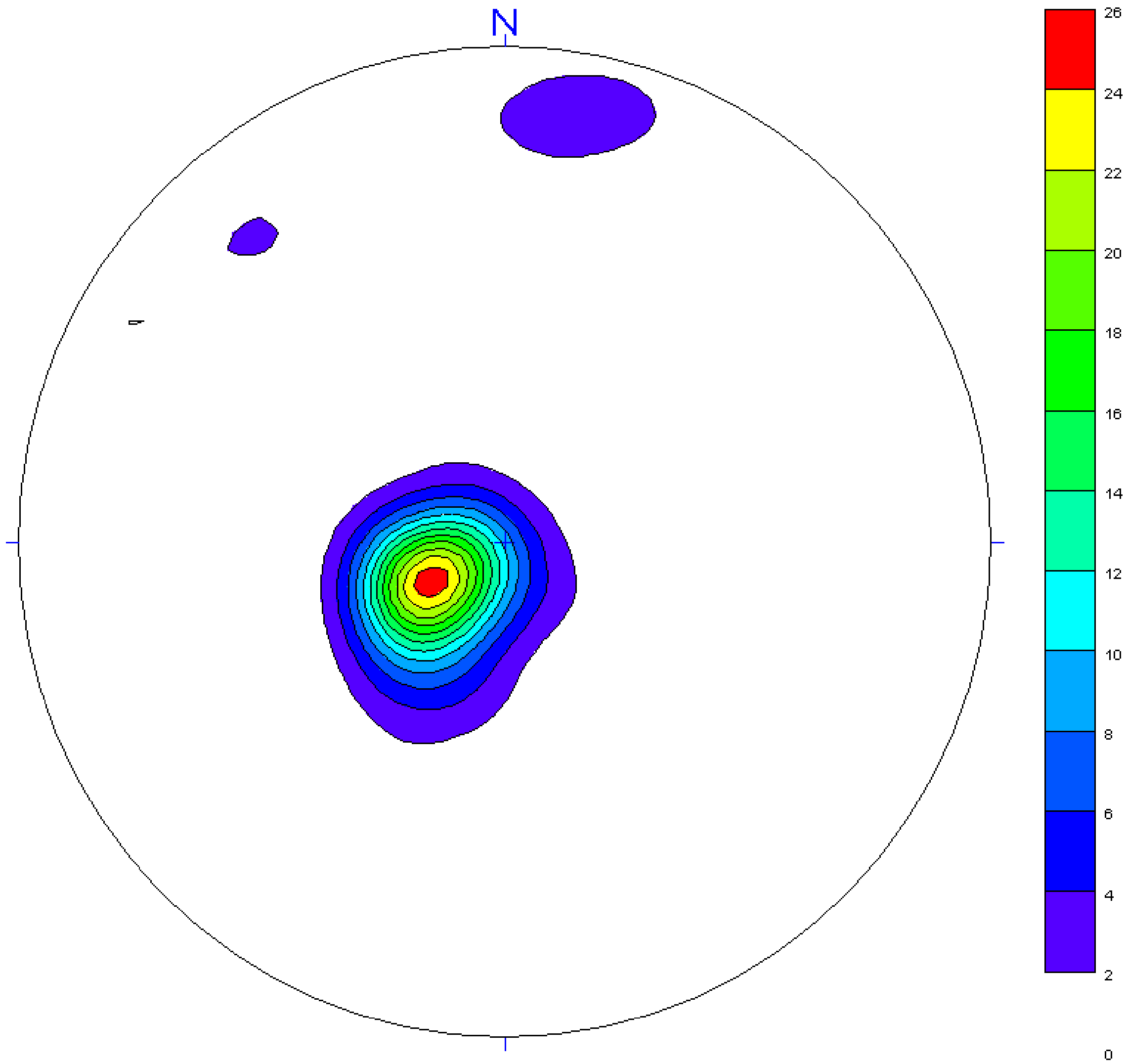

166
167
168
169


170
171
172
173
174


175
176
177
178

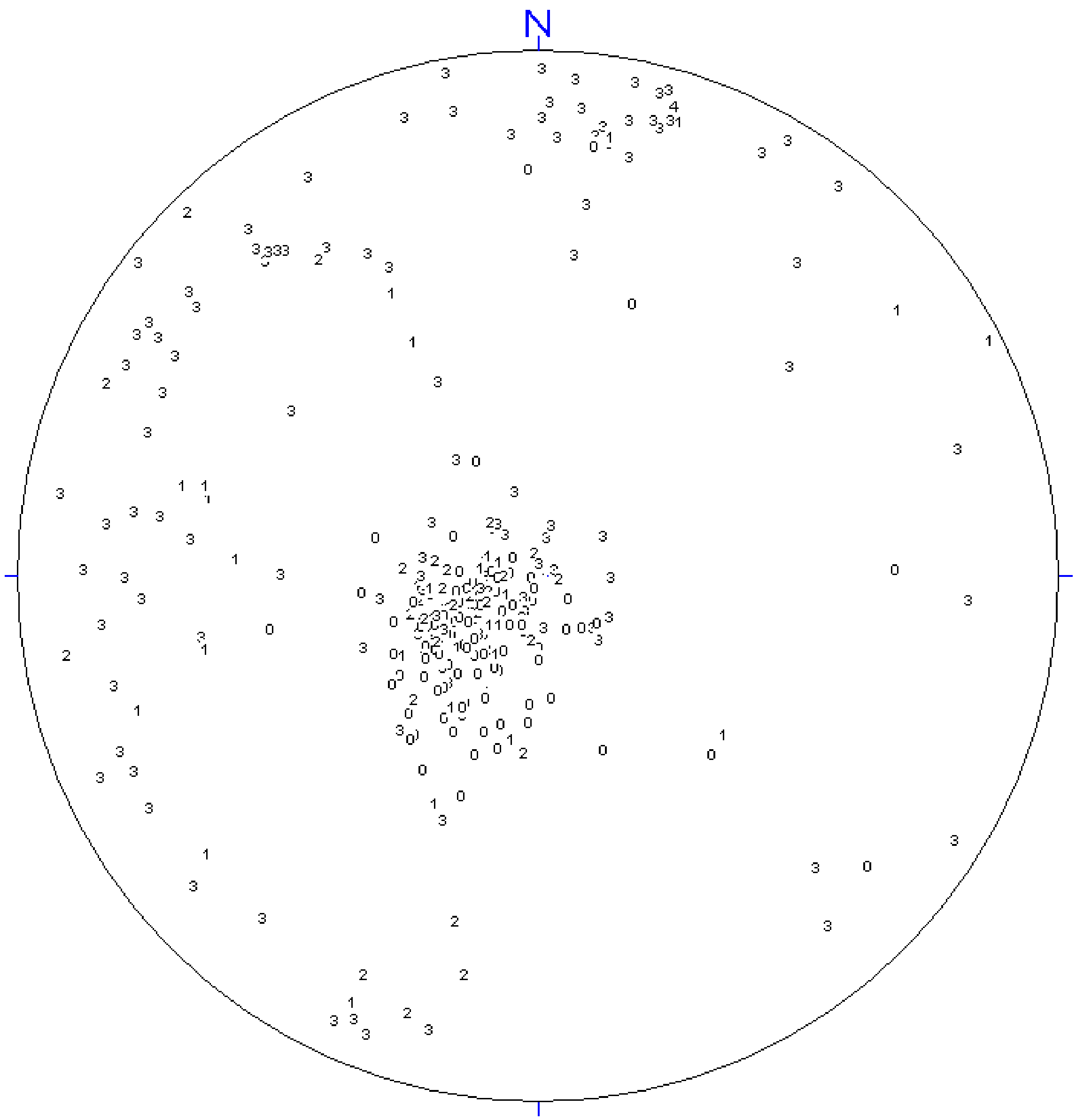

179
180
Tadpoles
0
90
Travel Time
Acoustic Image
Depth
1ft:5ft
Projections
Optical Image
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n3
NNSA/NSO
21 & 22 Sept 2010



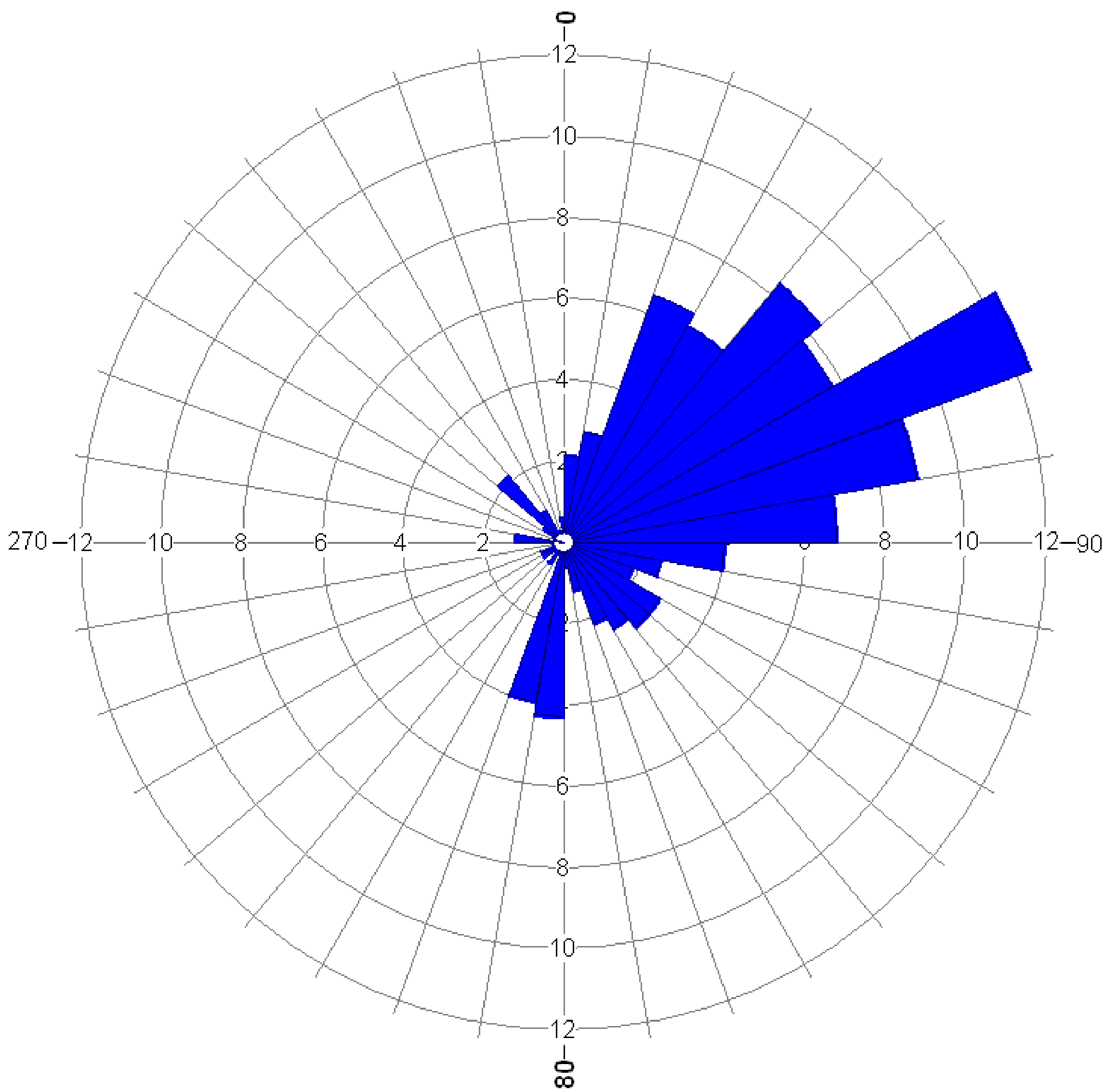
All directions are with respect to True North.

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n3
NNSA/NSO
21 & 22 Sept 2010



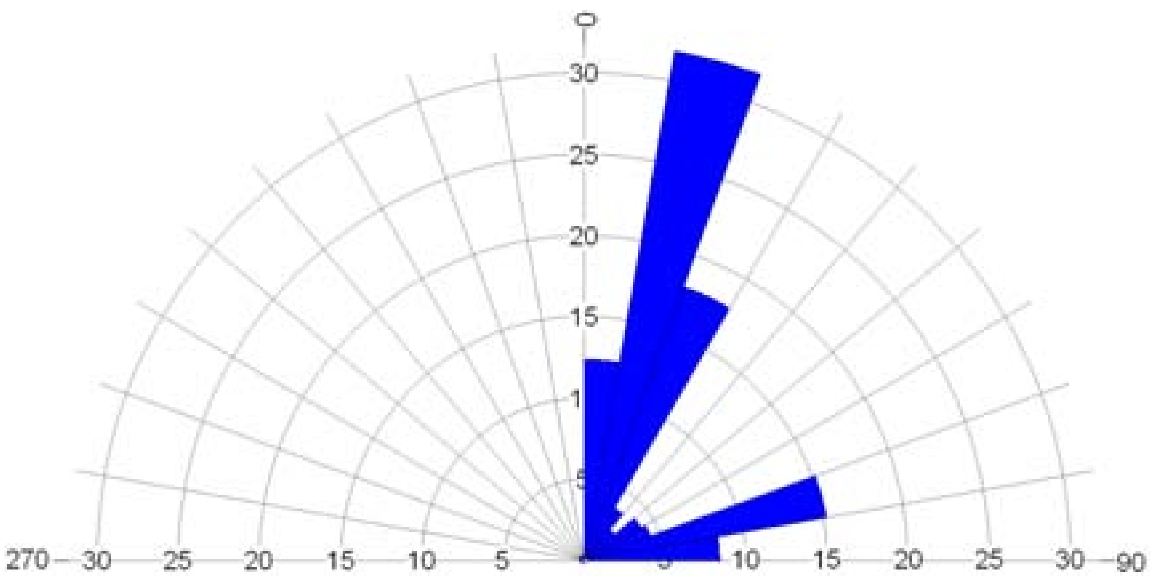
All directions are with respect to True North.

Rose Diagram – Dip Directions
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n3
NNSA/NSO
21 & 22 Sept 2010



All directions are with respect to True North.

Rose Diagram – Dip Angles
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n3
NNSA/NSO
21 & 22 Sept 2010



All directions are with respect to True North.

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Full-Waveform Sonic

Company NNSA/NSO
Well U-15N#3
Field NNSS
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15N#3
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900050.57
E: 676659.44

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Dual-Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5002.85

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

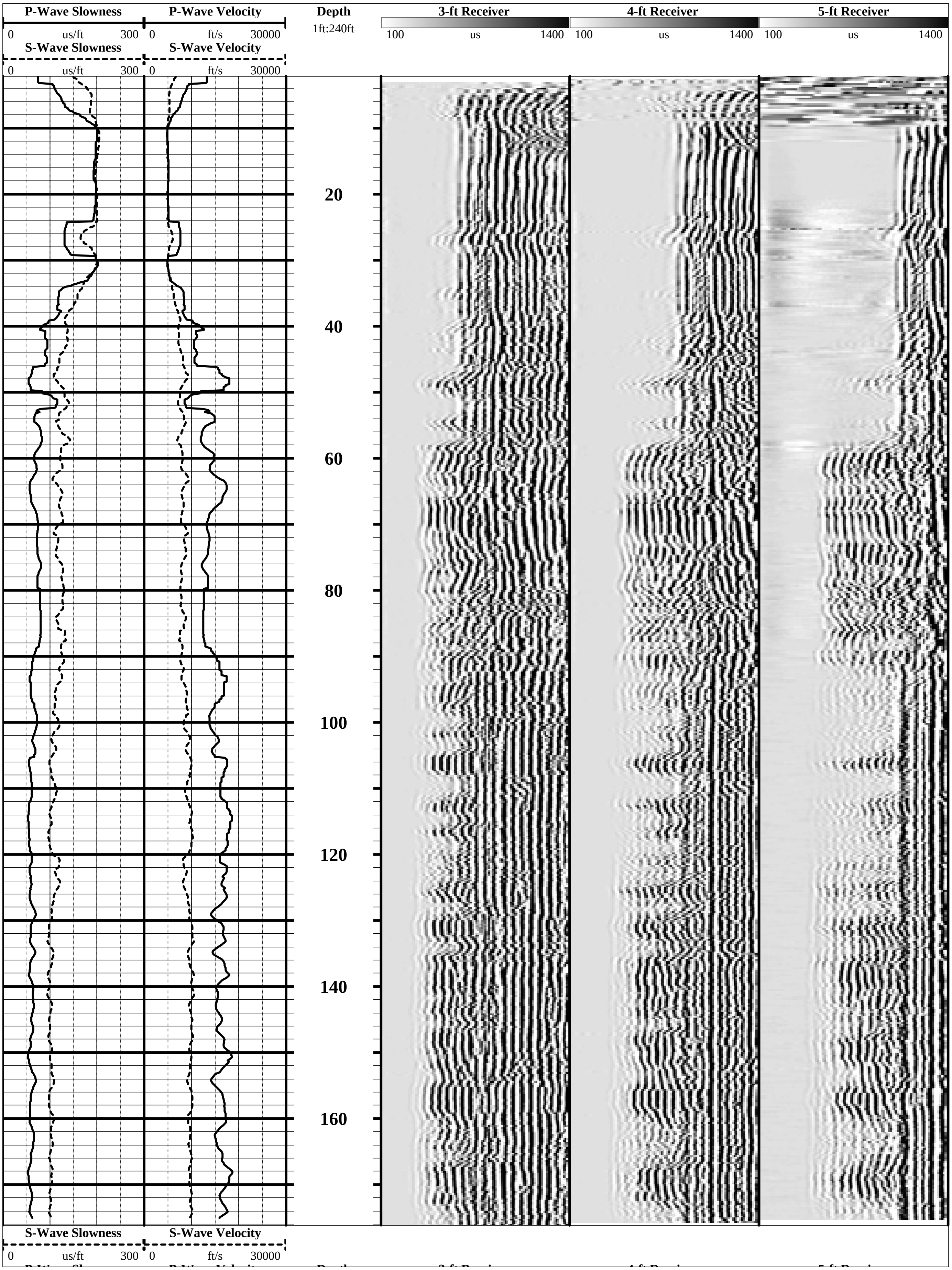
DRILLING MEAS. FROM

DATE ACQUIRED	22 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Full Waveform Sonic			
DEPTH-DRILLER	190'			
DEPTH-LOGGER	179.7'			
BTM LOG INTERVAL	179.7'			
TOP LOG INTERVAL	6.6'			
RECORDED BY	E. Eaton			
WITNESSED BY	C.Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	5 ft/min			
A.S.D.E.	0.2'			
SAMPLE INTERVAL	0.1'			

BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	10'	10"		Surf	9.5'
2	8"	10'	190'				

COMMENTS

NA - Not Available, N/A - Not Applicable



P-Wave Slowness
0 us/ft 300
S-Wave Slowness
0 us/ft 300
P-Wave Velocity
0 ft/s 30000
S-Wave Velocity
0 ft/s 30000
Depth
1ft:240ft
3-ft Receiver
100 us 1400
4-ft Receiver
100 us 1400
5-ft Receiver
100 us 1400
20
40
60
80
100
120
140
160
S-Wave Slowness
0 us/ft 300
S-Wave Velocity
0 ft/s 30000

P-Wave Slowness	P-Wave Velocity	Depth	3-ft Receiver	4-ft Receiver	5-ft Receiver
0 us/ft 300	0 ft/s 30000	1ft:240ft	100 us 1400	100 us 1400	100 us 1400

Borehole Deviation

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Company NNSA/NSO
Well U-15N#3
Field NNSS
County Nye
State Nevada

COMPANY NSSA/NSO
WELL U-15N#3
FIELD Nevada National Securities Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900050.57
E: 676659.44

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Optical Televiewer
Acoustic Televiewer
Dual Spacing Density
Caliper
Natural Gamma
Full Waveform Sonic
Video

PERMANENT DATUM Ground Level **ELEVATION** 5002.85

LOG MEAS. FROM Ground Level 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM

DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	TWO			
LOG TYPE	Borehole Deviation			
DEPTH-DRILLER	190			
DEPTH-LOGGER	180			
BTM LOG INTERVAL	180			
TOP LOG INTERVAL	4			
RECORDED BY	E. Eaton			
WITNESSED BY	C.Obi			
PROBE TYPE, S/N	OBI40, 023901			
LOGGING SPEED	3.5 ft/min			
A.S.D.E.	0.52 ft			
SAMPLE INTERVAL	0.0041 ft			

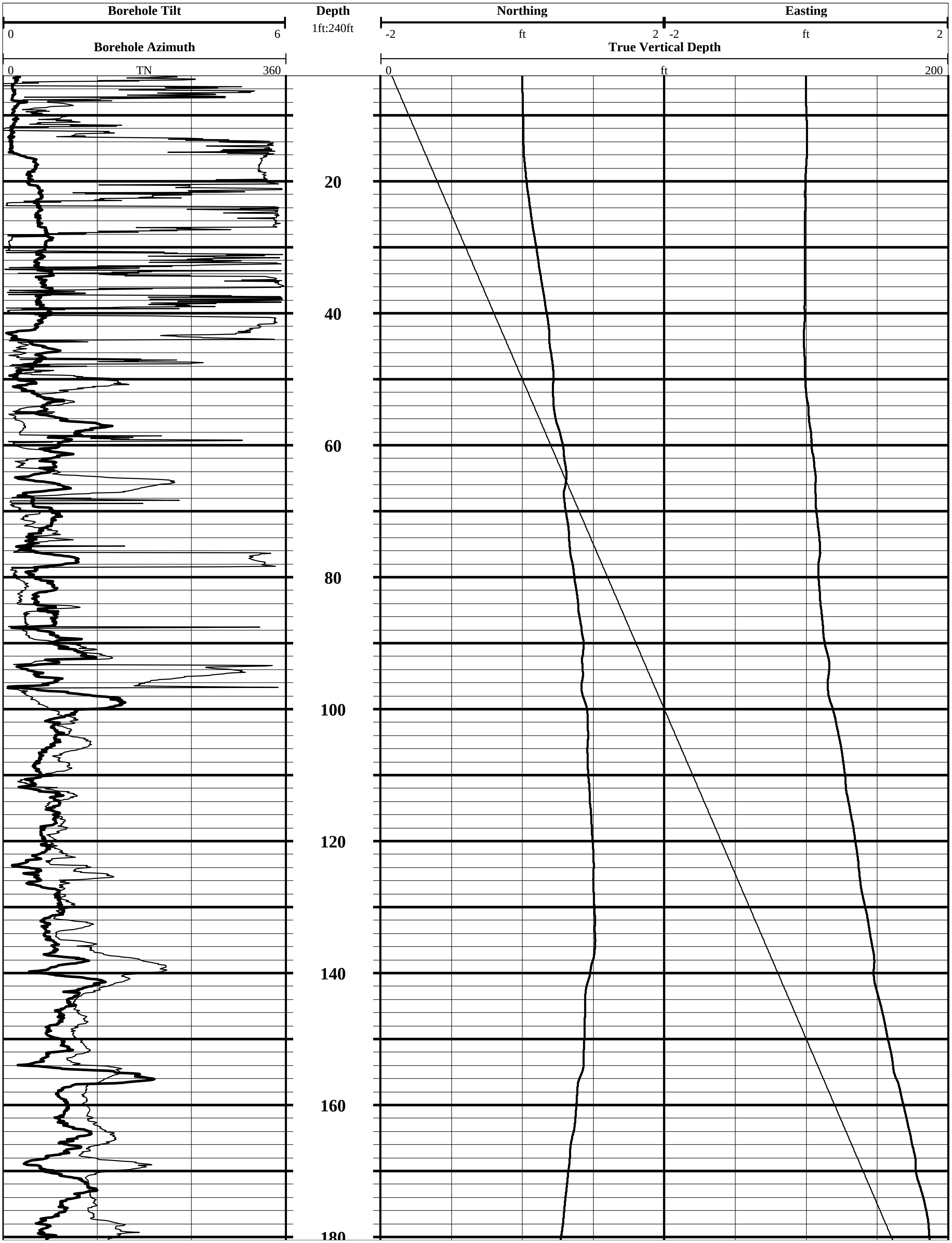
BOREHOLE RECORD				CASING RECORD			
RUN No.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
	12.25"	Surface	10	10		-1	9.5
	8"	10	190				

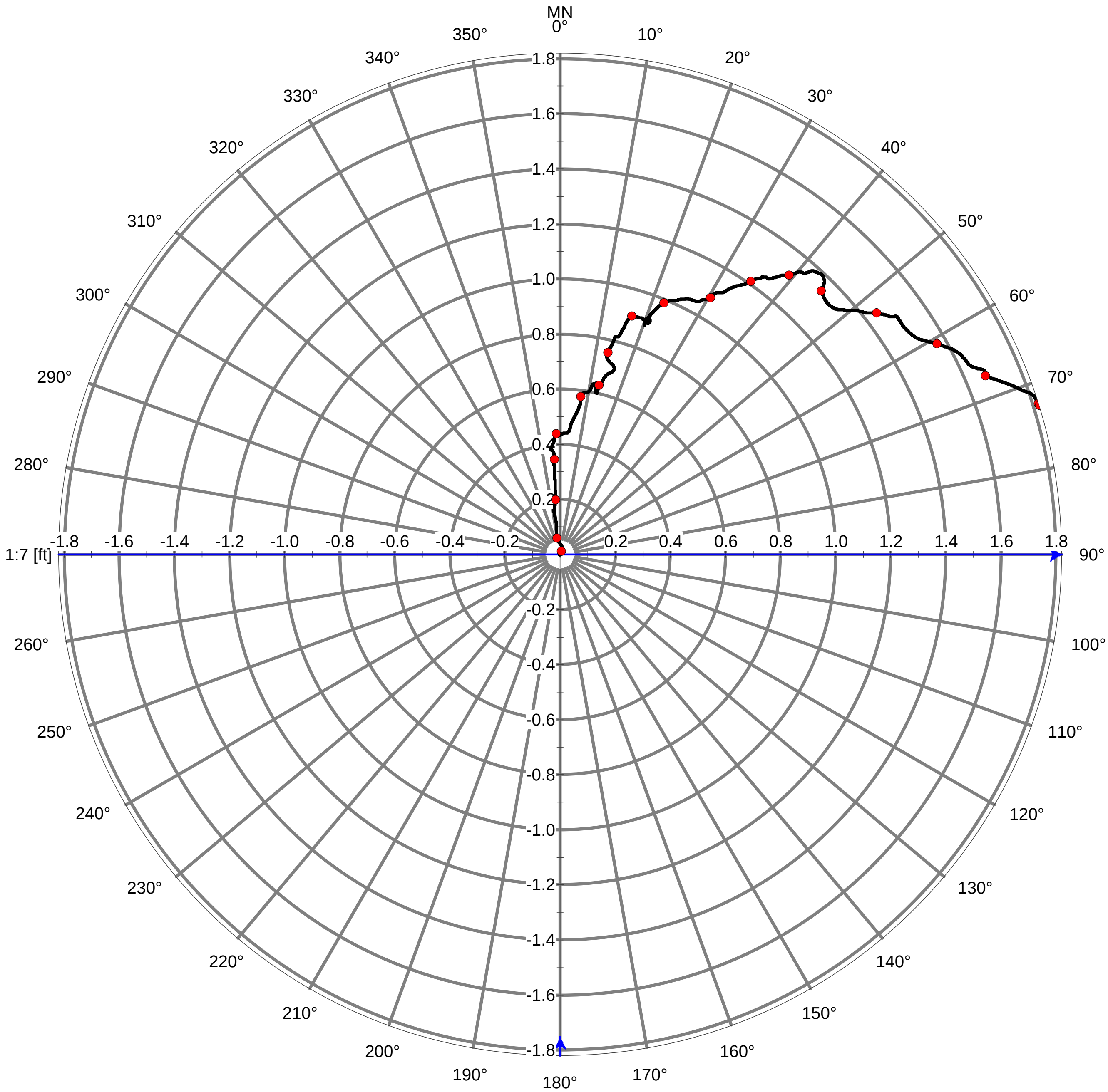
COMMENTS

NA - Not Available, N/A - Not Applicable

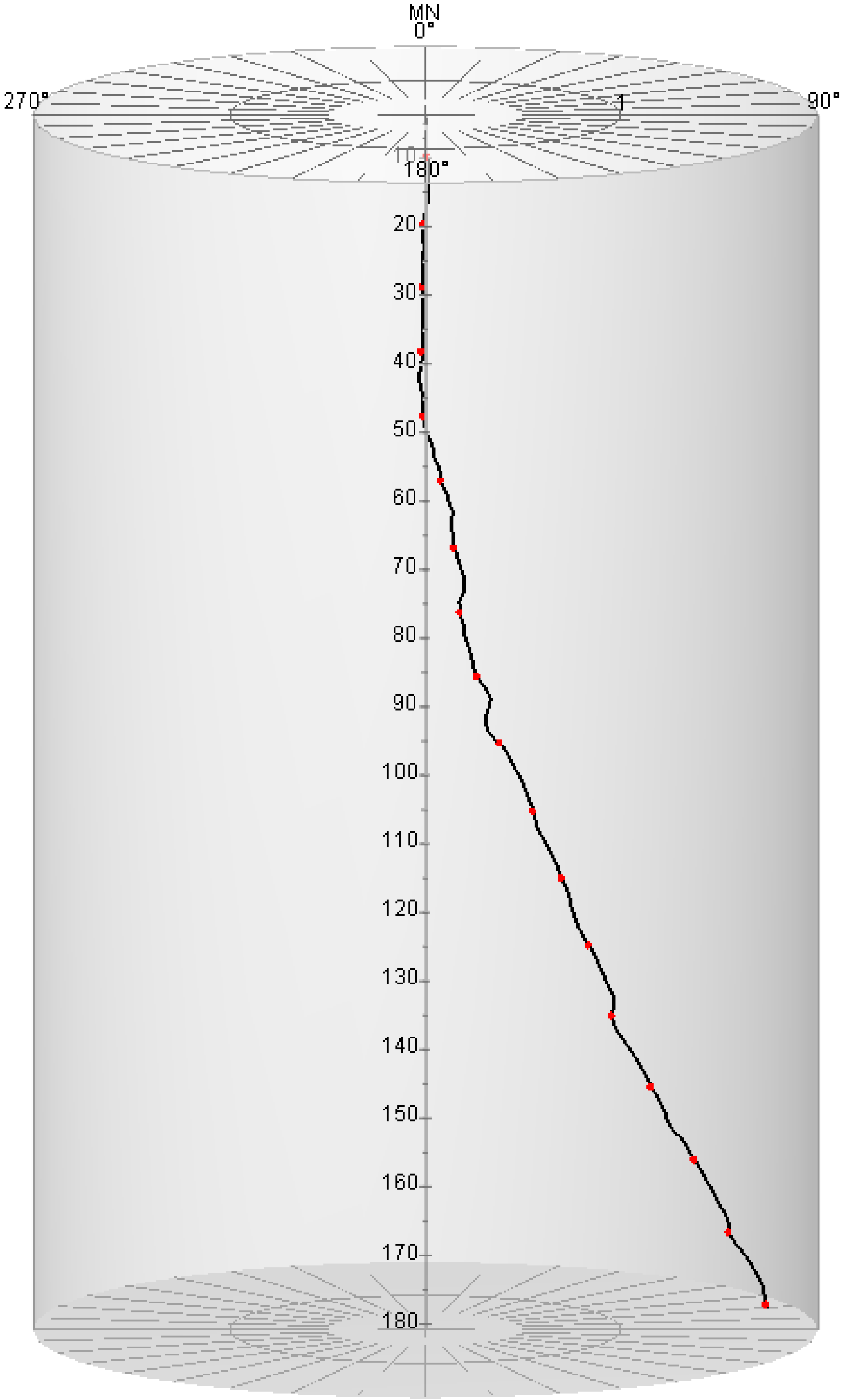
Could not reach driller's TD, due to fill.

Magnetic declination of 12.85 degrees East added to correct magnetic azimuth to True North.


Borehole Tilt
0
6
Borehole Azimuth
0
TN
360
Depth
1ft:240ft
20
40
60
80
100
120
140
160
180
Northing
-2
ft
2
Easting
-2
ft
2
True Vertical Depth
0
ft
200



MN
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
1:7 [ft]
-1.8
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
-0.2
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8


MN
0°
270°
90°
180°
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

Appendix F-5

Borehole Geophysical Log Plots for Instrument Hole U-15n#4

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Far Density
Near Density
Natural Gamma Ray
Caliper

Company	NNSA/NSO
Well	U-15N#4
Field	NNSS
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15N#4
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900018.49
E: 676612.53

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Full-Wave Sonic
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5002.79

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM G.L.

DATE ACQUIRED	22 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Far Density	Near Density	Natural Gamma Ray	Caliper
DEPTH-DRILLER	192'			
DEPTH-LOGGER	196.6'			
BTM LOG INTERVAL	195.5'	195.8'	191.0'	194.5'
TOP LOG INTERVAL	7.9'	8.2'	3.4'	6.9'
RECORDED BY	A. Caster			
WITNESSED BY	C. Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	10 ft/min			
A.S.D.E.	0.1'			
SAMPLE INTERVAL	0.1'			

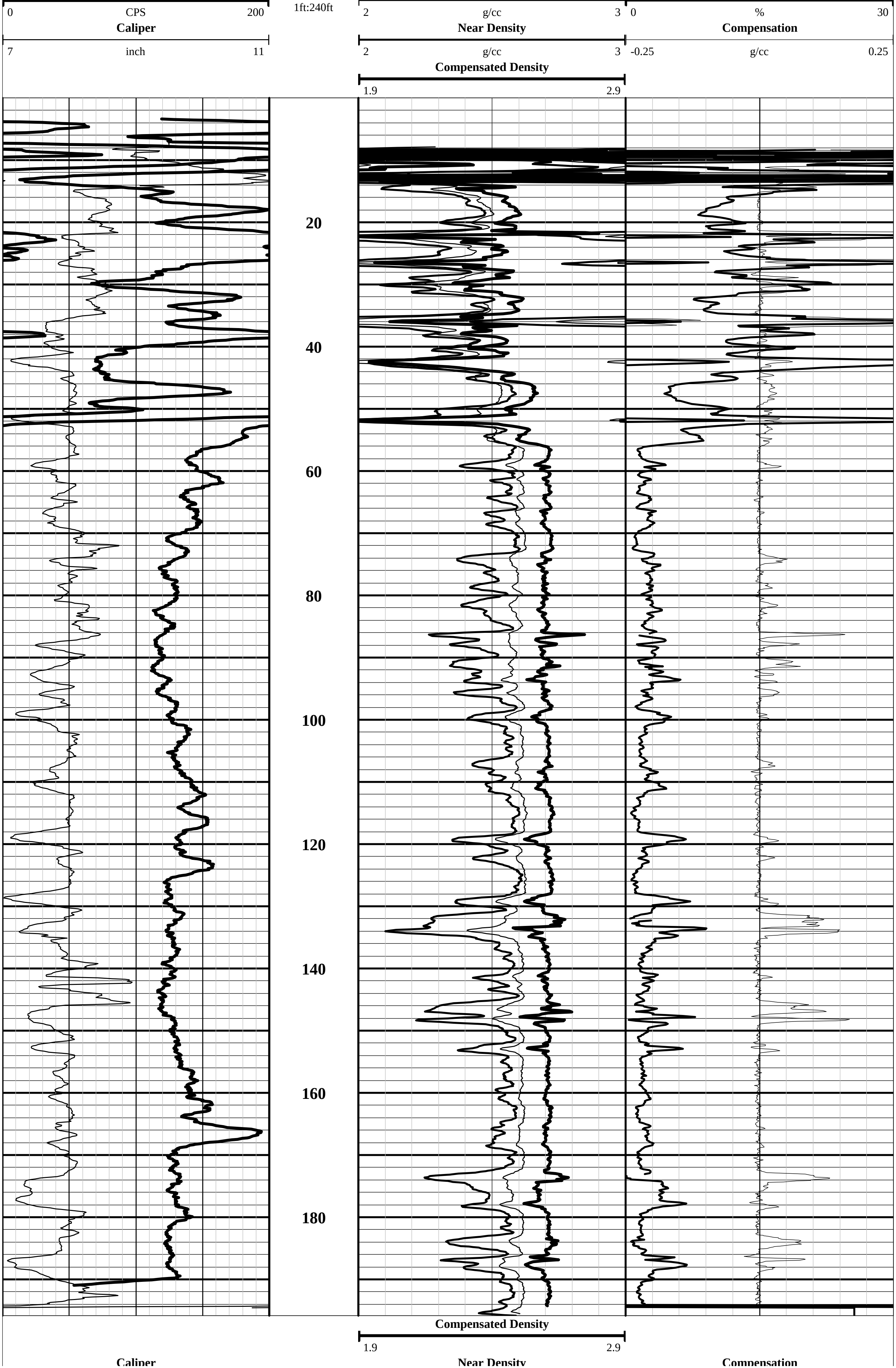
BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	surf	10'	10"		-1.0'	9.5'
2	8"	10'	192'				

COMMENTS

NA - Not Available, N/A - Not Applicable

Matrix Density of 2.64 used to calculate Density Porosity

Natural Gamma Ray	Depth	Far Density	Density Porosity


0 CPS 200
Caliper
7 inch 11
1ft:240ft
2 g/cc 3
Near Density
2 g/cc 3
Compensated Density
1.9 2.9
0 % 30
Compensation
-0.25 g/cc 0.25
20
40
60
80
100
120
140
160
180
Compensated Density
1.9 2.9
Caliper
Near Density
Compensation

Caliper				Near Density			Compensation		
7	inch	11		2	g/cc	3	-0.25	g/cc	0.25
Natural Gamma Ray			Depth	Far Density			Density Porosity		
0	CPS	200	1ft:240ft	2	g/cc	3	0	%	30

COLOG
BOREHOLE GEOPHYSICS & HYDROPHYSICS
A DIVISION OF LAYNE CHRISTENSEN COMPANY

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Acoustic Televiewer
Optical Televiewer

Company NNSA/NSO
Well U-15N#4
Field Nevada Test Site
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15N#4
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
N: 900018.49 E: 676612.53

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Dual Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM Ground Level **ELEVATION** 5002.79
LOG MEAS. FROM Ground Level **ABOVE PERMINANT DATUM**
DRILLING MEAS. FROM Ground Level

DATE ACQUIRED	22 Sept 2010	22 Sept 2010		
RUN NUMBER	THREE	TWO		
LOG TYPE	ABI	OBI		
DEPTH-DRILLER	192	192		
DEPTH-LOGGER	197	197		
BTM LOG INTERVAL	196	197		
TOP LOG INTERVAL	57	4		
RECORDED BY	E Eaton	E Eaton		
WITNESSED BY	C Obi	G Juniel		
PROBE TYPE, S/N	ABI-062605	OBI-023902		
LOGGING SPEED	5.5 ft/sec	3.5 ft/min		
A.S.D.E.	0.63 ft	0.54 ft		
SAMPLE INTERVAL	0.0068 ft	0.0041 ft		

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25"	Surface	10	10"		-1	9.5
	8"	10	192				

COMMENTS

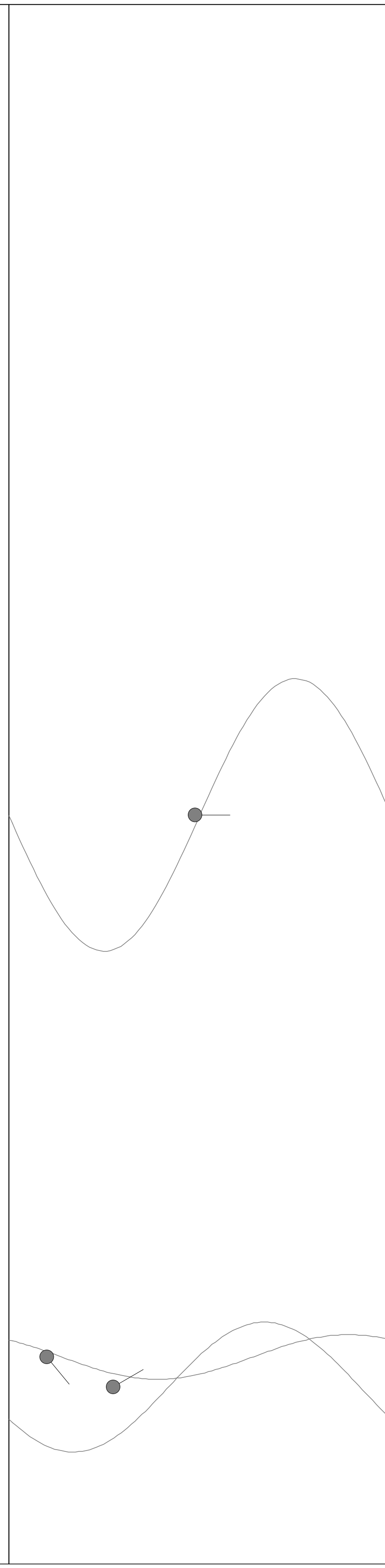
NA - Not Available, N/A - Not Applicable

Travel Time	Acoustic Image	Depth	Projections	Optical Image
0° 90° 180° 270° 0°	0° 90° 180° 270° 0°	1ft:5ft	0° 90° 180° 270° 0°	0° 90° 180° 270° 0°
			Tadpoles	
			0 90	

15

16

17

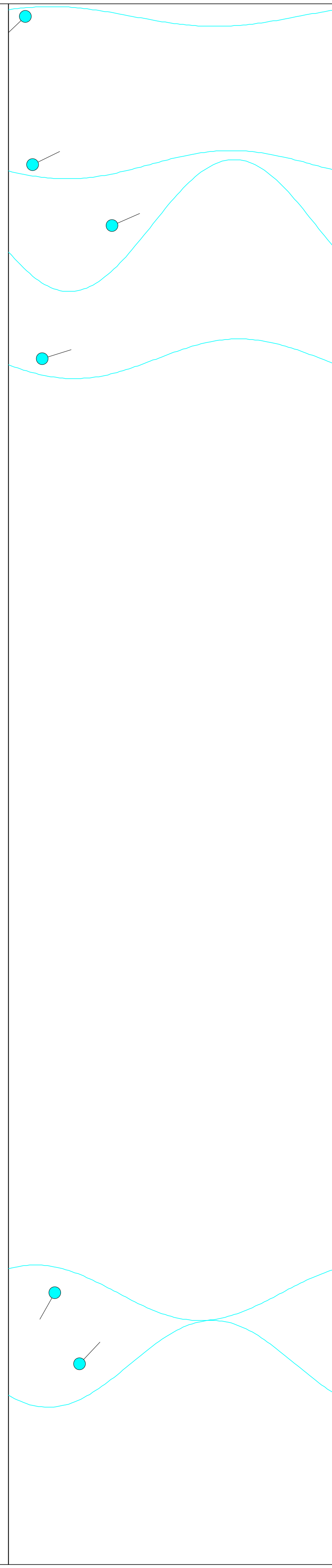


18

19

20

21



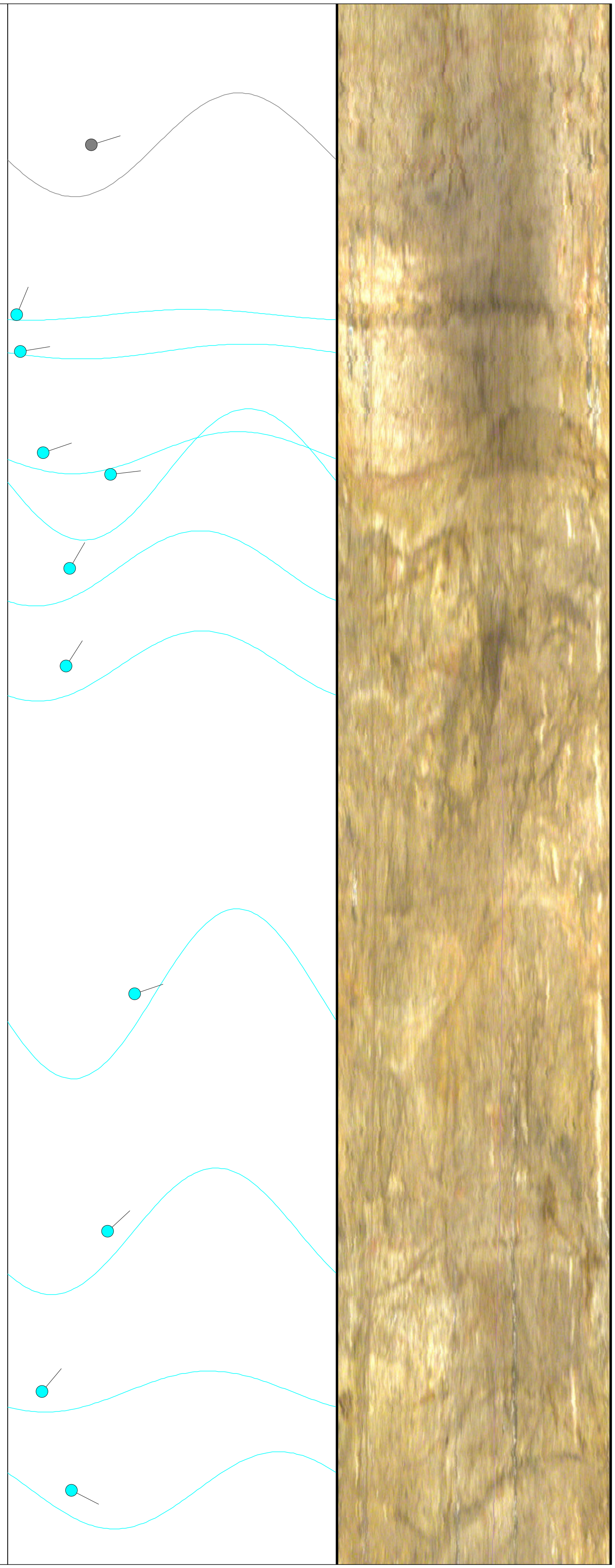
22

23

24

25

26

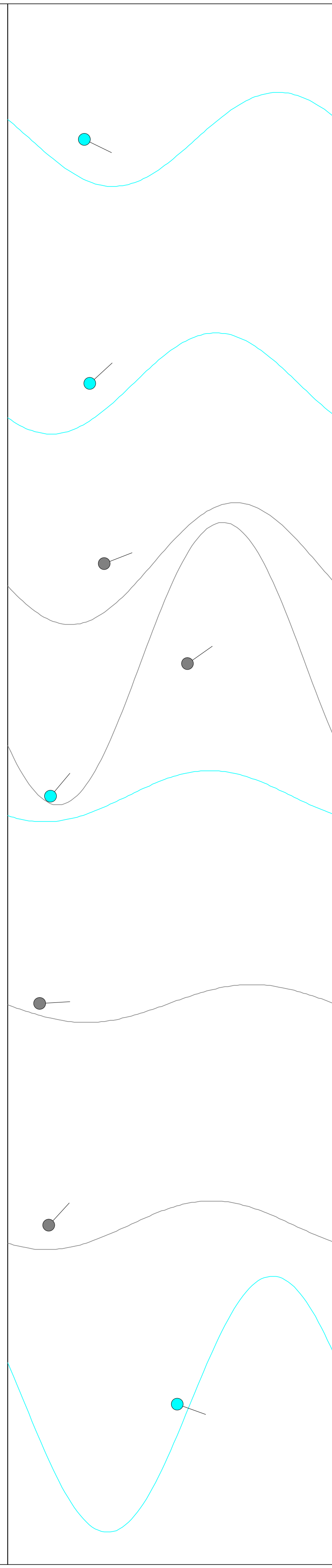


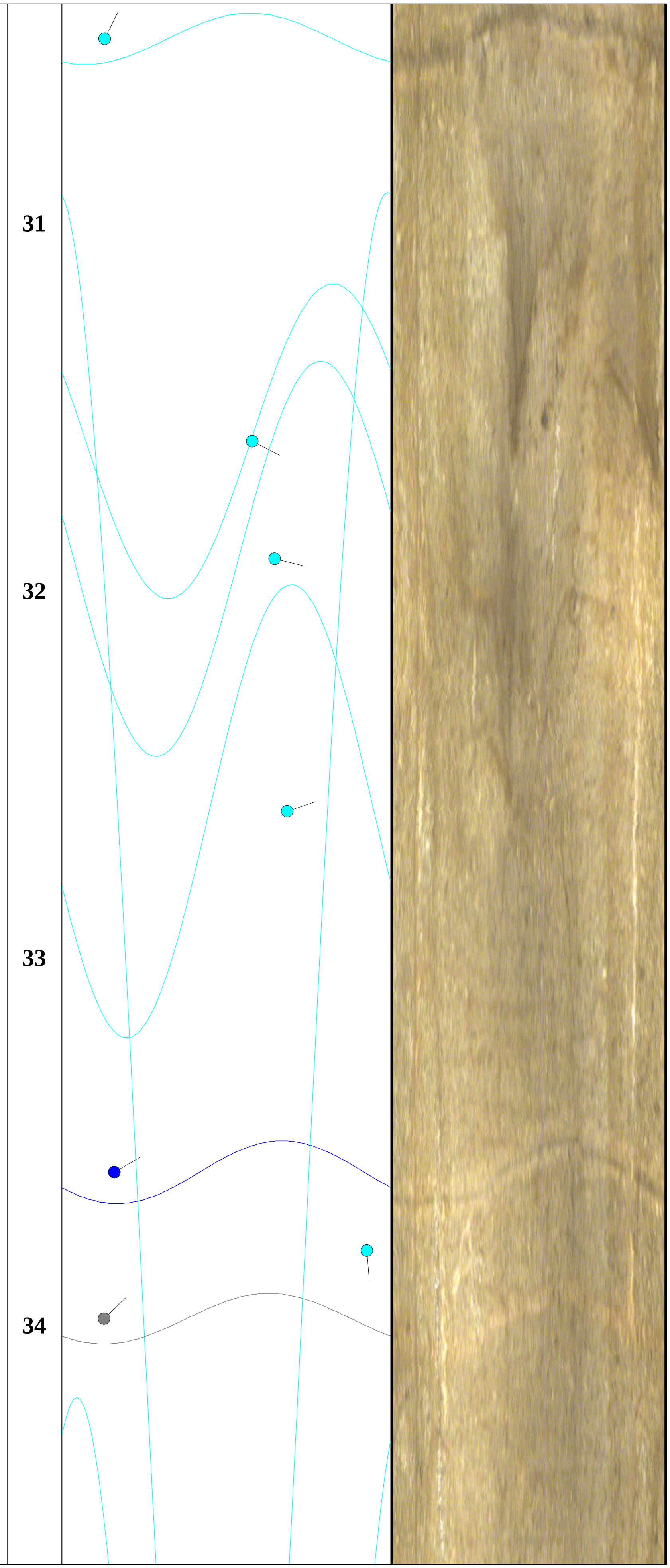
27

28

29

30



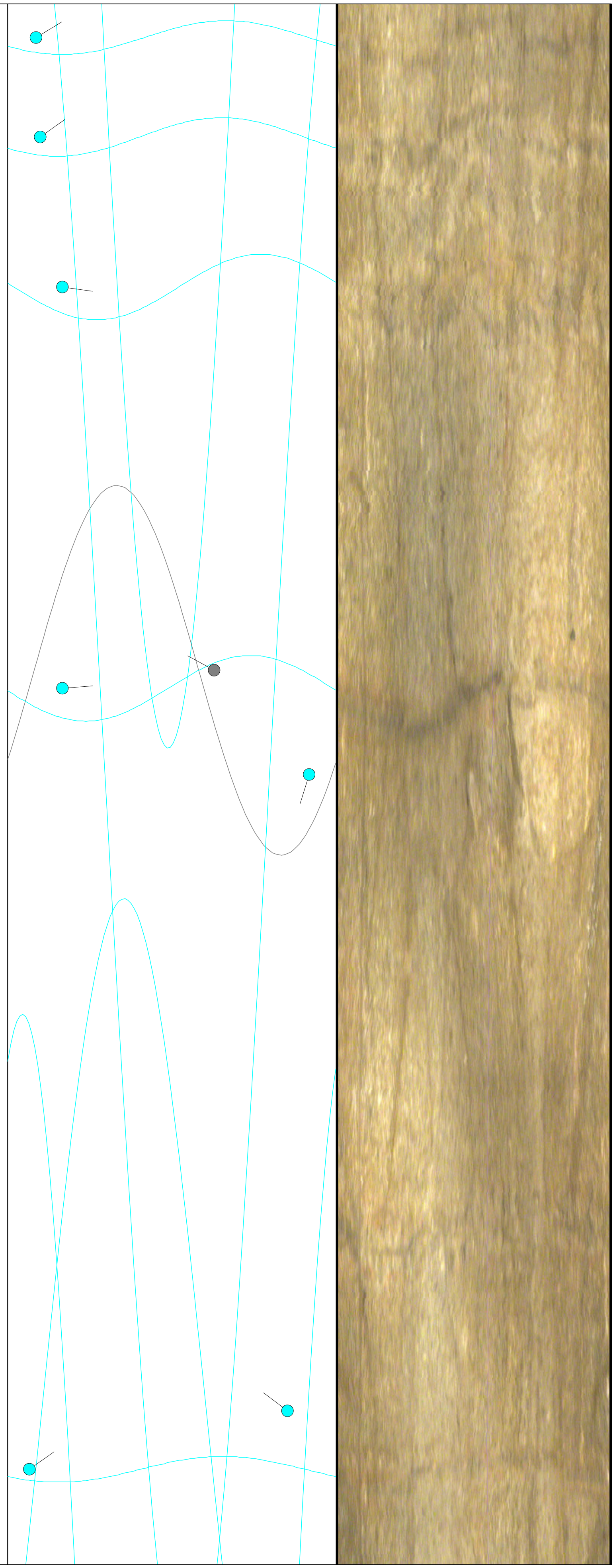

31
32
33
34

35

36

37

38



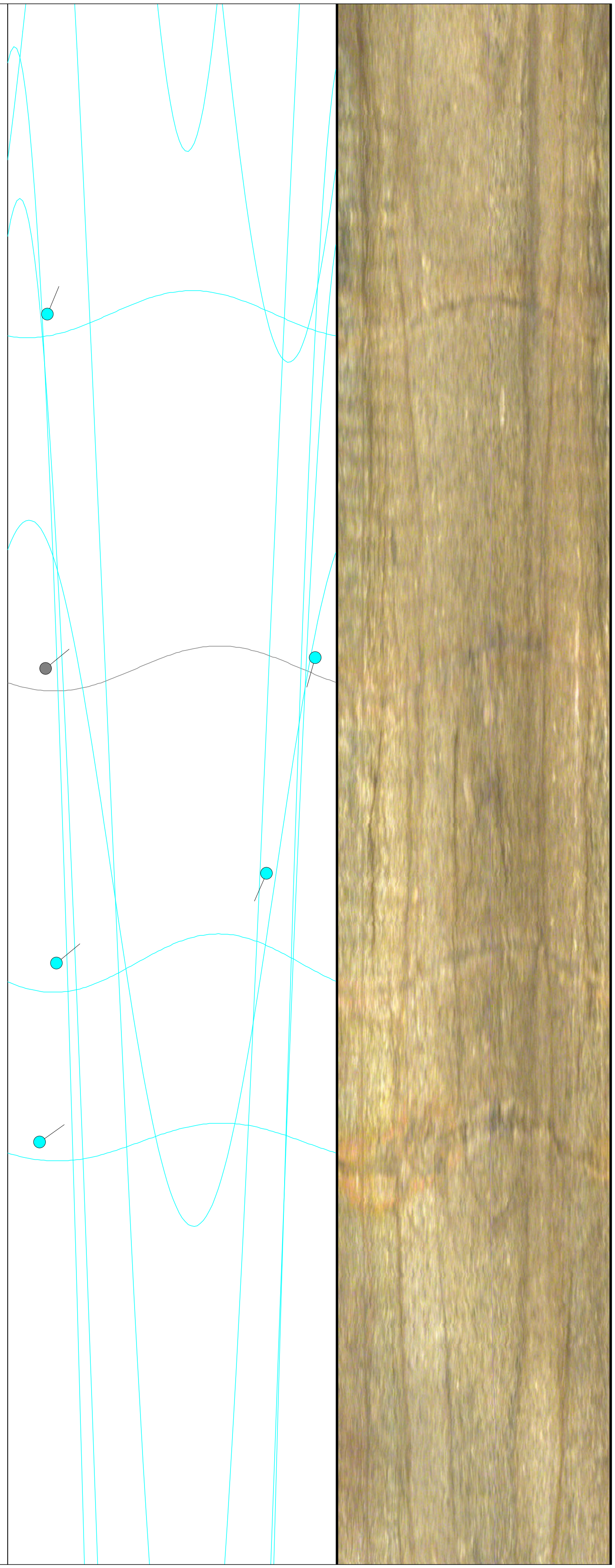
39

40

41

42

43

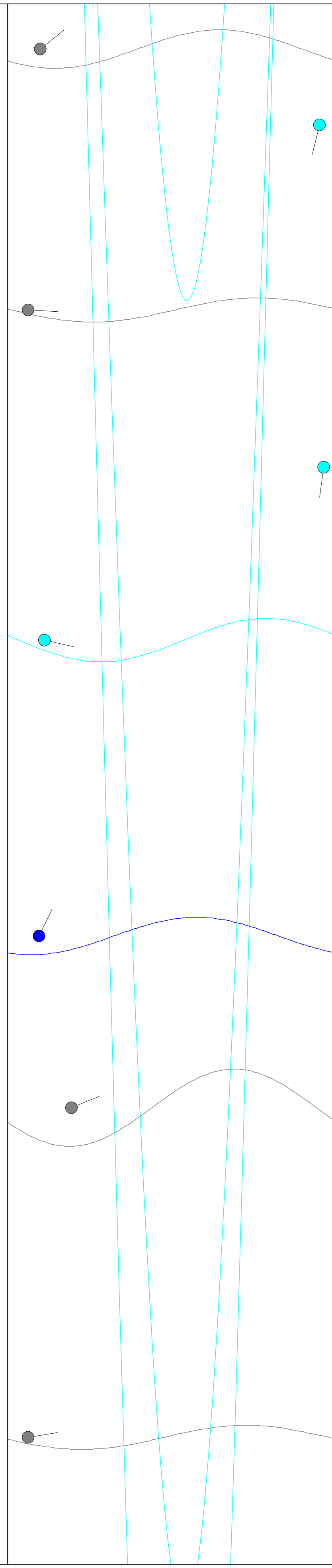


44

45

46

47

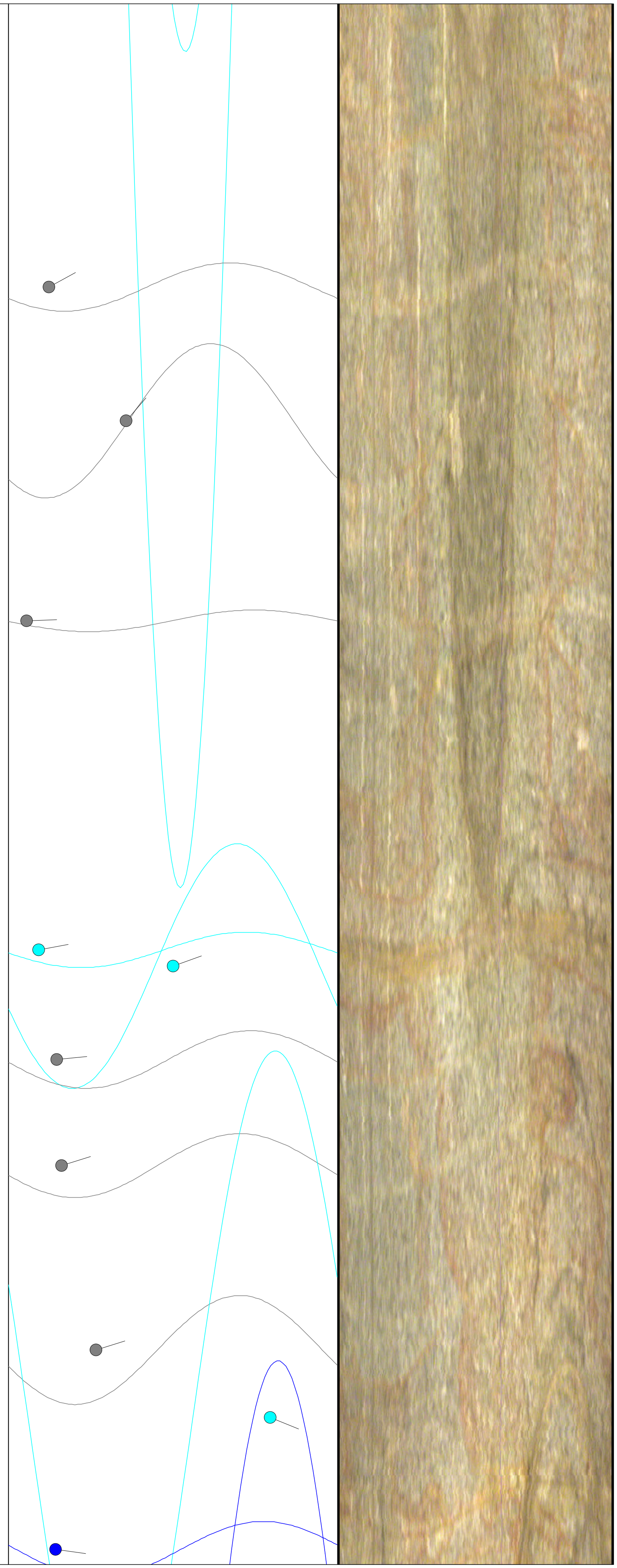


48

49

50

51

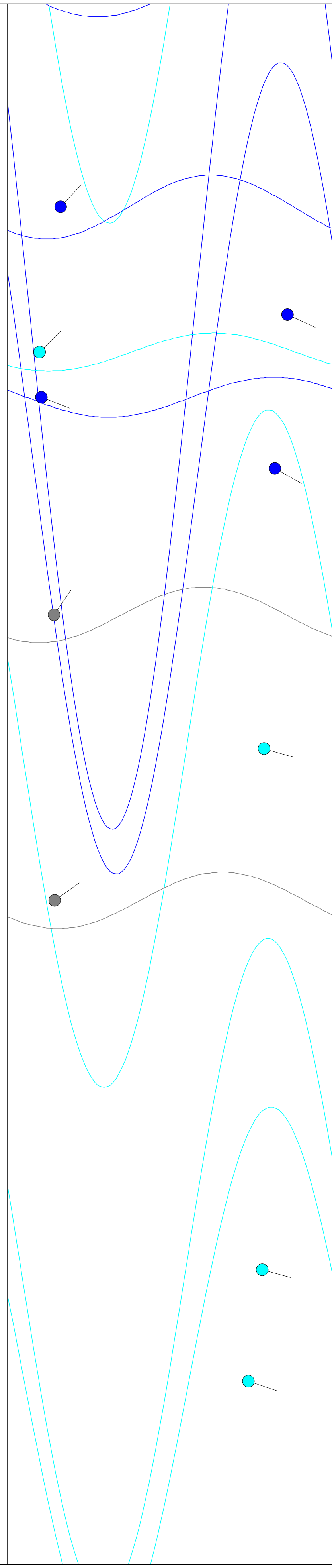


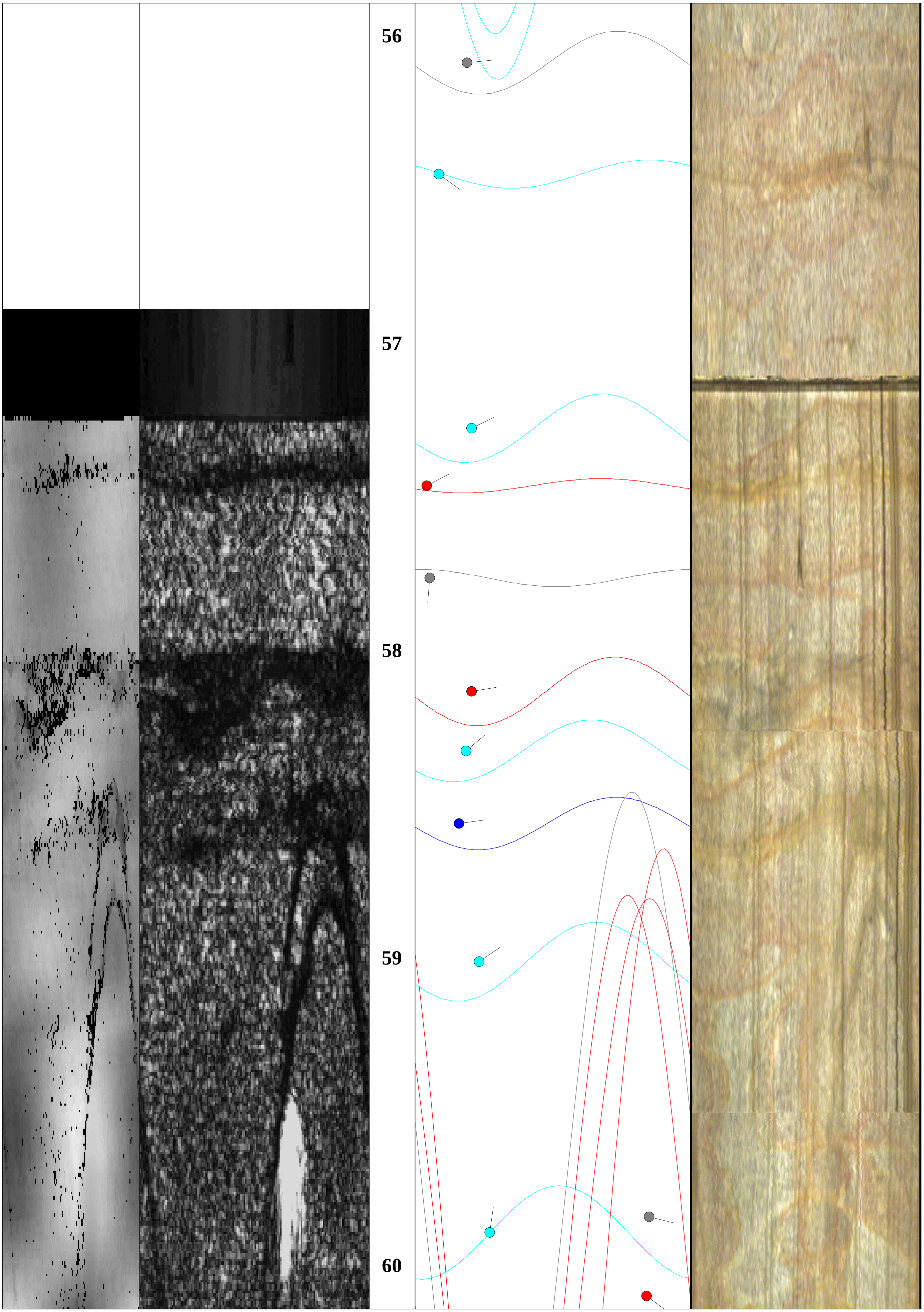
52

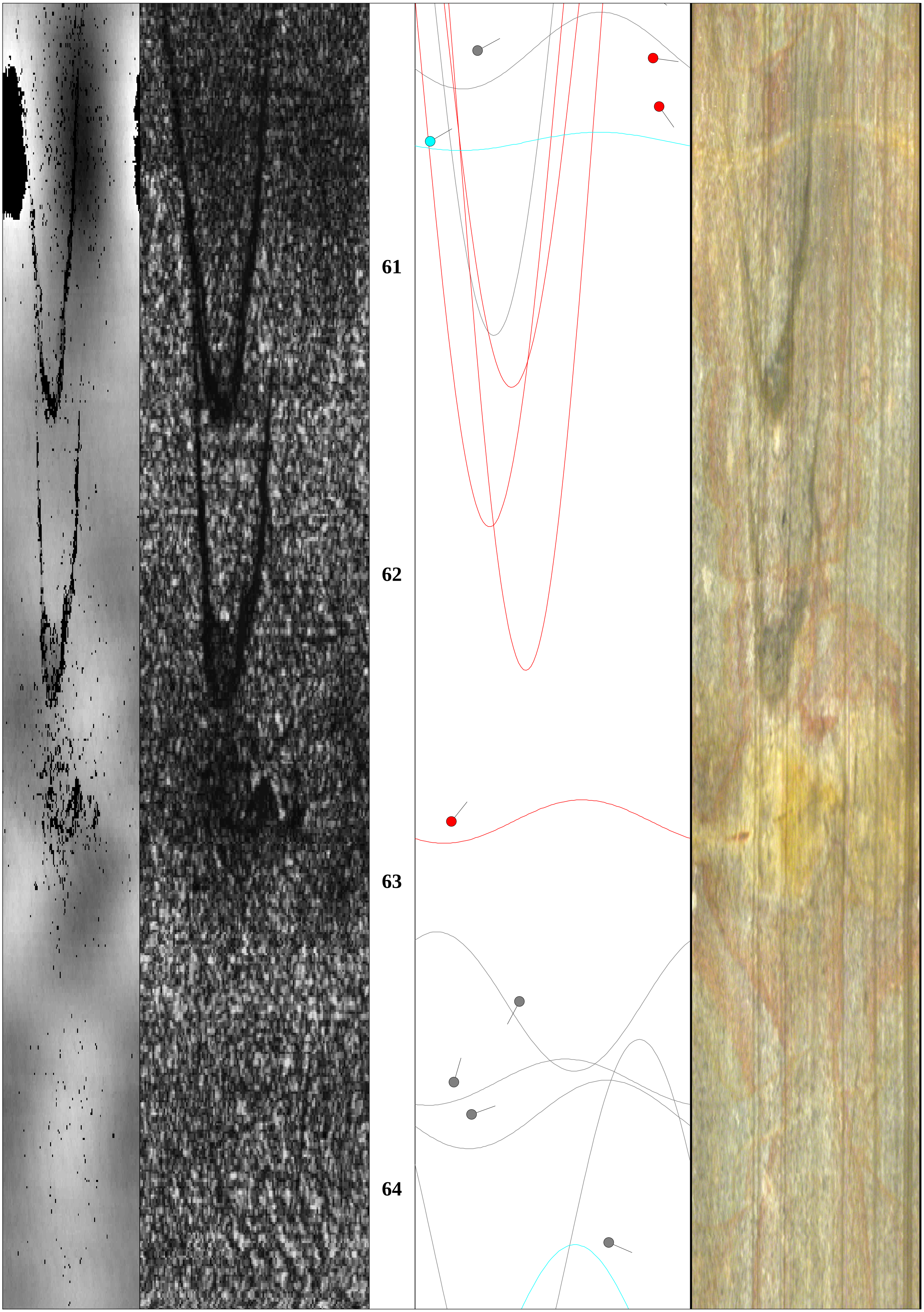
53

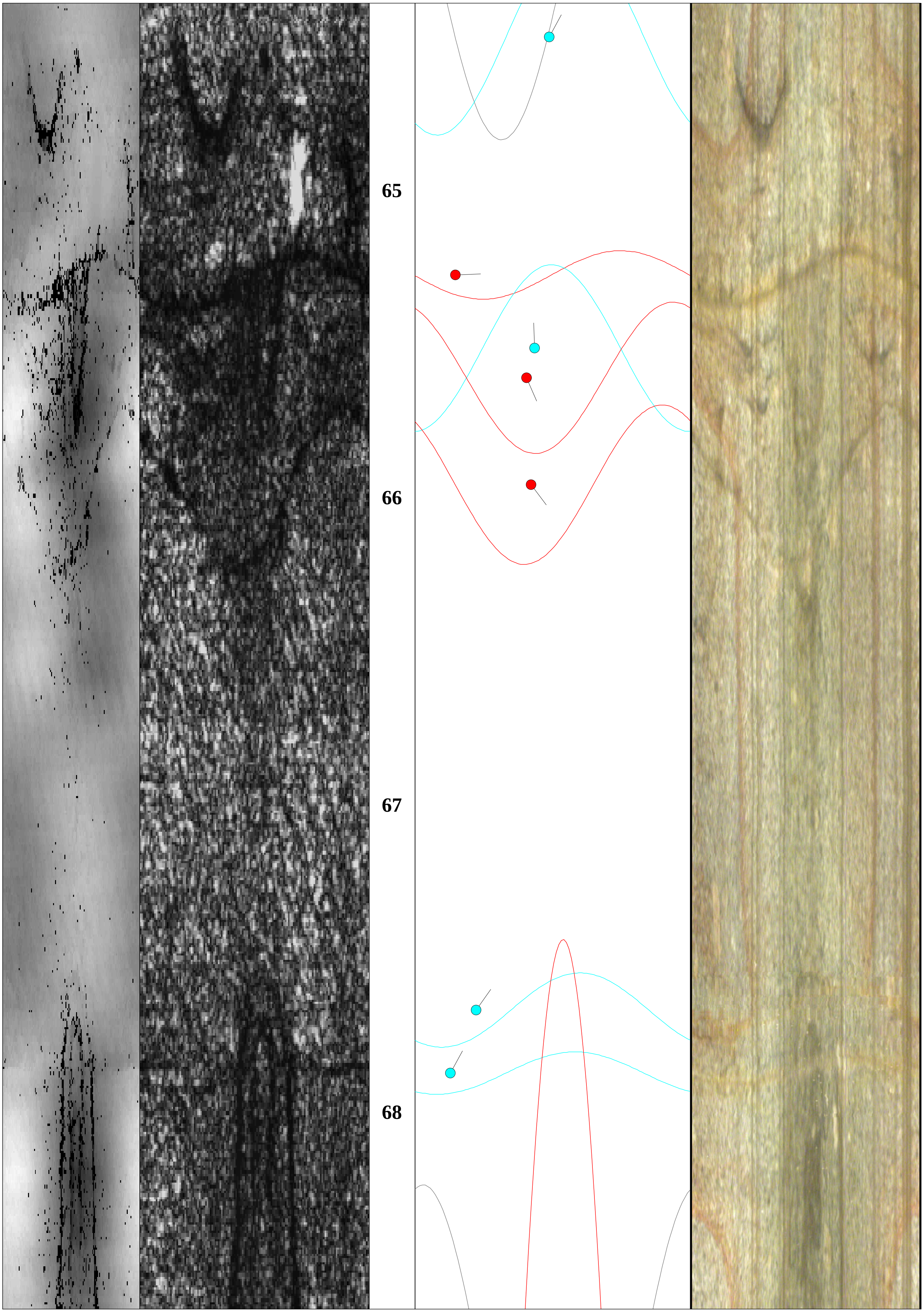
54

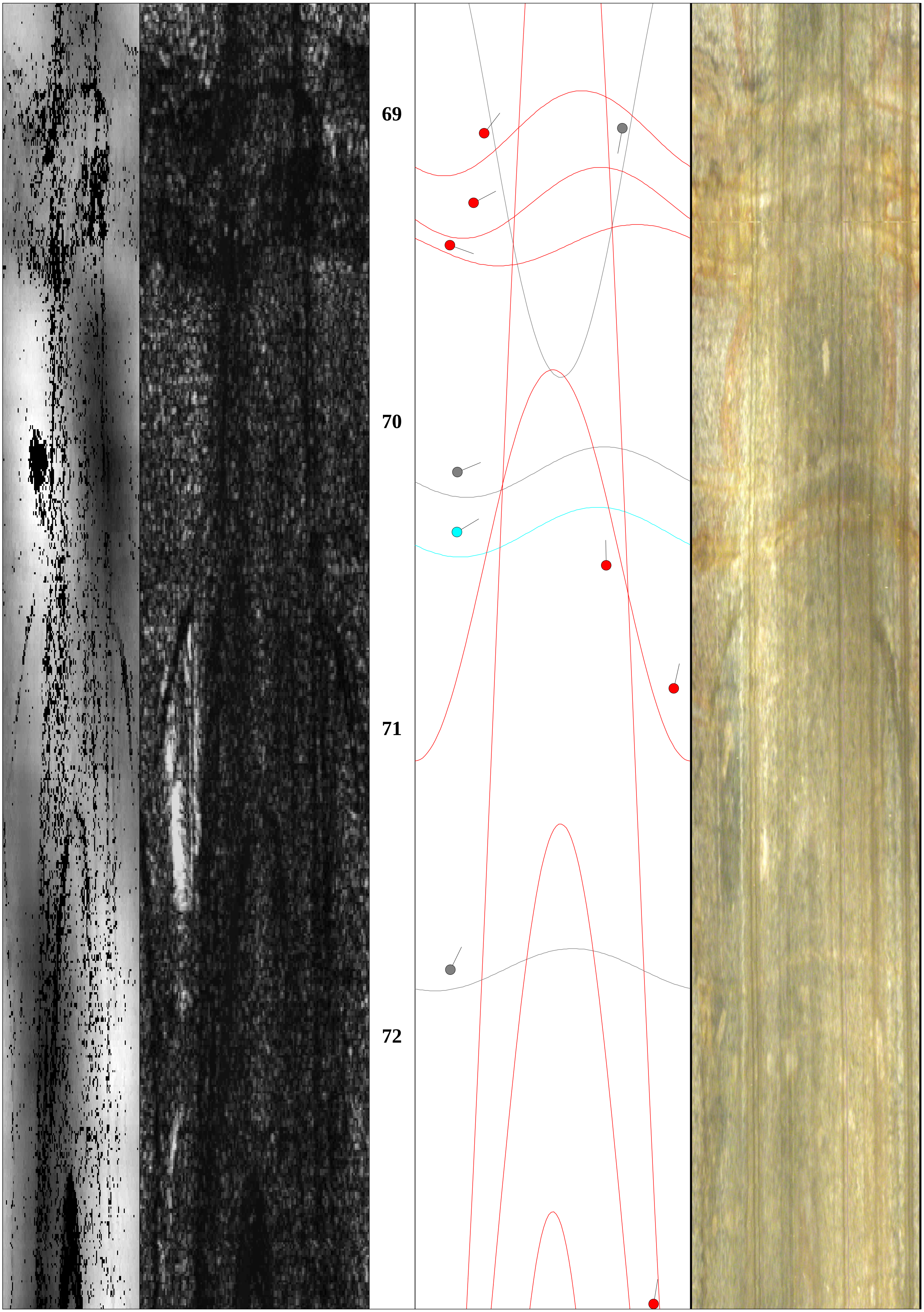
55

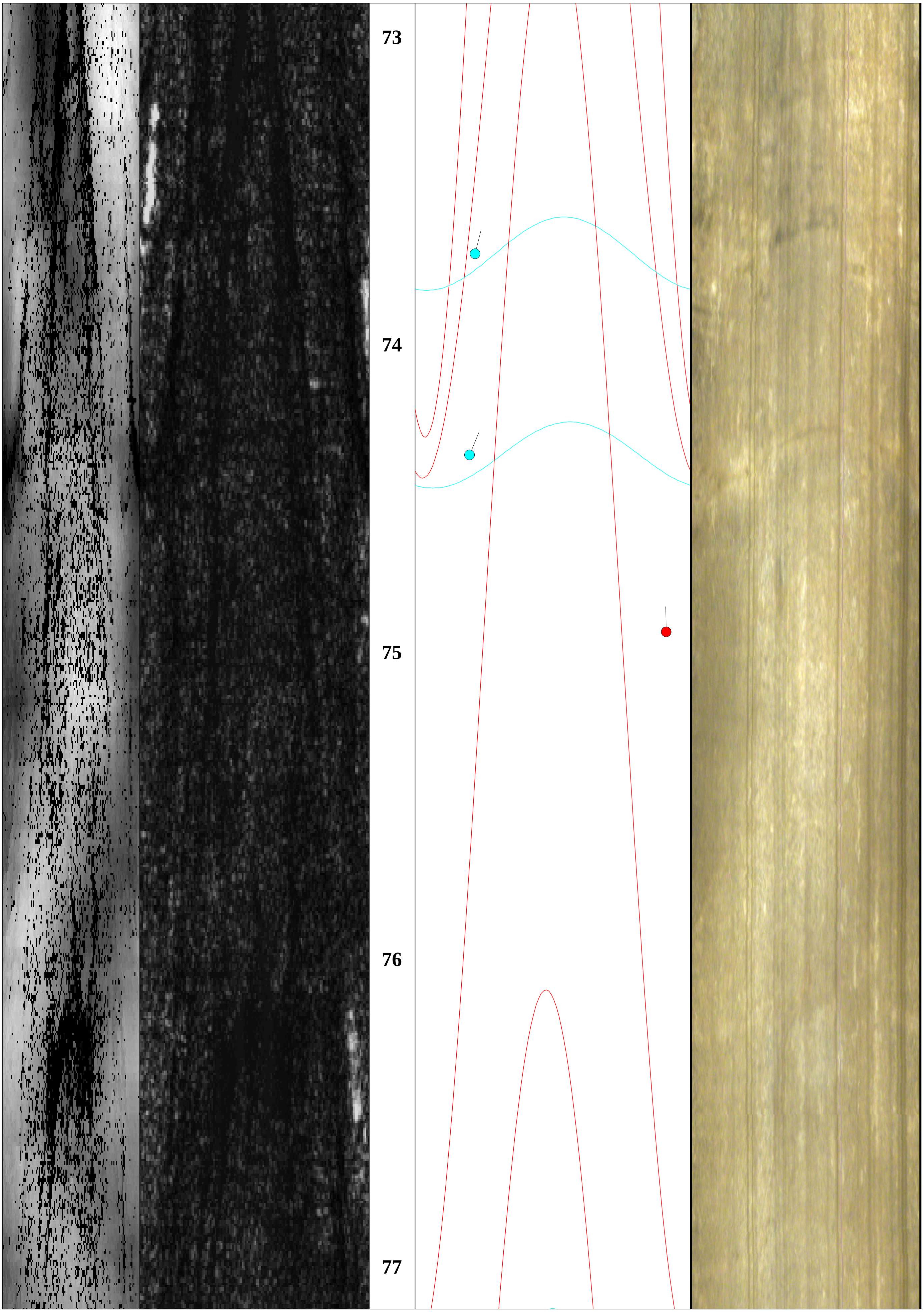


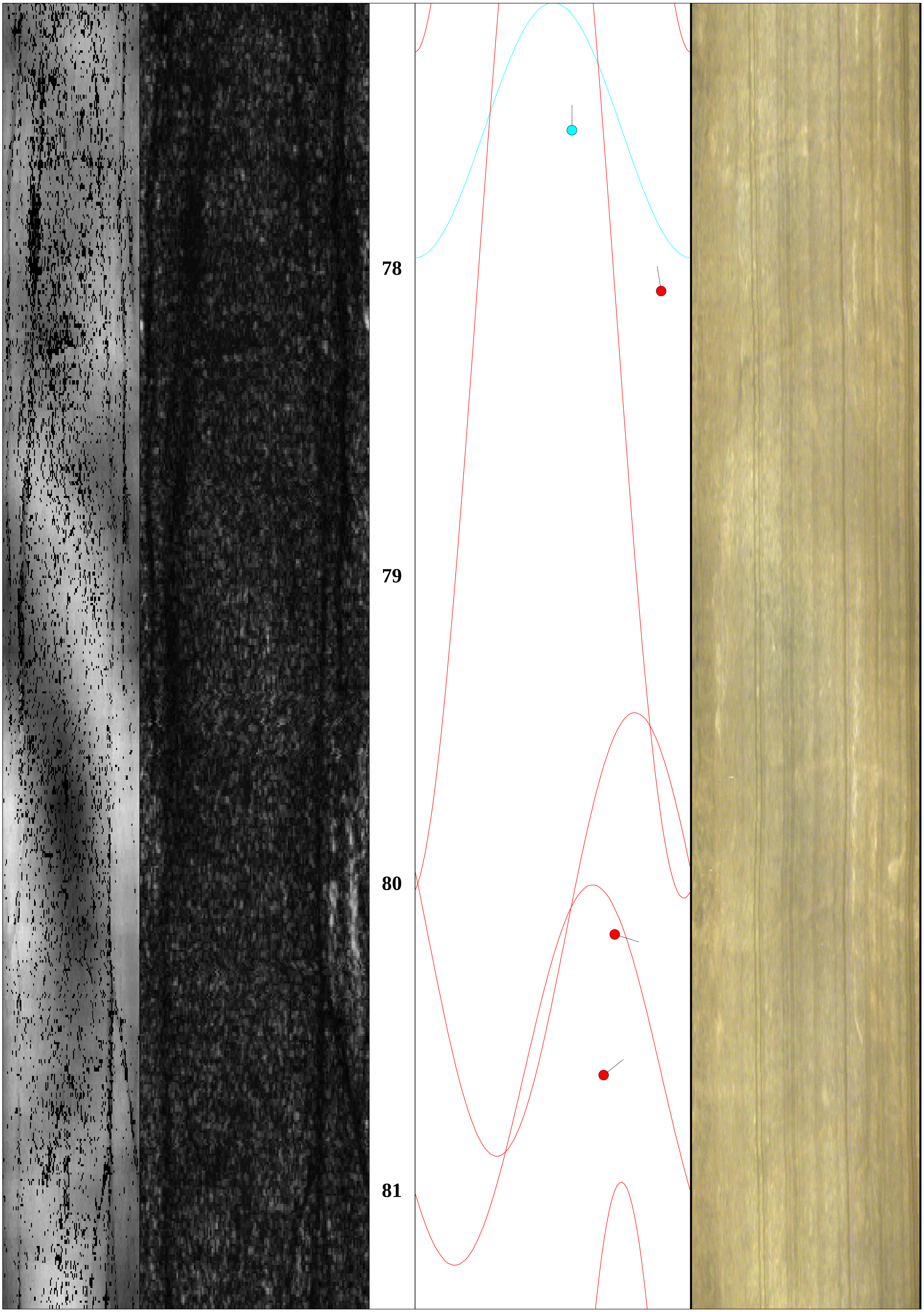

56
57
58
59
60

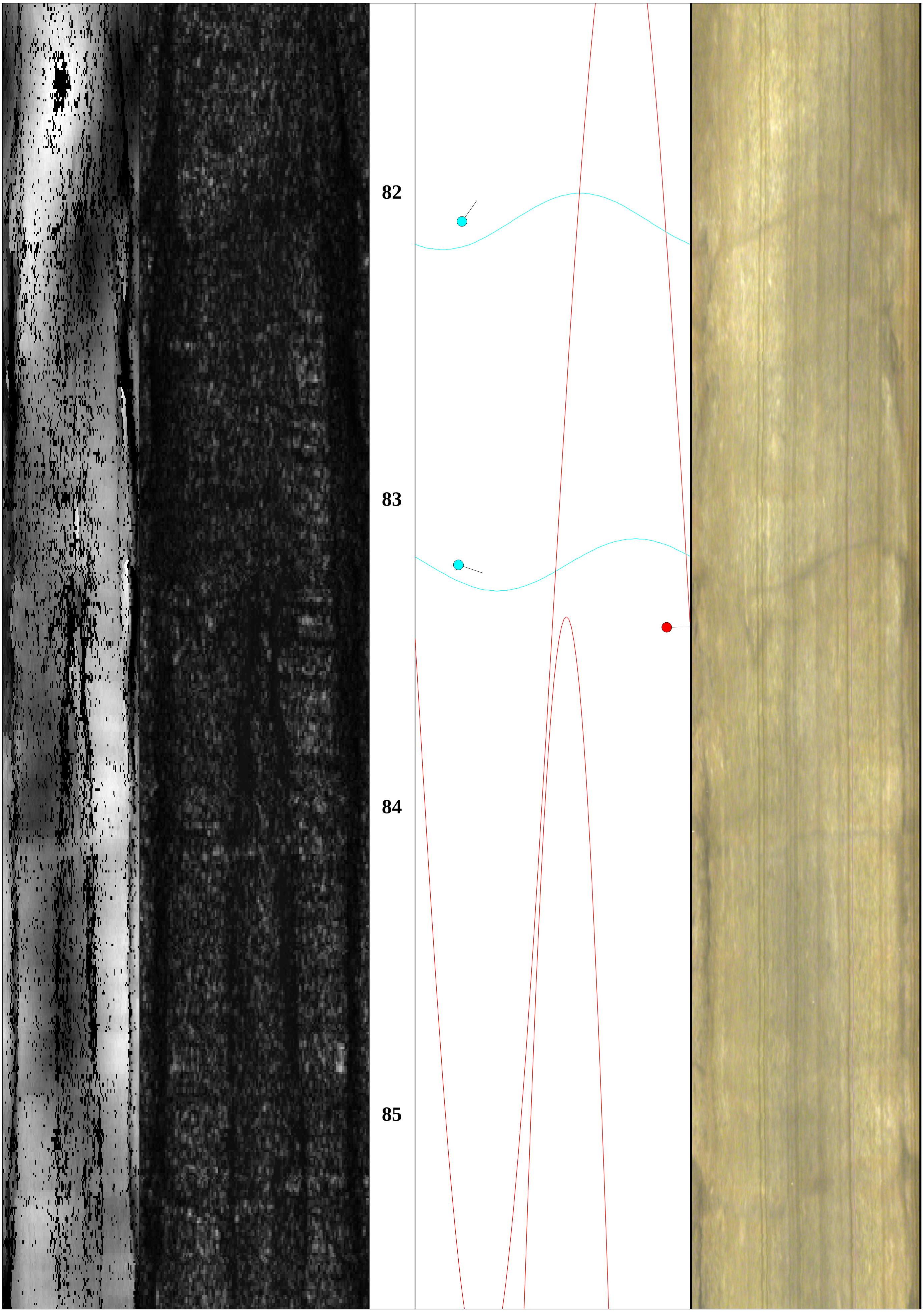

61
62
63
64

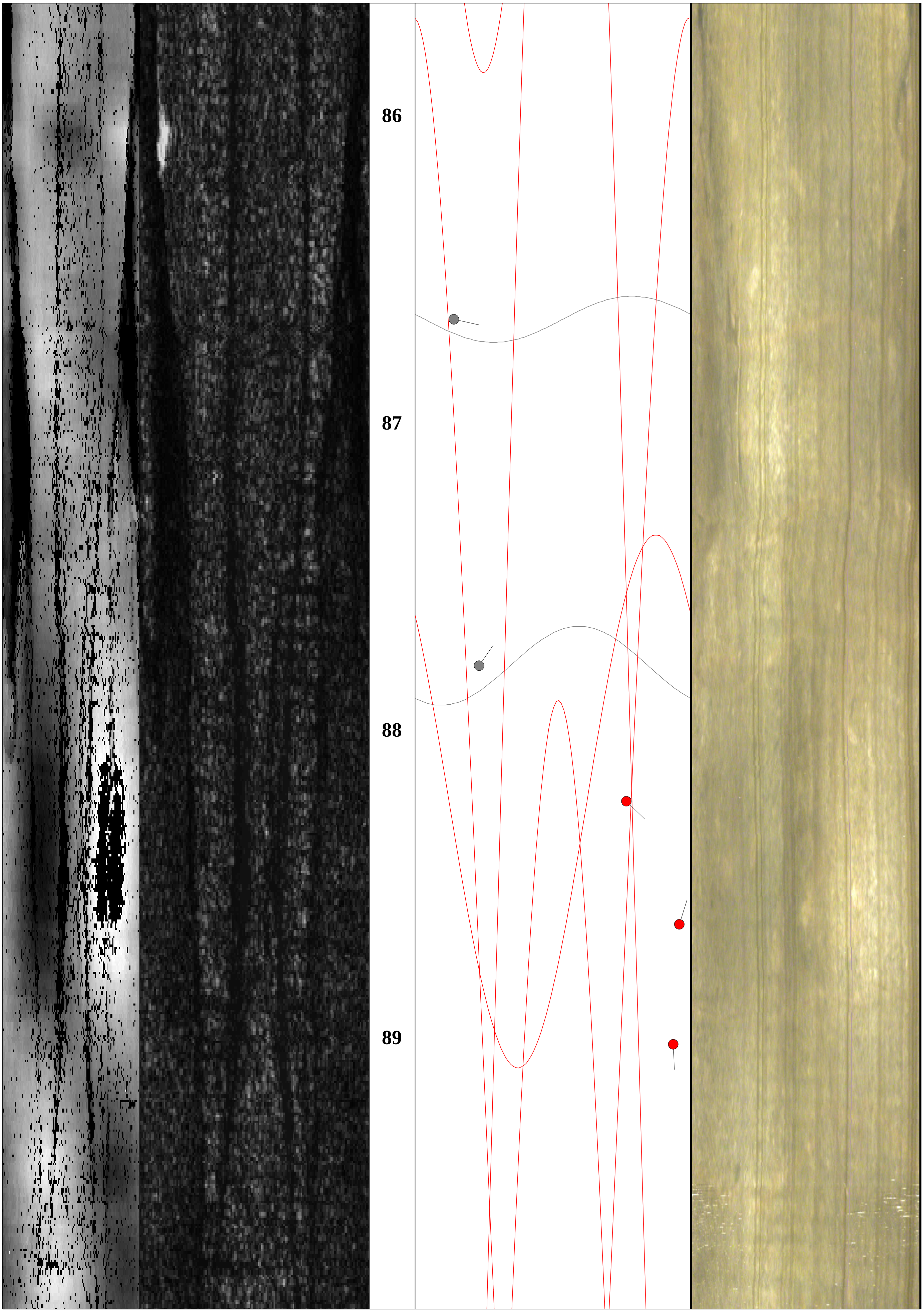

65
66
67
68

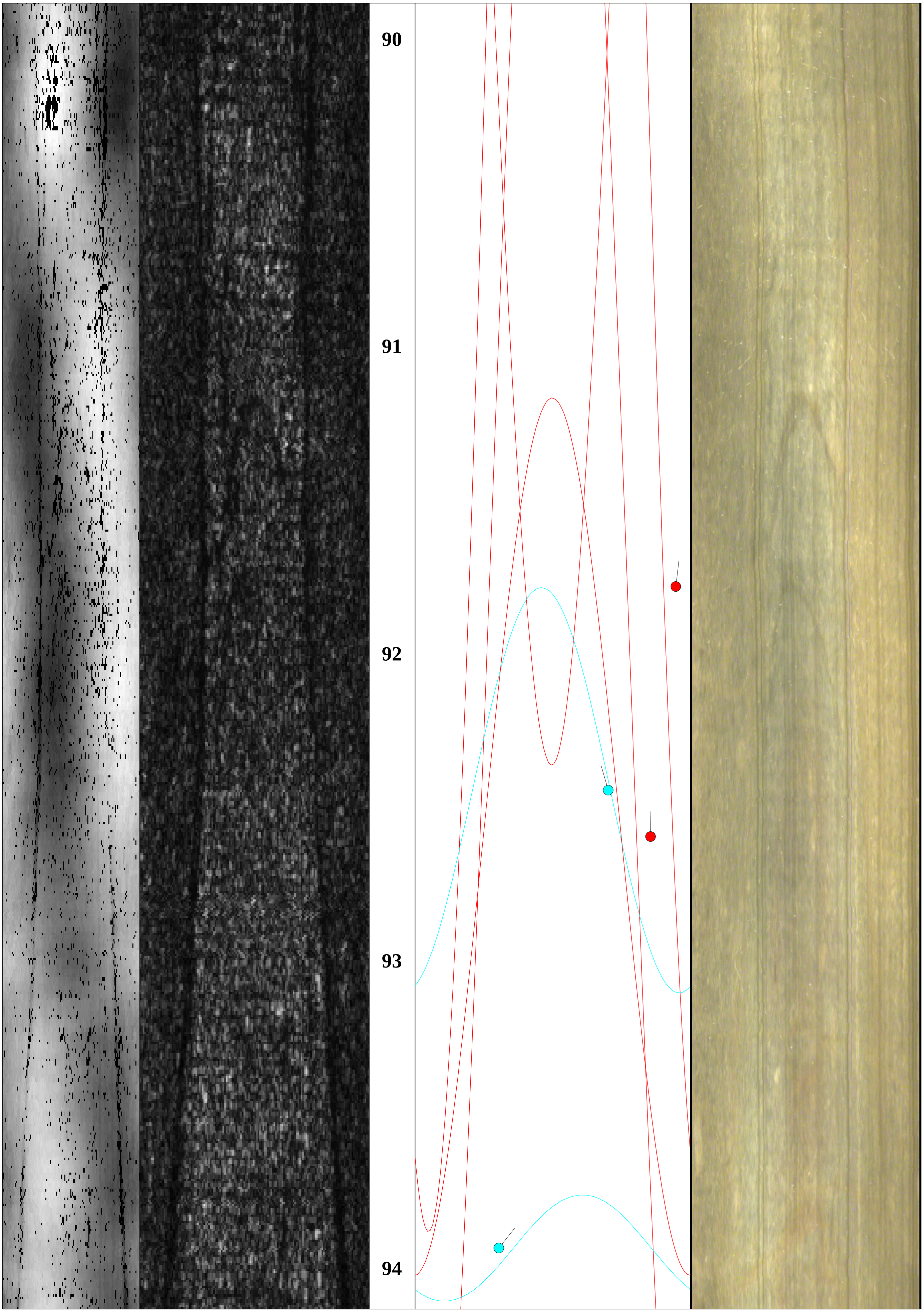

69
70
71
72

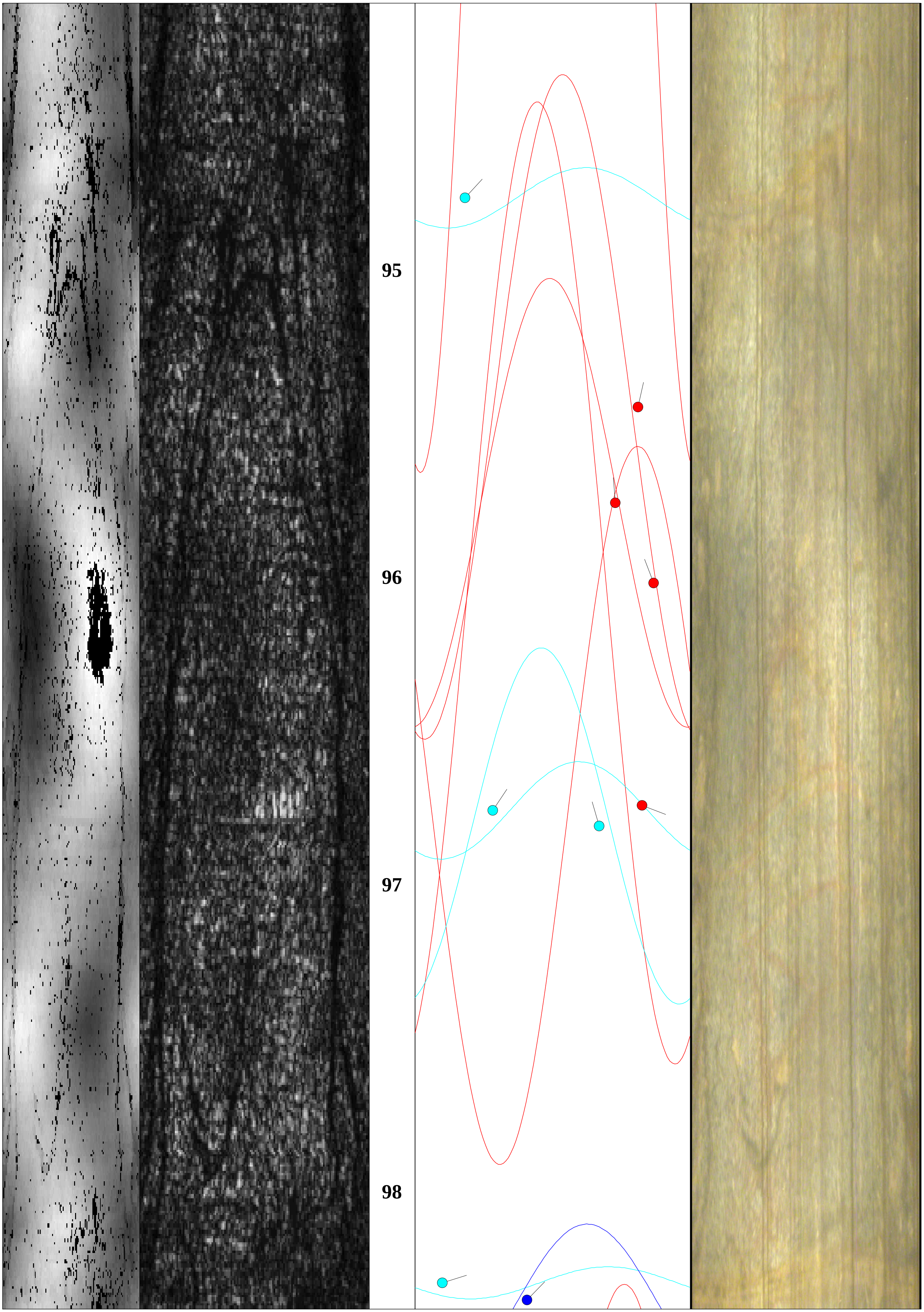

73
74
75
76
77

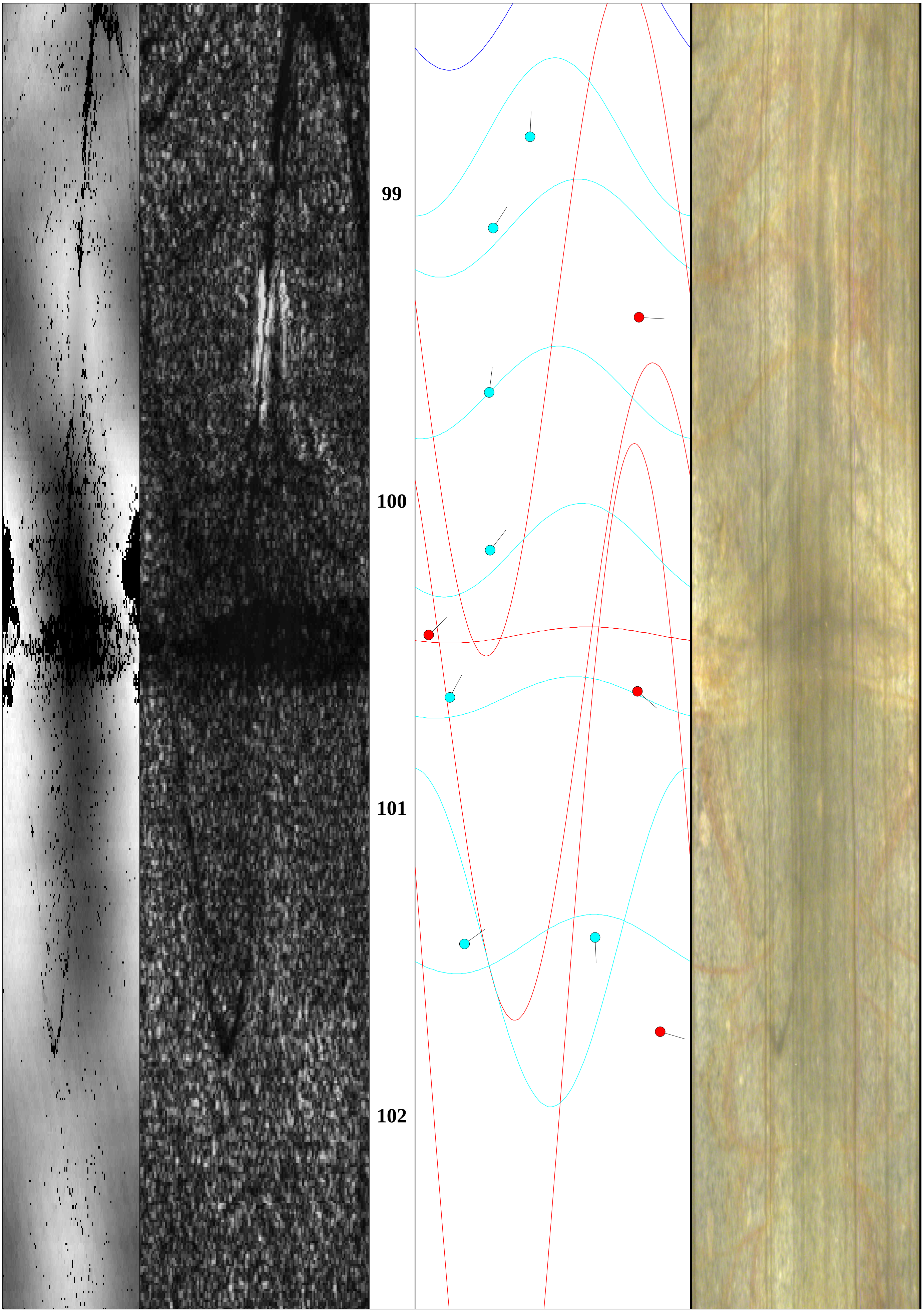

78
79
80
81

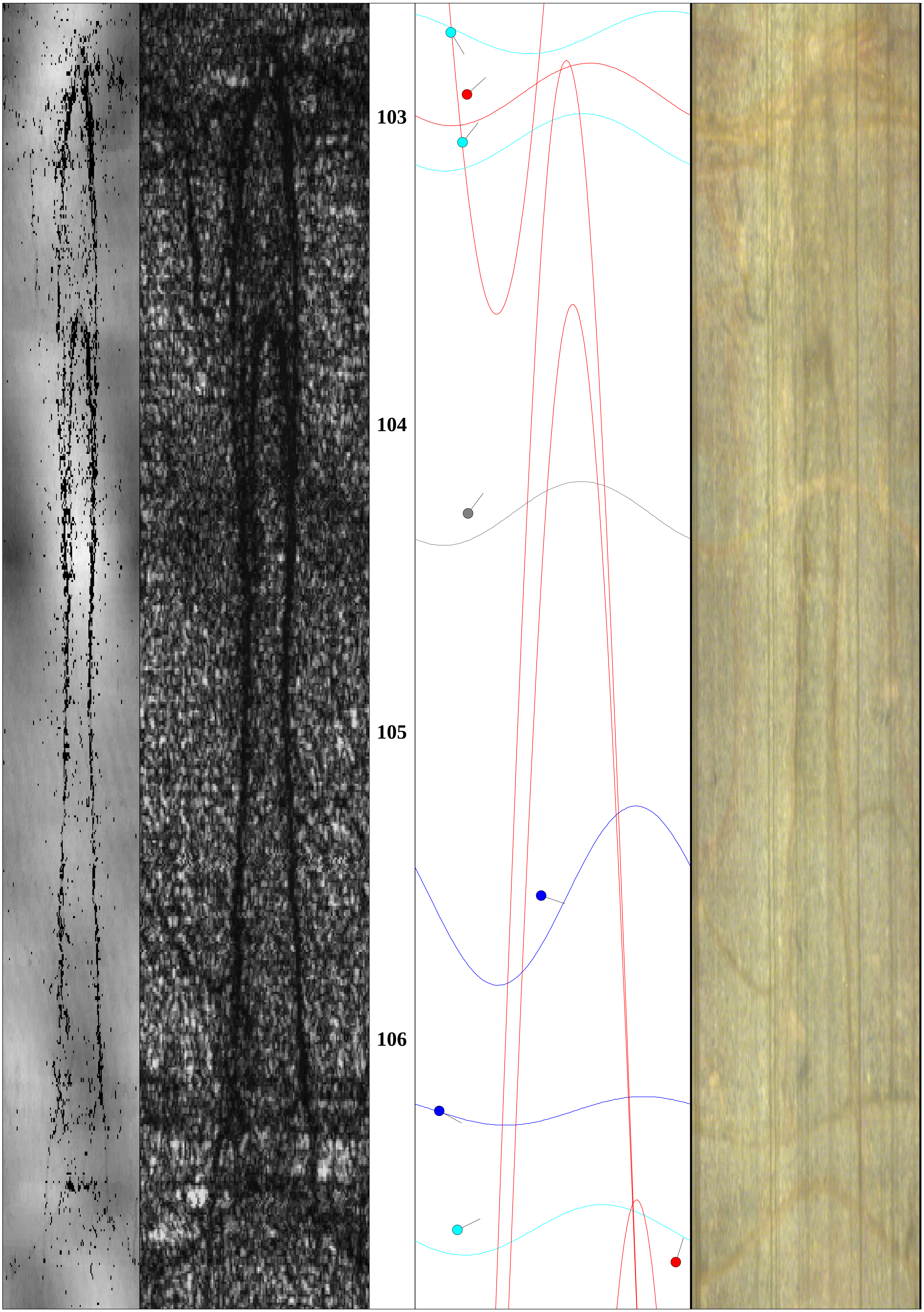

82
83
84
85

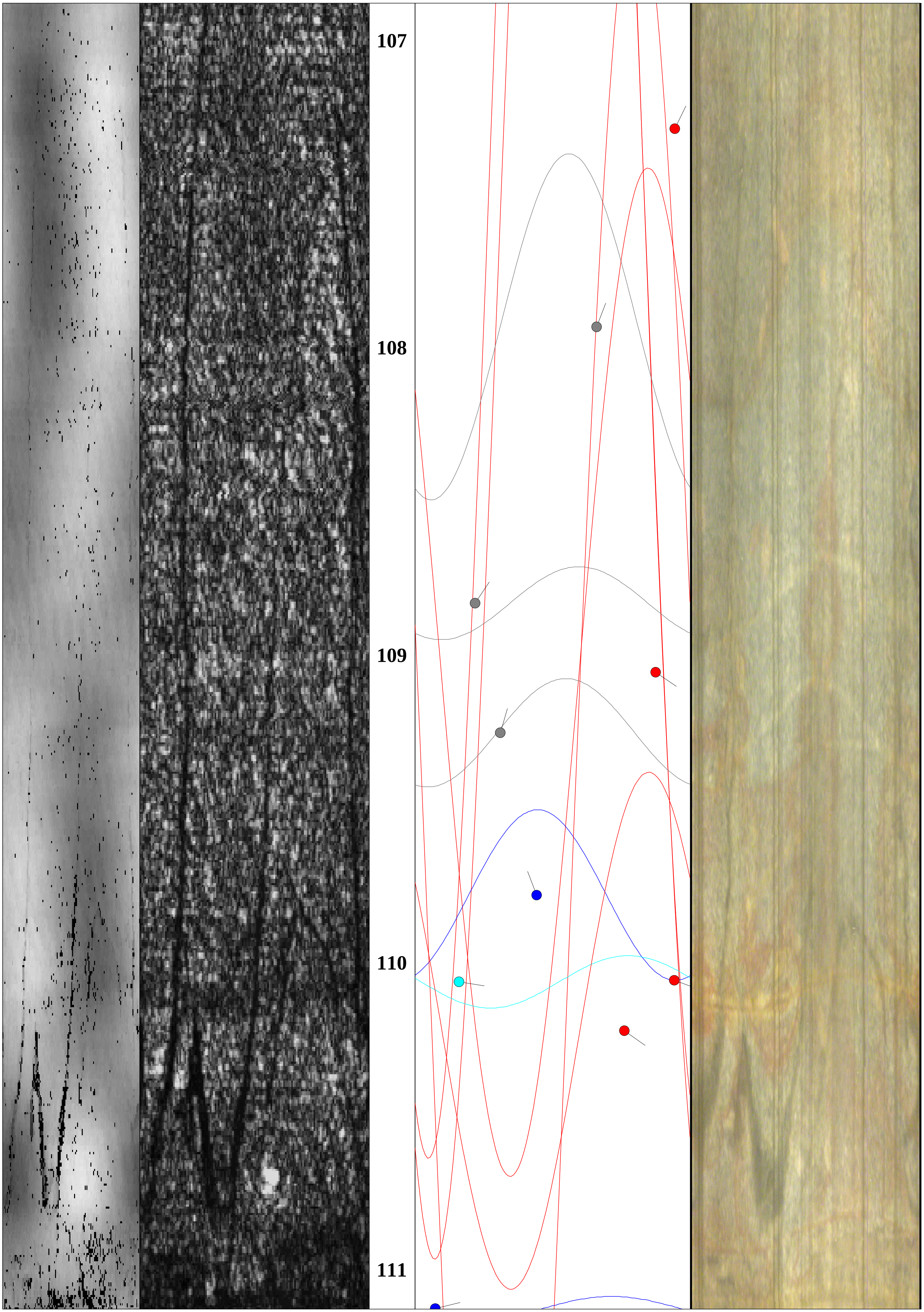

86
87
88
89

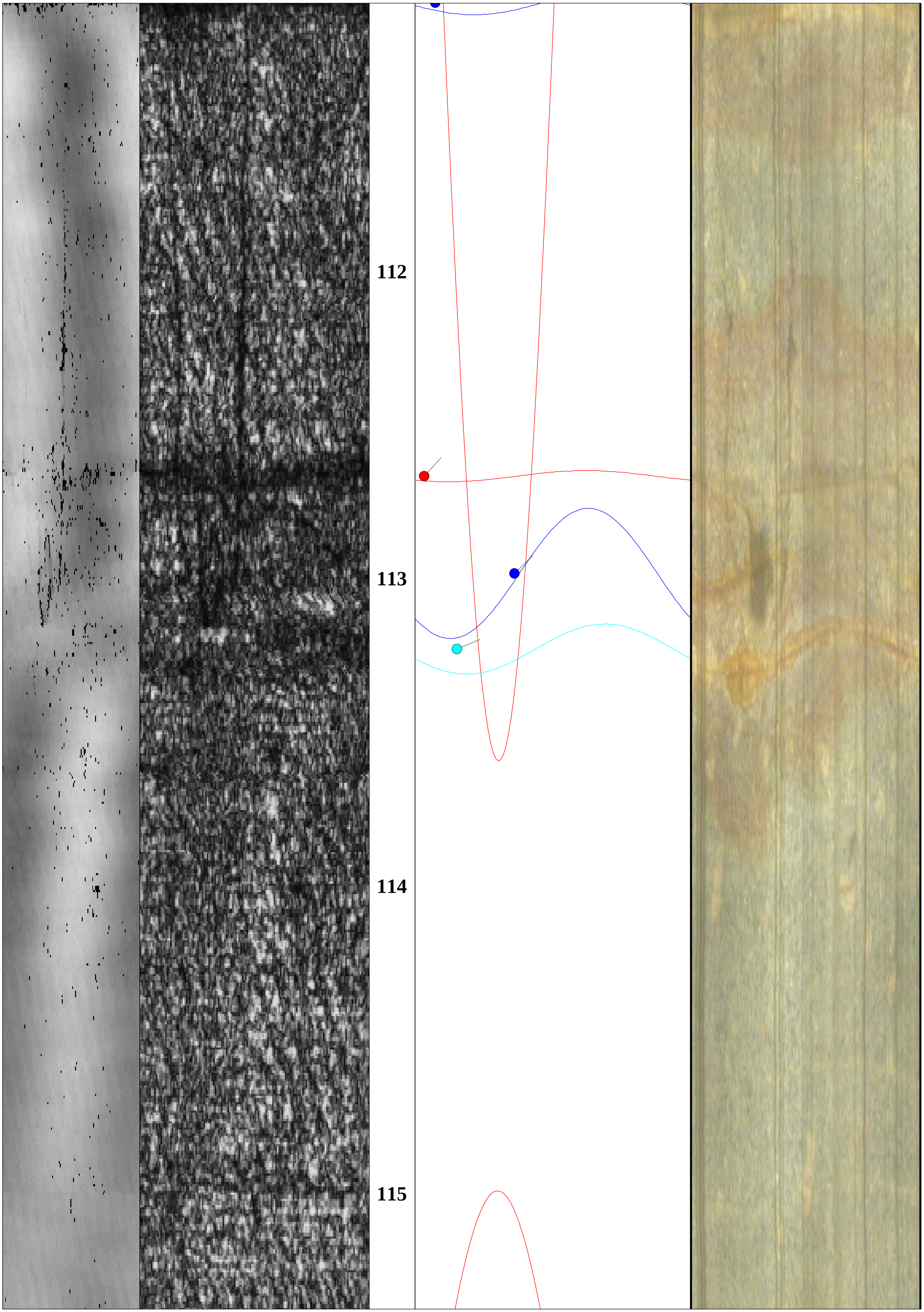

90
91
92
93
94

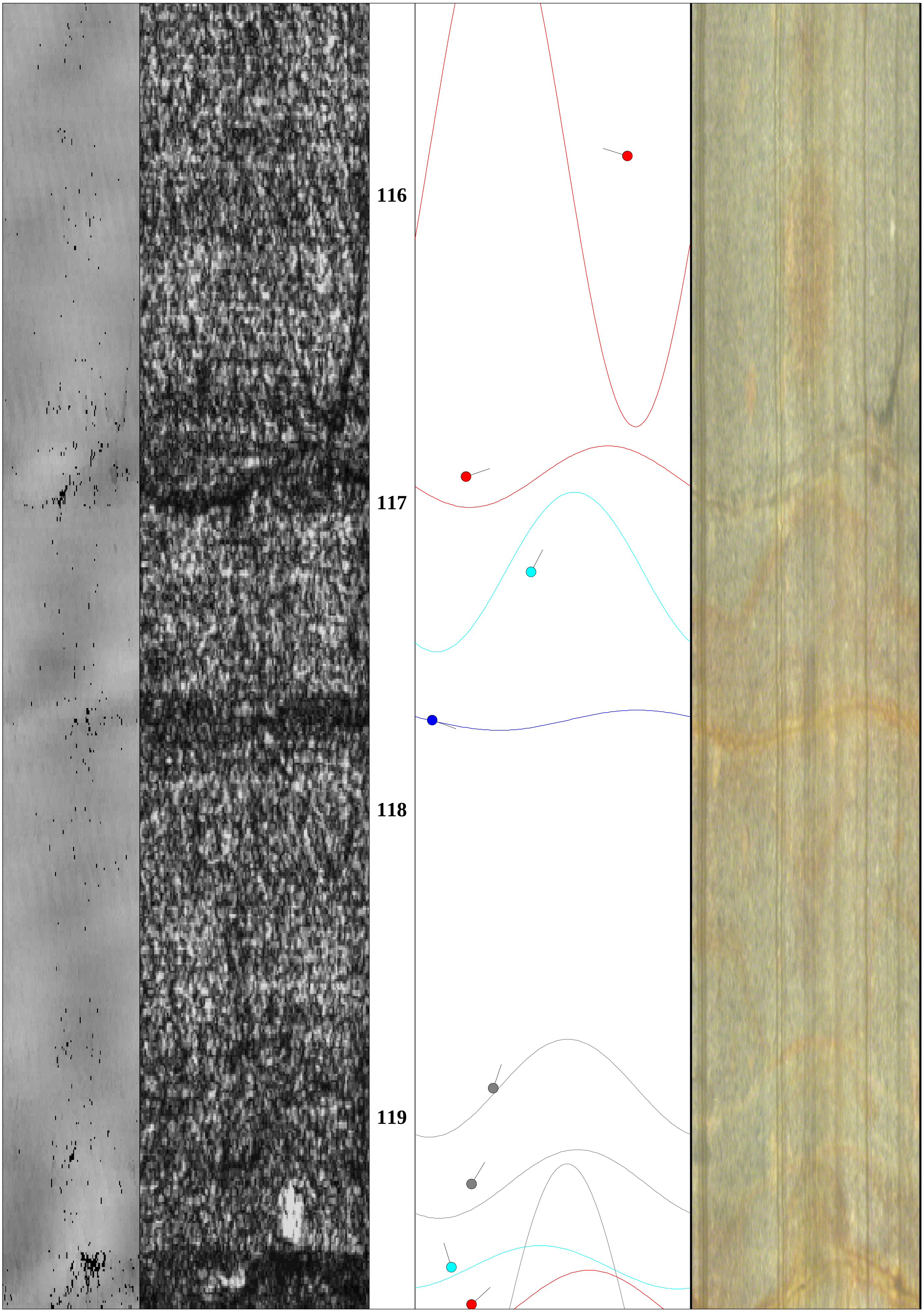

95
96
97
98

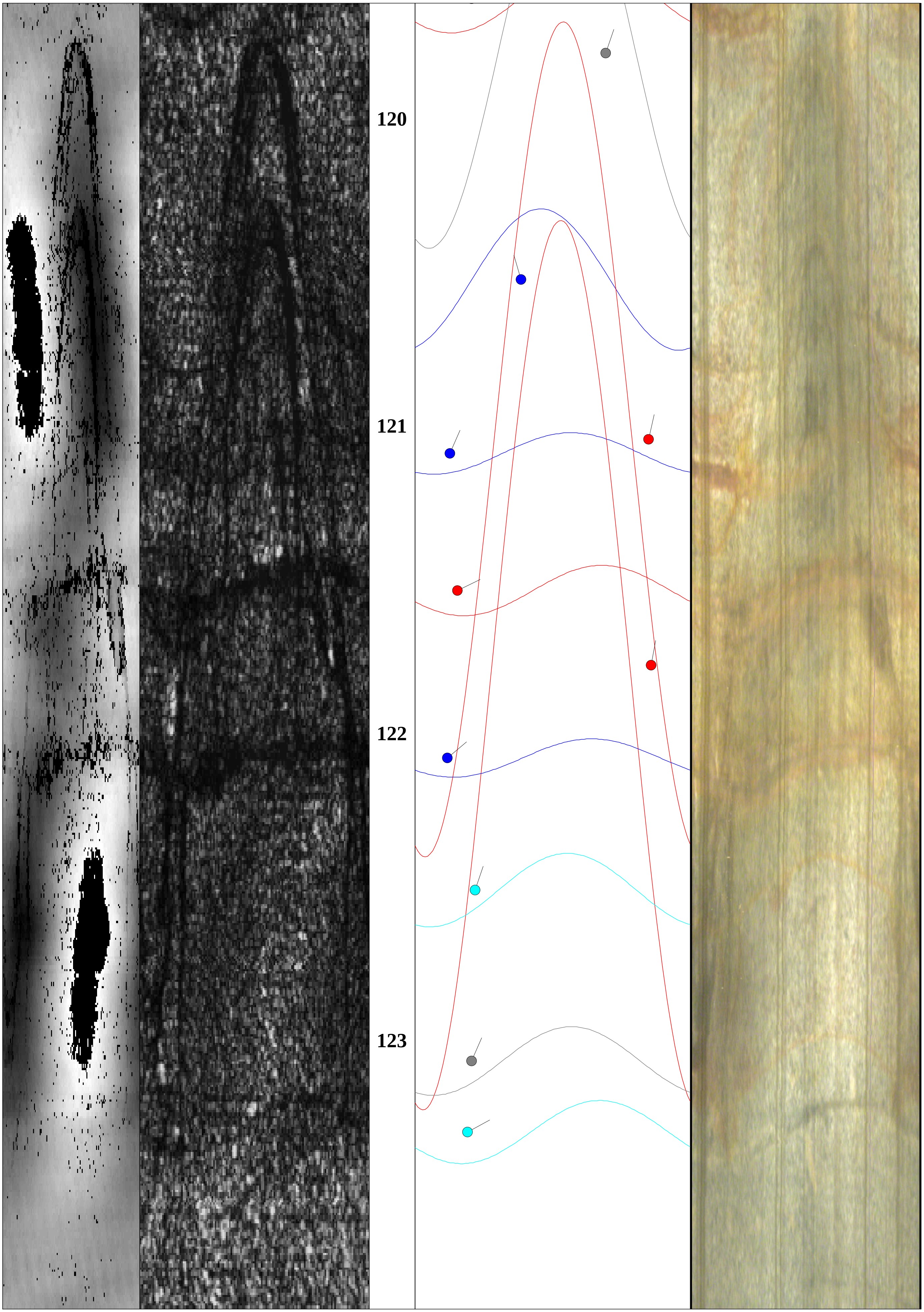

99
100
101
102

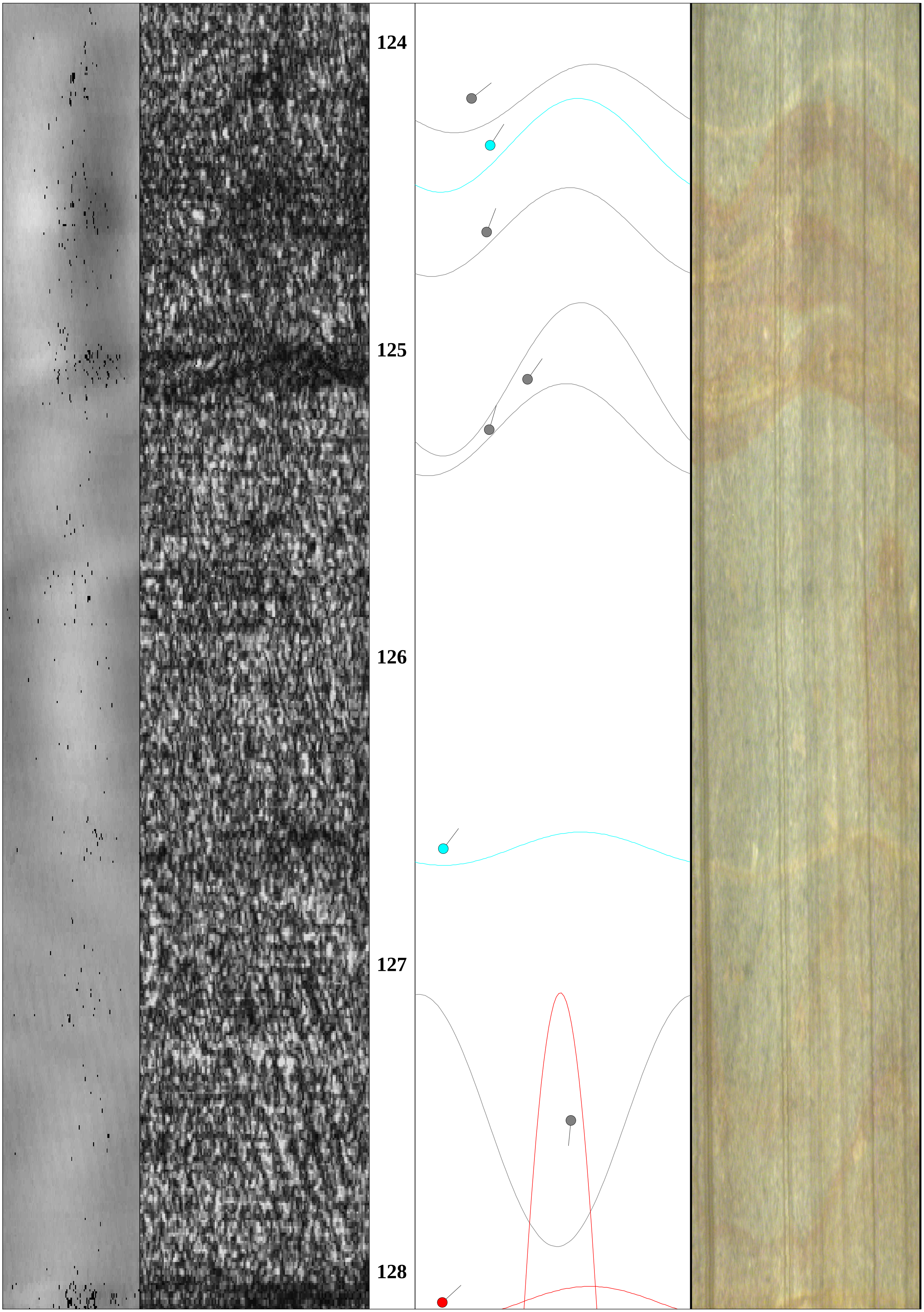

103
104
105
106

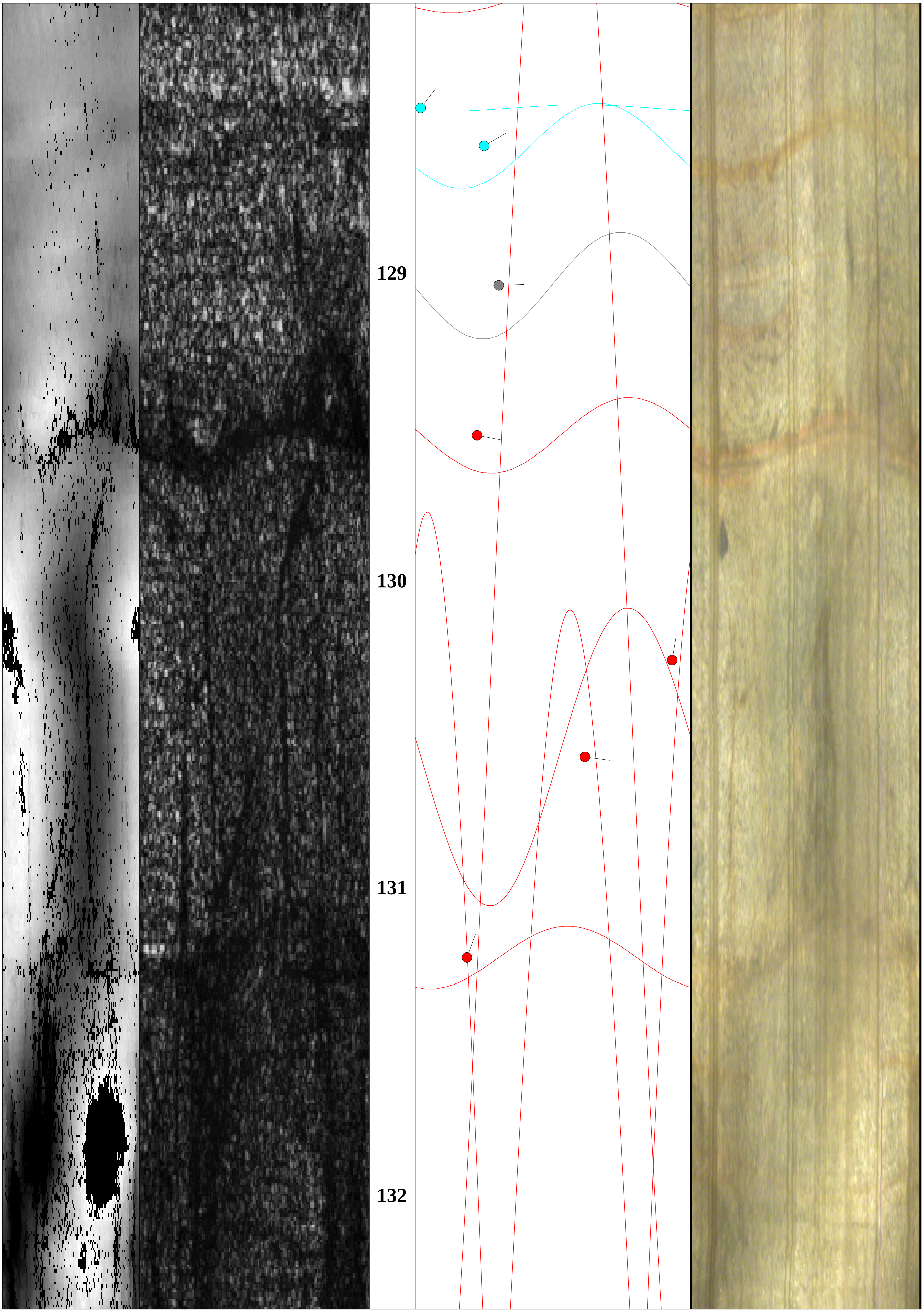

107
108
109
110
111

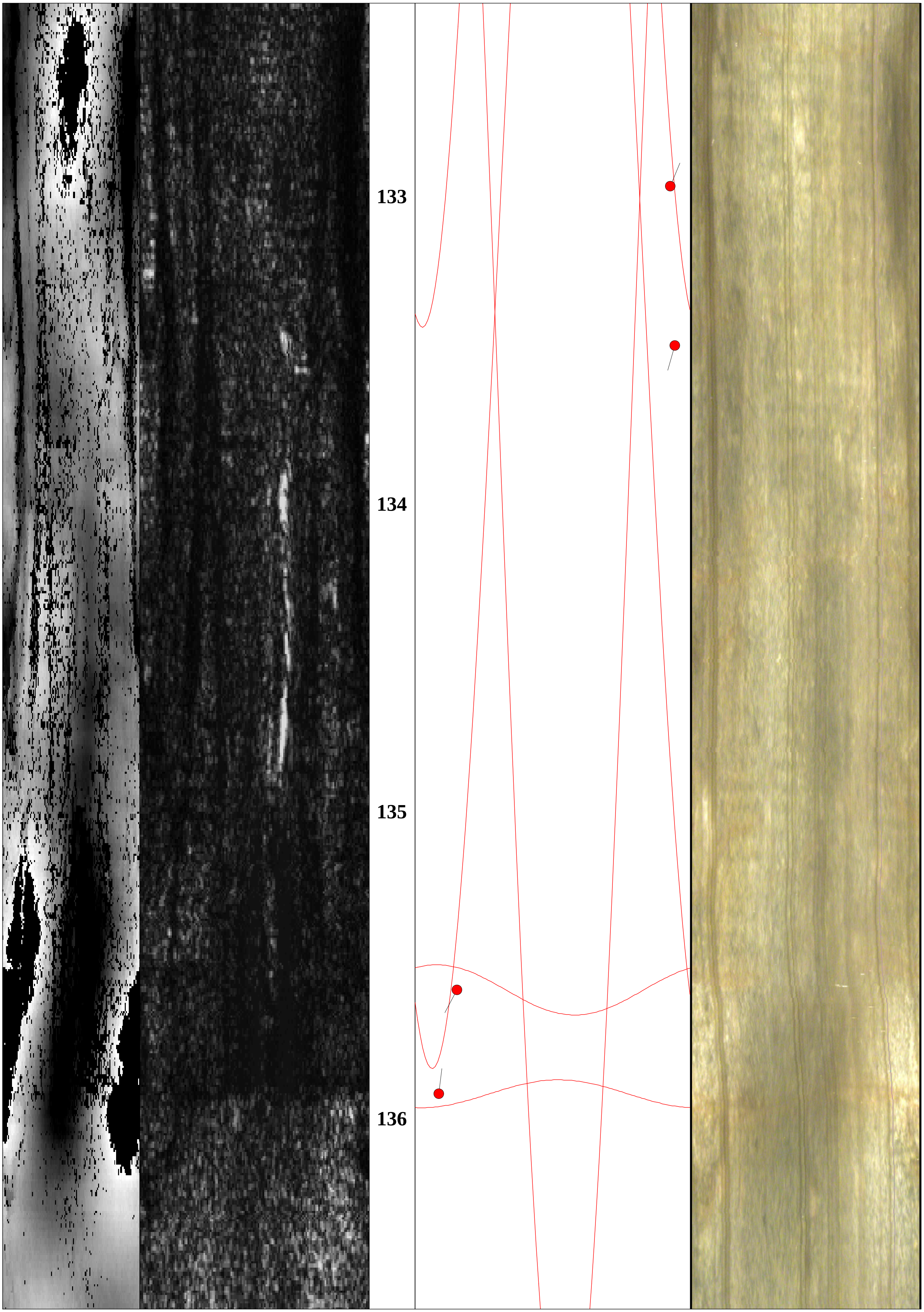

112
113
114
115

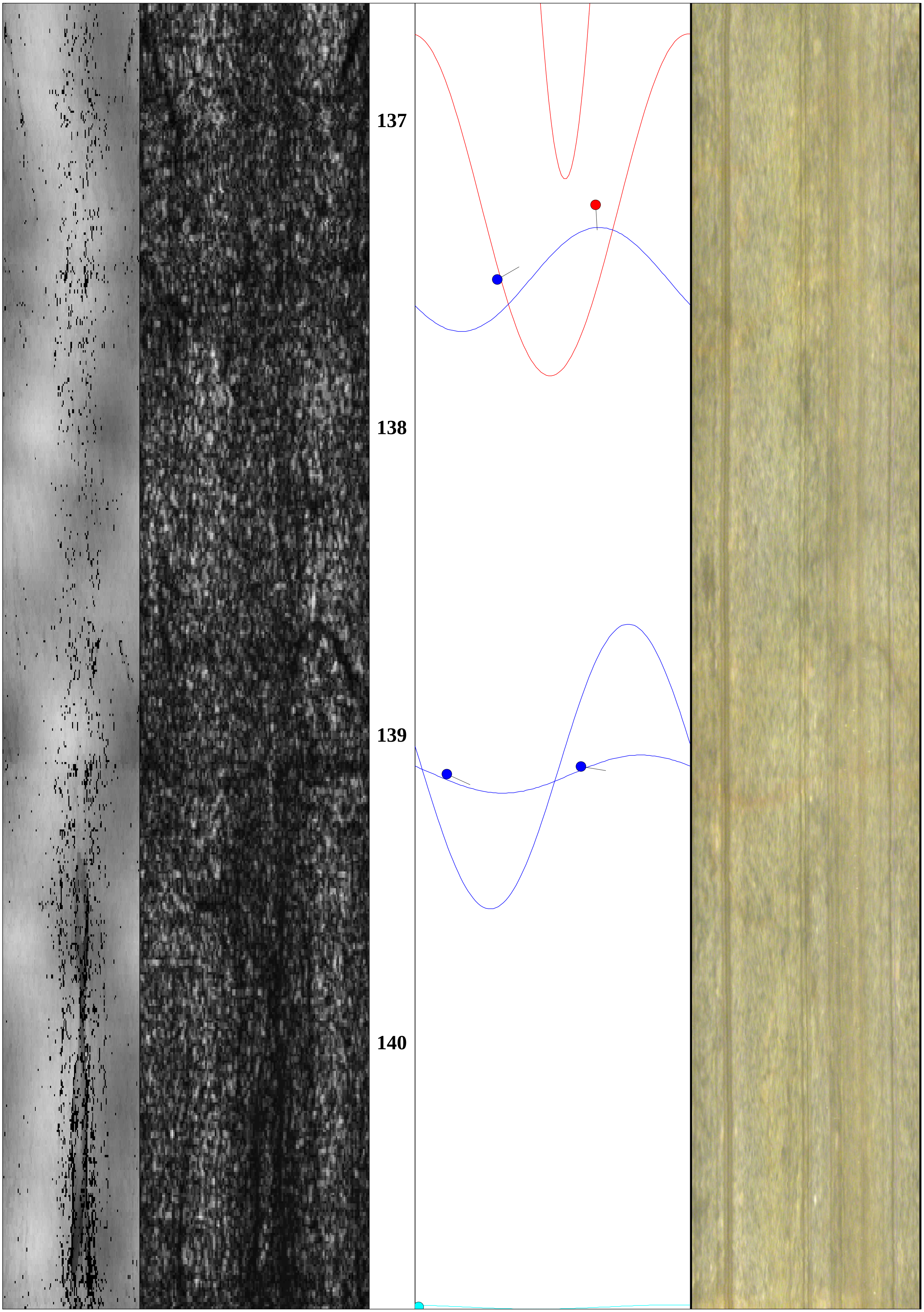

116
117
118
119

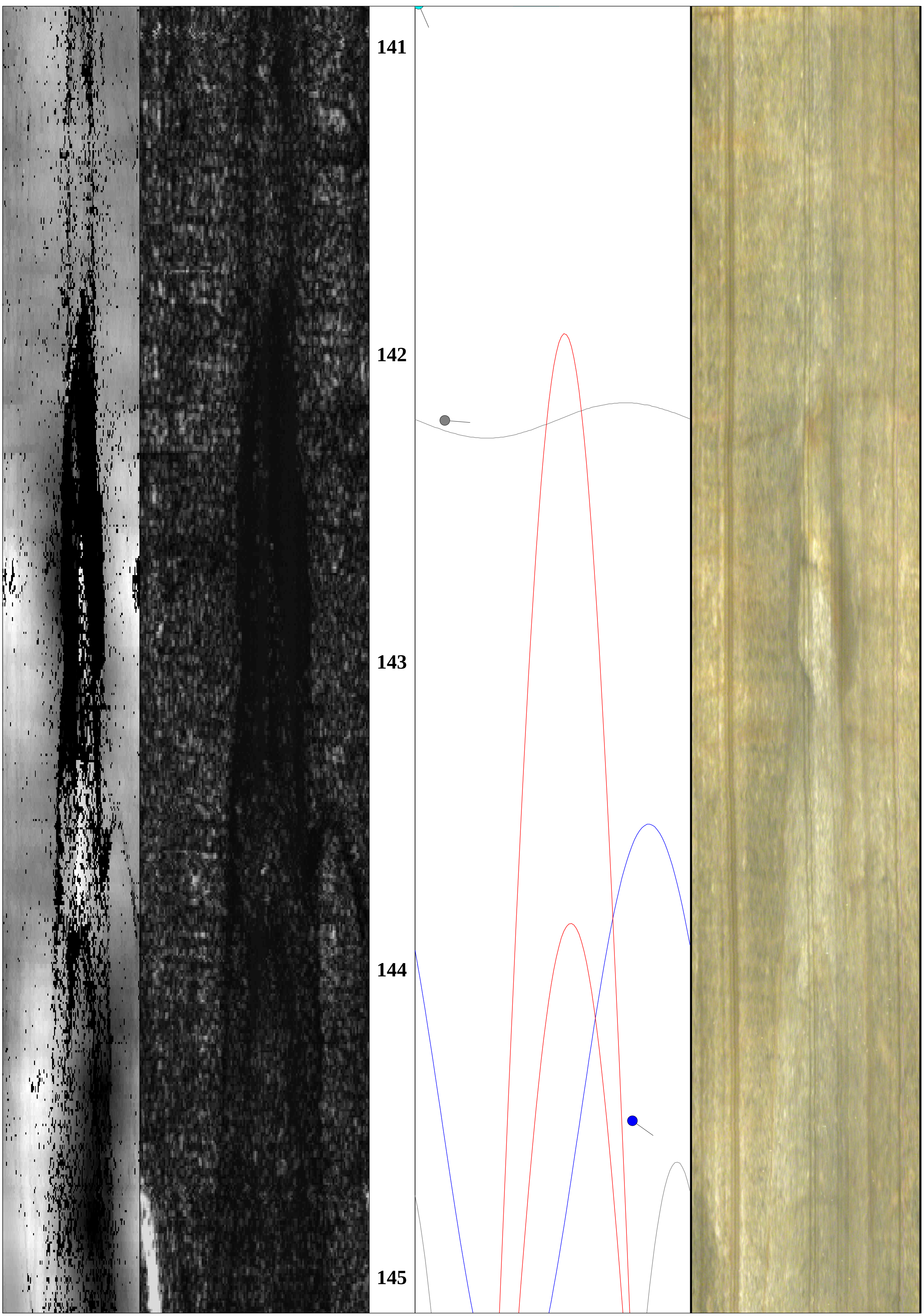

120
121
122
123

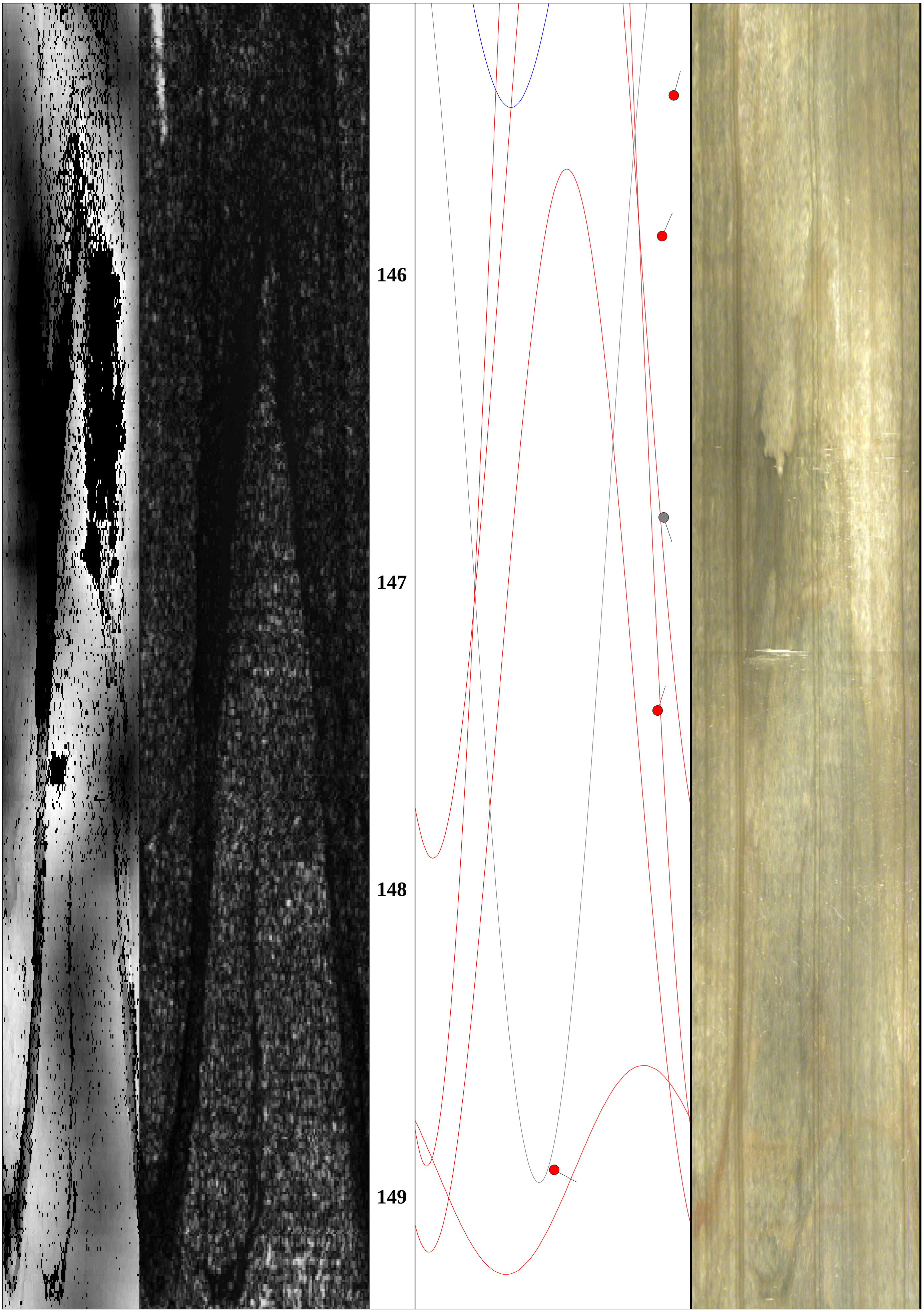

124
125
126
127
128

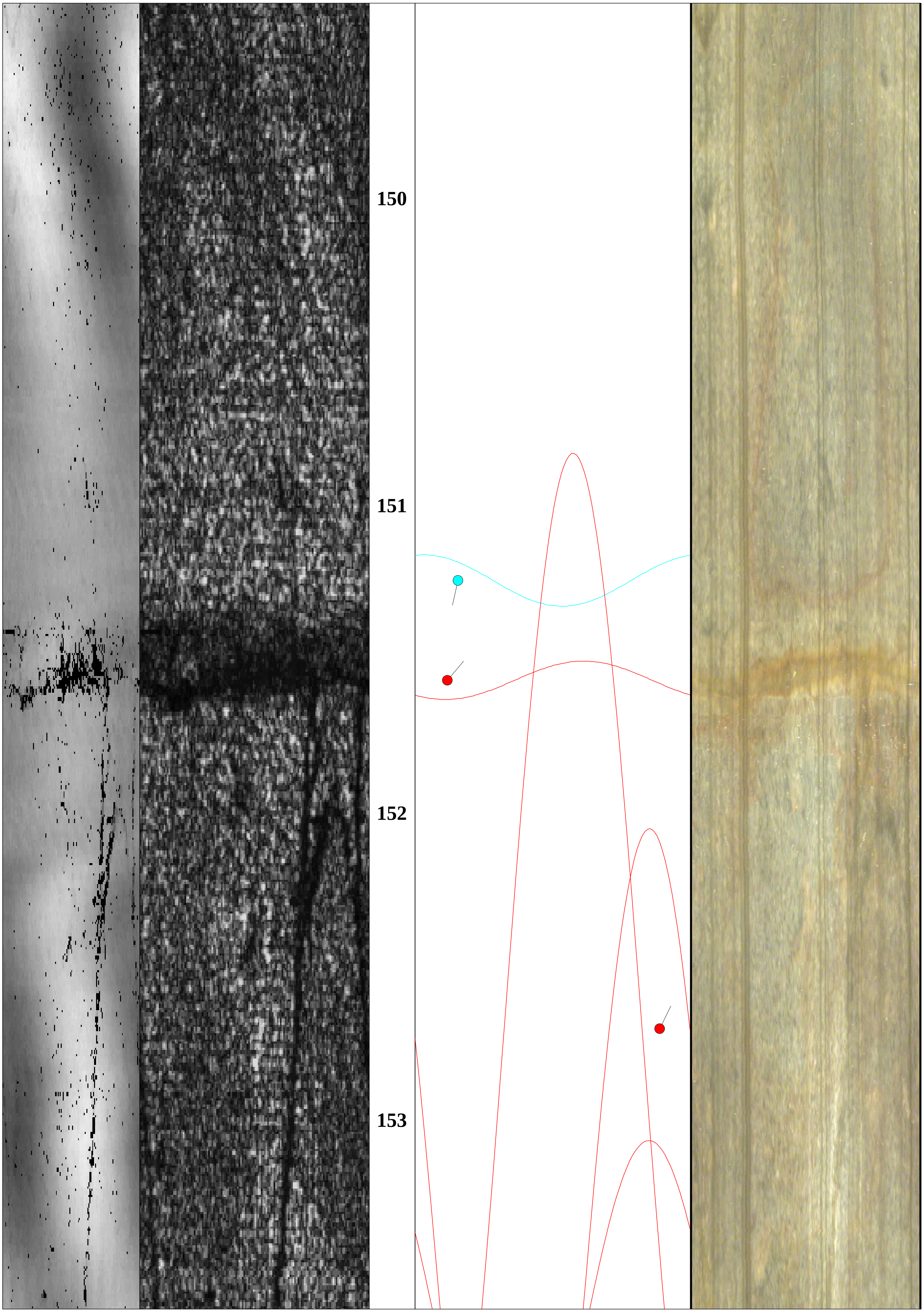

129
130
131
132

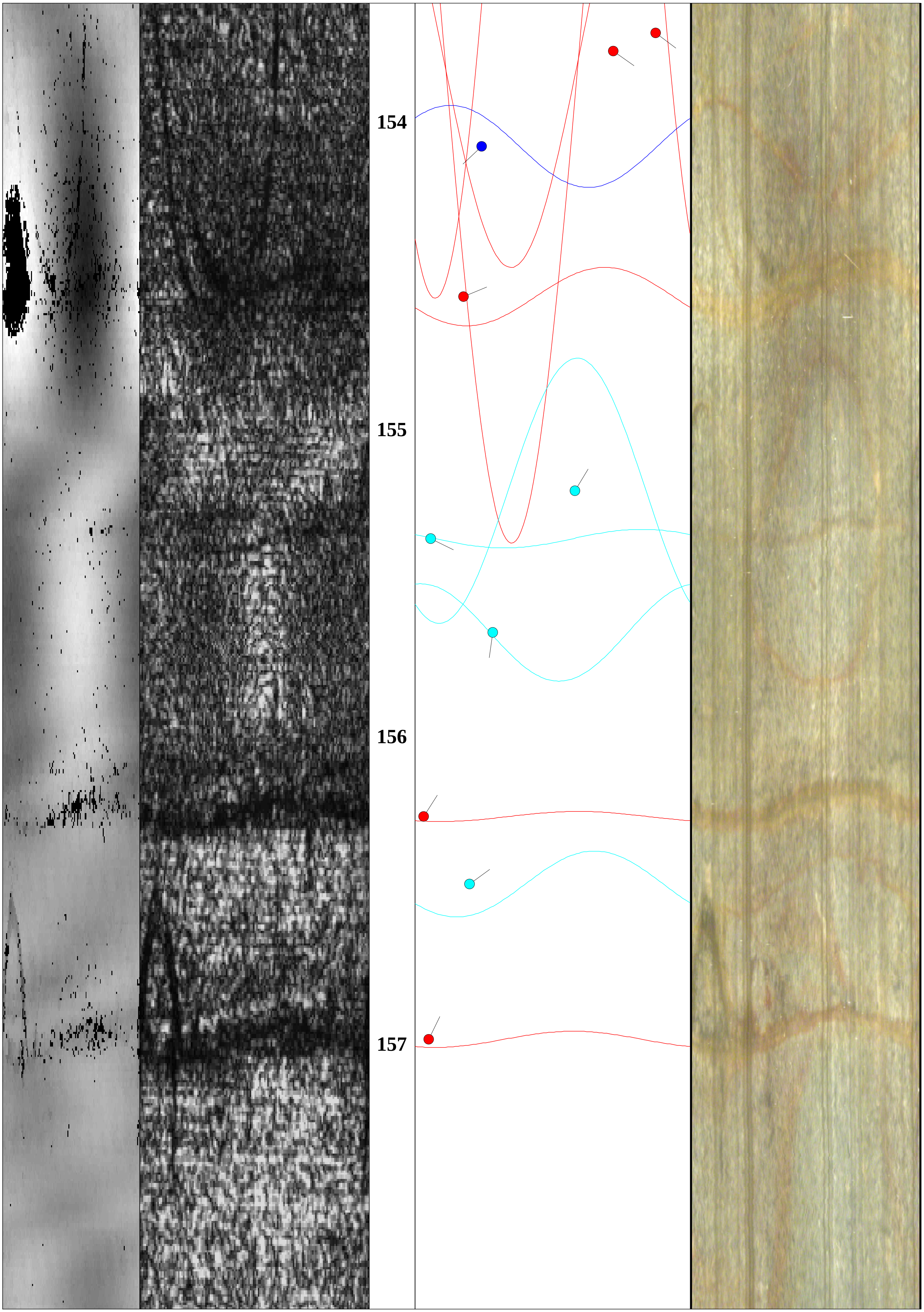

133
134
135
136

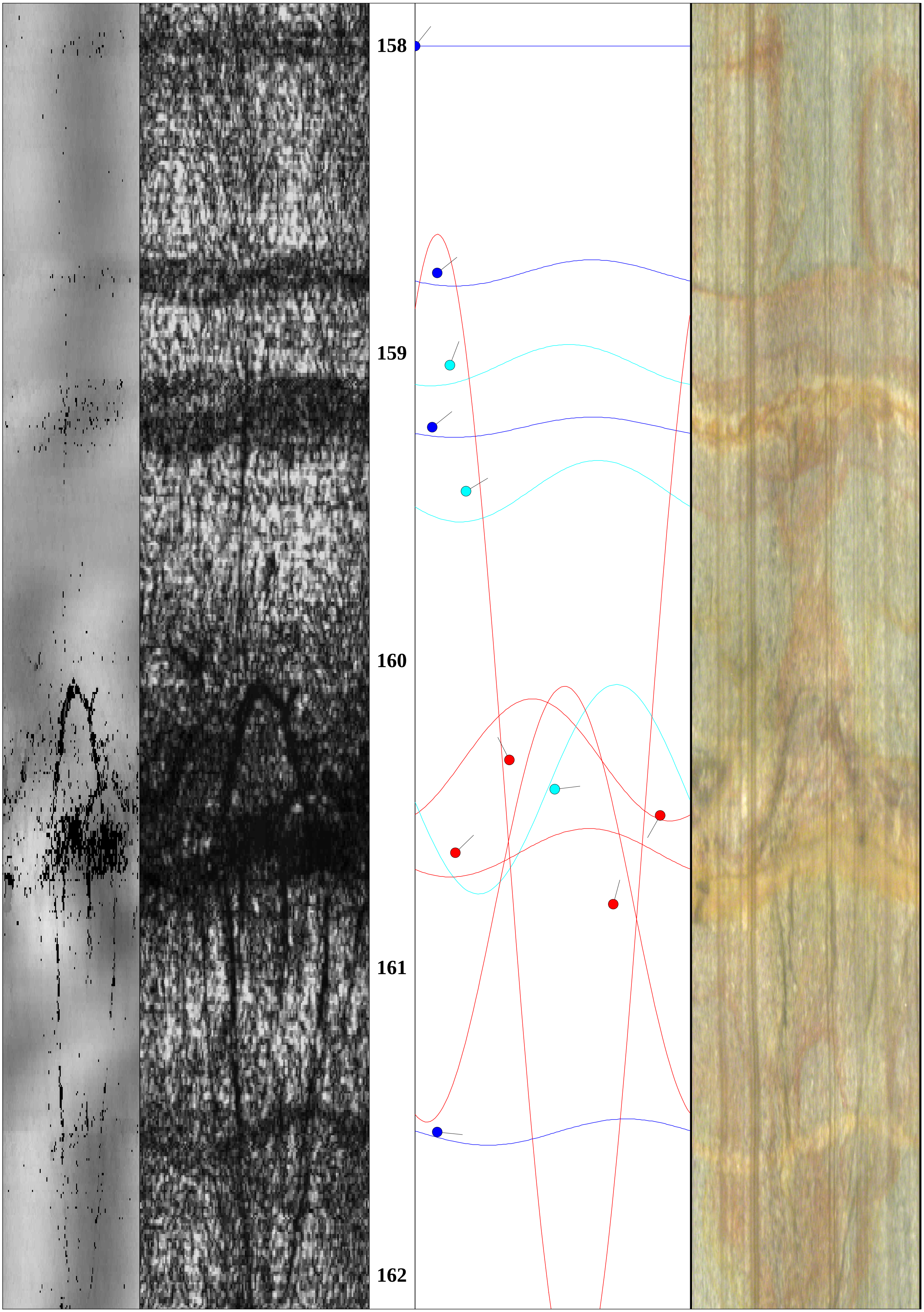

137
138
139
140

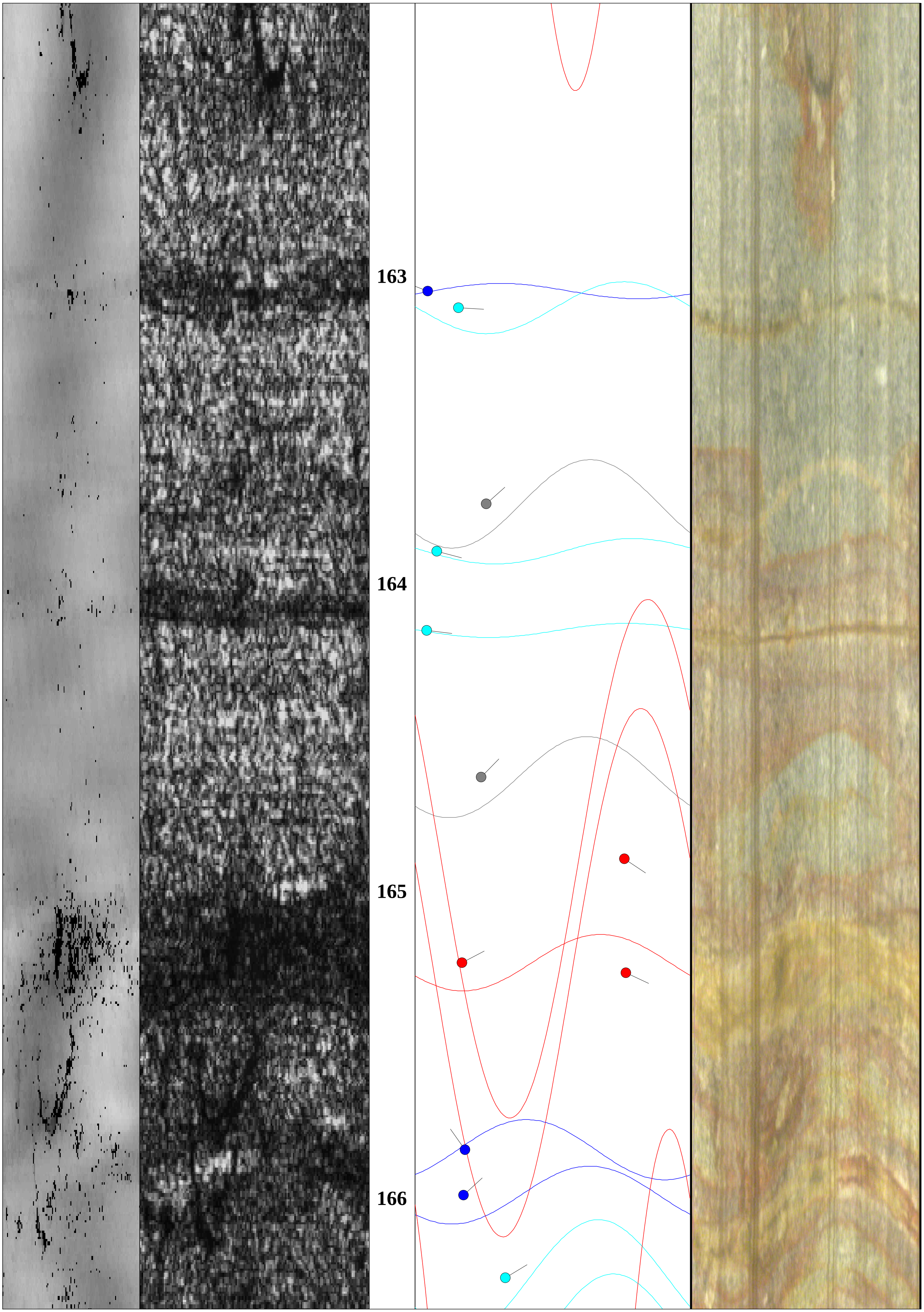

141
142
143
144
145

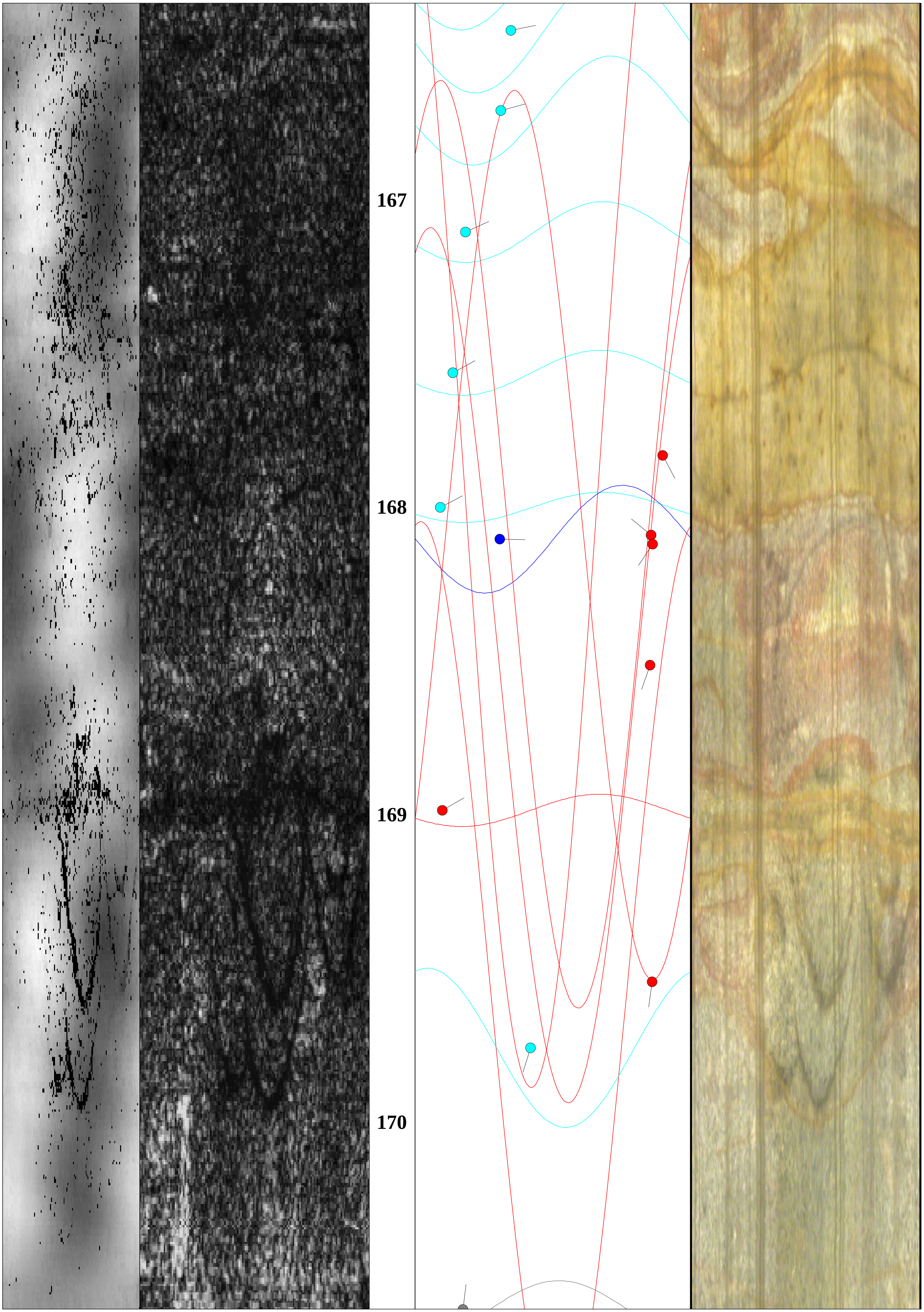

146
147
148
149

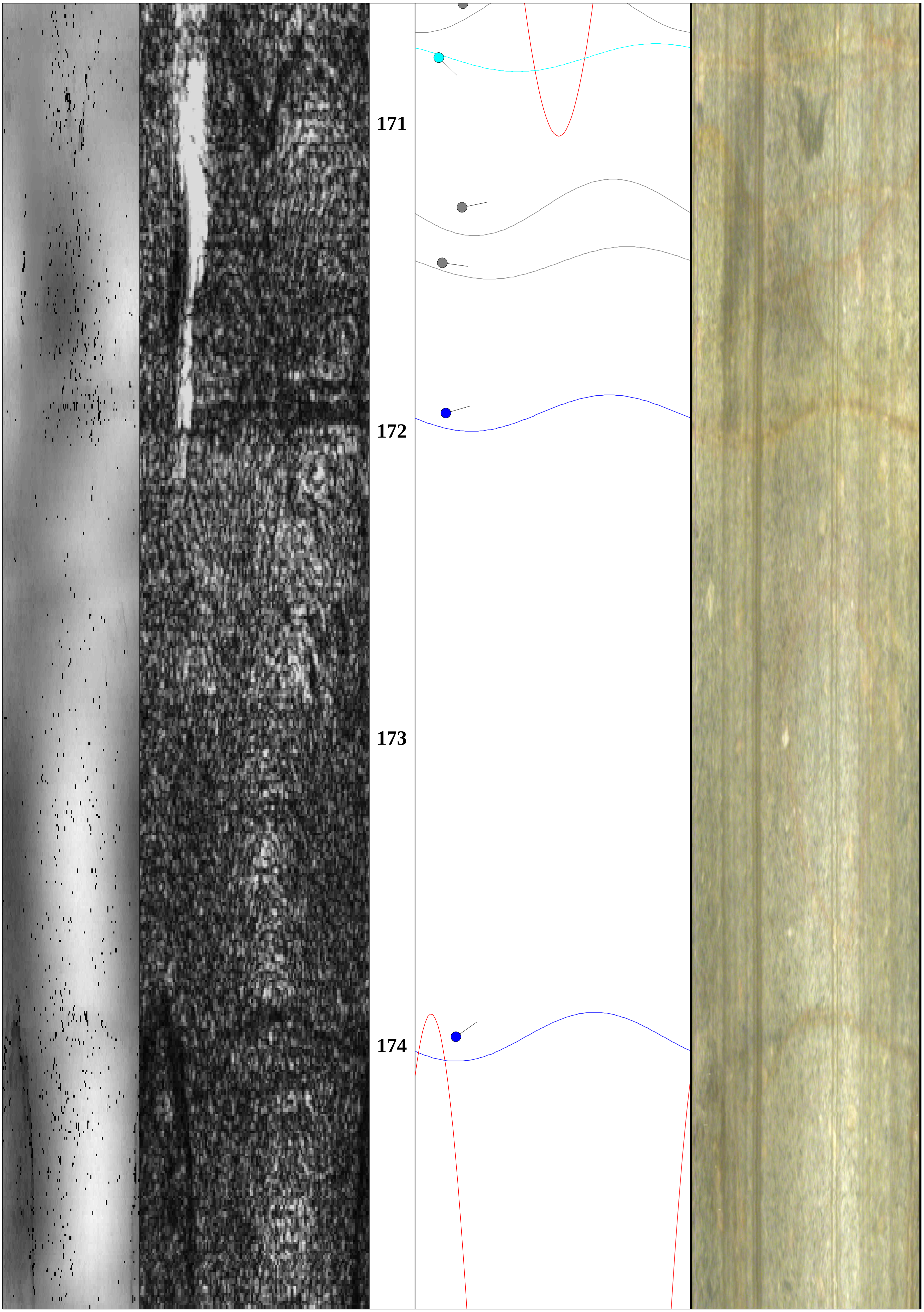

150
151
152
153

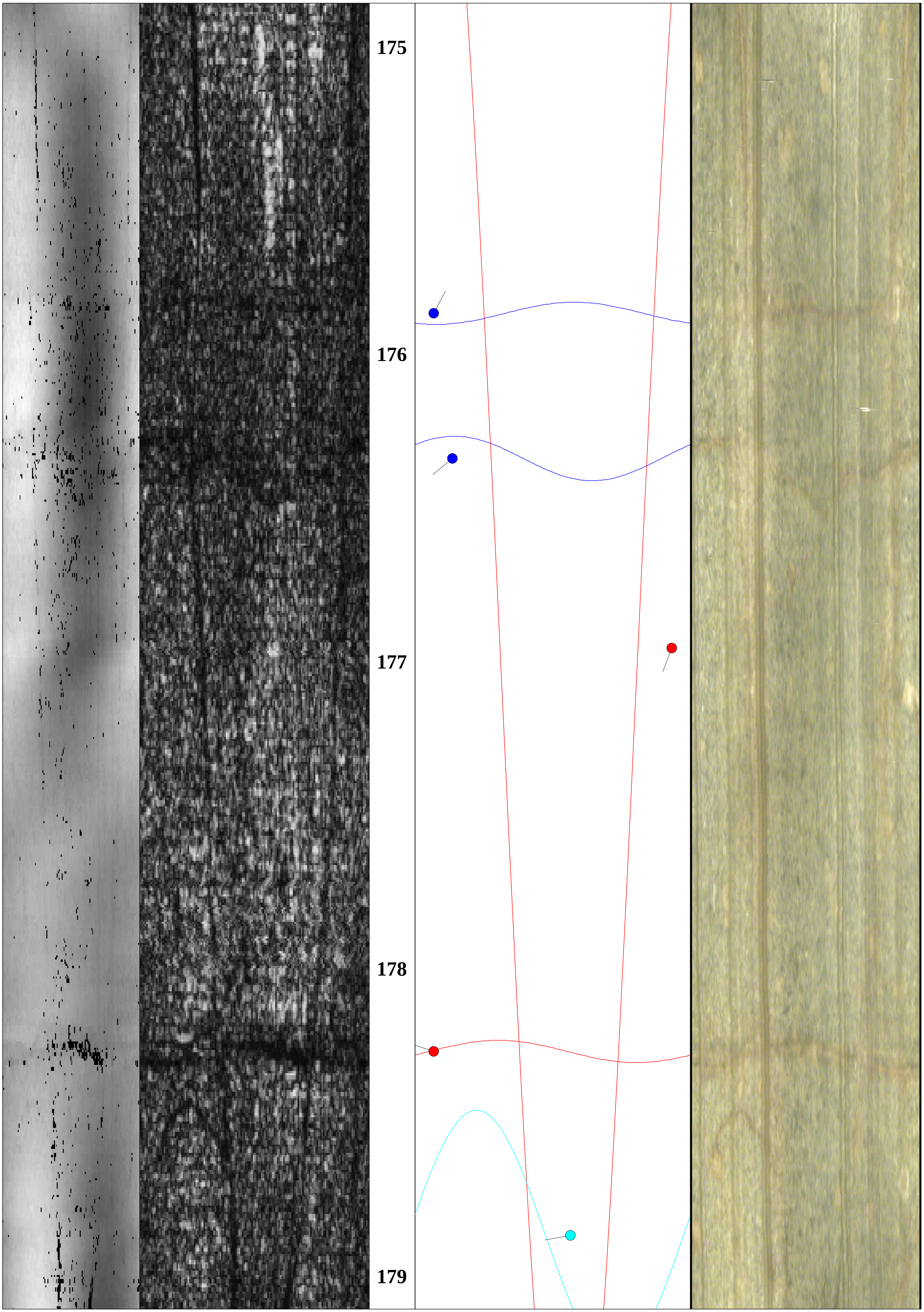

154
155
156
157

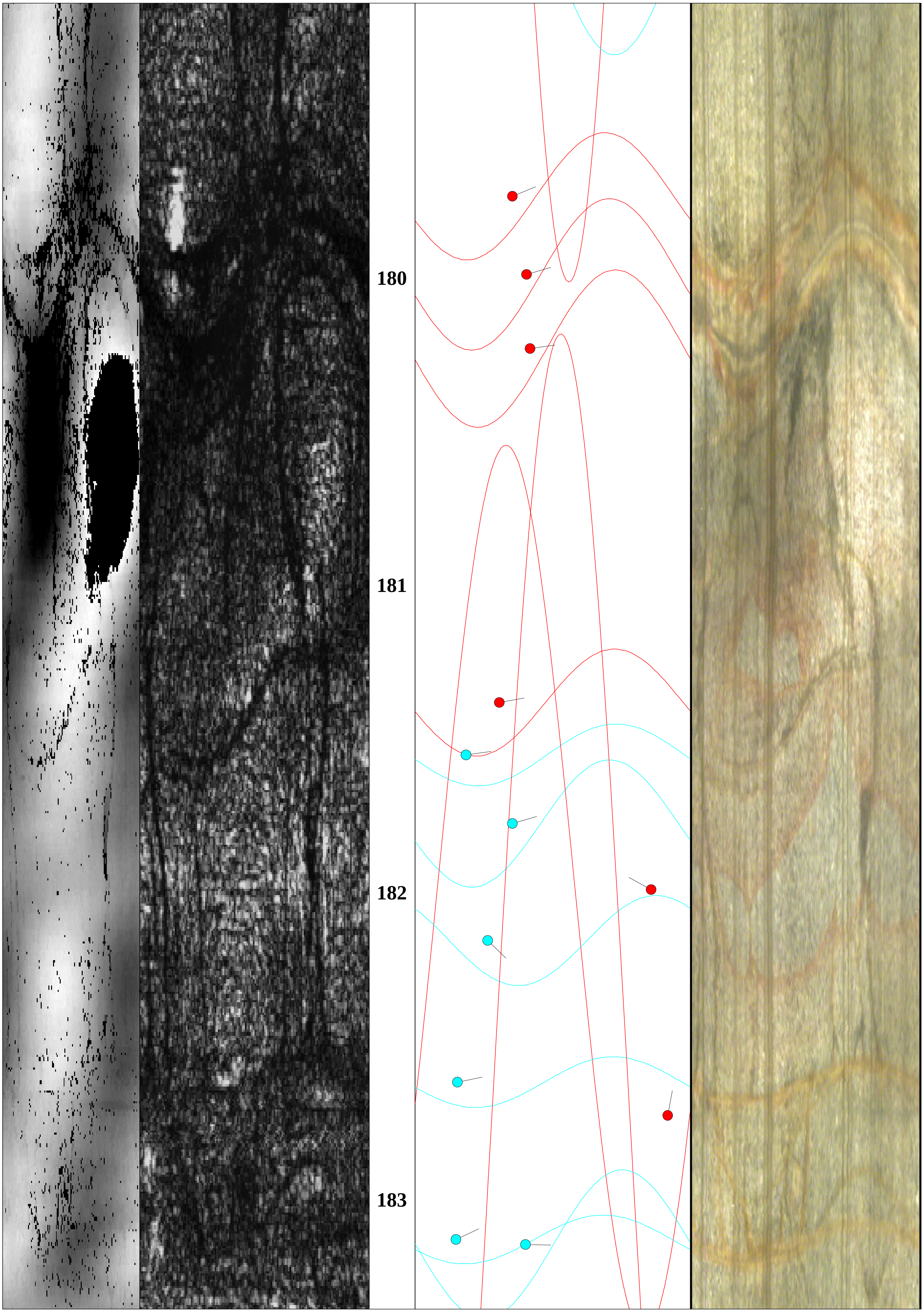

158
159
160
161
162

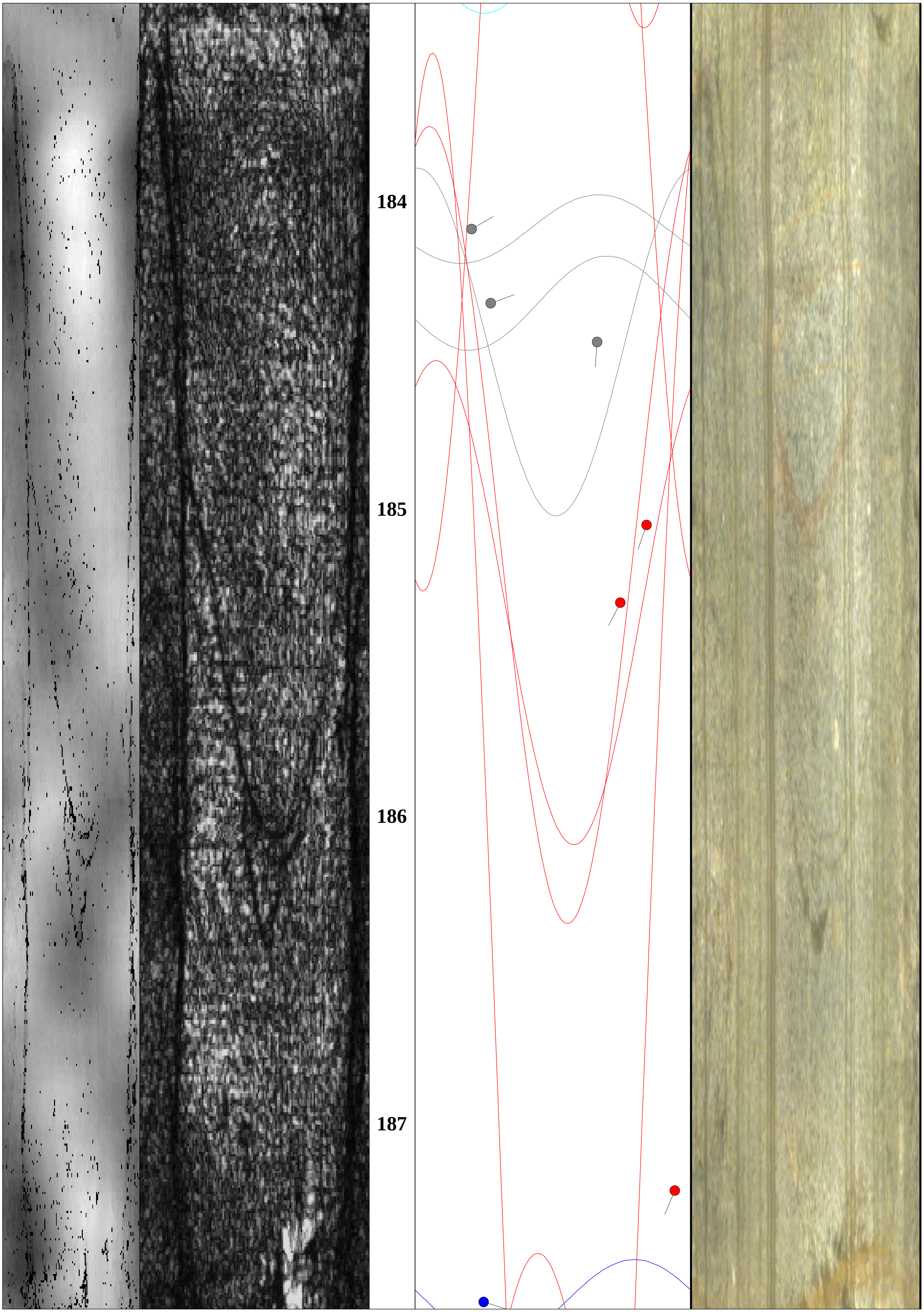

163
164
165
166

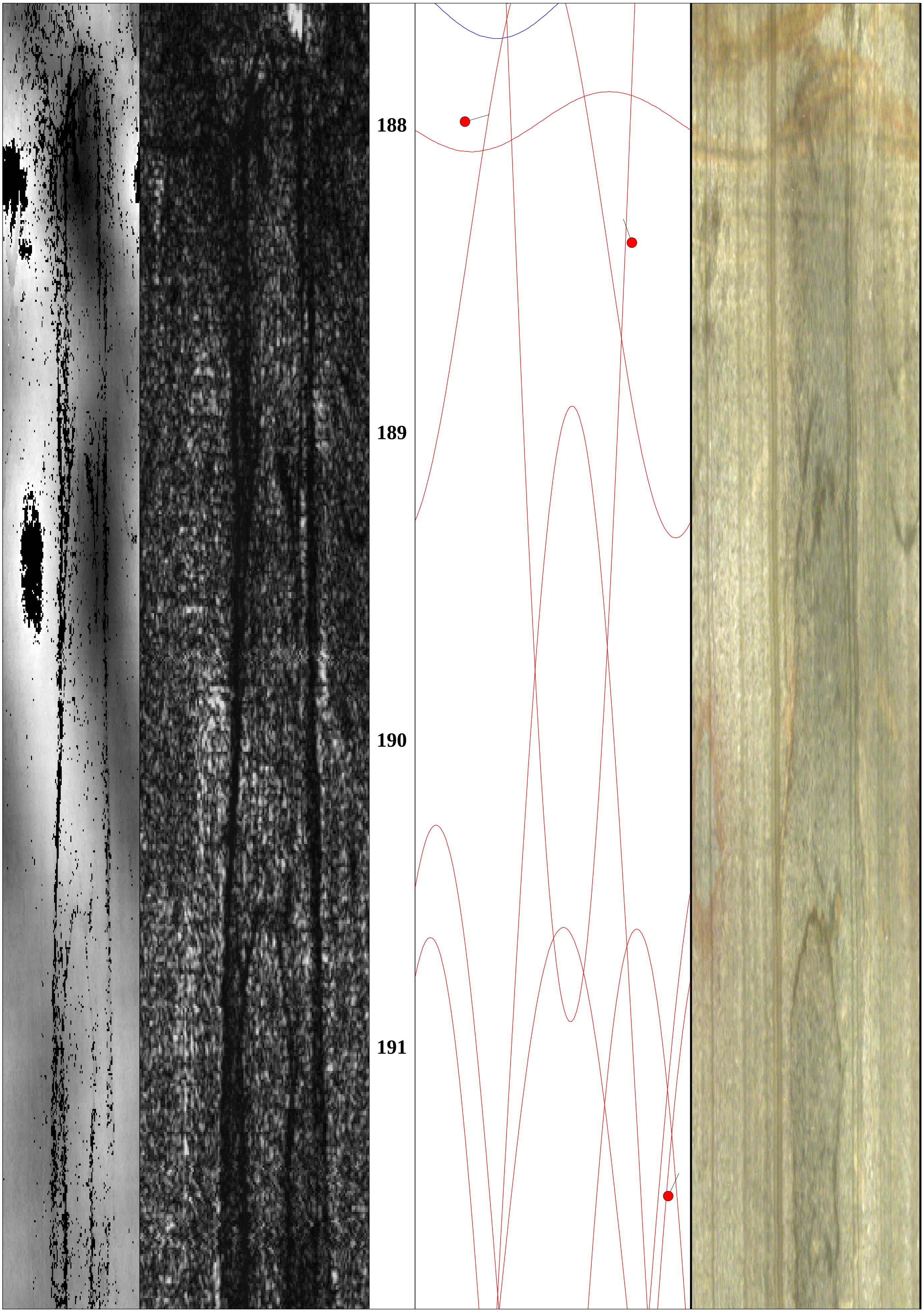

167
168
169
170

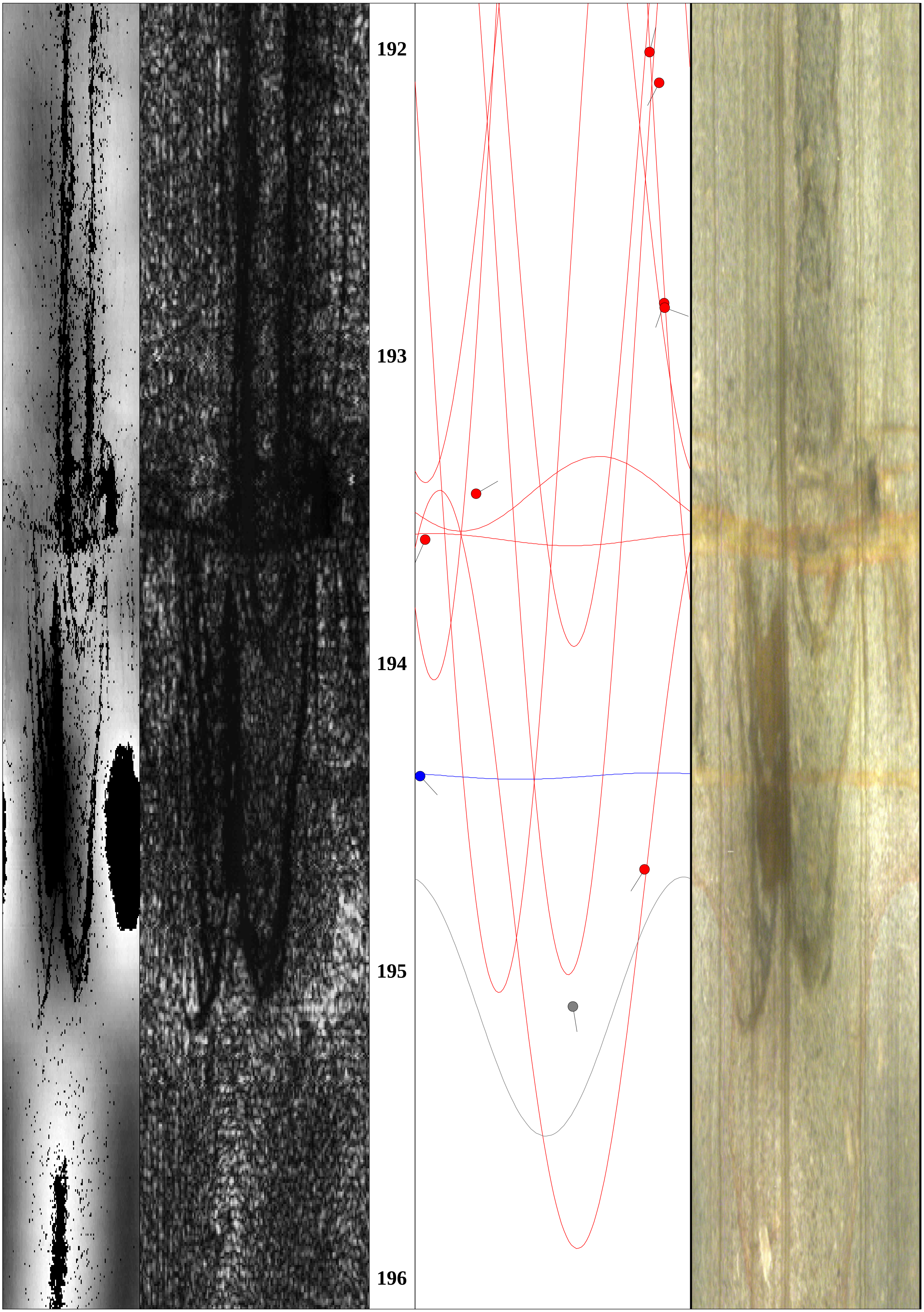

171
172
173
174


175
176
177
178
179

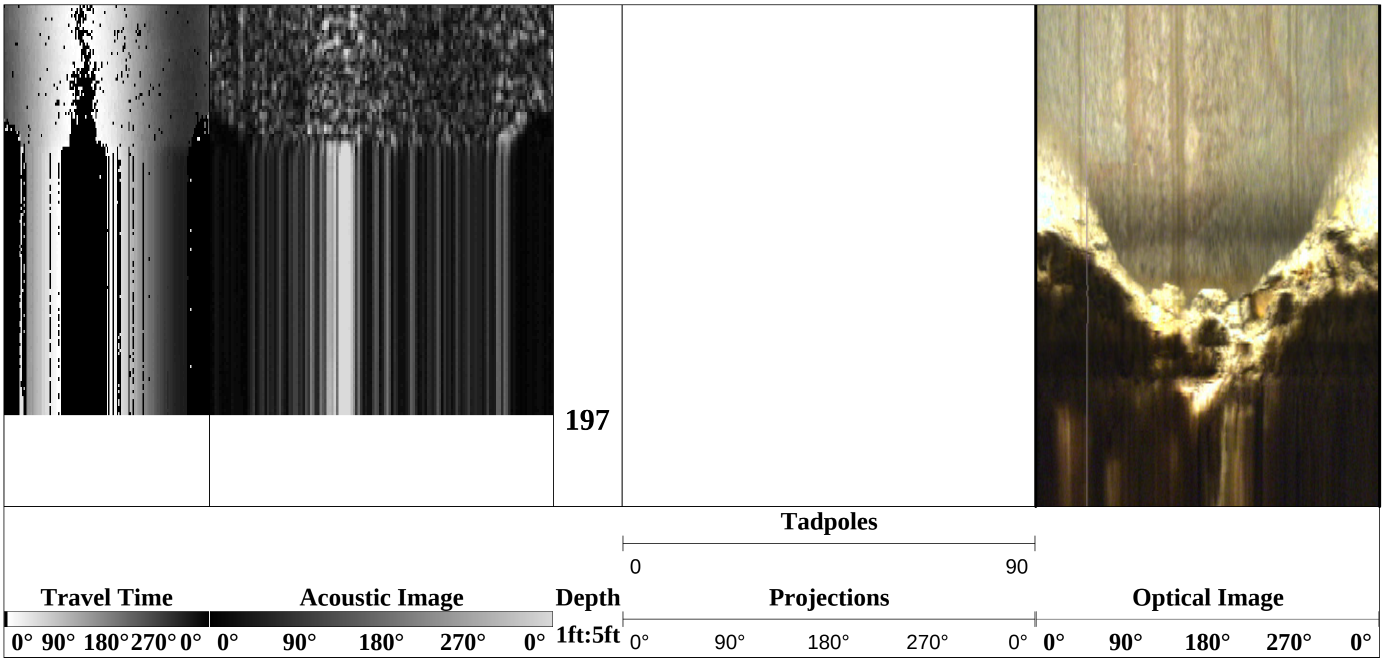

180
181
182
183


184
185
186
187

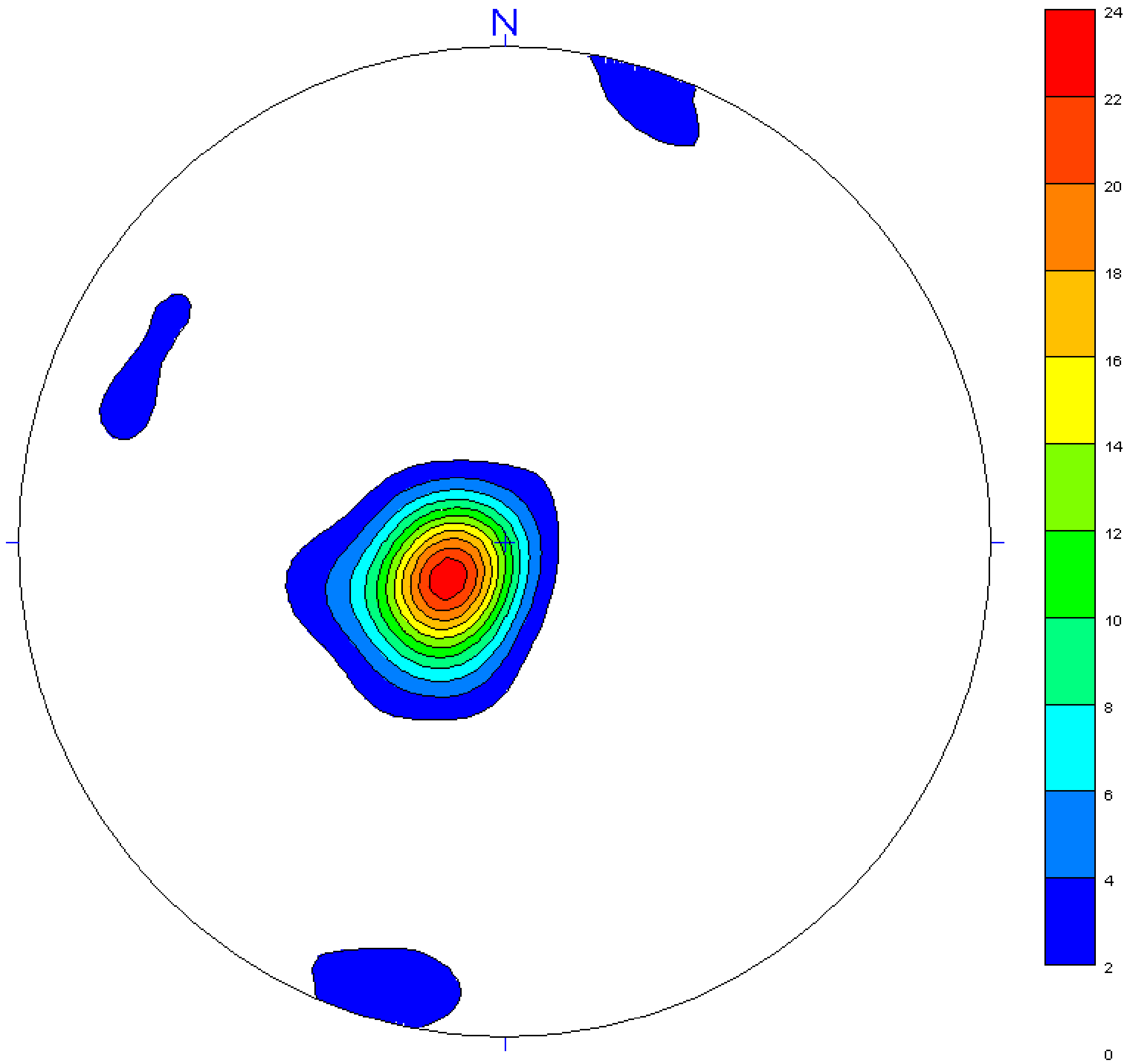

188
189
190
191



192
193
194
195
196

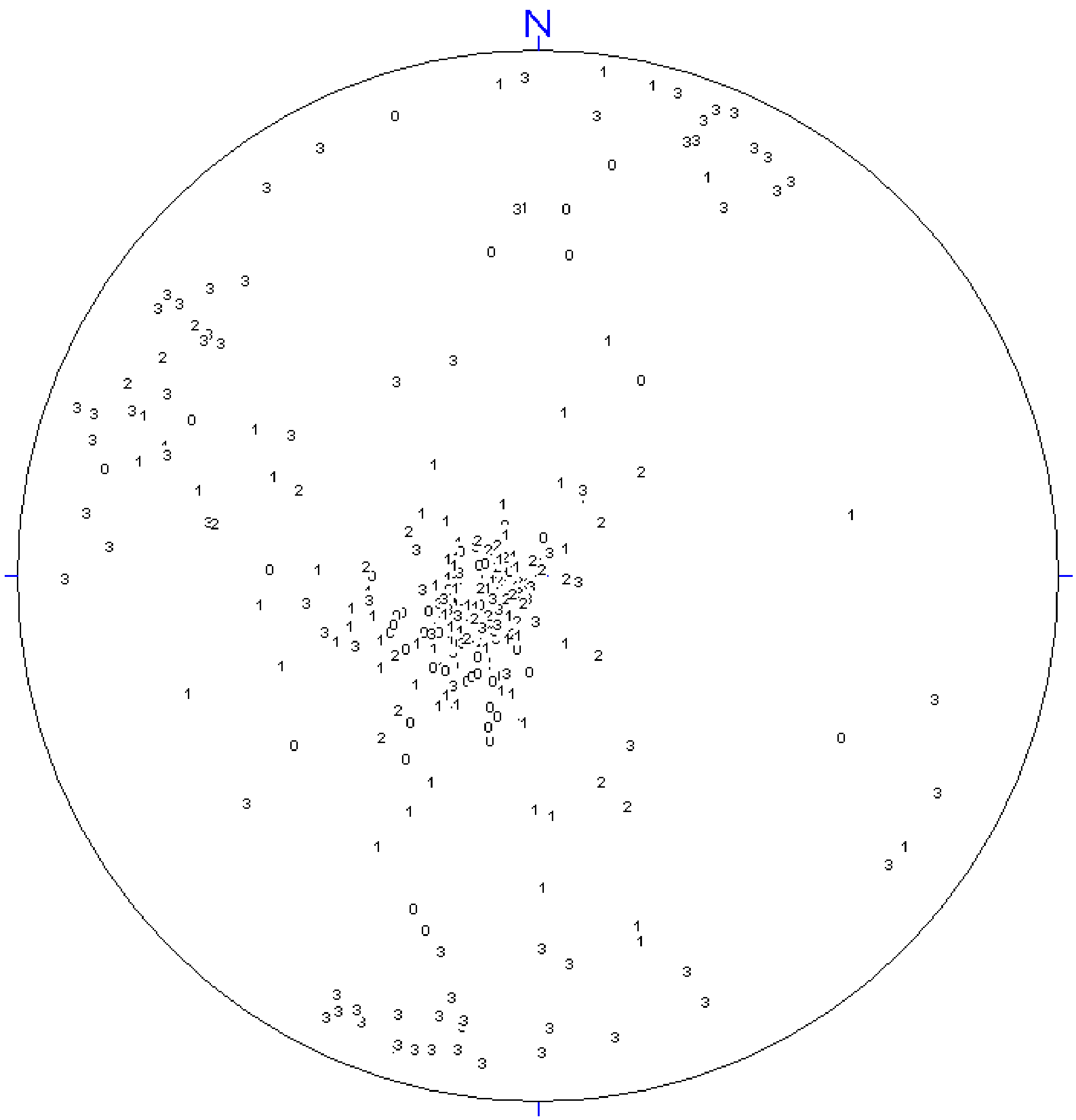

197
Tadpoles
0
90
Travel Time
Acoustic Image
Depth
1ft:5ft
Projections
Optical Image
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n4
NNSA/NSO
22 Sept 2010



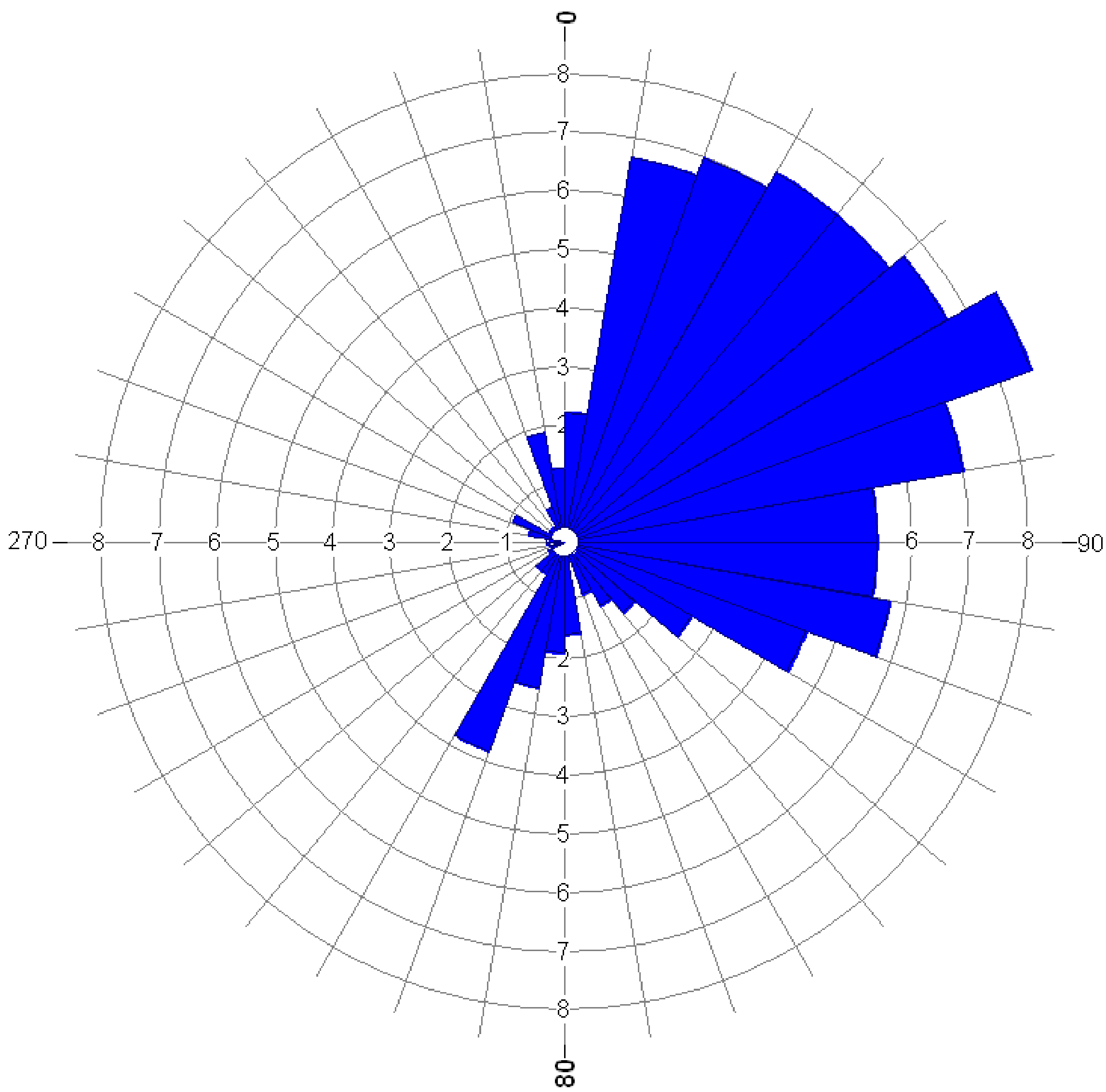
All directions are with respect to True North.

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n4
NNSA/NSO
22 Sept 2010



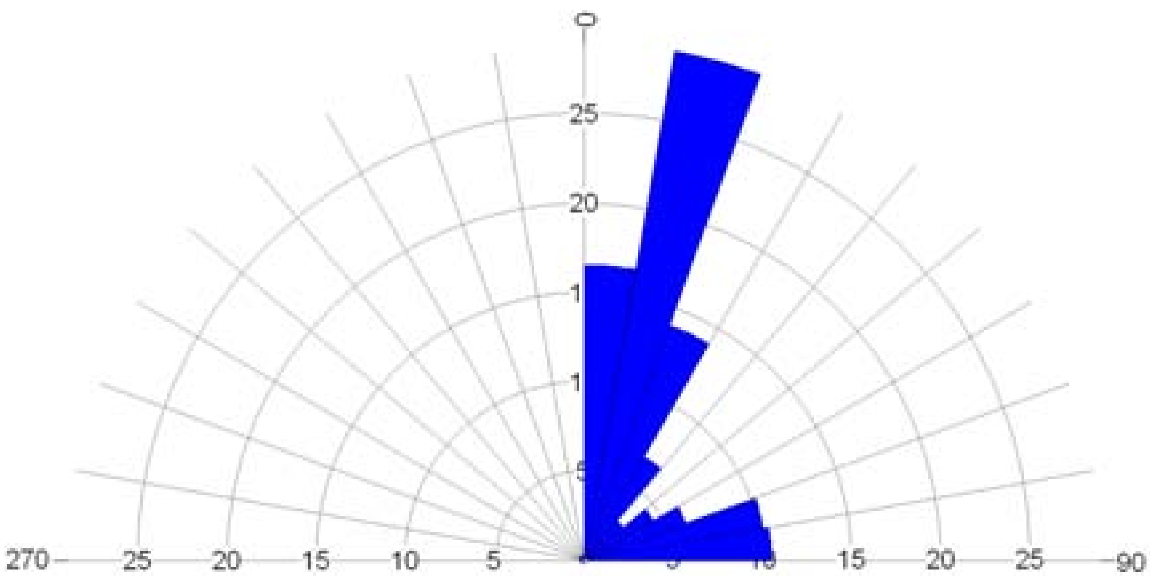
All directions are with respect to True North.

Rose Diagram – Dip Directions
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n4
NNSA/NSO
22 Sept 2010



All directions are with respect to True North.

Rose Diagram – Dip Angles
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n4
NNSA/NSO
22 Sept 2010



All directions are with respect to True North.

Full-Waveform Sonic

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Company NNSA/NSO
Well U-15N#4
Field NNSS
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15N#4
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900018.49
E: 676612.53

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Dual-Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5002.79

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM G.L.

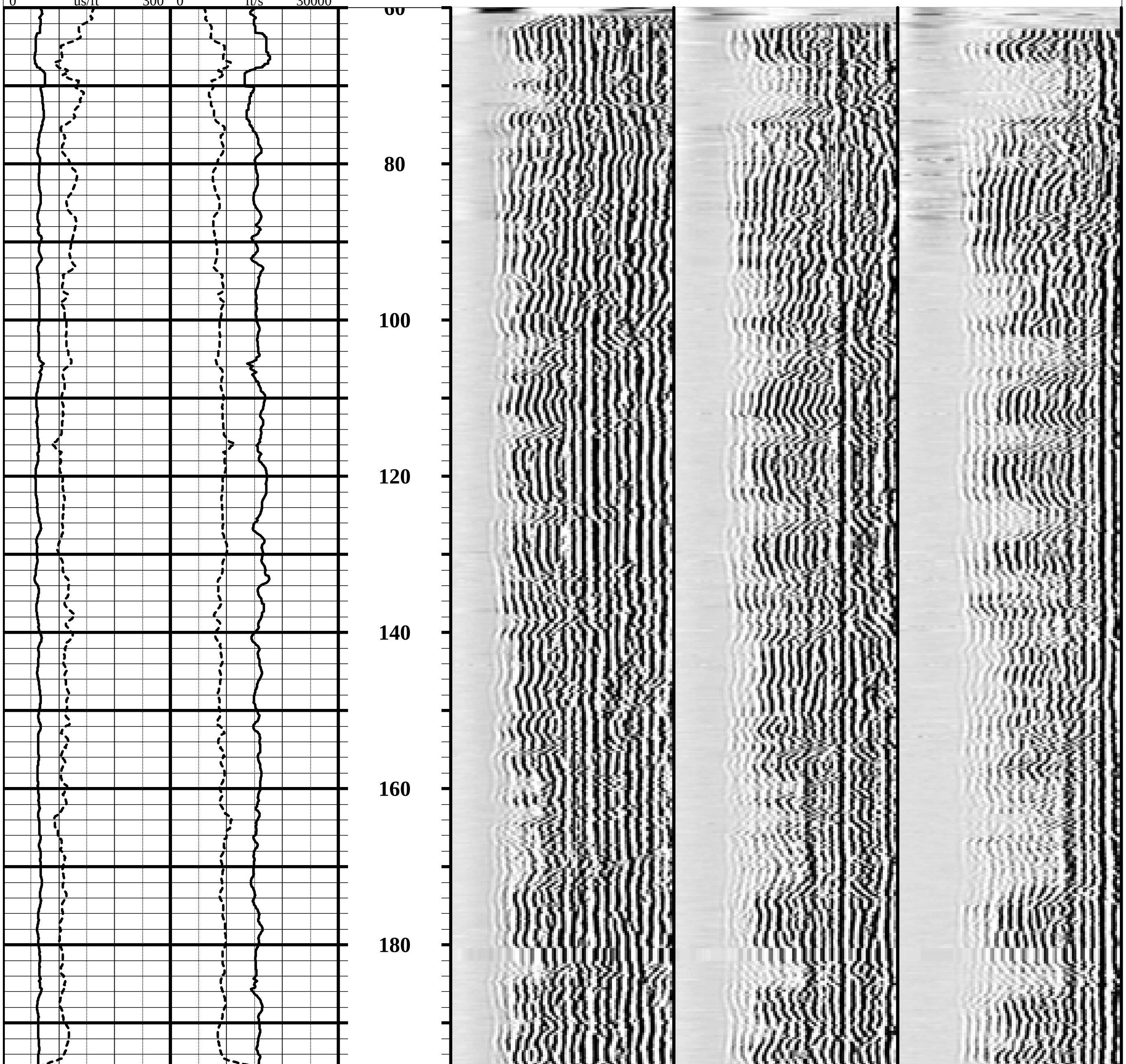
DATE ACQUIRED	22 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Full Waveform Sonic			
DEPTH-DRILLER	192'			
DEPTH-LOGGER	1969.1'			
BTM LOG INTERVAL	196.1'			
TOP LOG INTERVAL	60'			
RECORDED BY	A. Caster			
WITNESSED BY	C.Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	5 ft/min			
A.S.D.E.	0.1'			
SAMPLE INTERVAL	0.1'			

BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	10'	10"		-1.0'	9.5'
2	8"	10'	192'				

COMMENTS

NA - Not Available, N/A - Not Applicable

P-Wave Slowness	P-Wave Velocity	Depth	3-ft Receiver	4-ft Receiver	5-ft Receiver
0 us/ft 300	0 ft/s 30000	1ft:240ft	100 us 1400	100 us 1400	100 us 1400
S-Wave Slowness	S-Wave Velocity				
0 us/ft 300	0 ft/s 30000				



S-Wave Slowness	S-Wave Velocity				
0 us/ft 300	0 ft/s 30000				
P-Wave Slowness	P-Wave Velocity	Depth	3-ft Receiver	4-ft Receiver	5-ft Receiver
0 us/ft 300	0 ft/s 30000	1ft:240ft	100 us 1400	100 us 1400	100 us 1400

COLOG
Borehole Geophysics & Hydrophysics
A Division of Layne Christensen Company

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Borehole Deviation

Company NNSA/NSO
Well U-15N#4
Field NNSS
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15N#4
FIELD Nevada National Security Site
COUNTY Nye **STATE** NV

LOCATION
Area 15 (L/O)
N: 900018.49
E: 676612.53

QTR **SEC** **TWP** **RGE**

OTHER SERVICES

PERMANENT DATUM Ground Level **ELEVATION** 5002.79

LOG MEAS. FROM Ground Level 0.0 ft **ABOVE PERMINANT DATUM**

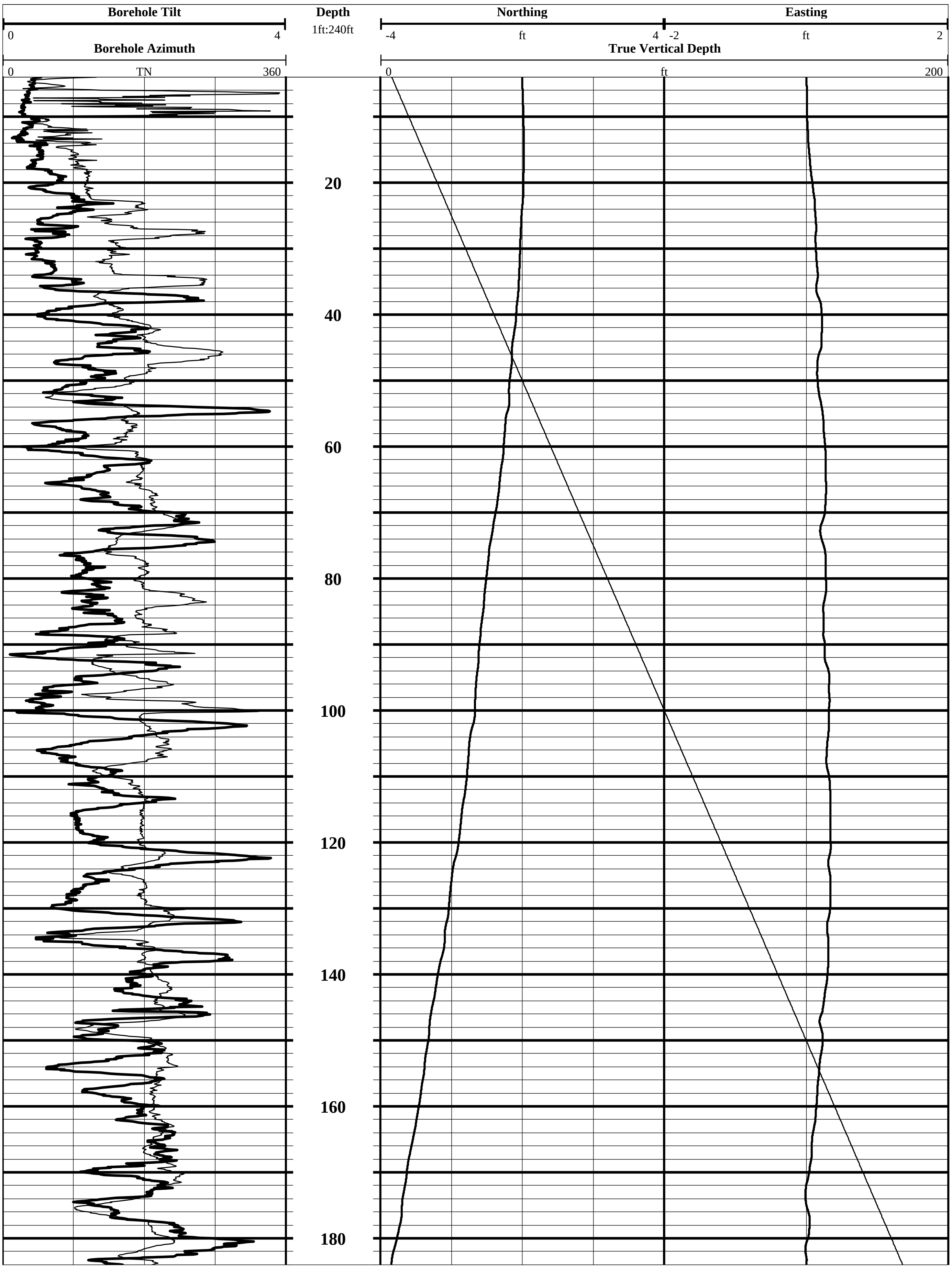
DRILLING MEAS. FROM

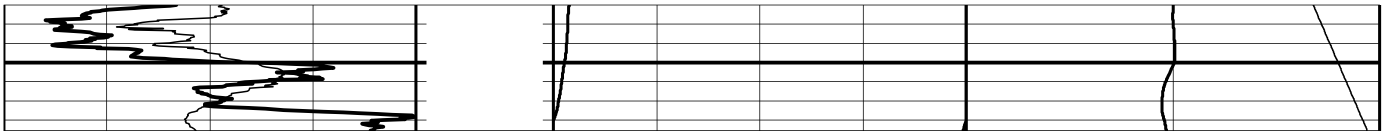
DATE ACQUIRED	22 Sept 2010			
RUN NUMBER	TWO			
LOG TYPE	Borehole Deviation			
DEPTH-DRILLER	192			
DEPTH-LOGGER	197			
BTM LOG INTERVAL	197			
TOP LOG INTERVAL	4"			
RECORDED BY	E. Eaton			
WITNESSED BY	G. Juniel			
PROBE TYPE, S/N	OBI40, 023902			
LOGGING SPEED	3.5 ft/min			
A.S.D.E.	0.54 ft			
SAMPLE INTERVAL	0.0041 ft			

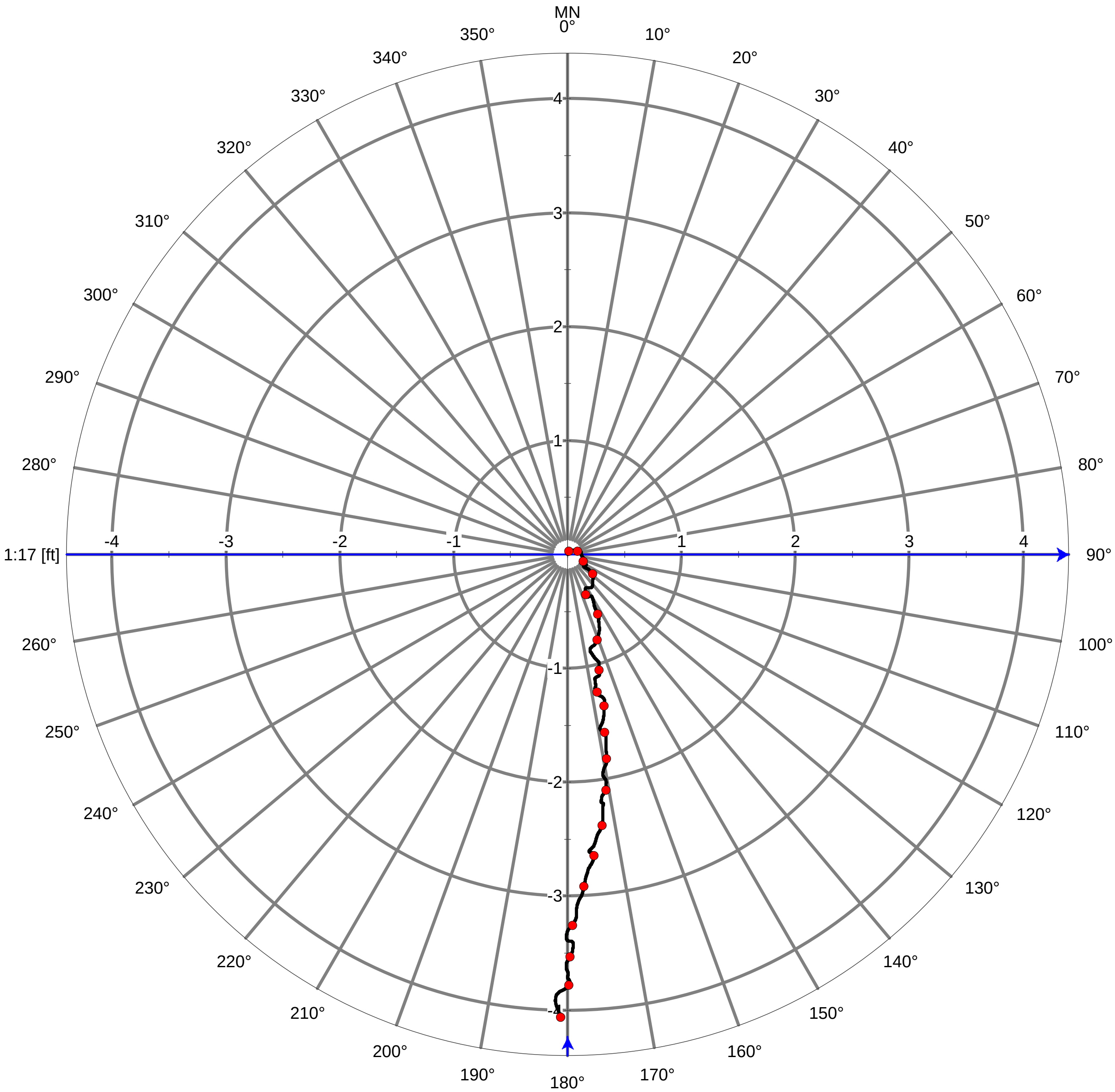
BOREHOLE RECORD				CASING RECORD			
RUN No.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
	12.25'	Surface	10	10		Surface	9.5
	8"	10	192				

COMMENTS

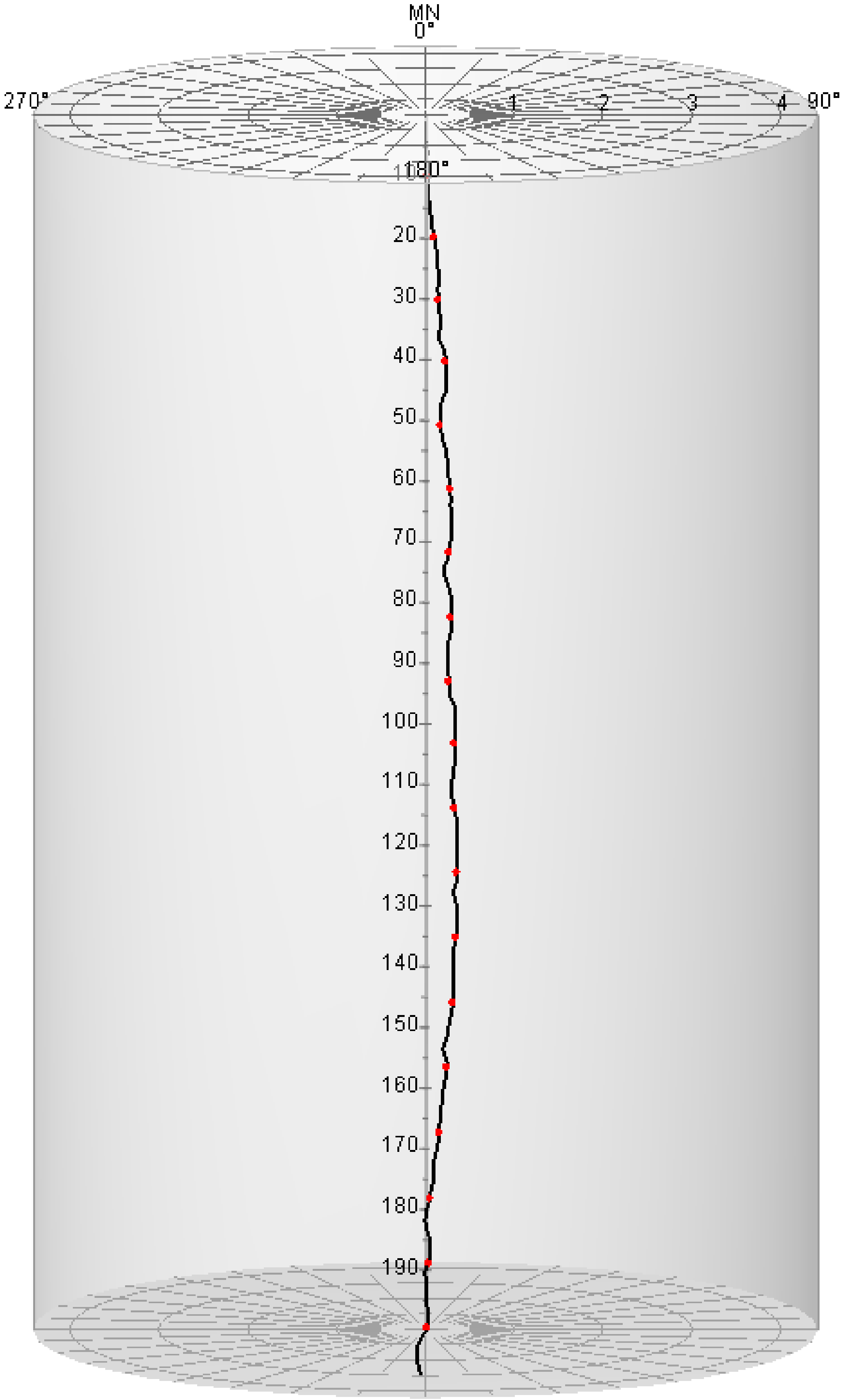
NA - Not Available, N/A - Not Applicable


Borehole Tilt
0
4
Borehole Azimuth
0
TN
360
Depth
1ft:240ft
20
40
60
80
100
120
140
160
180
Northing
-4
ft
4
Easting
-2
ft
2
True Vertical Depth
0
ft
200





MN
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
1:17 [ft]
280°
290°
300°
310°
320°
330°
340°
350°
-4
-3
-2
-1
1
2
3
4



MN
0°
270°
90°
1
2
3
4
180°
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

Appendix F-6

Borehole Geophysical Log Plots for Instrument Hole U-15n#5

COLOG — Borehole Geophysics & Hydrophysics — A Division of Layne Christensen Company
810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Far Density
Near Density
Natural Gamma Ray
Caliper

Company	NNSA/NSO
Well	U-15N#5
Field	NNSS
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15N#5
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900082.65
E: 676706.35

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Full-Wave Sonic
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5001.27
LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**
DRILLING MEAS. FROM G.L.

DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Far Density	Near Density	Natural Gamma Ray	Caliper
DEPTH-DRILLER	192'			
DEPTH-LOGGER	193.1'			
BTM LOG INTERVAL	192.0'	192.3'	187.5'	191.0'
TOP LOG INTERVAL	7.8'	8.1'	3.3'	6.8'
RECORDED BY	A. Caster			
WITNESSED BY	C. Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	10 ft/min			
A.S.D.E.	0.0'			
SAMPLE INTERVAL	0.1'			

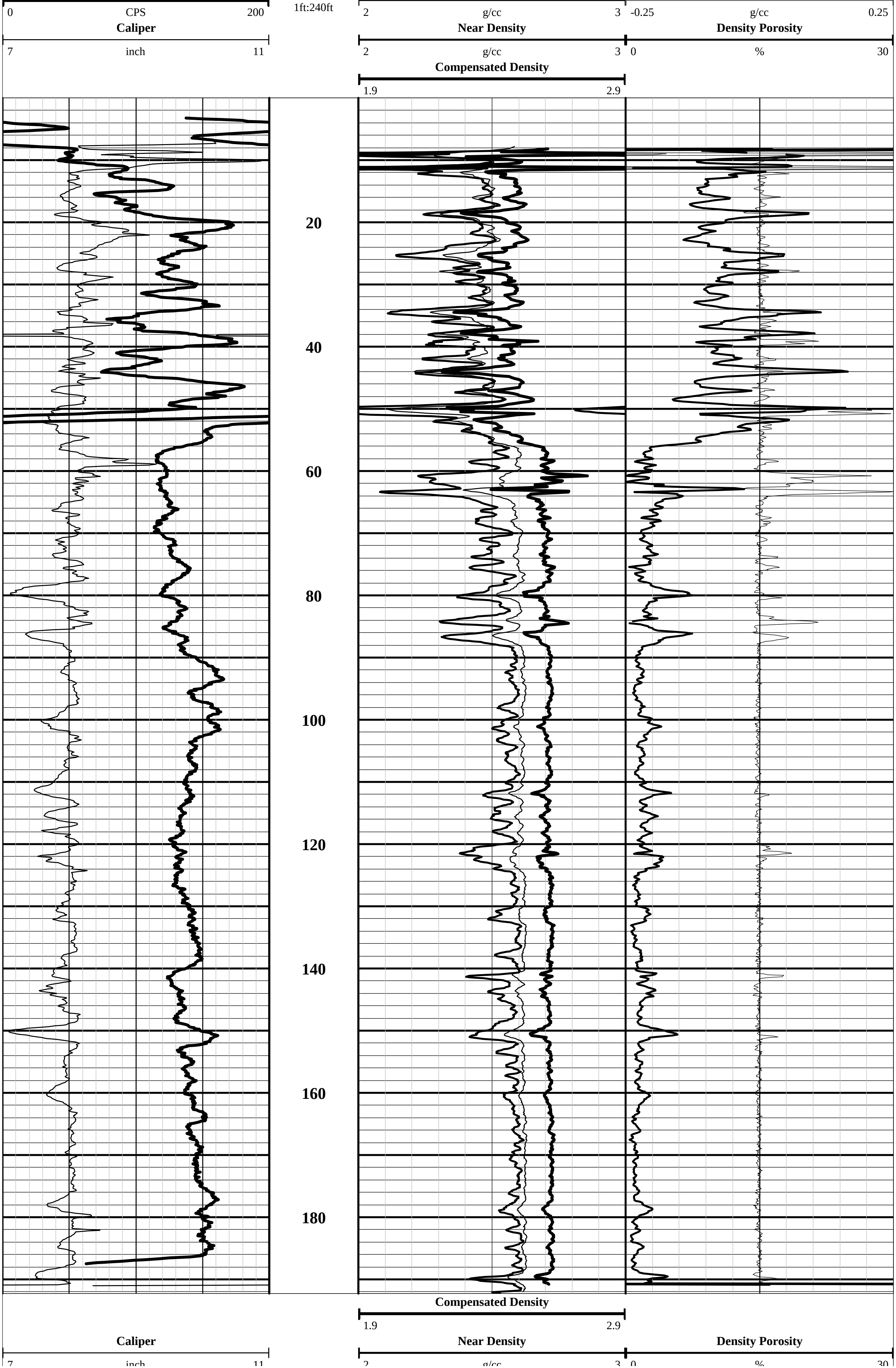
BOREHOLE RECORD				CASING RECORD			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	suef	10'	10"		-1.0'	9.5'
2	8"	10'	192'				

COMMENTS

NA - Not Available, N/A - Not Applicable

Matrix Density of 2.64 used to calculate Density Porosity

Natural Gamma Ray	Depth	Far Density	Compensation


0 CPS 200
Caliper
7 inch 11
1ft:240ft
2 g/cc 3
Near Density
2 g/cc 3
Compensated Density
1.9 2.9
-0.25 g/cc 0.25
Density Porosity
0 % 30
20
40
60
80
100
120
140
160
180
Compensated Density
1.9 2.9
Caliper
Near Density
Density Porosity

Natural Gamma Ray	Depth	Far Density	Compensation
7 inch 11		2 g/cc 3	0 % 30
0 CPS 200	1ft:240ft	2 g/cc 3	-0.25 g/cc 0.25

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Acoustic Televiewer
Optical Televiewer

Company	NNSA/NSO
Well	U-15N#5
Field	Nevada Test Site
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15N#5
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900082.65
E: 676706.35

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Dual Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 501..27

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM

DATE ACQUIRED	21 Sept 2010	21 Sept 2010		
RUN NUMBER	THREE	TWO		
LOG TYPE	ABI	OBI		
DEPTH-DRILLER	192	192		
DEPTH-LOGGER	193	193		
BTM LOG INTERVAL	193	193		
TOP LOG INTERVAL	57	4		
RECORDED BY	E Eaton	E Eaton		
WITNESSED BY	C Obi	C Obi		
PROBE TYPE, S/N	ABI-062605	OBI-023902		
LOGGING SPEED	5.5 ft/min	3.5 ft/min		
A.S.D.E.	0.47 ft	0.60 ft		
SAMPLE INTERVAL	0.0068 ft	0.0041 ft		

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25"	Surface	10	10"		-1	9.5
	8"	10	192				

COMMENTS

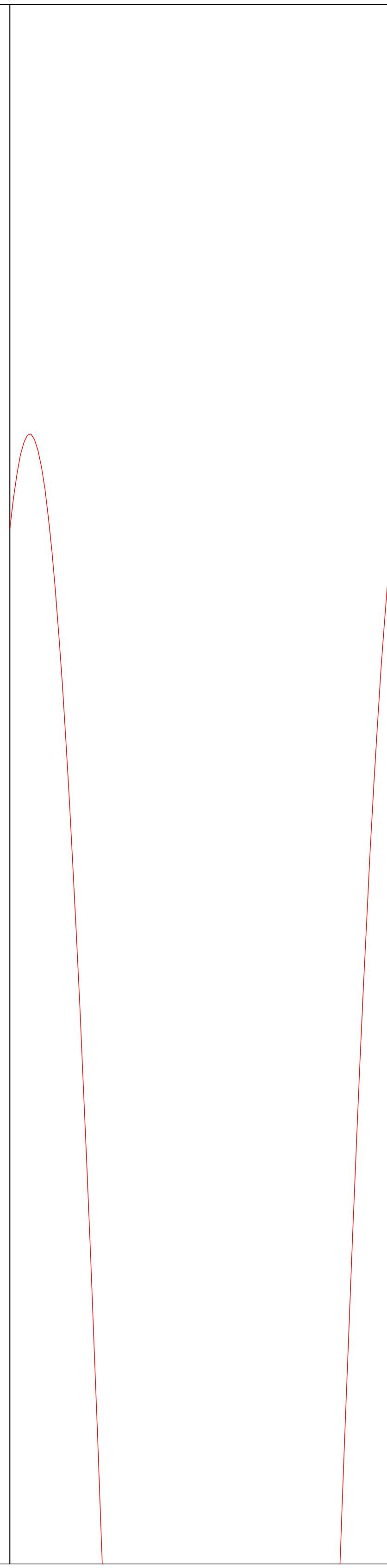
NA - Not Available, N/A - Not Applicable

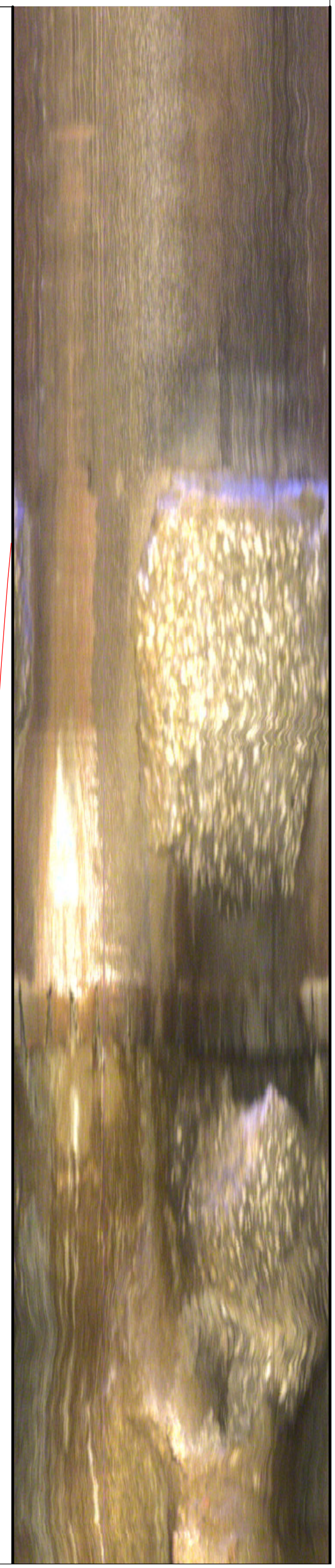
Travel Time	Acoustic Image	Depth	Projections	Optical Image
0° 90° 180° 270° 0°	0° 90° 180° 270° 0°	1ft:5ft	0° 90° 180° 270° 0° Tadpoles 0 90	0° 90° 180° 270° 0°

8

9

10



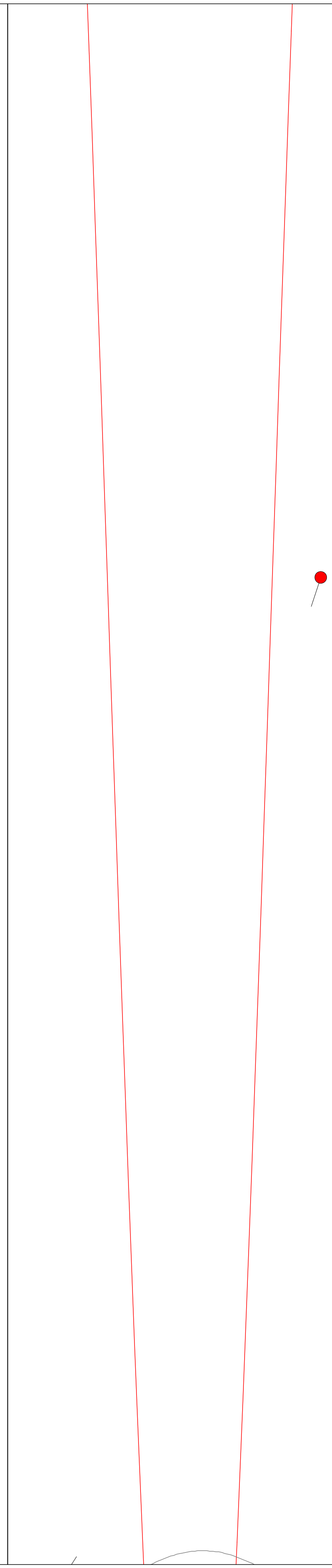


11

12

13

14



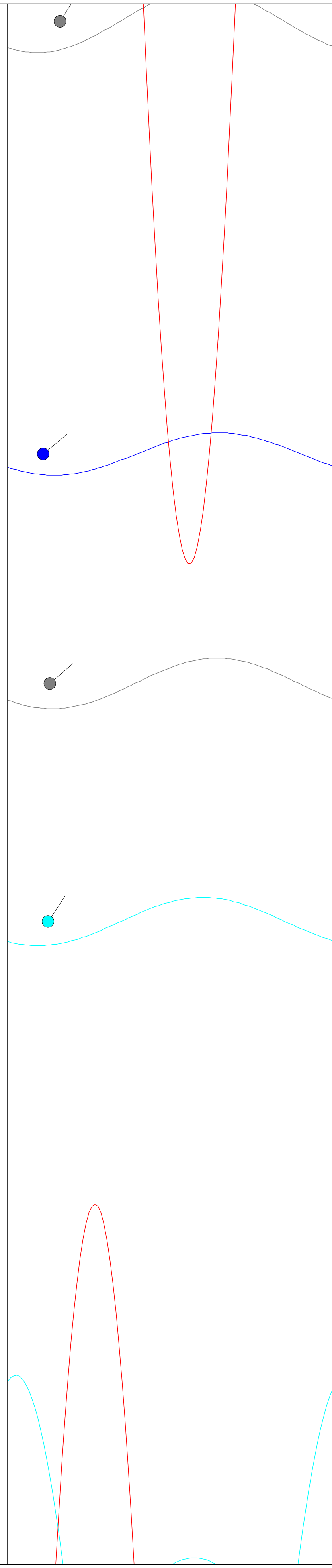
15

16

17

18

19

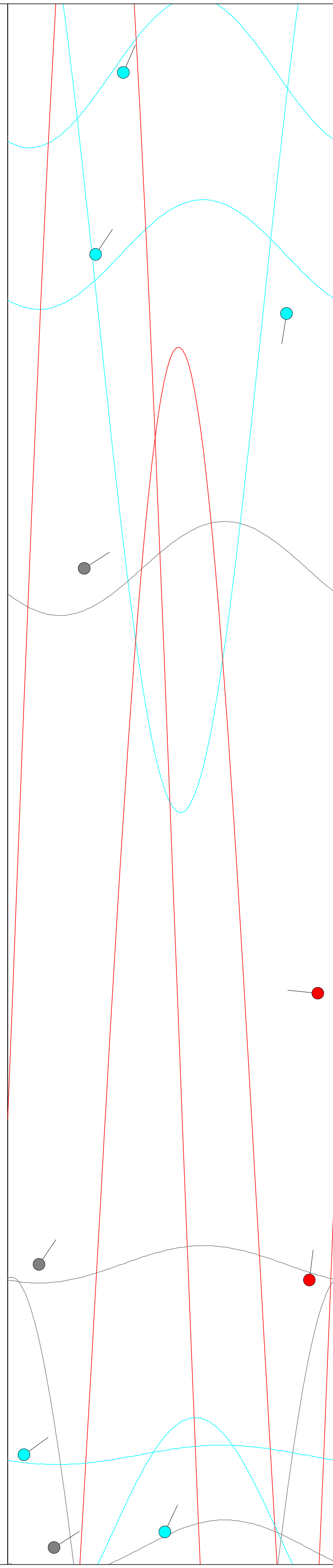


20

21

22

23



24

25

26

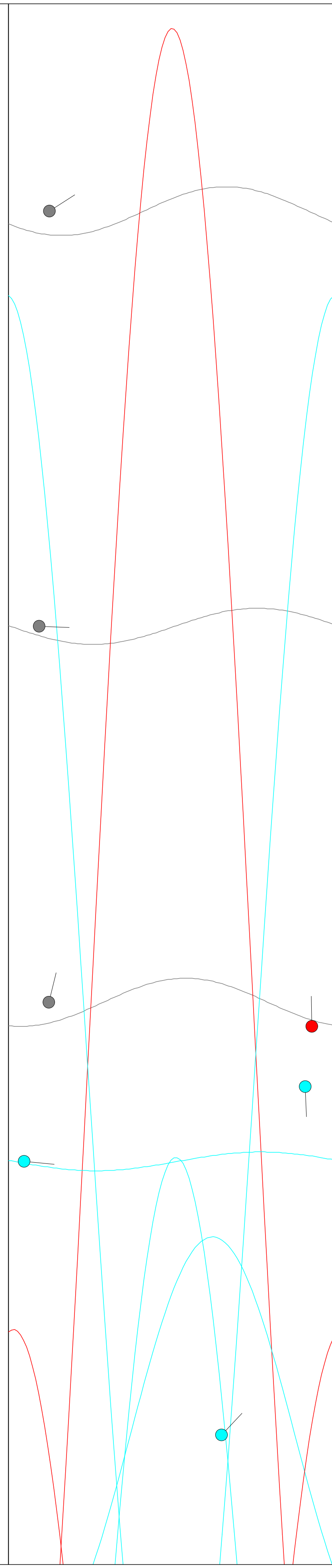
27

28

29

30

31



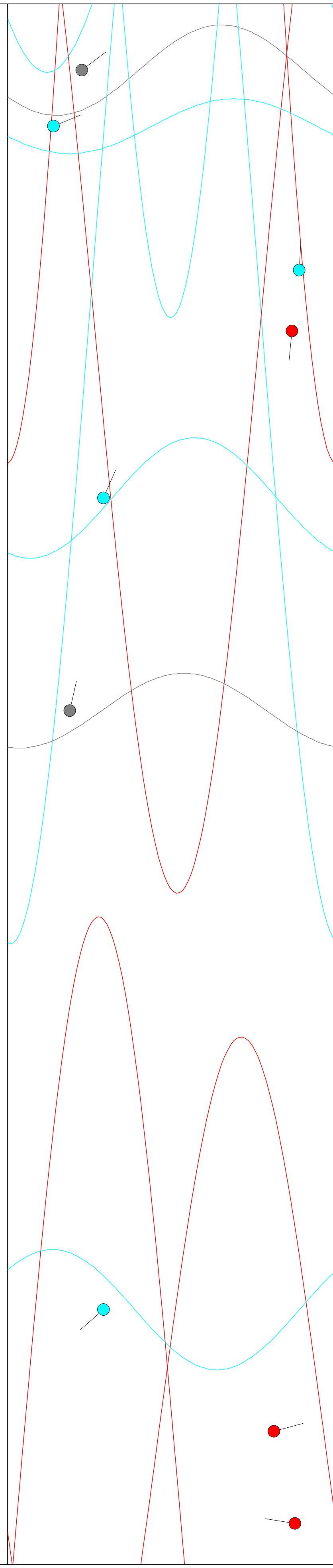
32

33

34

35

36

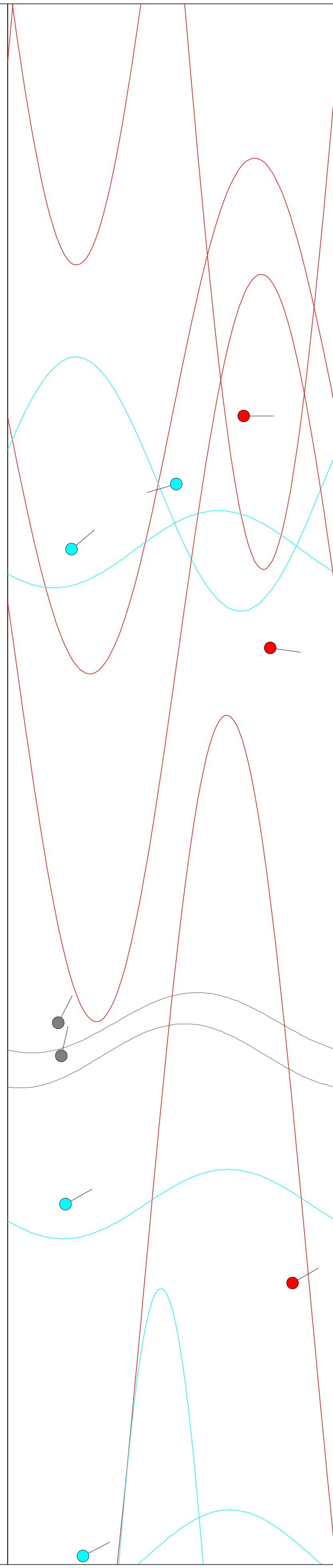


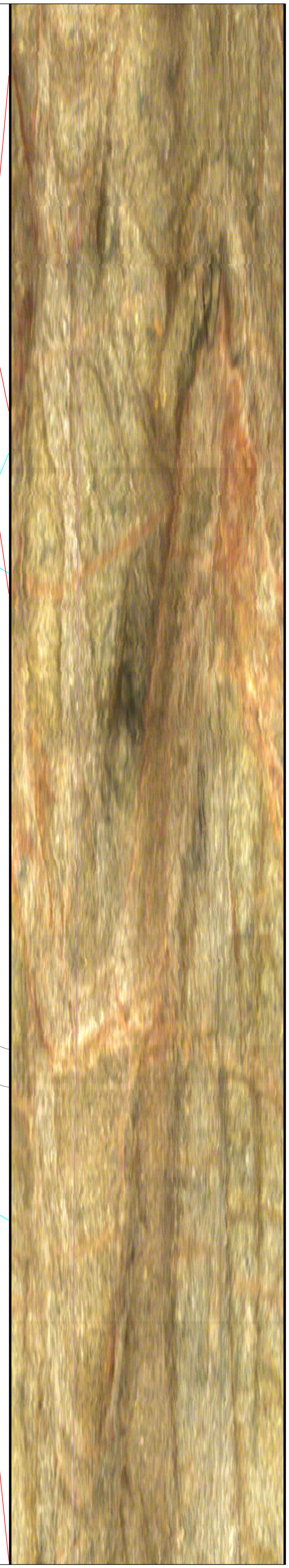
37

38

39

40



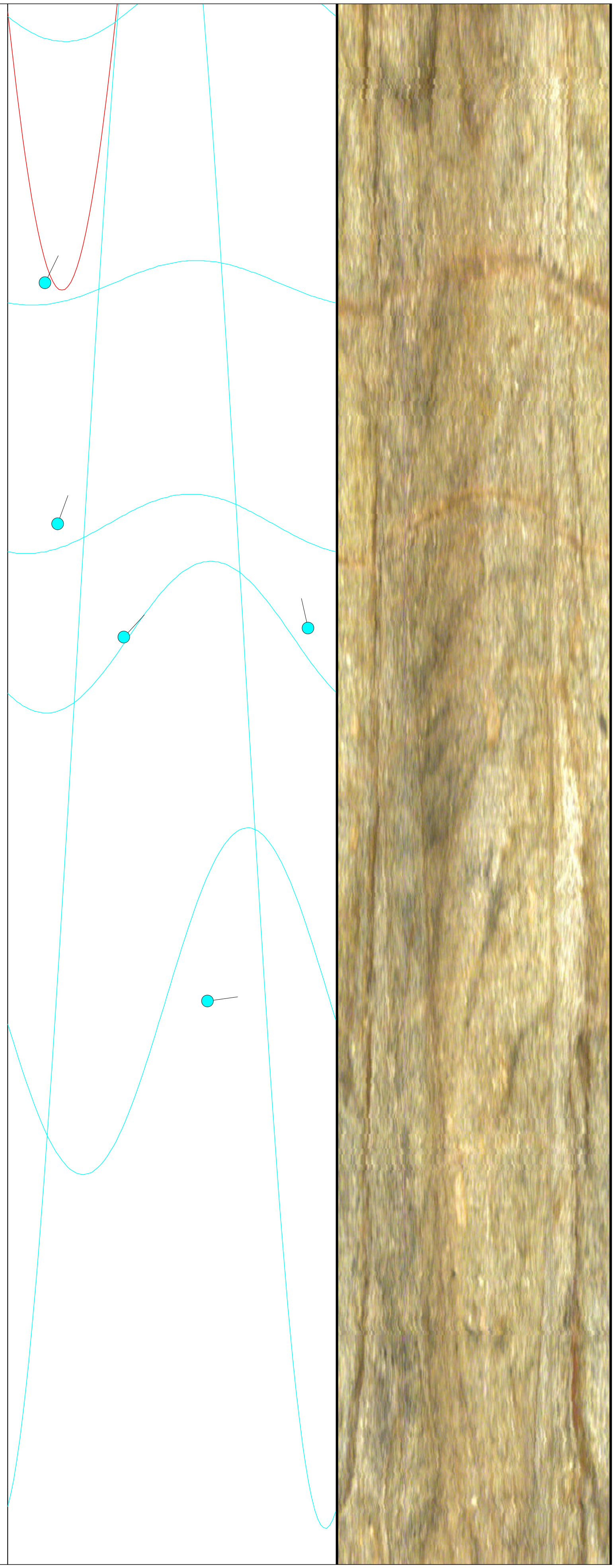


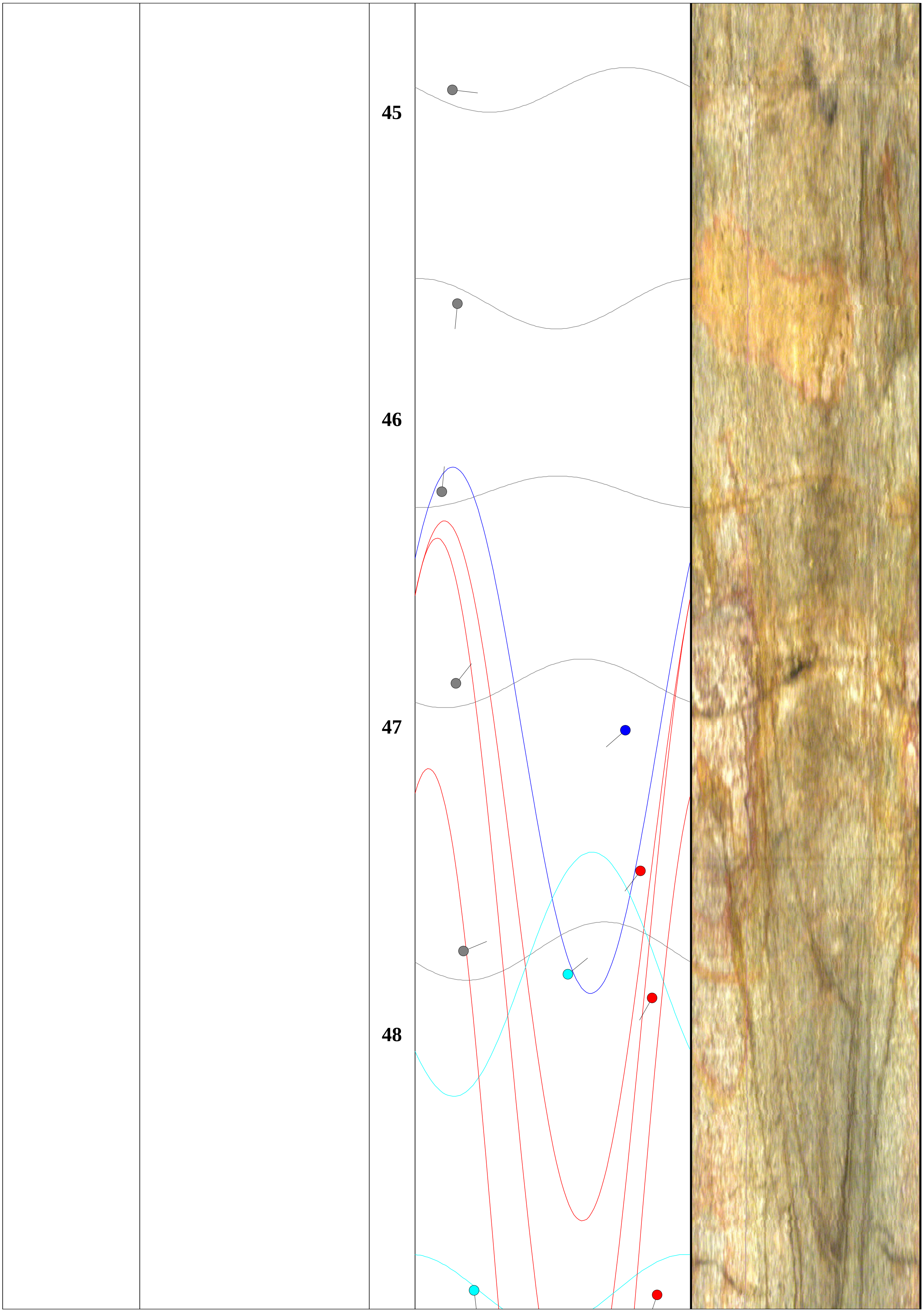
41

42

43

44




45
46
47
48

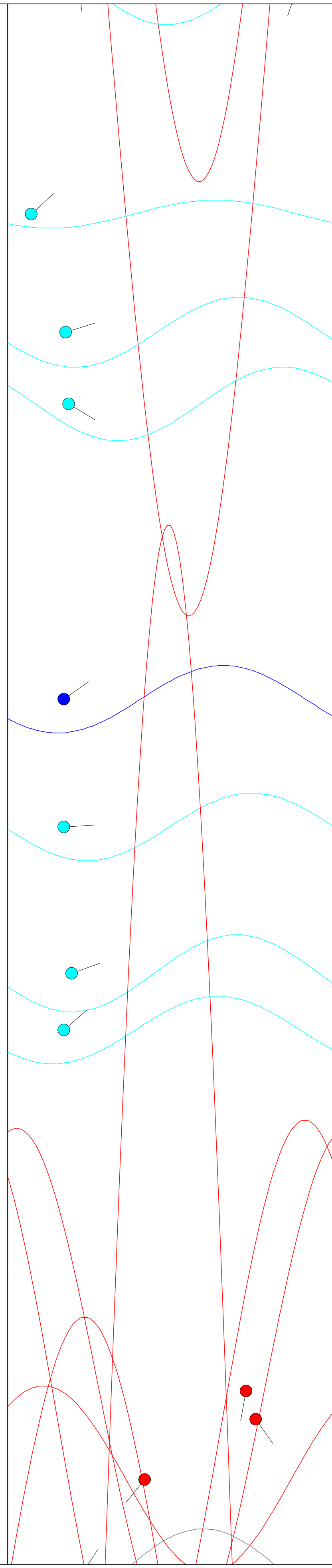
49

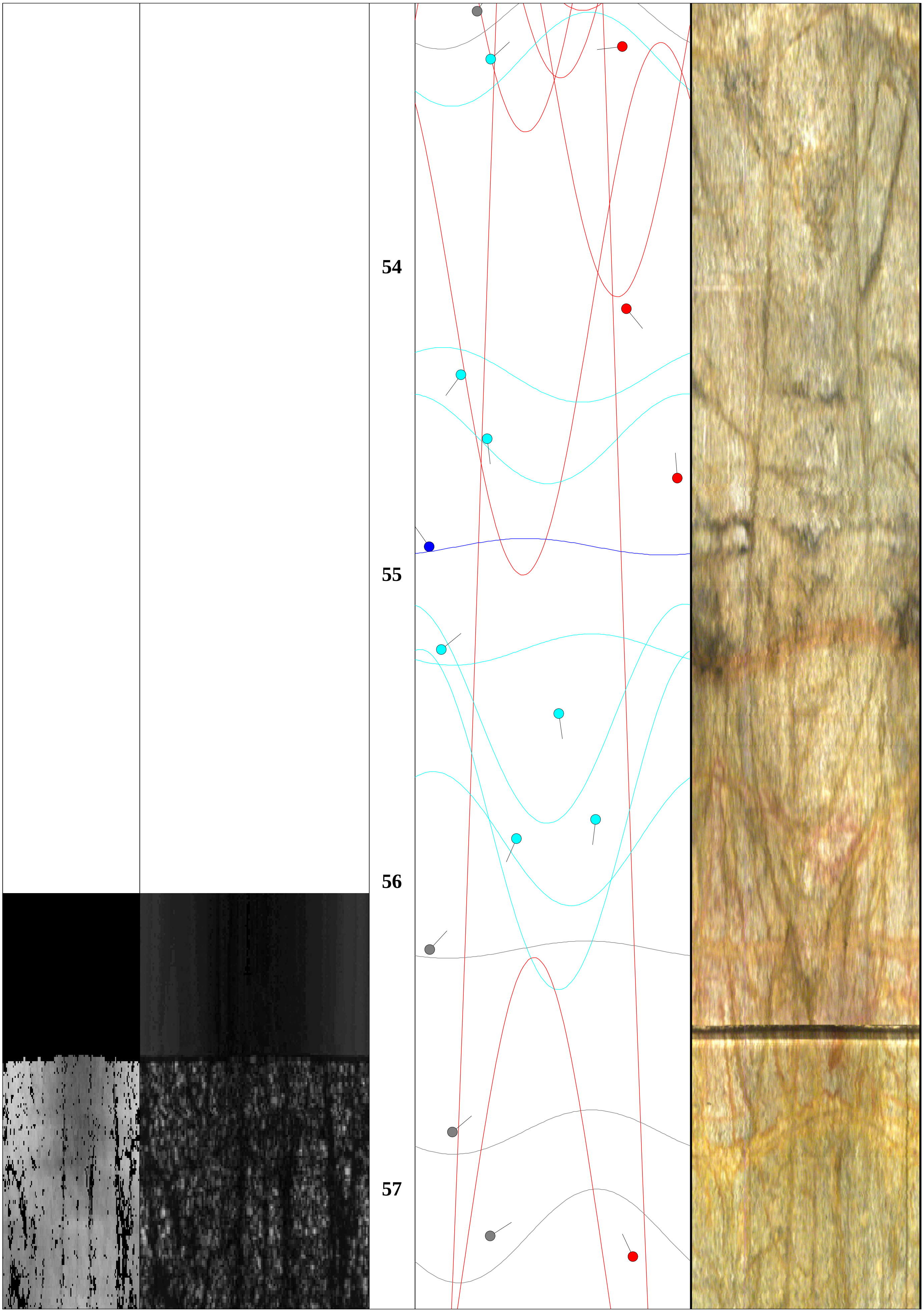
50

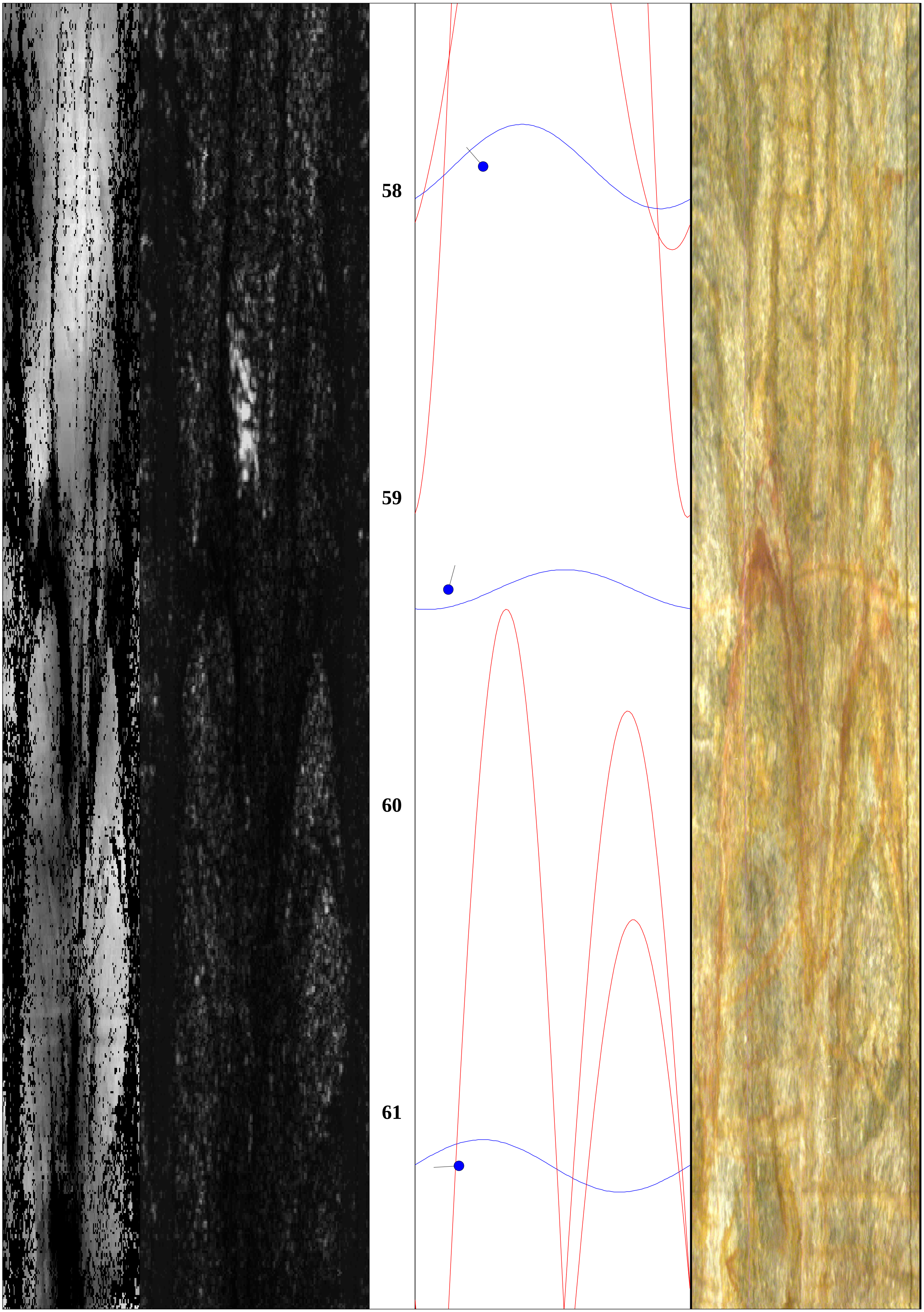
51

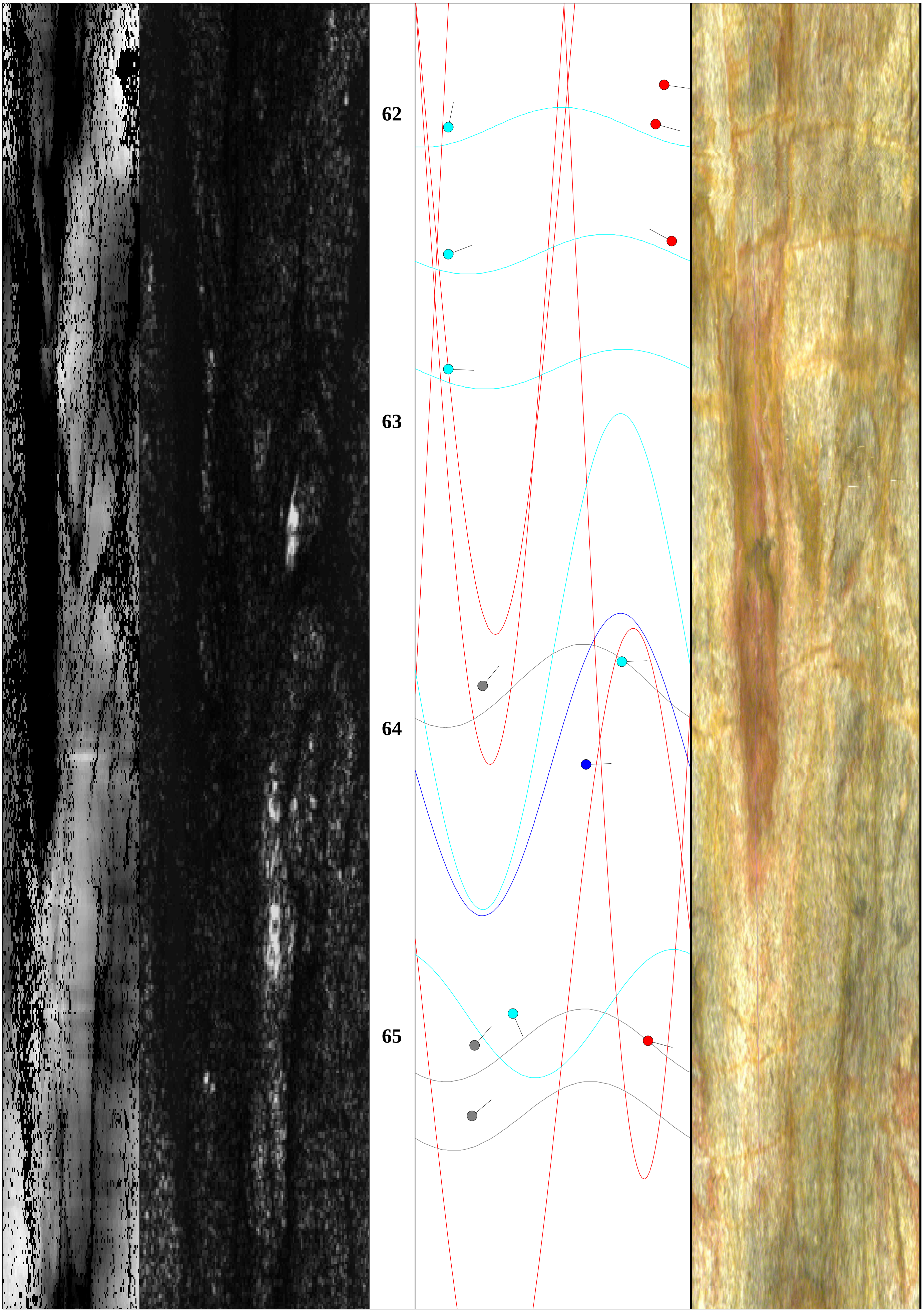
52

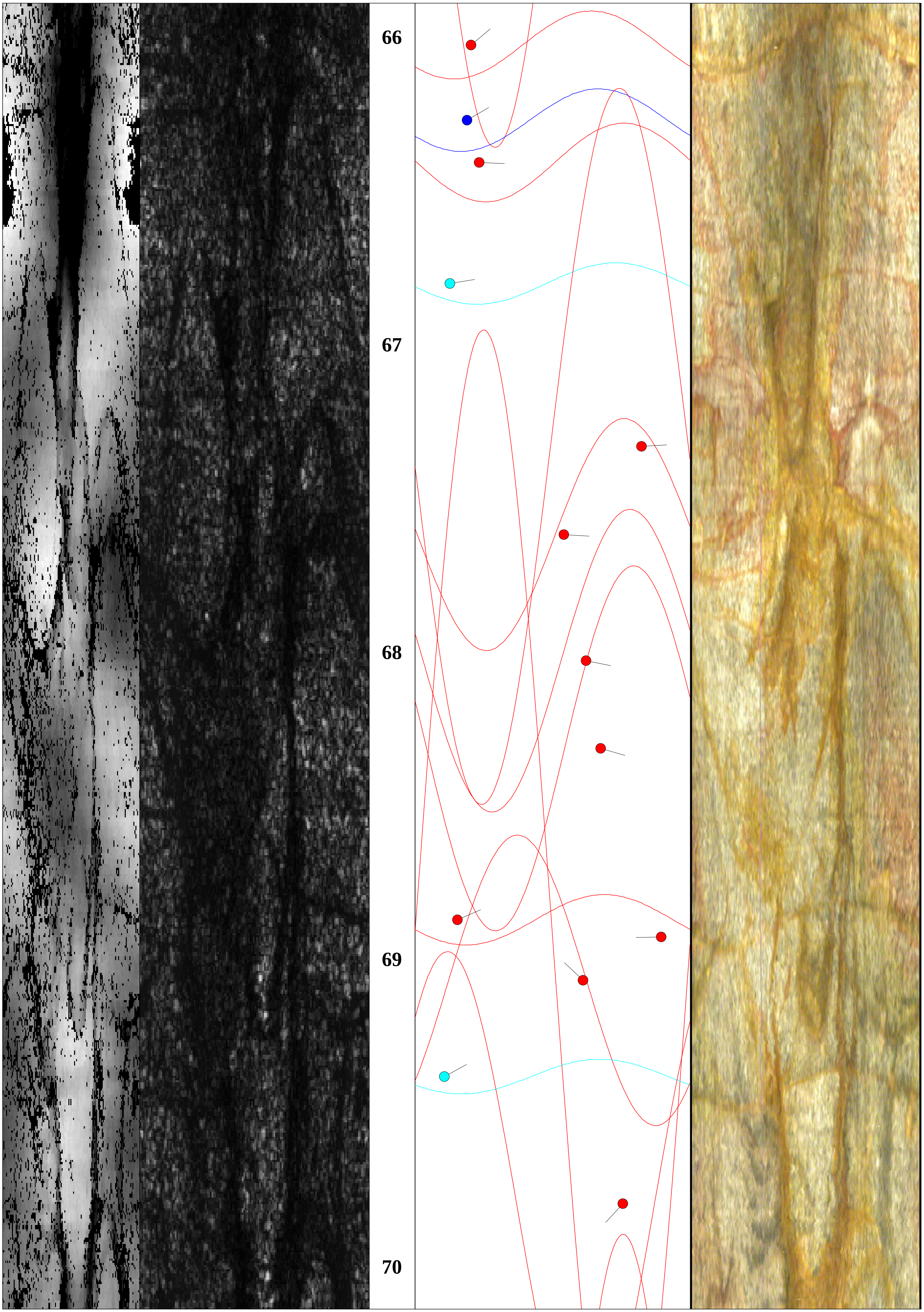
53

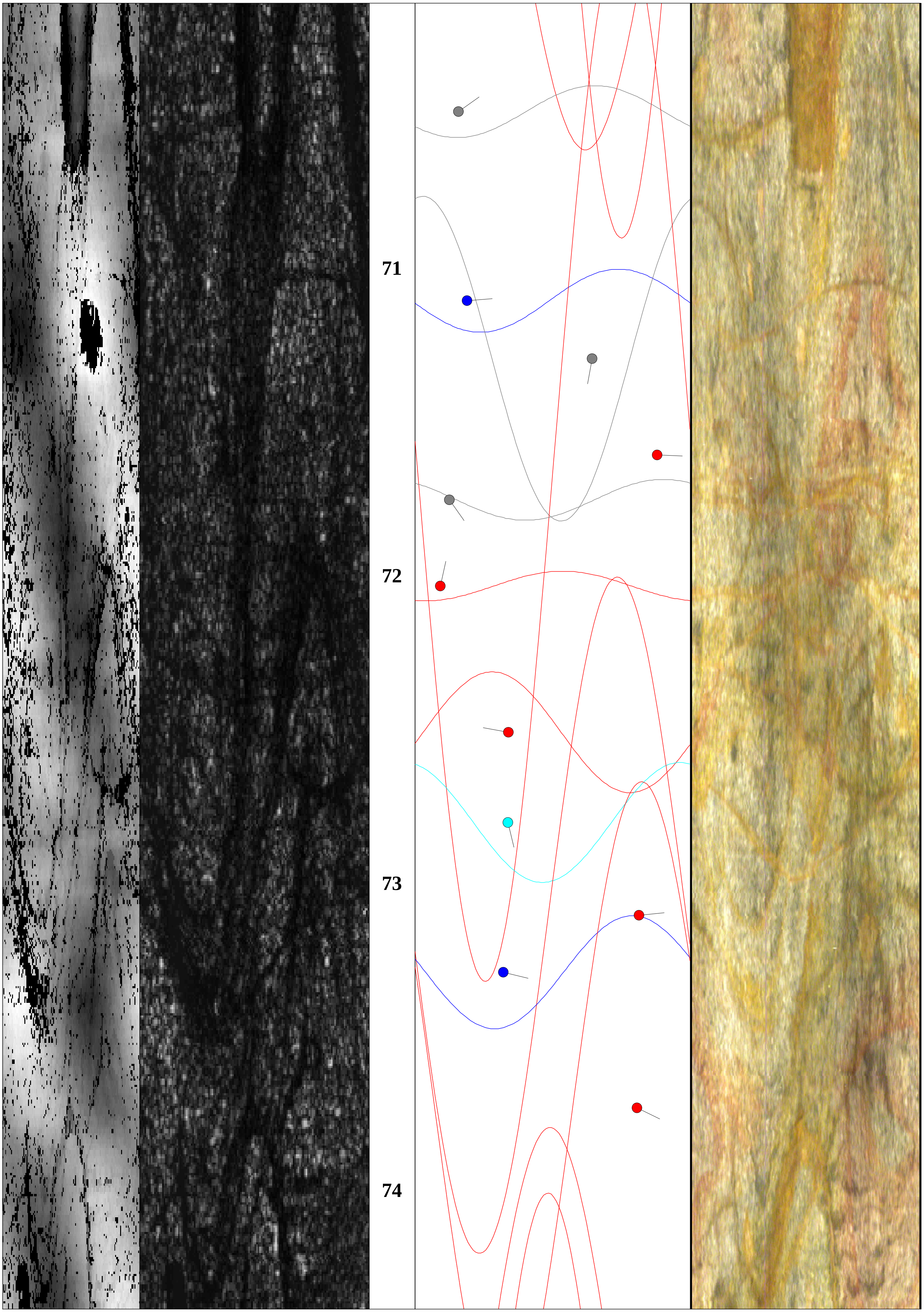


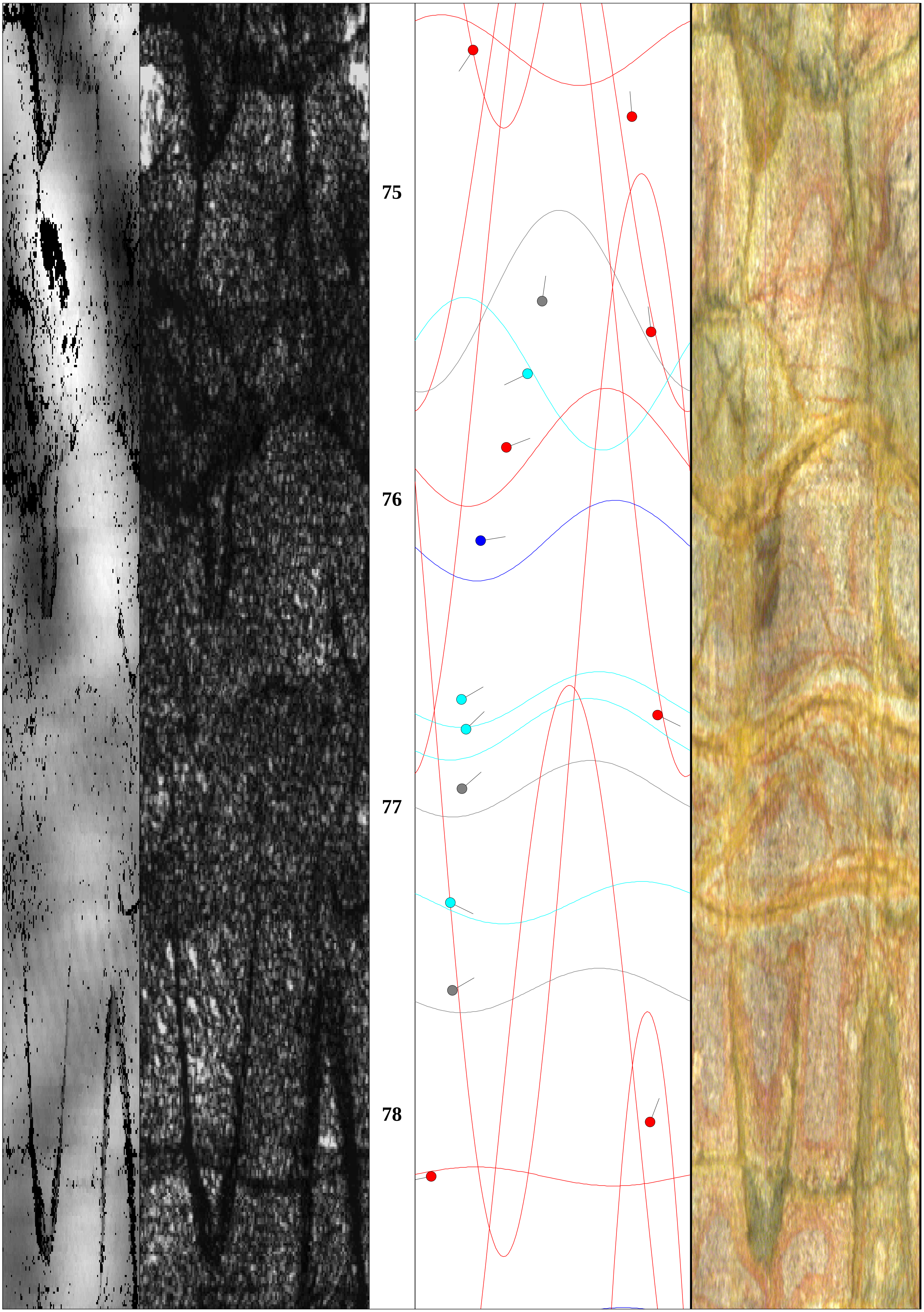

54
55
56
57

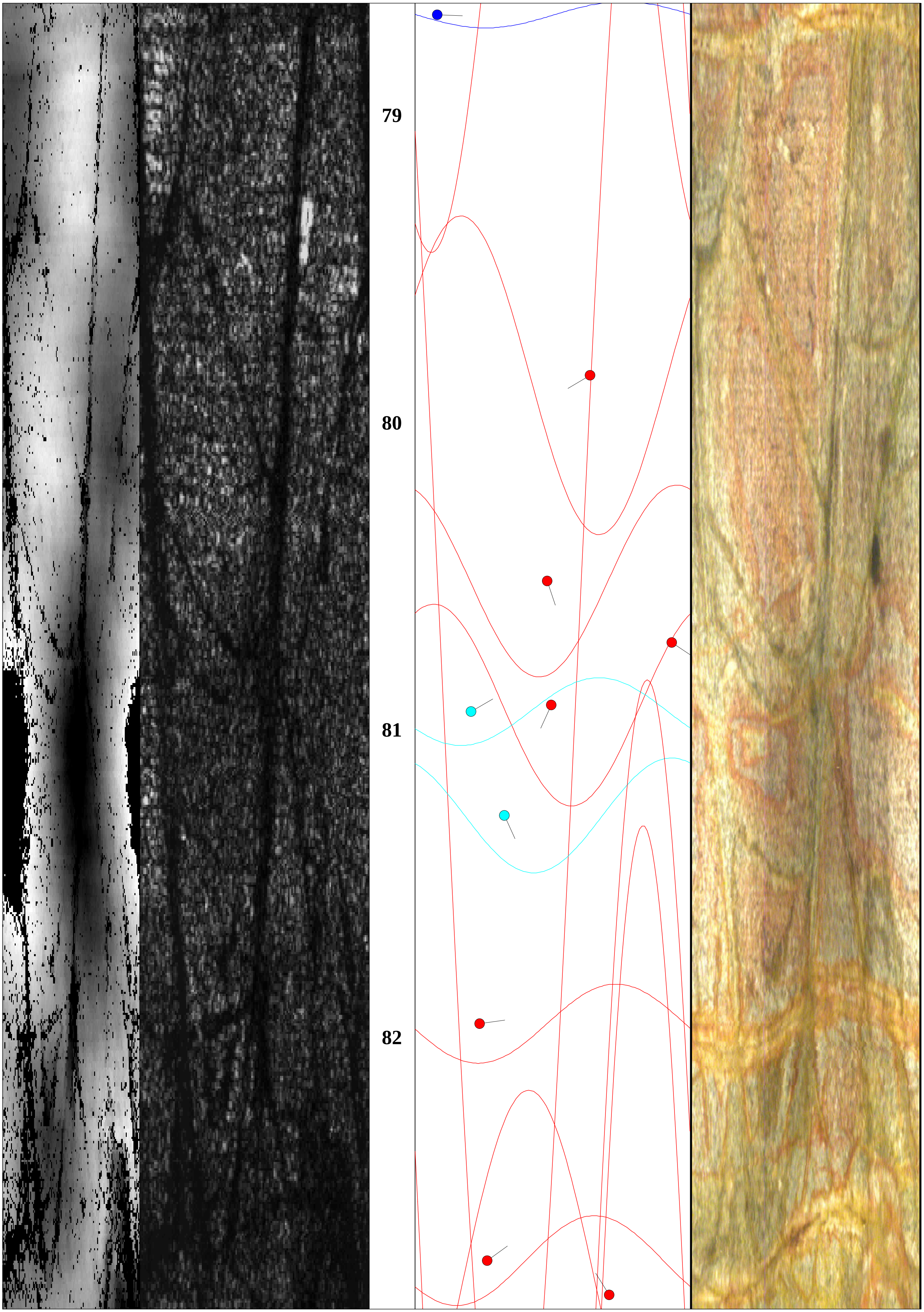

58
59
60
61

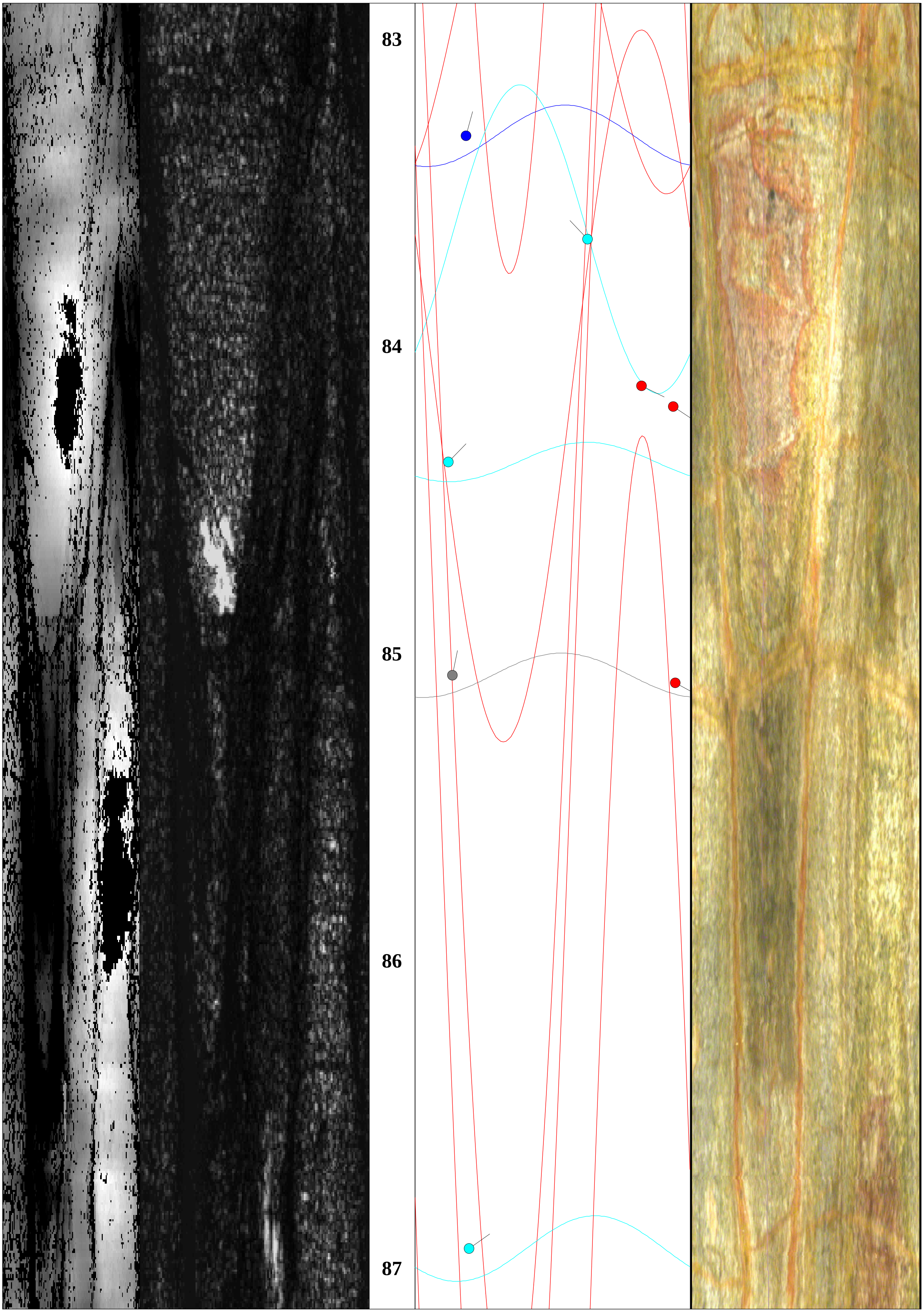

62
63
64
65

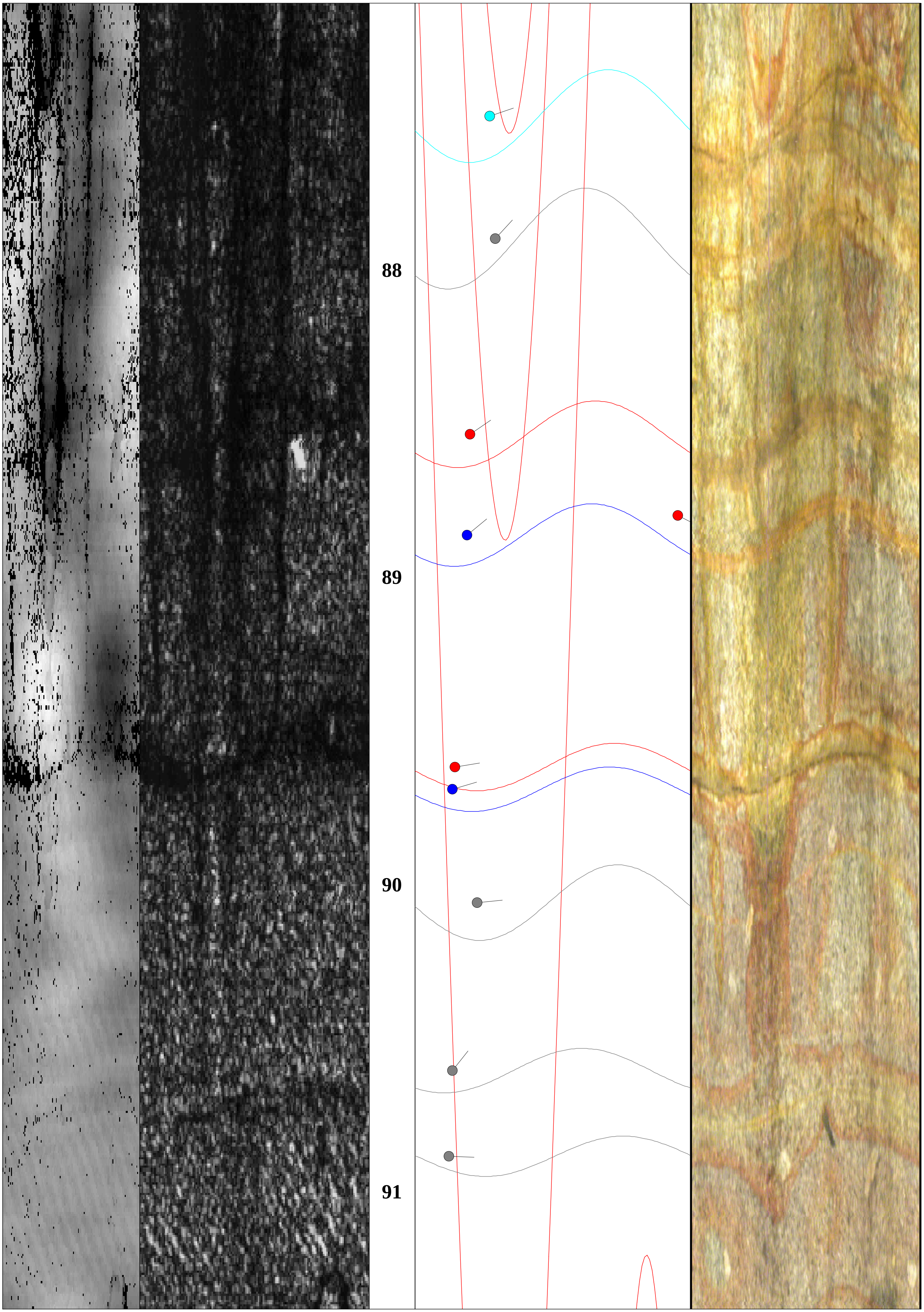

66
67
68
69
70

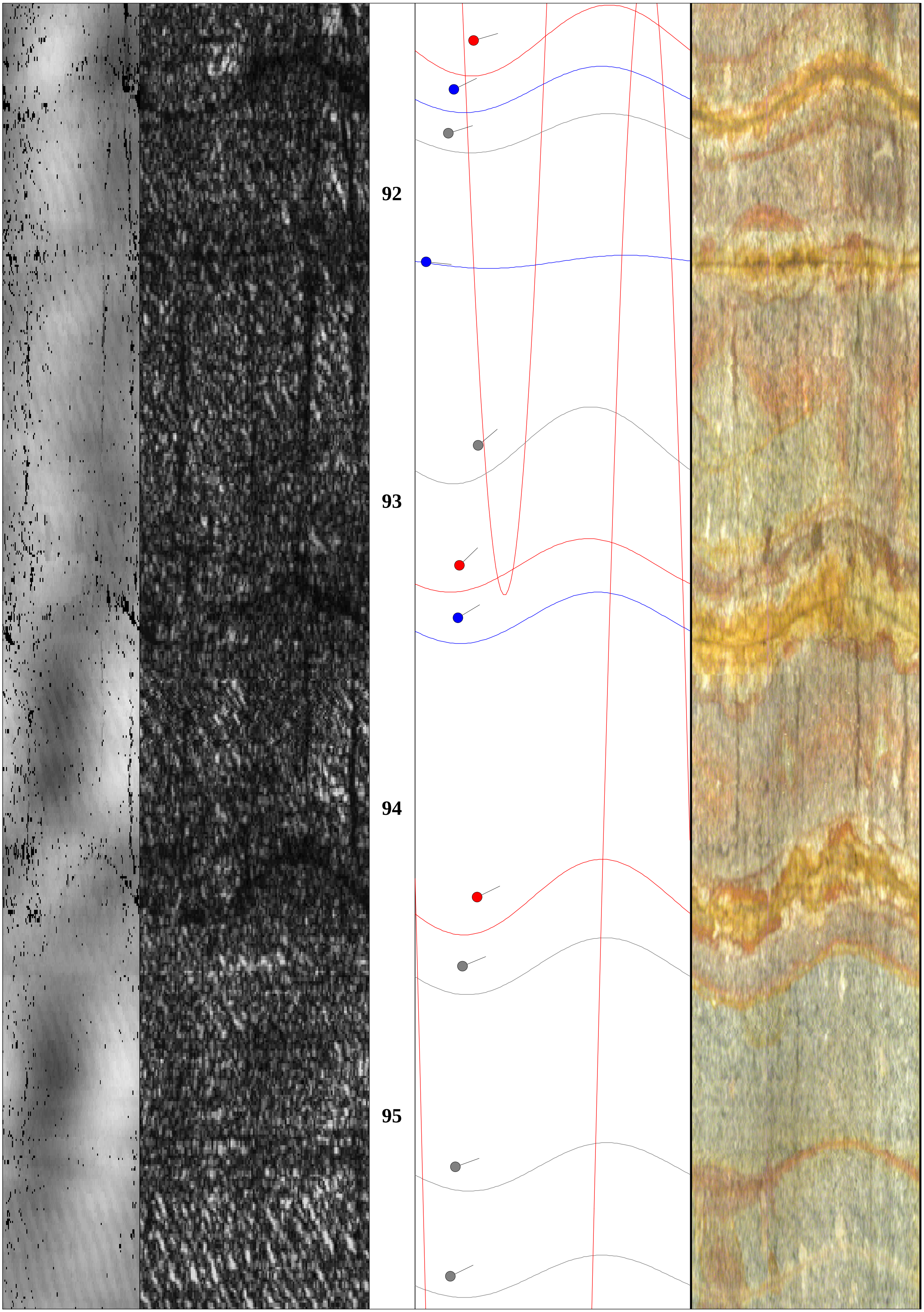

71
72
73
74

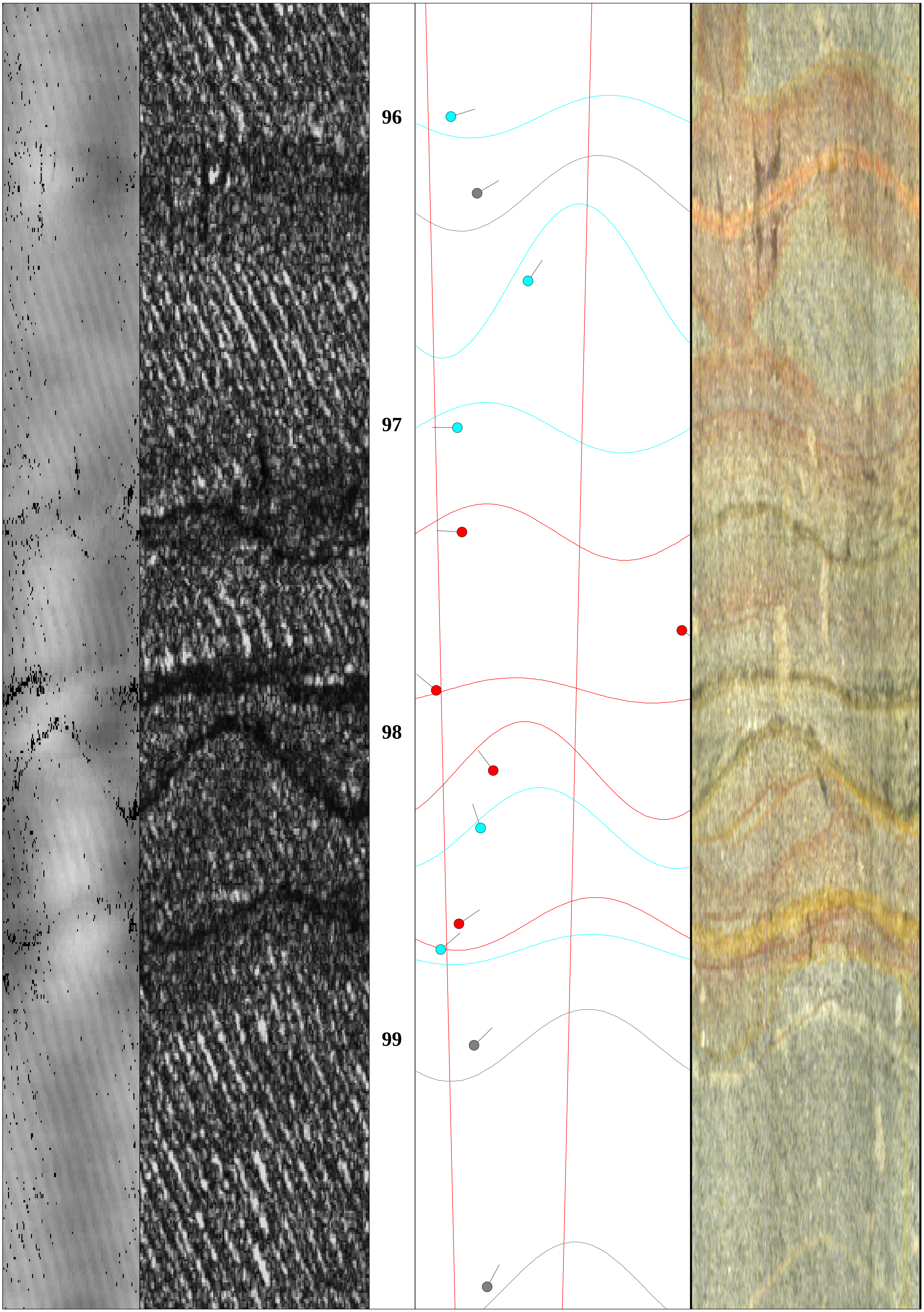

75
76
77
78

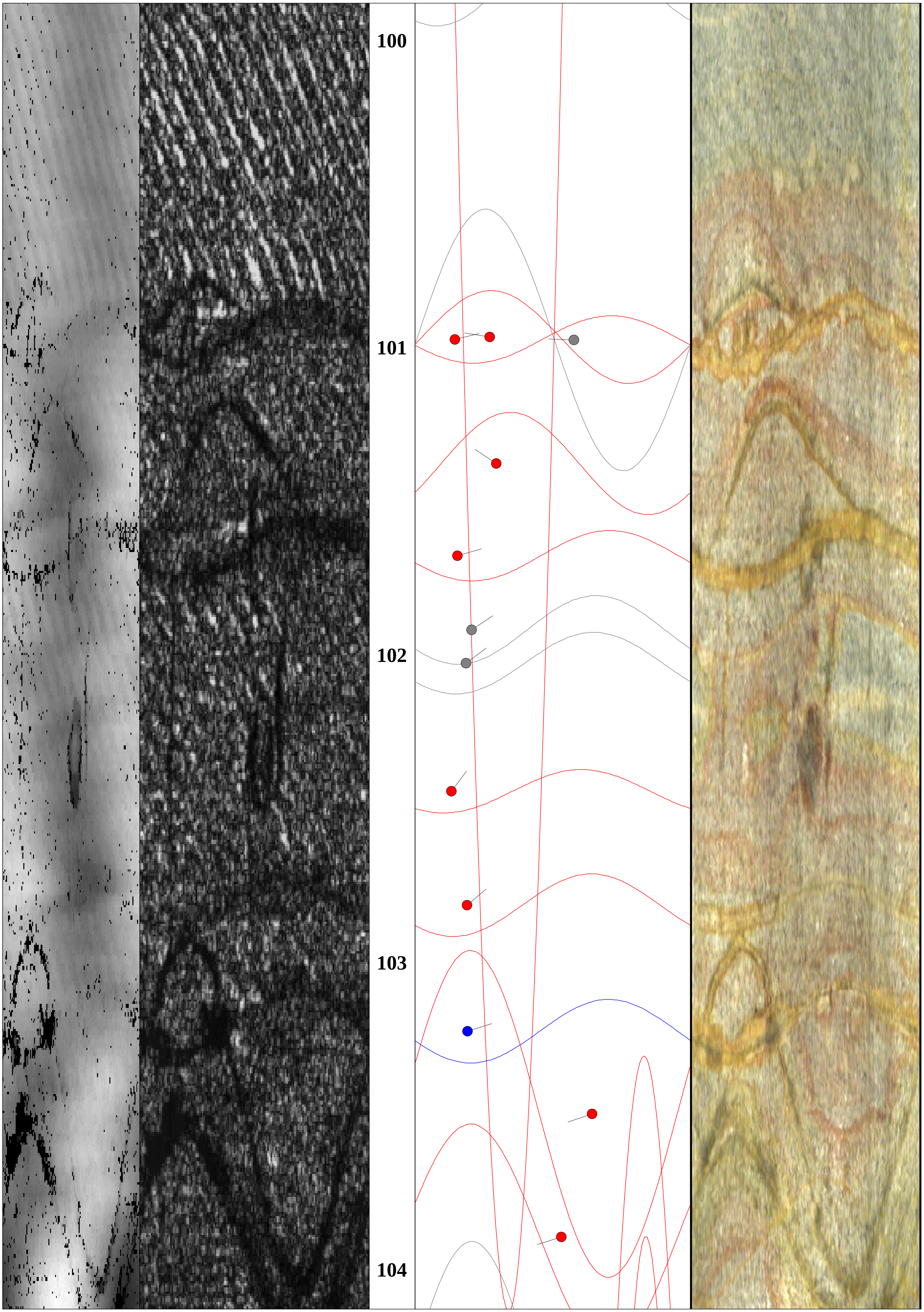

79
80
81
82

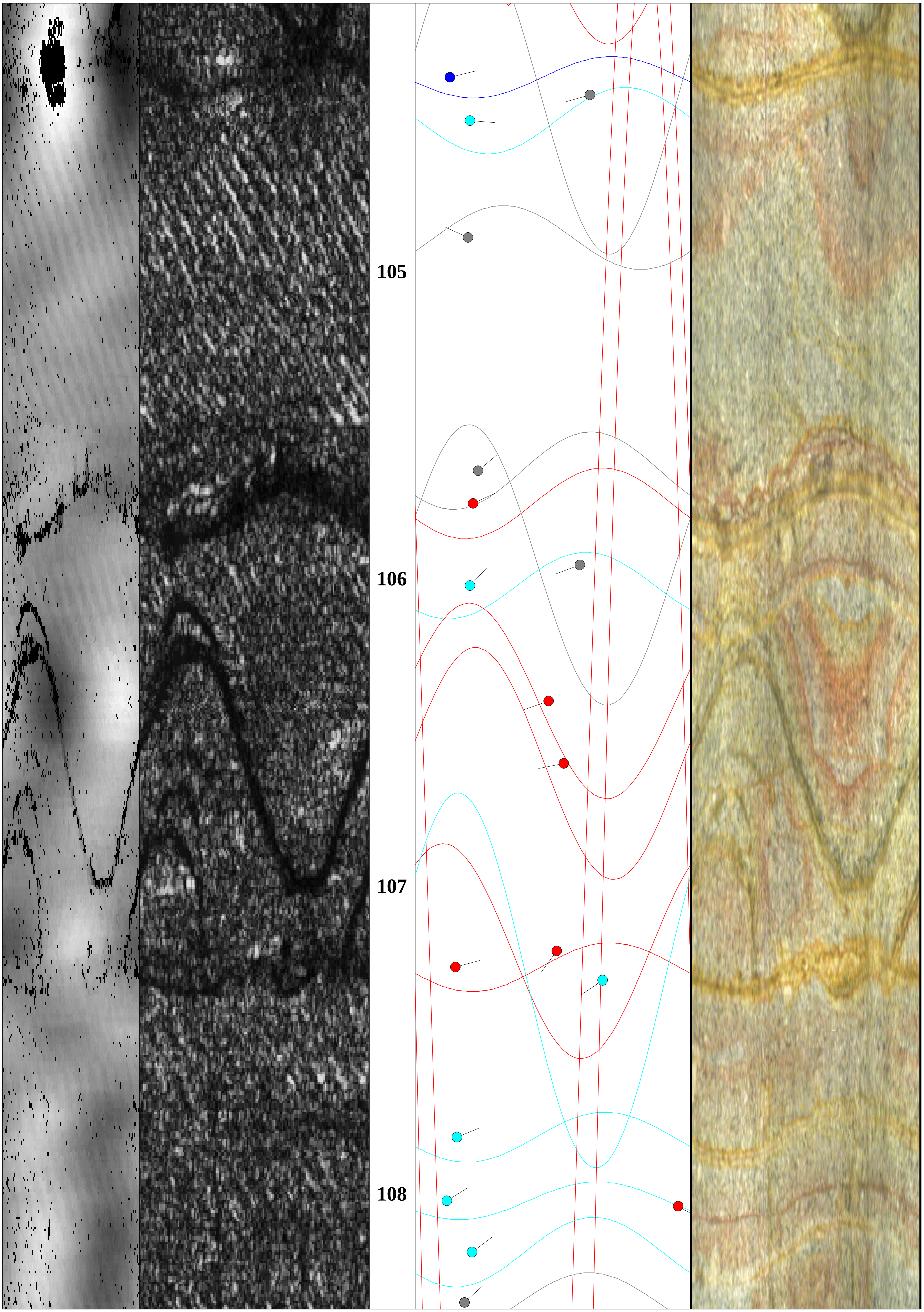

83
84
85
86
87

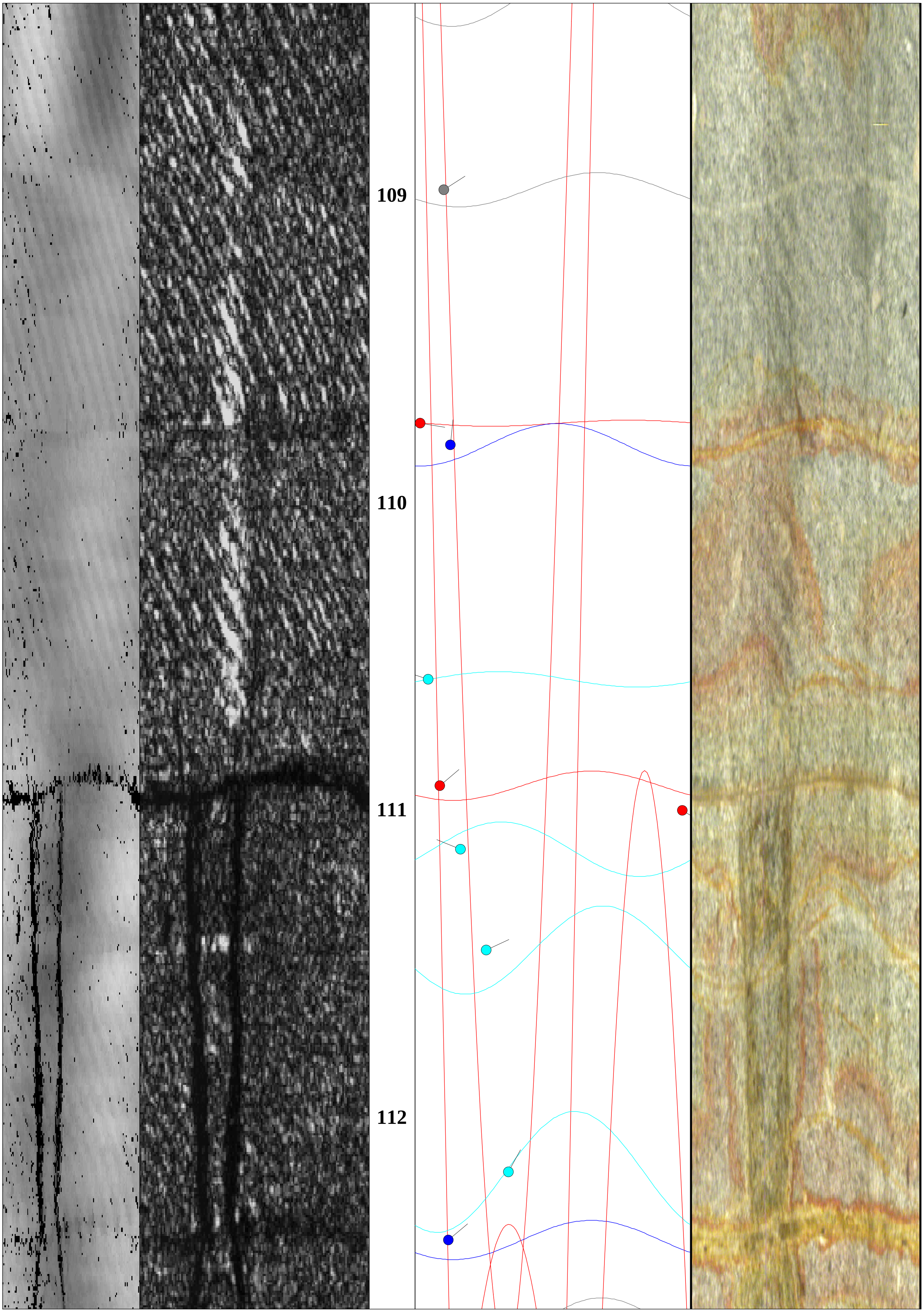

88
89
90
91

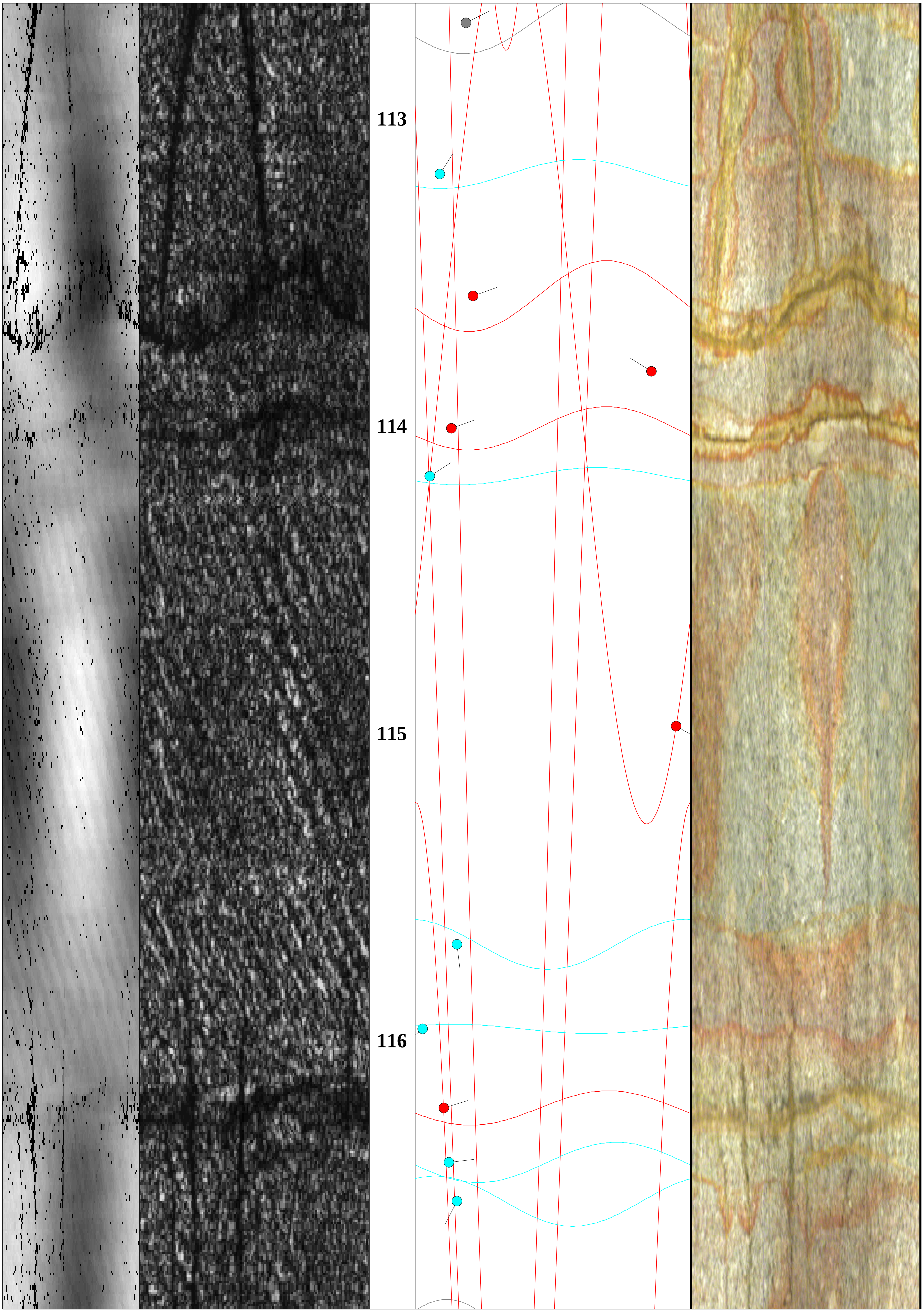

92
93
94
95


96
97
98
99

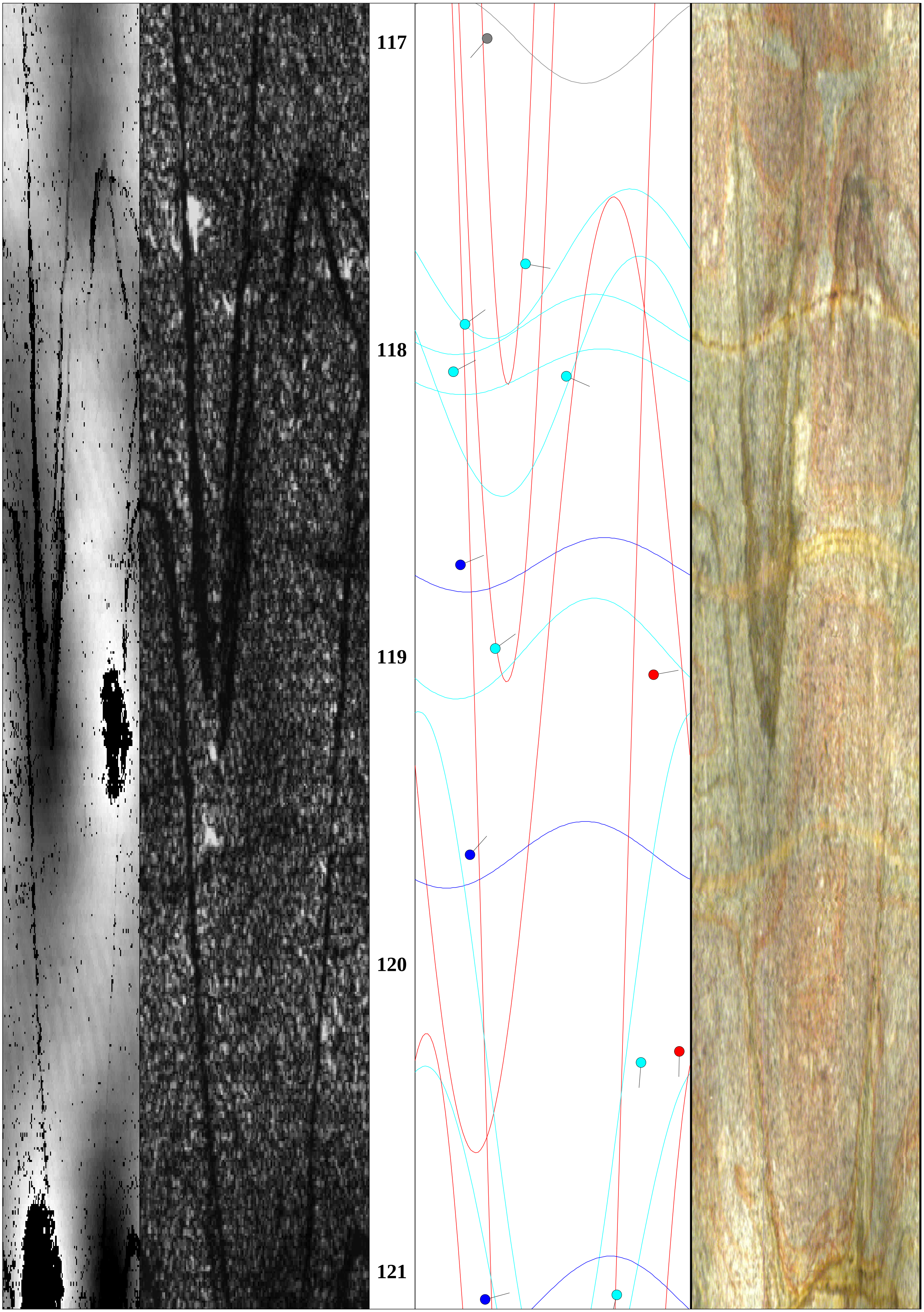

100
101
102
103
104

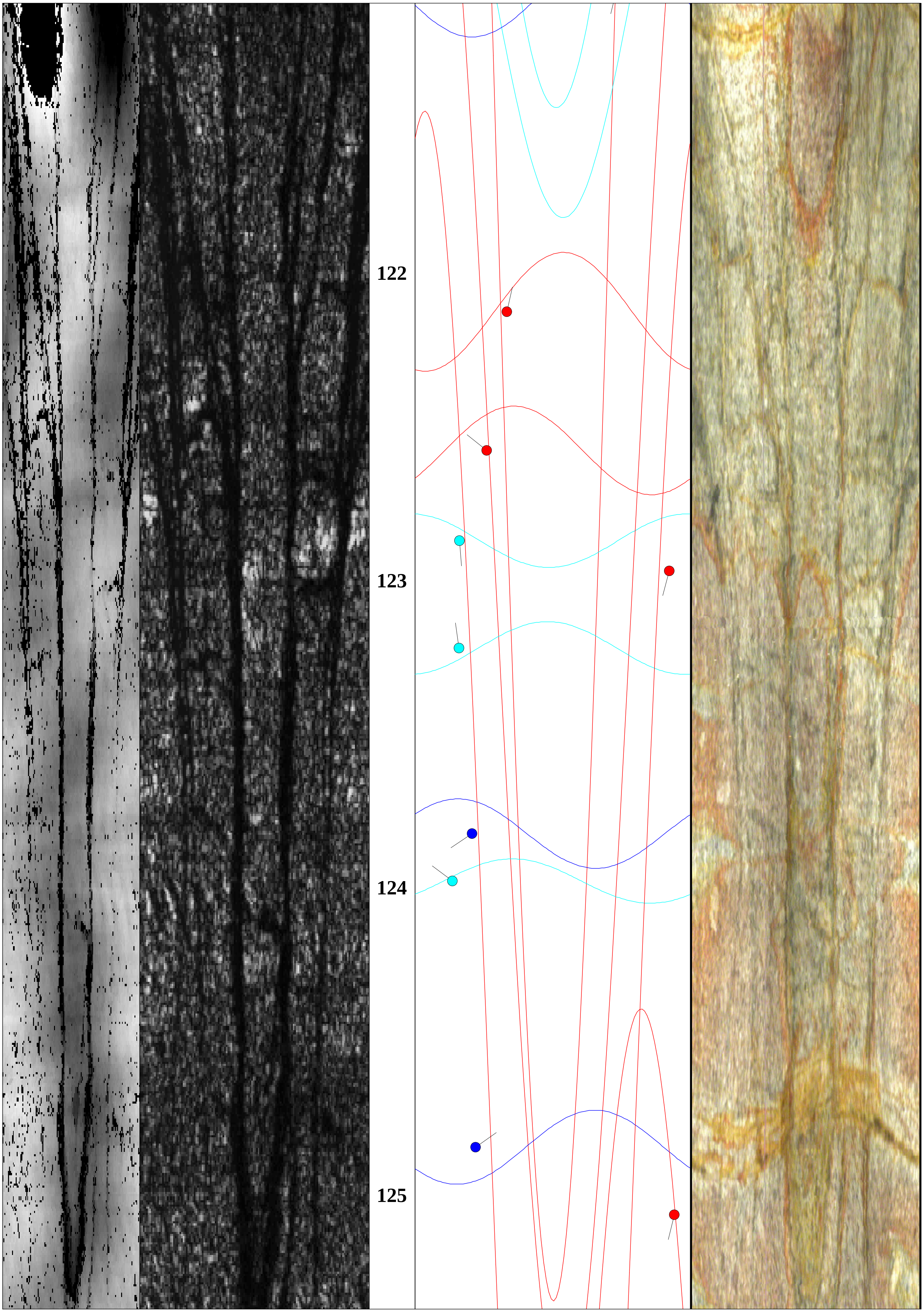

105
106
107
108

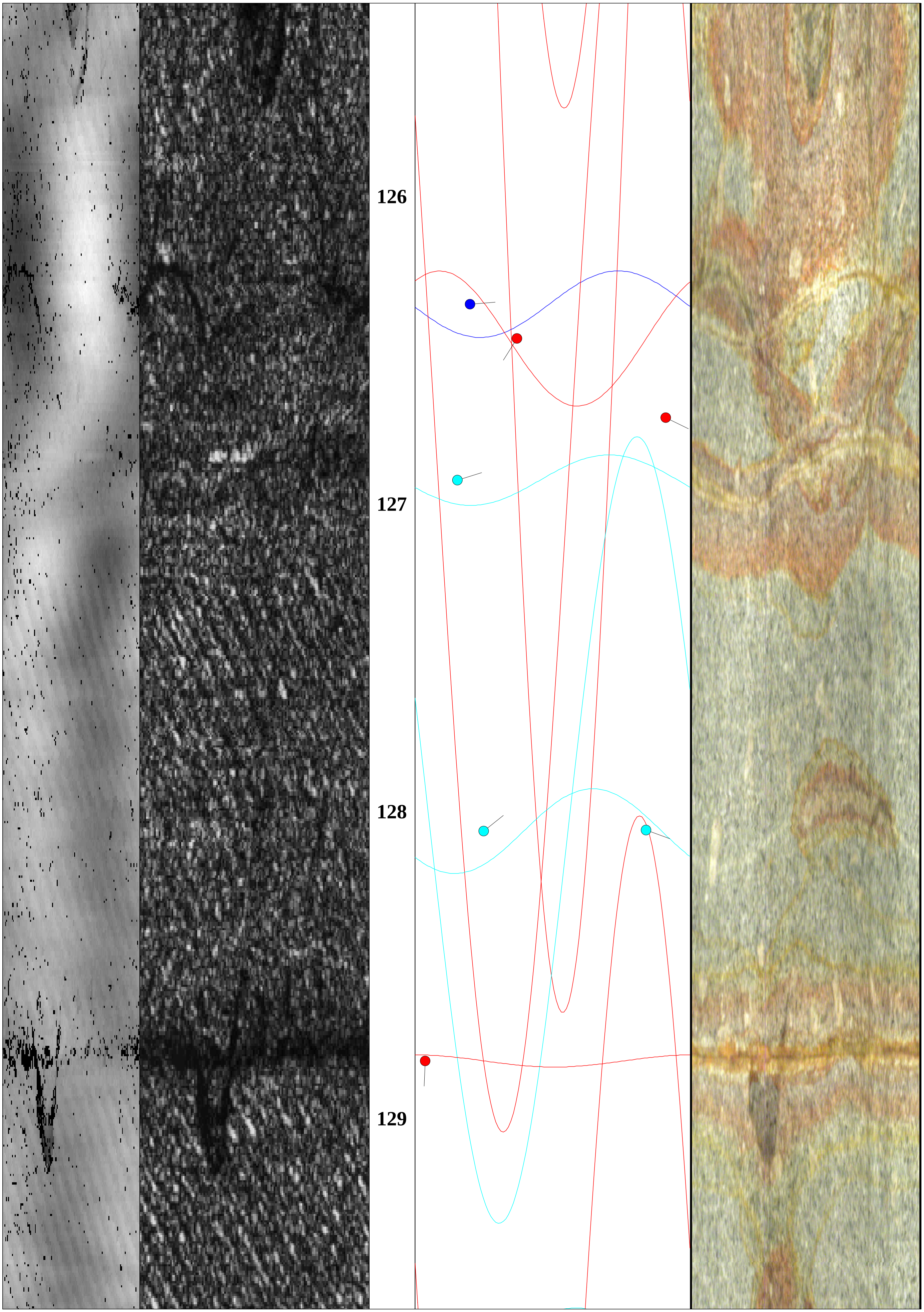

109
110
111
112



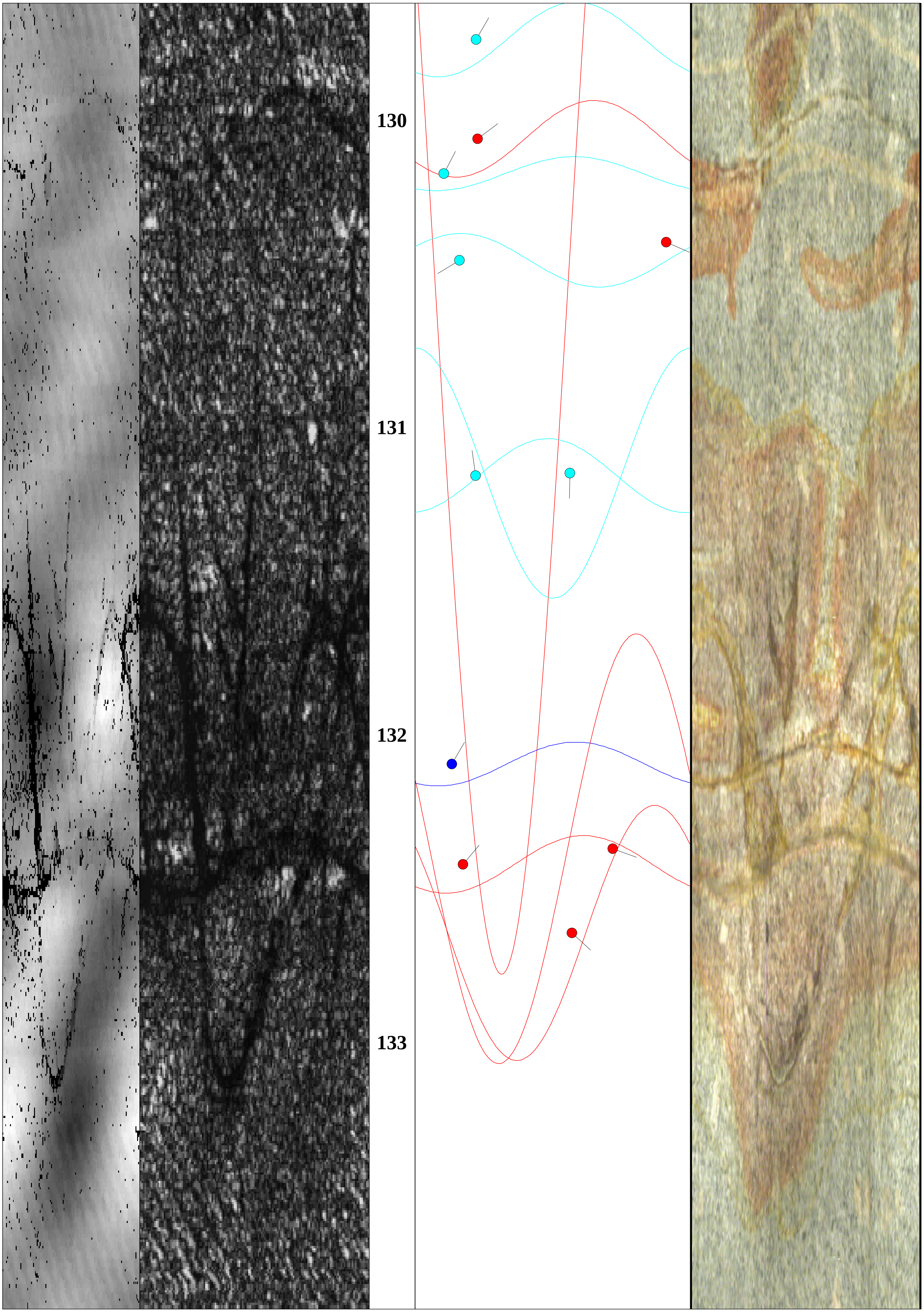
113
114
115
116

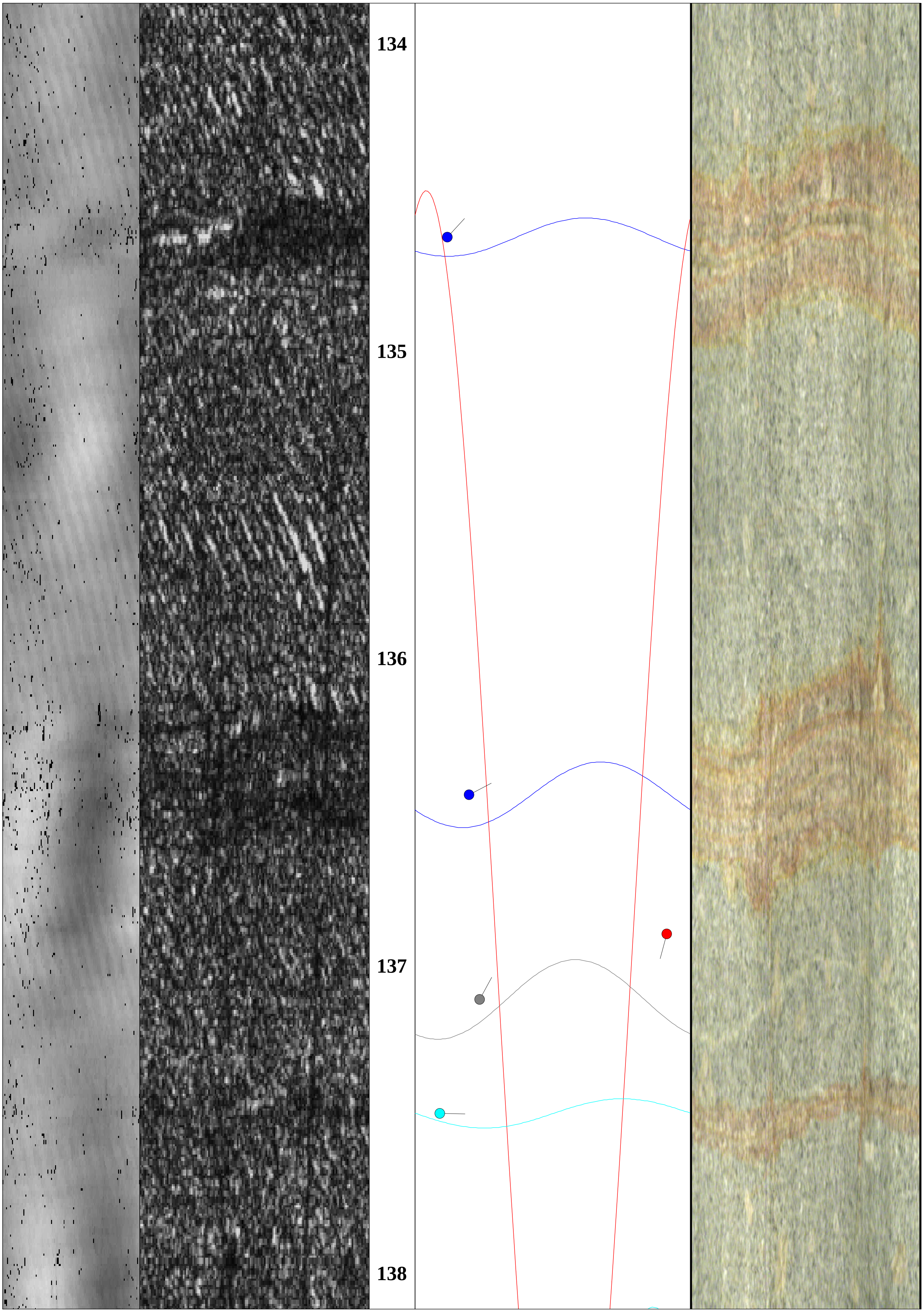

117
118
119
120
121

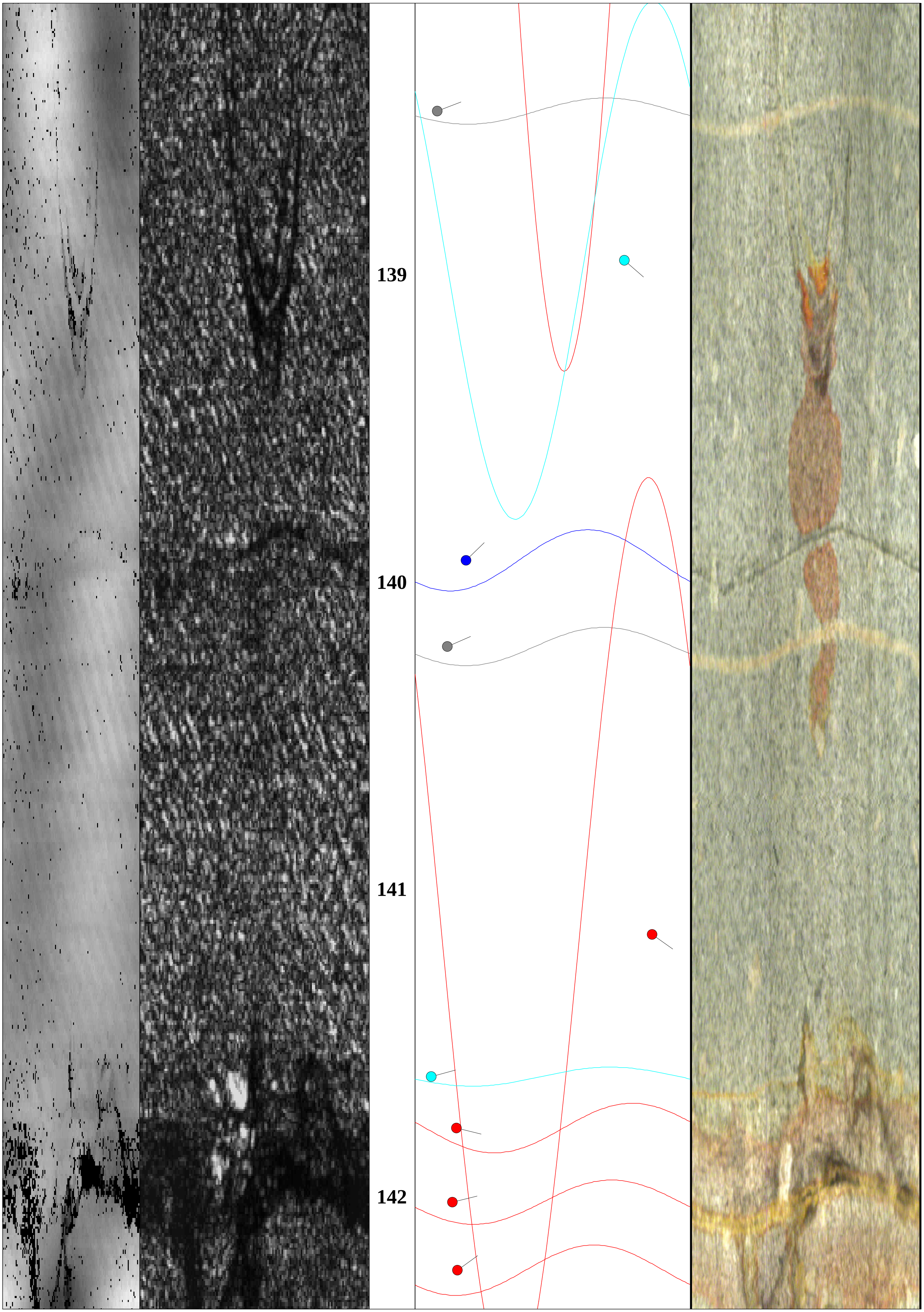

122
123
124
125

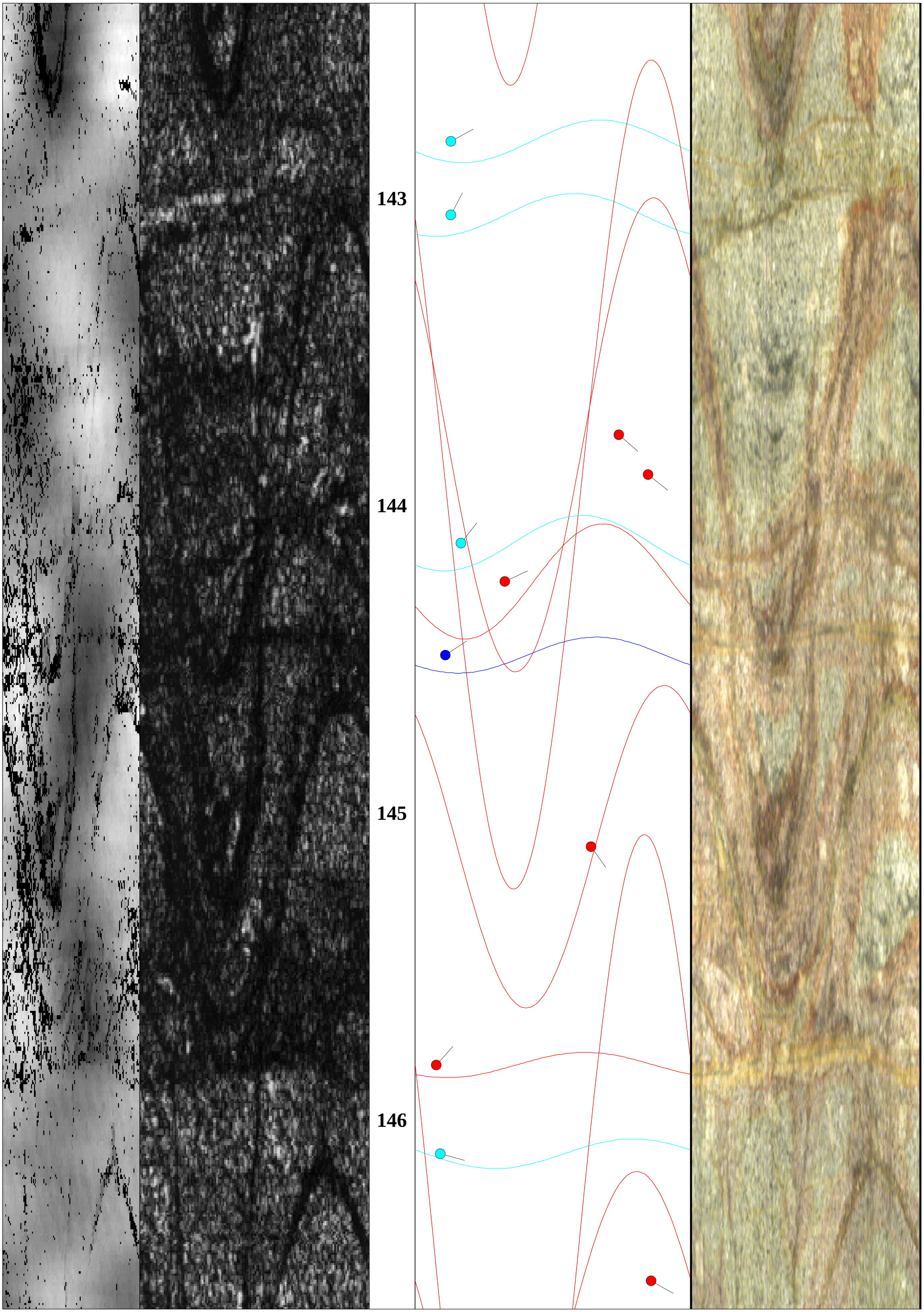


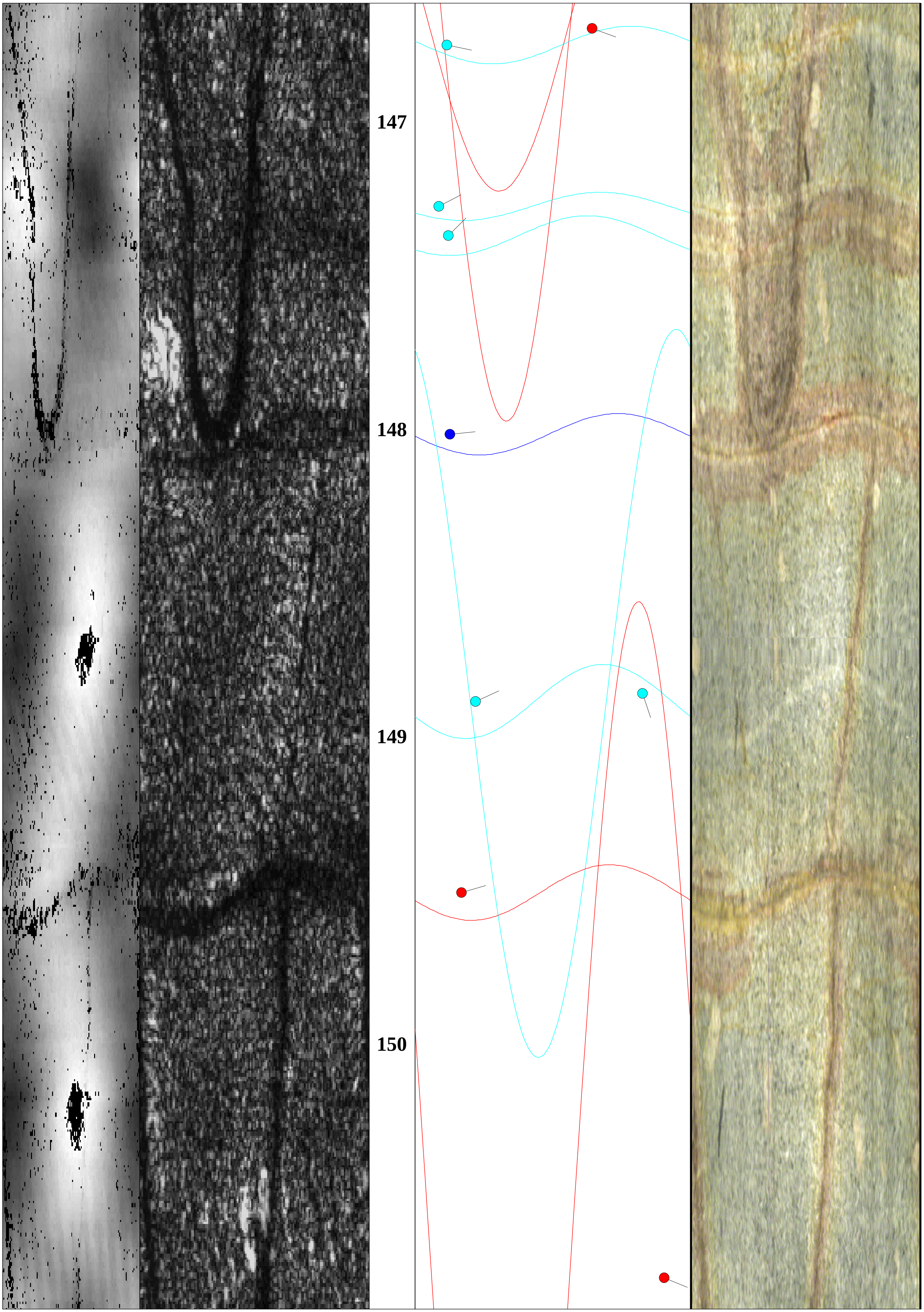
126
127
128
129

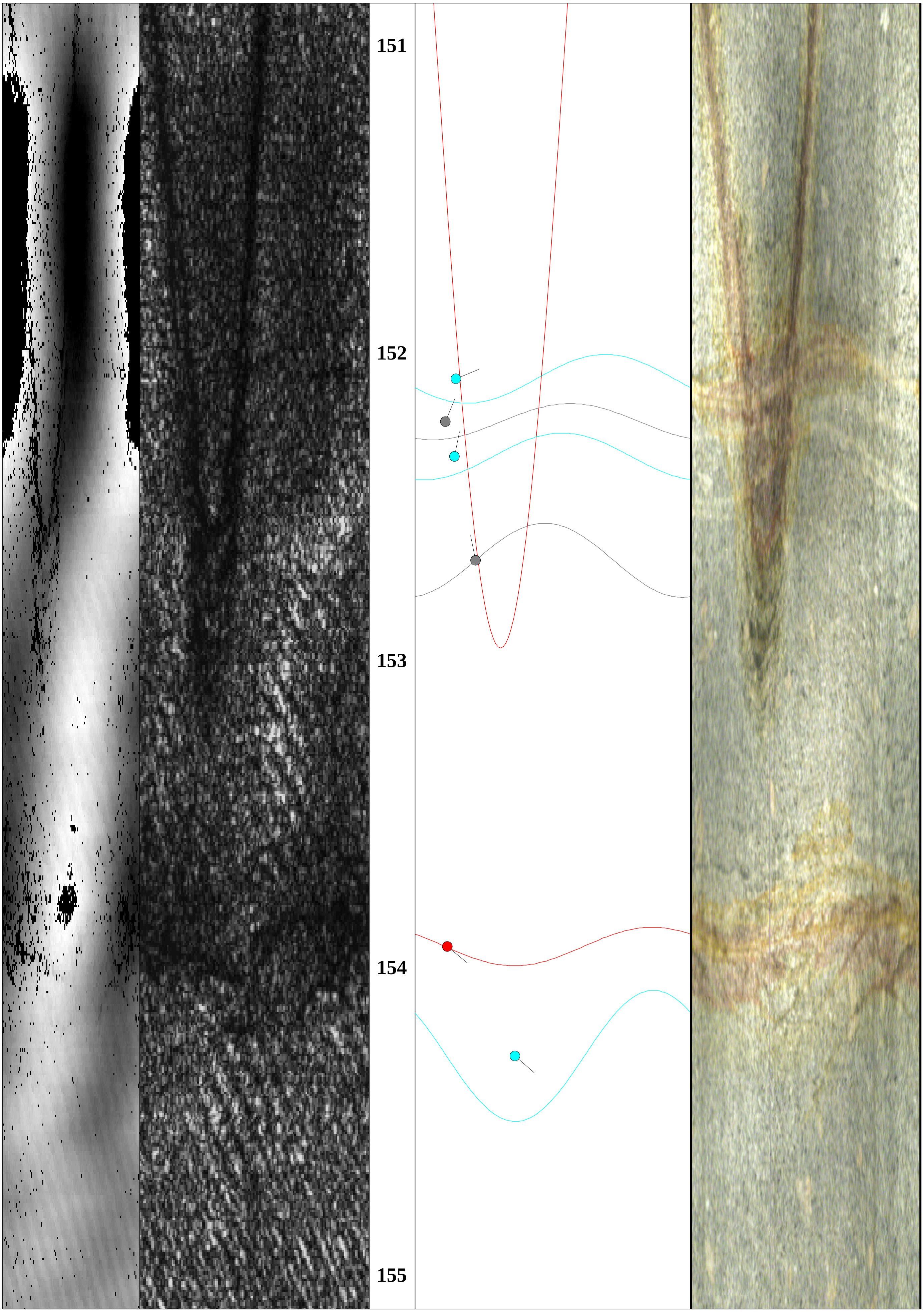

130
131
132
133

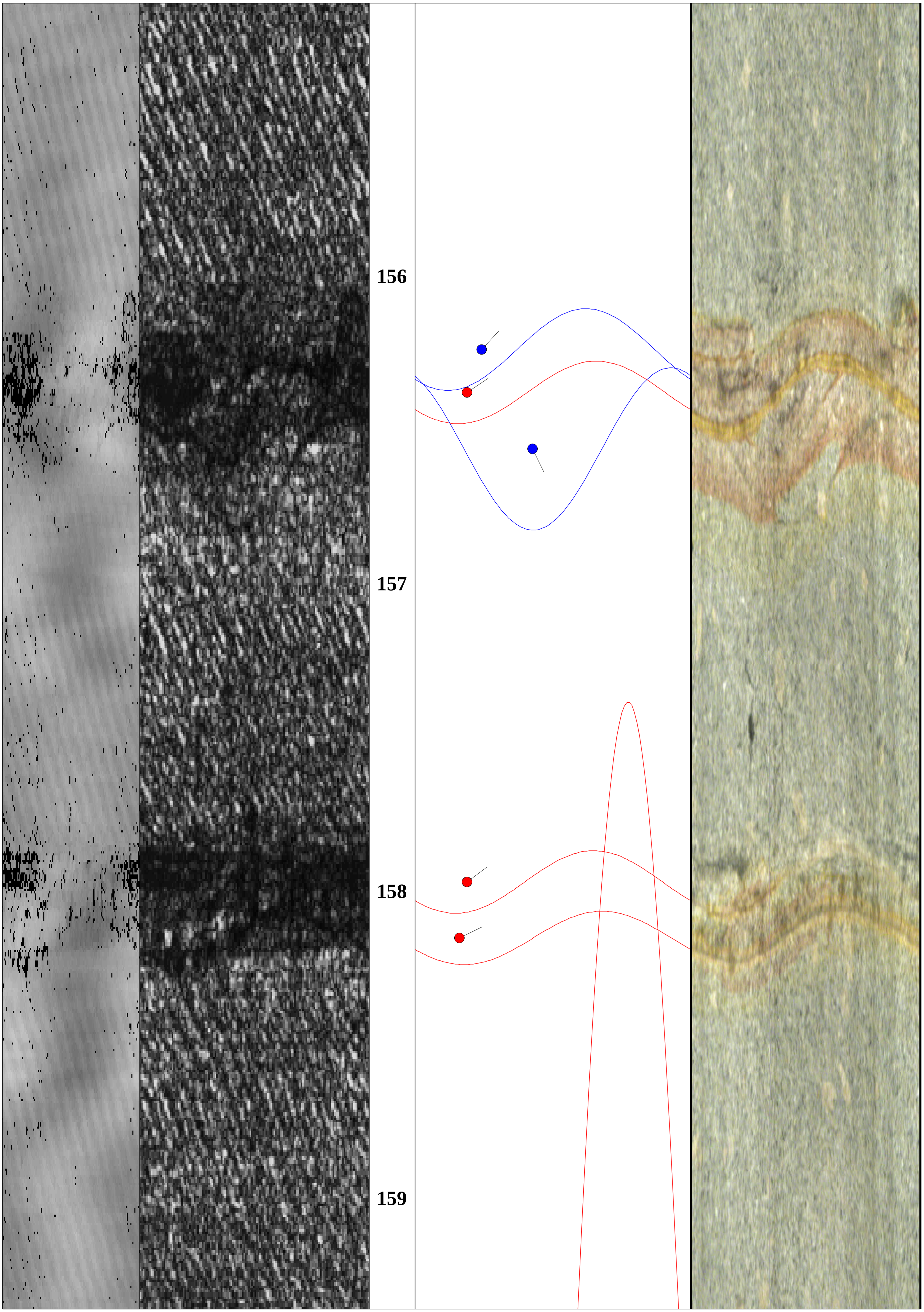

134
135
136
137
138

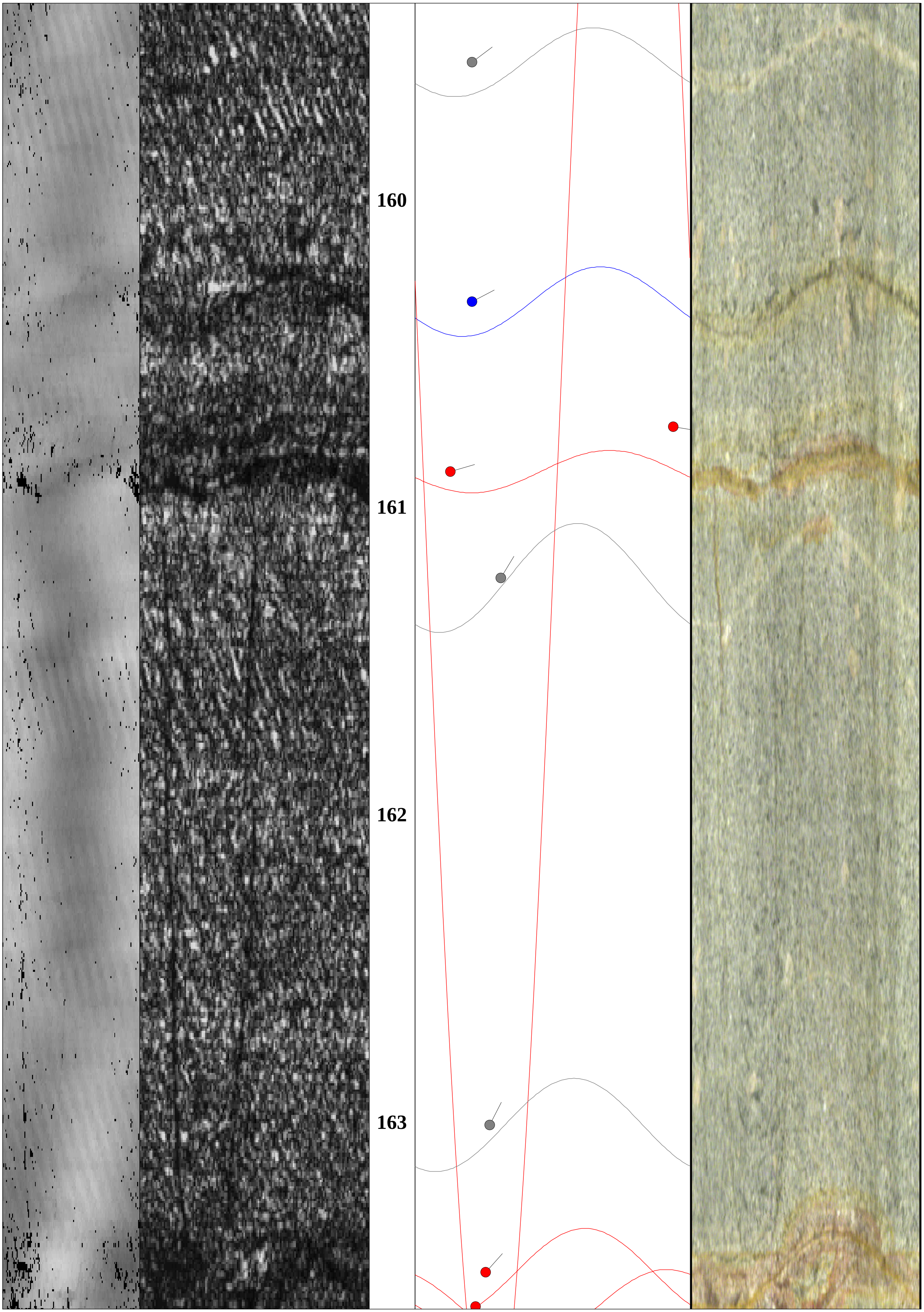

139
140
141
142

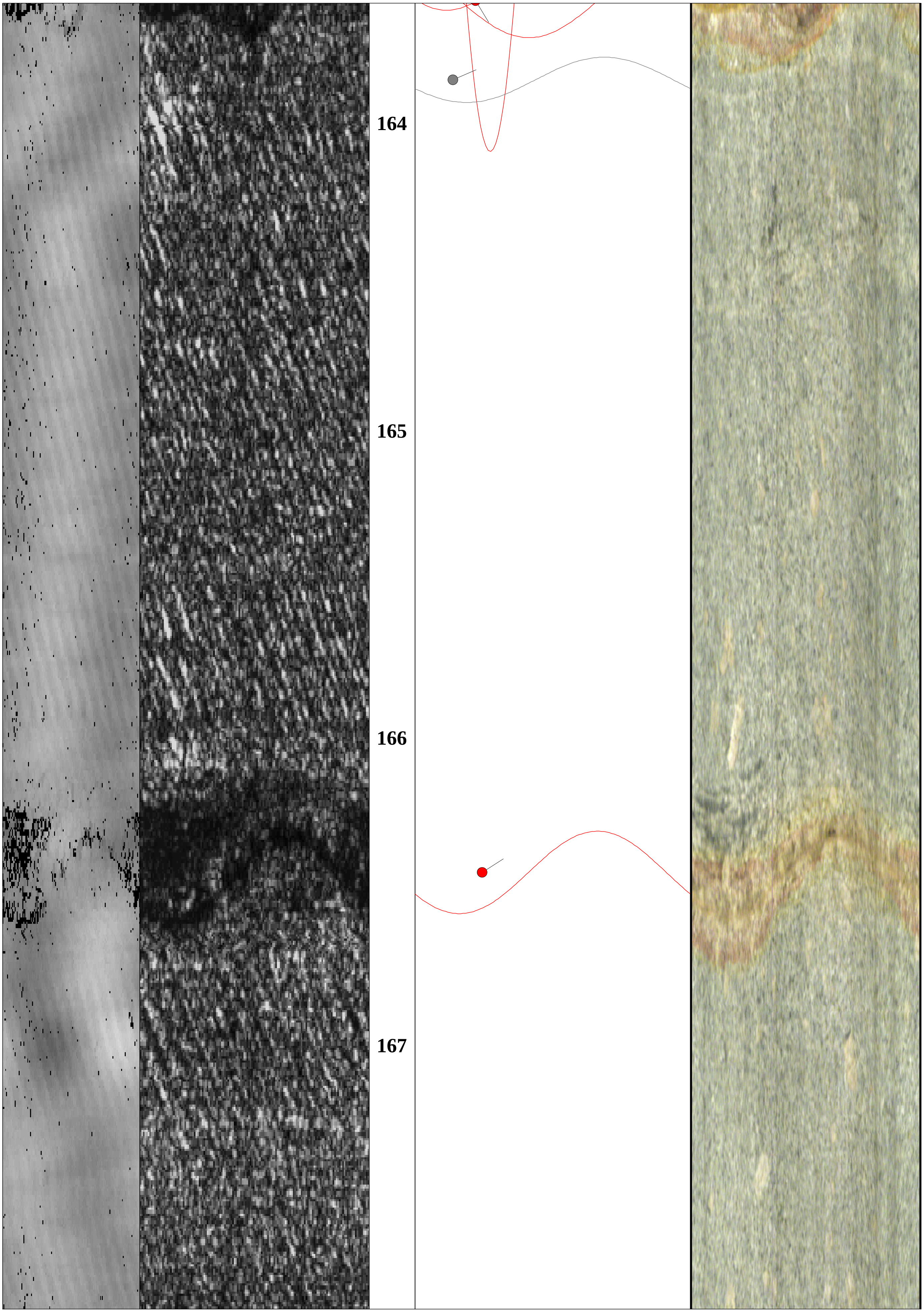

143
144
145
146

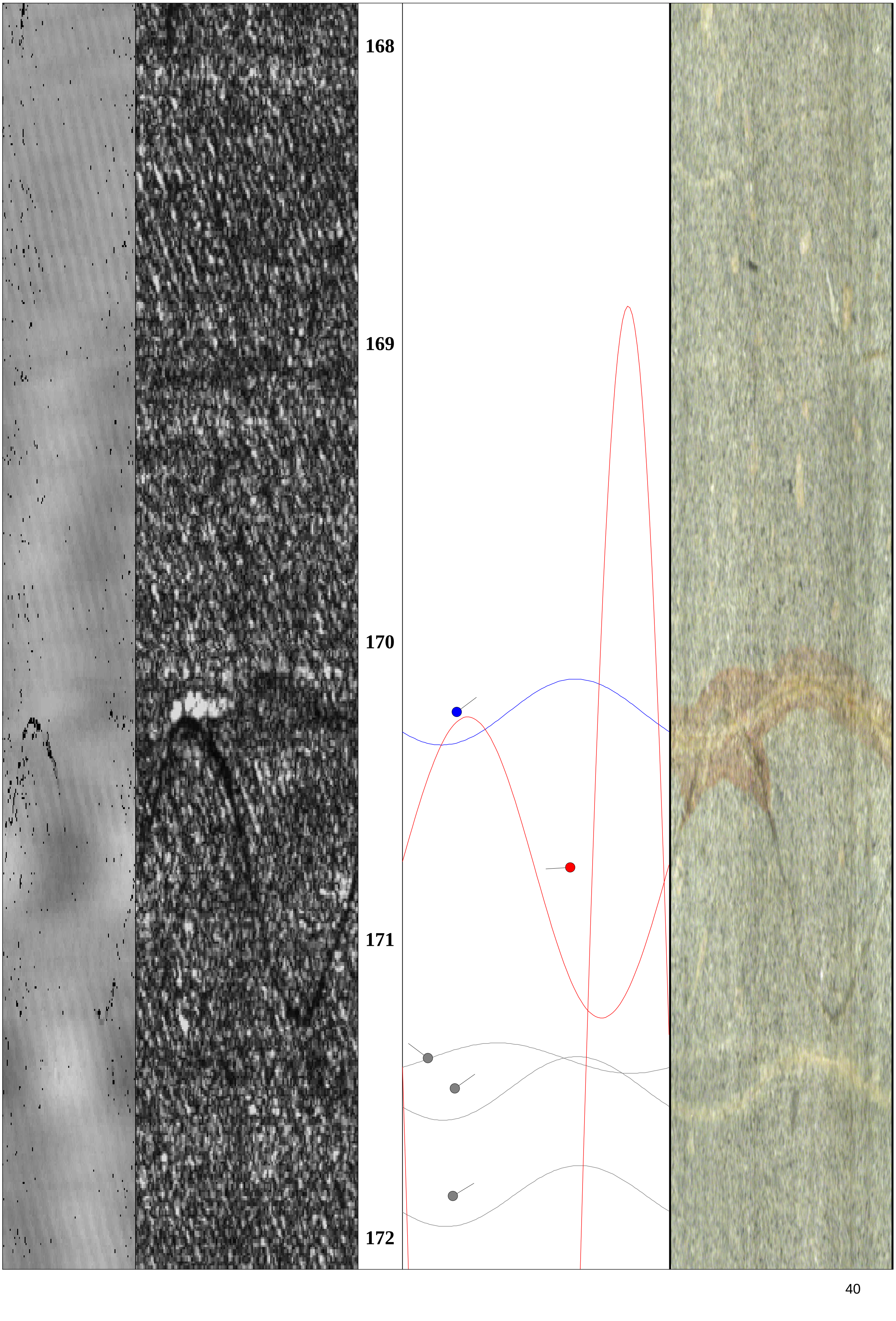

147
148
149
150

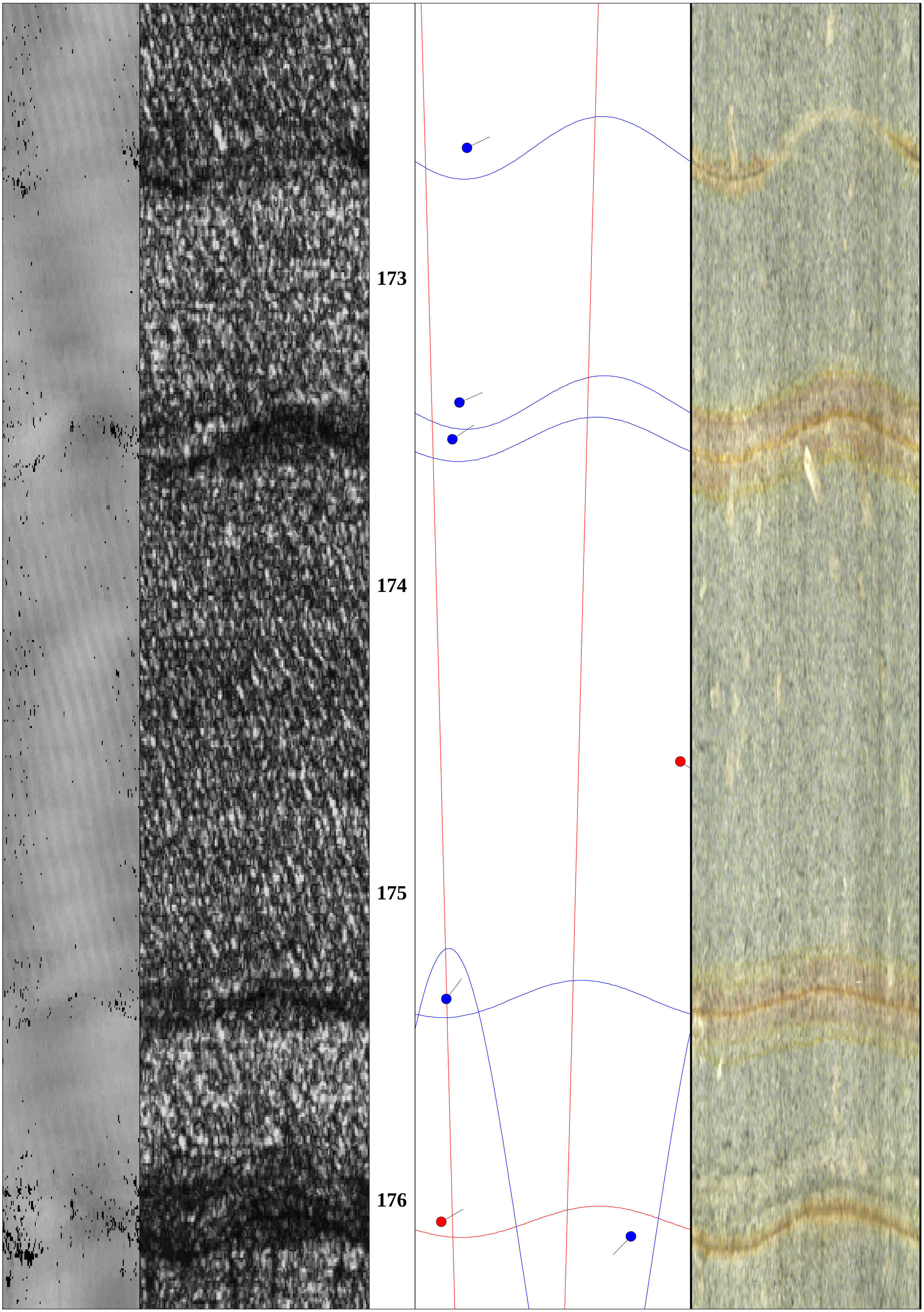

151
152
153
154
155

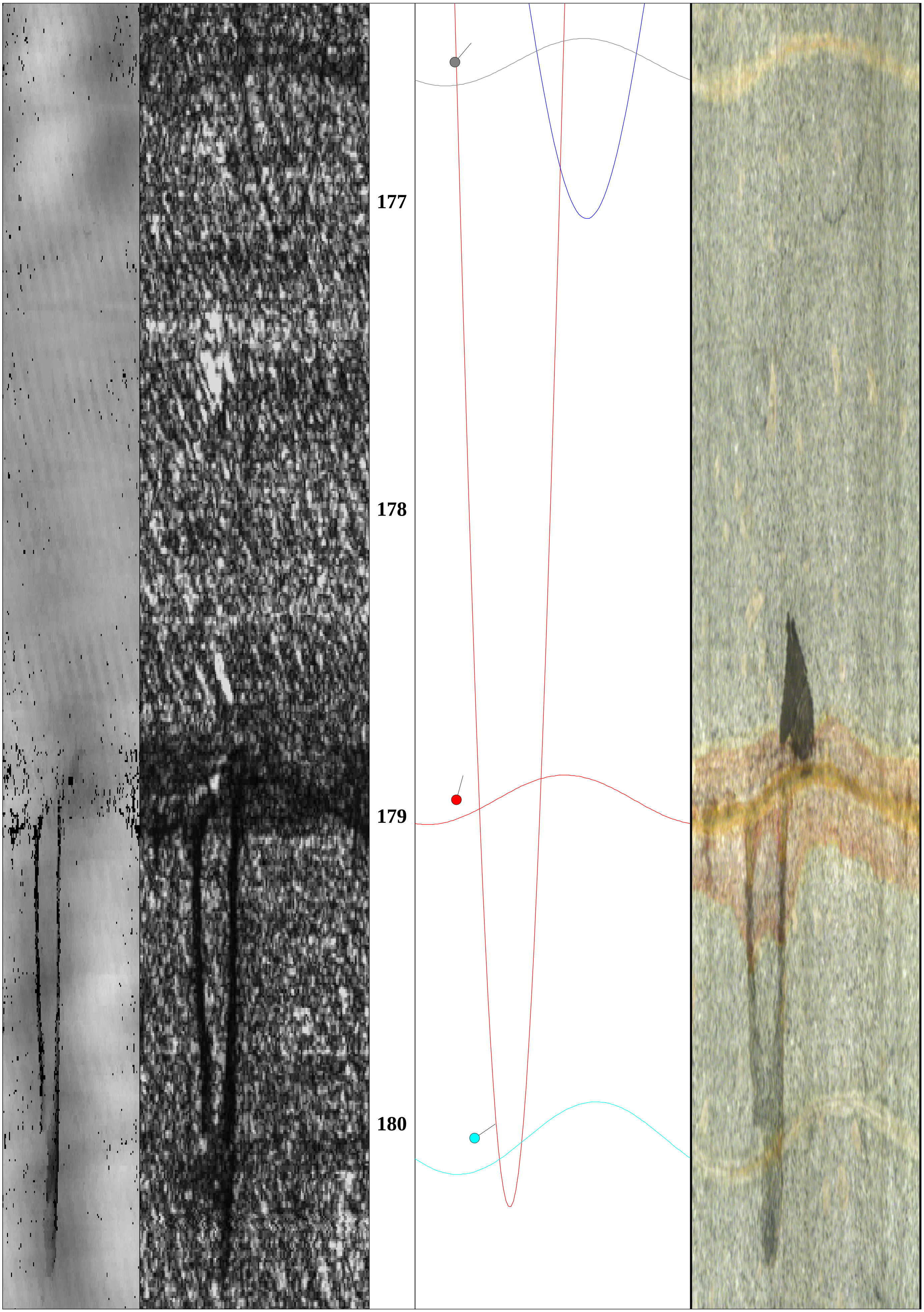

156
157
158
159

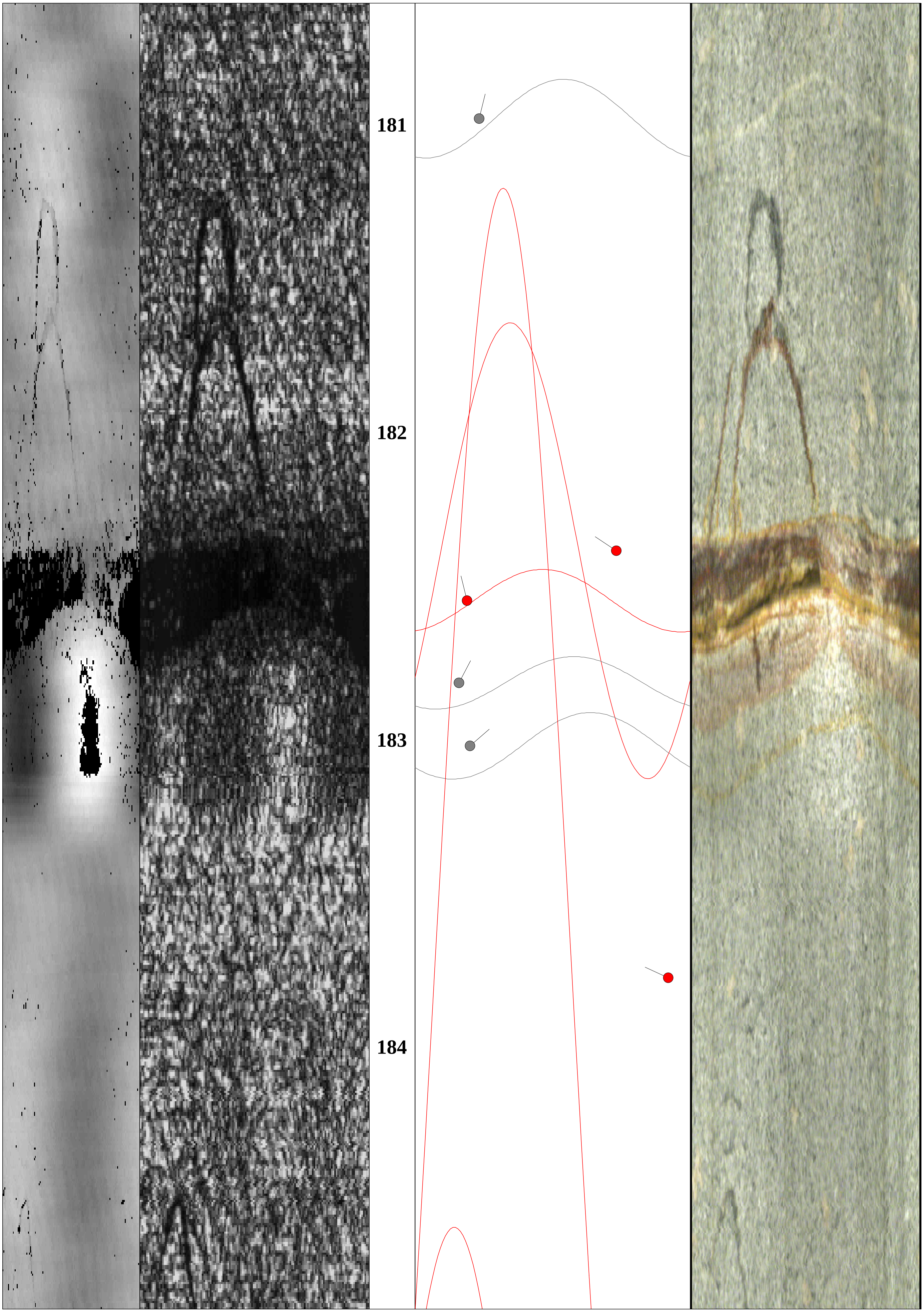

160
161
162
163

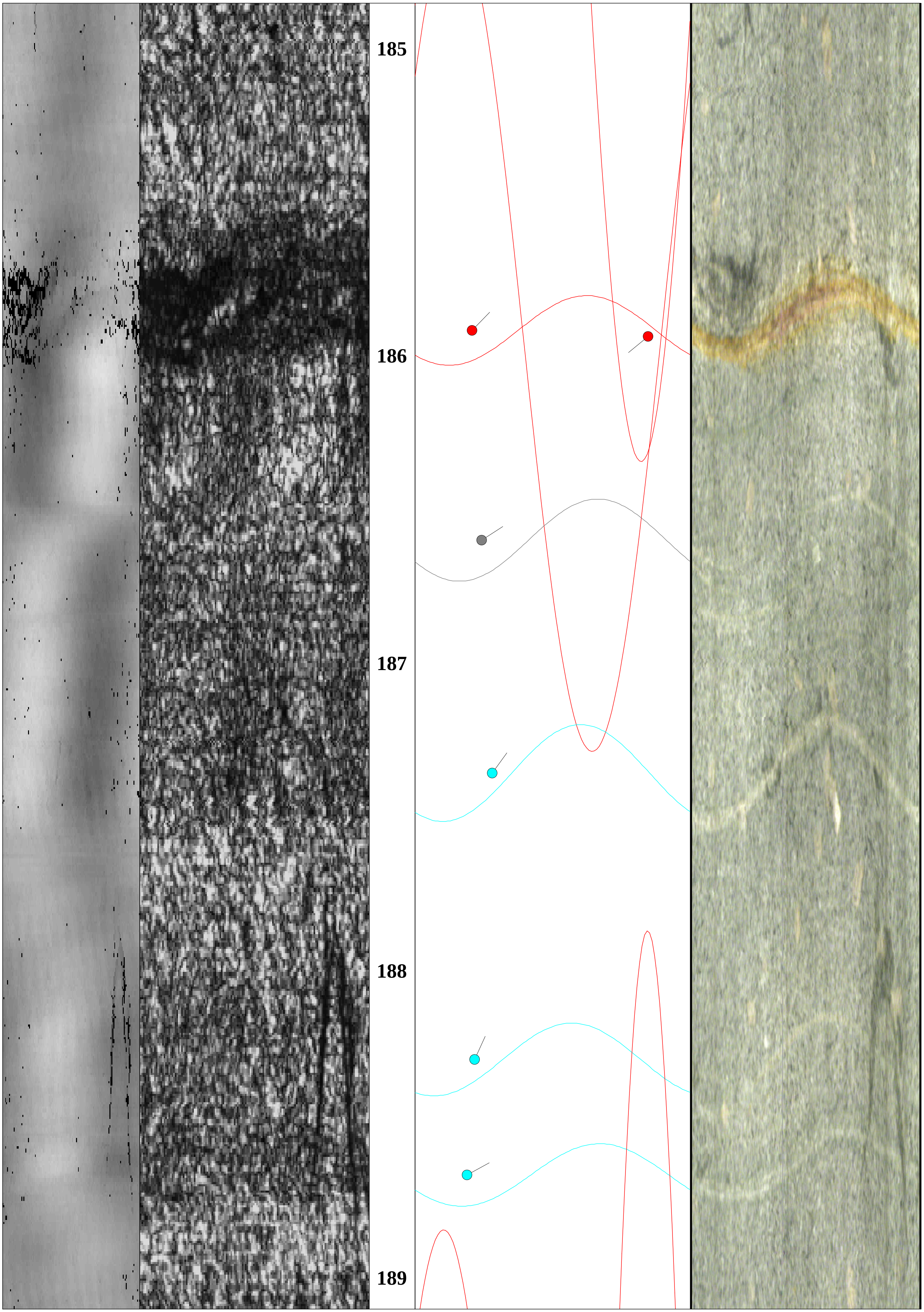

164
165
166
167

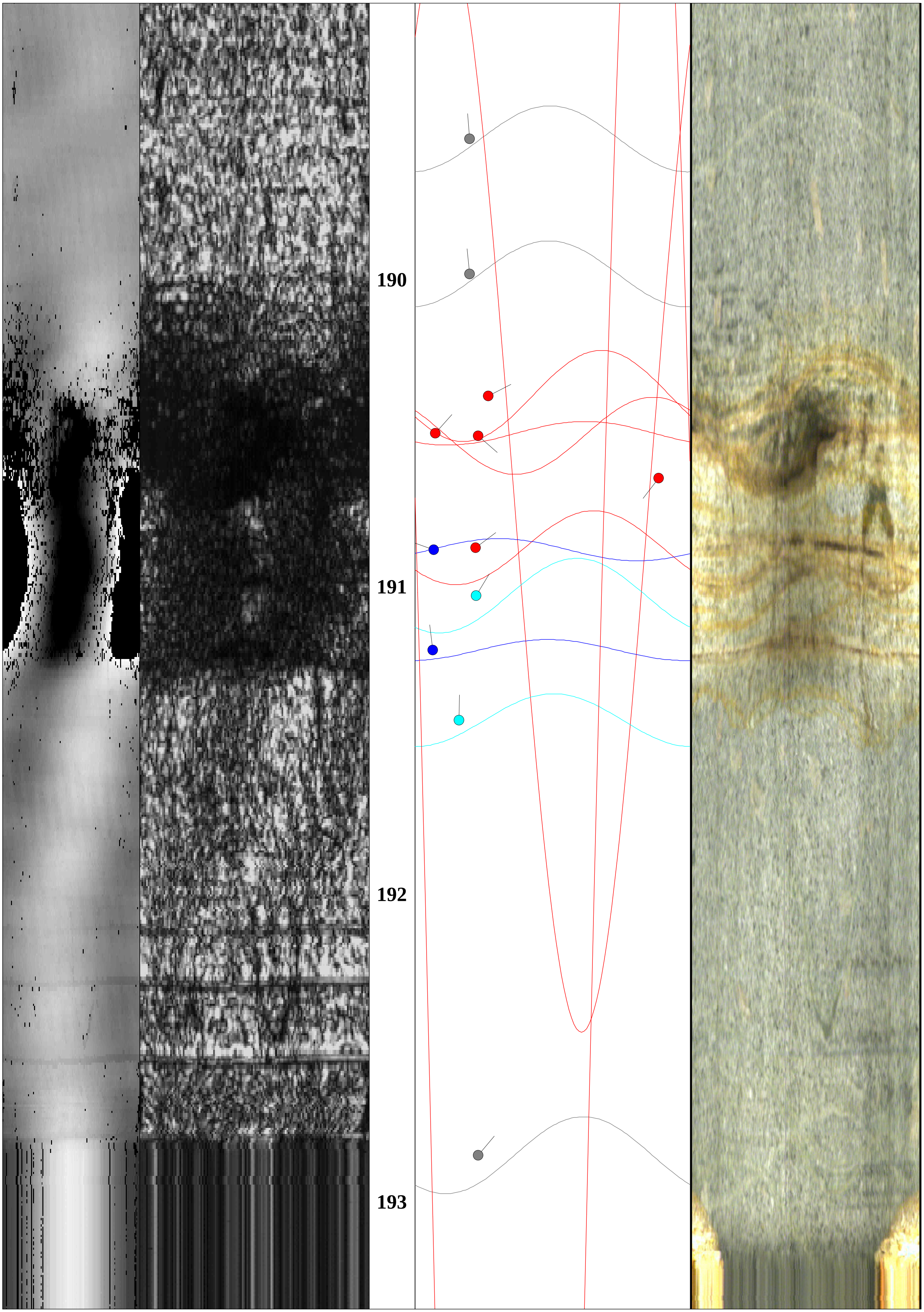

168
169
170
171
172

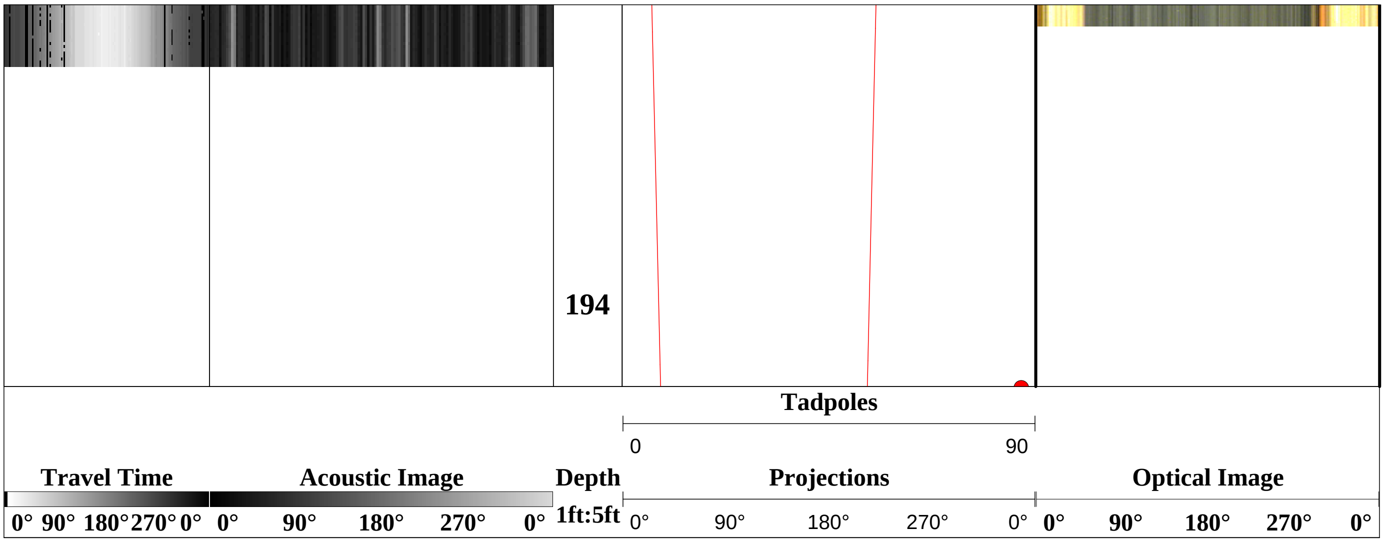

173
174
175
176


177
178
179
180

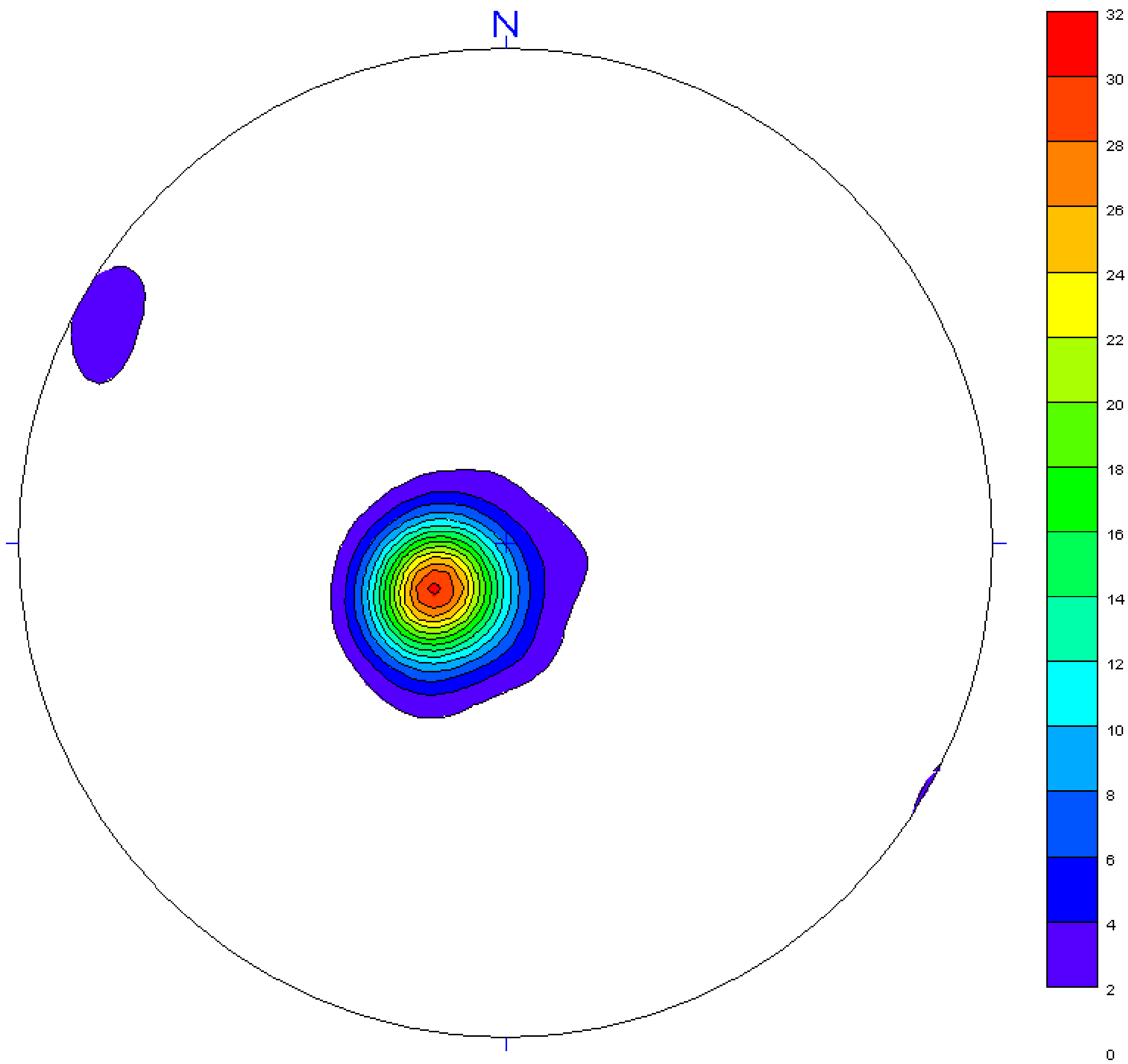

181
182
183
184


185
186
187
188
189


190
191
192
193

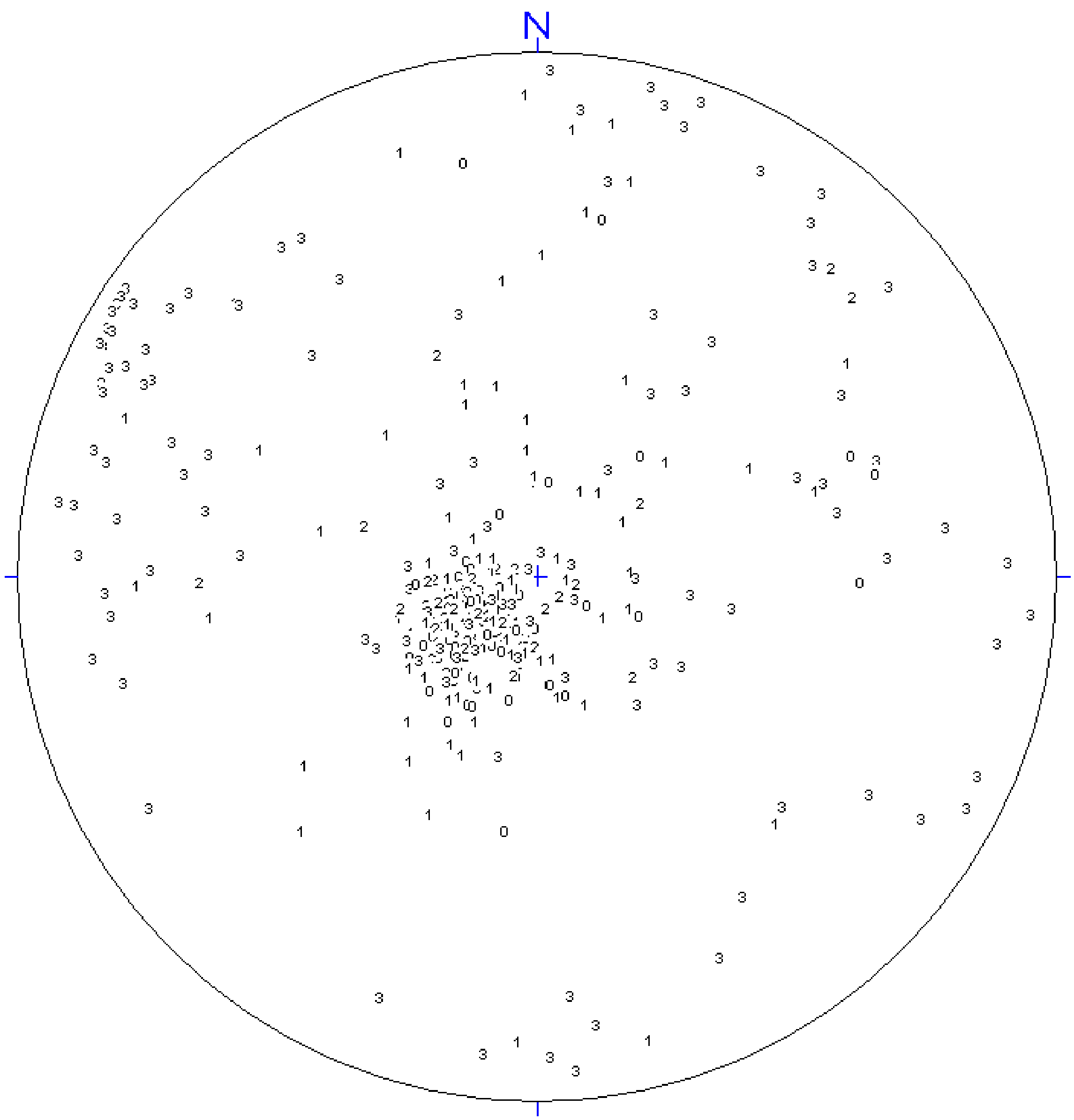

194
Tadpoles
0
90
Travel Time
Acoustic Image
Depth
Projections
Optical Image
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°
1ft:5ft
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n5
NNSA/NSO
21 Sept 2010



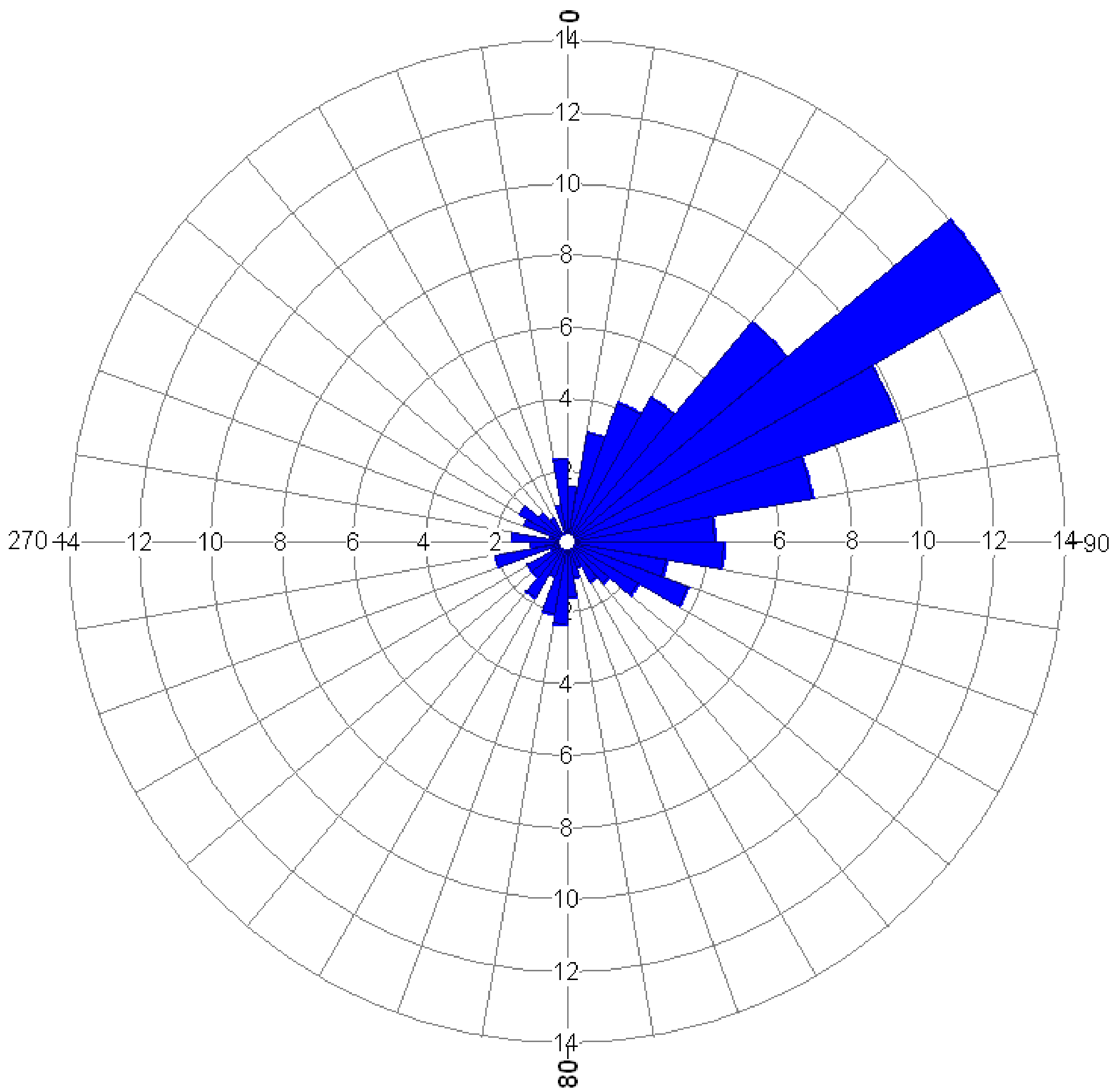
All directions are with respect to True North.

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n5
NNSA/NSO
21 Sept 2010



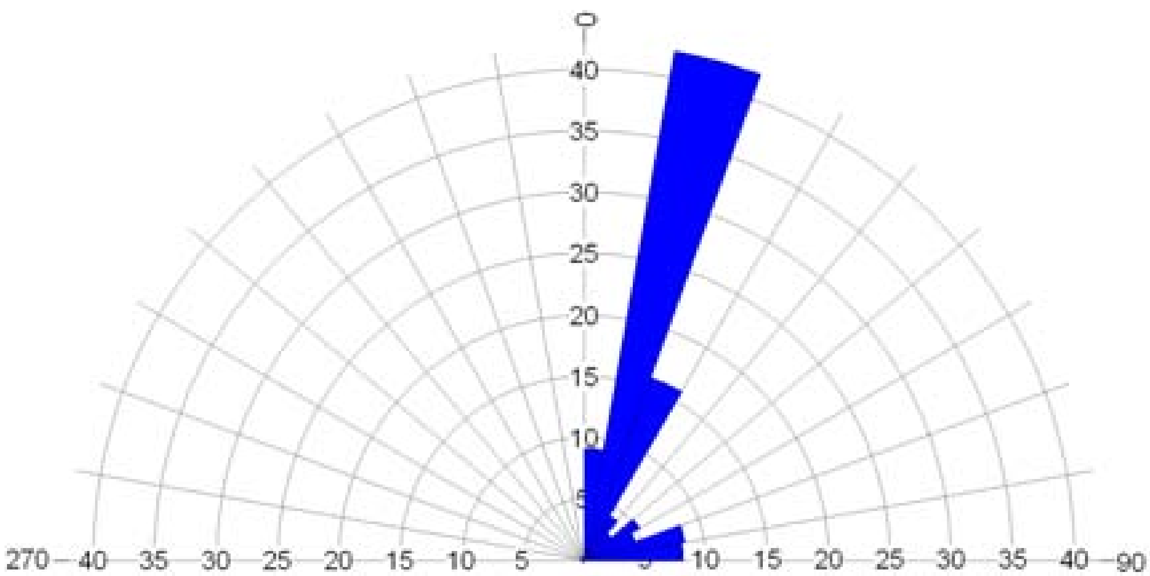
All directions are with respect to True North.

Rose Diagram – Dip Directions
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n5
NNSA/NSO
21 Sept 2010



All directions are with respect to True North.

Rose Diagram – Dip Angles
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n5
NNSA/NSO
21 Sept 2010



All directions are with respect to True North.

Full-Waveform Sonic

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Company NNSA/NSO
Well U-15N#5
Field NNSS
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15N#5
FIELD Nevada National Security Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900082.65
E: 676706.35

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Dual-Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5001.27

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

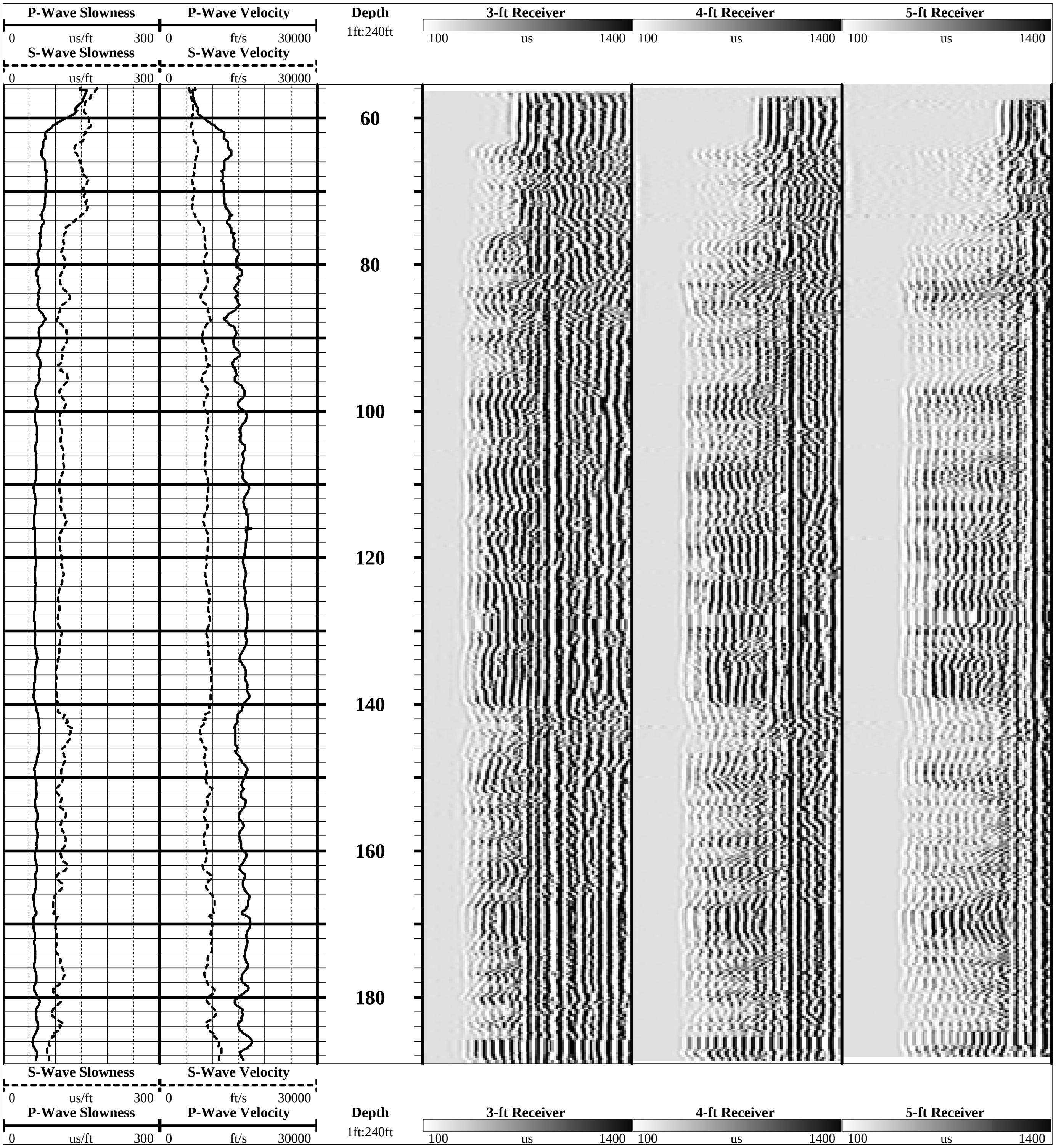
DRILLING MEAS. FROM G.L.

DATE ACQUIRED	22 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Full Waveform Sonic			
DEPTH-DRILLER	192'			
DEPTH-LOGGER	192.8'			
BTM LOG INTERVAL	192.8'			
TOP LOG INTERVAL	59.9'			
RECORDED BY	A. Caster			
WITNESSED BY	C.Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	5 ft/min			
A.S.D.E.	0.1'			
SAMPLE INTERVAL	0.1'			

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	10'	10"		-1.0'	9.5'
2	8"	10'	192'				

COMMENTS

NA - Not Available, N/A - Not Applicable


P-Wave Slowness
0 us/ft 300
S-Wave Slowness
0 us/ft 300
P-Wave Velocity
0 ft/s 30000
S-Wave Velocity
0 ft/s 30000
Depth
1ft:240ft
3-ft Receiver
100 us 1400
4-ft Receiver
100 us 1400
5-ft Receiver
100 us 1400
60
80
100
120
140
160
180
S-Wave Slowness
0 us/ft 300
P-Wave Slowness
0 us/ft 300
S-Wave Velocity
0 ft/s 30000
P-Wave Velocity
0 ft/s 30000
Depth
1ft:240ft
3-ft Receiver
100 us 1400
4-ft Receiver
100 us 1400
5-ft Receiver
100 us 1400

Borehole Deviation

COLOG
Borehole Geophysics & Hydrophysics
A Division of Layne Christensen Company

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Company NNSA/NSO
Well U-15N#5
Field NNSS
County Nye
State Nevada

COMPANY NSSA/NSO
WELL U-15N#5
FIELD Nevada National Securities Site
COUNTY Nye **STATE** NV

LOCATION
Area 15 (L/O)
N: 900082.65
E: 6766706.35

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Optical Televiewer
Acoustic Televiewer
Dual Spaced Density
Caliper
Natural Gamma
Full Waveform Sonic
Video

PERMANENT DATUM Ground Level **ELEVATION** 5001.27

LOG MEAS. FROM Ground Level 0.0 ft **ABOVE PERMINANT DATUM**

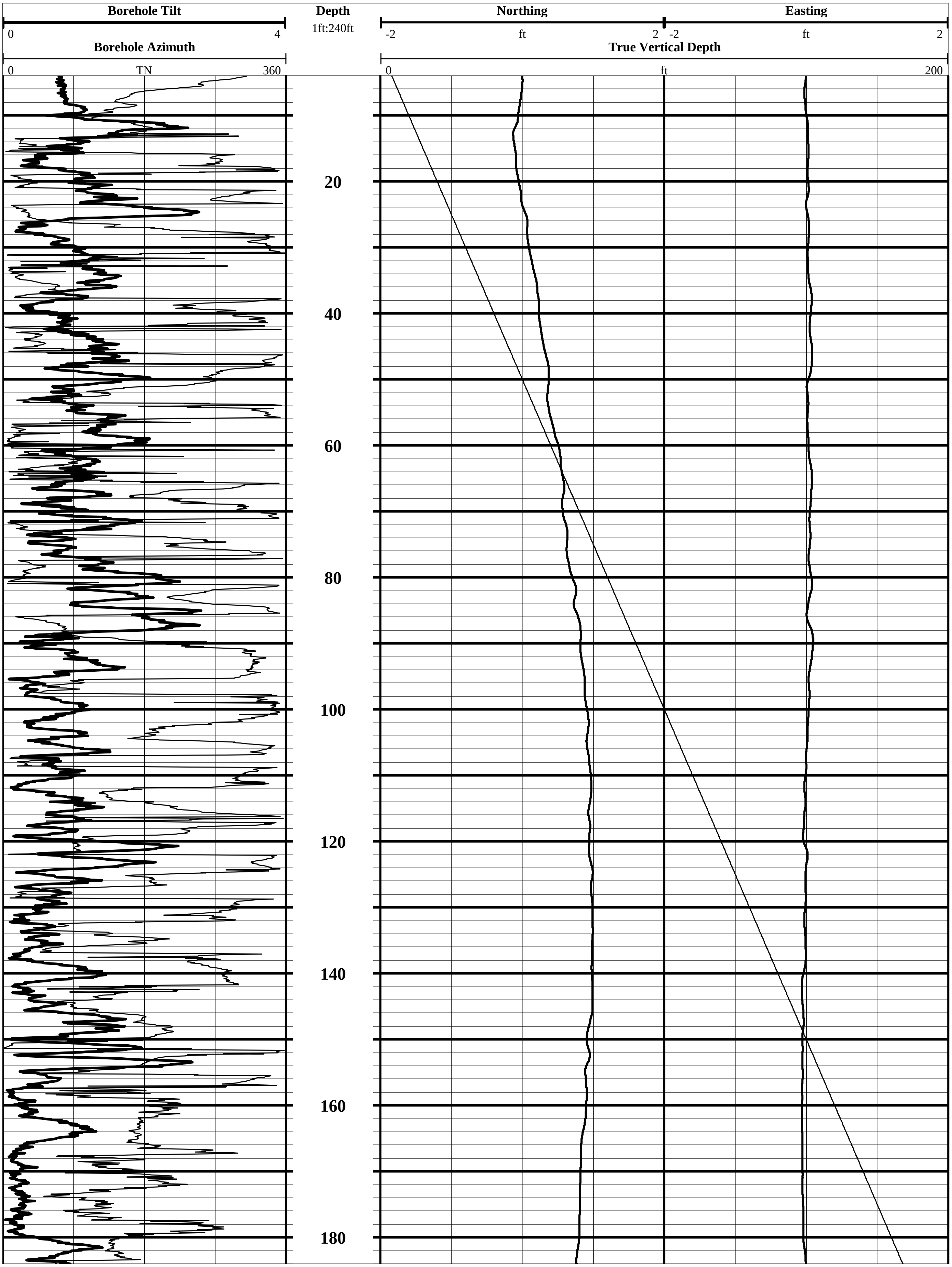
DRILLING MEAS. FROM

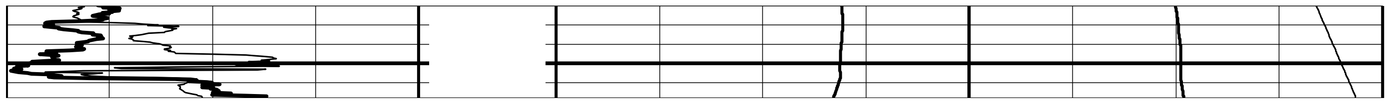
DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	TWO			
LOG TYPE	Borehole Deviation			
DEPTH-DRILLER	192'			
DEPTH-LOGGER	193'			
BTM LOG INTERVAL	193'			
TOP LOG INTERVAL	4			
RECORDED BY	E. Eaton			
WITNESSED BY	C. Obi			
PROBE TYPE, S/N	OBI40, 23902			
LOGGING SPEED	3.5 ft/min			
A.S.D.E.	0.60 ft			
SAMPLE INTERVAL	0.0041 ft			

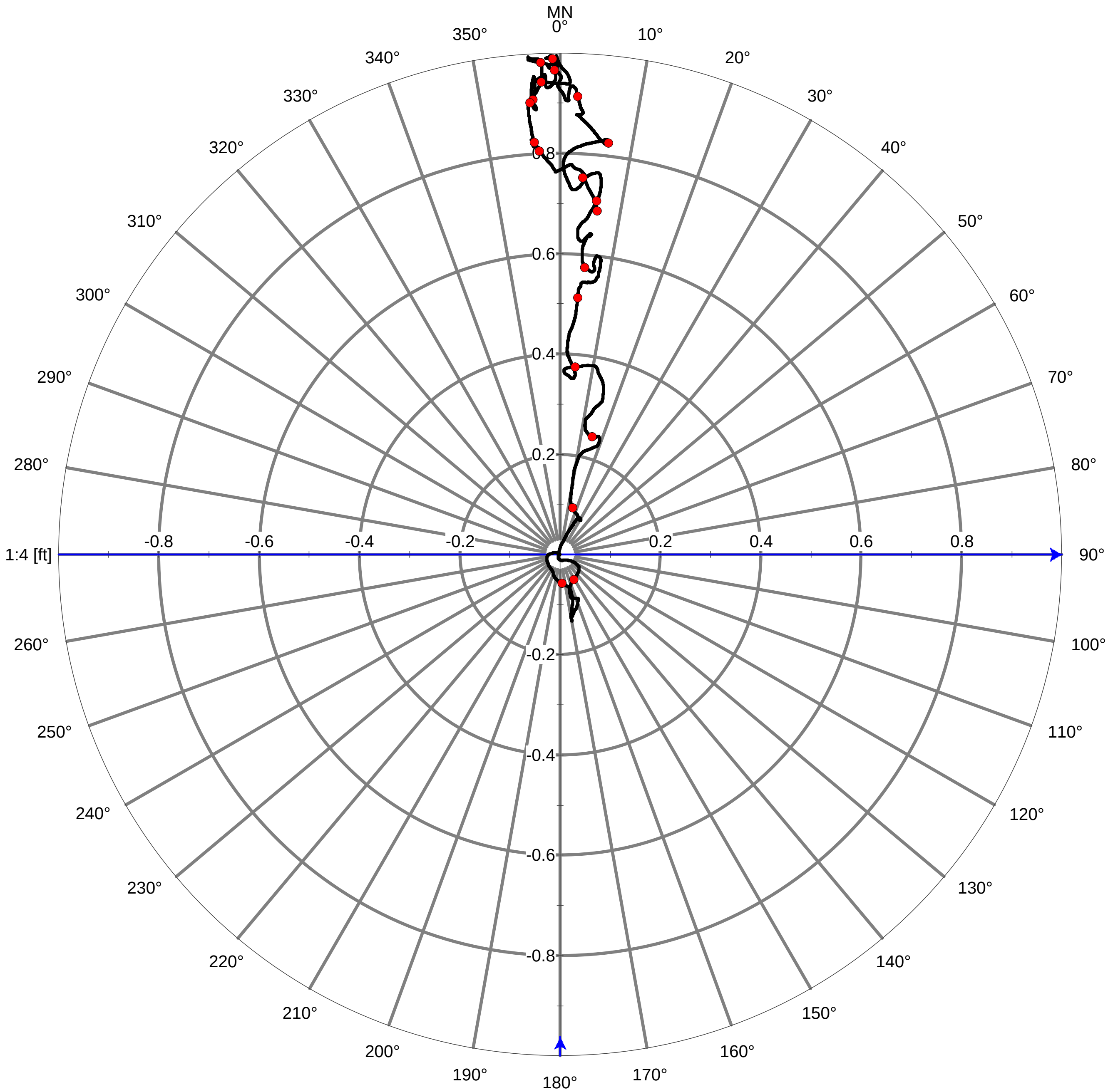
BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25"	Surface	10	10"		-1	9.5
	8"	10	192'				

COMMENTS

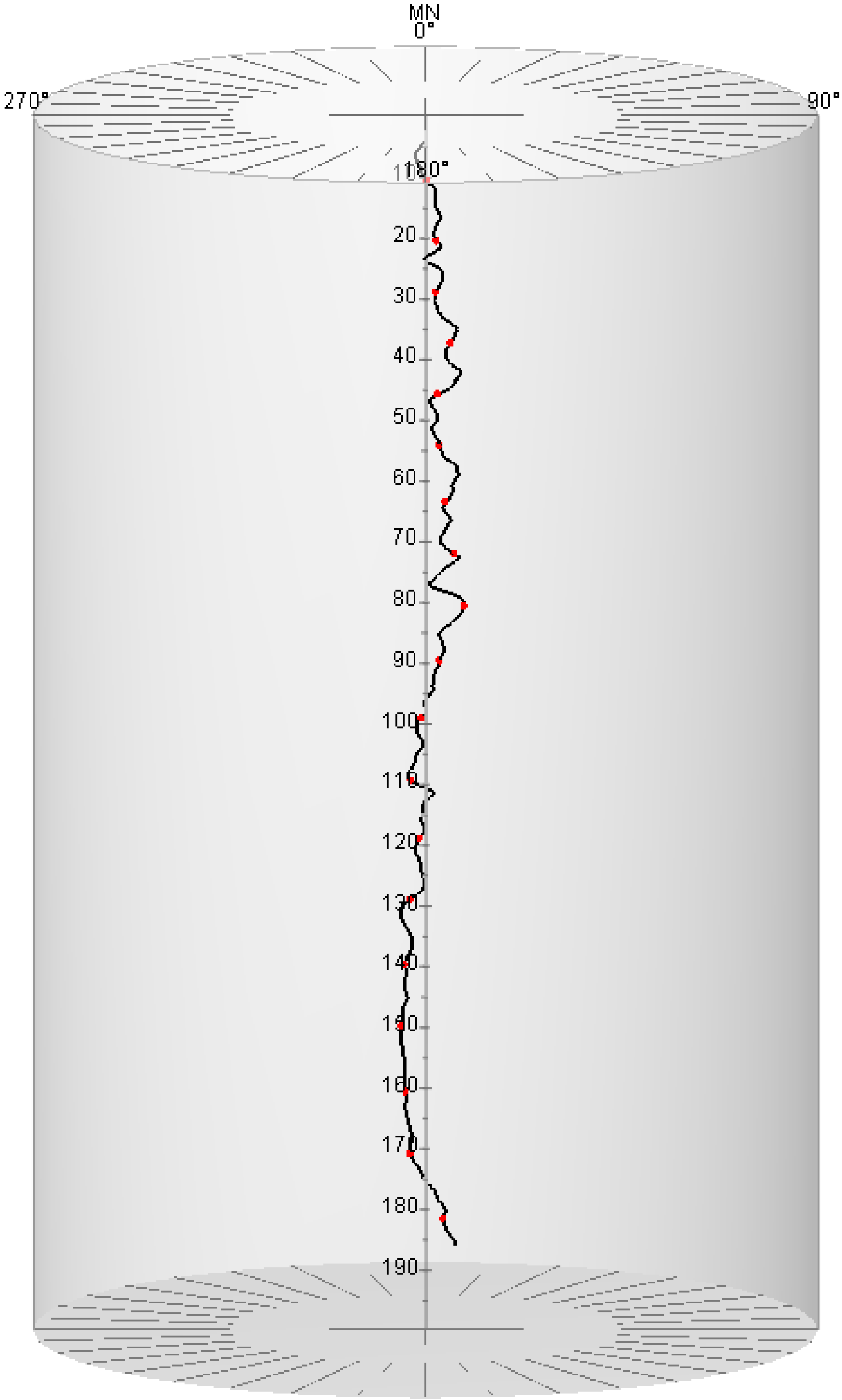
NA - Not Available, N/A - Not Applicable


Borehole Tilt
0
4
Borehole Azimuth
0
TN
360
Depth
1ft:240ft
20
40
60
80
100
120
140
160
180
Northing
-2
ft
2
Easting
-2
ft
2
True Vertical Depth
0
ft
200





MN
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
1:4 [ft]
-0.8
-0.6
-0.4
-0.2
0.2
0.4
0.6
0.8



MN
0°
270°
90°
180°
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

Appendix F-7

Borehole Geophysical Log Plots for Instrument Hole U-15n#6

Company NNSA/NSO
Well U-15N#6
Field NNSS
County Nye
State Nevada

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Far Density
Near Density
Natural Gamma Ray
Caliper

COMPANY	NNSA/NSO		
WELL	U-15N#6		
FIELD	Nevada National Security Site		
COUNTY	Nye	**STATE**	Nevada

LOCATION
Area 15 (L/O)
N: 900131.82
E: 676603.88

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Full-Wave Sonic
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5005.10

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM G.L.

DATE ACQUIRED	21 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Far Density	Near Density	Natural Gamma Ray	Caliper
DEPTH-DRILLER	190'			
DEPTH-LOGGER	188.5'			
BTM LOG INTERVAL	187.4'	187.7'	182.9'	186.4'
TOP LOG INTERVAL	7.4'	7.7'	2.9'	6.4'
RECORDED BY	A. Caster			
WITNESSED BY	C. Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	10 ft/min			
A.S.D.E.	0.0'			
SAMPLE INTERVAL	0.1'			

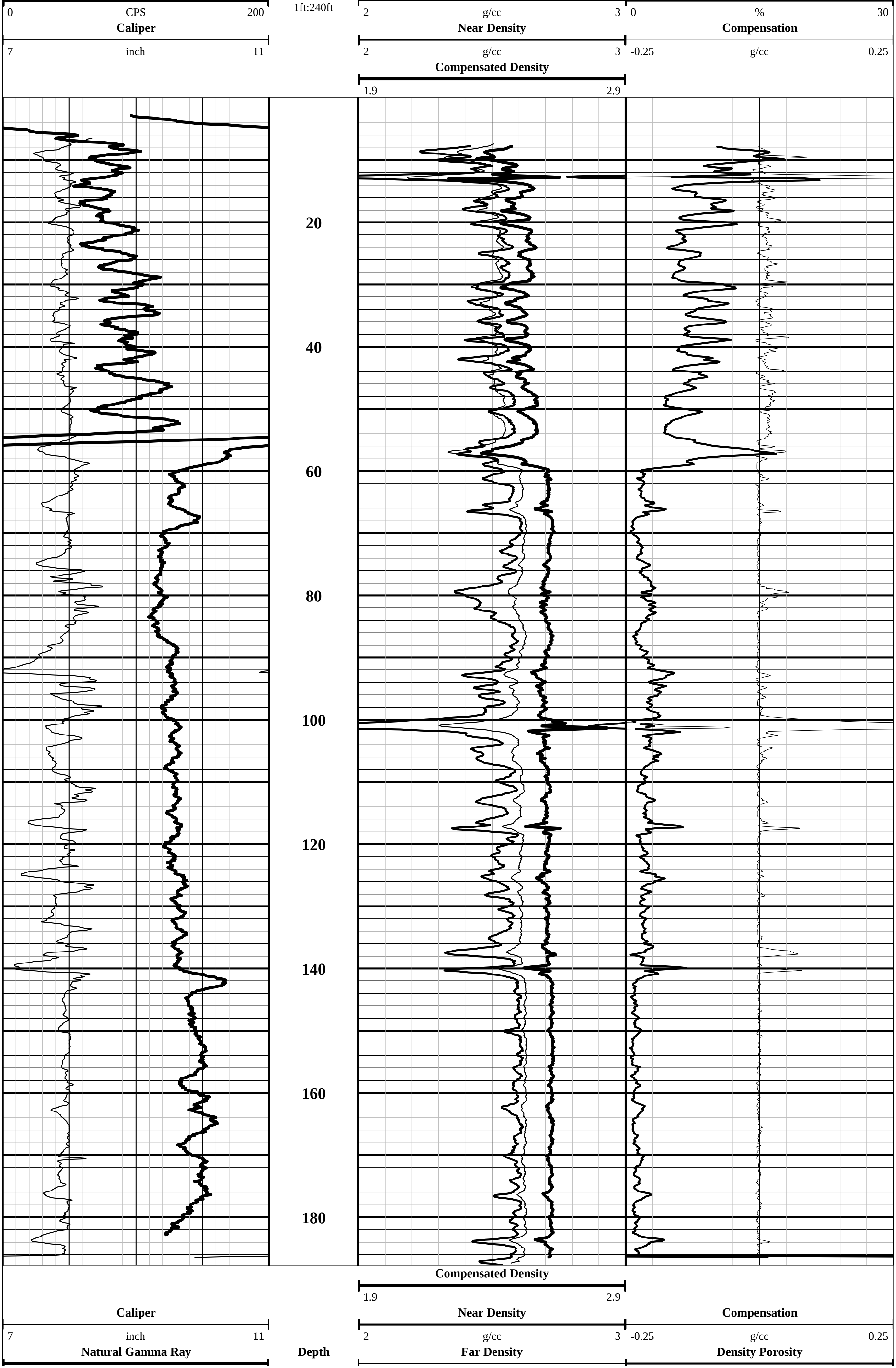
BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	7'	10"		-1.0'	6.5'
2	8"	7'	190'				

COMMENTS

NA - Not Available, N/A - Not Applicable

Matrix Density of 2.64 used to calculate Density Porosity

Natural Gamma Ray	Depth	Far Density	Density Porosity


0 CPS 200
Caliper
7 inch 11
1ft:240ft
2 g/cc 3
Near Density
2 g/cc 3
Compensated Density
1.9 2.9
0 % 30
Compensation
-0.25 g/cc 0.25
20
40
60
80
100
120
140
160
180
Compensated Density
1.9 2.9
Caliper
Near Density
Compensation
7 inch 11
Natural Gamma Ray
Depth
2 g/cc 3
Far Density
-0.25 g/cc 0.25
Density Porosity

0 CPS 200	1ft:240ft	2 g/cc 3	0 % 30

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Acoustic Televiewer
Optical Televiewer

Company	NNSA/NSO
Well	U-15N#6
Field	Nevada Test Site
County	Nye
State	Nevada

COMPANY NNSA/NSO
WELL U-15N#6
FIELD Nevada Test Site
COUNTY Nye **STATE** Nevada

LOCATION
Area 15 (L/O)
N: 900131.82
E: 676603.88

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Dual Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5005.10

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

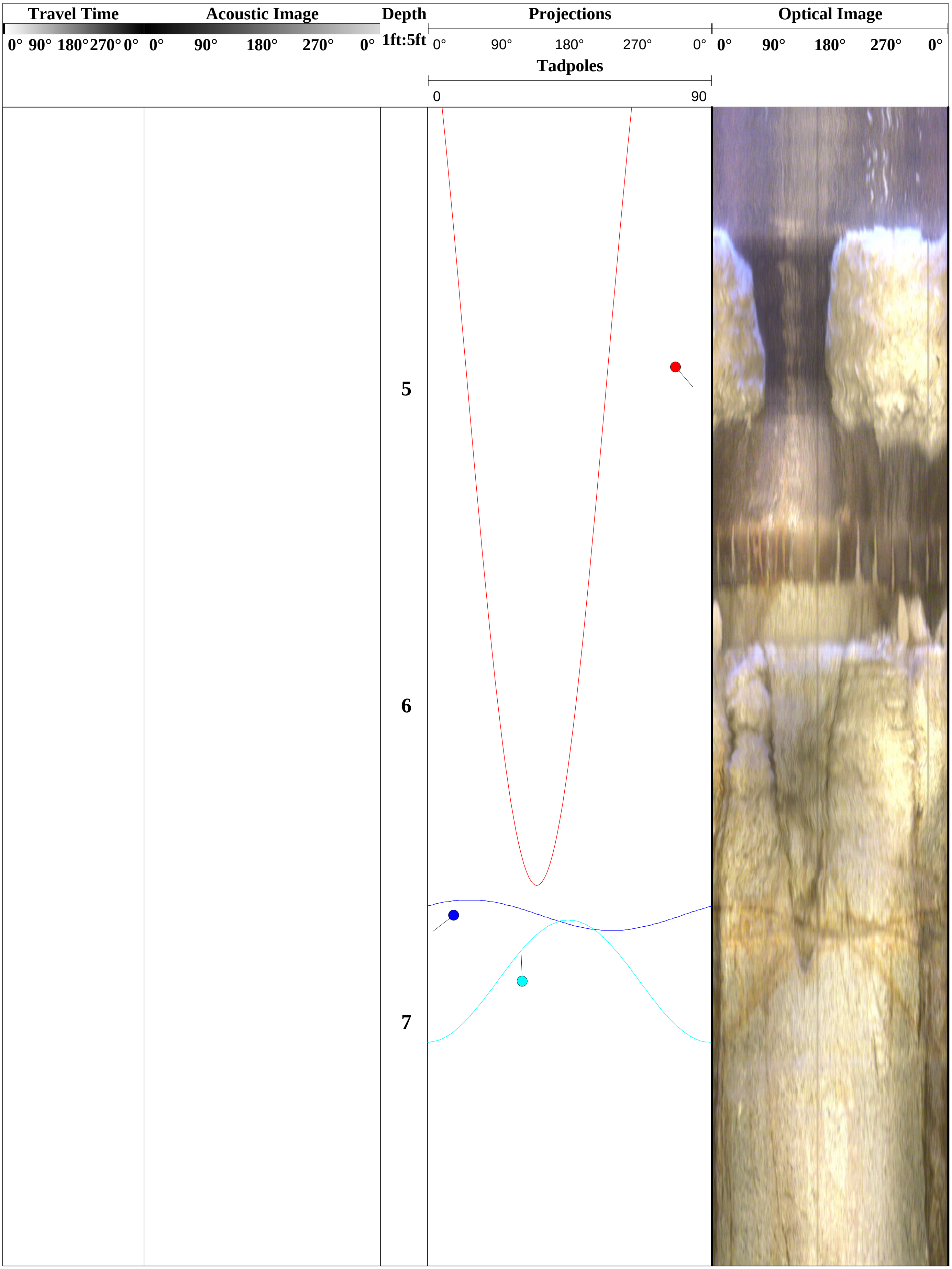
DRILLING MEAS. FROM

DATE ACQUIRED	20 Sept 2010	20 Sept 2010		
RUN NUMBER	THREE	ONE		
LOG TYPE	ABI	OBI		
DEPTH-DRILLER	190	190		
DEPTH-LOGGER	189	189		
BTM LOG INTERVAL	189	189		
TOP LOG INTERVAL	61	61		
RECORDED BY	E Eaton	E Eaton		
WITNESSED BY	C Obi	G Juniel		
PROBE TYPE, S/N	ABI-062695	OBI-023902		
LOGGING SPEED	5.5 ft/min	3.5 ft/min		
A.S.D.E.	0.46 ft	0.47 ft		
SAMPLE INTERVAL	0.16 ft	0.0041 ft		

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25"	Surface	7	10"		-1	6.5
	8"	10					

COMMENTS

NA - Not Available, N/A - Not Applicable


Travel Time
0° 90° 180° 270° 0°
Acoustic Image
0° 90° 180° 270° 0°
Depth
1ft:5ft
Projections
0° 90° 180° 270° 0°
Tadpoles
0 90
Optical Image
0° 90° 180° 270° 0°
5
6
7

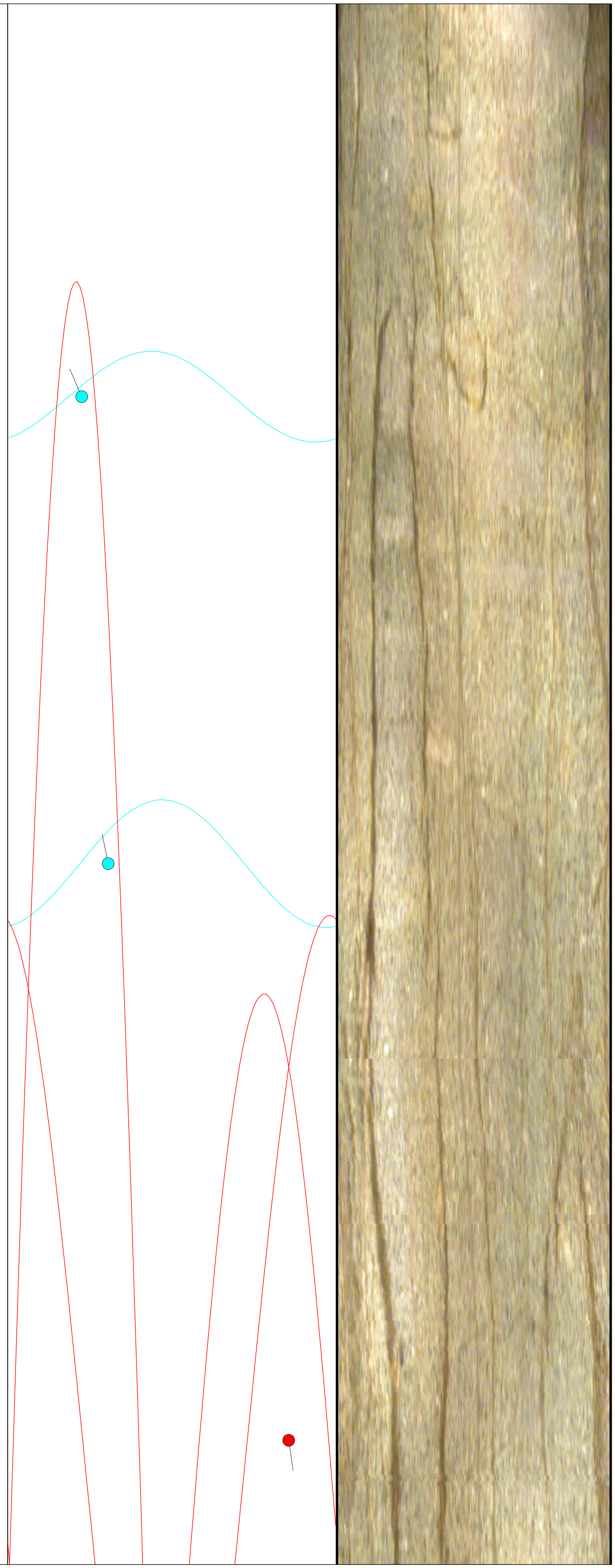
8

9

10

11

12

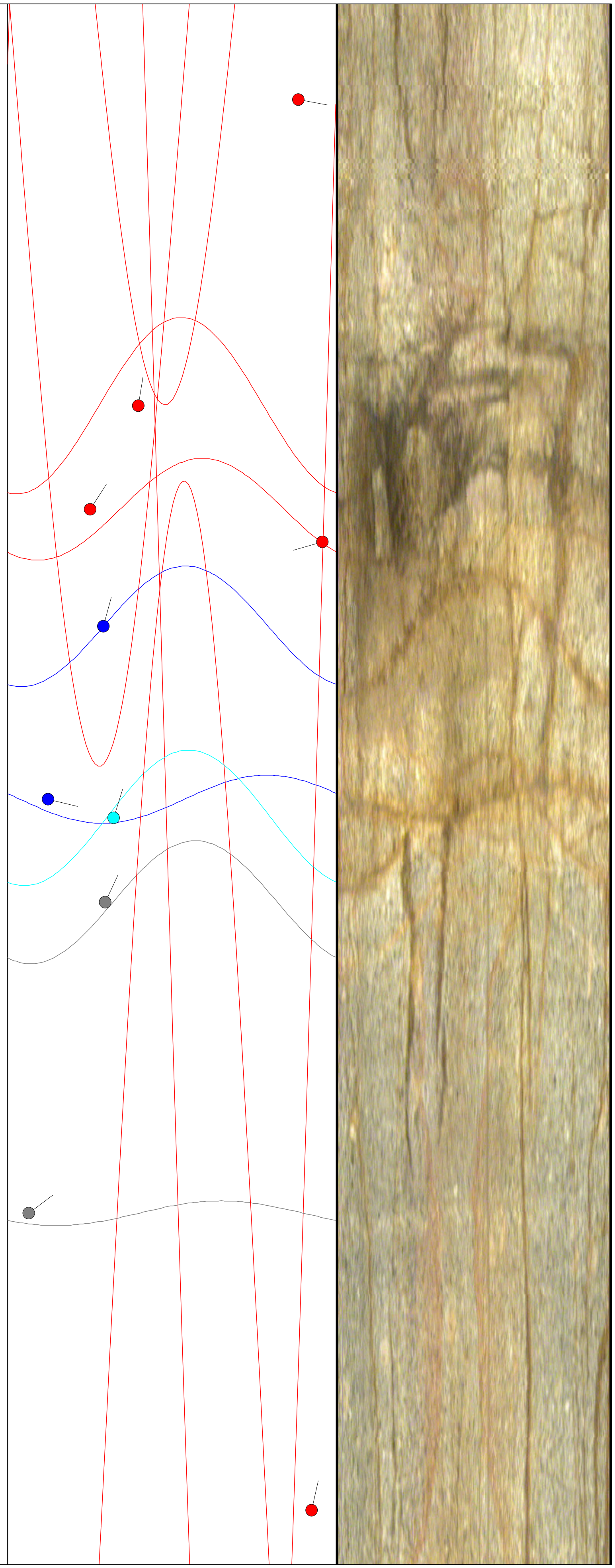


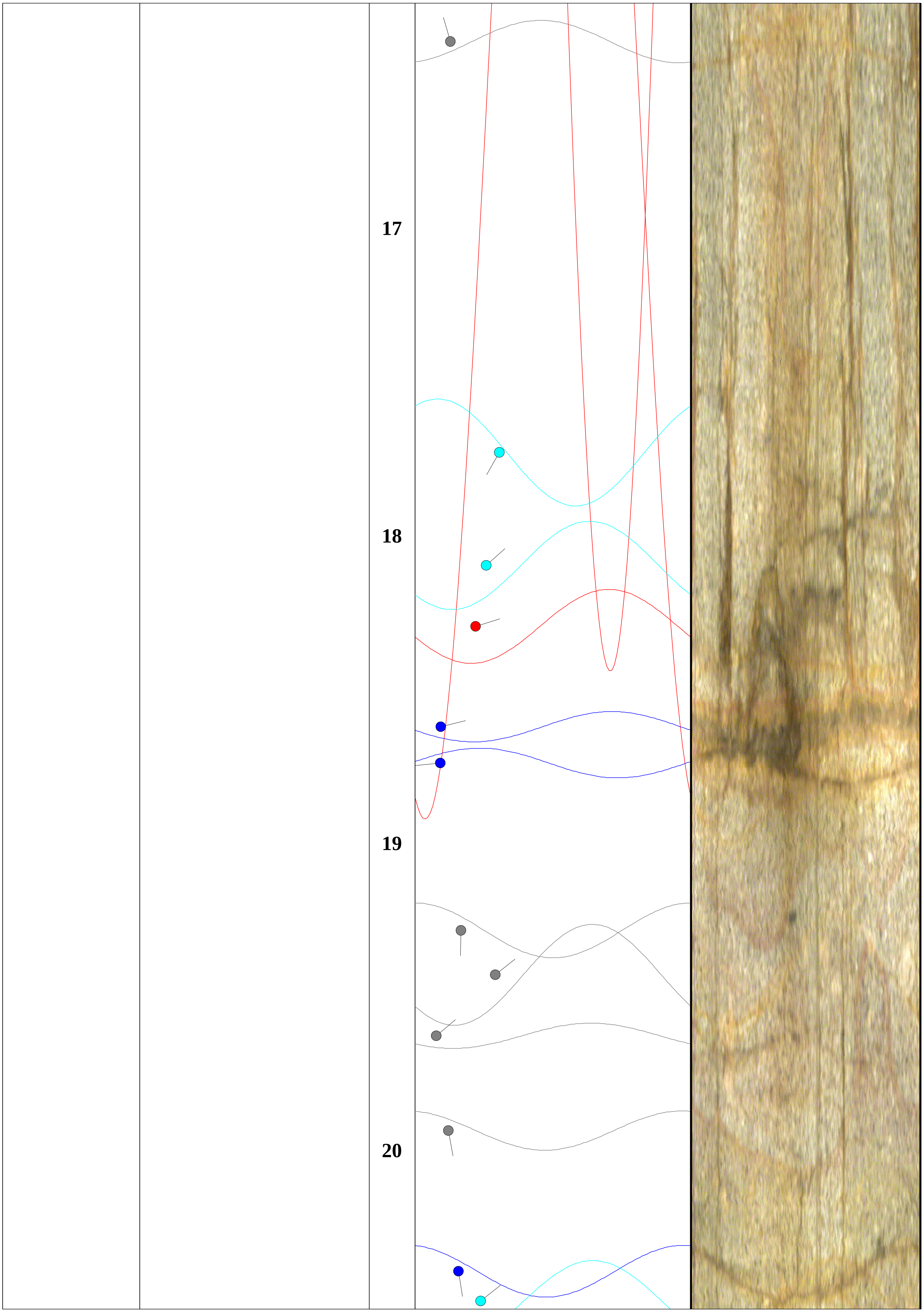
13

14

15

16



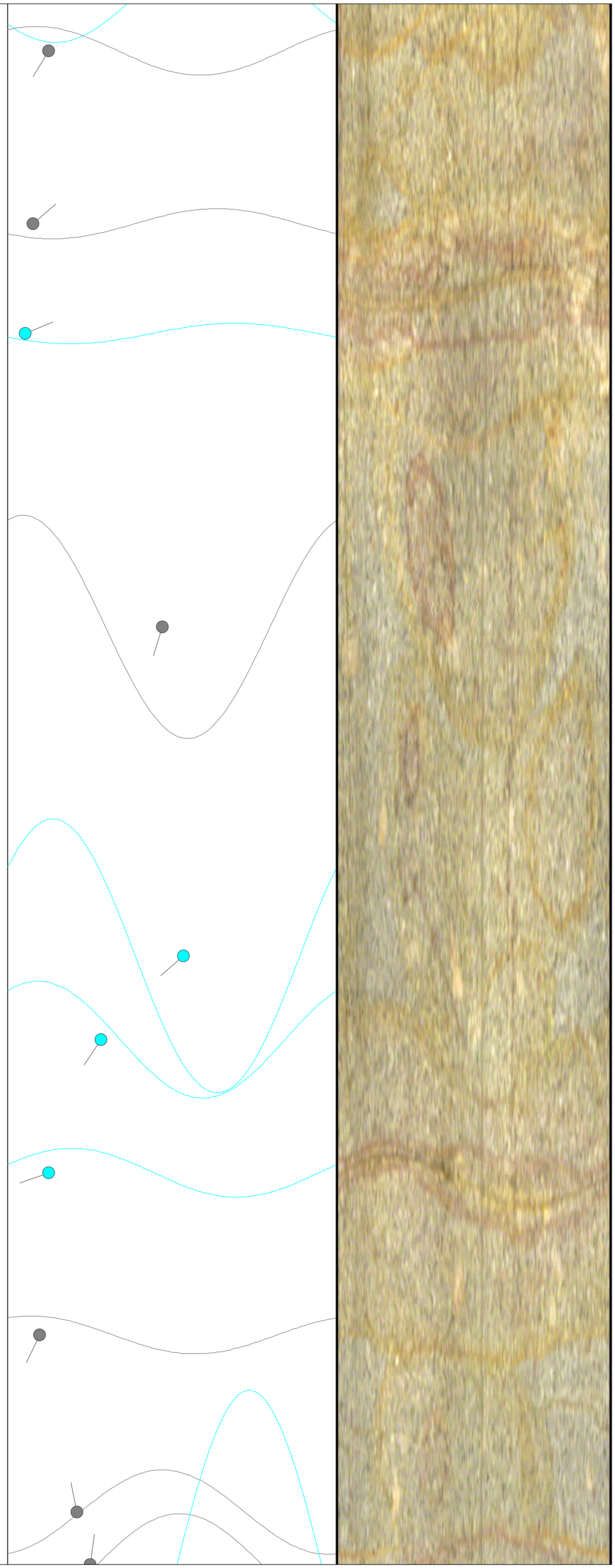

17
18
19
20

21

22

23

24



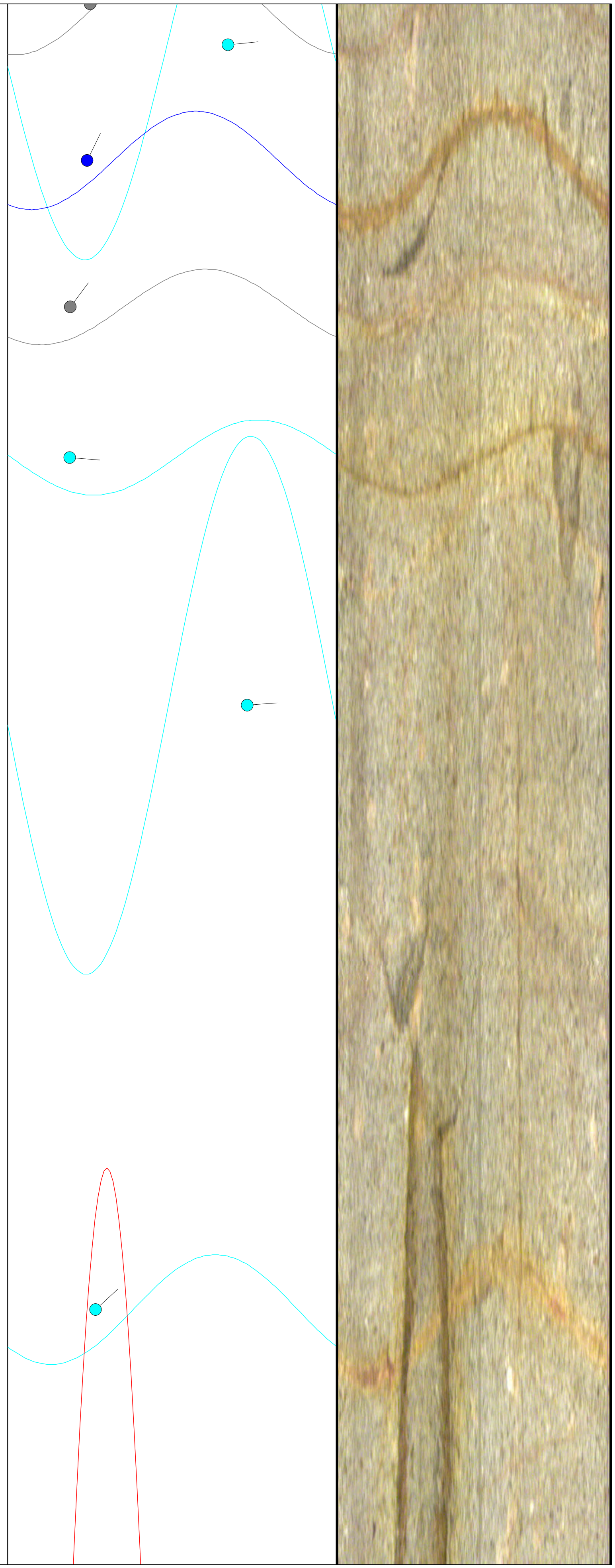
25

26

27

28

29

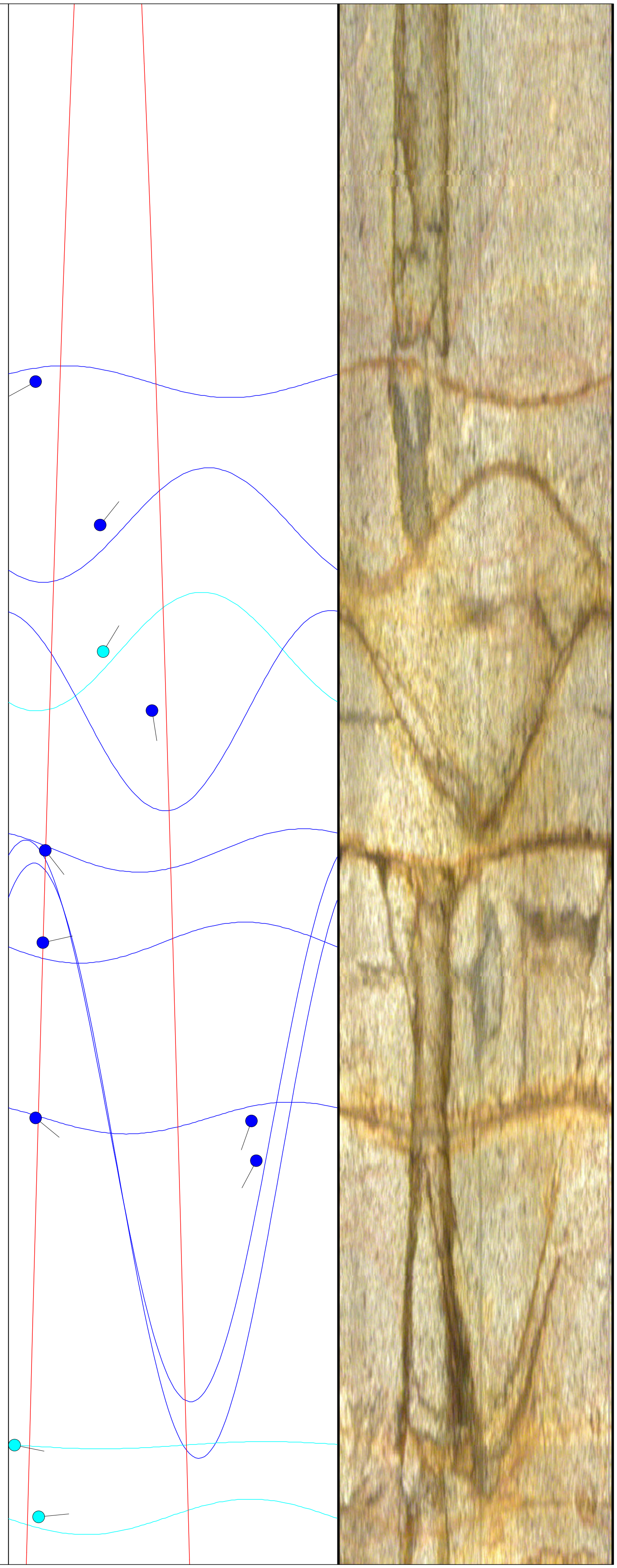


30

31

32

33

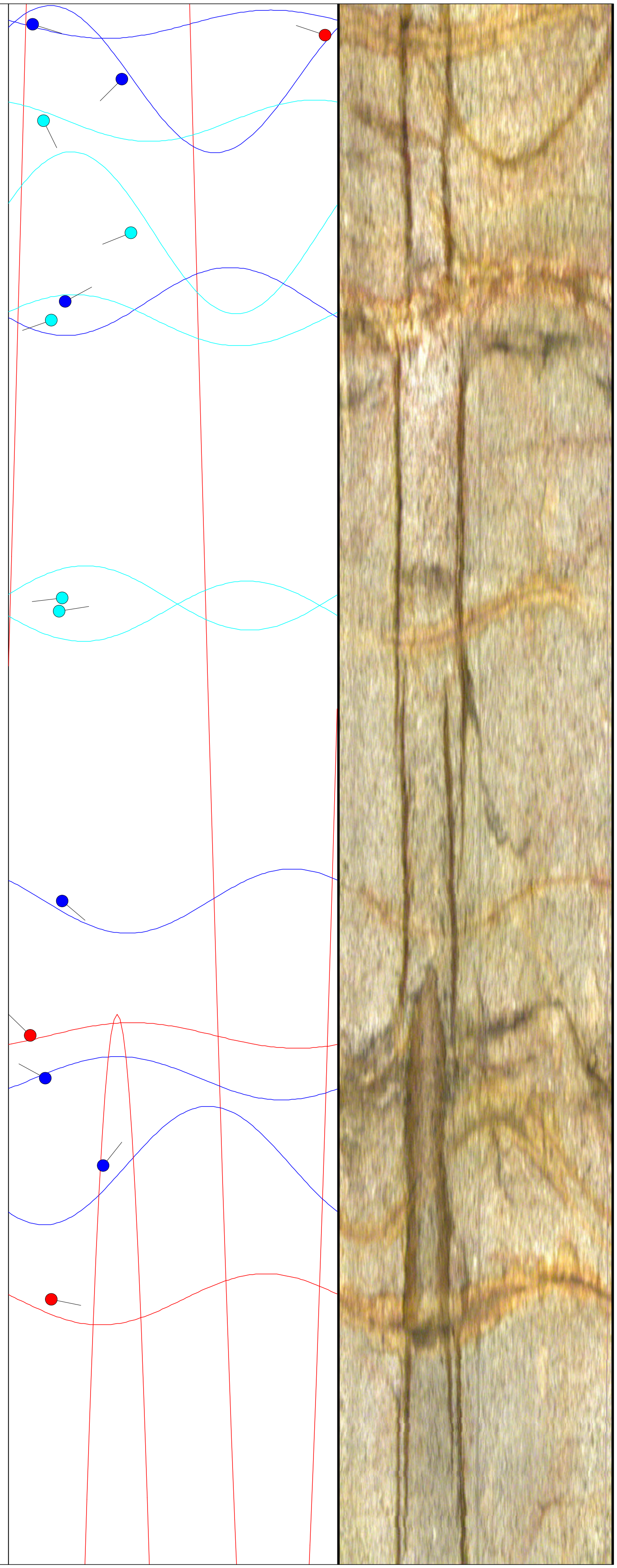


34

35

36

37

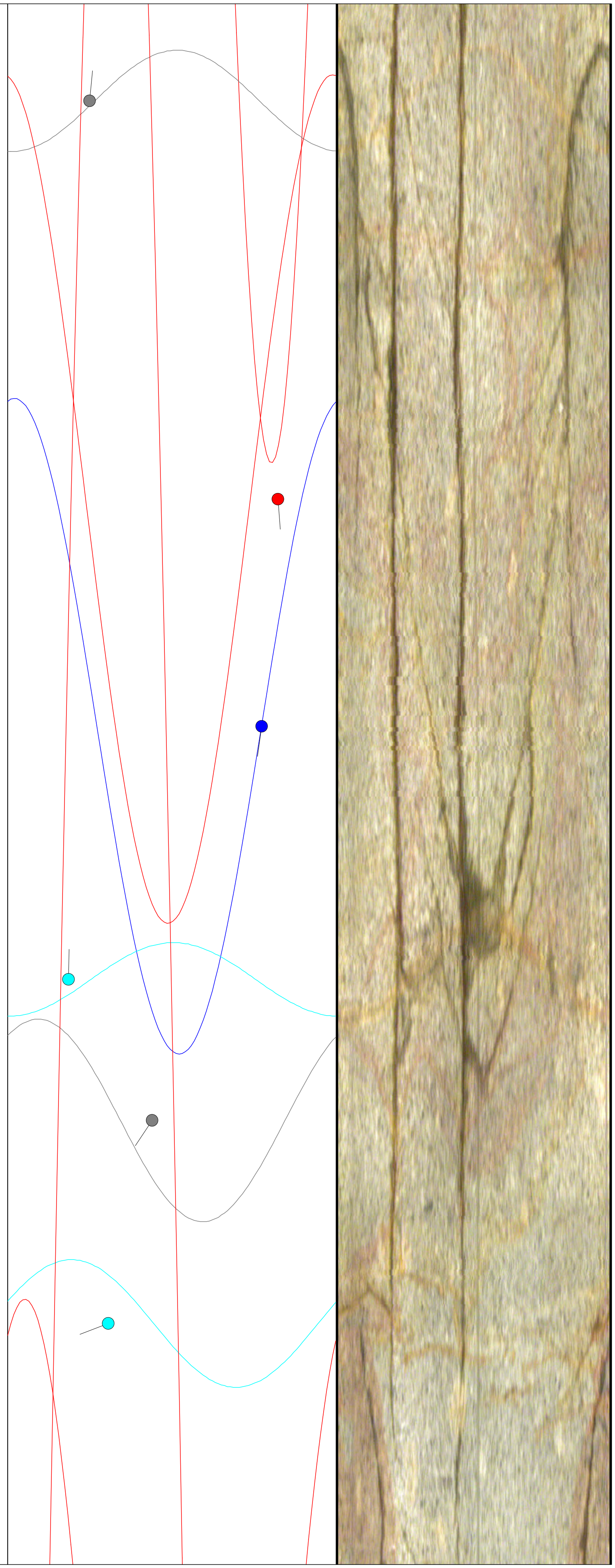


38

39

40

41



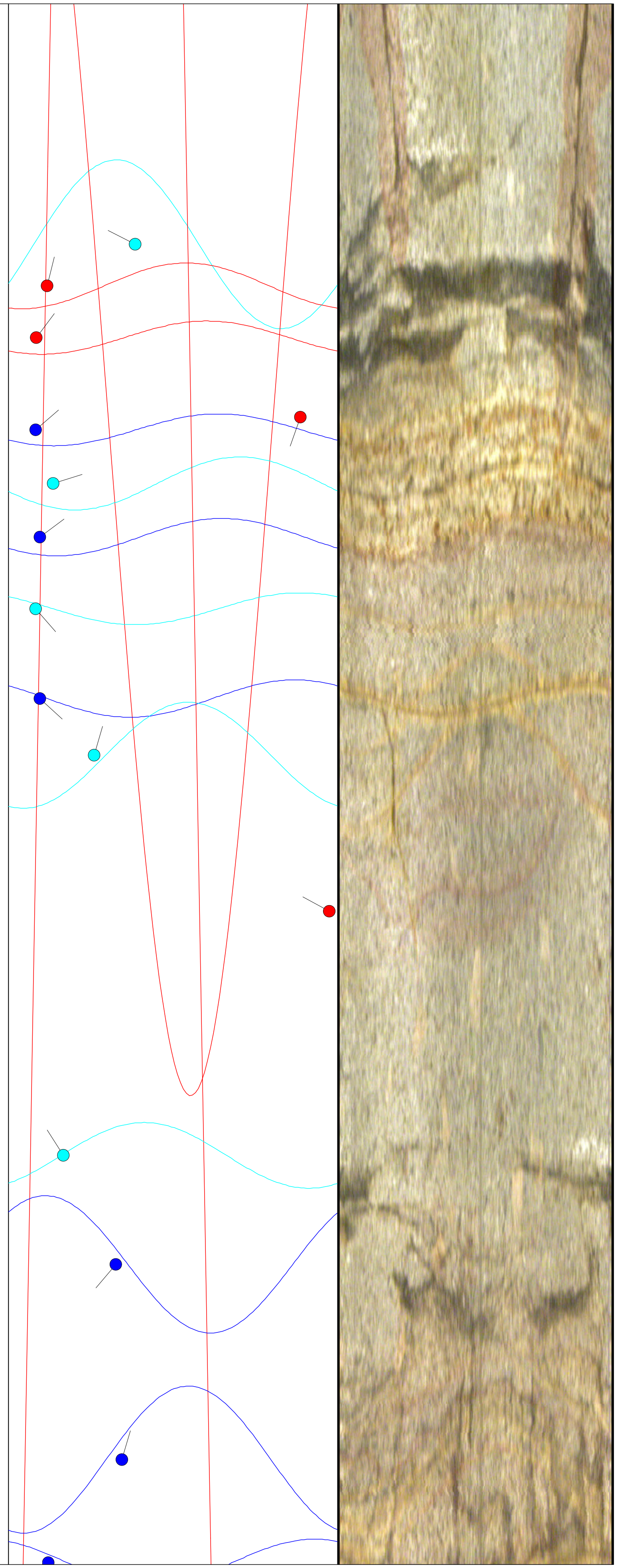
42

43

44

45

46

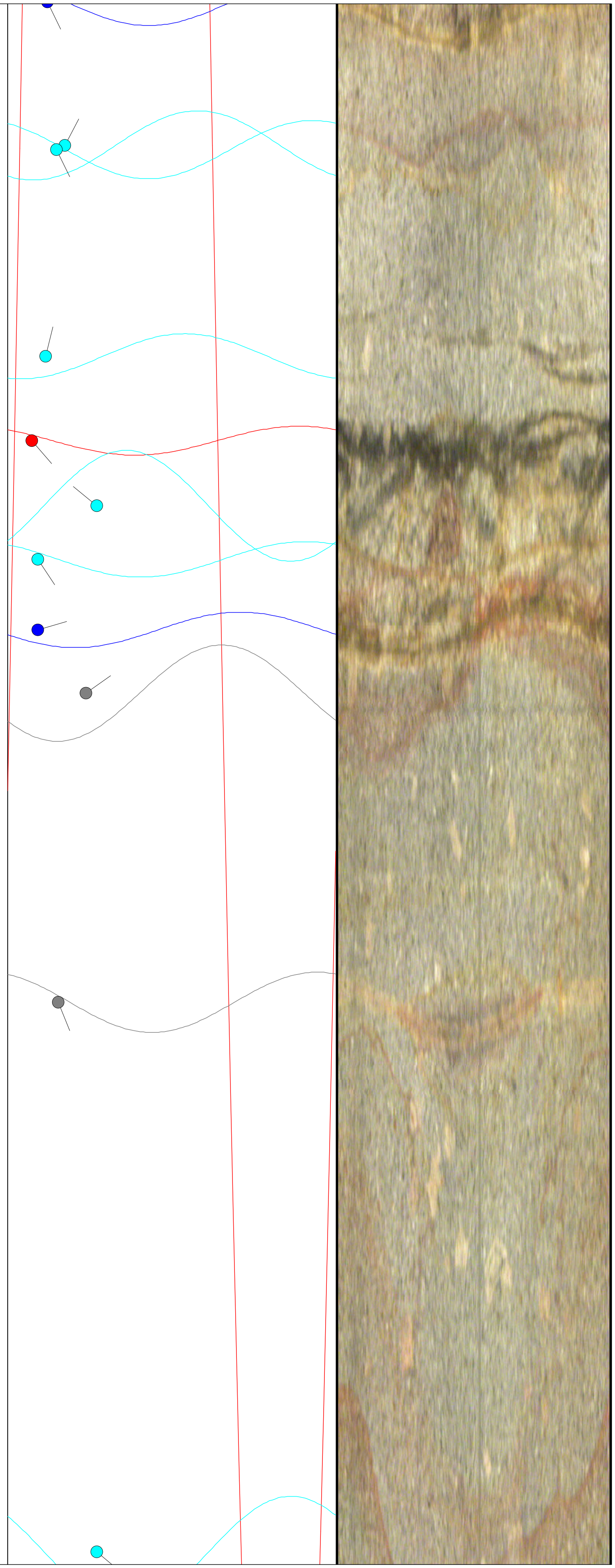


47

48

49

50

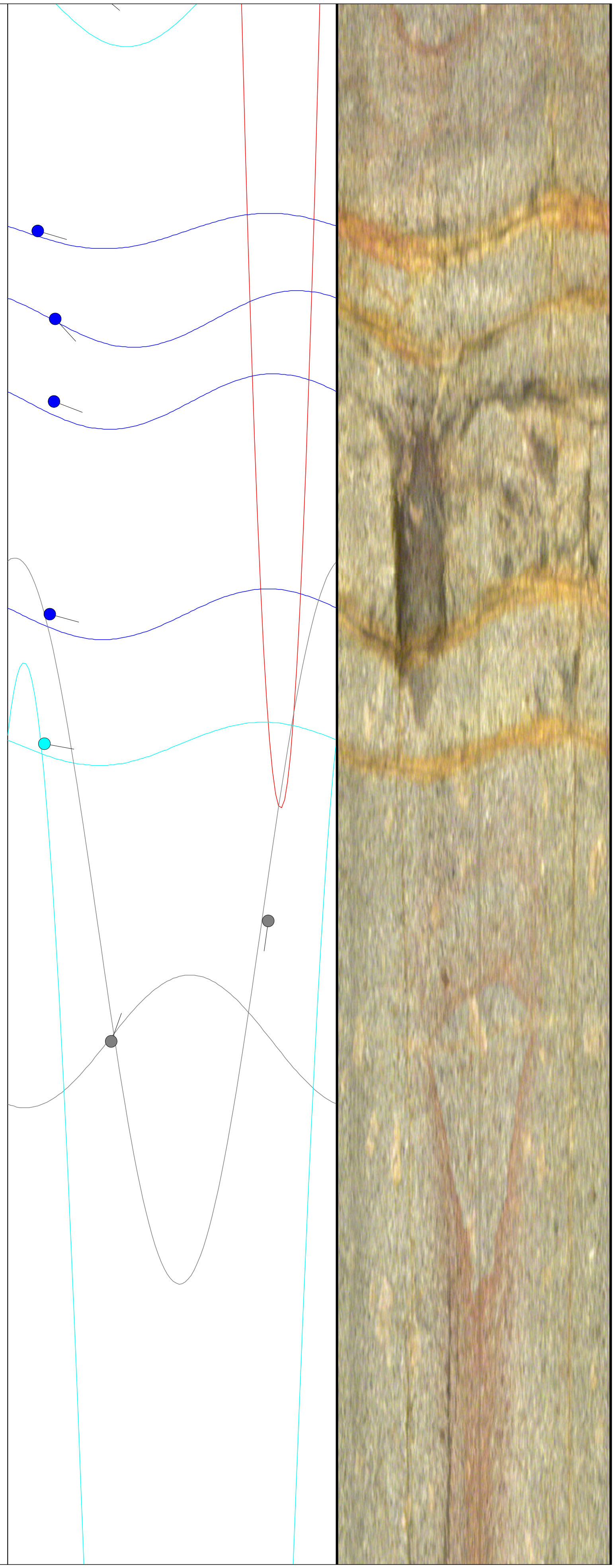


51

52

53

54

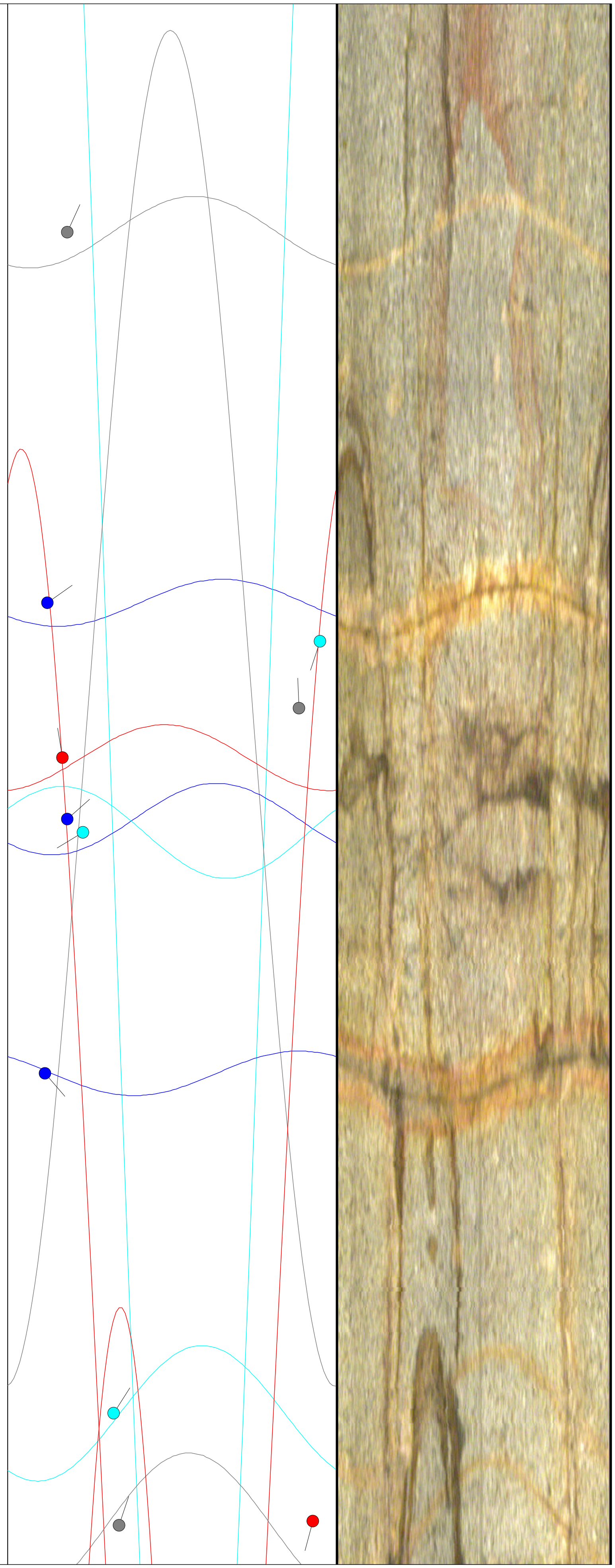


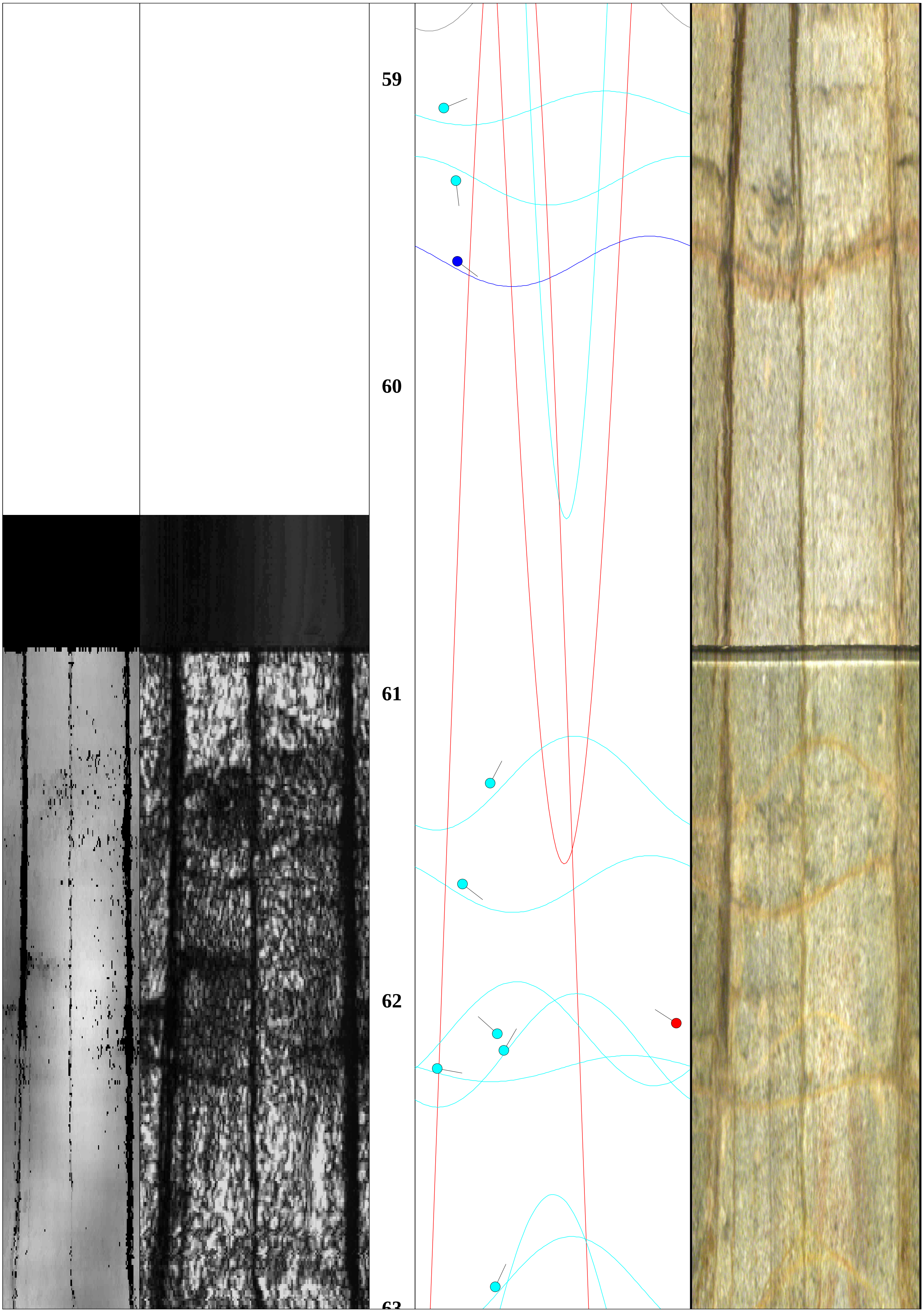
55

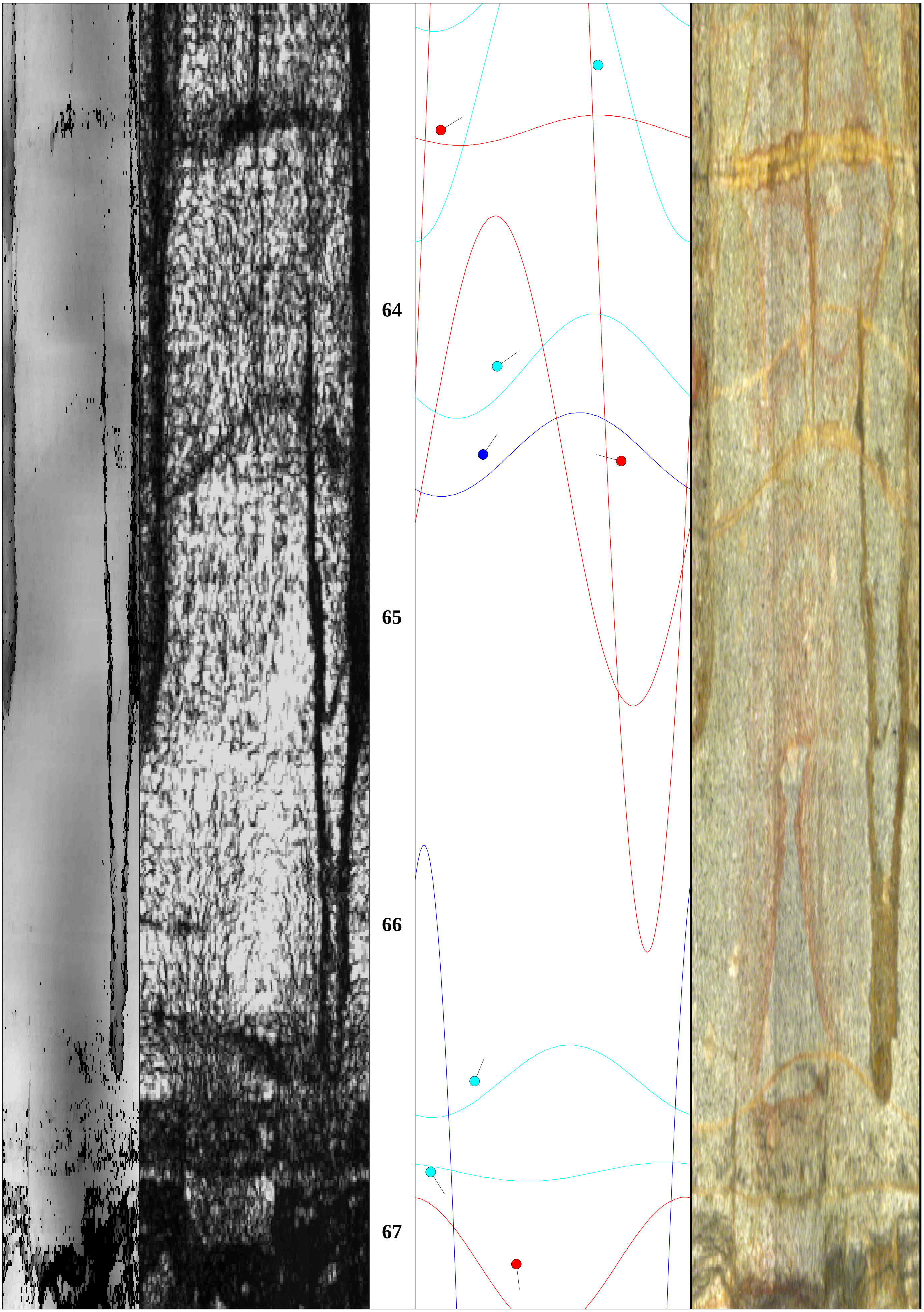
56

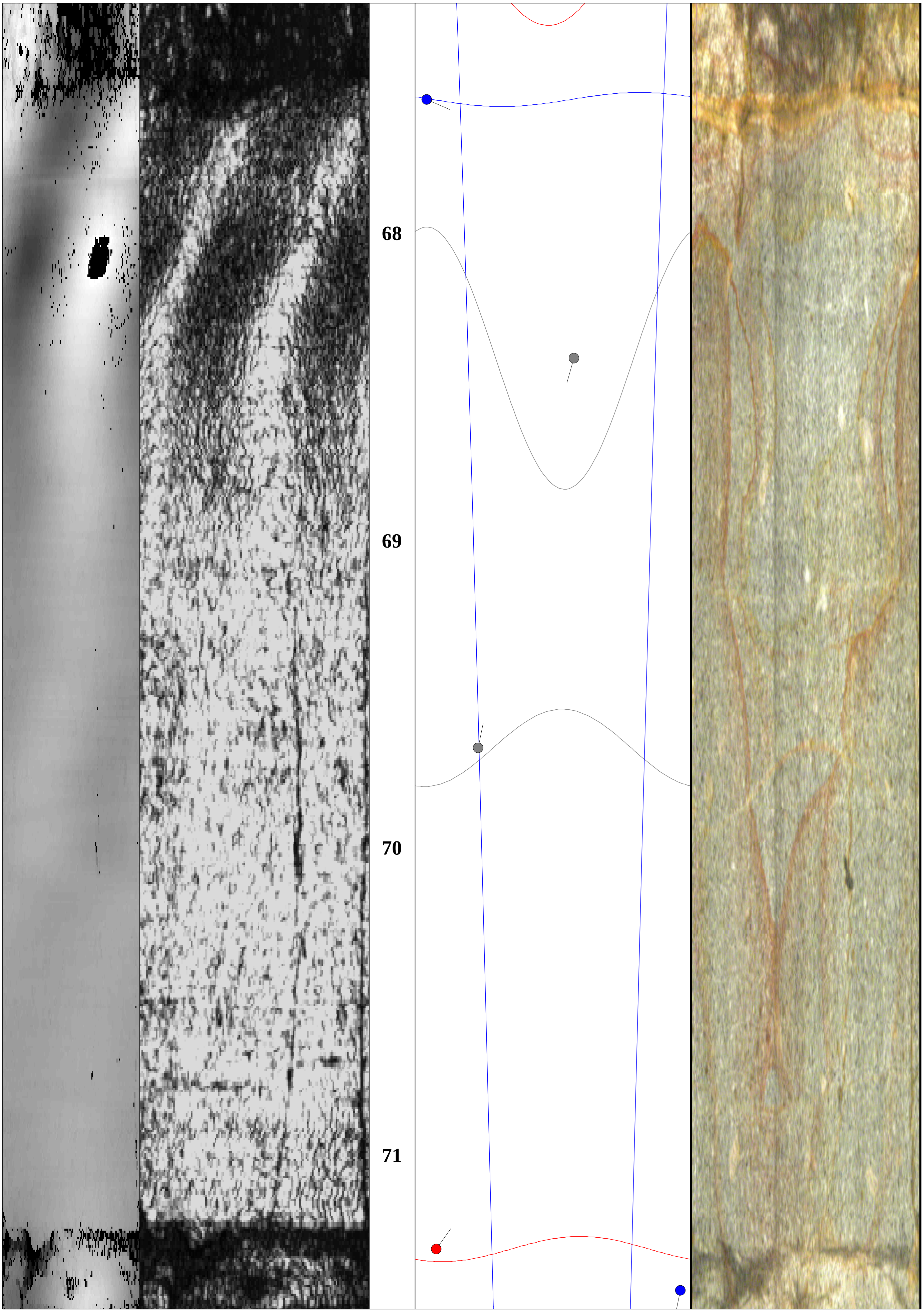
57

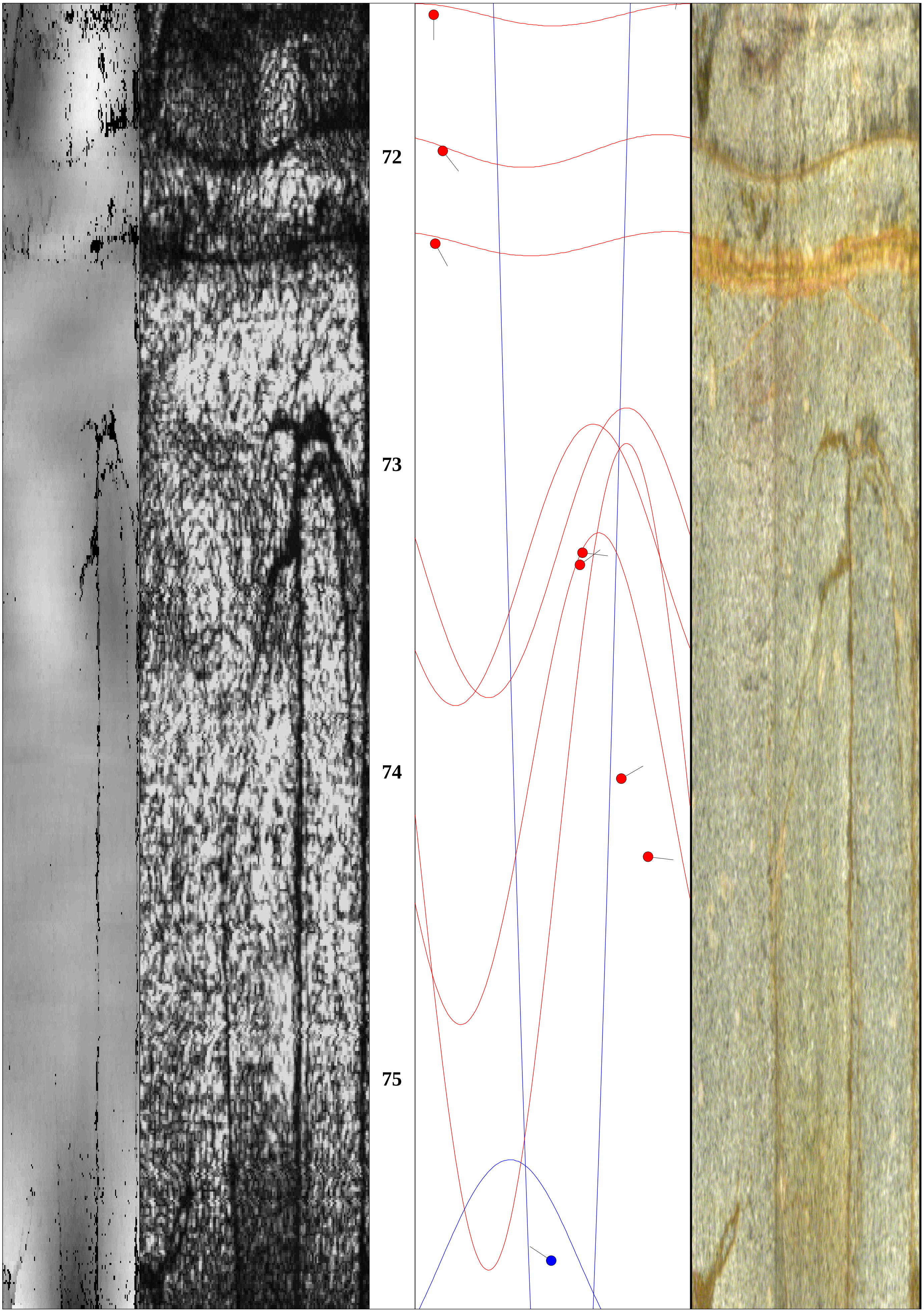
58

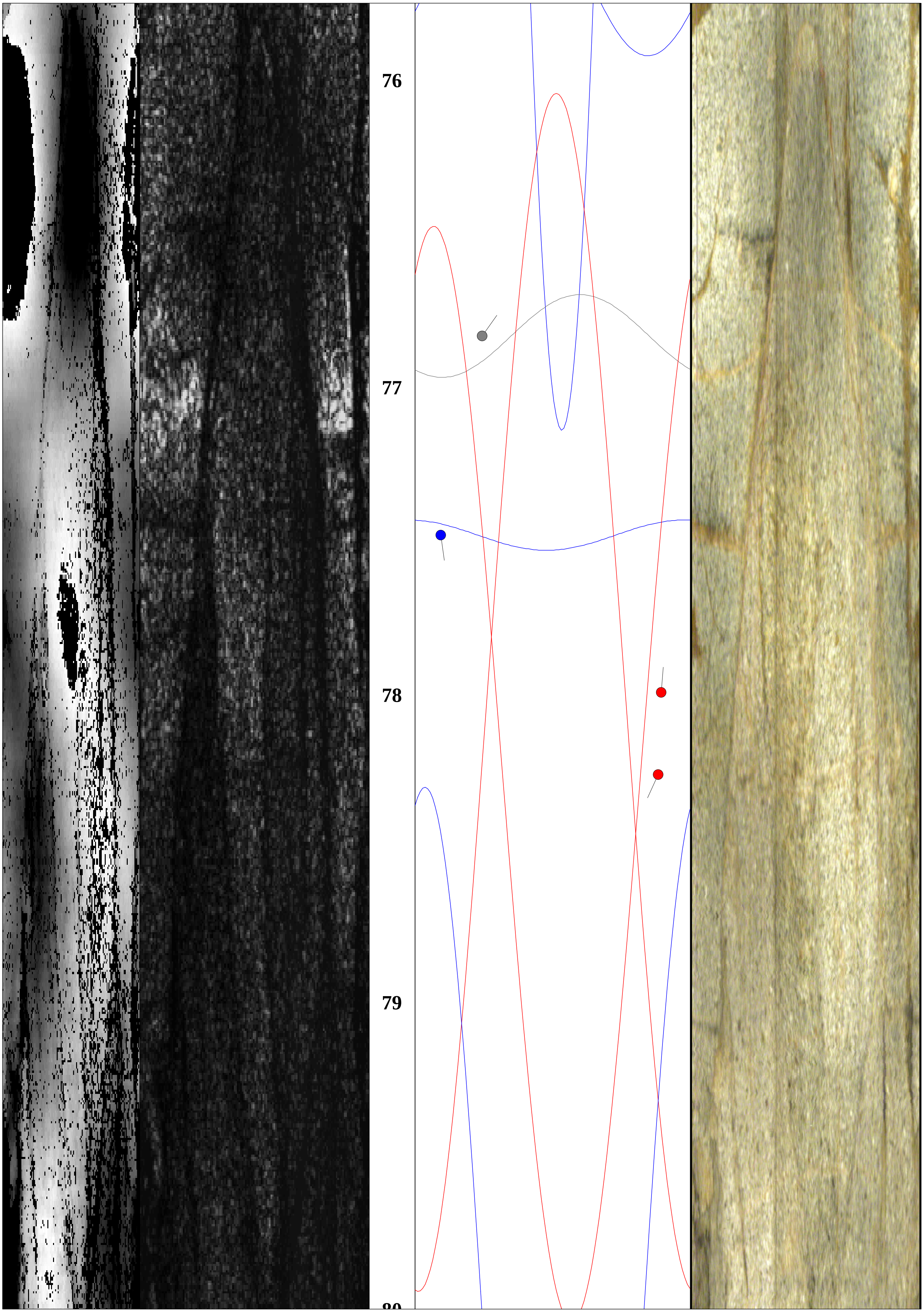


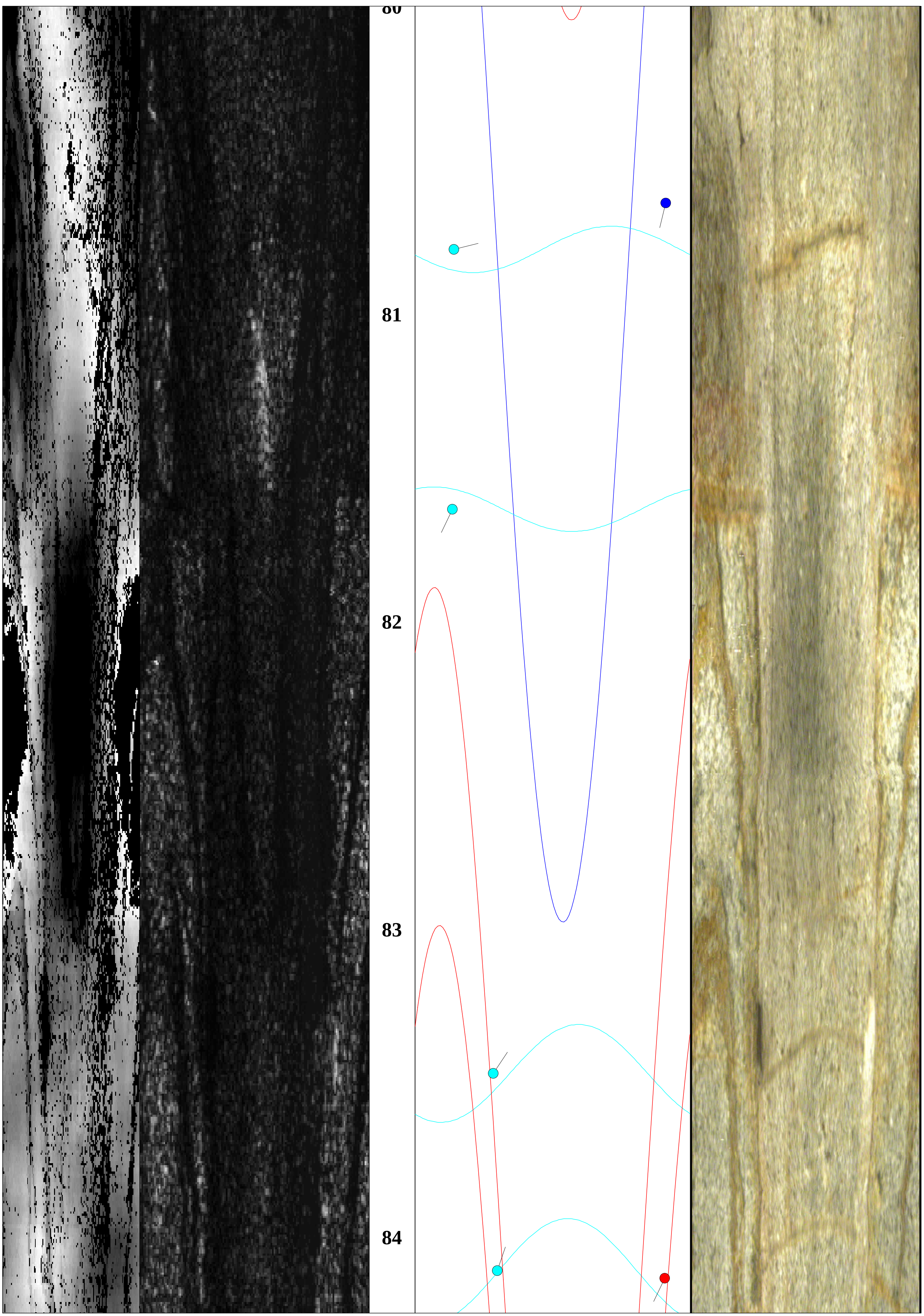

59
60
61
62

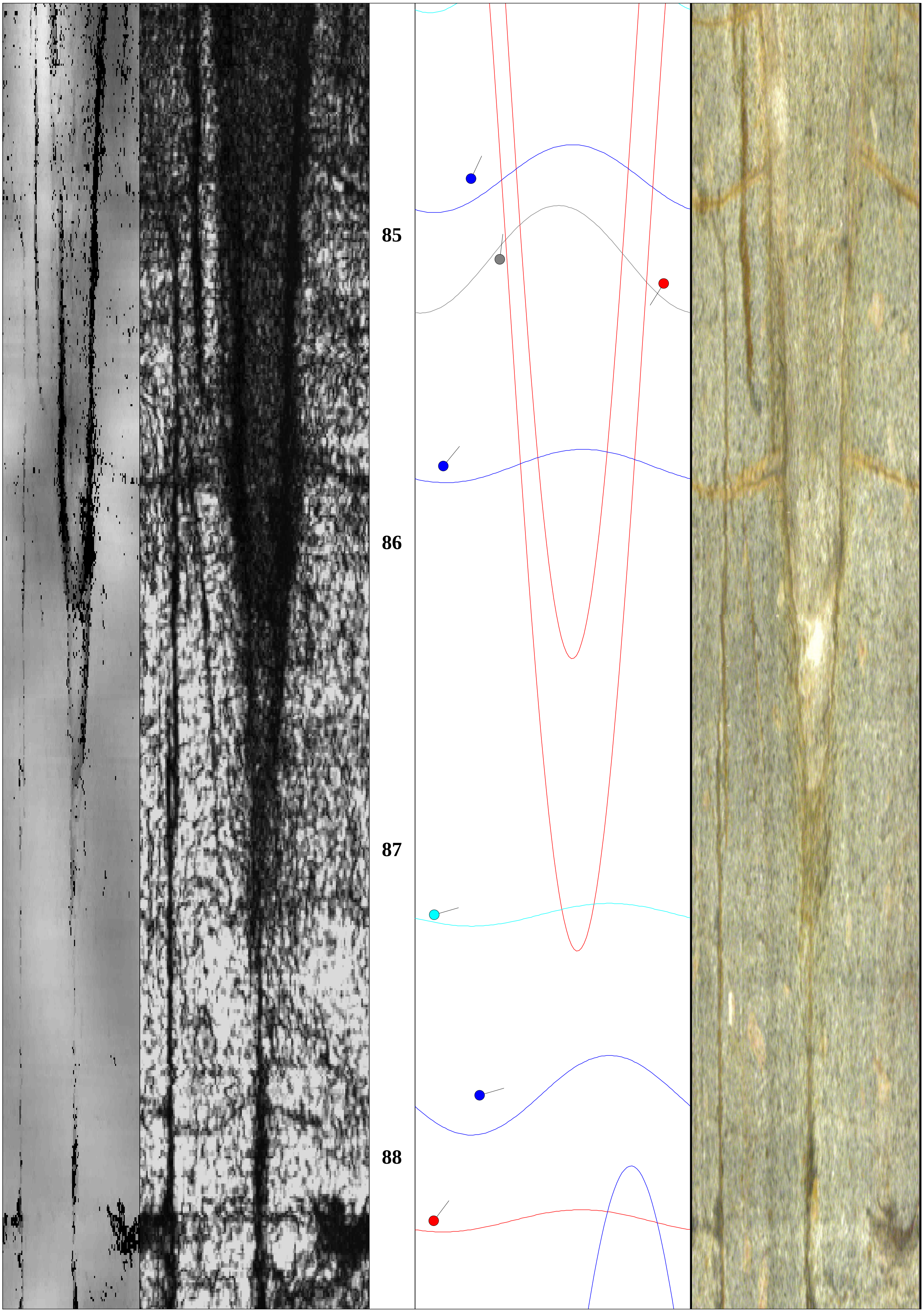

64
65
66
67

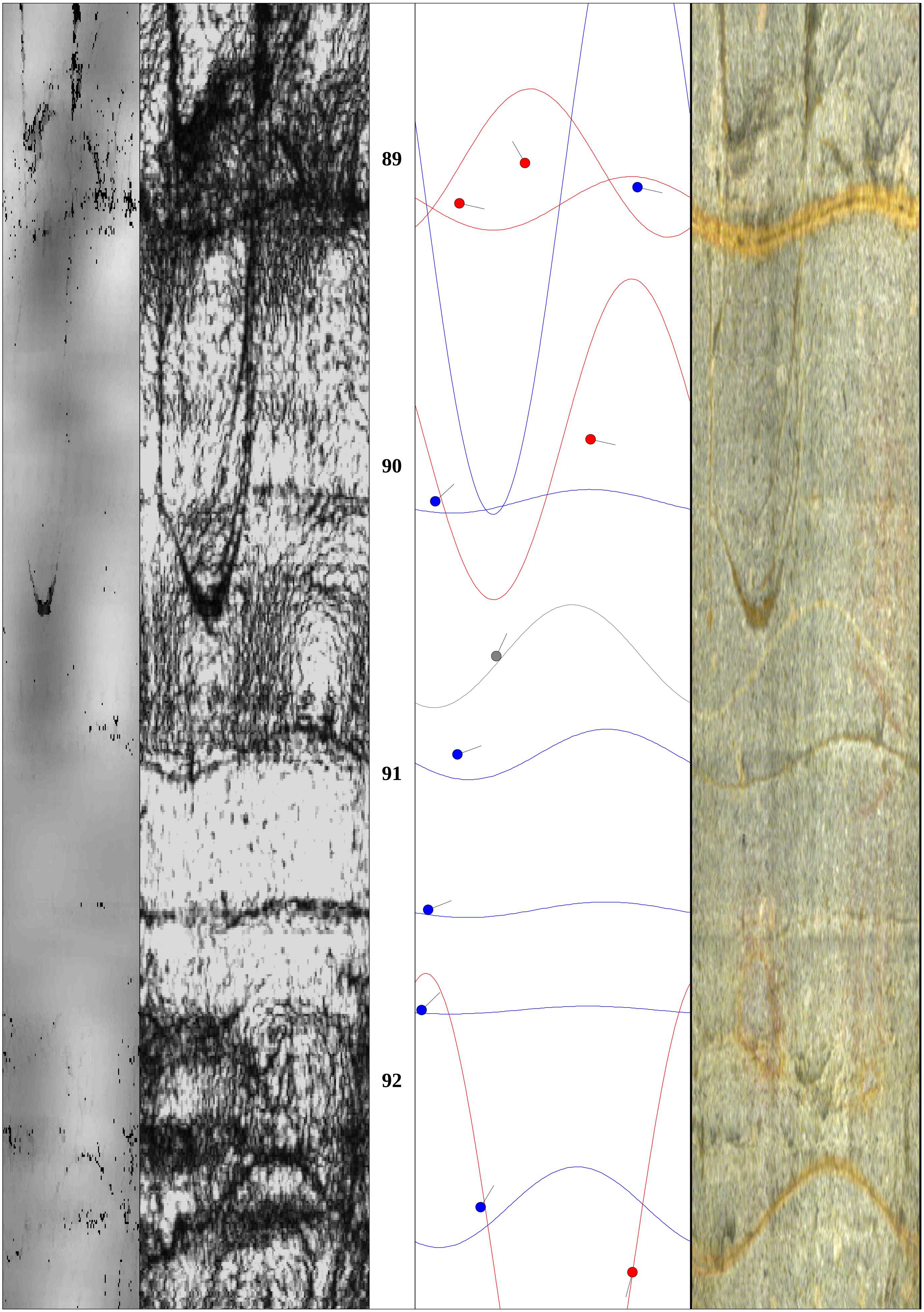

68
69
70
71

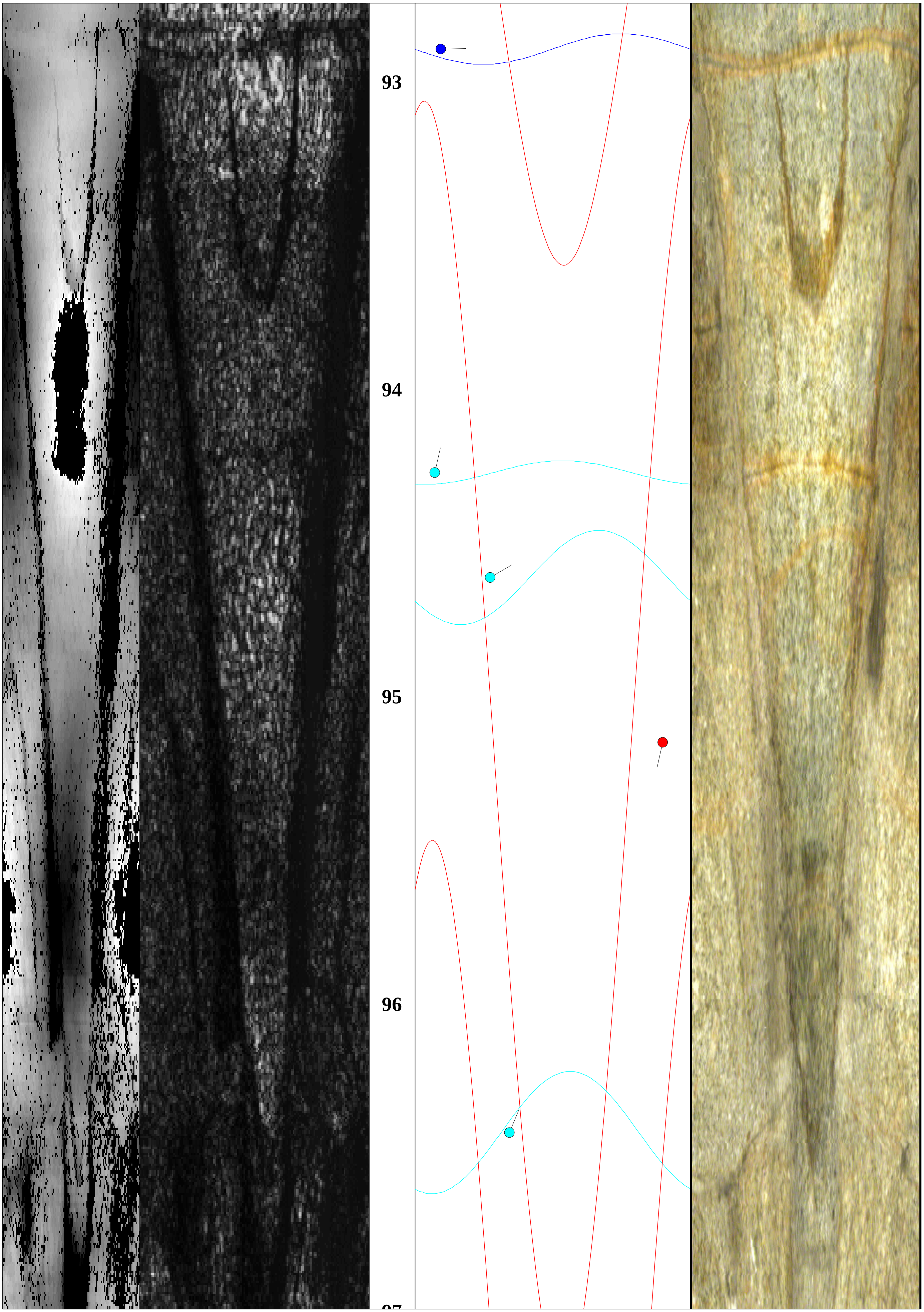

72
73
74
75

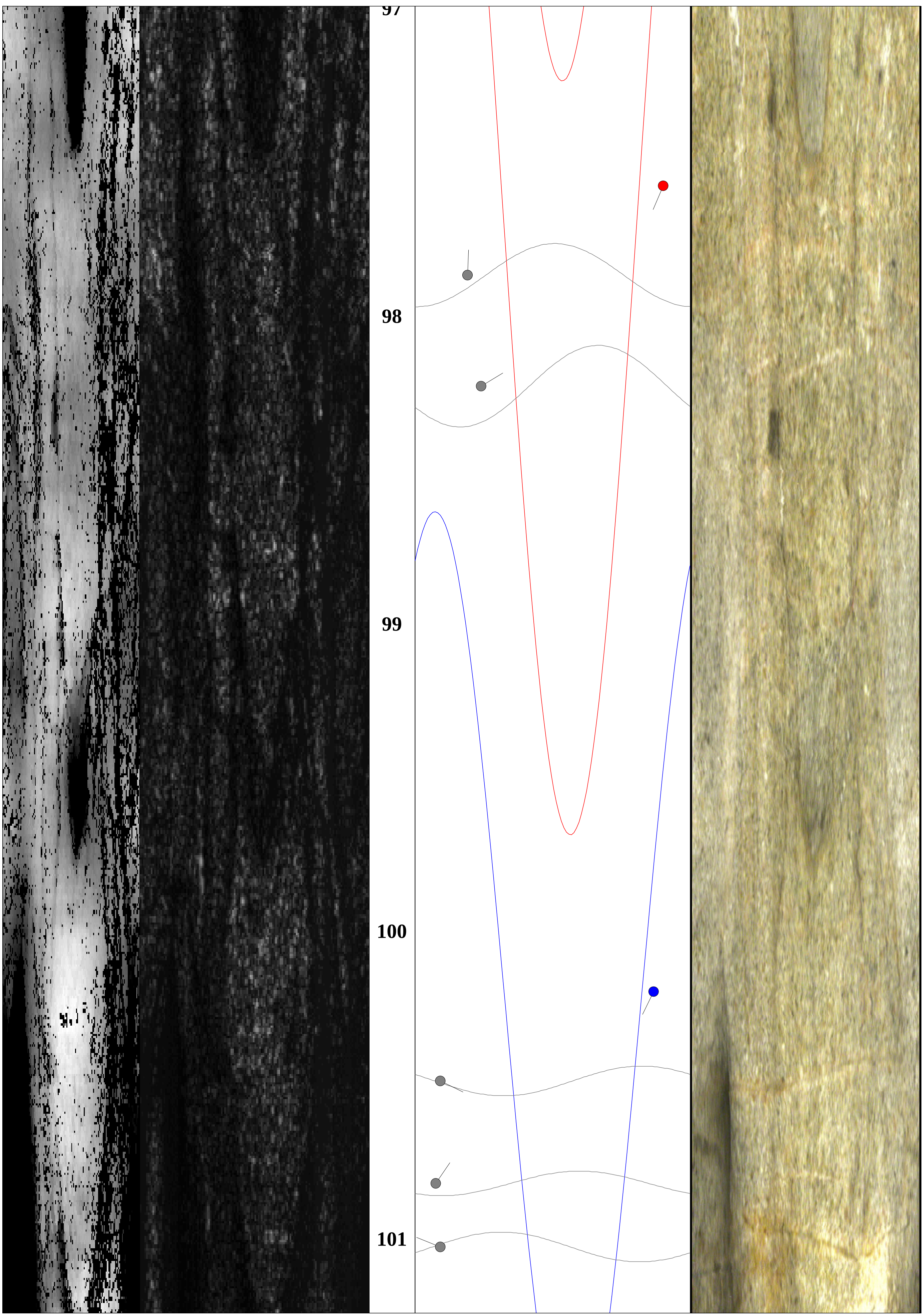

76
77
78
79

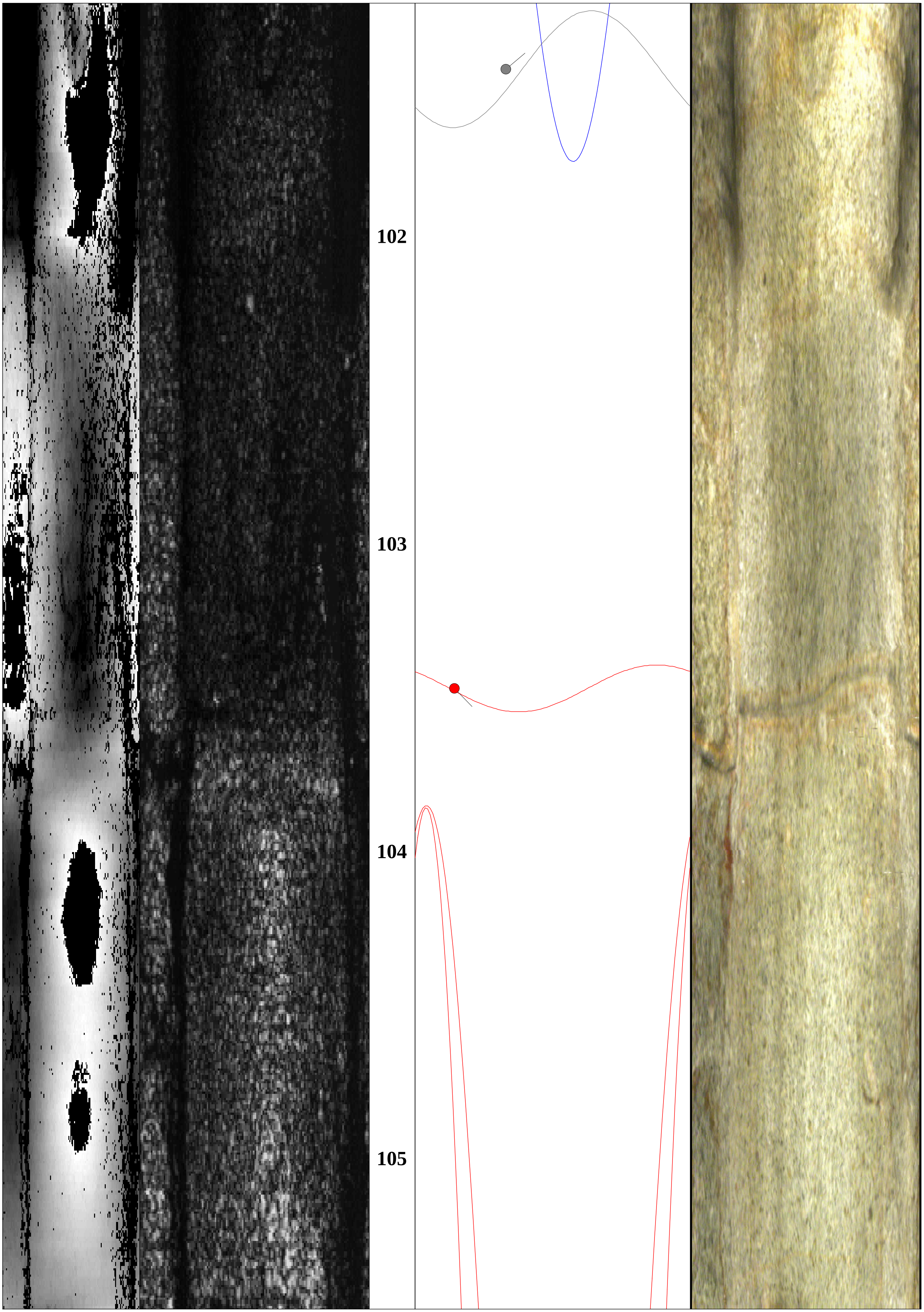

80
81
82
83
84

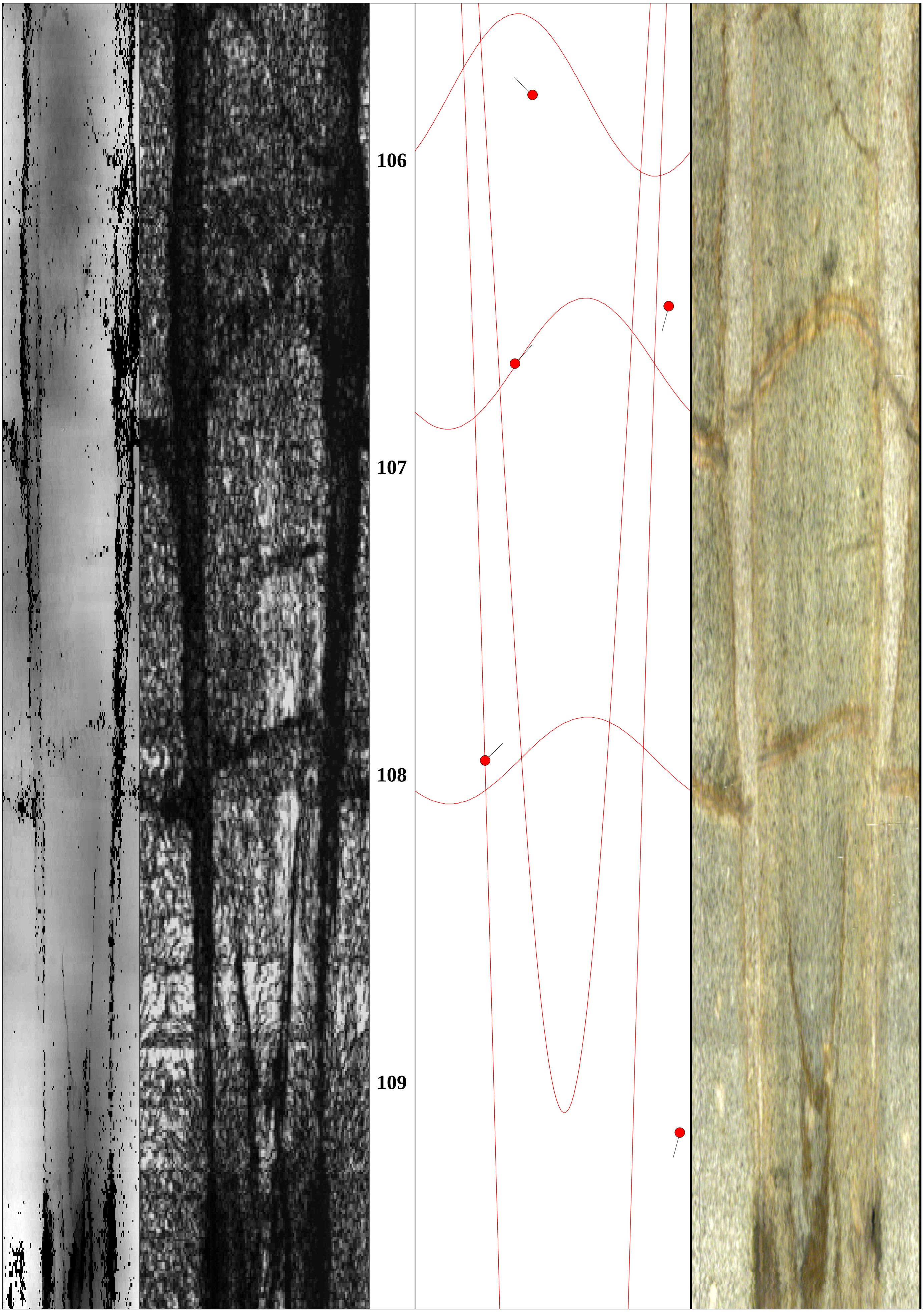

85
86
87
88

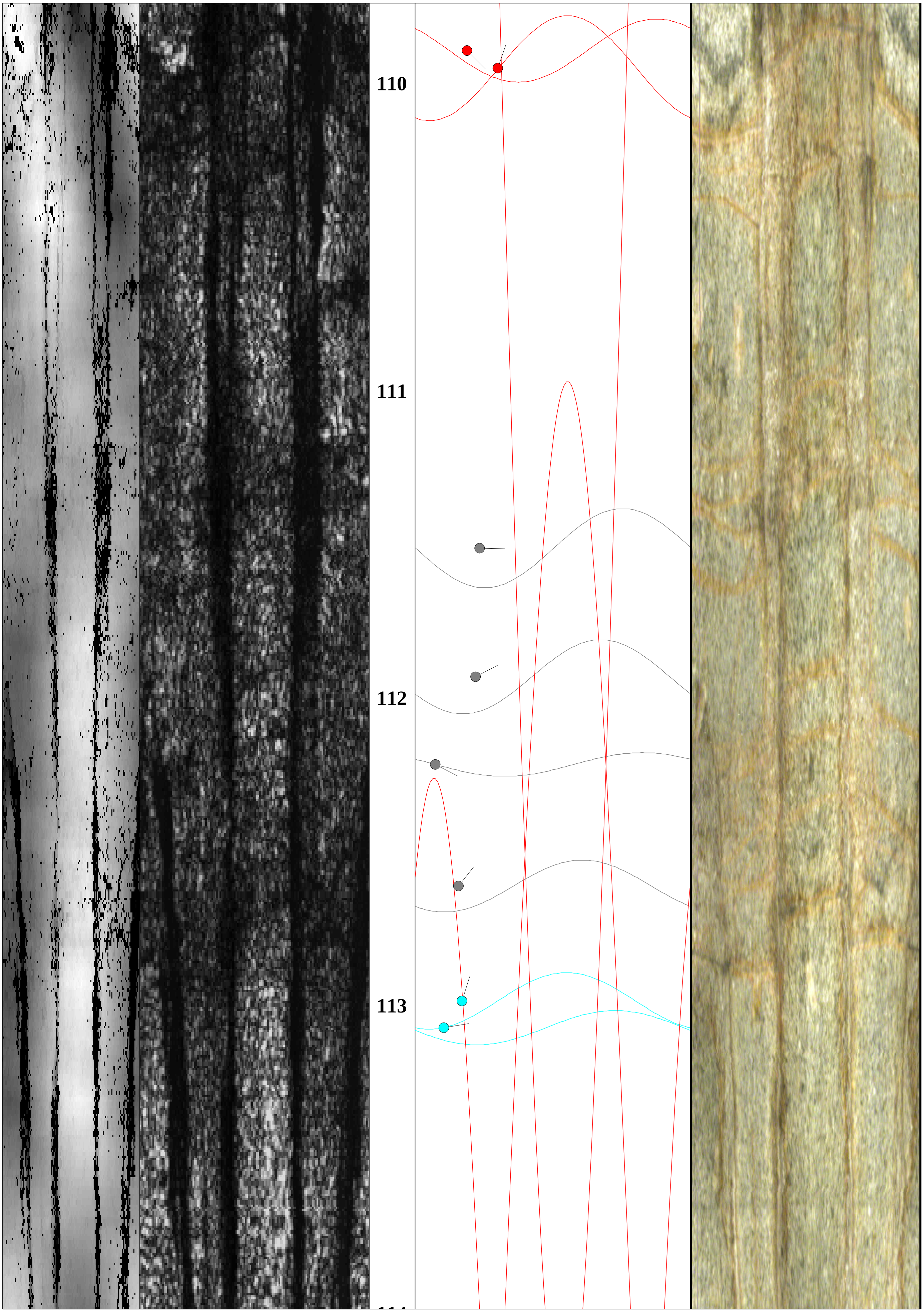

89
90
91
92

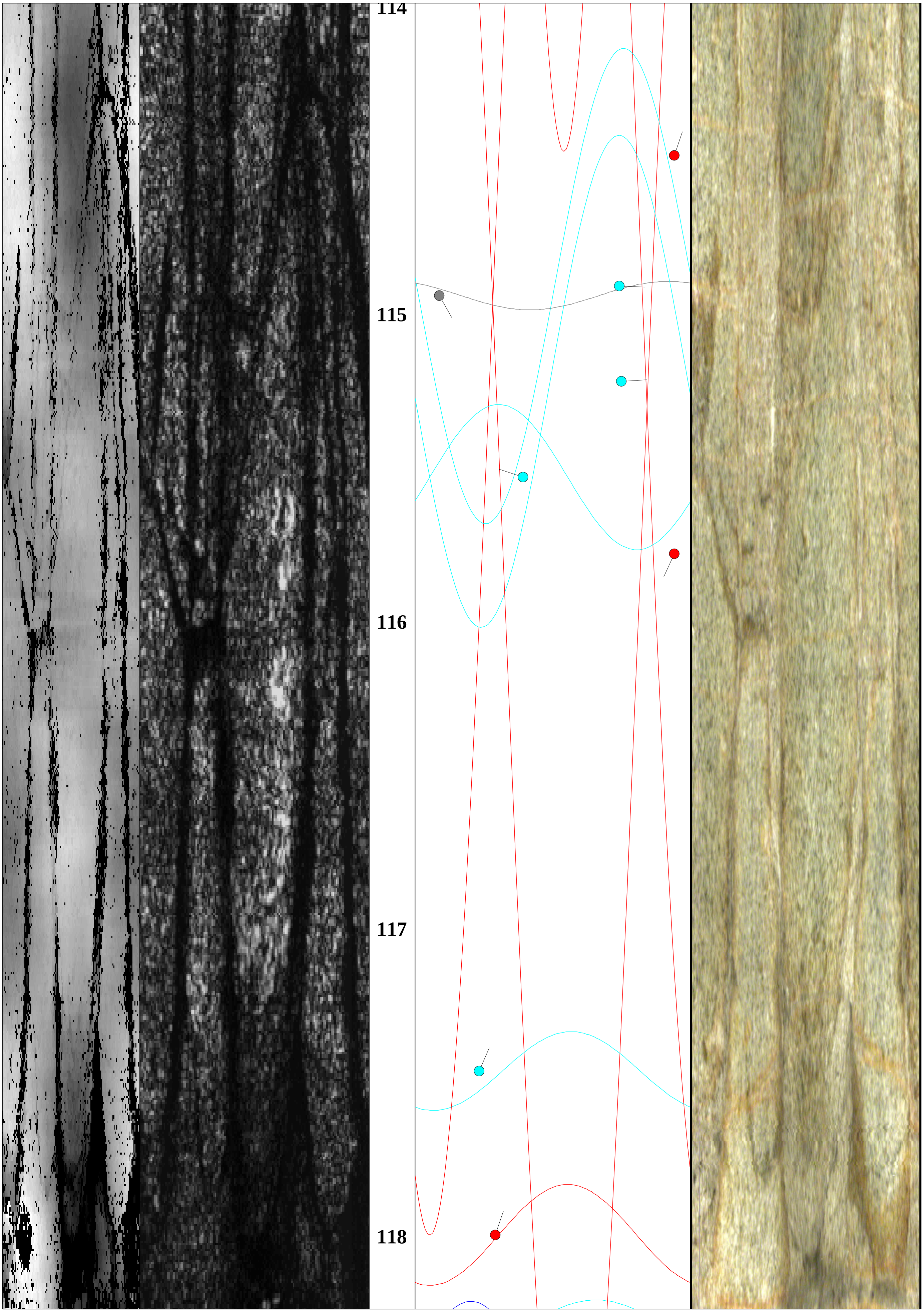

93
94
95
96

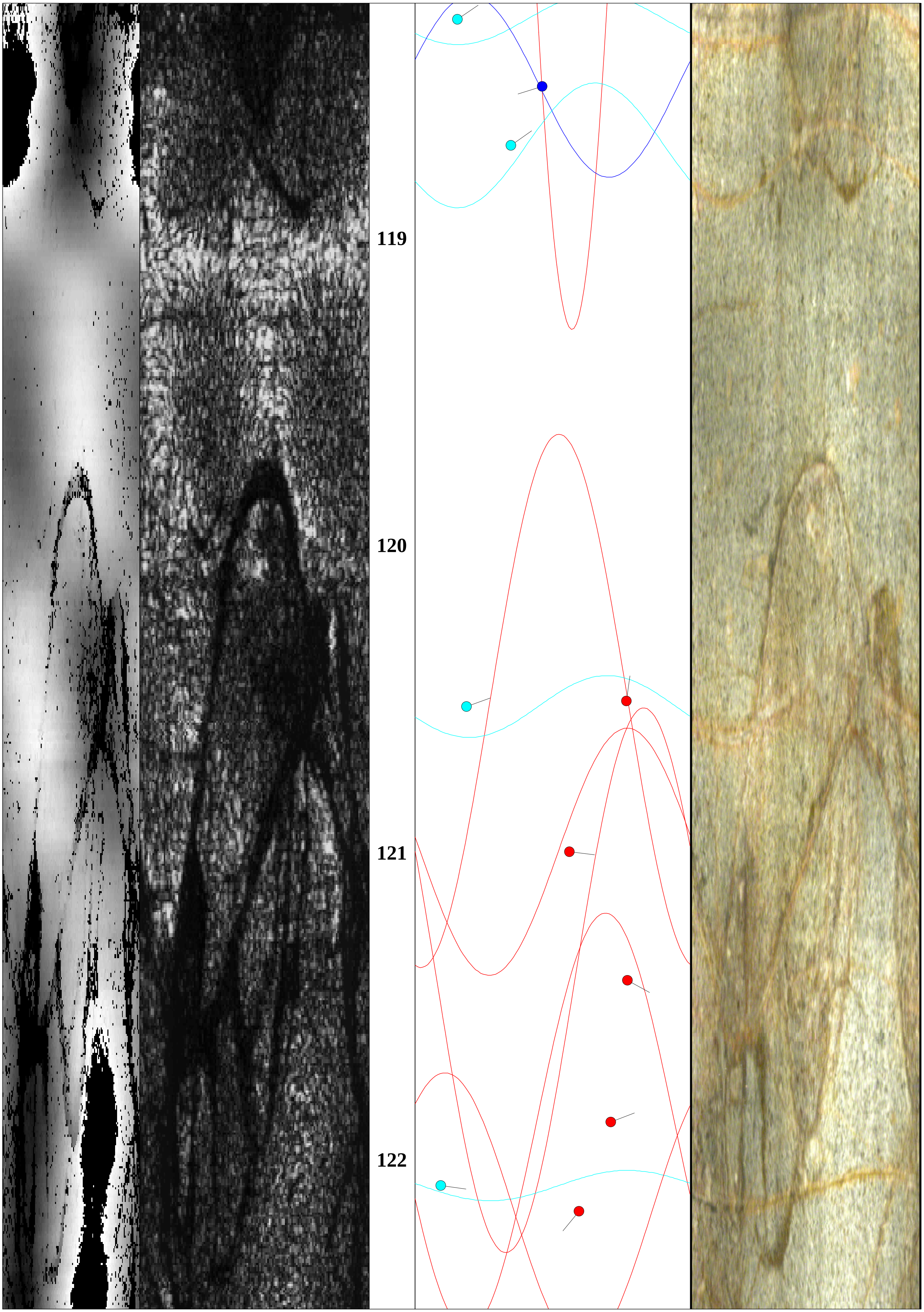

97
98
99
100
101

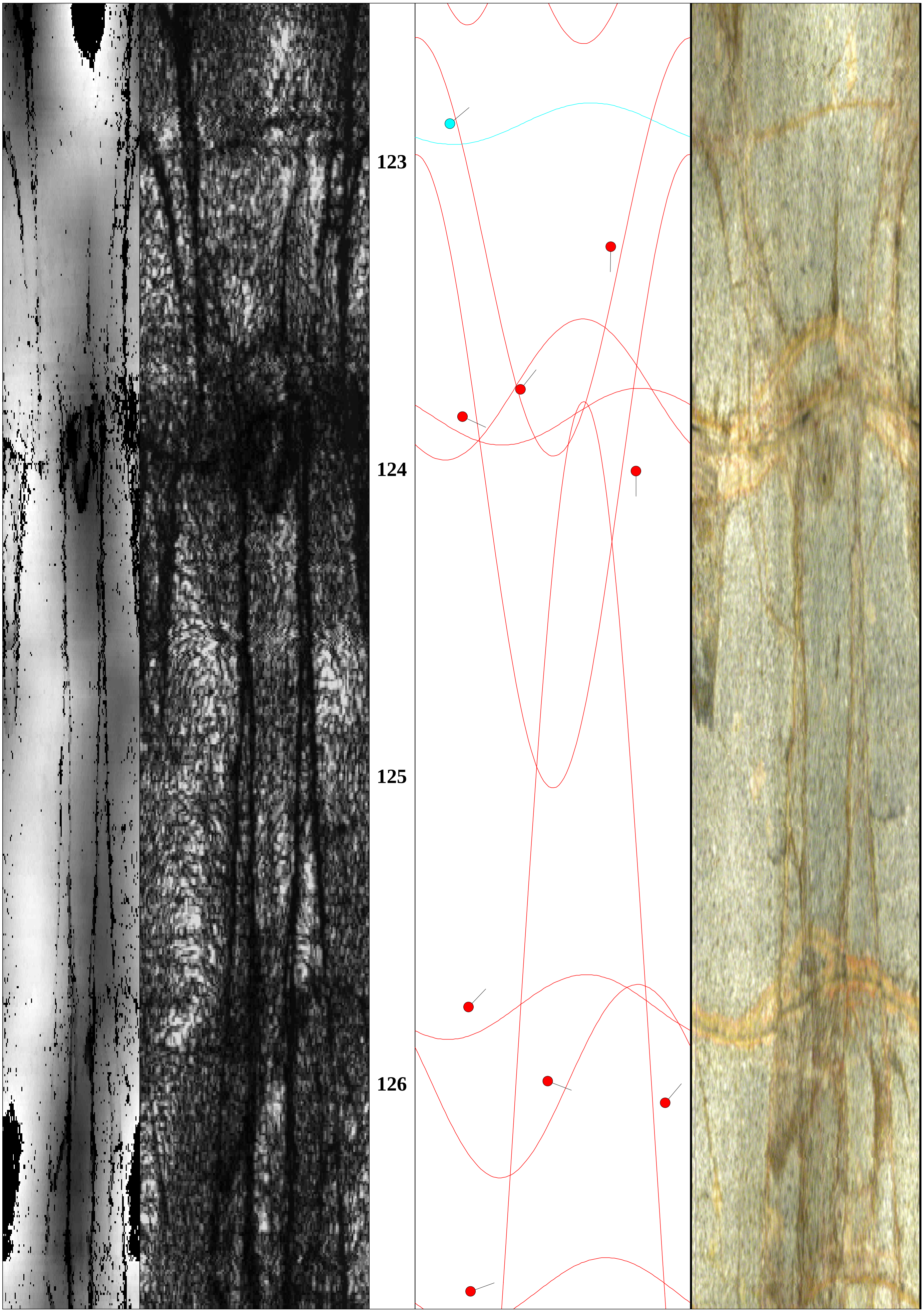

102
103
104
105

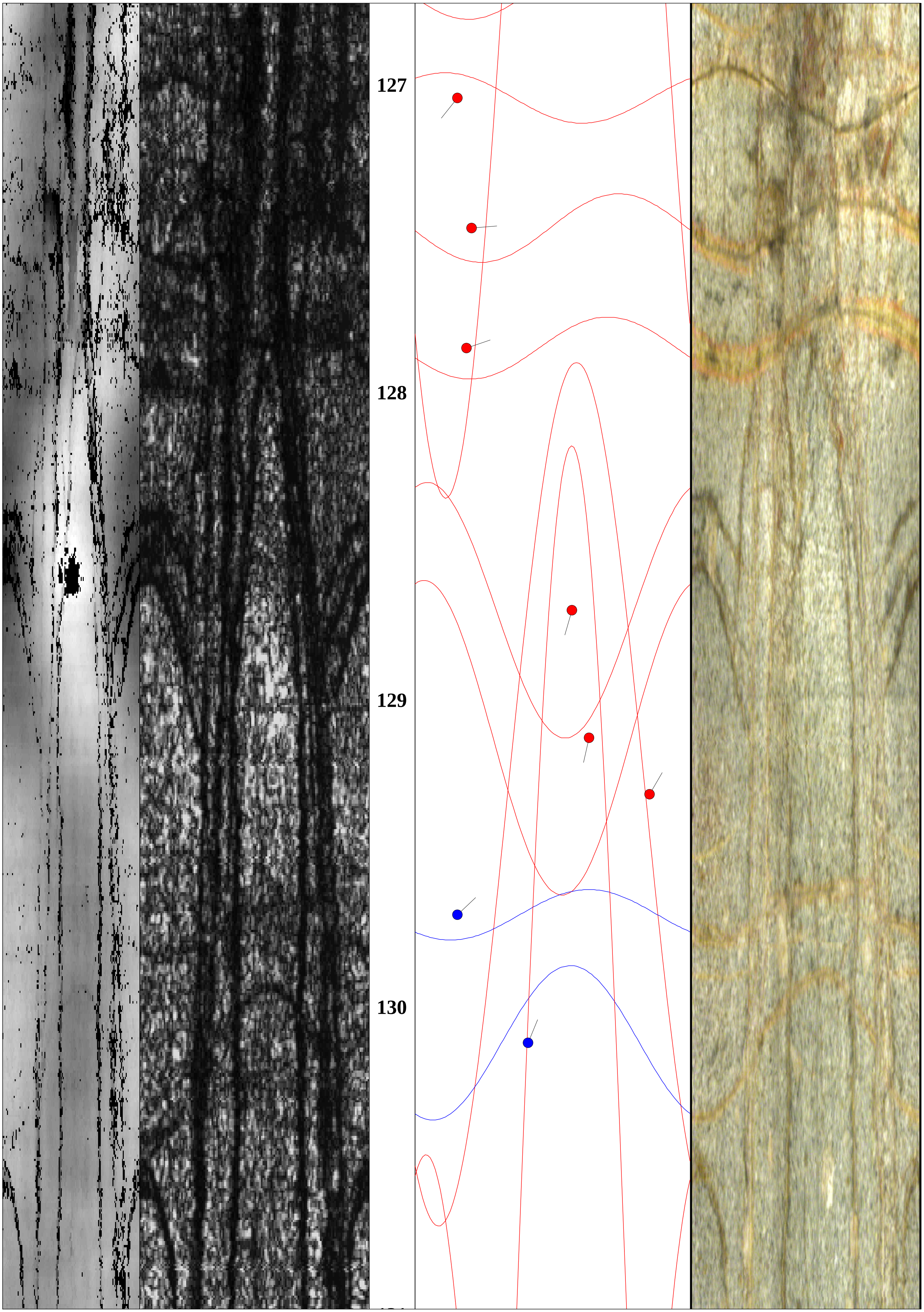

106
107
108
109

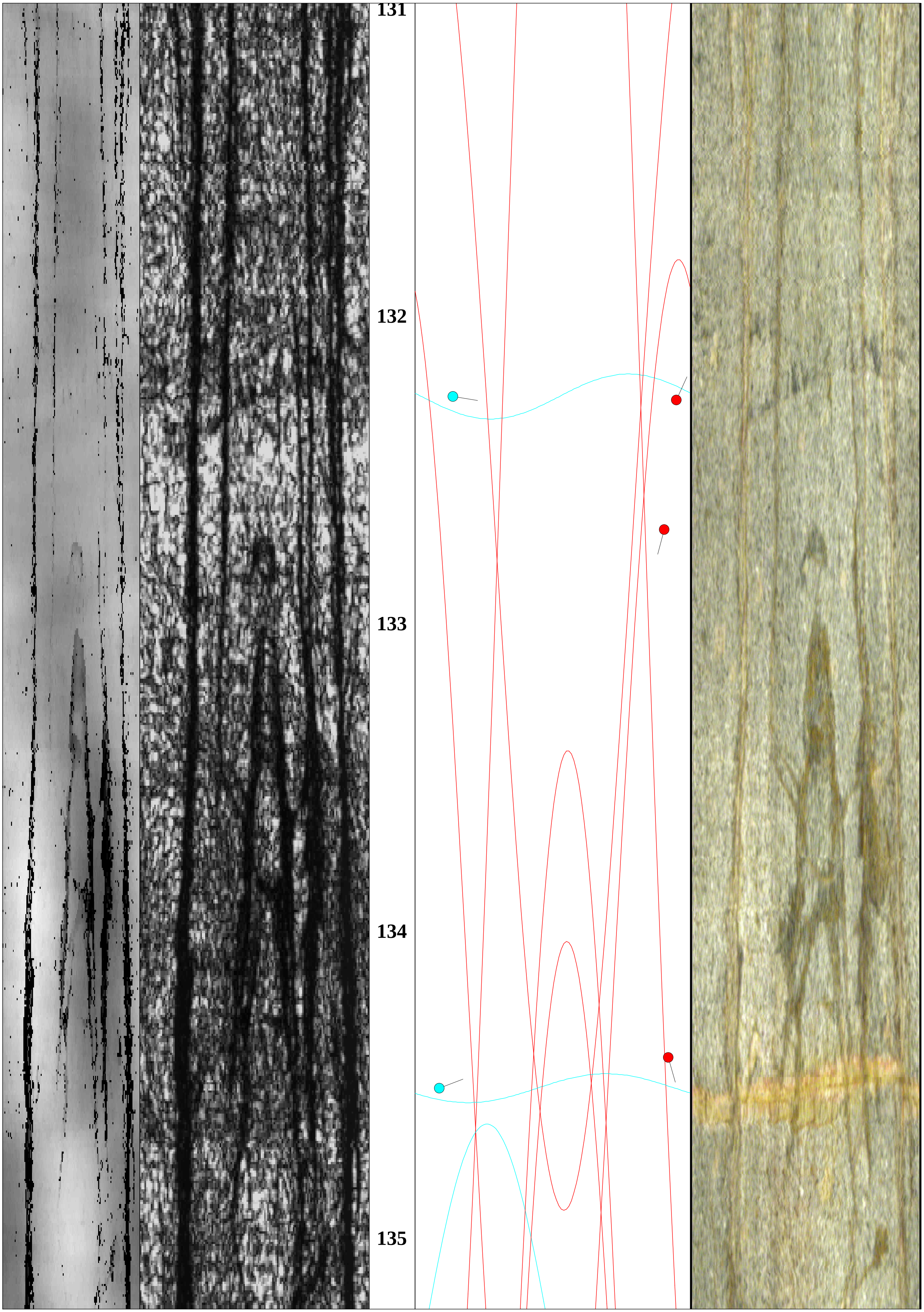

110
111
112
113

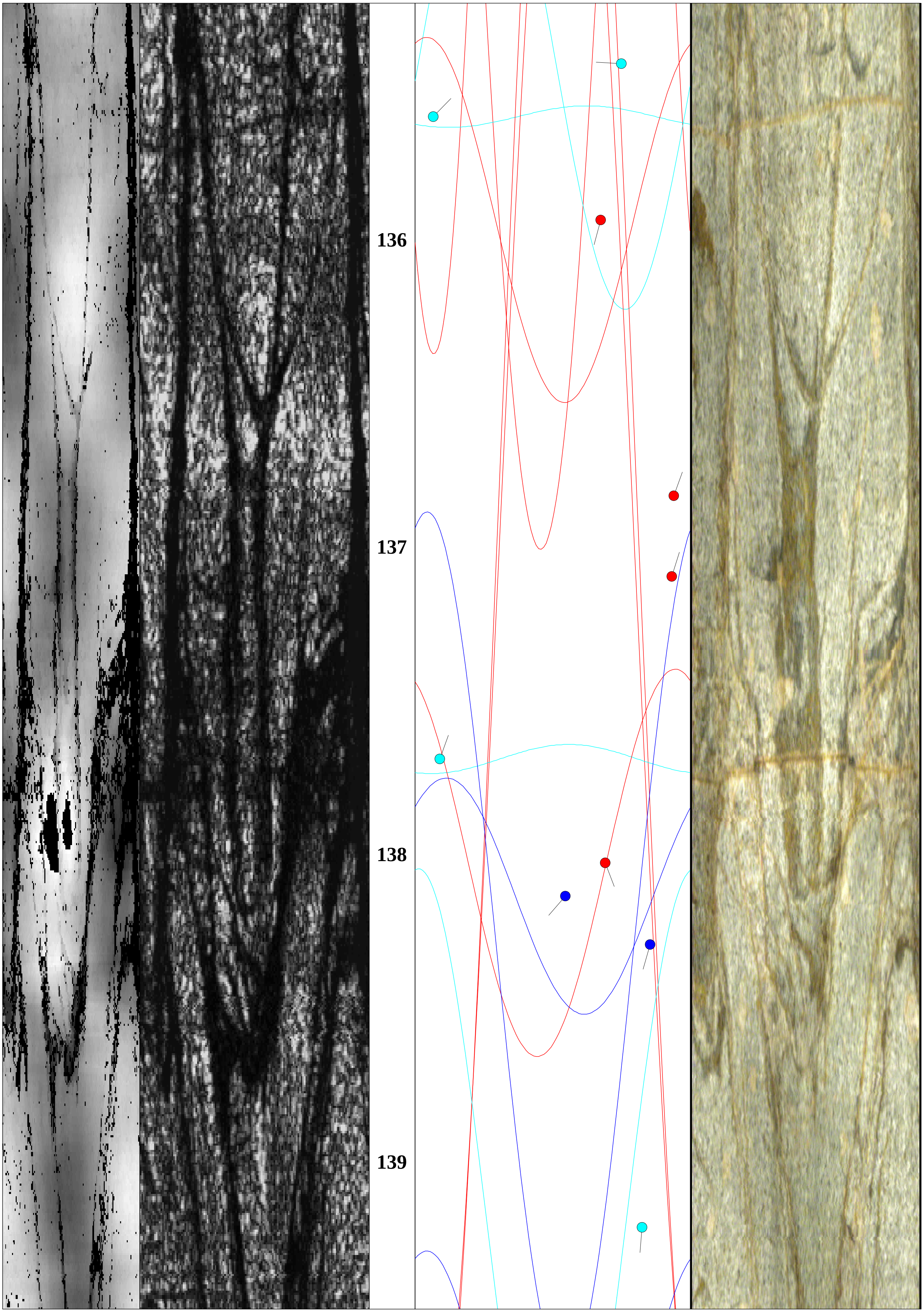

114
115
116
117
118

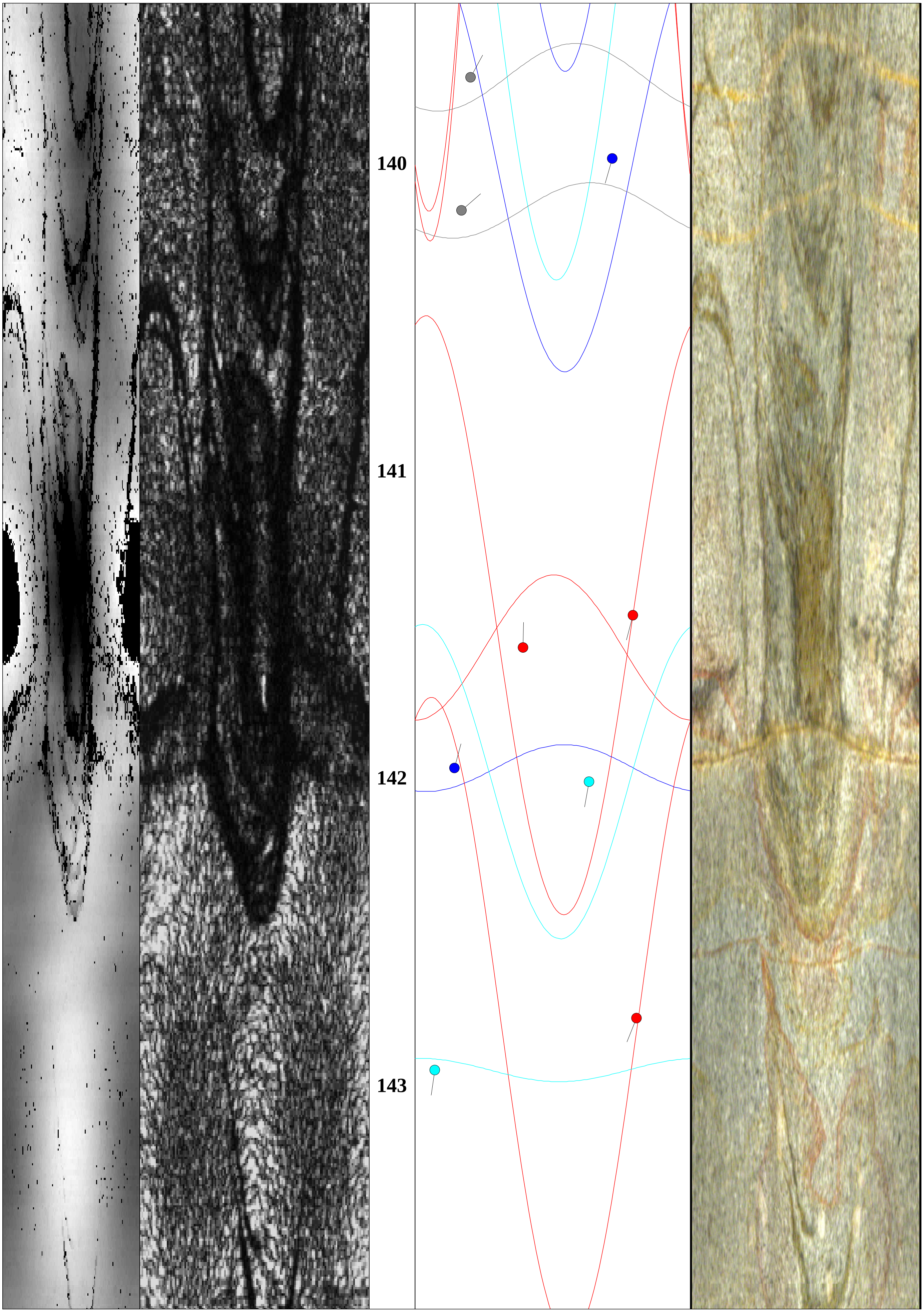

119
120
121
122

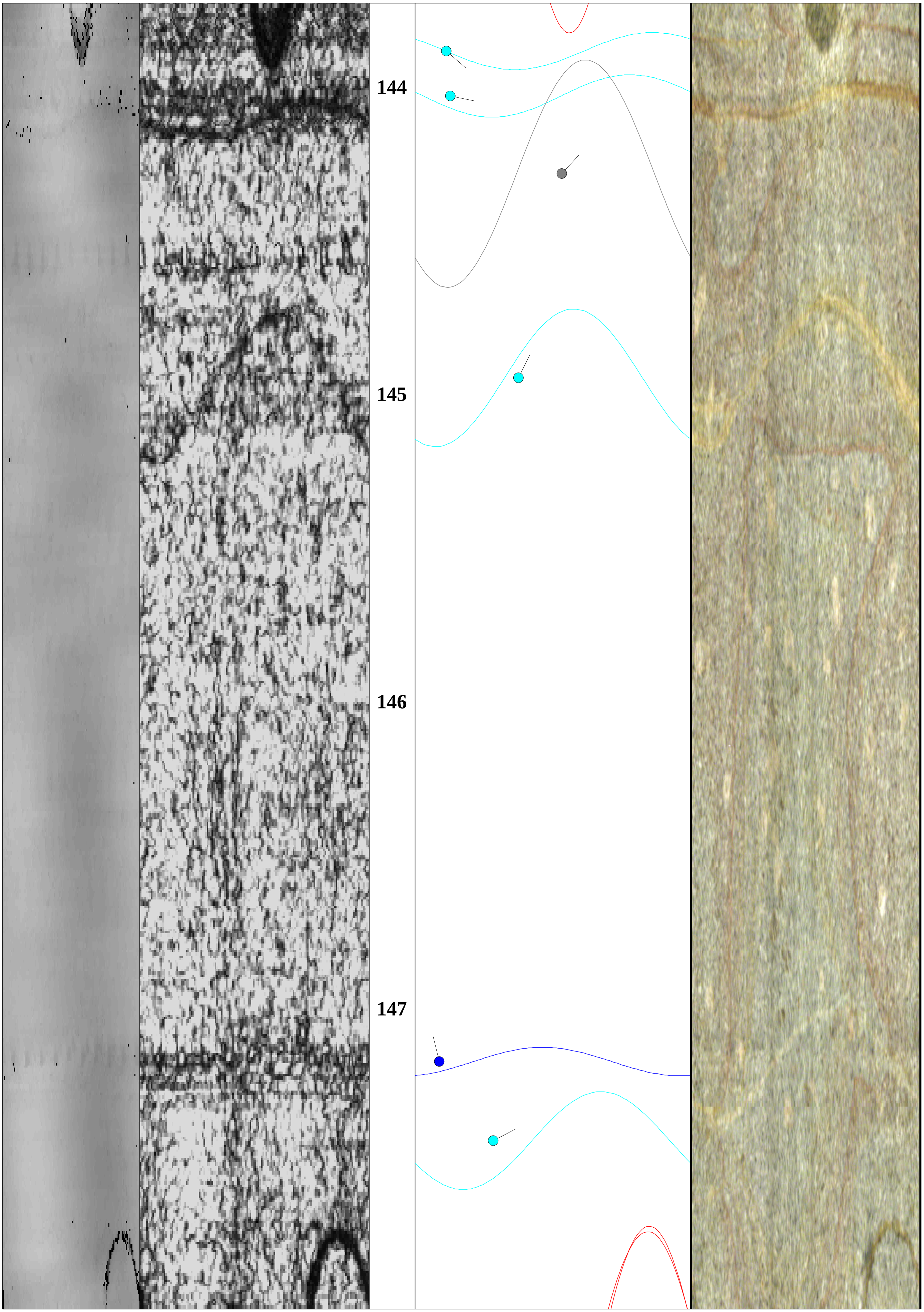

123
124
125
126

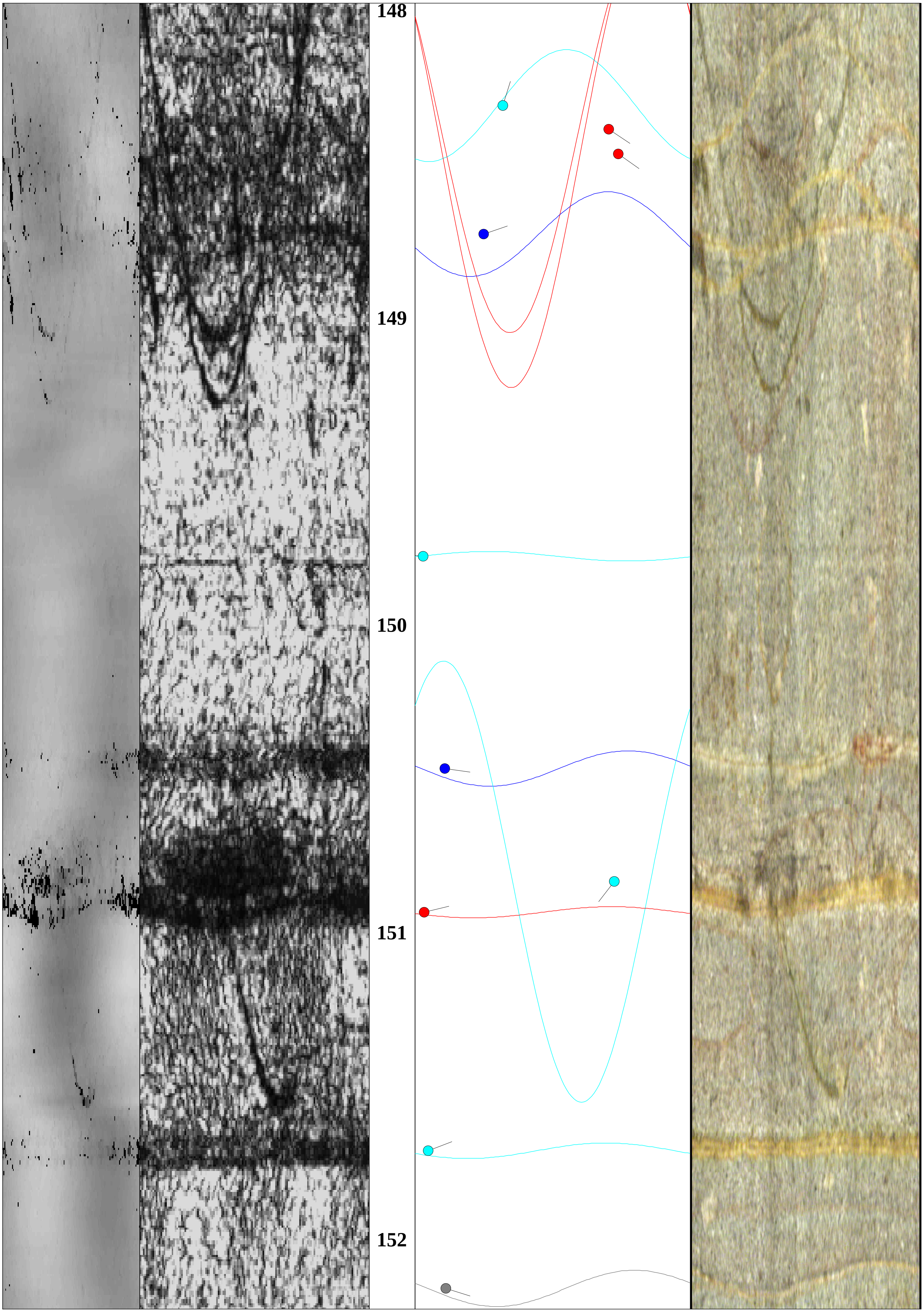

127
128
129
130

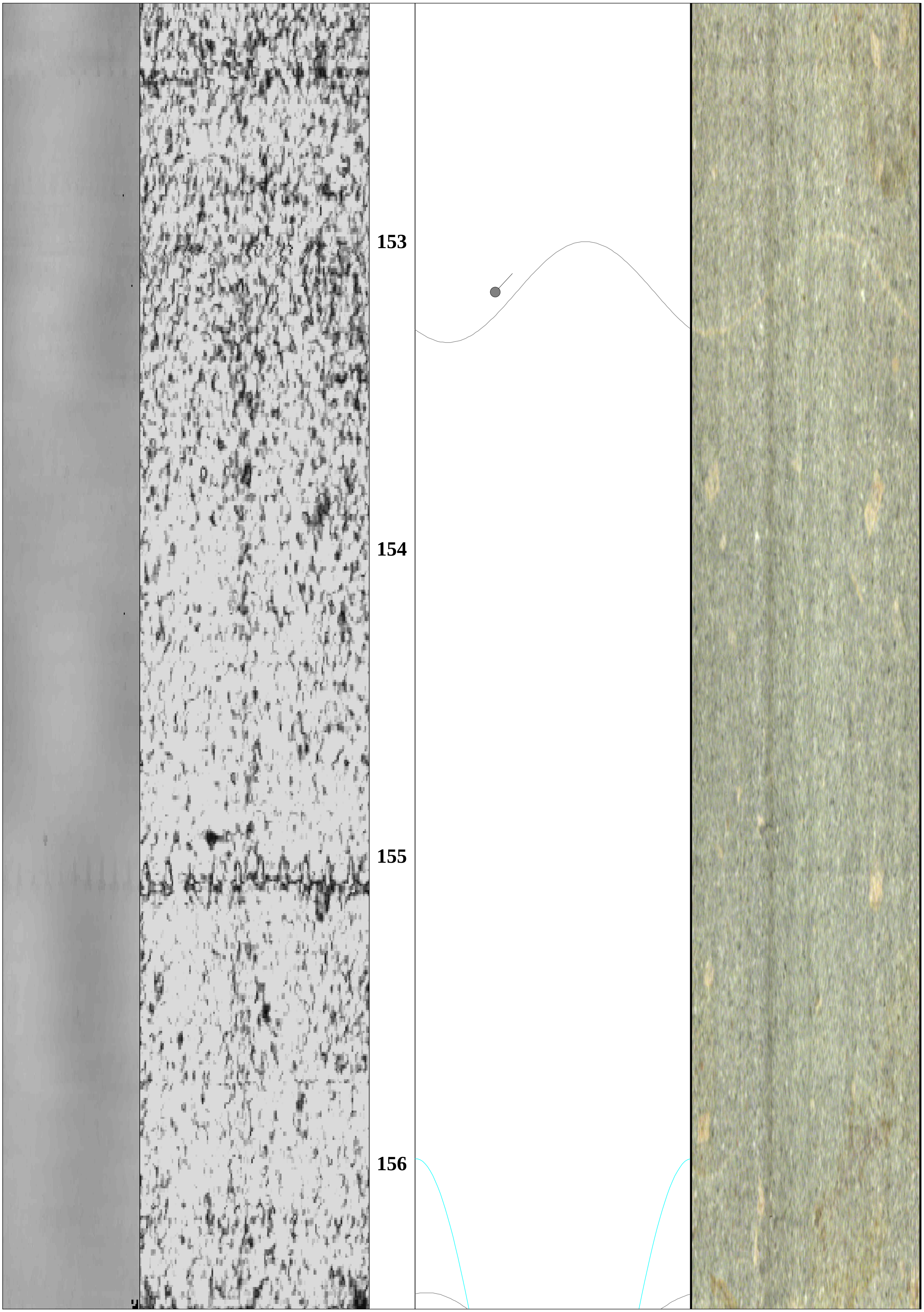

131
132
133
134
135

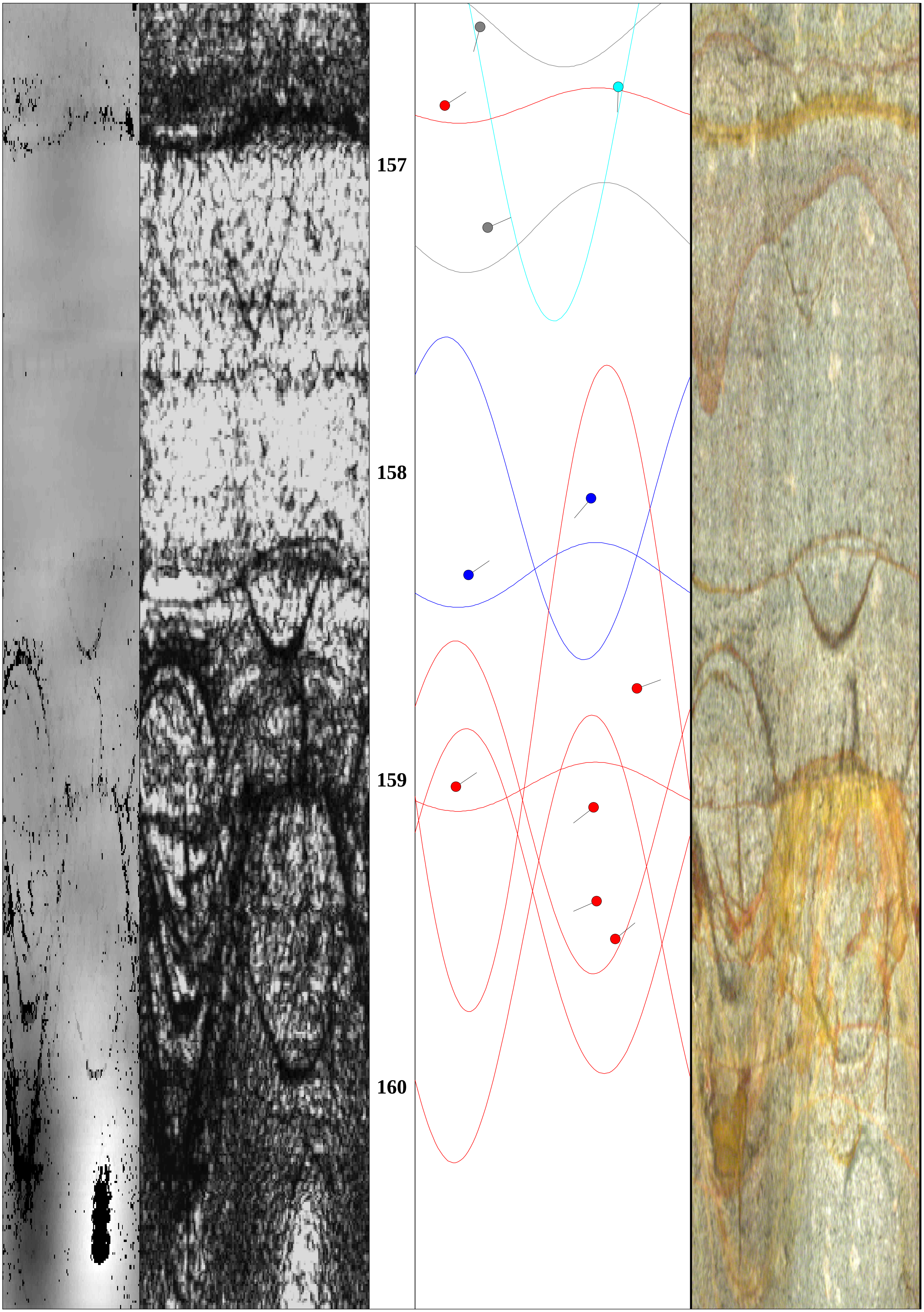

136
137
138
139

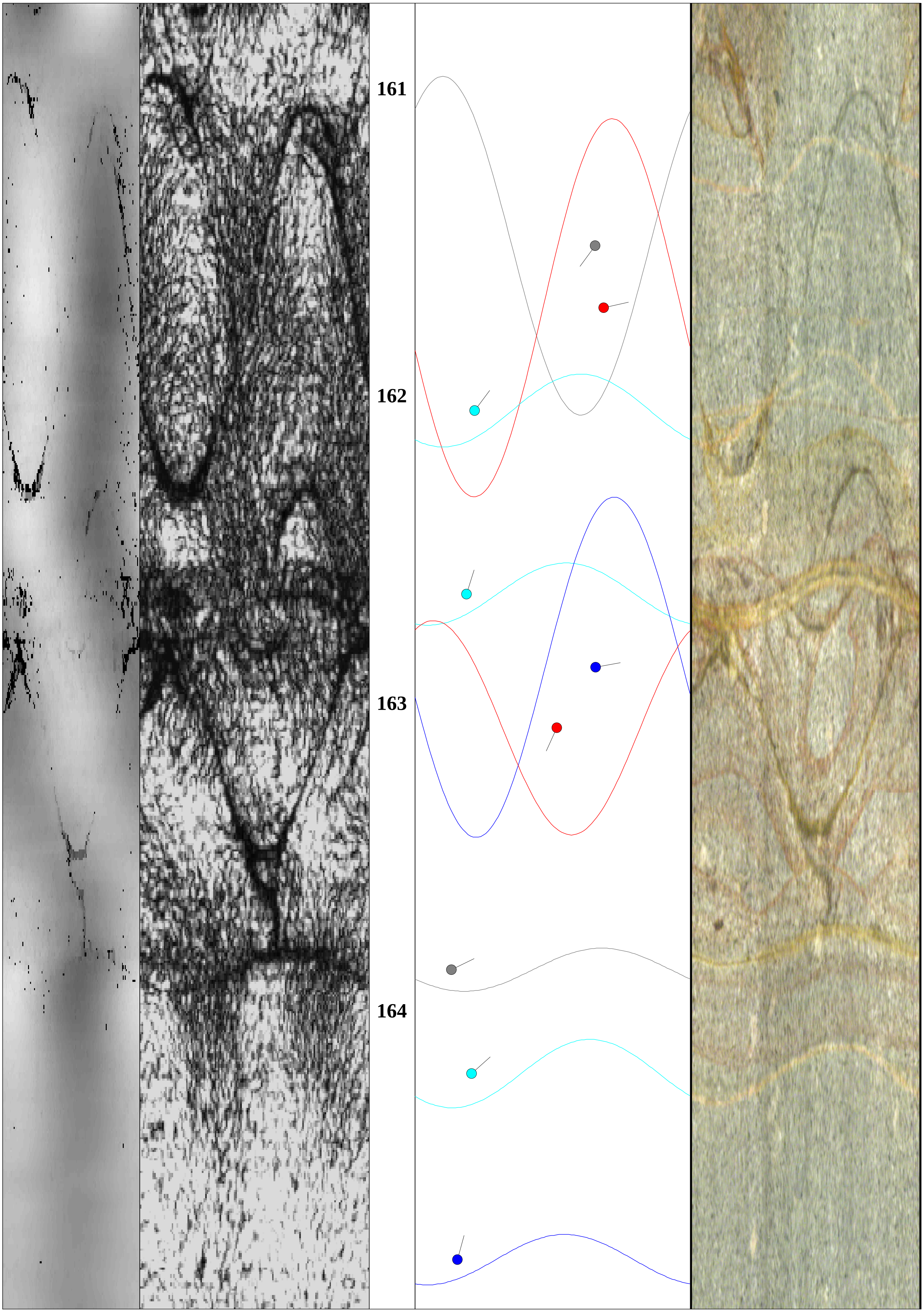

140
141
142
143

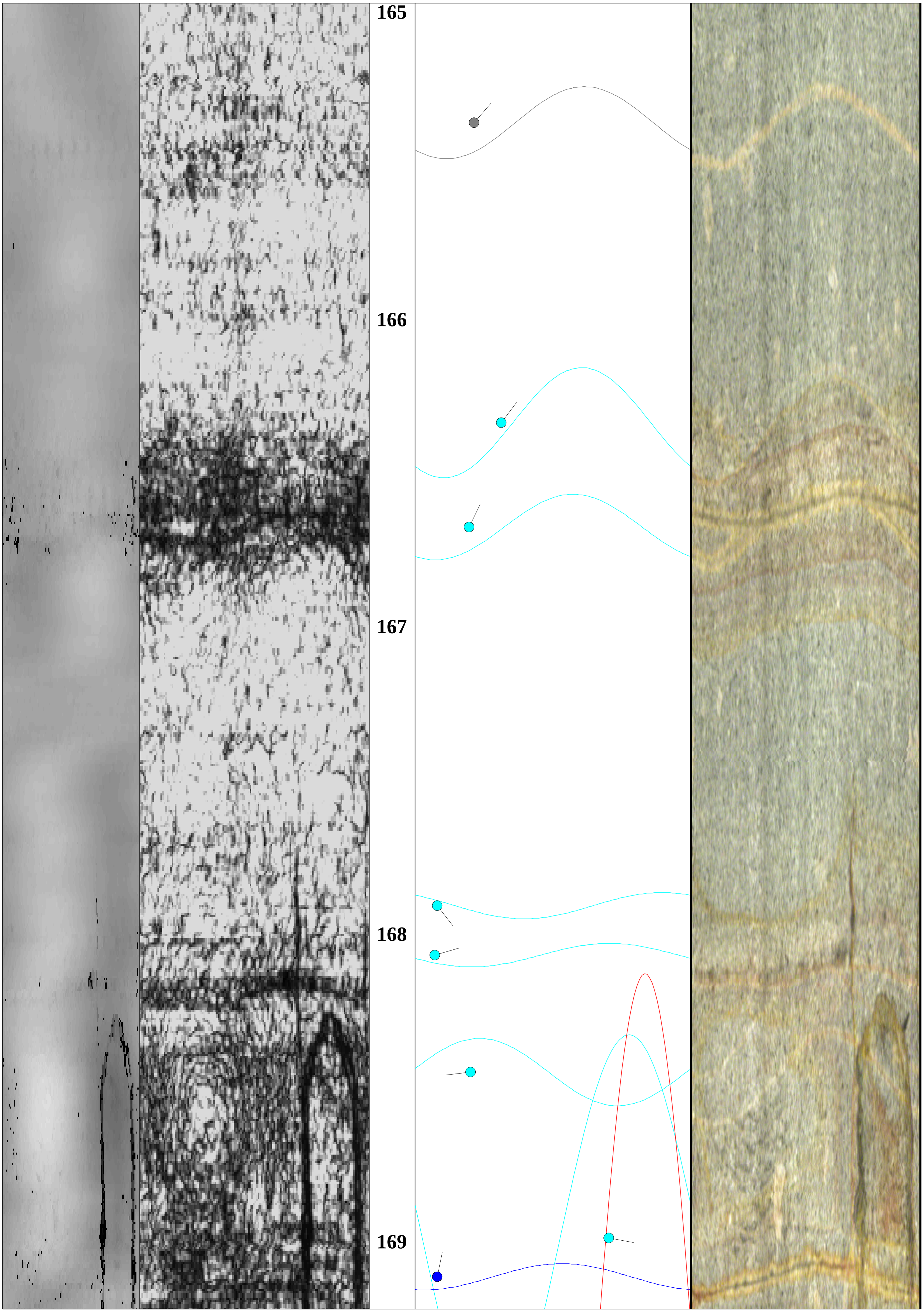

144
145
146
147

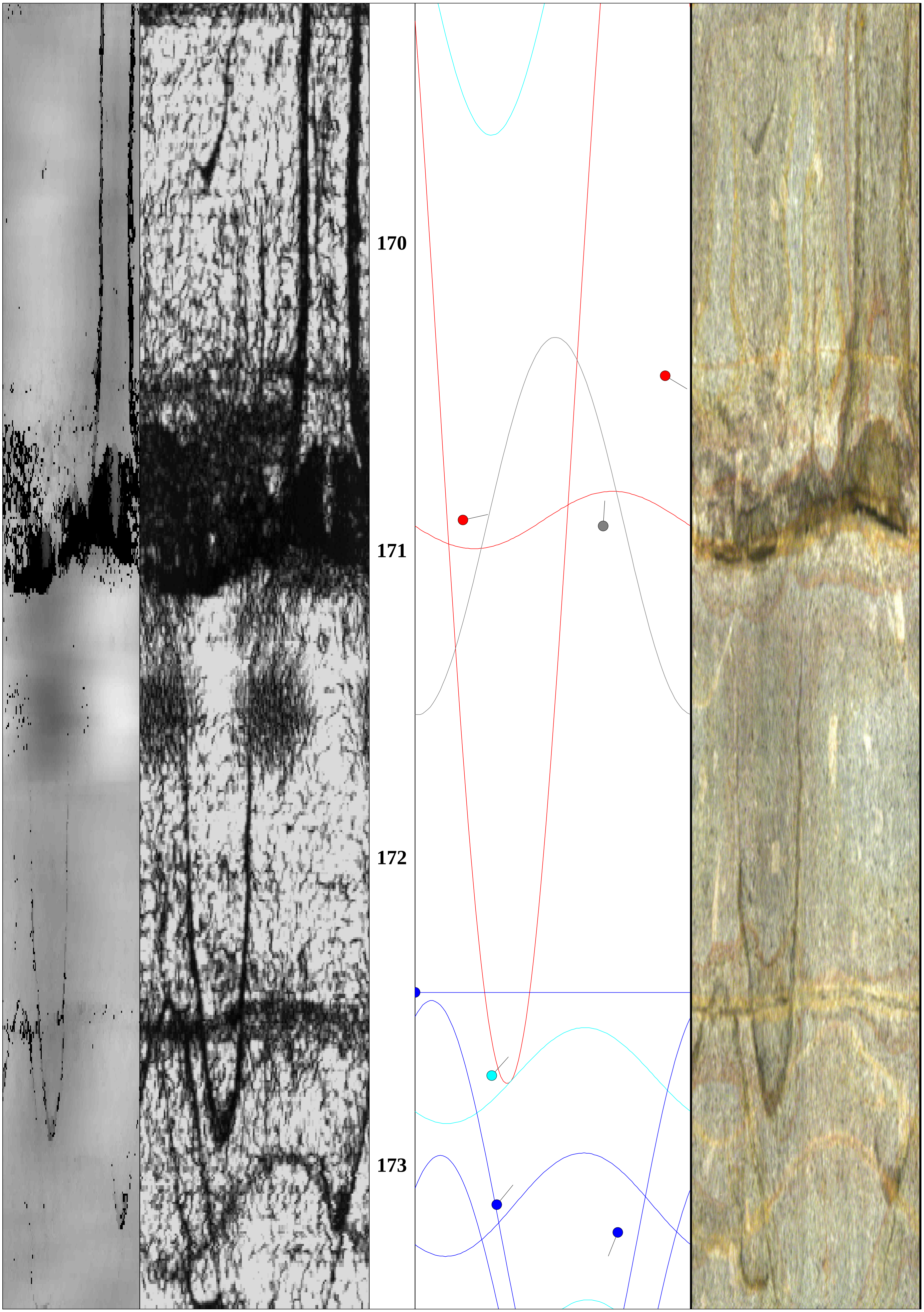

148
149
150
151
152

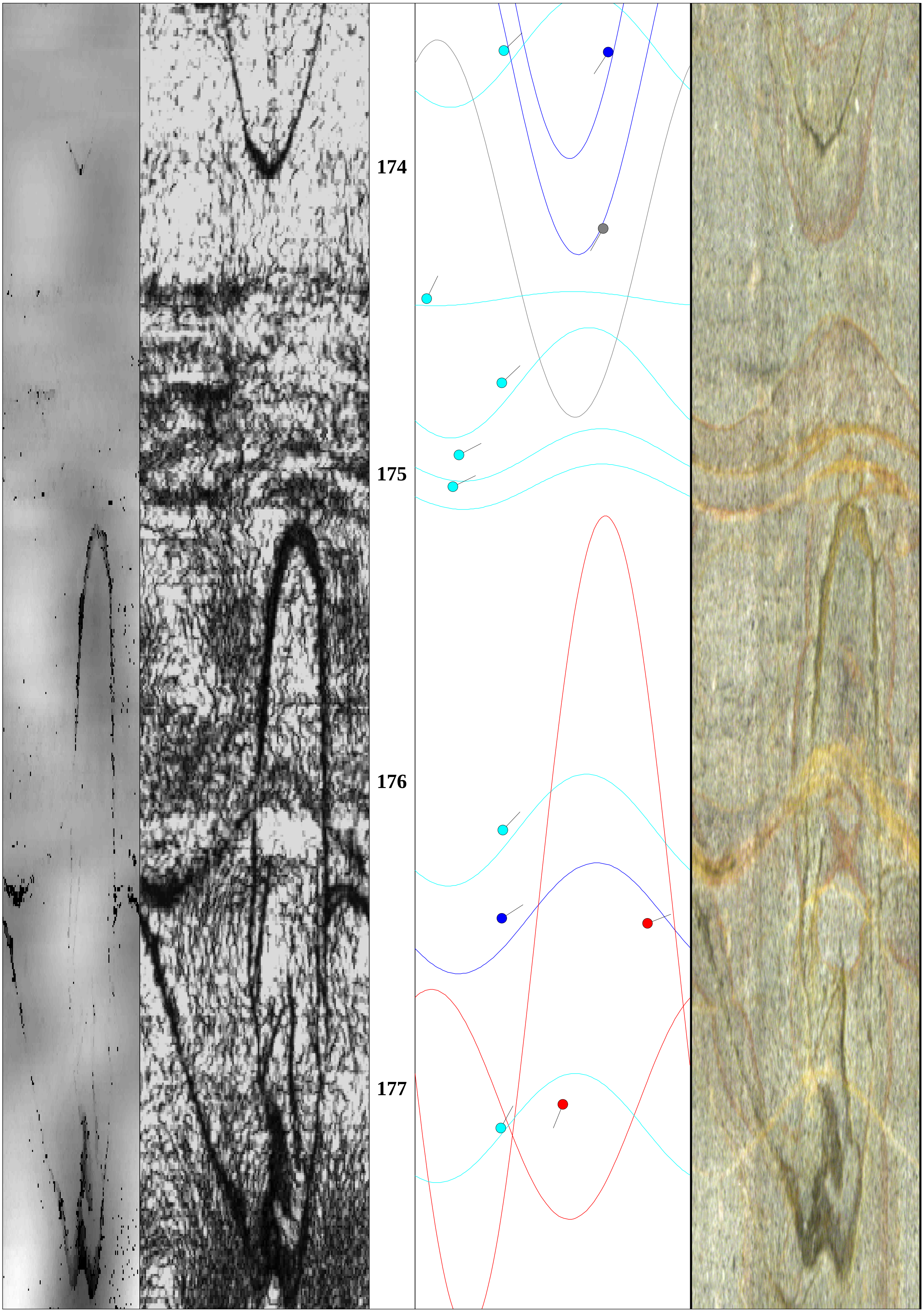

153
154
155
156

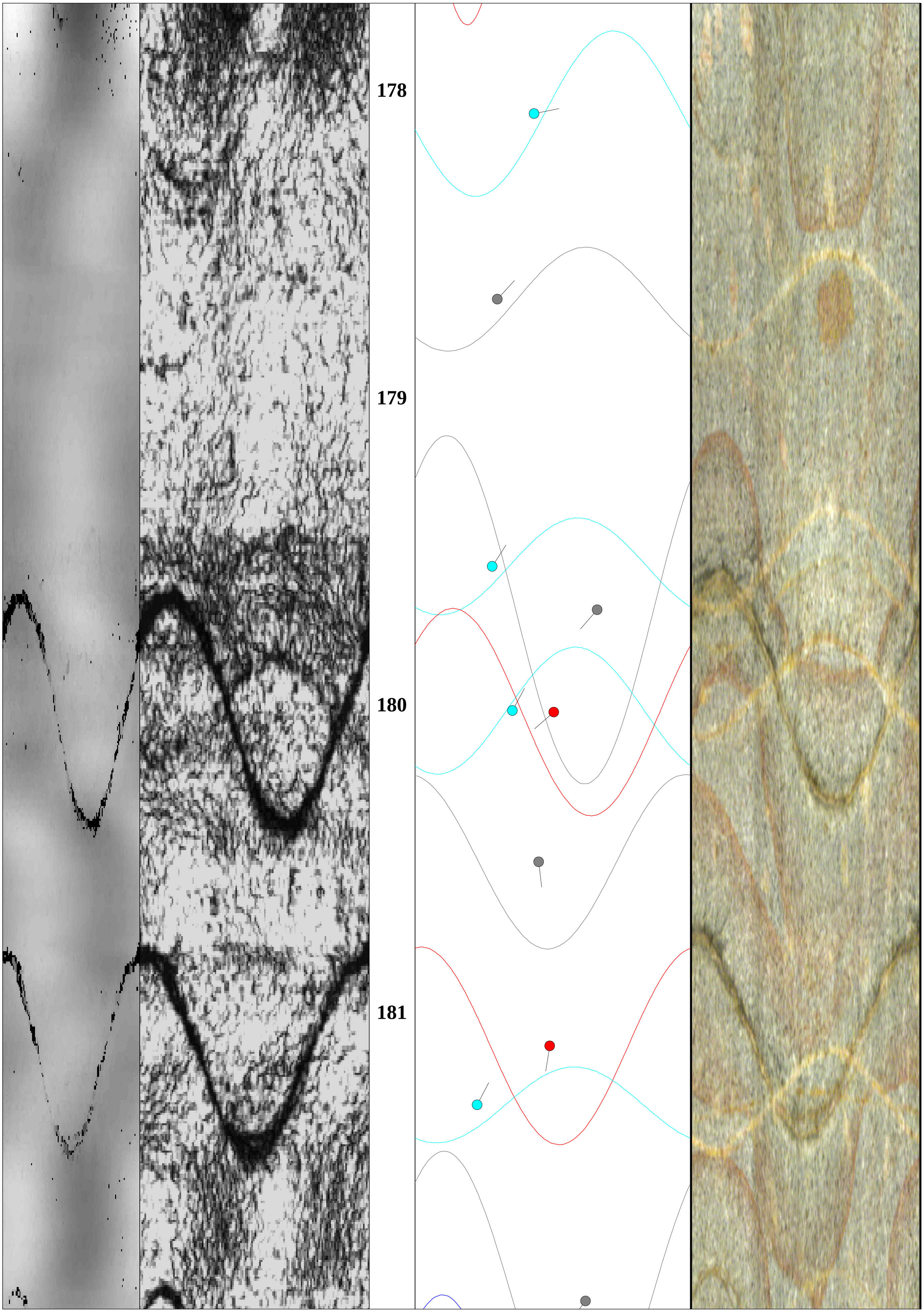

157
158
159
160

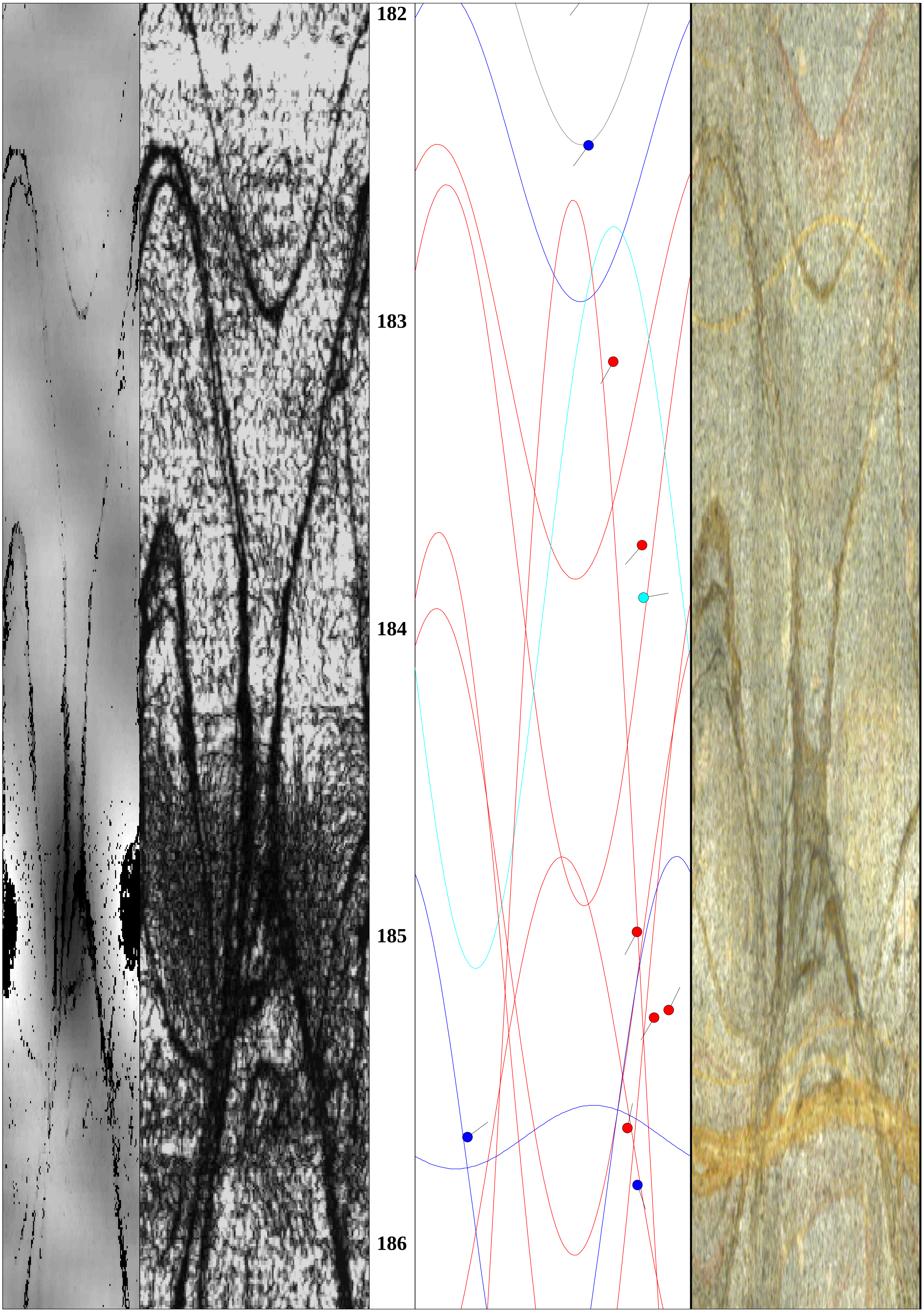

161
162
163
164

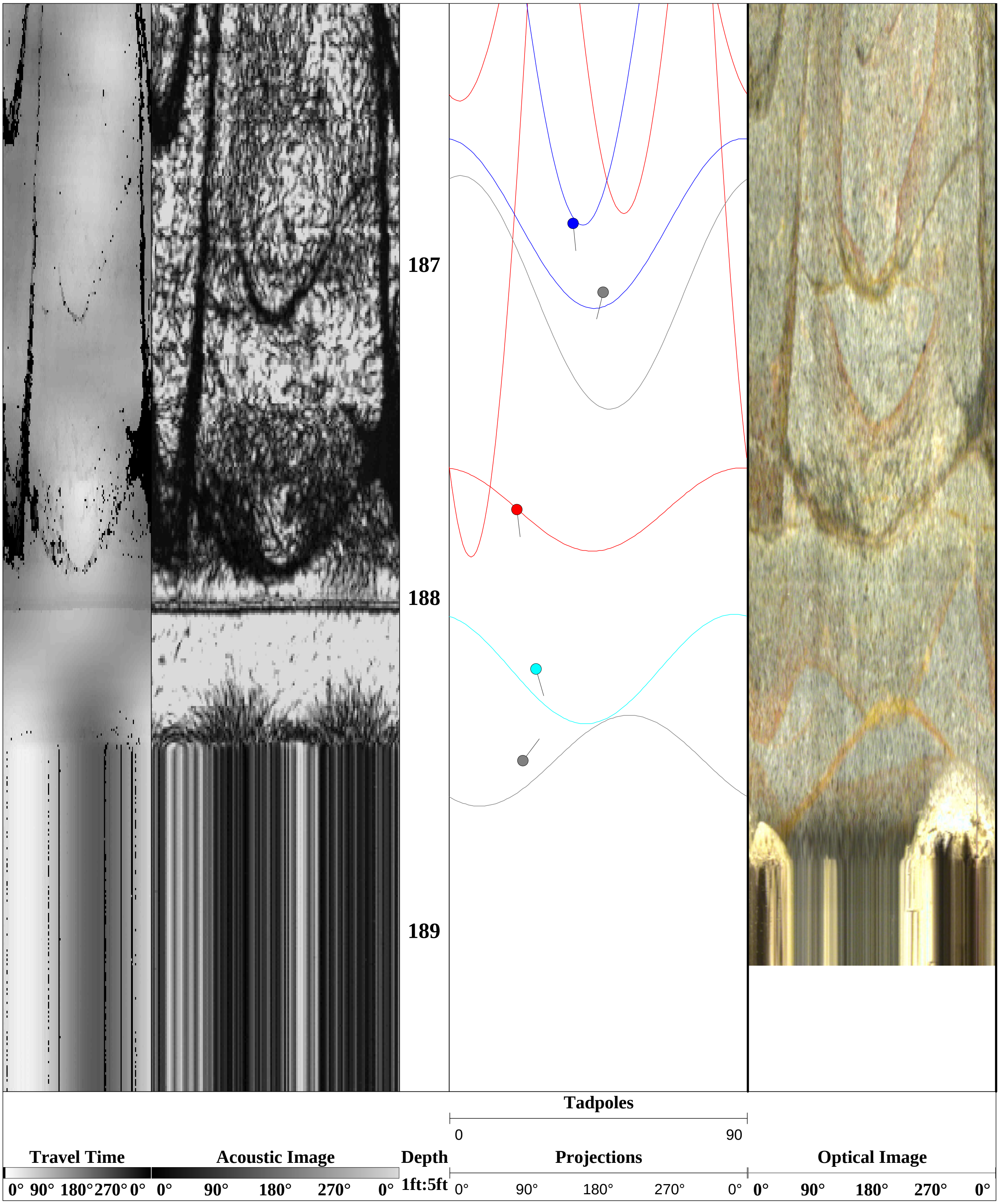

165
166
167
168
169


170
171
172
173

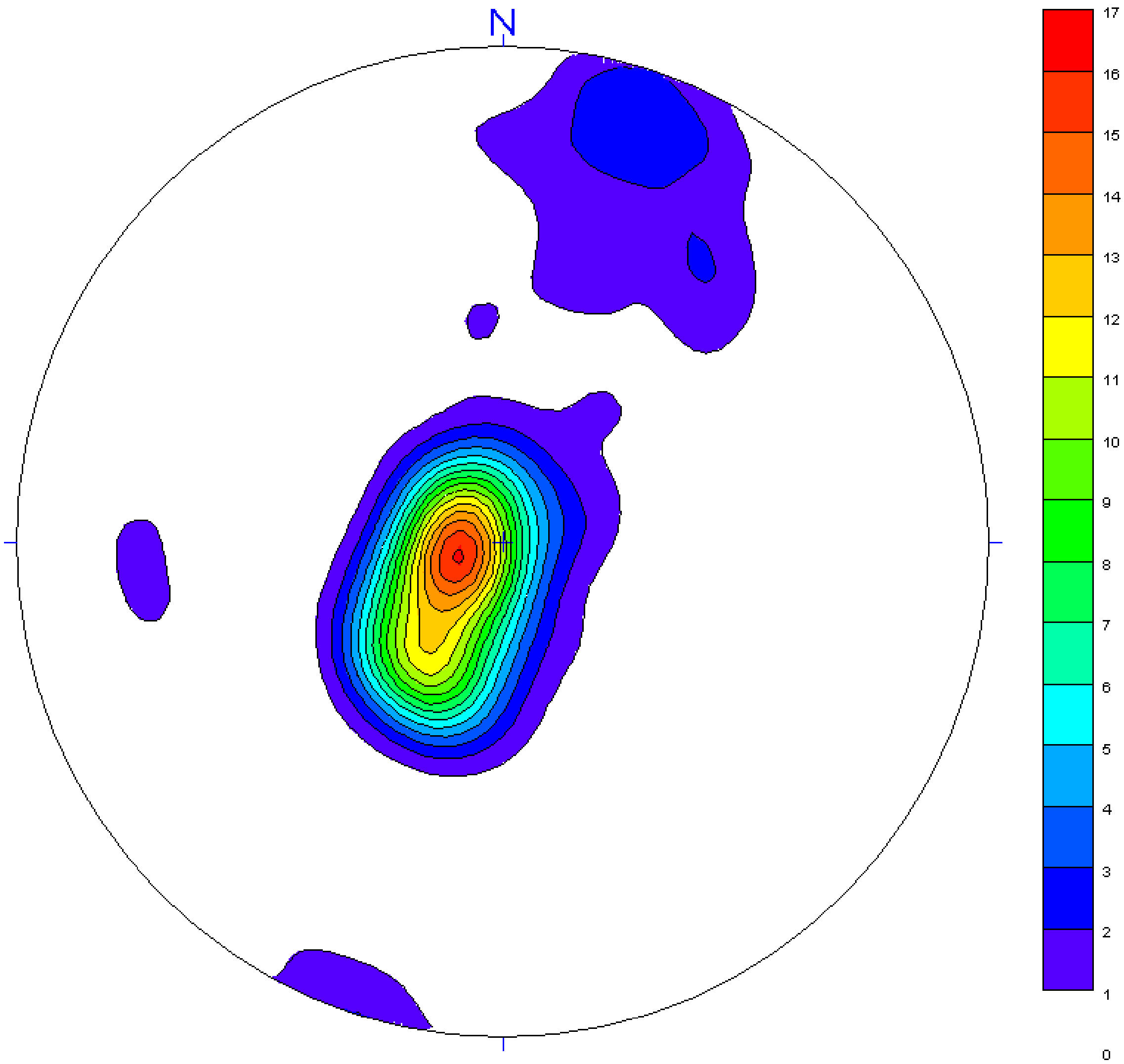

174
175
176
177


178
179
180
181


182
183
184
185
186

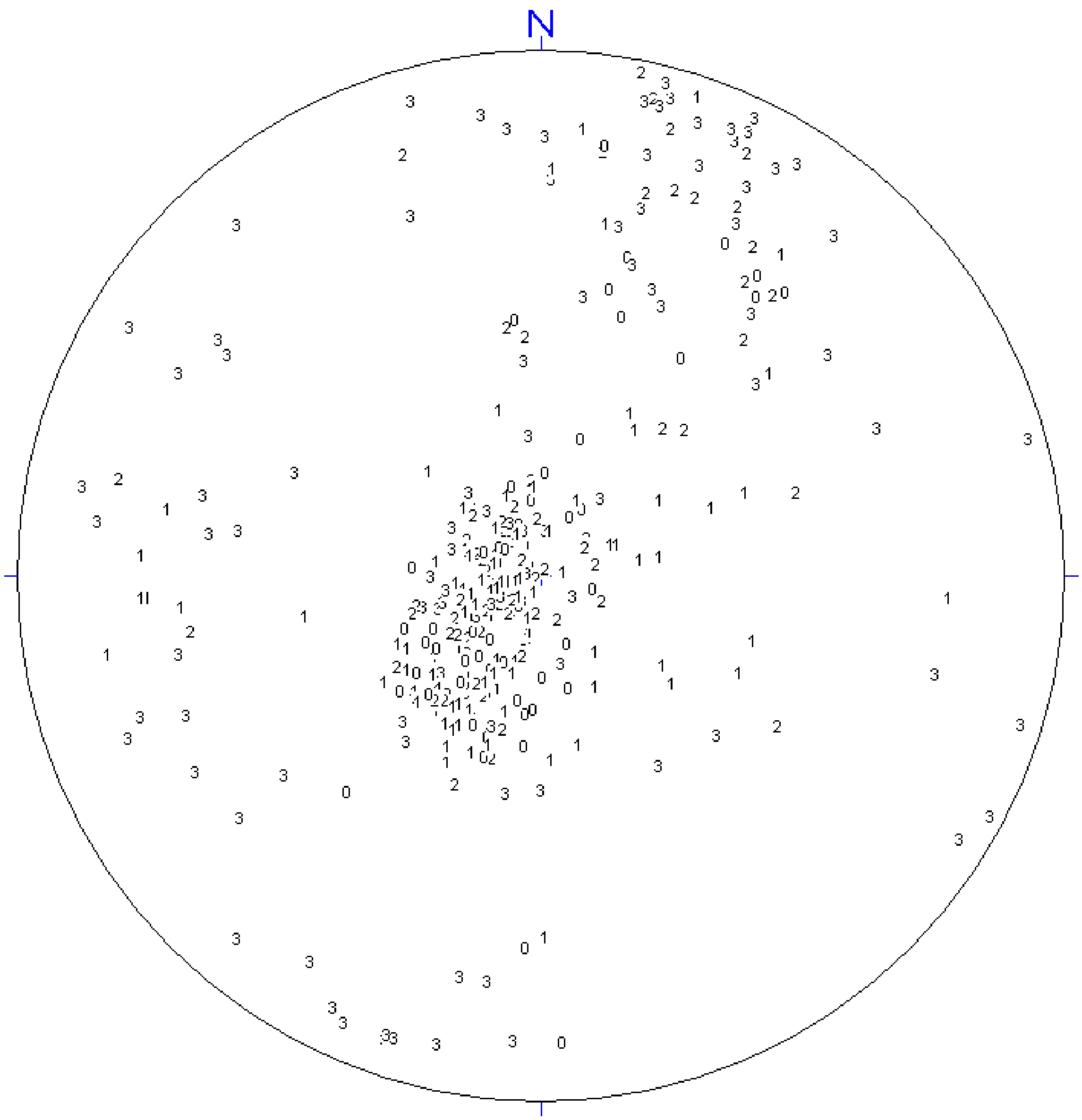

187
188
189
Tadpoles
0
90
Travel Time
Acoustic Image
Depth
Projections
Optical Image
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°
1ft:5ft
0° 90° 180° 270° 0°
0° 90° 180° 270° 0°

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n6
NNSA/NSO
20 Sept 2010



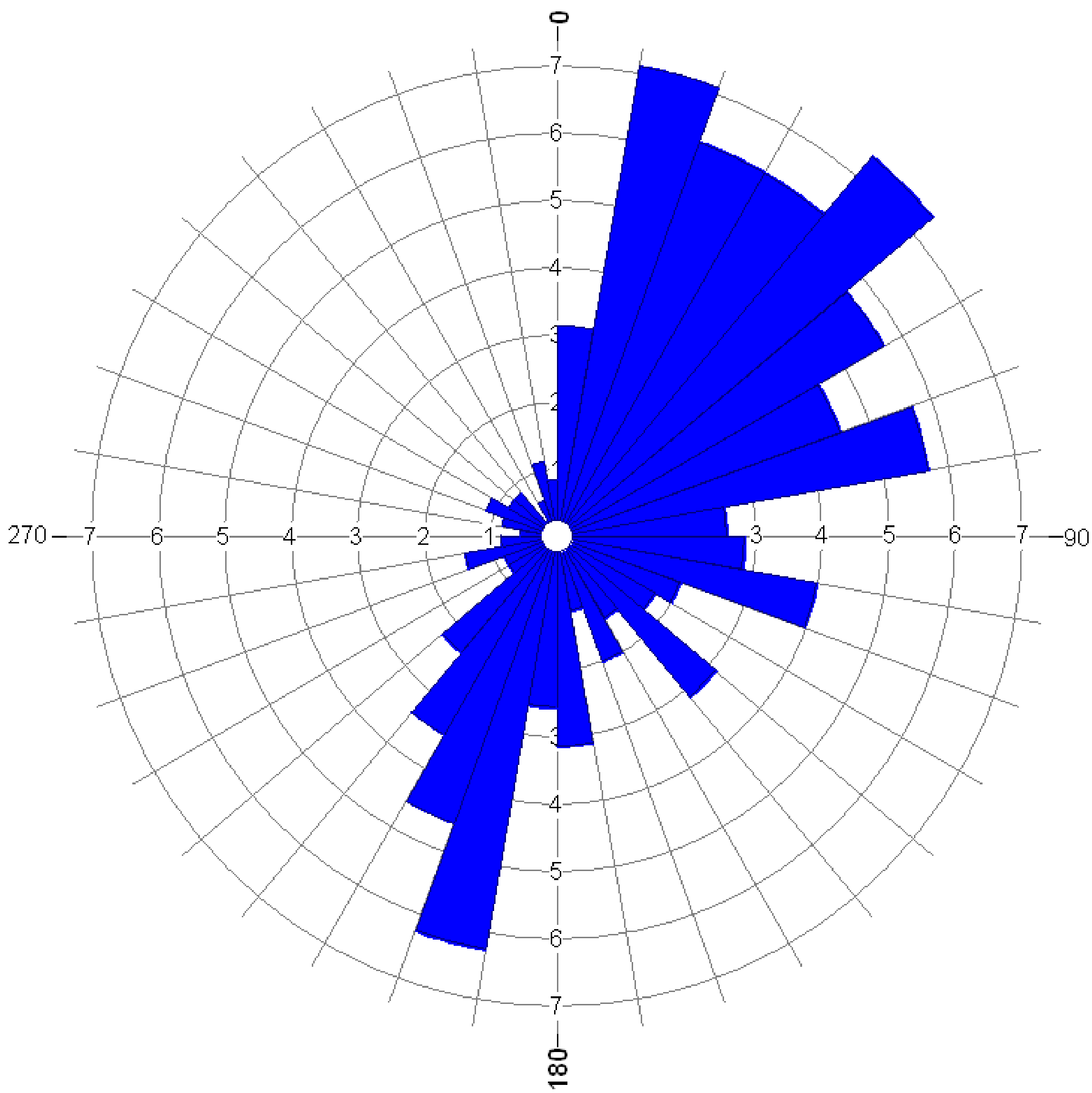
All directions are with respect to True North.

Stereonet Diagram – Schmidt Projection
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n6
NNSA/NSO
20 Sept 2010



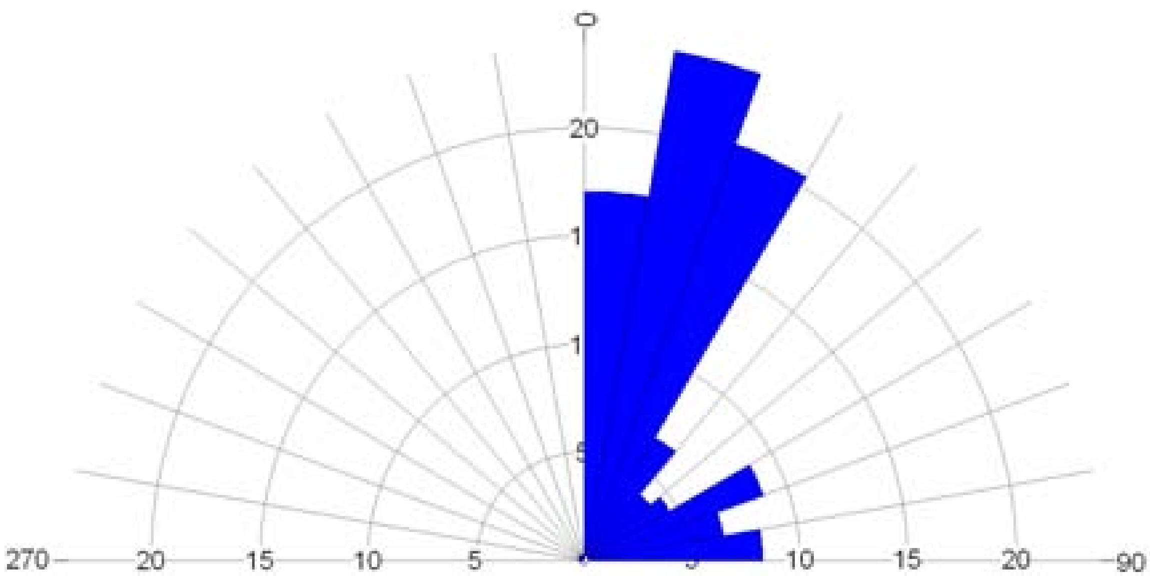
All directions are with respect to True North.

Rose Diagram – Dip Directions
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n6
NNSA/NSO
20 Sept 2010



All directions are with respect to True North.

Rose Diagram – Dip Angles
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15n6
NNSA/NSO
20 Sept 2010



All directions are with respect to True North.

Company	NNSA/NSO
Well	U-15N#6
Field	NNSS
County	Nye
State	Nevada

COLOG — Borehole Geophysics & Hydrophysics — A Division of Layne Christensen Company

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Full-Waveform Sonic

COMPANY	NNSA/NSO		
WELL	U-15N#6		
FIELD	Nevada National Security Site		
COUNTY	Nye	**STATE**	Nevada

LOCATION
Area 15 (L/O)
N: 900131.82
E: 676603.88

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Acoustic Televiewer
Optical Televiewer
Dual-Spaced Density
Caliper
Natural Gamma
Deviation
Video

PERMANENT DATUM G.L. **ELEVATION** 5005.10

LOG MEAS. FROM G.L. 0.0 ft **ABOVE PERMINANT DATUM**

DRILLING MEAS. FROM G.L.

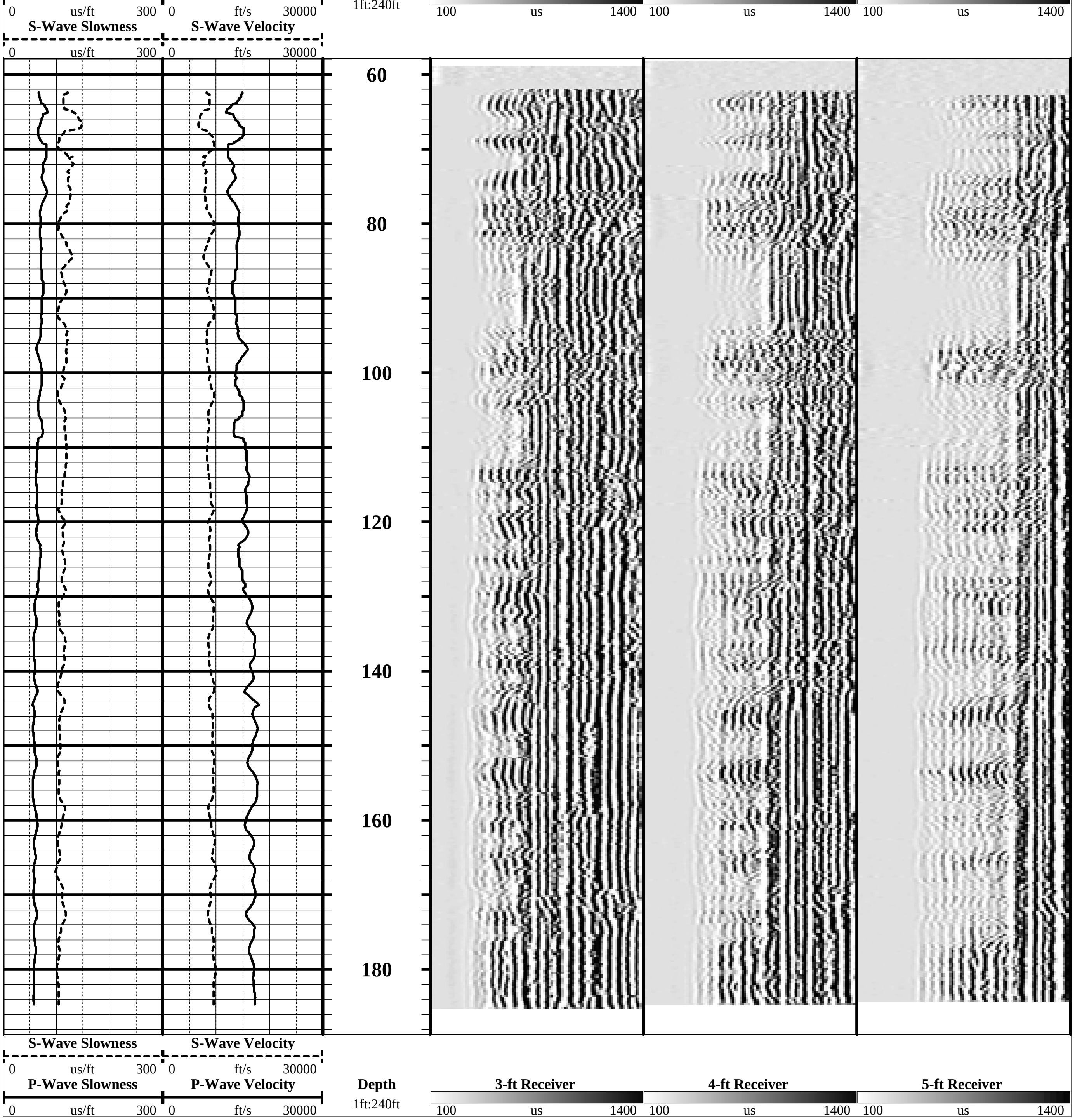
DATE ACQUIRED	20 Sept 2010			
RUN NUMBER	5			
LOG TYPE	Full Waveform Sonic			
DEPTH-DRILLER	190'			
DEPTH-LOGGER	189.0'			
BTM LOG INTERVAL	189.0'			
TOP LOG INTERVAL	62.2'			
RECORDED BY	E. Eaton			
WITNESSED BY	C.Obi			
PROBE TYPE, S/N	2SAA-F, 2656			
LOGGING SPEED	5 ft/min			
A.S.D.E.	0.4'			
SAMPLE INTERVAL	0.1'			

BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
1	12.25"	Surf	7'	10"		-1.0'	6.5'
2	8"	70	190'				

COMMENTS

NA - Not Available, N/A - Not Applicable

P-Wave Slowness	P-Wave Velocity	Depth	3-ft Receiver	4-ft Receiver	5-ft Receiver


1ft:240ft
0 us/ft 300
0 ft/s 30000
100 us 1400
100 us 1400
100 us 1400
S-Wave Slowness
S-Wave Velocity
0 us/ft 300
0 ft/s 30000
60
80
100
120
140
160
180
S-Wave Slowness
S-Wave Velocity
0 us/ft 300
0 ft/s 30000
P-Wave Slowness
P-Wave Velocity
Depth
1ft:240ft
3-ft Receiver
4-ft Receiver
5-ft Receiver
0 us/ft 300
0 ft/s 30000
100 us 1400
100 us 1400
100 us 1400

Borehole Deviation

810 Quail St. Suite E
Lakewood, Colorado
80215
Office: 303.279.0171
FAX: 303.278.0135
www.colog.com

Company NNSA/NSO
Well U-15N#6
Field NNSS
County Nye
State Nevada

COMPANY NNSA/NSO
WELL U-15N#6
FIELD Nevada National Securities Site
COUNTY Nye **STATE** NV

LOCATION
Area 15 (L/O)
N: 900131.82
E: 676603.88

QTR **SEC** **TWP** **RGE**

OTHER SERVICES
Optical Televiewer
Acoustic Televiewer
Dual Spaced Density
Caliper
Natural Gamma
Full Waveform Sonic
Video

PERMANENT DATUM Ground Level **ELEVATION** 5005.10

LOG MEAS. FROM Ground Level 0.0 ft **ABOVE PERMINANT DATUM**

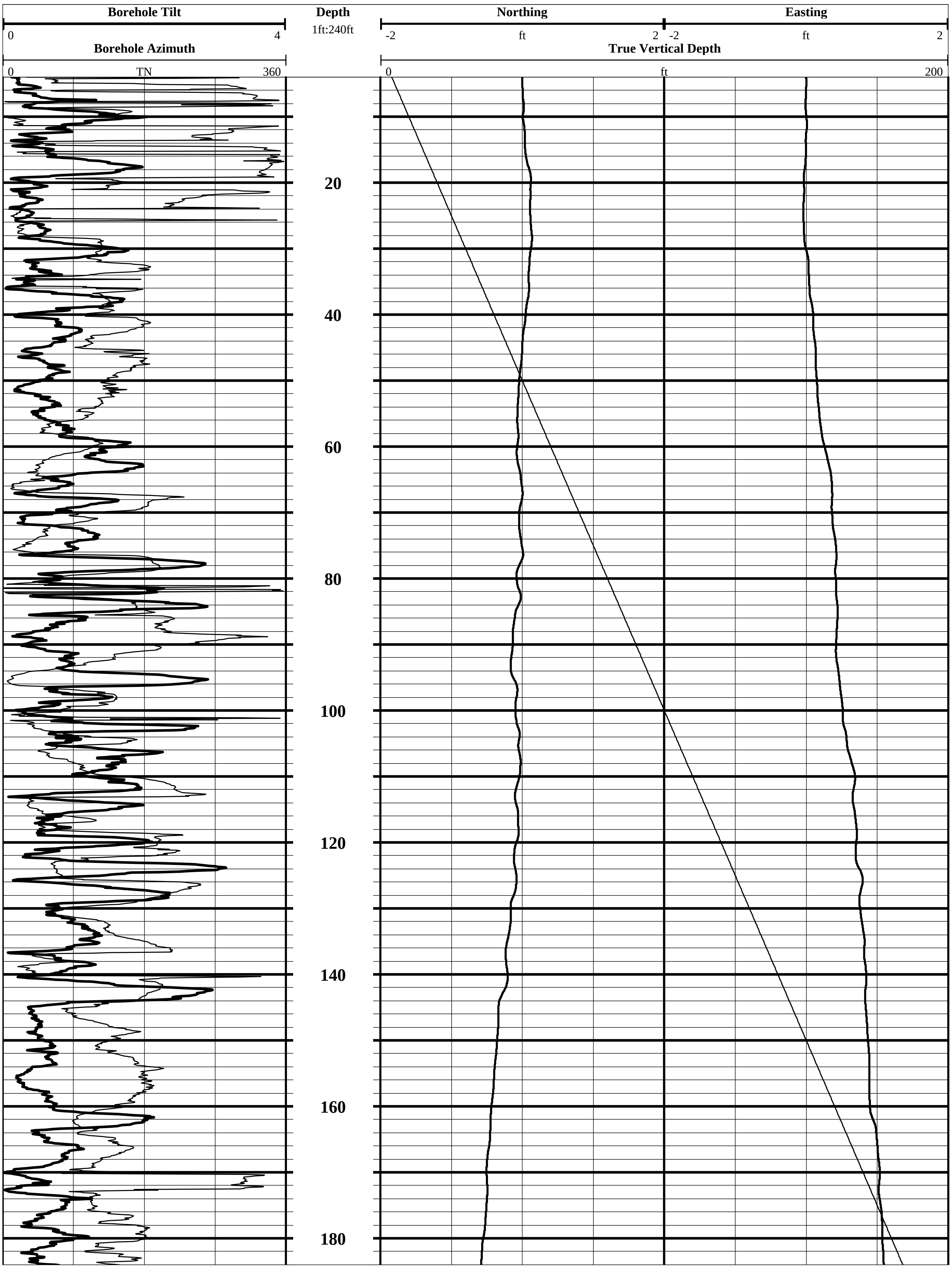
DRILLING MEAS. FROM

DATE ACQUIRED	20 Sept 2010			
RUN NUMBER	ONE			
LOG TYPE	Borehole Deviation			
DEPTH-DRILLER	190'			
DEPTH-LOGGER	189'			
BTM LOG INTERVAL	189'			
TOP LOG INTERVAL	4			
RECORDED BY	E.Eaton			
WITNESSED BY	G Juniel			
PROBE TYPE, S/N	OBI40, 23902			
LOGGING SPEED	3.5 ft/min			
A.S.D.E.	0.47 ft			
SAMPLE INTERVAL	0.0041 ft			

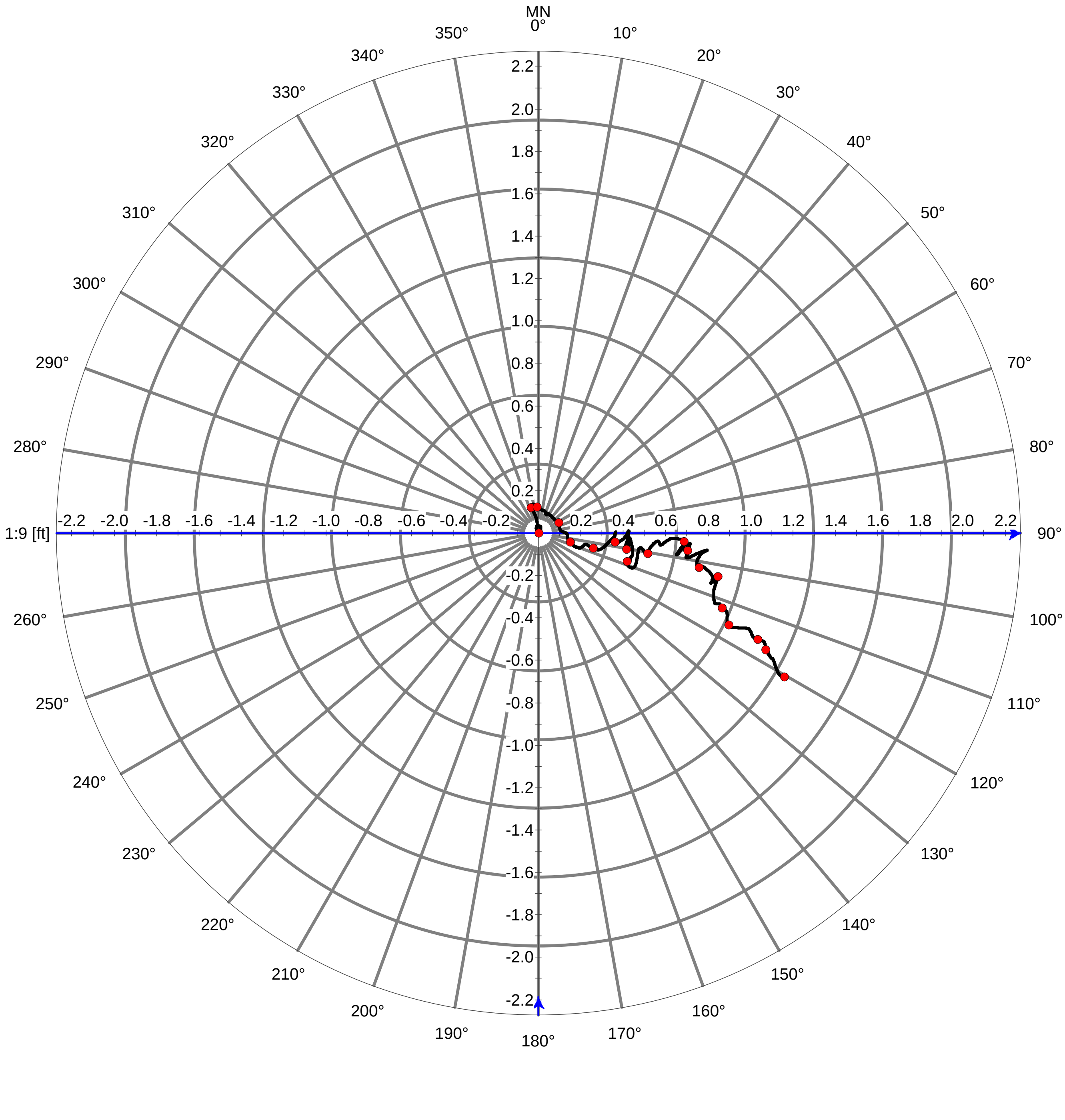
BOREHOLE RECORD				**CASING RECORD**			
RUN No.	**BIT**	**FROM**	**TO**	**SIZE**	**WGT.**	**FROM**	**TO**
	12.25"	Surface	7	10"		-1	6.5
	8"	10	190				

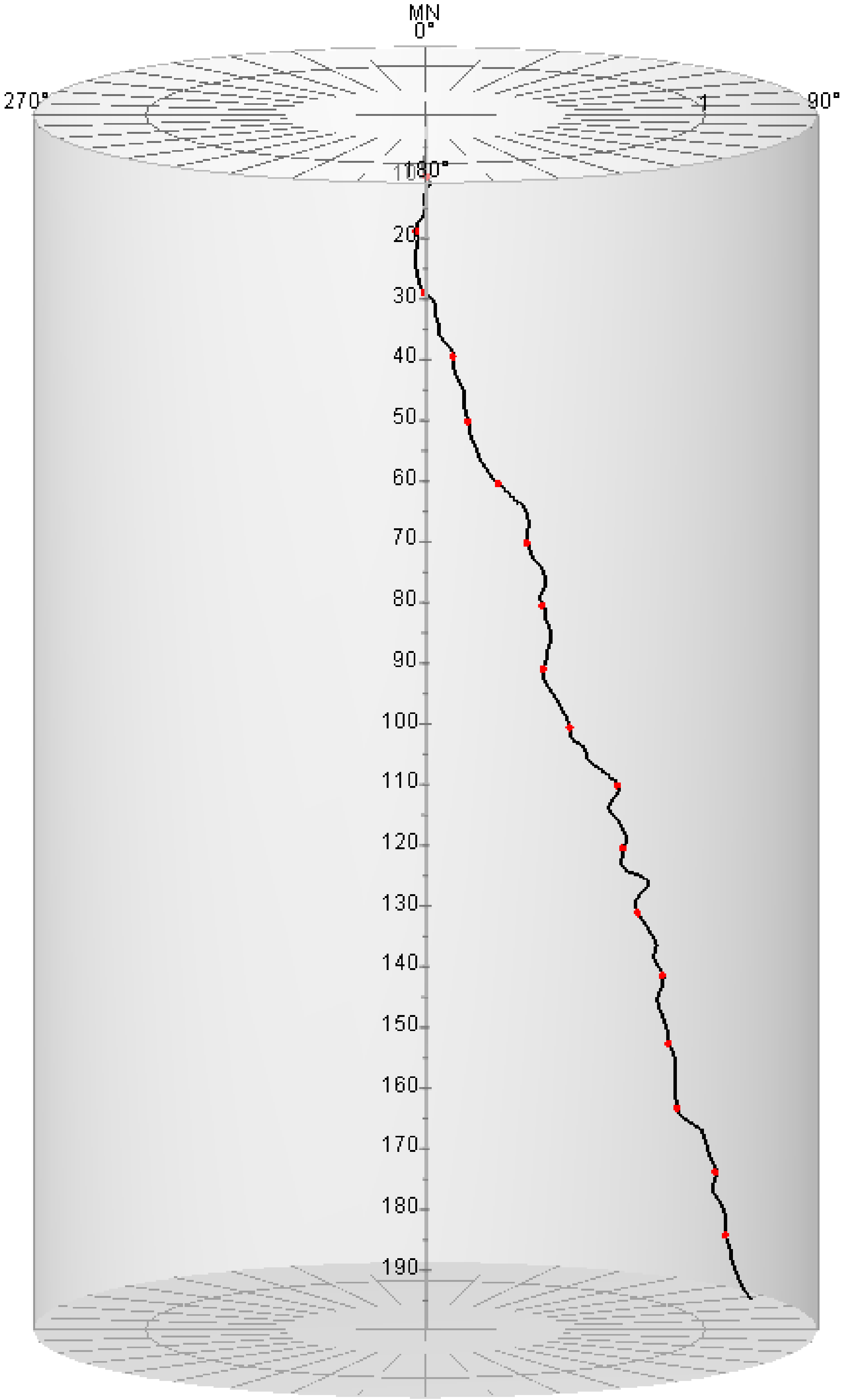
COMMENTS

NA - Not Available, N/A - Not Applicable



Borehole Tilt
0
4
Borehole Azimuth
0
TN
360
Depth
1ft:240ft
20
40
60
80
100
120
140
160
180
Northing
-2
ft
2
Easting
-2
ft
2
True Vertical Depth
0
ft
200


MN
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
1:9 [ft]
-2.2 -2.0 -1.8 -1.6 -1.4 -1.2 -1.0 -0.8 -0.6 -0.4 -0.2 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2
2.2 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 -0.2 -0.4 -0.6 -0.8 -1.0 -1.2 -1.4 -1.6 -1.8 -2.0 -2.2



MN
0°
270°
90°
180°
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190

APPENDIX G

Phase 1 Mechanical Testing Results on Core from Borehole U-15n, Nevada National Security Site, in Support of NCNS Source Physics Experiment

By

Scott Broome and Tom Pfeifle
Sandia National Laboratories

June 8, 2011

Sandia National Laboratories

Scott T. Broome
Member of the Technical Staff
Geomechanics Department 6914

Albuquerque, NM 87185-1033
Phone: (505) 845-0541
Fax: (505) 284-5756
e-mail:stbroom@sandia.gov

date: June 8, 2011

to: Aviva Sussman, Christopher Bradley, Wendee Brunish (LANL), Tarabay Antoun (LLNL), Margaret Townsend (NSTec), Dennis Barker (NSTec)

from: Scott Broome, Tom Pfeifle (SNL, 06914)

Subject: **Phase 1 mechanical testing results on core from borehole U-15n, Nevada National Security Site, in support of NCNS Source Physics Experiment**

Background

The Nevada National Security Site (NNSS) will serve as the geologic setting for a Source Physics Experiment (SPE) program. The SPE will provide ground truth data to create and improve strong ground motion and seismic S-wave generation and propagation models. The NNSS was chosen as the test bed because it provides a variety of geologic settings ranging from relatively simple to very complex.

Each series of SPE testing will comprise the setting and firing of explosive charges (source) placed in a central bore hole at varying depths and recording ground motions in instrumented bore holes located in two rings around the source positioned at different radii. Modeling using advanced simulation codes will be performed both *a priori* and after each test to predict ground response and to improve models based on acquired field data, respectively.

A key component in the predictive capability and ultimate validation of the models is the full understanding of the intervening geology between the source and the instrumented bore holes including the geomechanical behavior of the site rock/structural features. This memorandum reports on a limited scope of work for an initial phase of primarily unconfined compression testing.

Samples tested came from the U-15n core hole, which was drilled in granitic rock (quartz monzonite). The core hole was drilled at the location of the central SPE borehole, and thus represents material in which the explosive charges will be detonated. The U-15n location is the site of the first SPE, in Area 15 of the NNSS.

Sample Preparation and Experimental Methods

Specimen Preparation: Test specimens (right circular cylinders) were prepared from the 2.5-in-dia field core by cutting them to approximate length using a standard rock saw and then grinding the ends flat and parallel to final length such that the length-to-diameter ratio, L:D, on each test specimen is 2:1. Both the sawing and the grinding used standard tap water for cooling. All specimen dimensions were sized to provide representative results given the maximum grain size of this granite ranges from 0.5-6.35 mm (0.02-0.25 in). Phenocrysts in small quantities were observed along the core length and are as large as ~25.4 mm across. The dimensions and mass of each specimen were accurately measured. Field cores used in preparing the test specimens were selected from approximately every 20-foot interval of U-15n and had a useable length of approximately 6-7 inches so that the 5-inch-long specimens were prepared with sufficient material available near one end of each core to obtain thin sections and/or thicker billets of untested rock.

Calibration: Annual calibration of the load cell used to calculate unconfined compressive strength (UCS) is traceable to the U.S. National Institute of Standards and Technology. For all UCS tests, two strain gages were bonded at sample mid-height 180° apart. A shakedown test was performed with a right circular steel specimen (4340 steel) instrumented with the same strain gages as those used on the SPE granite samples prior to any SPE UCS testing. The shake down test verified that all components of the test system were functioning correctly by ensuring measured properties (Young's modulus and Poisson's ratio) matched those published for 4340 steel.

Bulk Density Determination: The bulk density of each UCS test specimen was determined from its mass and volume where volume is calculated using dimensional measurements assuming a right-circular-cylindrical geometry.

Unconfined Compressive Strength (UCS) Testing: UCS tests were performed on granite specimens prepared from field cores recovered from approximately every 20-foot interval of U-15n. Using this strategy, tests were run on what is thought to be both weathered and fresh granite to determine if there are differences in mechanical properties over the entire core hole depth (~200 ft). All specimens were instrumented to measure axial stress and axial and radial strains and were loaded quasi-statically in compression (axial strain rate of $\sim 1 \times 10^{-4}$/sec) under ambient pressure and temperature conditions. Loading continued until the peak axial stress (i.e., the UCS strength) was observed. All samples were loaded to failure. However during loading, unload/reload cycles were performed at various axial stress levels to acquire data to estimate the compressive elastic properties – Young's modulus, E_c, and Poisson's ratio, v_c.

Compressional and Shear Wave Velocity Measurements: Ultrasonic compressional and shear wave velocity measurements, V_p and V_s, were performed on each UCS specimen under ambient conditions prior to UCS testing. Wave speed measurements were made coincident with each specimen axis and also orthogonal to the axis across two diameters separated by 90°.

Experimental Results

Table 1 lists the results from the unconfined compressive strength tests for borehole U-15n. Included in Table 1 are the sample number, depth, density, maximum axial stress (i.e., UCS strength), Young's modulus, Poisson's ratio and failure mode. Elastic properties were determined from the average of the unload portion of two unload/reload loops performed while the sample was loaded at a constant axial strain rate of ~1E-04. Elastic properties for Sample SPE-UCS-5 were averaged from the slope during initial loading and one unload/reload cycle. Only one strain gage was used for the unload/reload cycle for this sample because the other strain gage had started to fail producing erratic data. This sample failed at the lowest stress and was from a highly altered zone adjacent to a fault. The failure mode for all samples was intact except for SPE-UCS-10. The failure mode for this sample was primarily along a pre existing weakness plane with a failure surface angle of ~79° where 0° is perpendicular to the core axis. Samples with an intact failure mode nominally failed at angles between 70° to 80° resulting in a fairly intact cone on either end of the sample.

Table 1. Sample #, Depth, Density, UCS Strength, Young's modulus, Poisson's Ratio and Failure Mode for U-15n

Sample	Depth (ft)	Density (g/cc)	$\sigma_{AX,MAX}$ (MPa)	E (GPa)	ν	Failure Mode[1]
SPE-UCS-1	14	2.65	235.6	75.94	0.254	Intact
SPE-UCS-2*	29	2.61	121.1	56.28	0.248	Intact
SPE-UCS-3	50	2.64	226.5	77.63	0.236	Intact
SPE-UCS-4	70	2.63	184.3	64.26	0.245	Intact
SPE-UCS-5**	87	2.55	41.6	35.07	0.16	Intact
SPE-UCS-6	108	2.64	210.2	70.28	0.218	Intact
SPE-UCS-7	132	2.63	205.4	76.4	0.201	Intact
SPE-UCS-8	154	2.64	192.8	75.67	0.232	Intact
SPE-UCS-9	177	2.64	227.8	77.79	0.24	Intact
SPE-UCS-10	192	2.65	165.8	76.38	0.22	Intact/Fracture

[1] Intact failure mode indicates failure through intact material rather than along planes of weakness

*Sample designated as weathered granite

**Sample from a highly altered zone adjacent to a fault. Elastic properties determined from initial loading and one unload/reload loop from one strain gage near failure

Sample SPE-UCS-9 had a chip on the top edge (Figure 1). It was decided to test the sample with the chip rather than cut it shorter and violate the 2:1 length-to-diameter ratio criterion. This sample failed at the highest stress and thus the chip was not likely to have significantly altered the UCS strength. Figure 2 shows a typical sample, complete with strain gages, mounted in the 5 MN load frame. The plastic curtain surrounding the loading platens ensured most tested pieces of the sample could be retained in the event of catastrophic failure. Plots of Engineering Axial Stress versus Axial, Lateral, and Volume strain for all ten UCS tests are presented at the end of this report. For these plots, volumetric strain is calculated from the axial and radial strains, i.e., $\varepsilon_v = \varepsilon_{ax} + 2\varepsilon_{rad}$.

Tables 2, 3 and 4 list the results from ultrasonic compressional and shear wave velocity measurements taken coincident with each specimen axis and also orthogonal to the axis across two diameters separated by 90° respectively. The S Wave parallel to the core axis for sample

SPE-UCS-3 was ambiguous and ν dynamic is not reported. Figure 3 shows a typical voltage versus time plot used to determine P and S wave velocities.

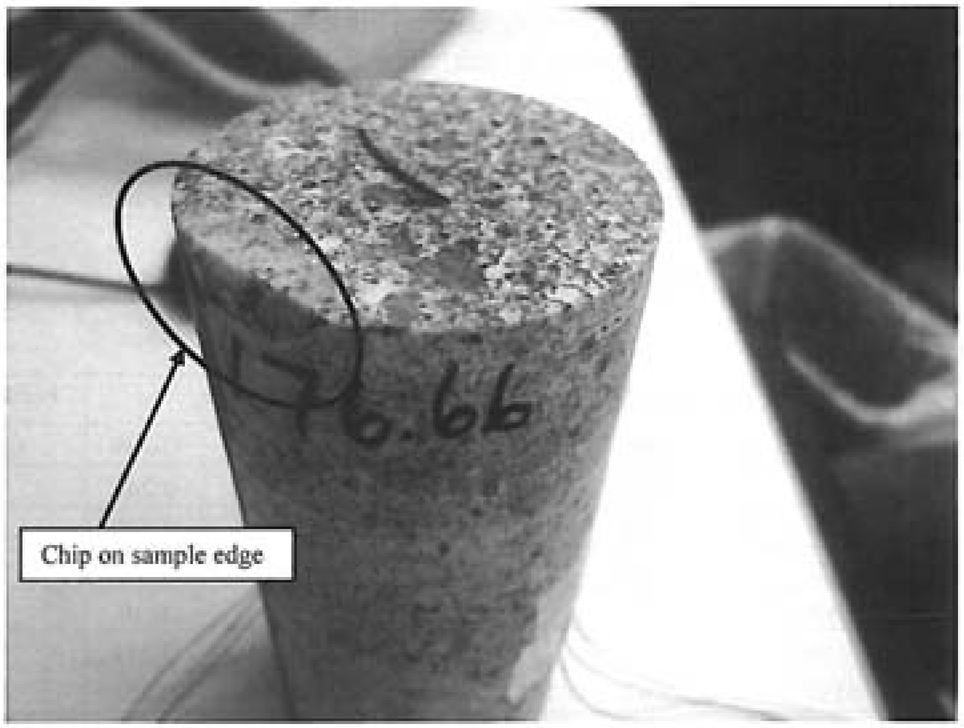


Figure 1. Sample SPE-UCS-9 with a chip on the top edge.

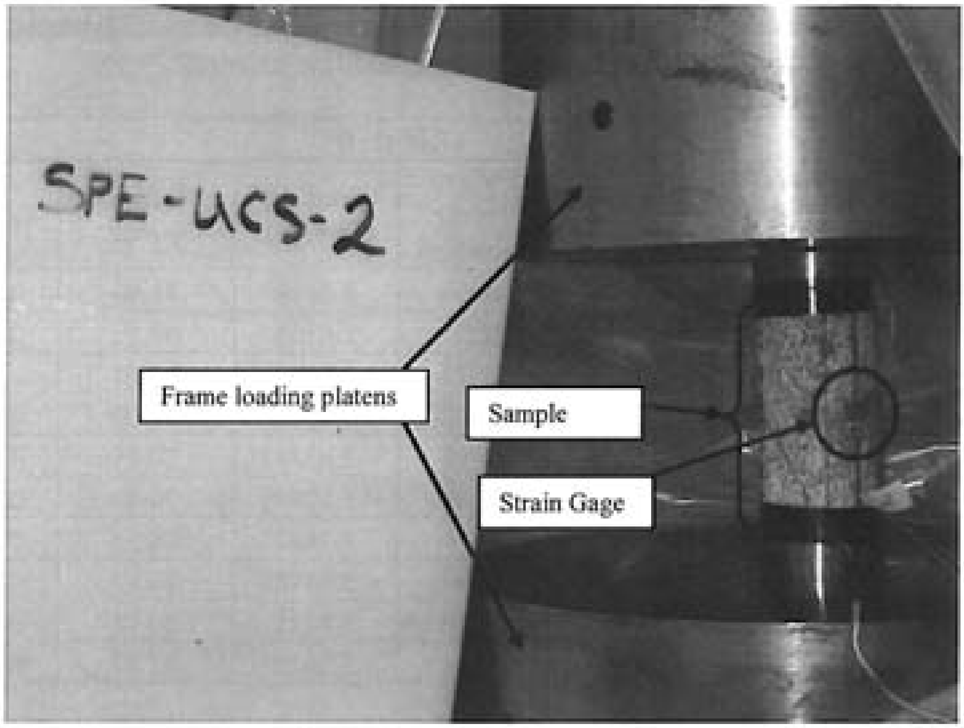


Figure 2. Sample SPE-UCS-2 mounted in load frame.

Table 2. P- and S-wave travel time and velocity and calculated values of dynamic *E* and *ν* along core axis

	Axial					
Sample #	P Wave Travel Time (µs)	P-Velocity (mm/µs)	S-Wave Travel Time (µs)	S-Velocity (mm/µs)	$E_{Dynamic}$ (GPa)	$\nu_{Dynamic}$
SPE-UCS-1	22.02	5.8344	37.24	3.4325	77.01	0.235
SPE-UCS-2	27.44	4.6883	43.36	2.9562	53.40	0.170
SPE-UCS-3*	21.19	6.1132	29.01	4.4499	97.94	N/A*
SPE-UCS-4	22.55	5.7025	36.55	3.5020	77.22	0.197
SPE-UCS-5	26.44	4.8752	40.59	3.1643	58.11	0.136
SPE-UCS-6	22.20	5.8016	36.36	3.5253	79.23	0.207
SPE-UCS-7	22.08	5.8195	36.53	3.5004	78.41	0.217
SPE-UCS-8	21.79	5.9275	37.26	3.4485	78.25	0.244
SPE-UCS-9	22.09	5.8879	38.43	3.3667	75.33	0.257
SPE-UCS-10	21.90	5.9079	36.03	3.5735	81.86	0.212

*For Axial direction on sample SPE-UCS-3, S Wave was ambiguous

Table 3. P- and S-wave travel time and velocity and calculated values of dynamic *E* and *ν* orthogonal to core axis (along red line on core)

	Radial - 0°					
Sample #	P-Wave Travel Time (µs)	P-Velocity (mm/µs)	S-Wave Travel Time (µs)	S-Velocity (mm/µs)	$E_{Dynamic}$ (GPa)	$\nu_{Dynamic}$
SPE-UCS-1	11.64	5.5804	18.96	3.3948	73.56	0.206
SPE-UCS-2	14.19	4.5381	22.54	2.8365	49.56	0.179
SPE-UCS-3	10.47	6.1757	17.73	3.6078	85.31	0.241
SPE-UCS-4	11.43	5.6718	18.32	3.5067	77.00	0.191
SPE-UCS-5	14.16	4.5552	21.81	2.9374	50.43	0.144
SPE-UCS-6	11.04	5.8819	18.35	3.5037	79.41	0.225
SPE-UCS-7	10.95	5.9386	17.2	3.7462	86.33	0.170
SPE-UCS-8	11.18	5.8110	18.14	3.5478	80.07	0.203
SPE-UCS-9	10.82	6.0165	16.88	3.8215	89.71	0.162
SPE-UCS-10	11.04	5.8960	18	3.5815	81.97	0.208

Table 4. P- and S-wave travel time and velocity and calculated values of dynamic *E* and *ν* orthogonal to core axis (perpendicular to red line on core)

	Radial - 90°					
Sample #	P-Wave Travel Time (µs)	P-Velocity (mm/µs)	S-Wave Travel Time (µs)	S-Velocity (mm/µs)	$E_{Dynamic}$ (GPa)	$\nu_{Dynamic}$
SPE-UCS-1	11.56	5.6199	18.56	3.4691	75.91	0.192
SPE-UCS-2	14.53	4.4299	22.8	2.8038	47.87	0.166
SPE-UCS-3	10.42	6.2061	17.6	3.6349	86.45	0.239
SPE-UCS-4	11.42	5.6768	18.78	3.4196	74.74	0.215
SPE-UCS-5	13.77	4.6868	21.3	3.0086	53.15	0.150
SPE-UCS-6	11.22	5.7852	18.74	3.4298	76.34	0.229
SPE-UCS-7	10.91	5.9609	18.46	3.4867	79.29	0.240
SPE-UCS-8	11.16	5.8217	18.51	3.4758	78.14	0.223
SPE-UCS-9	10.95	5.9433	17.14	3.7626	87.24	0.166
SPE-UCS-10	11.01	5.9125	17.25	3.7397	86.33	0.167

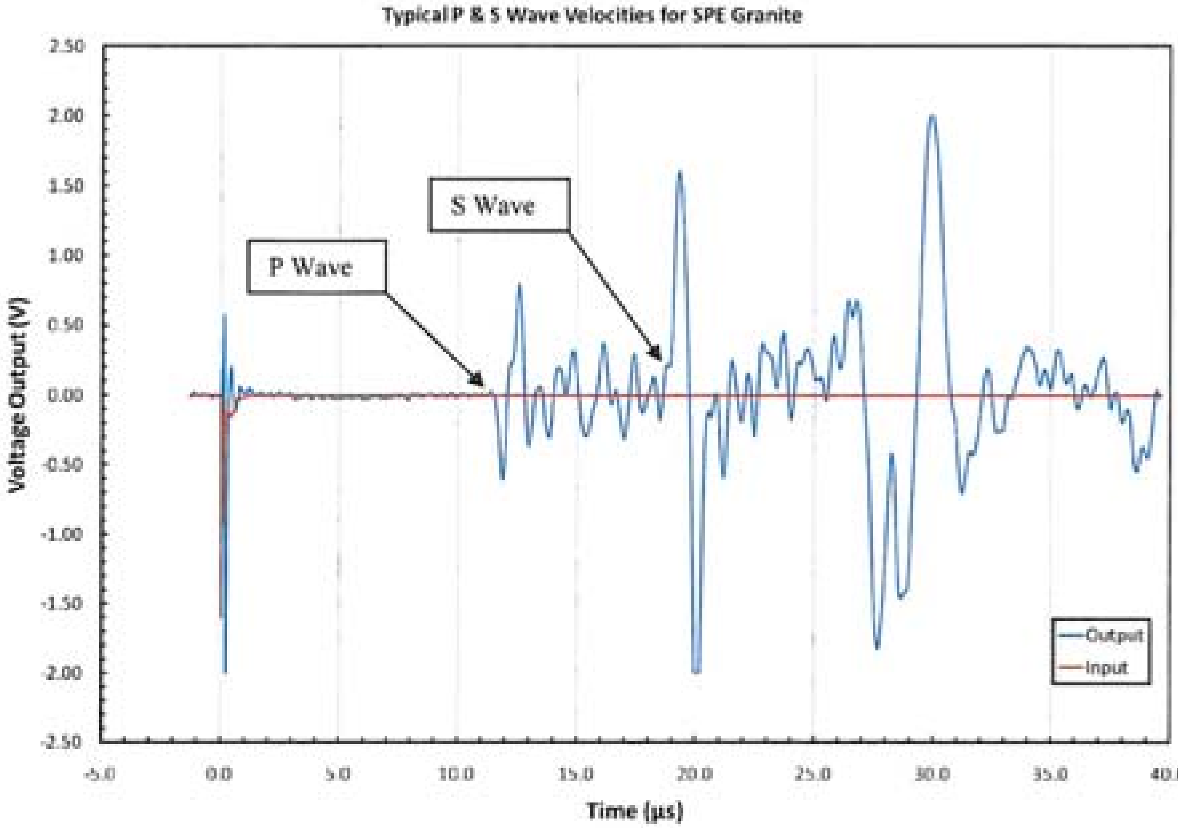


Figure 3. Typical velocity profile for determination of P & S wave speed.

The dynamic elastic Young's modulus, $E_{dynamic}$, was determined directly from:

$$E_{dynamic} = \frac{\rho V_S^2 \left(3V_P^2 - 4V_S^2\right)}{\left(V_P^2 - V_S^2\right)}$$

Where ρ is the sample density and V_P and V_S are the compressional and shear wave velocities, respectively. Values of dynamic elastic Poisson's ratio, $\nu_{dynamic}$, were calculated from:

$$\nu_{dynamic} = \frac{\left(V_P^2 - 2V_S^2\right)}{2\left(V_P^2 - V_S^2\right)}$$

Dynamic Young's modulus ranges from approximately 47.9 to 97.9 GPa and Poisson's ratio ranges from approximately 0.14 to 0.26 for all samples measured in the axial direction.

Analysis of Results

Figure 4 plots density, unconfined compressive strength, Young's modulus and Poisson's ratio as functions of depth. Density is reasonably uniform over the cored interval, i.e., ~2.63 g/cc, with the exception of two depths, -29 ft and -87 ft where it decreases slightly to 2.61 g/cc and somewhat more to 2.55 g/cc. Unconfined compressive strength, Young's modulus and Poisson's ratio follow this trend. The unconfined compressive strength is nominally 200 MPa or greater over the cored depth; however, at depths of -29 ft, -87 ft and -192 ft, the strength drops off to 121, 42 and 166 MPa, respectively.

As discussed above, Young's modulus was determined using two methods: 1) directly from stress-strain data acquired during quasi-static unload/reload cycles and 2) indirectly calculated from density and compressional and shear wave velocity measurements. The values of Young's Modulus determined from the quasi-static testing were nominally 76 GPa with lower values found from cores recovered at depths of -29 ft (56 GPa) and -87 ft (35 GPa). The values determined indirectly (dynamic methods) were consistently higher than the quasi-static values as expected except for cores recovered from near the surface (-14 ft and -29 ft). For the deeper cores, the dynamic moduli were about 5 to 20% higher than the quasi-static values except at a depth of -87 ft where the dynamic modulus was about 50% higher. There was no observable difference in Poisson's ratio using either the quasi-static or dynamic methods. In general, the values of Poisson's ratio (both measured quasi-statically and dynamically) ranged from about 0.15 to 0.25.

Compressional and shear wave velocities are plotted as a function of depth for measurements made parallel (axial) and normal (radial) to the specimen central axis in Figure 5. With the exception of measurements made at depths of -29 ft and -87 ft, compressional wave velocities are ~5,900 m/sec. At -29 ft and -87 ft, the compressional wave velocities are ~4,500 m/sec and ~4,700 m/sec, respectively. The shear wave velocities are ~3,600 m/sec but drop somewhat at -29 ft and -87 ft to ~2,900 m/sec and ~3,000 m/sec, respectively. Within the variability of the measurements, it appears there is no significant difference in velocities when measured parallel or normal to the specimen axis implying the recovered cores are reasonably isotropic (from a mechanical point of view).

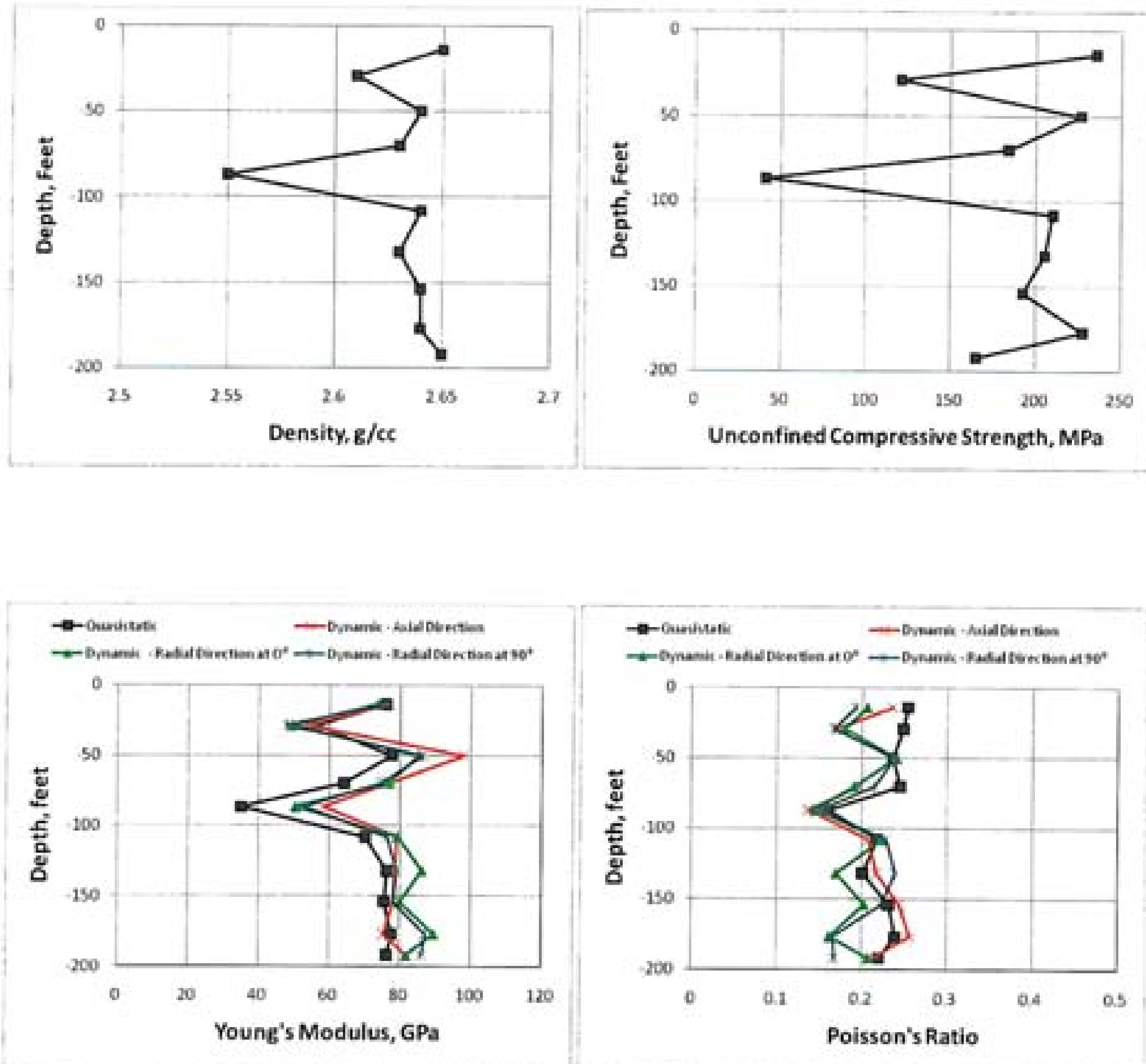


Figure 4. Density, UCS strength, Young's modulus and Poisson's ratio as functions of depth for Borehole U15-n.

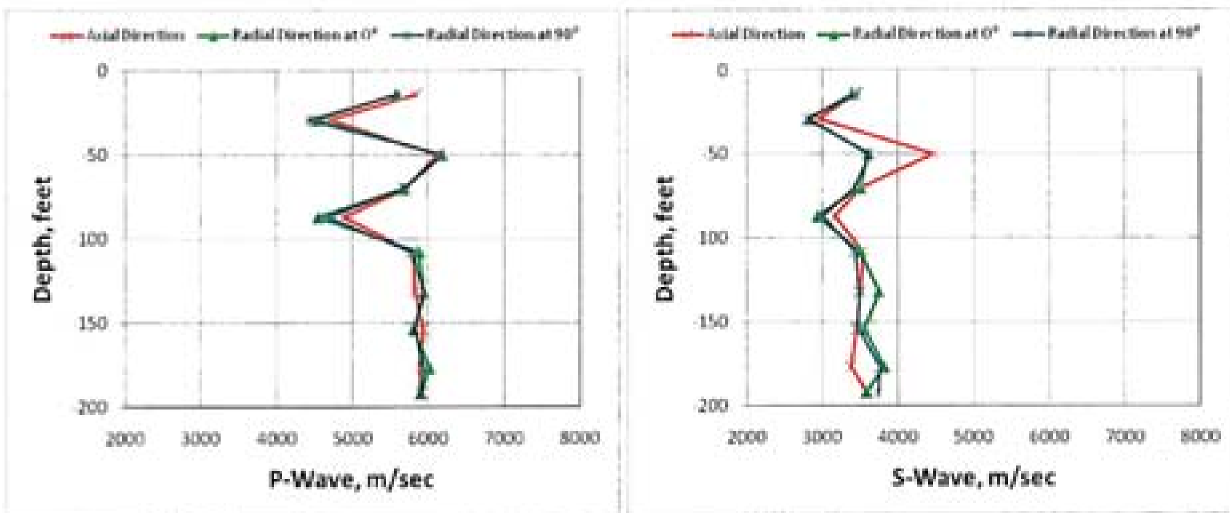


Figure 5. Compressional and shear wave velocities as functions of depth for Borehole U15-n.

A limited literature search was conducted to find relevant data sets that could be used for comparison with data acquired under this testing program. Schock et al (1973)[1] published data from quasi-static tests conducted on granodiorite samples recovered from the Climax stock, Area 15, Nevada National Security Site, Nye County, Nevada. Tests included hydrostatic compression to 4 GPa, triaxial compression at various confining pressures up to 700 MPa and uniaxial strain. The granodiorite tested in their study had a material density of 2.67 g/cc and a porosity of ~0.7%. Although Schock et al did not conduct any unconfined tests, they did perform one test at a confining pressure of 1 bar (0.1MPa). From plots presented in their paper, estimates of compressive strength, Young's modulus and Poisson's ratio were determined to be ~220 MPa, 60 GPa and 0.2-0.3, respectively. These values are in reasonably good agreement with those determined from the current study if values from depths of -29 ft and -87 ft are not used in the comparison. Wilder and Yow (1987)[2] presented data acquired from tests on Climax stock samples comprising granodiorite and quartz monzonite and also summarized data from Pratt el al. The quartz monzonite tested in this second study had a density of 2.635 g/cc and a porosity of 3.2%. Properties reported in this study for UCS strength, Young's modulus and Poisson's ratio were 200 MPa, 48 GPa, and 0.21. With the exception of Young's modulus which is somewhat lower than in the current study, these properties compare favorably with those measured in the current study, again assuming the values obtained at depths of -29 ft and -87 ft are not used in the comparison. Wilder and Yow also reported a dynamic Young's modulus of 82.8 GPa, and compressional and shear wave velocities of 6,058 m/sec and 3,541 m/sec, respectively, all of which are in very good agreement with the current study (with the exception of properties measured at depths of -29 ft and -87 ft). Both data sets presented in the referenced reports are from depths of 942 ft (HARD HAT) to 1519 ft (PILE DRIVER) below ground surface; deeper than the current tested range of 14 ft to 192 ft.

[1] Schock, R.N., H.C. Heard, and D.R. Stephens, 1973. "Stress-Strain Behavior of a Granodiorite and Two Graywackes on Compression to 20 Kilobars," *J. of Geophysical Research*, Vol 78, No. 26, September.
[2] Wilder, D.G. and J.L. Yow, Jr., 1987. "Geomechanics of the Spent Fuel Test – Climax," UCRL-53767, prepared by Lawrence Livermore National Laboratory, Livermore, CA, July.

Recommendations for Additional Studies

Split Hopkinson Pressure Bar: As an option, additional UCS tests could be performed at higher strain rates (500-2000/sec) using the Split Hopkinson Pressure Bar (SHPB) technique to evaluate the effects of strain rate on such mechanical properties as strength and elastic moduli. By combining the quasi-static and SHPB test results, strain rate effects over 6 to 7 orders of magnitude could be examined.

Two waxed samples (to preserve in situ moisture content), also from bore hole U-15n with depths of 50 and 157 ft, may be tested pending discussion of the results from this Phase 1 testing program. With the limited funding available, SHPB tests may be of higher priority than in situ moisture quasi-static UCS tests.

Optical Microscopy Thin Sections: Three polished dye-impregnated thin sections (mounted on 24x46 mm slides) were prepared both from the untested end pieces of core saved during specimen preparation and from each of the tested UCS specimens. The thin sections for each end piece and tested specimen were oriented to coincide with three orthogonal directions. It is assumed that examination of the sections through optical microscopy will be performed by LANL under separate funding. As an option, thicker billet sections could also be fabricated using the same impregnation procedure as the thin sections. These billets could then be imaged using other techniques such as laser scanning confocal microscopy and/or focused ion beam/scanning electron beam microscopy (FIB/SEM) to obtain three-dimensional images of the pore/microfracture network. This option includes only the preparation of the thicker billets and not the actual imaging.

Plots of Engineering Axial Stress versus Axial, Lateral, and Volume strain for all UCS tests

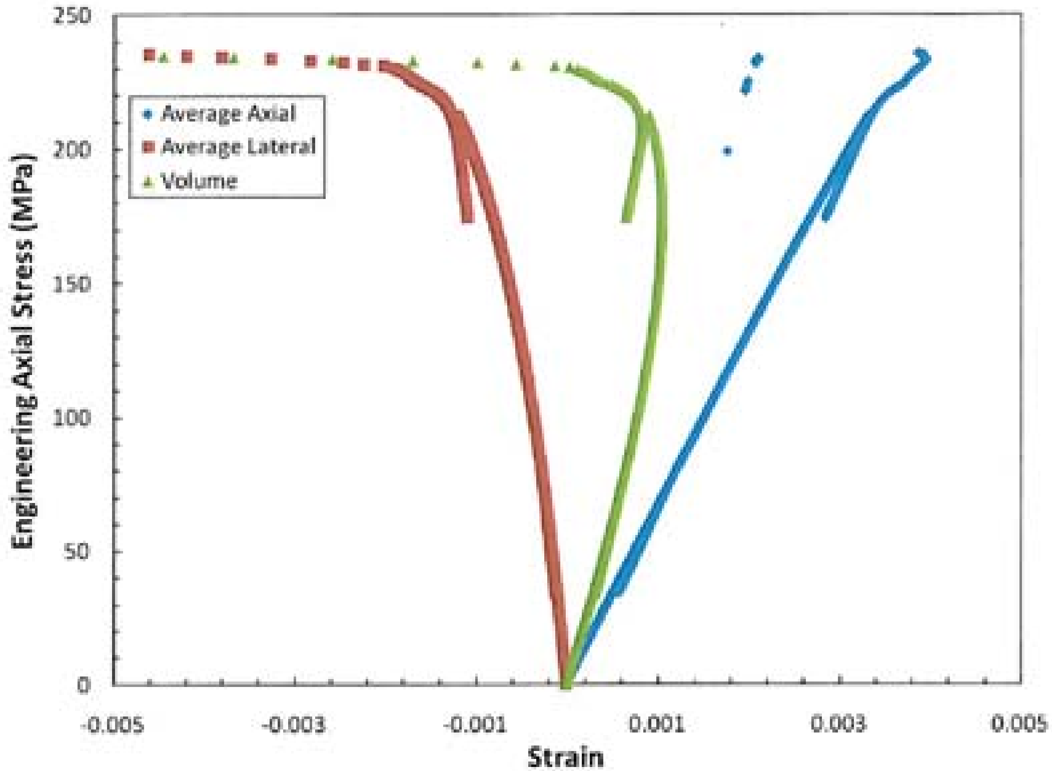


Figure 6. Sample SPE-UCS-1

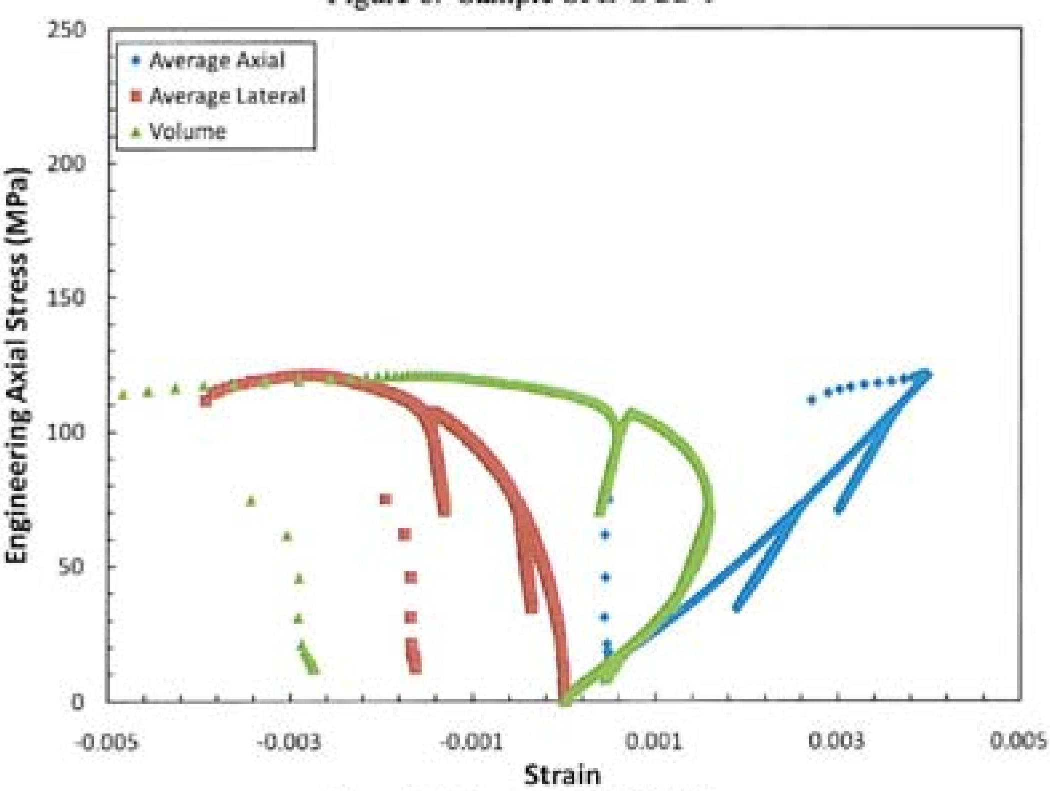


Figure 7. Sample SPE-UCS-2

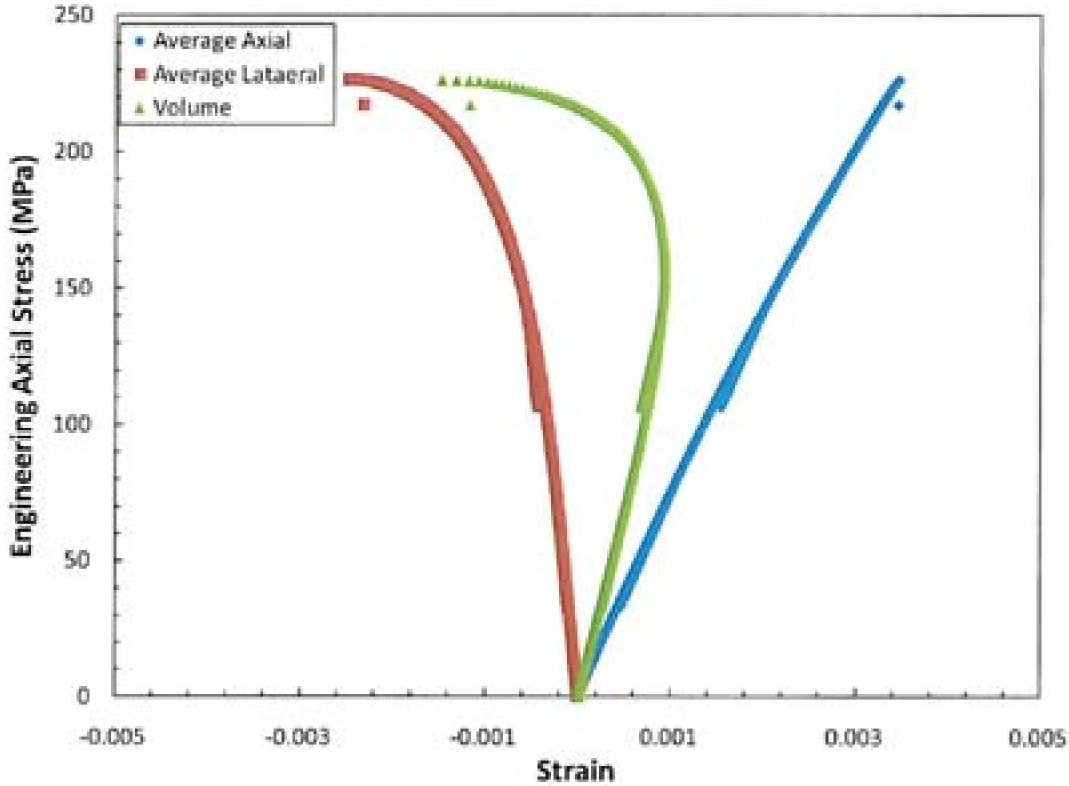


Figure 8. Sample SPE-UCS-3

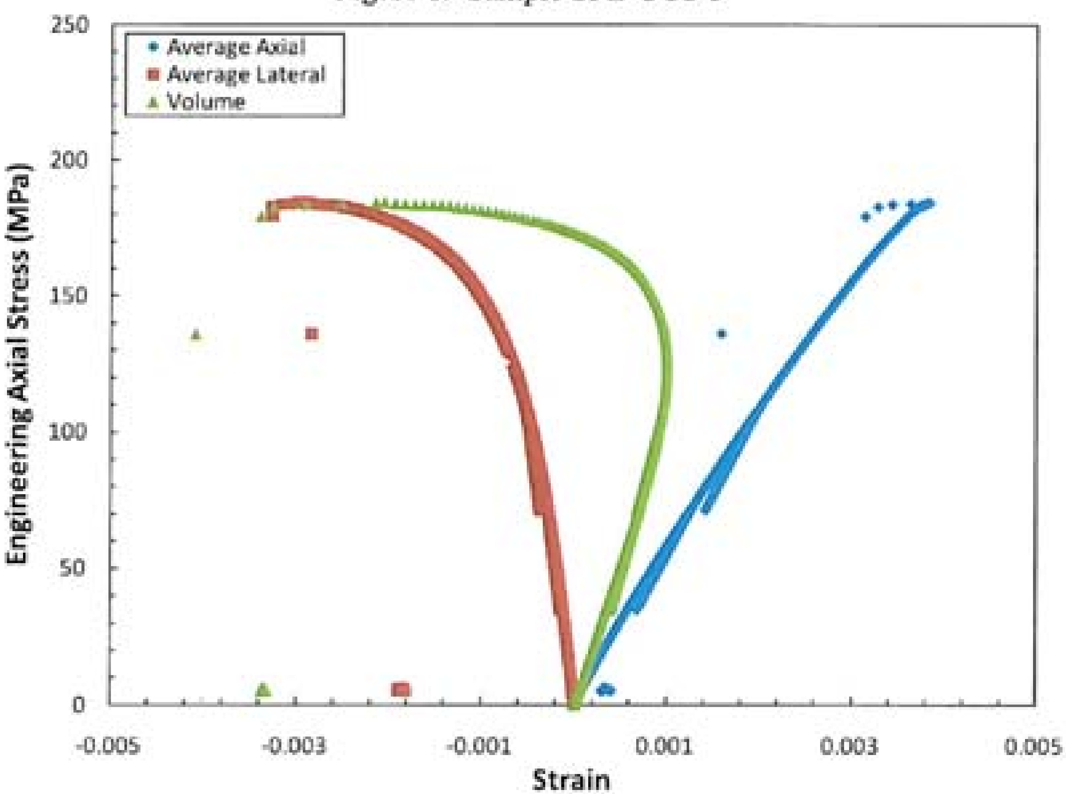


Figure 9. Sample SPE-UCS-4

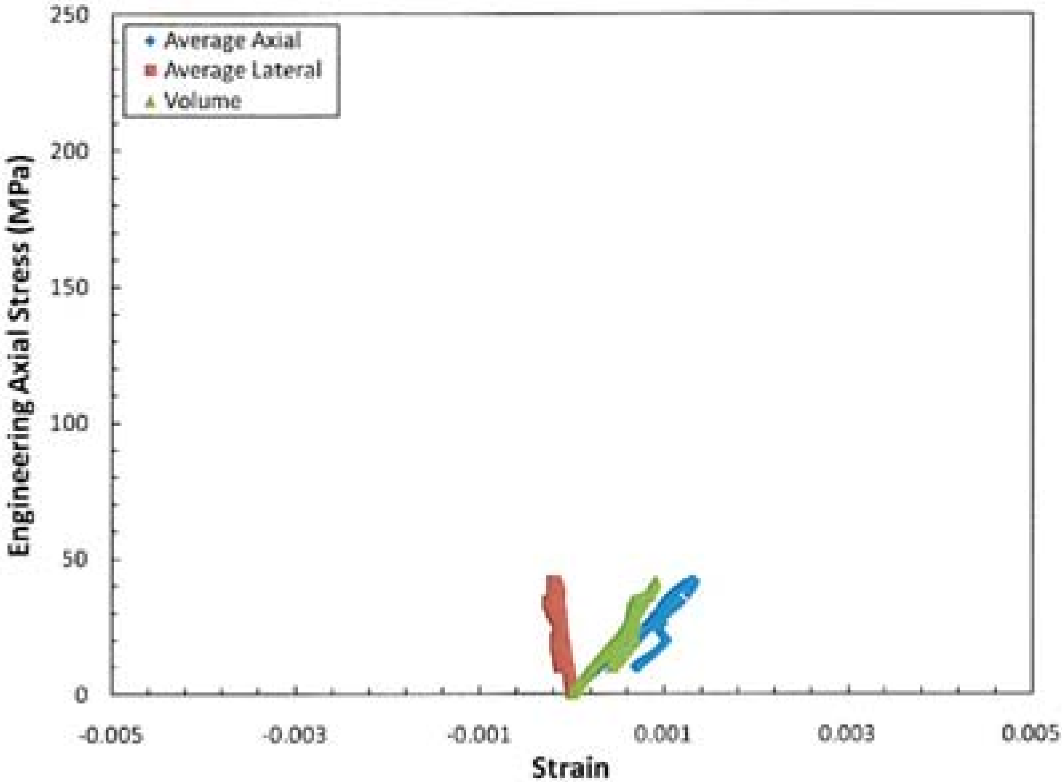


Figure 10. Sample SPE-UCS-5

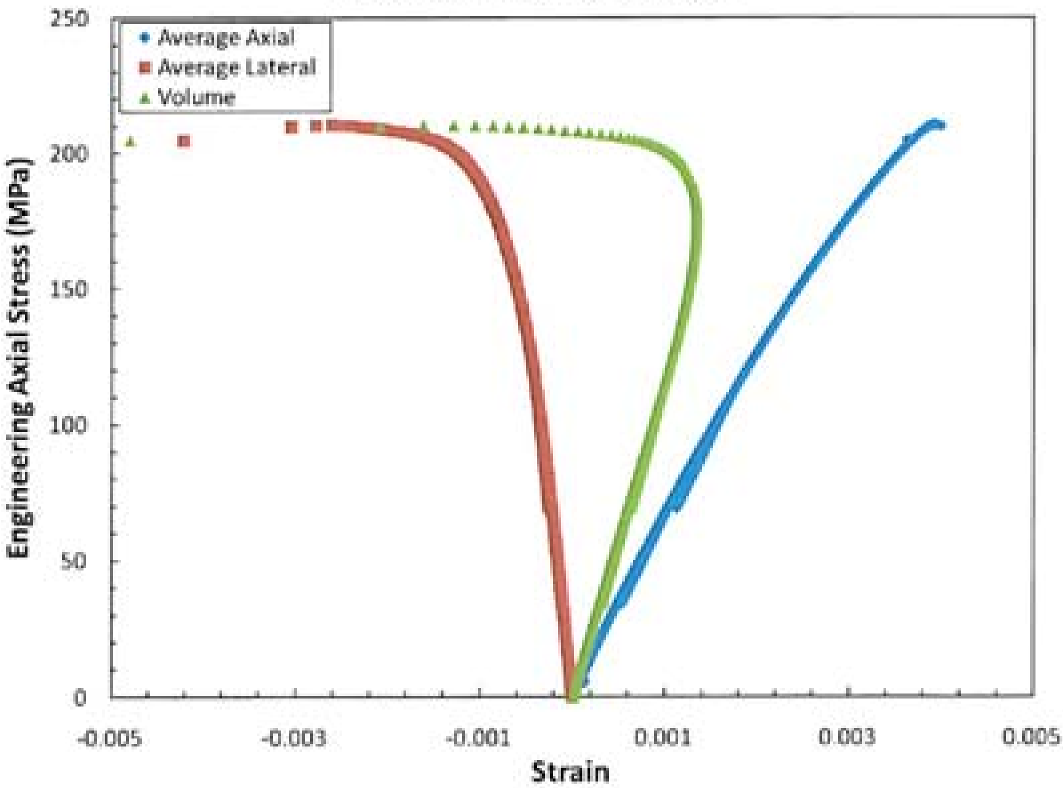


Figure 11. Sample SPE-UCS-6

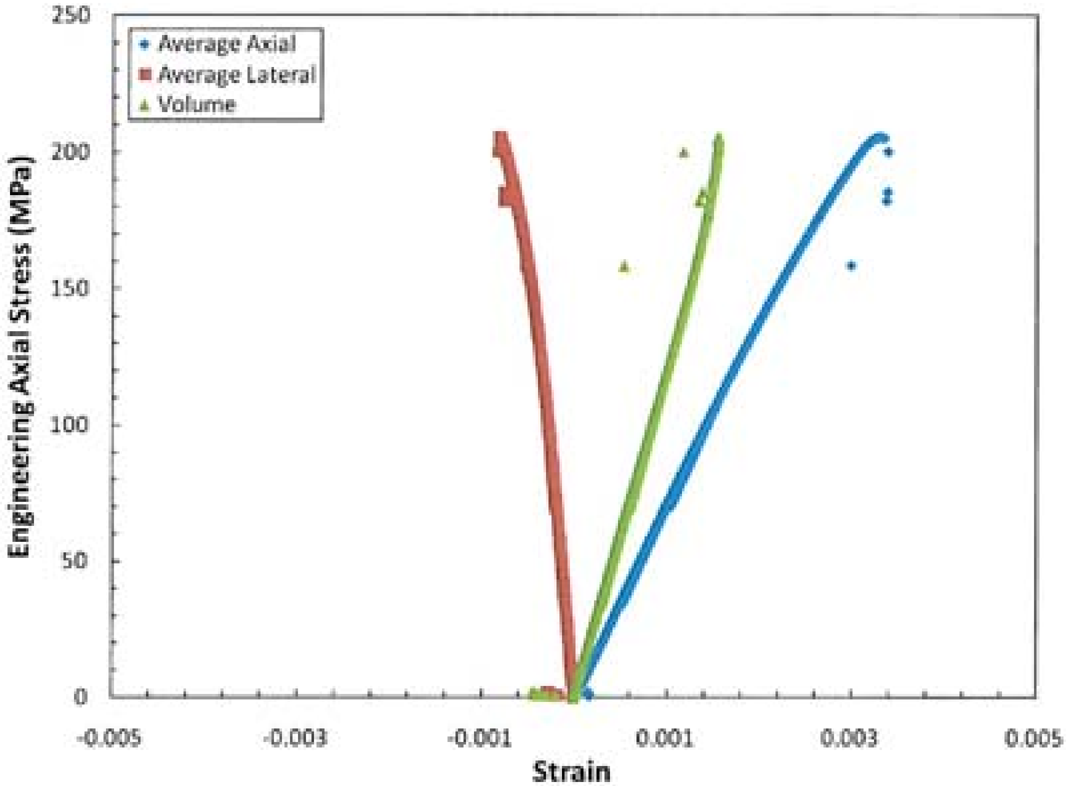


Figure 12. Sample SPE-UCS-7

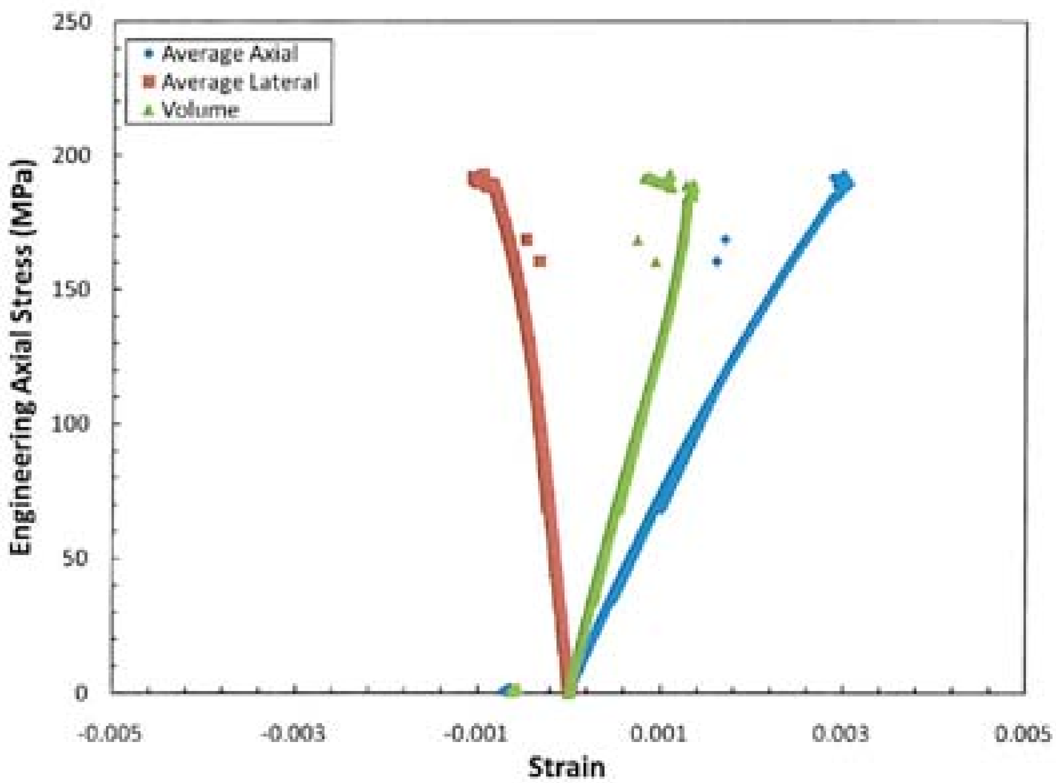


Figure 13. Sample SPE-UCS-8

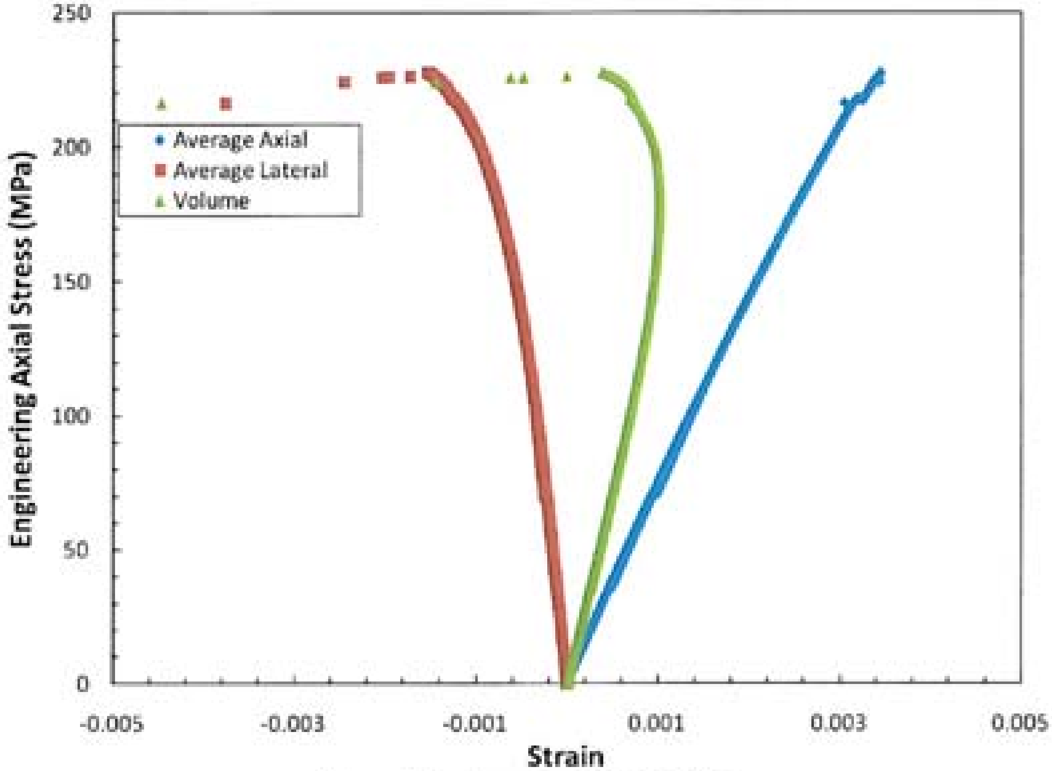


Figure 14. Sample SPE-UCS-9

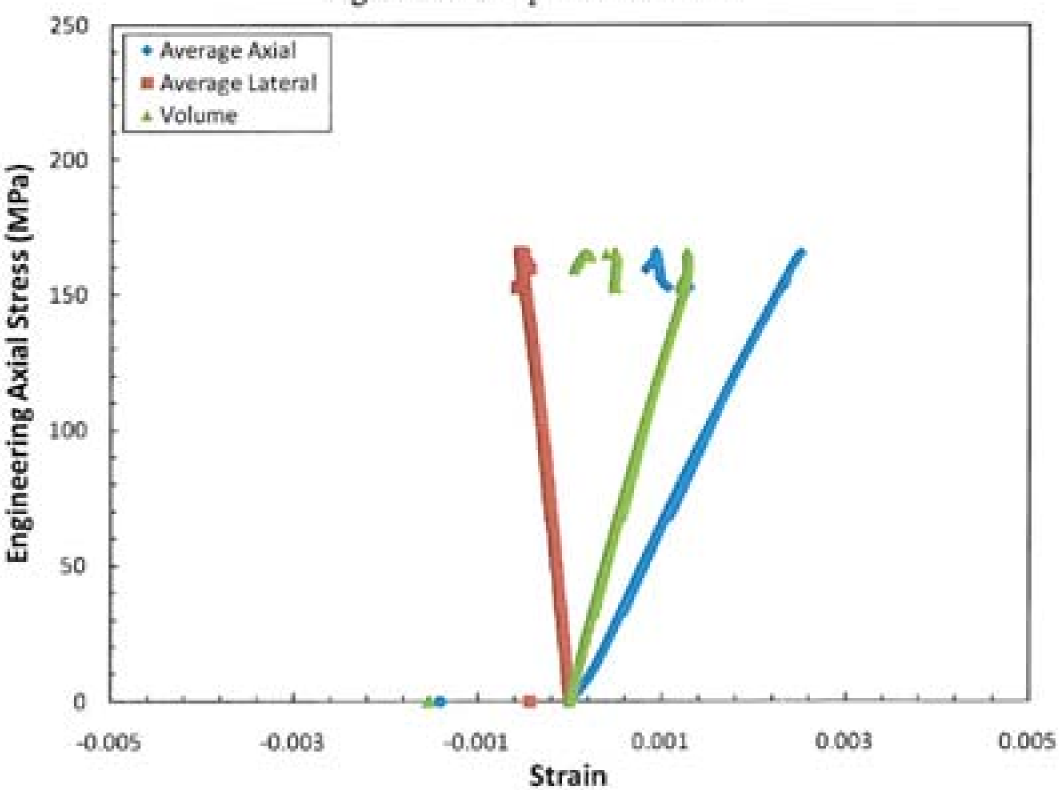


Figure 15. Sample SPE-UCS-10

APPENDIX H

Measurements of Compressional Velocity Made on Behalf of the Defense Threat Reduction Agency Interagency Geotechnical Assessment Team (IGAT) on Samples from the U-15n Core Hole

At the U.S. Geological Survey Core Library, Mercury, Nevada

November 21, 2011

Table H-1

Measurements of Compressional Velocity (Radial Direction) Made on Behalf of the Defense Threat Reduction Agency Interagency Geotechnical Assessment Team (IGAT) on Samples from the U-15n Core Hole

Note: Measurements made on “HQ” (2.5 inch diameter) core stored at the U.S. Geological Survey Core Library in Mercury Nevada, November 21, 2011.

Measurement Depth (feet)	**Path Length** (millimeters)	**Time** (micro seconds)	**Wavespeed** (kilometers/ second)	**Comments**
7.5	63.17	14.97	4.94	
8.5	63.52	14.38	4.42	
11.5	63.29	14.50	4.36	
12.5	63.40	14.50	4.37	
13.5	63.42	14.25	4.45	
15.5	63.32	16.50	3.84	
16.3	63.65	14.08	4.52	
17.6	48.12	12.73	3.78	
18.5	63.47	15.02	4.23	
19.5	63.37	14.09	4.50	
20.5	63.39	19.59	3.24	
21.2	63.57	16.88	3.77	
25.0	63.50	13.66	4.65	
26.2	63.31	21.36	2.96	
27.2	63.43	16.11	3.94	
28.1	63.40	18.14	3.50	
28.9	63.00	19.66	3.20	
30.1	63.30	17.29	3.66	
31.3	63.38	19.91	3.18	
32.0	63.35	19.91	3.18	
33.0	63.44	19.03	3.33	
34.5	63.32	18.98	3.34	
35.5	63.35	20.05	3.16	
36.9	63.40	18.72	3.39	
37.5	63.35	14.40	4.40	
38.5	63.33	16.35	3.87	
39.3	63.38	14.91	4.25	
41.5	63.37	14.74	4.30	
42.7	63.35	14.66	4.32	
43.5	63.27	13.64	4.64	
44.3	63.41	13.64	4.65	
45.0	63.46	13.47	4.71	

Table H-1

Measurements of Compressional Velocity (Radial Direction) made on Behalf of the Defense Threat Reduction Agency Interagency Geotechnical Assessment Team (IGAT) on Samples from the U-15n Core Hole (continued)

Measurement Depth (feet)	**Path Length** (millimeters)	**Time** (micro seconds)	**Wavespeed** (kilometers/ second)	**Comments**
46.3	63.40	13.22	4.80	
47.0	63.04	13.89	4.54	
48.0	62.95	13.21	4.77	
49.0	63.00	12.87	4.90	
51.4	62.99	13.00	4.85	
52.5	63.05	12.95	4.87	
53.7	63.07	13.54	4.66	
54.7	63.10	13.54	4.66	
56.8	63.11	13.54	4.66	
57.8	63.27	13.20	4.79	
58.8	63.40	13.03	4.87	
59.9	63.24	13.11	4.82	
61.1	63.22	13.58	4.66	
61.8	63.25	13.50	4.69	
62.7	36.14	8.46	4.27	
64.7	28.20	7.95	3.55	
65.7	63.23	12.77	4.95	
66.7	63.10	13.02	4.85	
67.7	63.41	13.87	4.57	
69.7	63.34	13.53	4.68	
71.1	63.38	13.53	4.68	
72.0	63.26	13.36	4.74	
73.0	63.30	13.39	4.73	
75.0	63.37	14.93	4.24	
78.0	44.42	14.37	3.09	
79.0	63.22	22.07	2.86	
80.0	64.88	48.64	1.33	
82.7	31.45	11.99	2.62	
88.8	51.42	18.68	2.75	
89.5	63.30	13.35	4.74	
90.5	63.33	13.01	4.87	
92.5	63.33	12.67	5.00	
93.5	63.43	13.09	4.85	
94.5	63.40	12.67	5.00	
97.0	63.41	12.67	5.00	

Table H-1

Measurements of Compressional Velocity (Radial Direction) made on Behalf of the Defense Threat Reduction Agency Interagency Geotechnical Assessment Team (IGAT) on Samples from the U-15n Core Hole (continued)

Measurement Depth (feet)	**Path Length** (millimeters)	**Time** (micro seconds)	**Wavespeed** (kilometers/ second)	**Comments**
98.0	63.41	13.60	4.66	
99.5	63.36	12.75	4.97	
100.5	63.33	12.75	4.97	
101.5	63.40	12.75	4.97	
103.5	63.36	13.93	4.55	
117.4	42.59	12.24	3.48	
109.8	63.42	12.58	5.04	
110.8	63.00	13.76	4.58	
112.8	63.52	13.34	4.76	
114.5	63.50	13.17	4.82	
115.5	63.51	12.58	5.05	
116.4	63.53	13.09	4.85	
117.3	63.37	13.09	4.84	
118.9	63.44	12.75	4.98	
119.9	63.40	12.75	4.97	
121.7	63.52	12.92	4.92	
122.7	63.46	12.92	4.91	
123.5	63.49	14.27	4.45	
124.1	63.50	16.72	3.80	
124.7	63.53	15.62	4.07	
126.0	63.47	13.00	4.88	
127.0	63.42	12.75	4.97	
129.0	63.52	15.57	4.08	across healed joint
129.0	63.54	13.00	4.89	not through joint (perpendicular)
130.0	63.55	14.77	4.30	
132.6	63.52	14.18	4.48	
133.7	63.41	13.16	4.82	
134.7	63.43	12.57	5.05	
135.7	63.33	12.57	5.04	
136.6	63.37	12.99	4.88	
140.0	63.37	12.40	5.11	
141.6	63.47	12.40	5.12	
143.0	63.42	12.40	5.11	
144.2	63.47	12.65	5.02	

Table H-1

Measurements of Compressional Velocity (Radial Direction) made on Behalf of the Defense Threat Reduction Agency Interagency Geotechnical Assessment Team (IGAT) on Samples from the U-15n Core Hole (continued)

Measurement Depth (feet)	**Path Length** (millimeters)	**Time** (micro seconds)	**Wavespeed** (kilometers/ second)	**Comments**
145.0	63.41	12.40	5.11	
146.0	63.42	12.40	5.11	
147.0	63.37	12.40	5.11	
149.5	63.43	14.09	4.50	
154.6	63.45	13.07	4.85	
156.2	63.44	18.66	3.40	
157.7	63.36	13.24	4.79	
158.7	63.44	14.34	4.42	
159.2	63.38	15.86	4.00	
160.2	63.44	13.41	4.73	
161.2	63.42	12.39	5.12	
162.1	63.40	12.80	4.95	
163.7	63.44	12.80	4.96	
165.0	63.39	12.80	4.95	
167.0	63.49	12.80	4.96	
168.5	63.40	15.51	4.09	
170.0	63.51	15.70	4.05	
171.0	63.44	13.30	4.77	
172.0	63.47	13.30	4.77	
174.8	63.45	12.97	4.89	
174.8	63.50	13.22	4.80	
180.7	63.48	13.22	4.80	
183.0	63.46	13.30	4.77	
184.0	63.47	13.30	4.77	
185.0	63.51	13.30	4.78	
185.7	63.47	13.30	4.77	
187.0	63.49	12.96	4.90	
189.0	63.50	13.00	4.88	
190.0	63.49	12.62	5.03	
191.0	63.47	13.21	4.80	
192.0	63.52	14.82	4.29	
193.0	63.48	13.30	4.77	
194.0	63.48	12.71	4.99	
195.0	63.49	16.69	3.80	
195.6	63.48	17.62	3.60	

Table H-2

Measurements of Compressional Velocity (Axial Direction) made on Behalf of the Defense Threat Reduction Agency Interagency Geotechnical Assessment Team (IGAT) on Samples from the U-15n Core Hole

Note: Measurements made on “HQ” (2.5 inch diameter) core stored at the U.S. Geological Survey Core Library in Mercury Nevada, November 21, 2011.

Measurement Depth (feet) (middle of interval)	**Path Length** (millimeters)	**Time** (micro seconds)	**Wavespeed** (kilometers/ second)
7.5	182.90	45.60	4.01
13.4	144.50	29.42	4.91
15.0	94.41	28.70	3.29
20.8	125.20	36.42	3.44
26.1	122.30	47.62	2.57
31.4	148.50	59.40	2.50
35.4	74.30	28.10	2.64
36.9	130.00	43.22	3.01
45.0	120.90	31.72	3.81
59.4	107.00	26.62	4.02
126.1	149.00	31.72	4.70
135.5	94.00	30.92	3.04
118.9	146.00	38.50	3.79
121.7	73.00	19.50	3.74
135.5	94.00	30.92	3.04
135.5	63.49	13.32	4.77

APPENDIX I

Projected Extent of Two Faults Encountered in Core Hole U-15n

By

UGTA/Boreholes Geology Group
National Security Technologies, LLC

March 8, 2011

Projected Extent of Two Faults Encountered in Core Hole U-15n

NSTec UGTA/Boreholes Geology Group
March 8, 2011

We have constructed a map and three vertical sections (attached) to illustrate the possible extents and orientations of the two main faults encountered in the U-15n core hole.

We made several simplifying assumptions to construct these drawings:

- We treated both faults as single dipping planes with strike and dip that do not change along the fault trace. We know that both faults are really zones of several fractures where encountered in the core hole, and used an average orientation of these planes. It is likely that both faults do change orientation slightly away from the core hole intercept (see discussions below), but we have very little to inform us as to what types of variation to expect.
- We call these structures "faults" mainly because they both consist of multiple fracture planes separated by gouge/fill material, and because slickensides were observed on some of the fracture surfaces. We do not have any information (or guesses) about amount or sense of displacement along the faults, because no "marker beds" are present in this massive granite body that could be use to determine offset.
- Our fracture orientation data came from Colog's tables, which they derived from their acoustic and optical televiewer logs (previously transmitted). We used our best judgment to select representative orientations from the Colog fracture tables.
- We treated all holes as vertical and straight. Most of the measured borehole deviations were less than a couple of feet, so we do not think this is a problem, given the uncertainty in the fault orientations. Holes U-15n#1, #2, and #4 experienced the greatest deviation, of up to 6 ft at TD. The other three instrument holes and the core hole showed less than 2 ft deviation at TD.

One thing to keep in mind is that the length of exposure of an angular feature in a borehole is a function of hole diameter. That is, the apparent linear exposure interval of a high-angle feature will be greater in a large hole than in a small hole. The linear extent of these features in the 36-inch hole will be greater than in the core hole, which was 3.8 inches in diameter.

A previous report by our group (*Preliminary Analysis of Fractures Identified on Borehole Image Logs from the SPE Drill Holes* by Lance Prothro, January 2011) described the orientations of fractures encountered in the SPE holes and subdivided them into four sets based on orientation. The two faults described here are interpreted to belong to Sets 1 and 2, which are a conjugate set (similar strikes but opposite dips). Both faults strike generally parallel to the present-day minimum horizontal stress direction, and normal to the strike of Basin-and-Range normal faults in the area. Thus, they are likely small faults that are not regionally significant.

Brief descriptions of the two faults addressed in this report are given below, followed by short discussions of the cross sections, the map, and other fractures encountered.

Fault #1 Characteristics (Fracture Set 1)

- Depth = 83 ft
- Dip magnitude = 80 degrees
- Dip direction = 15 degrees azimuth
- Strike = 105 degrees azimuth
- **Description from core:** The fault zone is exposed from the depth of 77.7 to 84 ft, and consists of several planes that range in dip magnitude from about 70 degrees to nearly vertical. The fault/fracture planes have thin gouge coats and slickensides in places. The granite is lighter in color, soft, and altered adjacent to fault/fracture planes. Little gouge is associated with zone, similar to Fault #2. Significantly decomposed, soft rock is only seen near center of zone (around 80 to 81 ft).

Fault #2 Characteristics (Fracture Set 2)

- Depth = 106 ft
- Dip magnitude = 79 degrees
- Dip direction = 205 degrees azimuth
- Strike = 295 degrees azimuth
- **Description from core:** Exposed between the depths of 104 and 108 ft. The fault zone is bounded by high-angle (approximately 80 degrees) planes at top and bottom of interval. The rocks are fractured and weathered (buff colored) between the bounding fractures. Alteration is confined to the region between uppermost and lowermost planes of the zone. This fault zone appears not to be as highly fractured as Fault #1. As in Fault #1, there is little gouge. Decomposed, soft rock is limited to the interval between 105 and 106.8 ft.

Cross Sections

Three cross sections were constructed (listed below). All instrument holes are marked with the proposed depths of the gage packages, and the core hole is marked with the proposed depths of the explosive packages. The map and cross sections were constructed at the scale of 1 inch = 20 feet and can be plotted to scale on B-size paper (11 by 17 inches).

- A-A' through U-15n#4, U-15n, and U-15n#1 (NE-SW)
- B-B' through U-15n#3, U-15n, and U-15n#6 (NW-SE)
- C-C' through U-15n#2, U-15n, and U-15n#5 (W-E)

After these cross sections were constructed, we reexamined the acoustic and optical logs for all the holes to determine whether there were any candidate fractures that could be interpreted to correlate with the projections of the two faults. Where such fractures were logged, we added a purple triangle to the section to indicate their depth. We also looked for high-rank (Rank 4 or 5) high-angle fractures in the instrument holes that could indicate faults that did not cross the core hole, and found a few, which are discussed at the end of this report (see Table 1 for fracture ranking criteria).

The relationship of the faults where they are projected to cross each other is unknown. On the cross sections we show them as if they both extend past each other, mainly to find the projected possible surface traces. It is likely, however, that one of the faults terminates against the other, though we do not know their relationship at this time.

Discussion of Cross Section A-A'

Neither fault is projected to cross U-15n#1 or #4.

Discussion of Cross Section B-B'

Neither fault is projected to cross U-15n#6, but Fault #2 may cross U-15n#3. In the acoustic and optical logs for U-15n#3, we found that several sets of high-angle fractures were logged near the bottom of the hole. Two of these are marked on the cross section with purple triangles and a brief description of the fractures. If the dip of Fault #2 decreases with depth, the upper of these two fractures (depth of 167.5 ft) could be interpreted to be its intercept. None of the high-angle fractures logged near the bottom of U-15n#3 ranks higher than Rank 3.

Discussion of Cross Section C-C'

Fault #1 may cross both U-15n#2 and U-15n#5. In U-15n#2, a series of fractures was logged between the depths of 29 and 41 ft, including a Set #1 fracture at 35.4 ft. If the dip of Fault #1 decreases upward, this interval could be interpreted to be the intercept of Fault #1. A Rank-3 fracture of Set #1 was logged in U-15n#5 at the depth of 183.8 ft. If the dip of Fault #1 decreases downward, this fracture could be interpreted to be the intercept of Fault #1. A Set #2 fracture was logged near the bottom of U-15n#2 (depth of 179.6 ft) that could be interpreted to be the intercept of Fault #2 with only a slight decrease in the fault's dip.

Map

The attached map shows the locations of all seven holes, the cross section locations, and the projected traces of both faults based on their interpreted orientations. The solid lines represent the traces at their subsurface locations. The dashed lines represent the projected surface traces of the faults, constructed from the surface intercepts from the three cross sections. By extending the surface traces of the faults along their strikes to the southeast, they are projected to meet approximately 200 ft from the U-15n core hole on an azimuth of about 110 degrees. There is no visible evidence of the trace of either fault or their intersection at the surface.

No faults were mapped within 1,000 ft of the SPE site on the 1:4800 geologic by the U.S. Geological Survey (Map I-328, *Preliminary Geologic Map of the Climax Stock and Vicinity, Nye County, Nevada*, by F. N. Houser and F. G. Poole, 1960) or on the geologic quadrangle map for the area at 1:24,000 (GQ-214, *Geologic Quadrangle Map of the Oak Spring Butte Quadrangle, Nye County Nevada*, by H. Barnes, F. N. Houser, and F. B. Poole, 1963). In fact, neither map shows any surface faults on the granitic body. The more detailed 1960 map shows numerous locations where joint patterns were mapped, the closest being on the hillock northeast of the SPE site.

Other Fractures

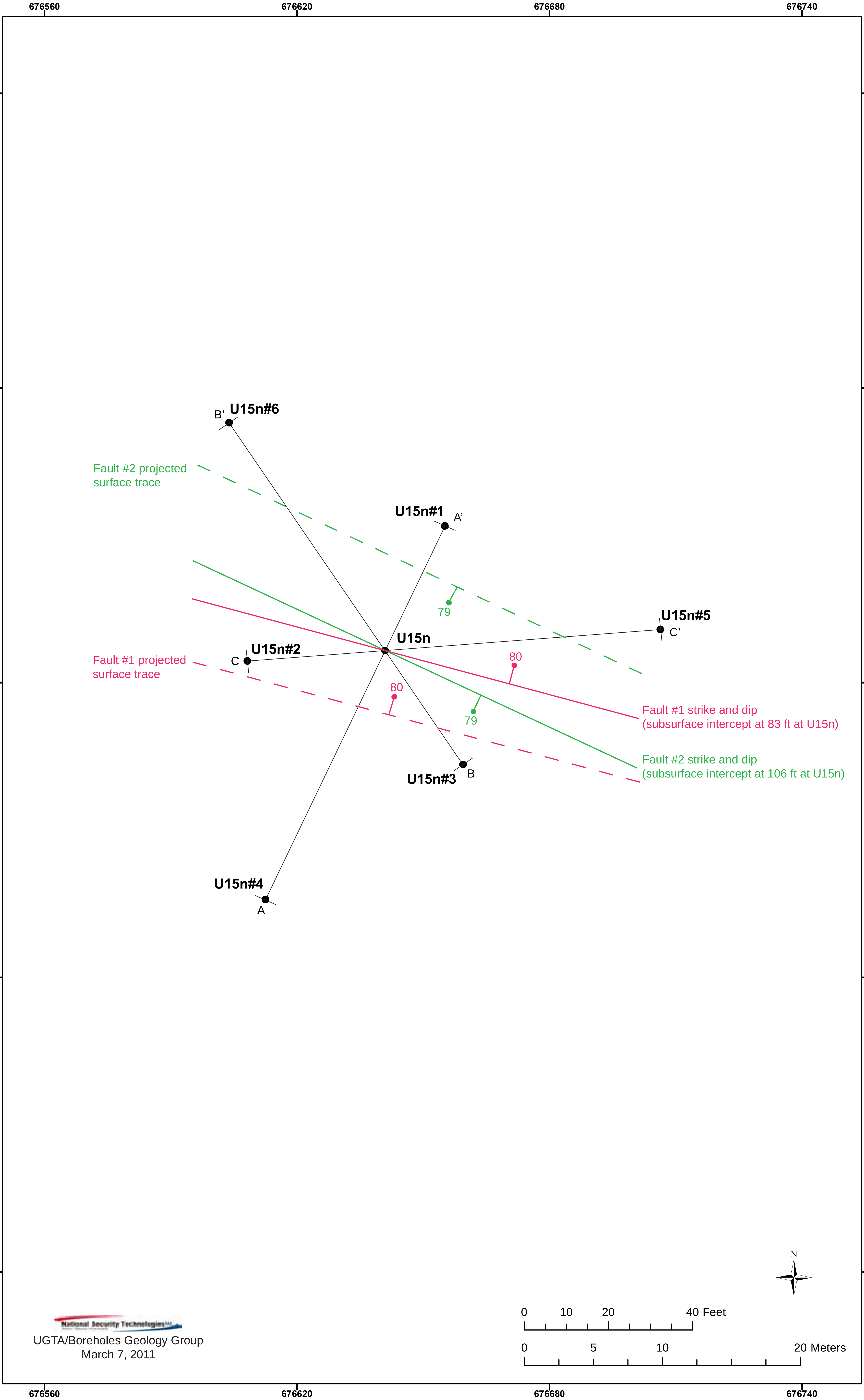
- **U-15n Core Hole**. Both faults have several Rank 4 and Rank 5 fractures associated with them. There are also a few Rank 4 fractures among fractures in the low-angle set. Three other isolated high-angle fractures were also noted in the core hole at Rank 4 or 5, which are listed below. None of these fractures have the associated severe breakouts and altered zones seen at the two fault zones described above.
    - 117 feet depth: Rank 4, Set 2, dip magnitude = 74 degrees; thin gouge (<1 mm thick) noted in core, but no slickensides
    - 155 feet depth: Rank 5; Set 2, dip magnitude = 60 degrees; thin clayey gouge (<1 mm) noted in core, but no slickensides
    - 168–170 feet depth: Rank 4, Set 2, dip magnitude – 64–66 degrees; thin clayey gouge (<1 mm) noted in core, but no slickensides

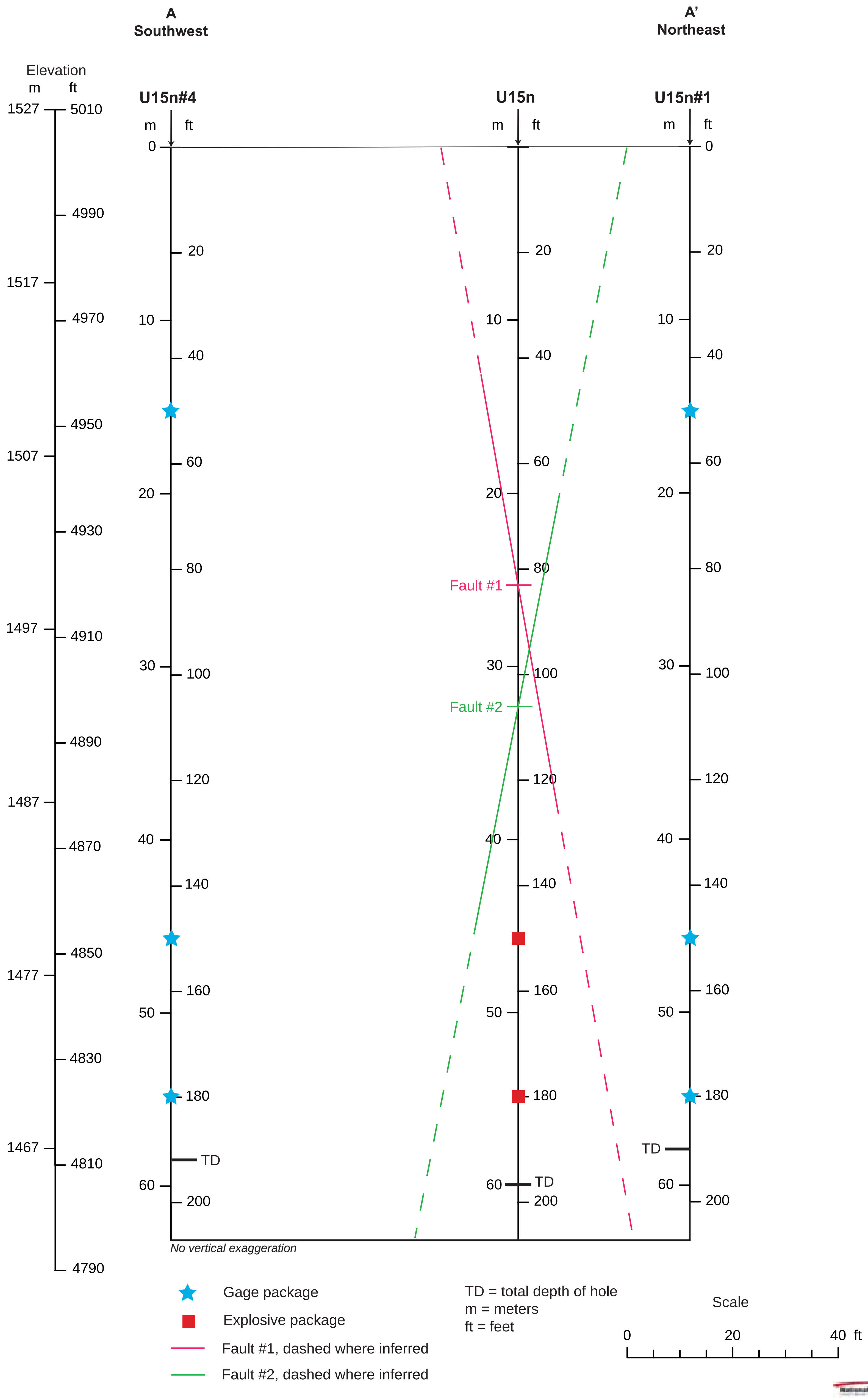
- **Hole U-15n#1** has one Rank 4 fracture, which is in the low-angle fracture set.
- **Hole U-15n#2** has seven Rank 4 fractures, which are all in the low-angle fracture set.
- **Hole U-15n#3** has a Rank 4 fracture at the depth of 81.9 ft, which belongs to Set 2 and has a dip of 82 degrees. This fracture caused a small breakout in the borehole wall (as seen on the caliper log), but appears not to be associated with a highly altered zone as seen in the two faults in the core hole.
- **Holes U-15n#4, #5, and #6** have no fractures ranked 4 or 5.

Table 1
Colog Feature Rankings

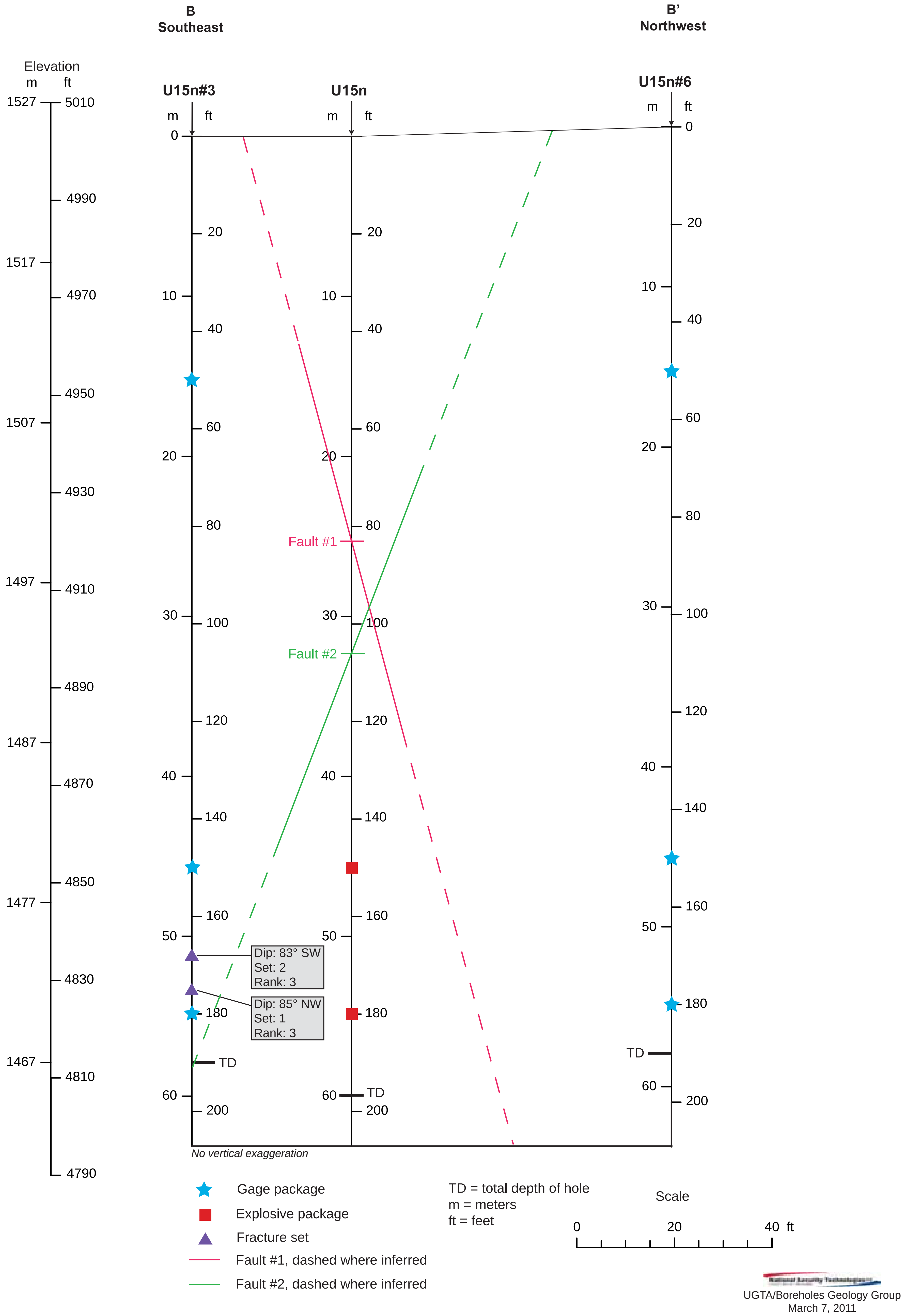
Rank	Observation	Flow Rating System [a]
0	No-Flow Feature (bedding, healed fractures, vein, etc.)	Sealed, no flow
1	Weak Feature (not continuous around the borehole)	Partial open crack
2	Clear, Distinct Feature	Continuous open crack
3	Distinct Feature with Apparent Aperture (visible on amplitude and travel-time images)	Wide open crack or cracks
4	Very Distinct, Wide, Possibly Interconnected Fracture (visible on amplitude and travel-time images)	Very wide crack or multiple interconnected fractures
5	Major Fracture Zone or Wash Out Zone (visible on amplitude and travel-time images)	Major fracture with large openings or breakouts

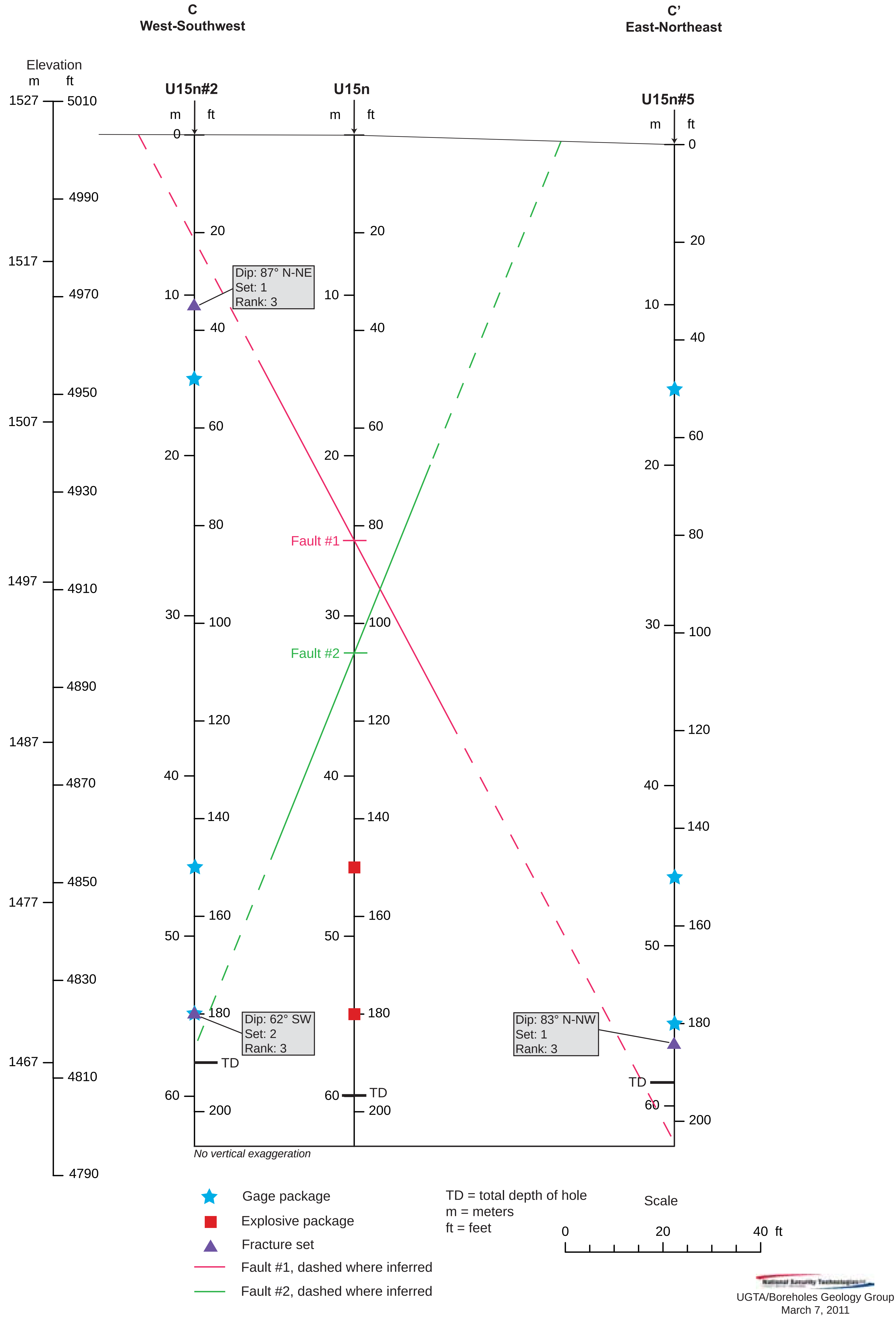
a Primarily referring to potential for fluid flow.


676560
676620
676680
676740
900210
900140
900070
900000
899930
U15n#6
B'
Fault #2 projected
surface trace
U15n#1
A'
79
U15n#5
C'
U15n
U15n#2
C
80
Fault #1 projected
surface trace
80
79
Fault #1 strike and dip
(subsurface intercept at 83 ft at U15n)
Fault #2 strike and dip
(subsurface intercept at 106 ft at U15n)
U15n#3
B
U15n#4
A
N
0 10 20 40 Feet
0 5 10 20 Meters
UGTA/Boreholes Geology Group
March 7, 2011



UGTA/Boreholes Geology Group
March 7, 2011


B
Southeast
B'
Northwest
Elevation
m ft
1527 5010
4990
1517
4970
4950
1507
4930
1497 4910
4890
1487
4870
4850
1477
4830
1467
4810
4790
U15n#3
U15n
U15n#6
m ft
0
10
20
30
40
50
60
20
40
60
80
100
120
140
160
180
200
Fault #1
Fault #2
Dip: 83° SW
Set: 2
Rank: 3
Dip: 85° NW
Set: 1
Rank: 3
TD
No vertical exaggeration
Gage package
Explosive package
Fracture set
Fault #1, dashed where inferred
Fault #2, dashed where inferred
TD = total depth of hole
m = meters
ft = feet
Scale
0 20 40 ft
UGTA/Boreholes Geology Group
March 7, 2011


C
West-Southwest
C'
East-Northeast
Elevation
m ft
U15n#2
U15n
U15n#5
Fault #1
Fault #2
Dip: 87° N-NE
Set: 1
Rank: 3
Dip: 62° SW
Set: 2
Rank: 3
Dip: 83° N-NW
Set: 1
Rank: 3
TD
No vertical exaggeration
Gage package
Explosive package
Fracture set
Fault #1, dashed where inferred
Fault #2, dashed where inferred
TD = total depth of hole
m = meters
ft = feet
Scale
0
20
40 ft
UGTA/Boreholes Geology Group
March 7, 2011

APPENDIX J

Fracture Data Tabulated from Borehole Image Logs by Colog, Inc.
U-15n Source Physics Experiment Holes

Appendix J-1: U-15n Core Hole

Appendix J-2: Instrument Hole U-15n#1

Appendix J-3: Instrument Hole U-15n#2

Appendix J-4: Instrument Hole U-15n#3

Appendix J-5: Instrument Hole U-15n#4

Appendix J-6: Instrument Hole U-15n#5

Appendix J-7: Instrument Hole U-15n#6

Appendix J-1

Fracture Data Tabulated from Borehole Image Logs by Colog, Inc. For the U-15n Core Hole

Orientation Summary Table
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15N
NNSA/NSO
31 July 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (deg. MN)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	4.56	15.0	88	101	8	4
2	4.79	15.7	139	152	19	3
3	4.83	15.8	157	170	11	3
4	5.27	17.3	111	124	86	3
5	5.88	19.3	148	161	16	1
6	5.96	19.6	19	32	25	1
7	5.98	19.6	255	268	1	3
8	6.01	19.7	105	118	8	2
9	6.26	20.6	18	30	24	1
10	6.32	20.7	86	99	9	3
11	6.34	20.8	60	73	10	1
12	6.36	20.9	91	104	14	3
13	6.41	21.0	36	49	14	1
14	6.43	21.1	46	59	16	1
15	6.64	21.8	51	64	14	3
16	7.19	23.6	70	83	3	2
17	7.21	23.6	98	110	14	2
18	7.71	25.3	55	68	57	2
19	7.73	25.4	256	269	24	1
20	7.75	25.4	53	66	59	3
21	7.80	25.6	54	67	8	4
22	7.83	25.7	135	148	8	2
23	7.85	25.8	54	66	64	1
24	7.90	25.9	113	126	4	3
25	7.92	26.0	73	85	3	1
26	7.95	26.1	102	115	6	3
27	8.49	27.8	108	121	80	1
28	8.53	28.0	33	46	2	2
29	8.54	28.0	117	130	88	1
30	8.56	28.1	63	76	10	1
31	8.58	28.2	95	108	8	2
32	8.62	28.3	85	98	14	3
33	9.10	29.9	275	288	16	2
34	9.31	30.6	79	92	68	2
35	9.40	30.8	73	86	71	1
36	9.49	31.1	80	93	66	3
37	9.53	31.3	95	108	8	2
38	9.56	31.4	94	106	4	2
39	9.59	31.5	29	42	6	1
40	9.80	32.2	79	92	75	3
41	9.83	32.3	80	93	7	2
42	9.87	32.4	69	82	12	2
43	10.01	32.9	114	127	14	3
44	10.10	33.1	89	102	8	2
45	10.16	33.3	117	130	8	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15N
NNSA/NSO
31 July 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (deg. MN)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
46	10.35	34.0	242	255	3	2
47	10.38	34.1	244	256	1	3
48	10.63	34.9	117	130	77	1
49	10.74	35.3	90	103	10	1
50	10.98	36.0	13	26	27	1
51	11.03	36.2	89	102	8	1
52	11.06	36.3	199	212	5	1
53	11.08	36.4	133	146	17	2
54	11.27	37.0	56	69	12	1
55	11.51	37.8	58	71	3	2
56	11.55	37.9	69	82	10	3
57	11.75	38.6	160	173	9	1
58	11.86	38.9	109	122	8	2
59	12.18	40.0	80	93	12	2
60	12.50	41.0	344	356	6	1
61	12.53	41.1	105	117	55	2
62	12.80	42.0	142	155	51	1
63	12.80	42.0	11	24	11	1
64	12.89	42.3	77	90	14	2
65	12.91	42.4	83	96	19	1
66	13.08	42.9	132	144	69	1
67	13.12	43.0	77	90	36	1
68	13.31	43.7	64	77	6	2
69	13.35	43.8	47	60	6	2
70	13.39	43.9	63	76	7	2
71	13.52	44.4	70	83	14	2
72	13.57	44.5	43	56	1	2
73	13.60	44.6	42	55	10	3
74	13.62	44.7	166	179	2	1
75	14.22	46.6	56	68	5	2
76	14.34	47.1	75	88	5	2
77	14.37	47.1	82	95	8	2
78	14.74	48.4	28	41	27	1
79	15.02	49.3	85	98	20	2
80	15.28	50.1	123	135	11	1
81	15.30	50.2	120	132	13	2
82	15.51	50.9	177	190	82	1
83	15.87	52.1	149	162	2	2
84	15.89	52.1	70	82	12	2
85	15.93	52.3	99	111	10	1
86	16.28	53.4	81	94	12	2
87	16.31	53.5	96	109	16	3
88	16.34	53.6	112	125	10	1
89	16.43	53.9	101	114	24	1
90	16.60	54.5	348	0	84	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15N
NNSA/NSO
31 July 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (deg. MN)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
91	16.74	54.9	360	13	26	1
92	16.87	55.4	105	118	4	2
93	16.89	55.4	251	264	67	2
94	16.90	55.4	91	104	10	2
95	17.12	56.2	32	44	27	1
96	17.17	56.3	38	51	30	1
97	17.34	56.9	80	93	3	2
98	17.36	57.0	80	93	10	2
99	17.47	57.3	121	134	10	2
100	17.50	57.4	136	149	6	1
101	18.13	59.5	62	75	71	2
102	18.20	59.7	7	20	23	2
103	18.31	60.1	45	58	3	2
104	18.98	62.3	113	126	78	3
105	19.25	63.2	232	245	27	1
106	19.50	64.0	119	132	80	3
107	20.39	66.9	14	26	8	1
108	20.42	67.0	14	27	8	2
109	20.49	67.2	48	61	7	2
110	20.51	67.3	61	74	7	2
111	20.74	68.1	51	64	3	1
112	20.77	68.1	60	73	8	2
113	21.58	70.8	84	97	1	1
114	22.81	74.9	12	25	68	3
115	22.83	74.9	33	46	6	2
116	23.43	76.9	30	43	83	1
117	23.50	77.1	7	20	86	2
118	24.21	79.4	355	7	81	5
119	24.65	80.9	358	11	76	5
120	25.31	83.1	13	26	83	4
121	25.38	83.3	257	270	73	3
122	25.51	83.7	259	272	64	4
123	25.75	84.5	268	281	72	2
124	25.92	85.0	275	288	72	4
125	26.09	85.6	273	286	81	1
126	26.54	87.1	261	274	80	1
127	26.94	88.4	74	87	14	2
128	26.94	88.4	5	18	77	4
129	27.09	88.9	3	16	84	1
130	27.20	89.3	81	94	12	3
131	27.35	89.7	56	69	8	1
132	27.80	91.2	20	33	10	2
133	27.99	91.8	121	134	8	2
134	28.02	91.9	106	119	10	2
135	28.38	93.1	75	88	8	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15N
NNSA/NSO
31 July 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (deg. MN)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
136	28.69	94.1	48	61	8	1
137	29.85	97.9	29	42	24	1
138	30.15	98.9	41	53	10	1
139	30.36	99.6	27	40	26	1
140	30.52	100.1	35	48	10	1
141	31.03	101.8	52	65	4	2
142	31.05	101.9	64	77	10	3
143	31.14	102.2	59	72	10	1
144	31.32	102.8	66	79	18	3
145	31.42	103.1	194	207	81	3
146	31.89	104.6	189	201	83	4
147	32.10	105.3	193	205	80	4
148	32.34	106.1	200	213	64	5
149	32.55	106.8	62	75	9	2
150	32.56	106.8	191	204	70	1
151	32.65	107.1	202	215	74	2
152	32.81	107.6	188	201	74	1
153	32.83	107.7	194	207	73	2
154	33.21	109.0	66	79	18	1
155	33.75	110.7	14	26	26	1
156	34.00	111.6	124	137	75	3
157	34.08	111.8	118	130	76	3
158	34.49	113.2	50	63	12	2
159	34.74	114.0	195	208	85	1
160	35.01	114.9	54	66	4	1
161	35.03	114.9	15	27	6	2
162	35.08	115.1	342	355	70	1
163	35.64	116.9	208	221	74	4
164	35.74	117.3	206	219	78	1
165	35.83	117.6	103	115	10	2
166	35.85	117.6	108	121	16	2
167	35.91	117.8	22	35	12	1
168	36.28	119.0	36	49	13	2
169	36.42	119.5	55	68	12	1
170	36.64	120.2	37	50	20	1
171	36.76	120.6	63	76	18	1
172	36.82	120.8	111	124	80	2
173	36.94	121.2	82	95	10	1
174	37.14	121.9	46	59	22	1
175	37.57	123.3	62	75	19	1
176	37.61	123.4	93	106	78	1
177	37.64	123.5	66	79	24	2
178	37.68	123.6	68	81	22	3
179	37.69	123.7	197	210	73	1
180	37.80	124.0	25	38	79	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15N
NNSA/NSO
31 July 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (deg. MN)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
181	37.84	124.1	84	97	18	1
182	37.93	124.4	74	87	18	2
183	38.23	125.4	60	73	25	2
184	38.31	125.7	183	195	7	2
185	38.80	127.3	269	282	3	1
186	38.82	127.4	82	95	14	2
187	38.93	127.7	110	123	3	1
188	38.95	127.8	77	90	10	2
189	38.95	127.8	220	233	62	2
190	39.61	129.9	115	128	86	2
191	39.80	130.6	37	50	29	1
192	40.05	131.4	99	112	12	2
193	40.11	131.6	55	68	22	1
194	40.20	131.9	256	268	3	1
195	40.41	132.6	41	54	15	2
196	40.69	133.5	161	174	56	3
197	40.87	134.1	198	211	37	3
198	41.05	134.7	68	80	25	2
199	41.18	135.1	65	78	6	1
200	41.20	135.2	73	86	12	3
201	41.23	135.3	62	75	20	1
202	41.29	135.5	26	39	20	2
203	41.80	137.1	204	217	60	2
204	42.06	138.0	61	73	19	1
205	42.33	138.9	52	65	18	2
206	42.43	139.2	207	220	73	1
207	42.45	139.3	76	89	20	2
208	42.89	140.7	246	259	3	1
209	43.65	143.2	236	249	20	1
210	45.11	148.0	212	225	43	1
211	45.32	148.7	214	227	41	2
212	45.41	149.0	211	224	59	3
213	45.44	149.1	314	327	71	2
214	45.57	149.5	275	288	69	1
215	45.88	150.5	260	273	52	3
216	45.93	150.7	237	250	60	2
217	46.45	152.4	109	122	10	2
218	46.66	153.1	313	325	3	1
219	47.34	155.3	184	197	60	5
220	47.50	155.9	99	112	79	1
221	47.62	156.2	50	63	12	2
222	47.75	156.7	89	102	78	3
223	47.82	156.9	9	22	59	1
224	47.93	157.3	6	19	75	1
225	47.96	157.3	202	215	52	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15N
NNSA/NSO
31 July 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (deg. MN)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
226	47.98	157.4	341	354	72	1
227	48.07	157.7	5	18	15	2
228	48.26	158.3	159	171	50	3
229	48.28	158.4	187	200	59	2
230	48.41	158.8	70	83	12	1
231	48.51	159.2	61	74	10	1
232	48.58	159.4	247	260	77	2
233	48.58	159.4	191	204	54	3
234	48.81	160.1	340	353	7	1
235	48.82	160.2	340	353	8	1
236	49.31	161.8	105	117	6	1
237	49.41	162.1	68	81	4	3
238	49.53	162.5	206	219	58	2
239	49.54	162.5	188	201	42	1
240	49.59	162.7	292	305	75	1
241	49.65	162.9	309	322	9	1
242	49.89	163.7	107	120	10	2
243	49.94	163.9	107	120	73	1
244	50.28	165.0	51	64	16	1
245	50.35	165.2	27	40	8	2
246	50.46	165.5	59	72	8	1
247	50.48	165.6	71	84	16	1
248	50.56	165.9	66	79	7	1
249	50.67	166.2	64	77	10	3
250	50.99	167.3	69	81	1	2
251	51.01	167.4	213	226	23	1
252	51.07	167.6	196	209	31	3
253	51.10	167.7	21	34	29	1
254	51.18	167.9	200	213	74	4
255	51.23	168.1	282	294	30	1
256	51.39	168.6	188	201	65	4
257	51.49	168.9	35	48	22	1
258	51.51	169.0	69	81	12	3
259	51.55	169.1	24	37	80	1
260	51.65	169.5	215	228	67	2
261	51.74	169.8	216	229	63	1
262	51.91	170.3	38	51	22	2
263	51.95	170.4	195	208	66	4
264	52.01	170.7	61	74	20	2
265	52.23	171.4	41	54	23	1
266	52.25	171.4	209	222	73	1
267	52.26	171.5	144	157	11	1
268	52.33	171.7	109	122	20	2
269	52.68	172.8	114	127	81	3
270	52.70	172.9	95	108	10	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table
Acoustic Televiewer Features
Nevada Test Site
Source Physics Experiment
U-15N
NNSA/NSO
31 July 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (deg. MN)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
271	52.73	173.0	67	80	12	3
272	52.82	173.3	116	129	81	2
273	53.13	174.3	116	129	83	1
274	53.15	174.4	12	25	13	3
275	53.18	174.5	39	52	18	3
276	53.45	175.4	199	211	74	3
277	53.46	175.4	61	74	18	2
278	53.50	175.5	37	49	80	1
279	53.69	176.1	114	127	79	1
280	53.74	176.3	68	81	10	3
281	54.57	179.0	88	101	15	3
282	54.68	179.4	189	202	85	1
283	54.70	179.5	75	88	4	2
284	54.82	179.8	239	252	43	3
285	54.83	179.9	279	292	56	1
286	55.19	181.1	49	62	8	1
287	55.29	181.4	67	80	12	1
288	55.44	181.9	182	194	35	2
289	55.60	182.4	6	19	84	2
290	55.61	182.5	42	55	22	2
291	55.83	183.2	20	33	77	1
292	55.87	183.3	6	19	14	2
293	56.49	185.3	153	166	2	1
294	56.51	185.4	43	56	14	3
295	57.20	187.7	67	80	20	1
296	57.27	187.9	270	283	33	1
297	57.32	188.1	247	260	43	2
298	57.49	188.6	34	47	8	2
299	57.52	188.7	249	262	57	2
300	57.56	188.9	251	264	53	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Appendix J-2

Fracture Data Tabulated from Borehole Image Logs by Colog, Inc. for Instrument Hole U-15n#1

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	2.17	7.1	120	133	75	3
2	2.20	7.2	178	190	38	4
3	2.29	7.5	181	194	7	0
4	2.66	8.7	64	77	25	0
5	2.76	9.1	52	65	21	0
6	2.94	9.6	49	62	6	0
7	3.00	9.8	47	60	10	0
8	3.27	10.7	231	244	19	0
9	3.29	10.8	29	42	34	0
10	3.64	12.0	82	94	18	1
11	3.81	12.5	28	41	15	1
12	3.84	12.6	27	40	8	2
13	3.88	12.7	346	358	14	0
14	3.89	12.8	104	117	66	1
15	3.97	13.0	318	330	27	1
16	3.98	13.1	32	44	32	1
17	4.03	13.2	26	39	22	1
18	4.15	13.6	41	54	24	2
19	4.33	14.2	8	21	24	2
20	4.33	14.2	19	32	35	3
21	4.54	14.9	95	108	8	0
22	4.72	15.5	7	20	77	2
23	4.91	16.1	92	105	49	1
24	4.99	16.4	149	162	59	1
25	5.16	16.9	9	22	80	1
26	5.87	19.3	54	67	7	2
27	6.46	21.2	5	18	25	1
28	6.54	21.5	175	187	13	1
29	6.61	21.7	188	201	24	1
30	6.62	21.7	354	7	27	1
31	7.26	23.8	189	202	80	1
32	7.51	24.6	114	127	9	2
33	7.76	25.5	33	46	21	1
34	8.04	26.4	21	33	22	0
35	8.06	26.5	145	158	6	3
36	8.11	26.6	70	83	13	1
37	8.12	26.7	176	189	10	3
38	8.18	26.9	123	135	7	2
39	8.28	27.2	280	293	9	1
40	8.41	27.6	195	208	84	2
41	8.56	28.1	127	140	11	0
42	8.62	28.3	118	130	10	2
43	8.71	28.6	171	184	9	3
44	8.72	28.6	343	356	17	3
45	8.80	28.9	113	126	10	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
46	8.85	29.0	249	262	16	1
47	9.08	29.8	49	61	15	3
48	9.10	29.9	286	299	15	3
49	9.21	30.2	10	23	25	0
50	9.25	30.3	199	212	51	2
51	9.26	30.4	109	122	8	1
52	9.59	31.5	20	32	21	2
53	9.71	31.9	76	89	6	0
54	9.75	32.0	178	191	19	0
55	9.86	32.3	31	43	12	1
56	9.92	32.5	69	82	3	0
57	9.96	32.7	91	104	12	2
58	10.05	33.0	109	122	6	0
59	10.14	33.3	110	123	8	0
60	10.17	33.4	128	141	7	2
61	10.19	33.4	99	112	5	0
62	10.21	33.5	48	61	6	0
63	10.28	33.7	115	128	9	2
64	10.47	34.4	28	41	16	2
65	10.53	34.6	111	124	9	1
66	10.57	34.7	108	120	9	1
67	10.68	35.1	53	66	6	2
68	10.73	35.2	30	43	6	0
69	10.77	35.3	111	124	9	0
70	10.80	35.4	93	106	5	0
71	10.91	35.8	257	270	14	1
72	10.97	36.0	61	74	7	1
73	10.99	36.1	196	209	15	0
74	11.04	36.2	152	165	10	2
75	11.13	36.5	85	98	9	0
76	11.14	36.6	162	175	8	2
77	11.23	36.8	1	14	21	2
78	11.24	36.9	50	62	15	1
79	11.28	37.0	120	133	7	0
80	11.32	37.1	89	102	12	1
81	11.35	37.2	79	92	16	1
82	11.39	37.4	70	83	9	1
83	11.45	37.6	124	137	7	0
84	11.49	37.7	22	35	6	0
85	11.51	37.8	112	125	35	0
86	11.53	37.8	38	51	31	0
87	11.57	38.0	143	156	7	3
88	11.60	38.1	136	148	9	3
89	11.61	38.1	184	196	81	2
90	11.68	38.3	113	125	7	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
91	11.80	38.7	354	7	4	1
92	11.99	39.4	143	156	11	2
93	12.13	39.8	115	128	8	1
94	12.27	40.2	28	41	19	1
95	12.30	40.3	157	170	13	1
96	12.38	40.6	43	56	82	1
97	12.48	41.0	35	47	25	0
98	12.57	41.3	74	87	9	0
99	12.71	41.7	47	60	6	2
100	12.77	41.9	68	81	21	0
101	12.91	42.3	13	26	64	3
102	13.47	44.2	185	198	45	2
103	13.51	44.3	88	101	5	0
104	13.66	44.8	108	121	11	0
105	13.94	45.7	20	33	33	0
106	14.10	46.3	340	353	9	1
107	14.14	46.4	331	344	63	1
108	14.35	47.1	147	160	8	0
109	14.69	48.2	132	144	13	1
110	15.10	49.5	60	73	17	1
111	15.12	49.6	283	296	18	1
112	15.15	49.7	148	161	10	1
113	15.26	50.1	117	130	21	0
114	15.51	50.9	98	111	8	1
115	16.48	54.1	104	117	72	2
116	16.65	54.6	24	37	9	1
117	16.72	54.9	48	61	16	1
118	16.90	55.4	120	133	10	2
119	17.00	55.8	103	115	10	2
120	17.31	56.8	30	43	27	0
121	17.88	58.7	125	138	9	2
122	18.10	59.4	19	32	25	0
123	18.61	61.1	141	154	4	3
124	18.67	61.3	125	137	6	3
125	18.77	61.6	10	22	27	0
126	19.12	62.7	29	42	28	3
127	19.26	63.2	66	79	9	0
128	19.36	63.5	104	117	78	3
129	19.58	64.2	97	110	69	3
130	19.64	64.5	224	236	13	1
131	19.71	64.7	285	298	75	3
132	19.77	64.9	41	53	4	2
133	20.05	65.8	88	101	10	1
134	20.06	65.8	29	42	27	1
135	20.18	66.2	111	124	7	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
136	20.24	66.4	84	96	6	1
137	20.58	67.5	97	110	13	1
138	20.99	68.9	132	145	65	3
139	21.31	69.9	64	76	11	2
140	21.37	70.1	20	32	84	3
141	21.39	70.2	208	221	77	3
142	21.44	70.3	119	132	6	2
143	21.51	70.6	100	113	5	3
144	21.61	70.9	39	51	6	2
145	21.64	71.0	53	66	83	3
146	21.75	71.4	69	82	68	3
147	21.86	71.7	46	59	84	3
148	21.99	72.2	207	219	79	3
149	22.14	72.6	33	46	28	3
150	22.17	72.7	201	214	13	1
151	22.33	73.3	34	47	8	1
152	22.49	73.8	39	52	6	2
153	22.80	74.8	213	226	17	1
154	22.82	74.9	27	40	29	1
155	23.25	76.3	225	238	19	0
156	23.28	76.4	36	49	55	0
157	23.66	77.6	44	56	11	3
158	23.69	77.7	37	50	27	3
159	24.10	79.1	0	13	3	2
160	24.12	79.1	42	55	10	2
161	24.13	79.2	7	20	33	0
162	24.24	79.5	27	40	82	3
163	24.42	80.1	92	105	7	3
164	24.73	81.2	38	50	10	3
165	24.82	81.4	49	62	11	3
166	24.91	81.7	261	274	51	3
167	24.96	81.9	33	46	14	0
168	24.99	82.0	28	41	22	0
169	25.04	82.1	193	206	45	0
170	25.22	82.7	29	42	30	3
171	25.26	82.9	43	56	11	3
172	25.53	83.8	103	116	9	0
173	25.54	83.8	201	214	89	3
174	25.63	84.1	213	226	70	3
175	25.64	84.1	34	47	13	3
176	25.72	84.4	27	40	9	3
177	25.99	85.3	274	287	45	0
178	26.44	86.7	3	16	67	3
179	26.72	87.7	141	153	31	0
180	26.72	87.7	42	55	8	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
181	26.96	88.5	86	99	37	3
182	27.00	88.6	73	86	22	1
183	27.06	88.8	78	91	65	3
184	27.16	89.1	58	71	14	3
185	27.37	89.8	151	164	9	3
186	27.51	90.3	41	54	23	2
187	27.67	90.8	300	313	1	3
188	27.76	91.1	224	237	18	1
189	27.81	91.3	36	49	24	1
190	27.84	91.3	195	207	81	3
191	27.88	91.5	1	14	12	3
192	27.95	91.7	88	101	15	3
193	28.01	91.9	90	103	9	3
194	28.07	92.1	109	121	78	2
195	28.14	92.3	29	42	24	0
196	28.62	93.9	14	27	88	3
197	28.66	94.0	100	113	9	2
198	29.00	95.2	67	80	13	0
199	29.26	96.0	69	82	7	0
200	29.30	96.1	40	53	20	1
201	29.41	96.5	16	29	17	0
202	29.47	96.7	14	27	85	3
203	29.59	97.1	81	93	16	1
204	29.64	97.2	78	90	15	1
205	29.72	97.5	280	293	37	2
206	29.89	98.1	61	74	18	0
207	29.92	98.2	218	231	73	3
208	30.05	98.6	88	101	17	0
209	30.09	98.7	72	85	15	0
210	30.15	98.9	157	169	23	0
211	30.34	99.5	334	347	38	3
212	30.40	99.8	281	294	14	0
213	30.50	100.1	24	37	15	1
214	30.72	100.8	93	106	10	0
215	30.87	101.3	30	43	10	1
216	31.43	103.1	69	82	14	2
217	31.57	103.6	42	55	16	1
218	31.73	104.1	12	24	79	3
219	31.75	104.2	191	204	11	0
220	31.87	104.6	62	75	11	0
221	31.93	104.8	198	211	51	3
222	31.97	104.9	204	216	59	2
223	32.17	105.6	36	48	25	0
224	32.42	106.4	9	22	86	3
225	32.53	106.7	150	163	13	0

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
226	32.58	106.9	44	57	12	1
227	32.71	107.3	91	104	13	1
228	32.77	107.5	186	199	62	3
229	32.78	107.6	67	80	11	1
230	32.82	107.7	43	56	20	0
231	33.02	108.3	219	232	45	3
232	33.31	109.3	31	44	23	0
233	33.37	109.5	271	284	57	3
234	33.40	109.6	10	23	81	3
235	33.86	111.1	33	46	16	0
236	33.95	111.4	188	201	70	1
237	34.41	112.9	28	41	33	1
238	34.55	113.4	42	55	32	0
239	34.56	113.4	39	52	14	0
240	34.60	113.5	50	63	11	0
241	34.78	114.1	56	69	17	1
242	34.83	114.3	68	81	20	1
243	34.98	114.8	43	56	26	2
244	35.11	115.2	17	30	89	3
245	35.28	115.8	36	49	19	0
246	35.35	116.0	34	46	22	0
247	35.42	116.2	109	121	77	3
248	35.69	117.1	11	24	22	1
249	35.73	117.2	27	40	9	1
250	35.79	117.4	22	35	11	1
251	35.93	117.9	60	73	4	0
252	36.02	118.2	96	109	8	0
253	36.09	118.4	37	50	11	0
254	36.42	119.5	31	44	13	3
255	36.59	120.0	244	257	67	3
256	36.61	120.1	217	230	58	3
257	36.62	120.2	95	108	63	3
258	36.67	120.3	93	106	59	1
259	36.79	120.7	237	250	56	3
260	36.82	120.8	50	63	26	1
261	37.16	121.9	104	117	19	4
262	37.18	122.0	16	28	84	3
263	37.34	122.5	51	64	16	1
264	37.38	122.6	28	41	11	3
265	37.43	122.8	55	68	10	1
266	37.59	123.3	233	246	69	3
267	37.62	123.4	40	53	10	1
268	37.64	123.5	16	28	46	0
269	37.73	123.8	36	49	9	2
270	37.80	124.0	1	14	20	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
271	37.82	124.1	356	9	10	1
272	37.98	124.6	234	247	2	1
273	38.04	124.8	301	314	2	1
274	38.09	125.0	51	64	17	1
275	38.27	125.6	358	11	52	0
276	38.28	125.6	99	112	17	0
277	38.71	127.0	118	130	36	1
278	38.75	127.1	349	2	19	3
279	38.77	127.2	109	122	41	1
280	38.83	127.4	114	127	39	3
281	38.96	127.8	59	72	14	1
282	38.97	127.9	53	66	49	3
283	38.99	127.9	196	209	77	3
284	39.14	128.4	217	230	50	3
285	39.53	129.7	244	257	53	3
286	39.65	130.1	222	235	46	2
287	39.79	130.6	222	234	51	3
288	39.83	130.7	46	58	25	1
289	39.95	131.1	222	234	49	3
290	40.03	131.3	41	54	36	2
291	40.11	131.6	53	65	21	1
292	40.41	132.6	206	219	71	3
293	40.82	133.9	13	25	84	3
294	40.83	134.0	15	28	81	3
295	41.02	134.6	186	198	65	3
296	41.06	134.7	180	192	78	3
297	41.13	134.9	187	200	73	3
298	41.19	135.1	45	58	20	0
299	41.29	135.5	32	45	29	3
300	41.38	135.8	34	47	28	0
301	41.38	135.8	201	214	75	3
302	41.57	136.4	190	203	80	3
303	41.97	137.7	33	46	22	2
304	42.07	138.0	35	48	23	0
305	42.20	138.4	169	182	63	3
306	42.31	138.8	193	206	72	3
307	42.37	139.0	47	60	18	0
308	42.38	139.1	181	194	57	3
309	42.51	139.5	249	261	27	0
310	42.52	139.5	186	199	69	3
311	42.66	140.0	70	83	18	0
312	42.71	140.1	91	104	17	3
313	43.08	141.4	206	219	72	3
314	43.27	142.0	31	44	10	0
315	43.38	142.3	55	68	15	0

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
316	43.39	142.4	196	208	77	3
317	43.71	143.4	62	75	13	0
318	43.82	143.8	73	85	16	0
319	43.85	143.9	25	38	84	3
320	44.01	144.4	59	72	17	0
321	44.07	144.6	259	272	14	0
322	44.10	144.7	76	89	15	0
323	44.25	145.2	127	140	81	2
324	44.27	145.3	75	87	14	0
325	44.37	145.6	79	92	14	0
326	44.74	146.8	200	213	81	2
327	45.02	147.7	16	28	28	0
328	45.05	147.8	14	27	17	0
329	45.16	148.2	78	91	10	3
330	45.24	148.4	76	89	15	0
331	45.34	148.8	40	52	29	0
332	45.44	149.1	79	92	13	0
333	45.66	149.8	190	203	70	0
334	45.74	150.1	124	137	23	0
335	45.81	150.3	59	72	9	0
336	45.83	150.4	74	86	9	0
337	45.85	150.4	202	214	74	3
338	45.86	150.5	72	85	9	0
339	45.86	150.5	196	209	67	0
340	45.92	150.7	165	178	55	3
341	46.00	150.9	148	161	61	3
342	46.02	151.0	209	222	73	3
343	46.08	151.2	204	217	76	3
344	46.20	151.6	186	199	48	3
345	46.74	153.4	203	216	53	3
346	46.74	153.4	208	221	45	3
347	46.79	153.5	218	231	59	3
348	46.81	153.6	46	59	13	0
349	46.84	153.7	195	208	80	3
350	47.02	154.3	206	219	66	3
351	47.22	154.9	208	221	74	1
352	47.28	155.1	203	216	71	3
353	47.37	155.4	59	72	22	1
354	47.38	155.5	199	212	67	3
355	47.56	156.1	196	209	74	3
356	47.66	156.4	206	219	72	3
357	47.70	156.5	70	83	13	1
358	47.74	156.6	211	223	74	3
359	47.92	157.2	47	60	15	1
360	48.00	157.5	45	58	8	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
361	48.02	157.6	45	58	11	1
362	48.05	157.7	14	26	81	3
363	48.11	157.8	189	202	2	1
364	48.13	157.9	65	78	15	1
365	48.25	158.3	204	217	62	3
366	48.41	158.8	168	181	68	3
367	48.46	159.0	54	67	16	0
368	48.53	159.2	189	202	73	3
369	48.75	159.9	52	65	12	3
370	48.91	160.5	68	81	21	3
371	49.03	160.9	65	78	19	1
372	49.21	161.5	116	129	80	3
373	49.42	162.2	81	94	15	1
374	49.49	162.4	110	123	78	3
375	49.52	162.5	56	68	19	1
376	49.83	163.5	63	75	11	1
377	49.89	163.7	65	77	16	3
378	49.90	163.7	227	240	51	1
379	49.99	164.0	105	118	80	3
380	50.01	164.1	205	218	48	3
381	50.01	164.1	60	73	11	1
382	50.28	165.0	76	89	12	1
383	50.54	165.8	65	78	6	1
384	50.70	166.3	239	252	65	3
385	50.95	167.2	57	70	17	1
386	51.02	167.4	59	72	29	1
387	51.28	168.2	55	68	6	2
388	51.45	168.8	68	81	14	2
389	51.52	169.0	50	63	2	1
390	51.56	169.2	78	91	25	1
391	51.68	169.6	66	79	30	1
392	52.10	170.9	69	82	15	1
393	52.22	171.3	70	83	21	1
394	52.30	171.6	17	30	71	2
395	52.39	171.9	188	201	60	3
396	52.39	171.9	51	64	7	1
397	52.48	172.2	66	79	16	1
398	52.67	172.8	67	79	9	1
399	52.75	173.1	67	80	19	2
400	52.82	173.3	78	90	64	3
401	52.89	173.5	77	90	40	3
402	52.97	173.8	135	148	78	3
403	53.26	174.7	62	74	17	1
404	53.38	175.1	67	79	20	2
405	53.66	176.1	232	245	56	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #1
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
406	53.67	176.1	66	79	20	2
407	53.69	176.2	216	229	58	1
408	53.79	176.5	50	63	22	2
409	53.81	176.5	127	140	79	3
410	53.97	177.1	63	76	44	3
411	54.03	177.3	216	229	69	3
412	54.15	177.7	73	86	23	2
413	54.39	178.5	65	78	12	1
414	54.44	178.6	346	358	63	3
415	54.49	178.8	260	273	10	1
416	54.72	179.5	85	98	13	1
417	54.81	179.8	74	87	14	1
418	54.93	180.2	348	1	13	1
419	55.08	180.7	103	115	79	3
420	55.48	182.0	54	67	14	1
421	55.61	182.4	109	121	81	3
422	55.71	182.8	73	86	11	1
423	55.76	182.9	13	26	83	3
424	56.02	183.8	98	111	21	1
425	56.15	184.2	69	82	9	1
426	56.23	184.5	206	219	13	1
427	56.42	185.1	187	200	43	3
428	56.58	185.6	174	187	24	1
429	56.65	185.9	68	81	10	1
430	56.88	186.6	205	218	27	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Appendix J-3

Fracture Data Tabulated from Borehole Image Logs by Colog, Inc.
For Instrument Hole U-15n#2

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #2
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	4.07	13.4	77	90	10	0
2	4.23	13.9	82	95	11	0
3	4.43	14.6	108	121	14	3
4	4.53	14.9	186	199	6	0
5	4.82	15.8	140	153	15	1
6	5.08	16.7	27	40	18	1
7	5.69	18.7	55	68	7	2
8	5.78	19.0	162	174	7	1
9	6.02	19.8	134	147	11	1
10	6.25	20.5	57	70	13	1
11	6.30	20.7	39	52	25	2
12	6.33	20.8	71	84	19	1
13	6.41	21.0	75	88	12	1
14	6.54	21.5	61	74	22	1
15	6.75	22.1	138	151	16	1
16	6.79	22.3	127	140	18	1
17	6.80	22.3	180	193	14	1
18	6.88	22.6	90	103	13	1
19	6.97	22.9	135	148	20	1
20	7.03	23.1	94	107	15	0
21	7.05	23.1	78	90	18	0
22	7.32	24.0	177	190	11	1
23	7.39	24.2	147	160	33	1
24	7.45	24.4	145	157	25	1
25	7.55	24.8	71	84	16	0
26	7.71	25.3	22	34	3	0
27	8.04	26.4	88	101	34	1
28	8.22	27.0	327	340	4	2
29	8.25	27.1	135	148	26	1
30	8.41	27.6	91	104	15	2
31	8.44	27.7	93	106	13	1
32	8.56	28.1	96	109	15	2
33	8.58	28.2	282	295	7	2
34	8.72	28.6	96	109	7	1
35	8.88	29.1	119	132	8	0
36	9.02	29.6	101	113	4	1
37	9.09	29.8	83	95	12	0
38	9.21	30.2	54	67	13	1
39	9.34	30.6	16	28	5	1
40	9.41	30.9	168	181	8	0
41	9.48	31.1	283	296	7	1
42	9.55	31.3	93	106	15	1
43	9.68	31.8	40	53	15	0
44	9.74	32.0	51	64	10	1
45	9.86	32.4	104	117	11	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #2
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
46	9.94	32.6	32	45	23	0
47	10.06	33.0	89	102	11	0
48	10.13	33.3	113	126	8	0
49	10.26	33.7	26	39	30	1
50	10.44	34.3	7	20	19	1
51	10.52	34.5	23	35	22	1
52	10.55	34.6	44	57	10	0
53	10.63	34.9	59	72	16	0
54	10.77	35.4	12	25	87	3
55	10.90	35.8	89	102	11	0
56	10.98	36.0	117	130	20	1
57	11.04	36.2	148	160	9	1
58	11.16	36.6	112	125	12	1
59	11.43	37.5	96	109	4	1
60	11.60	38.1	43	56	24	0
61	11.66	38.3	80	92	12	0
62	12.12	39.8	169	182	15	1
63	12.27	40.3	138	151	22	1
64	12.44	40.8	133	146	7	1
65	12.54	41.2	158	171	7	1
66	12.62	41.4	55	68	29	1
67	12.69	41.6	80	93	8	1
68	12.73	41.8	84	96	12	1
69	12.87	42.2	293	306	54	1
70	12.91	42.3	105	118	10	1
71	13.16	43.2	52	65	16	1
72	13.18	43.3	291	304	75	1
73	13.70	45.0	34	47	30	1
74	13.78	45.2	116	129	46	1
75	13.82	45.3	250	262	6	1
76	13.98	45.9	103	116	8	2
77	14.04	46.1	97	109	5	1
78	14.05	46.1	70	82	26	0
79	14.07	46.2	80	93	82	3
80	14.07	46.2	32	45	24	0
81	14.13	46.4	221	233	5	2
82	14.22	46.7	146	159	7	2
83	14.30	46.9	105	118	8	2
84	14.36	47.1	139	152	5	1
85	14.40	47.3	137	150	7	1
86	14.48	47.5	38	50	2	2
87	14.59	47.9	113	126	10	2
88	14.69	48.2	90	103	8	1
89	14.78	48.5	102	115	17	1
90	14.84	48.7	201	214	72	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #2
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
91	14.85	48.7	196	209	7	2
92	14.93	49.0	129	142	15	1
93	14.95	49.1	181	194	14	1
94	15.08	49.5	77	90	8	1
95	15.32	50.3	51	64	17	0
96	15.34	50.3	38	51	19	0
97	15.39	50.5	58	71	12	0
98	15.53	51.0	224	237	9	1
99	15.68	51.4	25	38	87	3
100	15.71	51.5	90	103	45	2
101	15.83	52.0	67	80	15	0
102	15.86	52.1	109	122	13	0
103	15.96	52.4	38	51	14	1
104	16.08	52.8	66	78	13	0
105	16.16	53.0	15	28	29	0
106	16.22	53.2	87	99	31	1
107	16.26	53.3	201	214	18	1
108	16.45	54.0	99	112	12	0
109	16.56	54.3	41	54	21	0
110	16.65	54.6	54	67	21	0
111	16.79	55.1	196	209	60	0
112	17.67	58.0	63	76	19	1
113	17.79	58.4	52	65	15	0
114	18.14	59.5	166	179	26	0
115	18.31	60.1	80	93	14	2
116	18.58	61.0	24	37	55	0
117	18.81	61.7	75	88	17	1
118	18.85	61.8	118	131	11	2
119	19.03	62.4	224	237	3	3
120	19.11	62.7	21	34	3	3
121	19.21	63.0	294	307	28	1
122	19.30	63.3	98	111	11	1
123	19.34	63.4	222	234	21	1
124	19.38	63.6	29	42	59	0
125	20.29	66.6	102	115	3	1
126	20.29	66.6	40	53	20	1
127	20.55	67.4	98	111	17	0
128	20.62	67.7	47	60	22	1
129	20.69	67.9	4	17	29	1
130	20.75	68.1	327	340	19	2
131	20.78	68.2	121	134	19	3
132	20.91	68.6	85	98	20	3
133	20.96	68.8	254	267	11	1
134	20.99	68.9	139	152	63	3
135	21.00	68.9	235	247	19	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #2
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
136	21.05	69.1	311	324	61	2
137	21.06	69.1	234	247	31	3
138	21.13	69.3	107	120	9	1
139	21.27	69.8	33	45	51	3
140	21.28	69.8	131	144	25	0
141	21.30	69.9	194	207	58	1
142	21.42	70.3	14	27	15	2
143	21.44	70.4	3	16	20	2
144	21.48	70.5	132	145	44	3
145	21.51	70.6	102	115	7	2
146	21.52	70.6	224	237	16	1
147	21.71	71.2	331	344	48	3
148	21.76	71.4	86	99	56	3
149	21.92	71.9	21	34	42	1
150	22.05	72.3	339	352	17	0
151	22.05	72.4	305	318	3	1
152	22.12	72.6	224	237	7	0
153	22.20	72.8	293	306	6	2
154	22.20	72.9	17	29	10	2
155	22.26	73.0	45	58	22	2
156	22.41	73.5	43	56	28	0
157	22.54	74.0	250	263	1	2
158	22.60	74.1	40	53	23	3
159	22.74	74.6	119	132	5	4
160	22.75	74.6	318	331	52	3
161	22.84	75.0	94	107	6	3
162	23.40	76.8	186	199	17	1
163	23.40	76.8	69	82	9	1
164	23.51	77.1	53	66	25	2
165	23.66	77.6	55	68	56	1
166	23.88	78.4	58	71	20	0
167	24.06	78.9	202	215	54	0
168	24.10	79.1	50	63	17	0
169	24.24	79.5	119	132	8	2
170	24.37	80.0	80	93	6	3
171	24.45	80.2	101	113	3	4
172	24.55	80.6	116	129	14	3
173	24.65	80.9	205	218	7	0
174	24.87	81.6	75	88	6	3
175	24.91	81.7	234	247	68	0
176	24.91	81.7	64	76	3	4
177	24.98	81.9	149	162	3	4
178	25.07	82.3	76	89	9	3
179	25.47	83.6	242	255	58	1
180	25.60	84.0	36	49	17	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #2
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
181	25.65	84.2	83	96	5	3
182	25.70	84.3	65	78	41	3
183	25.78	84.6	52	65	16	0
184	25.90	85.0	51	64	29	0
185	26.01	85.3	7	20	37	0
186	26.09	85.6	54	67	69	3
187	26.20	86.0	108	121	12	1
188	26.30	86.3	42	55	30	1
189	26.49	86.9	239	251	27	1
190	26.51	87.0	37	50	34	2
191	26.67	87.5	27	39	9	2
192	26.70	87.6	141	153	22	2
193	27.23	89.3	92	104	14	0
194	27.97	91.8	53	66	14	3
195	28.03	92.0	62	74	6	3
196	28.09	92.2	32	45	15	1
197	28.15	92.4	36	49	46	1
198	28.81	94.5	70	83	15	1
199	28.89	94.8	87	100	72	3
200	29.15	95.6	47	59	23	1
201	29.39	96.4	43	56	24	1
202	29.51	96.8	67	79	12	1
203	29.57	97.0	163	176	10	3
204	29.69	97.4	251	263	11	2
205	29.81	97.8	66	79	29	4
206	29.98	98.4	96	109	16	0
207	30.13	98.9	70	83	10	0
208	30.31	99.4	115	127	9	1
209	30.44	99.9	305	318	80	3
210	30.50	100.1	40	53	9	3
211	30.65	100.6	86	99	15	3
212	30.74	100.9	318	330	78	3
213	30.77	100.9	302	315	85	2
214	30.90	101.4	121	134	22	3
215	31.03	101.8	66	79	20	1
216	31.15	102.2	111	124	35	3
217	31.32	102.8	198	211	15	1
218	31.76	104.2	153	166	17	3
219	31.76	104.2	58	71	28	1
220	31.86	104.5	208	220	11	1
221	32.03	105.1	219	232	21	1
222	32.77	107.5	42	55	19	0
223	32.88	107.9	58	71	19	0
224	33.10	108.6	17	30	5	1
225	33.14	108.7	70	83	9	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #2
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
226	33.24	109.1	68	81	13	3
227	33.36	109.4	126	138	18	1
228	33.40	109.6	41	54	27	1
229	33.49	109.9	57	70	16	0
230	33.52	110.0	357	9	76	3
231	33.63	110.3	38	50	23	0
232	33.64	110.4	347	0	75	2
233	33.76	110.8	23	35	28	0
234	33.93	111.3	17	29	53	0
235	34.02	111.6	88	101	15	0
236	34.14	112.0	27	40	31	0
237	34.34	112.7	33	45	29	0
238	34.34	112.7	118	131	28	3
239	34.47	113.1	105	118	7	4
240	34.59	113.5	129	142	18	3
241	34.62	113.6	104	117	9	0
242	34.69	113.8	101	114	9	0
243	35.51	116.5	276	288	13	2
244	35.52	116.5	112	125	12	2
245	35.59	116.8	30	42	25	1
246	35.75	117.3	197	210	2	2
247	35.92	117.9	113	126	10	0
248	36.20	118.8	118	131	13	3
249	36.37	119.3	45	58	26	1
250	36.51	119.8	69	82	3	1
251	36.53	119.9	76	89	14	1
252	36.70	120.4	120	133	81	3
253	36.71	120.5	123	136	73	3
254	36.79	120.7	163	176	42	1
255	36.88	121.0	105	118	16	3
256	37.00	121.4	74	87	12	4
257	37.11	121.8	125	138	29	3
258	37.27	122.3	117	130	51	3
259	37.43	122.8	74	87	29	3
260	37.65	123.5	27	39	70	3
261	37.80	124.0	66	79	18	2
262	37.91	124.4	58	71	73	3
263	38.64	126.8	17	30	76	3
264	38.79	127.3	33	46	74	1
265	39.06	128.1	8	21	78	1
266	39.06	128.2	6	19	78	3
267	39.13	128.4	16	29	46	3
268	39.17	128.5	13	26	83	1
269	39.26	128.8	11	24	9	3
270	39.36	129.1	19	32	81	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #2
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
271	39.40	129.3	60	73	15	1
272	39.48	129.5	71	84	16	2
273	39.54	129.7	59	72	23	1
274	39.64	130.1	33	46	28	2
275	39.69	130.2	43	56	18	1
276	39.71	130.3	121	134	83	3
277	39.83	130.7	147	160	7	2
278	39.88	130.8	37	49	15	1
279	40.15	131.7	72	85	10	3
280	40.20	131.9	83	96	13	0
281	40.27	132.1	132	145	16	1
282	40.45	132.7	215	228	7	1
283	40.50	132.9	190	203	3	1
284	40.77	133.8	68	81	18	0
285	40.93	134.3	27	40	72	0
286	41.02	134.6	238	251	14	0
287	41.03	134.6	210	222	5	3
288	41.08	134.8	64	76	8	0
289	41.86	137.3	6	19	81	3
290	42.12	138.2	59	71	25	2
291	42.16	138.3	11	24	83	3
292	42.23	138.6	186	199	48	3
293	42.30	138.8	16	29	83	3
294	42.42	139.2	46	59	13	1
295	42.63	139.9	197	210	52	1
296	43.00	141.1	182	195	52	3
297	43.31	142.1	59	72	14	1
298	43.35	142.2	203	215	35	3
299	43.46	142.6	204	216	34	3
300	43.50	142.7	115	128	73	3
301	43.53	142.8	216	229	35	0
302	43.56	142.9	117	130	72	3
303	43.57	142.9	118	131	67	3
304	43.91	144.1	123	136	76	3
305	43.93	144.1	126	138	70	1
306	44.02	144.4	212	225	32	2
307	44.11	144.7	98	111	7	1
308	44.21	145.1	101	114	65	1
309	44.47	145.9	115	127	80	3
310	44.53	146.1	31	44	20	1
311	44.66	146.5	112	125	10	2
312	44.72	146.7	71	84	8	1
313	45.07	147.9	69	82	11	0
314	45.37	148.9	120	133	62	3
315	45.62	149.7	83	96	69	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #2
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
316	45.63	149.7	54	67	24	1
317	45.66	149.8	102	115	12	1
318	45.97	150.8	7	20	78	1
319	46.00	150.9	27	40	22	0
320	46.05	151.1	60	73	22	0
321	46.11	151.3	23	36	79	3
322	46.37	152.1	211	224	65	3
323	46.71	153.3	213	226	10	3
324	46.80	153.6	7	20	5	2
325	46.92	153.9	183	196	68	3
326	47.19	154.8	356	9	10	3
327	47.30	155.2	9	22	33	1
328	47.36	155.4	233	246	74	3
329	47.50	155.8	223	235	29	2
330	47.94	157.3	217	230	35	1
331	47.96	157.4	213	226	69	3
332	48.04	157.6	227	240	21	0
333	48.20	158.1	88	101	16	0
334	48.23	158.2	212	225	87	3
335	48.54	159.3	45	58	10	0
336	48.69	159.7	35	48	69	3
337	48.83	160.2	210	223	24	0
338	48.90	160.4	54	67	15	0
339	48.99	160.7	11	23	42	0
340	49.10	161.1	245	258	63	3
341	49.10	161.1	97	110	2	3
342	49.16	161.3	22	35	80	3
343	49.19	161.4	202	215	8	0
344	49.41	162.1	20	33	44	3
345	49.43	162.2	20	33	81	3
346	49.77	163.3	56	69	21	0
347	49.80	163.4	219	231	11	0
348	49.87	163.6	27	40	63	3
349	49.91	163.7	77	90	10	3
350	49.98	164.0	71	84	27	1
351	50.25	164.9	48	61	13	0
352	50.29	165.0	57	70	12	0
353	50.53	165.8	282	295	83	3
354	50.74	166.5	64	77	26	0
355	50.83	166.8	70	83	18	0
356	51.13	167.8	70	83	72	3
357	51.18	167.9	81	94	72	3
358	51.44	168.8	112	124	84	3
359	51.64	169.4	70	83	12	1
360	51.89	170.3	81	93	23	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #2
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
361	51.96	170.5	15	28	81	3
362	51.96	170.5	49	62	21	0
363	52.02	170.7	270	283	8	0
364	52.28	171.5	355	8	6	2
365	52.62	172.7	203	216	72	3
366	52.72	173.0	23	36	10	2
367	52.78	173.2	34	47	7	0
368	52.85	173.4	212	225	65	3
369	53.01	173.9	53	66	11	2
370	53.16	174.4	133	146	32	3
371	53.67	176.1	12	25	68	3
372	54.07	177.4	168	181	38	3
373	54.48	178.7	196	209	69	3
374	54.75	179.6	215	228	64	3
375	55.78	183.0	98	111	76	3
376	55.84	183.2	113	126	84	3
377	56.46	185.3	99	112	74	1
378	56.93	186.8	103	116	74	3
379	57.87	189.9	14	27	79	3
380	57.89	189.9	100	113	6	1
381	57.94	190.1	346	359	81	3
382	58.62	192.3	93	106	23	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Appendix J-4

Fracture Data Tabulated from Borehole Image Logs by Colog, Inc. For Instrument Hole U-15n#3

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #3
NNSA/NSO
21 and 22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	4.86	15.9	59	72	26	1
2	5.17	17.0	26	38	16	0
3	5.69	18.7	51	64	18	1
4	5.82	19.1	48	60	22	2
5	5.84	19.2	264	277	2	3
6	5.98	19.6	57	69	16	1
7	6.18	20.3	85	98	20	1
8	6.22	20.4	149	162	21	0
9	6.27	20.6	270	283	58	0
10	6.71	22.0	65	78	22	3
11	6.74	22.1	253	266	73	3
12	6.97	22.9	68	81	21	3
13	7.08	23.2	90	103	78	3
14	7.18	23.6	273	286	11	3
15	7.23	23.7	322	335	10	0
16	7.51	24.6	85	98	30	0
17	7.51	24.6	210	223	86	3
18	7.74	25.4	25	38	84	3
19	7.75	25.4	22	35	4	0
20	7.84	25.7	55	68	8	0
21	8.01	26.3	198	211	45	0
22	8.03	26.3	7	19	28	2
23	8.17	26.8	180	192	77	3
24	8.21	26.9	230	243	52	3
25	8.51	27.9	38	51	32	0
26	8.64	28.4	104	117	1	2
27	8.72	28.6	191	204	6	3
28	8.83	29.0	50	62	24	3
29	8.93	29.3	75	88	21	2
30	9.18	30.1	120	133	81	3
31	9.19	30.2	43	56	13	2
32	9.23	30.3	220	233	67	3
33	9.46	31.0	41	54	23	3
34	9.53	31.3	195	208	78	3
35	9.70	31.8	116	129	79	3
36	10.10	33.1	187	200	74	3
37	10.18	33.4	186	199	52	3
38	10.21	33.5	56	69	23	1
39	10.35	34.0	38	51	9	1
40	10.41	34.2	121	134	71	3
41	10.66	35.0	138	151	70	3
42	10.72	35.2	109	122	71	3
43	10.90	35.8	50	63	16	3
44	10.93	35.9	62	75	12	0
45	11.15	36.6	36	49	17	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #3
NNSA/NSO
21 and 22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
46	11.22	36.8	88	101	8	0
47	11.25	36.9	128	141	76	3
48	11.35	37.3	115	128	71	3
49	11.38	37.4	358	11	8	3
50	11.52	37.8	96	109	58	3
51	11.62	38.1	122	135	80	3
52	11.88	39.0	47	60	10	1
53	11.90	39.0	71	84	11	1
54	12.04	39.5	62	75	26	0
55	12.07	39.6	73	86	17	3
56	12.42	40.7	139	152	8	3
57	12.49	41.0	99	111	5	0
58	12.66	41.6	127	140	89	3
59	12.80	42.0	189	202	72	3
60	12.81	42.0	103	116	10	2
61	12.86	42.2	102	115	57	1
62	12.92	42.4	185	197	8	3
63	12.93	42.4	191	204	71	3
64	13.02	42.7	250	263	1	3
65	13.08	42.9	69	82	13	2
66	13.12	43.1	75	88	9	1
67	13.18	43.2	89	102	14	0
68	13.33	43.7	342	355	31	0
69	13.34	43.8	308	321	13	3
70	13.35	43.8	94	107	19	3
71	13.43	44.1	45	57	14	3
72	13.74	45.1	133	146	10	3
73	13.77	45.2	162	175	14	3
74	13.91	45.7	122	135	48	3
75	13.94	45.8	315	328	40	0
76	14.05	46.1	86	99	19	1
77	14.08	46.2	117	130	18	3
78	14.38	47.2	321	334	77	3
79	14.50	47.6	27	40	17	0
80	14.57	47.8	319	332	13	3
81	14.66	48.1	312	325	74	0
82	14.73	48.3	150	163	42	1
83	14.93	49.0	153	166	55	3
84	15.38	50.5	319	332	7	0
85	15.52	50.9	77	90	5	1
86	15.57	51.1	68	81	5	1
87	15.63	51.3	79	92	26	3
88	15.69	51.5	89	102	42	3
89	15.86	52.1	39	52	10	3
90	15.87	52.1	98	111	63	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #3
NNSA/NSO
21 and 22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
91	15.93	52.3	62	75	7	3
92	16.04	52.6	274	287	73	3
93	16.08	52.8	79	92	12	3
94	16.27	53.4	31	44	14	2
95	16.45	54.0	118	131	4	0
96	16.49	54.1	311	323	40	1
97	16.74	54.9	121	134	80	3
98	16.98	55.7	237	250	11	3
99	17.13	56.2	315	328	11	3
100	17.22	56.5	41	54	4	3
101	17.27	56.7	58	70	12	3
102	17.28	56.7	194	207	81	3
103	17.41	57.1	17	30	5	3
104	17.68	58.0	72	85	6	2
105	18.03	59.1	169	182	80	3
106	18.09	59.4	51	64	7	0
107	18.64	61.1	33	46	15	0
108	19.14	62.8	234	247	75	1
109	19.20	63.0	188	201	76	3
110	19.40	63.7	182	194	80	3
111	19.92	65.4	57	70	18	1
112	20.04	65.8	208	221	79	3
113	20.28	66.5	26	39	16	1
114	20.31	66.7	38	51	13	1
115	20.41	67.0	72	85	13	1
116	20.53	67.4	73	86	12	0
117	20.55	67.4	176	189	73	3
118	20.59	67.5	63	76	9	0
119	20.61	67.6	187	200	61	3
120	20.62	67.7	89	102	69	3
121	20.68	67.9	105	118	7	1
122	21.16	69.4	67	80	12	0
123	21.21	69.6	46	59	19	0
124	21.47	70.4	66	79	20	0
125	21.53	70.7	72	85	11	0
126	21.69	71.2	39	52	16	0
127	21.88	71.8	24	37	73	2
128	21.99	72.1	3	16	20	0
129	22.14	72.6	10	22	26	1
130	22.30	73.2	16	29	77	2
131	22.31	73.2	78	91	11	0
132	22.50	73.8	10	23	68	2
133	22.76	74.7	66	79	16	0
134	23.46	77.0	33	45	14	0
135	23.57	77.3	33	46	28	0

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #3
NNSA/NSO
21 and 22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
136	23.67	77.7	34	47	24	0
137	23.86	78.3	180	192	87	3
138	23.91	78.4	26	39	21	1
139	24.06	78.9	40	53	20	0
140	24.28	79.7	29	42	25	0
141	24.76	81.2	14	27	57	2
142	24.77	81.3	19	32	37	0
143	24.97	81.9	196	209	83	4
144	25.12	82.4	25	38	40	1
145	25.75	84.5	188	200	71	0
146	26.14	85.8	55	68	20	0
147	26.66	87.5	191	204	86	3
148	26.72	87.7	64	77	13	1
149	26.77	87.8	58	70	20	1
150	26.80	87.9	73	86	18	0
151	26.90	88.2	58	71	12	0
152	26.98	88.5	31	44	9	0
153	27.08	88.8	84	97	10	0
154	27.67	90.8	75	88	73	3
155	27.78	91.2	191	204	78	3
156	27.84	91.4	65	78	81	3
157	27.90	91.5	195	208	85	3
158	27.91	91.6	86	99	64	3
159	28.51	93.5	196	209	80	3
160	28.69	94.1	127	140	74	3
161	28.96	95.0	194	206	78	3
162	28.97	95.1	94	107	20	3
163	29.14	95.6	63	76	11	3
164	29.34	96.3	151	164	33	3
165	29.39	96.4	63	76	16	2
166	29.55	96.9	140	153	70	0
167	29.78	97.7	140	152	77	3
168	29.97	98.3	185	198	80	3
169	30.04	98.6	48	61	77	3
170	30.05	98.6	150	163	79	3
171	30.33	99.5	77	90	19	2
172	30.64	100.5	70	83	10	2
173	30.64	100.5	105	118	56	1
174	30.81	101.1	55	67	11	2
175	30.82	101.1	104	116	60	1
176	31.39	103.0	197	210	79	1
177	31.40	103.0	114	127	14	0
178	31.52	103.4	69	82	18	2
179	31.63	103.8	77	90	10	2
180	31.65	103.9	184	197	85	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #3
NNSA/NSO
21 and 22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
181	31.79	104.3	72	85	13	2
182	32.01	105.0	312	325	13	0
183	32.30	106.0	32	44	2	0
184	32.47	106.5	67	80	19	0
185	32.60	107.0	7	19	2	0
186	32.75	107.5	60	73	15	0
187	33.09	108.6	179	192	66	0
188	33.24	109.1	45	58	22	3
189	33.30	109.2	84	97	8	3
190	33.51	110.0	316	329	67	3
191	33.51	110.0	182	195	72	3
192	33.60	110.3	42	54	33	3
193	33.72	110.6	49	62	21	3
194	33.89	111.2	59	72	6	1
195	34.01	111.6	67	80	19	1
196	34.08	111.8	59	72	14	1
197	34.34	112.7	53	66	27	0
198	34.77	114.1	38	51	32	0
199	34.79	114.1	33	46	27	0
200	35.00	114.8	69	81	18	2
201	35.07	115.1	61	73	19	2
202	35.15	115.3	75	88	18	2
203	35.23	115.6	109	122	8	1
204	35.36	116.0	66	79	7	0
205	35.73	117.2	69	82	12	0
206	35.84	117.6	16	29	7	0
207	35.98	118.0	60	73	14	0
208	36.09	118.4	62	75	9	0
209	36.28	119.0	11	24	9	0
210	36.41	119.5	35	48	6	0
211	36.45	119.6	79	91	44	0
212	36.47	119.6	99	112	83	3
213	36.53	119.8	69	82	16	3
214	36.59	120.0	55	68	19	3
215	36.82	120.8	28	41	24	0
216	36.89	121.0	357	10	12	0
217	37.22	122.1	75	88	19	2
218	37.33	122.5	59	72	77	3
219	37.54	123.2	139	151	10	3
220	37.80	124.0	89	102	14	2
221	37.93	124.4	79	92	56	3
222	38.01	124.7	76	89	56	1
223	38.04	124.8	49	62	21	0
224	38.26	125.5	13	25	29	0
225	38.33	125.8	71	84	71	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #3
NNSA/NSO
21 and 22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
226	38.44	126.1	50	63	73	1
227	38.77	127.2	98	111	68	3
228	38.77	127.2	96	109	73	3
229	38.80	127.3	52	65	28	0
230	38.89	127.6	83	96	73	3
231	38.95	127.8	67	80	13	3
232	39.30	128.9	73	86	10	1
233	39.38	129.2	63	76	76	3
234	39.51	129.6	12	25	9	0
235	39.58	129.9	67	80	77	3
236	39.81	130.6	23	36	79	1
237	39.84	130.7	23	36	83	3
238	39.86	130.8	30	43	18	0
239	40.02	131.3	56	69	18	0
240	40.17	131.8	46	58	16	0
241	40.60	133.2	169	182	87	3
242	40.81	133.9	358	11	14	0
243	40.86	134.1	2	15	23	0
244	40.94	134.3	21	34	42	3
245	40.96	134.4	145	158	22	3
246	41.01	134.5	21	34	84	3
247	41.07	134.8	39	52	74	3
248	41.13	134.9	121	134	75	3
249	41.31	135.5	84	97	7	0
250	41.53	136.3	14	27	80	3
251	41.54	136.3	37	50	24	0
252	41.70	136.8	163	176	80	3
253	41.93	137.6	80	92	82	2
254	42.24	138.6	72	85	19	0
255	42.26	138.7	91	104	17	2
256	42.72	140.2	54	67	23	0
257	42.99	141.0	60	73	16	0
258	43.22	141.8	73	86	16	0
259	43.32	142.1	77	90	17	3
260	43.33	142.2	64	77	30	3
261	43.67	143.3	29	42	37	0
262	43.74	143.5	69	82	23	0
263	43.77	143.6	193	206	2	2
264	44.09	144.6	41	54	30	0
265	44.16	144.9	53	66	17	0
266	44.17	144.9	91	104	20	2
267	44.47	145.9	80	93	17	1
268	44.50	146.0	86	99	17	3
269	44.56	146.2	190	203	73	1
270	44.62	146.4	50	63	13	0

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #3
NNSA/NSO
21 and 22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
271	44.70	146.7	292	305	5	2
272	44.85	147.2	56	69	10	0
273	45.25	148.5	66	79	17	0
274	45.54	149.4	46	58	24	0
275	45.89	150.6	21	34	22	0
276	46.22	151.6	11	24	26	0
277	46.28	151.8	141	154	67	3
278	46.41	152.3	139	152	69	3
279	46.73	153.3	80	93	15	2
280	46.89	153.9	75	87	14	0
281	47.02	154.3	61	74	17	0
282	47.28	155.1	328	341	3	1
283	47.61	156.2	15	28	28	0
284	47.83	156.9	40	53	15	0
285	47.89	157.1	59	72	18	0
286	48.05	157.7	100	113	26	0
287	48.11	157.9	243	256	88	1
288	48.42	158.9	74	87	6	0
289	48.58	159.4	331	344	11	0
290	49.02	160.8	74	87	8	0
291	49.03	160.9	32	45	11	1
292	49.13	161.2	56	69	17	3
293	49.33	161.9	73	86	20	0
294	49.37	162.0	64	77	17	3
295	49.74	163.2	39	52	17	0
296	49.85	163.6	273	286	1	3
297	50.02	164.1	51	63	20	2
298	50.18	164.6	40	52	15	0
299	50.32	165.1	219	231	83	3
300	50.60	166.0	50	63	22	0
301	50.68	166.3	68	81	9	3
302	51.05	167.5	194	207	84	3
303	51.08	167.6	353	6	20	0
304	51.76	169.8	63	76	9	2
305	52.14	171.1	73	86	4	2
306	52.33	171.7	113	126	79	2
307	52.46	172.1	64	77	13	2
308	52.64	172.7	30	43	26	1
309	52.82	173.3	135	147	85	2
310	53.05	174.1	140	153	67	3
311	53.22	174.6	89	102	9	1
312	53.23	174.6	303	316	86	3
313	53.33	175.0	151	164	50	1
314	53.56	175.7	91	104	49	1
315	53.69	176.1	139	152	70	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #3
NNSA/NSO
21 and 22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
316	53.71	176.2	55	67	10	2
317	53.84	176.6	147	160	63	3
318	53.85	176.7	134	147	10	2
319	53.91	176.9	151	164	58	3
320	54.11	177.5	7	20	11	2
321	54.32	178.2	19	32	32	0
322	54.43	178.6	43	56	30	2
323	54.54	178.9	40	53	26	0
324	54.72	179.5	144	157	62	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Appendix J-5

Fracture Data Tabulated from Borehole Image Logs by Colog, Inc. For Instrument Hole U-15n#4

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #4
NNSA/NSO
22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	4.85	15.9	90	102	44	0
2	5.23	17.2	140	152	9	0
3	5.25	17.2	60	73	25	0
4	5.39	17.7	226	239	5	1
5	5.52	18.1	64	76	7	1
6	5.57	18.3	67	79	28	1
7	5.68	18.6	72	85	9	1
8	6.45	21.2	209	222	13	1
9	6.51	21.4	43	56	20	1
10	6.79	22.3	73	86	23	0
11	6.93	22.8	22	35	3	1
12	6.96	22.9	80	93	4	1
13	7.05	23.1	72	85	10	1
14	7.07	23.2	83	96	28	1
15	7.14	23.4	30	43	17	1
16	7.23	23.7	32	45	16	1
17	7.50	24.6	71	84	35	1
18	7.70	25.3	48	61	27	1
19	7.83	25.7	40	53	10	1
20	7.91	26.0	117	130	17	1
21	8.08	26.5	115	128	21	1
22	8.29	27.2	47	60	22	1
23	8.44	27.7	68	81	26	0
24	8.52	28.0	55	67	49	0
25	8.63	28.3	40	53	12	1
26	8.80	28.9	86	99	9	0
27	8.99	29.5	42	55	11	0
28	9.13	30.0	109	122	46	1
29	9.30	30.5	26	38	12	1
30	9.63	31.6	116	129	52	1
31	9.73	31.9	103	116	58	1
32	9.94	32.6	71	84	62	1
33	10.24	33.6	60	73	14	2
34	10.30	33.8	175	188	83	1
35	10.36	34.0	46	59	12	0
36	10.59	34.7	59	72	8	1
37	10.67	35.0	54	67	9	1
38	10.80	35.4	97	110	15	1
39	11.12	36.5	299	312	56	0
40	11.13	36.5	86	98	15	1
41	11.20	36.8	196	209	83	1
42	11.73	38.5	307	320	77	1
43	11.78	38.6	55	68	6	1
44	12.12	39.8	22	35	11	1
45	12.40	40.7	196	209	84	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #4
NNSA/NSO
22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
46	12.41	40.7	51	64	10	0
47	12.58	41.3	203	216	71	1
48	12.65	41.5	50	63	13	1
49	12.80	42.0	54	67	9	1
50	13.19	43.3	52	65	9	0
51	13.25	43.5	193	206	85	1
52	13.41	44.0	93	106	6	0
53	13.54	44.4	187	200	86	1
54	13.68	44.9	102	115	10	1
55	13.93	45.7	26	39	9	2
56	14.07	46.2	68	81	17	0
57	14.34	47.1	81	94	6	0
58	14.68	48.2	61	74	11	0
59	14.79	48.5	41	54	32	0
60	14.96	49.1	88	101	5	0
61	15.23	50.0	79	92	8	1
62	15.25	50.0	70	82	45	1
63	15.32	50.3	84	97	13	0
64	15.41	50.6	73	85	15	0
65	15.56	51.1	73	85	24	0
66	15.62	51.3	111	124	72	1
67	15.73	51.6	98	111	13	2
68	15.91	52.2	42	55	15	2
69	16.00	52.5	114	127	77	2
70	16.03	52.6	45	58	9	1
71	16.07	52.7	110	123	9	2
72	16.13	52.9	119	132	73	2
73	16.25	53.3	34	47	13	0
74	16.36	53.7	105	118	70	1
75	16.49	54.1	55	68	13	0
76	16.79	55.1	105	117	70	1
77	16.89	55.4	108	121	66	1
78	17.10	56.1	84	97	17	0
79	17.21	56.5	126	139	8	1
80	17.46	57.3	63	75	19	1
81	17.52	57.5	52	65	5	3
82	17.61	57.8	185	198	4	0
83	17.72	58.1	77	90	19	3
84	17.78	58.3	47	60	17	1
85	17.85	58.6	78	91	14	2
86	17.99	59.0	53	66	21	1
87	18.24	59.9	103	116	76	0
88	18.26	59.9	7	20	25	1
89	18.32	60.1	126	139	75	3
90	18.38	60.3	62	75	20	0

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #4
NNSA/NSO
22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
91	18.39	60.3	97	110	78	3
92	18.43	60.5	144	157	80	3
93	18.47	60.6	57	70	5	1
94	19.14	62.8	34	47	14	3
95	19.32	63.4	209	222	33	0
96	19.40	63.7	15	28	15	0
97	19.43	63.8	65	78	20	0
98	19.56	64.2	112	125	63	0
99	19.66	64.5	28	41	45	1
100	19.90	65.3	83	96	13	3
101	19.97	65.5	358	11	40	1
102	20.00	65.6	157	170	36	3
103	20.10	66.0	142	155	37	3
104	20.63	67.7	34	47	22	1
105	20.69	67.9	27	40	13	1
106	21.05	69.1	190	203	66	0
107	21.05	69.1	36	49	24	3
108	21.12	69.3	58	71	21	3
109	21.16	69.4	98	110	12	3
110	21.39	70.2	61	74	16	0
111	21.45	70.4	54	66	16	1
112	21.48	70.5	0	13	65	3
113	21.60	70.9	13	26	87	3
114	21.88	71.8	32	45	14	0
115	22.21	72.9	10	23	80	3
116	22.47	73.7	10	23	22	1
117	22.66	74.4	16	29	20	1
118	22.84	74.9	360	12	84	3
119	23.64	77.6	0	13	52	1
120	23.80	78.1	351	4	82	3
121	24.44	80.2	106	119	65	3
122	24.58	80.6	51	64	63	3
123	25.02	82.1	37	50	17	1
124	25.37	83.2	104	117	16	1
125	25.43	83.4	89	102	84	3
126	26.42	86.7	97	110	13	0
127	26.76	87.8	36	49	22	0
128	26.89	88.2	134	147	69	3
129	27.01	88.6	17	30	87	3
130	27.14	89.0	178	191	83	3
131	27.97	91.8	7	20	85	3
132	28.18	92.5	345	357	64	1
133	28.22	92.6	359	12	78	3
134	28.63	93.9	34	47	28	1
135	28.89	94.8	39	52	17	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #4
NNSA/NSO
22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
136	29.09	95.5	13	26	74	3
137	29.19	95.8	356	9	67	3
138	29.27	96.0	339	352	78	3
139	29.49	96.8	110	123	74	3
140	29.49	96.8	34	46	26	1
141	29.51	96.8	345	358	60	1
142	29.96	98.3	68	81	9	1
143	29.98	98.4	44	57	37	2
144	30.12	98.8	3	16	38	1
145	30.21	99.1	34	47	26	1
146	30.30	99.4	93	106	74	3
147	30.37	99.7	9	22	25	1
148	30.53	100.2	39	52	25	1
149	30.61	100.4	46	59	5	3
150	30.67	100.6	130	143	72	3
151	30.68	100.6	27	40	12	1
152	30.91	101.4	177	190	57	1
153	30.92	101.4	49	62	17	1
154	31.01	101.7	106	119	80	3
155	31.31	102.7	135	148	10	1
156	31.37	102.9	44	57	19	3
157	31.42	103.1	36	49	18	1
158	31.79	104.3	37	50	19	0
159	32.17	105.5	107	120	42	2
160	32.38	106.2	115	127	9	2
161	32.50	106.6	63	76	15	1
162	32.53	106.7	17	30	86	3
163	32.70	107.3	26	39	86	3
164	32.90	107.9	21	34	60	0
165	33.17	108.8	30	43	20	0
166	33.24	109.1	124	137	77	3
167	33.30	109.3	14	27	28	0
168	33.46	109.8	339	352	41	2
169	33.55	110.1	109	122	84	3
170	33.55	110.1	95	108	14	1
171	33.60	110.2	125	138	68	3
172	33.87	111.1	66	79	7	2
173	34.34	112.7	29	42	4	3
174	34.44	113.0	44	57	34	2
175	34.51	113.2	60	73	15	1
176	35.32	115.9	288	301	69	3
177	35.64	116.9	69	82	17	3
178	35.73	117.2	27	40	39	1
179	35.88	117.7	99	112	5	2
180	36.24	118.9	18	31	27	0

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #4
NNSA/NSO
22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
181	36.34	119.2	30	43	20	0
182	36.42	119.5	345	358	13	1
183	36.46	119.6	44	57	19	3
184	36.51	119.8	18	31	63	0
185	36.74	120.5	345	358	36	2
186	36.90	121.1	13	26	78	3
187	36.91	121.1	24	37	14	2
188	37.05	121.5	59	72	17	3
189	37.12	121.8	10	23	80	3
190	37.21	122.1	45	58	14	2
191	37.34	122.5	20	33	24	1
192	37.51	123.1	22	35	21	0
193	37.58	123.3	54	67	18	1
194	37.85	124.2	47	60	19	0
195	37.90	124.3	31	43	25	1
196	37.98	124.6	19	32	24	0
197	38.13	125.1	35	48	38	0
198	38.18	125.3	16	29	25	0
199	38.60	126.6	35	48	10	1
200	38.87	127.5	185	198	50	0
201	39.04	128.1	45	58	10	3
202	39.16	128.5	31	44	3	1
203	39.19	128.6	59	72	23	1
204	39.33	129.0	87	100	28	0
205	39.48	129.5	98	111	21	3
206	39.70	130.3	10	23	85	3
207	39.80	130.6	97	110	56	3
208	40.00	131.2	23	36	19	3
209	40.53	133.0	22	35	85	3
210	40.69	133.5	196	209	85	3
211	41.32	135.6	212	225	13	3
212	41.43	135.9	10	23	9	3
213	41.84	137.3	176	189	56	3
214	41.92	137.5	55	68	29	2
215	42.40	139.1	97	109	54	2
216	42.41	139.1	103	116	10	2
217	42.93	140.9	73	86	2	1
218	43.35	142.2	87	99	11	0
219	44.04	144.5	124	137	70	2
220	44.32	145.4	15	28	88	3
221	44.46	145.9	24	36	84	3
222	44.74	146.8	162	174	80	0
223	44.93	147.4	18	31	80	3
224	45.39	148.9	118	131	44	3
225	46.10	151.2	188	201	12	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #4
NNSA/NSO
22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
226	46.20	151.6	38	50	13	3
227	46.54	152.7	26	39	82	3
228	46.85	153.7	126	139	79	3
229	46.87	153.8	125	138	65	3
230	46.96	154.1	226	239	21	2
231	47.11	154.6	66	79	16	3
232	47.30	155.2	31	44	54	1
233	47.35	155.4	91	104	5	1
234	47.45	155.7	186	199	23	1
235	47.63	156.3	30	43	5	3
236	47.70	156.5	51	64	20	1
237	47.85	157.0	23	36	6	3
238	48.16	158.0	10	23	1	2
239	48.38	158.7	45	58	9	2
240	48.48	159.0	20	33	13	1
241	48.54	159.3	44	57	7	2
242	48.60	159.5	55	68	18	1
243	48.87	160.3	336	348	32	3
244	48.90	160.4	81	94	47	1
245	48.92	160.5	209	222	78	3
246	48.96	160.6	42	55	15	3
247	49.01	160.8	15	28	67	3
248	49.24	161.5	83	96	8	2
249	49.70	163.1	323	336	5	2
250	49.71	163.1	85	98	15	1
251	49.91	163.7	46	59	26	0
252	49.96	163.9	85	98	8	1
253	50.03	164.2	69	82	5	1
254	50.18	164.6	42	54	24	0
255	50.26	164.9	123	136	68	3
256	50.37	165.2	57	70	17	3
257	50.37	165.3	114	126	68	3
258	50.55	165.8	331	344	18	2
259	50.59	166.0	43	55	17	2
260	50.68	166.3	56	69	31	1
261	50.73	166.5	75	88	32	1
262	50.81	166.7	71	84	29	1
263	50.94	167.1	59	72	18	1
264	51.07	167.6	55	67	14	1
265	51.15	167.8	151	164	80	3
266	51.21	168.0	54	67	11	1
267	51.23	168.1	310	323	78	3
268	51.24	168.1	86	99	29	2
269	51.24	168.1	213	226	75	3
270	51.36	168.5	200	213	75	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #4
NNSA/NSO
22 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
271	51.51	169.0	57	70	11	3
272	51.68	169.6	187	200	76	3
273	51.74	169.8	196	209	37	1
274	52.00	170.6	12	25	17	0
275	52.06	170.8	119	132	8	1
276	52.21	171.3	74	87	18	0
277	52.26	171.5	87	100	11	0
278	52.41	172.0	65	78	12	2
279	53.03	174.0	49	62	14	2
280	53.61	175.9	13	25	6	2
281	53.75	176.3	238	251	13	2
282	53.94	177.0	201	214	82	3
283	54.34	178.3	311	324	7	3
284	54.52	178.9	262	275	50	1
285	54.78	179.7	65	78	34	3
286	54.86	180.0	71	84	39	3
287	54.93	180.2	79	92	40	3
288	55.28	181.4	74	87	28	3
289	55.34	181.6	71	84	17	1
290	55.41	181.8	69	82	32	1
291	55.47	182.0	299	312	79	3
292	55.52	182.2	132	145	21	1
293	55.66	182.6	70	82	13	1
294	55.70	182.7	10	23	84	3
295	55.82	183.1	62	74	14	1
296	55.82	183.2	89	102	36	1
297	56.11	184.1	57	70	20	0
298	56.18	184.3	68	81	26	0
299	56.22	184.5	184	197	59	0
300	56.41	185.1	199	212	75	3
301	56.48	185.3	207	220	67	3
302	57.06	187.2	203	216	84	3
303	57.17	187.6	105	118	22	2
304	57.30	188.0	72	85	16	3
305	57.42	188.4	340	353	72	3
306	58.37	191.5	25	38	85	3
307	58.52	192.0	14	27	79	3
308	58.56	192.1	207	220	77	3
309	58.77	192.8	200	213	79	3
310	58.78	192.9	109	122	82	3
311	58.96	193.5	56	69	22	3
312	59.01	193.6	230	243	1	3
313	59.24	194.4	50	63	2	2
314	59.34	194.7	212	225	73	3
315	59.47	195.1	171	184	48	0

All directions have been corrected for borehole deviation, and are with respect to true north.

Appendix J-6

Fracture Data Tabulated from Borehole Image Logs by Colog, Inc.
For Instrument Hole U-15n#5

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #5
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	3.72	12.2	199	212	85	3
2	4.56	15.0	33	45	14	0
3	4.92	16.1	51	64	10	2
4	5.11	16.8	49	62	12	0
5	5.31	17.4	33	46	11	1
6	5.89	19.3	24	37	32	1
7	6.05	19.8	34	46	24	1
8	6.10	20.0	189	202	76	1
9	6.31	20.7	57	70	21	0
10	6.66	21.9	275	288	85	3
11	6.89	22.6	34	47	9	0
12	6.90	22.6	7	19	83	3
13	7.04	23.1	54	67	5	1
14	7.11	23.3	25	38	43	1
15	7.12	23.4	57	70	13	0
16	7.21	23.6	76	89	14	0
17	7.27	23.9	184	197	75	0
18	7.78	25.5	48	61	7	0
19	7.86	25.8	67	80	16	0
20	7.97	26.2	79	92	15	0
21	8.04	26.4	169	182	69	0
22	8.05	26.4	71	84	14	0
23	8.17	26.8	64	77	17	0
24	8.20	26.9	86	99	13	0
25	8.60	28.2	58	71	11	0
26	8.95	29.4	92	105	8	0
27	9.26	30.4	14	26	11	0
28	9.28	30.4	359	12	83	3
29	9.33	30.6	178	191	81	1
30	9.39	30.8	95	108	4	1
31	9.62	31.6	43	56	58	1
32	9.78	32.1	53	66	20	0
33	9.83	32.2	68	80	13	1
34	9.95	32.6	3	16	80	1
35	9.99	32.8	185	198	78	3
36	10.13	33.3	24	37	26	1
37	10.31	33.8	13	26	17	0
38	10.81	35.5	229	242	26	1
39	10.91	35.8	75	88	73	3
40	10.98	36.0	279	292	79	3
41	11.36	37.3	90	103	65	3
42	11.42	37.5	254	267	46	1
43	11.47	37.6	50	63	17	1
44	11.55	37.9	97	110	72	3
45	11.86	38.9	27	40	14	0

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #5
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
46	11.89	39.0	13	26	15	0
47	12.02	39.4	61	74	16	1
48	12.08	39.6	59	72	78	3
49	12.31	40.4	63	75	21	1
50	12.55	41.2	27	39	10	1
51	12.74	41.8	20	33	14	1
52	12.83	42.1	347	0	82	1
53	12.84	42.1	42	55	32	1
54	13.14	43.1	82	95	55	1
55	13.69	44.9	97	110	12	0
56	13.91	45.6	185	198	14	0
57	14.09	46.2	6	19	9	0
58	14.28	46.9	39	52	13	0
59	14.33	47.0	229	242	69	2
60	14.47	47.5	218	231	74	3
61	14.55	47.7	67	80	16	0
62	14.57	47.8	51	64	50	1
63	14.59	47.9	209	222	77	3
64	14.88	48.8	173	186	19	1
65	14.89	48.9	198	210	79	3
66	15.08	49.5	47	60	7	1
67	15.18	49.8	73	85	16	1
68	15.24	50.0	120	133	17	1
69	15.48	50.8	55	68	15	2
70	15.59	51.1	86	99	15	1
71	15.71	51.5	70	83	17	1
72	15.76	51.7	49	62	15	1
73	16.05	52.7	190	203	65	3
74	16.08	52.8	144	157	68	3
75	16.13	52.9	219	232	37	3
76	16.21	53.2	33	46	20	0
77	16.24	53.3	264	277	68	3
78	16.25	53.3	48	61	25	1
79	16.50	54.1	141	154	69	3
80	16.57	54.4	216	229	15	1
81	16.63	54.6	174	187	24	1
82	16.67	54.7	356	8	86	3
83	16.74	54.9	325	337	5	2
84	16.84	55.3	50	63	9	1
85	16.90	55.5	172	185	47	1
86	17.01	55.8	187	199	59	1
87	17.03	55.9	204	216	33	1
88	17.14	56.2	55	68	4	0
89	17.32	56.8	55	68	11	0
90	17.42	57.2	59	72	23	0

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #5
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
91	17.44	57.2	335	348	70	3
92	17.66	57.9	317	330	22	2
93	18.07	59.3	16	29	9	2
94	18.65	61.2	265	278	15	2
95	18.87	61.9	98	111	81	3
96	18.91	62.0	105	118	77	3
97	18.91	62.1	5	18	10	1
98	19.03	62.4	299	312	85	3
99	19.04	62.5	66	79	9	1
100	19.15	62.8	94	107	10	1
101	19.44	63.8	89	101	67	1
102	19.46	63.9	39	52	21	0
103	19.54	64.1	89	102	55	2
104	19.79	64.9	158	171	33	1
105	19.82	65.0	105	117	76	3
106	19.82	65.0	42	55	19	0
107	19.89	65.3	51	64	18	0
108	20.13	66.0	51	64	18	3
109	20.20	66.3	60	73	17	2
110	20.24	66.4	92	105	21	3
111	20.36	66.8	78	91	12	1
112	20.52	67.3	86	99	74	3
113	20.61	67.6	92	104	48	3
114	20.74	68.0	100	112	56	3
115	20.82	68.3	105	118	61	3
116	20.99	68.9	66	79	14	3
117	21.01	68.9	269	282	80	3
118	21.05	69.1	314	326	55	3
119	21.15	69.4	61	73	10	1
120	21.28	69.8	222	235	68	3
121	21.49	70.5	56	69	14	0
122	21.67	71.1	88	101	17	2
123	21.73	71.3	190	203	59	0
124	21.83	71.6	92	105	79	3
125	21.87	71.8	150	163	13	0
126	21.96	72.0	9	22	7	3
127	22.10	72.5	279	292	31	3
128	22.19	72.8	168	181	31	1
129	22.28	73.1	84	97	72	3
130	22.34	73.3	105	117	28	2
131	22.47	73.7	115	128	72	3
132	22.72	74.5	213	226	19	3
133	22.79	74.8	356	9	71	3
134	22.97	75.4	8	21	43	0
135	23.00	75.5	354	6	78	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #5
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
136	23.04	75.6	245	258	36	1
137	23.11	75.8	70	82	30	3
138	23.21	76.1	82	95	22	2
139	23.36	76.7	62	74	15	1
140	23.38	76.7	116	128	79	3
141	23.39	76.8	47	60	16	1
142	23.45	76.9	51	64	15	0
143	23.57	77.3	121	134	12	1
144	23.65	77.6	62	75	11	0
145	23.78	78.0	21	34	75	3
146	23.84	78.2	256	268	7	3
147	23.98	78.7	100	113	7	2
148	24.34	79.9	239	252	59	3
149	24.54	80.5	163	176	45	3
150	24.60	80.7	123	136	85	3
151	24.66	80.9	204	216	47	3
152	24.67	80.9	66	79	17	1
153	24.77	81.3	156	168	30	1
154	24.98	82.0	82	94	22	3
155	25.22	82.7	52	65	25	3
156	25.25	82.8	329	342	65	3
157	25.40	83.3	17	30	18	2
158	25.50	83.7	318	330	56	1
159	25.64	84.1	115	128	75	3
160	25.66	84.2	123	136	85	3
161	25.72	84.4	48	61	10	1
162	25.93	85.1	18	31	10	0
163	25.94	85.1	118	130	87	3
164	26.50	86.9	52	65	16	1
165	26.67	87.5	71	84	22	1
166	26.79	87.9	40	53	25	0
167	26.99	88.5	54	67	17	3
168	27.07	88.8	117	130	86	3
169	27.08	88.9	52	65	17	2
170	27.32	89.6	77	90	13	3
171	27.34	89.7	72	84	12	2
172	27.45	90.1	83	96	20	0
173	27.62	90.6	39	52	12	0
174	27.70	90.9	93	106	11	0
175	27.89	91.5	75	88	19	3
176	27.94	91.7	67	80	13	2
177	27.98	91.8	75	88	11	0
178	28.11	92.2	106	118	4	2
179	28.29	92.8	52	65	20	0
180	28.41	93.2	50	63	15	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #5
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
181	28.46	93.4	64	77	14	2
182	28.74	94.3	65	78	20	3
183	28.81	94.5	70	82	16	0
184	29.01	95.2	71	84	13	0
185	29.11	95.5	62	75	11	0
186	29.26	96.0	72	84	11	1
187	29.34	96.3	59	72	20	0
188	29.43	96.5	34	47	37	1
189	29.57	97.0	271	284	14	1
190	29.67	97.4	273	286	16	3
191	29.77	97.7	122	135	87	3
192	29.83	97.9	308	321	7	3
193	29.91	98.1	323	336	25	3
194	29.97	98.3	342	355	21	1
195	30.06	98.6	58	70	14	3
196	30.09	98.7	51	64	8	1
197	30.18	99.0	48	61	19	0
198	30.42	99.8	30	43	23	0
199	30.78	101.0	278	291	24	3
200	30.78	101.0	78	90	13	3
201	30.78	101.0	271	284	52	0
202	30.90	101.4	304	316	26	3
203	30.99	101.7	75	88	14	3
204	31.07	101.9	56	69	19	0
205	31.10	102.0	53	66	17	0
206	31.22	102.4	36	48	12	3
207	31.34	102.8	48	61	17	3
208	31.46	103.2	69	82	17	2
209	31.54	103.5	253	266	58	3
210	31.67	103.9	254	267	48	3
211	31.81	104.4	73	85	11	2
212	31.83	104.4	255	267	57	0
213	31.85	104.5	93	106	18	1
214	31.97	104.9	295	308	17	0
215	32.20	105.7	52	65	20	0
216	32.24	105.8	68	81	19	3
217	32.30	106.0	249	262	54	0
218	32.31	106.0	46	59	18	1
219	32.43	106.4	249	262	43	3
220	32.49	106.6	258	271	49	3
221	32.68	107.2	217	230	47	3
222	32.70	107.3	76	88	13	3
223	32.71	107.3	236	249	62	1
224	32.86	107.8	69	82	13	1
225	32.93	108.0	59	72	10	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #5
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
226	32.93	108.0	119	132	86	3
227	32.98	108.2	53	66	18	1
228	33.03	108.4	47	60	15	0
229	33.22	109.0	61	74	10	0
230	33.45	109.7	101	114	2	3
231	33.47	109.8	8	21	12	2
232	33.70	110.6	286	299	4	1
233	33.81	110.9	50	63	8	3
234	33.83	111.0	121	134	87	3
235	33.87	111.1	291	304	15	1
236	33.97	111.5	65	78	23	1
237	34.19	112.2	27	40	31	1
238	34.26	112.4	47	59	11	2
239	34.35	112.7	61	74	16	0
240	34.50	113.2	24	37	8	1
241	34.62	113.6	67	80	19	3
242	34.69	113.8	303	316	78	3
243	34.75	114.0	65	77	12	3
244	34.80	114.2	48	61	6	1
245	35.05	115.0	119	132	85	3
246	35.26	115.7	172	185	14	1
247	35.34	116.0	220	233	3	1
248	35.42	116.2	77	90	9	3
249	35.48	116.4	87	100	11	1
250	35.52	116.5	206	218	15	1
251	35.66	117.0	221	233	24	0
252	35.88	117.7	99	112	36	1
253	35.94	117.9	53	66	17	1
254	35.99	118.1	60	73	13	1
255	35.99	118.1	112	125	49	1
256	36.18	118.7	65	78	15	2
257	36.27	119.0	53	66	26	1
258	36.29	119.1	79	92	78	3
259	36.47	119.7	38	51	17	2
260	36.66	120.3	181	194	86	3
261	36.67	120.3	185	198	74	1
262	36.91	121.1	194	207	66	1
263	36.91	121.1	72	85	21	2
264	37.23	122.1	14	27	29	3
265	37.36	122.6	308	320	22	3
266	37.45	122.9	172	185	16	1
267	37.48	123.0	194	207	84	3
268	37.56	123.2	355	8	13	1
269	37.74	123.8	234	247	19	2
270	37.79	124.0	305	318	12	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #5
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
271	38.05	124.9	53	66	20	2
272	38.12	125.1	193	206	84	3
273	38.51	126.4	82	95	18	2
274	38.55	126.5	213	225	33	3
275	38.62	126.7	115	128	81	3
276	38.69	126.9	73	86	13	1
277	39.03	128.1	110	123	75	1
278	39.04	128.1	52	65	22	1
279	39.26	128.8	176	189	4	3
280	39.54	129.7	30	43	20	1
281	39.64	130.1	53	66	21	3
282	39.68	130.2	28	41	10	1
283	39.75	130.4	113	126	82	3
284	39.76	130.5	239	252	14	1
285	39.97	131.2	180	193	51	1
286	39.98	131.2	353	6	20	1
287	40.26	132.1	29	41	12	2
288	40.35	132.4	109	122	64	3
289	40.36	132.4	38	51	15	3
290	40.43	132.7	133	146	51	3
291	41.04	134.6	40	52	11	2
292	41.59	136.5	62	74	17	2
293	41.73	136.9	195	207	82	3
294	41.79	137.1	29	42	21	0
295	41.90	137.5	89	102	8	1
296	42.21	138.5	68	80	8	0
297	42.36	139.0	130	143	69	1
298	42.65	139.9	48	61	17	2
299	42.74	140.2	69	82	11	0
300	43.02	141.2	125	138	77	3
301	43.16	141.6	75	87	5	1
302	43.21	141.8	105	117	13	3
303	43.29	142.0	77	90	12	3
304	43.35	142.2	54	67	14	3
305	43.53	142.8	60	73	11	1
306	43.60	143.1	25	37	12	1
307	43.82	143.8	131	144	66	3
308	43.86	143.9	128	141	76	3
309	43.93	144.1	35	48	15	1
310	43.97	144.3	64	77	28	3
311	44.04	144.5	51	64	9	2
312	44.23	145.1	145	158	57	3
313	44.45	145.8	31	44	7	3
314	44.53	146.1	95	108	8	1
315	44.66	146.5	119	132	76	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #5
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
316	44.71	146.7	108	121	57	3
317	44.73	146.8	92	104	10	1
318	44.89	147.3	55	68	8	1
319	44.92	147.4	40	53	12	1
320	45.12	148.0	79	91	12	2
321	45.37	148.9	161	173	73	1
322	45.38	148.9	63	76	20	1
323	45.57	149.5	72	85	15	3
324	45.95	150.8	112	125	82	3
325	46.36	152.1	68	81	13	1
326	46.40	152.2	21	34	10	0
327	46.43	152.3	11	24	13	1
328	46.54	152.7	350	3	22	0
329	46.92	153.9	126	139	9	3
330	47.03	154.3	131	144	32	1
331	47.62	156.2	44	57	22	2
332	47.66	156.4	57	69	17	3
333	47.72	156.6	154	167	39	2
334	48.15	158.0	52	65	17	3
335	48.20	158.2	63	76	14	3
336	48.63	159.6	52	65	19	0
337	48.87	160.3	61	74	19	2
338	48.99	160.7	98	111	84	3
339	49.04	160.9	73	86	12	3
340	49.14	161.2	31	44	28	0
341	49.69	163.0	25	38	25	0
342	49.83	163.5	39	51	24	3
343	49.87	163.6	148	161	19	3
344	49.94	163.9	61	74	12	0
345	50.73	166.4	58	70	22	3
346	51.89	170.2	52	65	18	2
347	52.05	170.8	268	281	57	3
348	52.24	171.4	308	321	9	0
349	52.27	171.5	54	66	18	0
350	52.38	171.9	58	70	17	0
351	52.60	172.6	63	76	17	2
352	52.86	173.4	67	80	14	2
353	52.89	173.5	55	67	12	2
354	53.21	174.6	124	136	86	3
355	53.45	175.4	35	48	10	2
356	53.67	176.1	57	70	8	3
357	53.68	176.1	224	237	71	2
358	53.81	176.6	39	52	13	0
359	54.54	179.0	15	28	14	3
360	54.88	180.1	54	66	19	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #5
NNSA/NSO
21 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
361	55.16	181.0	10	23	22	0
362	55.59	182.4	304	317	67	3
363	55.64	182.6	345	358	18	3
364	55.72	182.8	25	38	15	0
365	55.78	183.0	48	61	18	0
366	56.02	183.8	295	308	83	3
367	56.67	185.9	43	55	19	3
368	56.67	185.9	231	244	76	3
369	56.88	186.6	56	69	21	0
370	57.11	187.4	34	47	25	1
371	57.39	188.3	23	36	20	1
372	57.51	188.7	60	73	17	1
373	57.77	189.5	356	8	18	0
374	57.91	190.0	354	7	18	0
375	58.03	190.4	63	76	24	3
376	58.06	190.5	41	54	6	3
377	58.07	190.5	132	144	21	3
378	58.11	190.7	217	230	80	3
379	58.18	190.9	52	65	19	3
380	58.18	190.9	286	299	7	2
381	58.23	191.0	30	43	20	1
382	58.28	191.2	350	3	7	2
383	58.35	191.4	358	11	16	1
384	58.78	192.9	35	47	22	0
385	59.19	194.2	123	136	87	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Appendix J-7

Fracture Data Tabulated from Borehole Image Logs by Colog, Inc.
For Instrument Hole U-15n#6

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #6
NNSA/NSO
20 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	1.50	4.9	138	151	78	3
2	2.03	6.7	233	246	8	2
3	2.09	6.9	358	11	30	1
4	2.69	8.8	337	350	20	1
5	3.08	10.1	349	2	28	1
6	3.56	11.7	172	185	77	3
7	3.74	12.3	100	113	80	3
8	4.00	13.1	10	23	36	3
9	4.08	13.4	33	46	23	3
10	4.11	13.5	255	268	86	3
11	4.18	13.7	15	28	26	2
12	4.33	14.2	103	116	11	2
13	4.34	14.2	18	31	29	1
14	4.41	14.5	25	38	27	0
15	4.67	15.3	53	66	6	0
16	4.91	16.1	13	26	83	3
17	5.00	16.4	344	357	12	0
18	5.40	17.7	209	222	28	1
19	5.52	18.1	48	61	23	1
20	5.58	18.3	73	86	20	3
21	5.68	18.6	76	89	8	2
22	5.71	18.7	264	277	8	2
23	5.88	19.3	180	193	15	0
24	5.92	19.4	51	64	26	0
25	5.98	19.6	49	62	7	0
26	6.08	19.9	169	182	11	0
27	6.22	20.4	171	184	14	2
28	6.25	20.5	52	65	22	1
29	6.29	20.7	211	224	11	0
30	6.44	21.1	49	62	7	0
31	6.53	21.4	68	81	5	1
32	6.77	22.2	197	210	42	0
33	7.04	23.1	229	242	48	1
34	7.11	23.3	213	226	26	1
35	7.22	23.7	250	263	11	1
36	7.36	24.1	205	218	9	0
37	7.50	24.6	349	2	19	0
38	7.55	24.8	8	21	23	0
39	7.58	24.9	84	97	60	1
40	7.68	25.2	26	39	22	2
41	7.80	25.6	37	50	17	0
42	7.92	26.0	94	107	17	1
43	8.13	26.7	86	99	66	1
44	8.63	28.3	47	60	24	1
45	9.16	30.0	242	254	7	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #6
NNSA/NSO
20 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
46	9.28	30.4	38	51	25	2
47	9.38	30.8	31	44	26	1
48	9.43	30.9	171	184	39	2
49	9.55	31.3	142	155	10	2
50	9.62	31.6	78	90	10	2
51	9.77	32.1	129	141	7	2
52	9.77	32.1	199	212	66	2
53	9.81	32.2	208	221	68	2
54	10.04	32.9	100	113	2	1
55	10.10	33.1	84	97	8	1
56	10.16	33.3	106	119	7	2
57	10.17	33.4	288	301	86	3
58	10.20	33.5	225	238	31	2
59	10.24	33.6	154	167	10	1
60	10.33	33.9	249	261	34	1
61	10.38	34.1	62	75	16	2
62	10.40	34.1	251	264	12	1
63	10.63	34.9	264	276	15	1
64	10.64	34.9	81	94	14	1
65	10.88	35.7	130	143	15	2
66	10.99	36.1	315	328	6	3
67	11.03	36.2	299	311	10	2
68	11.10	36.4	38	51	26	2
69	11.21	36.8	100	113	12	3
70	11.52	37.8	5	18	22	0
71	11.84	38.9	175	188	74	3
72	12.03	39.5	188	200	70	2
73	12.24	40.2	1	14	17	1
74	12.36	40.6	213	226	40	0
75	12.53	41.1	250	263	28	1
76	12.93	42.4	298	311	35	1
77	12.96	42.5	14	27	11	3
78	13.01	42.7	36	49	8	3
79	13.07	42.9	199	212	80	3
80	13.08	42.9	49	62	7	2
81	13.13	43.1	72	85	12	1
82	13.17	43.2	53	66	9	2
83	13.23	43.4	138	151	7	1
84	13.30	43.7	132	145	9	2
85	13.35	43.8	16	29	23	1
86	13.48	44.2	299	311	88	3
87	13.69	44.9	328	341	15	1
88	13.77	45.2	220	233	29	2
89	13.94	45.7	16	29	31	2
90	14.02	46.0	154	167	11	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #6
NNSA/NSO
20 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
91	14.14	46.4	28	41	16	1
92	14.15	46.4	153	166	13	1
93	14.32	47.0	14	27	10	1
94	14.39	47.2	139	152	7	3
95	14.44	47.4	309	322	24	1
96	14.48	47.5	145	158	8	1
97	14.55	47.7	74	87	8	2
98	14.60	47.9	54	67	21	0
99	14.85	48.7	158	171	14	0
100	15.31	50.2	130	143	24	1
101	15.51	50.9	106	118	8	2
102	15.58	51.1	137	150	13	2
103	15.65	51.3	111	124	13	2
104	15.83	51.9	104	117	12	2
105	15.93	52.3	100	113	10	1
106	16.08	52.8	188	201	71	0
107	16.18	53.1	19	32	28	0
108	16.80	55.1	24	37	16	0
109	17.11	56.1	55	68	11	2
110	17.14	56.2	198	211	85	1
111	17.20	56.4	358	11	80	0
112	17.24	56.6	351	4	15	3
113	17.29	56.7	48	61	16	2
114	17.30	56.8	239	252	21	1
115	17.50	57.4	138	151	10	2
116	17.78	58.3	33	46	29	1
117	17.87	58.6	195	208	83	3
118	17.88	58.7	18	31	31	0
119	18.01	59.1	68	80	9	1
120	18.08	59.3	173	186	13	1
121	18.17	59.6	127	140	14	2
122	18.68	61.3	26	39	24	1
123	18.78	61.6	131	144	15	1
124	18.92	62.1	303	316	85	3
125	18.93	62.1	309	322	27	1
126	18.95	62.2	29	42	28	1
127	18.96	62.2	110	123	7	1
128	19.18	62.9	24	36	24	1
129	19.27	63.2	359	12	58	1
130	19.33	63.4	66	79	7	3
131	19.57	64.2	56	68	26	1
132	19.65	64.5	35	48	21	2
133	19.66	64.5	284	297	67	3
134	20.27	66.5	22	35	19	1
135	20.36	66.8	151	164	5	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #6
NNSA/NSO
20 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
136	20.46	67.1	174	187	33	3
137	20.60	67.6	107	120	4	2
138	20.85	68.4	195	208	51	0
139	21.24	69.7	10	22	21	0
140	21.74	71.3	35	48	7	3
141	21.77	71.4	192	204	87	2
142	21.81	71.5	181	194	6	3
143	21.94	72.0	145	158	9	3
144	22.03	72.3	160	173	7	3
145	22.34	73.3	97	109	54	3
146	22.35	73.3	53	65	52	3
147	22.56	74.0	60	73	66	3
148	22.64	74.3	96	109	76	3
149	23.04	75.6	303	316	44	2
150	23.42	76.8	34	47	23	0
151	23.62	77.5	162	175	6	2
152	23.77	78.0	4	17	83	3
153	23.85	78.3	204	217	77	3
154	24.58	80.6	193	206	83	2
155	24.62	80.8	81	94	13	1
156	24.88	81.6	204	217	14	1
157	25.44	83.5	31	43	27	1
158	25.64	84.1	17	30	29	1
159	25.65	84.1	205	218	80	3
160	25.85	84.8	24	37	19	2
161	25.93	85.1	7	20	28	0
162	25.96	85.2	212	225	81	3
163	26.14	85.8	41	53	10	2
164	26.58	87.2	70	83	7	1
165	26.76	87.8	73	86	21	2
166	26.89	88.2	40	53	6	3
167	27.13	89.0	330	343	35	3
168	27.16	89.1	102	115	73	2
169	27.17	89.2	104	117	15	3
170	27.41	89.9	103	115	57	3
171	27.47	90.1	47	60	7	2
172	27.62	90.6	25	38	27	0
173	27.72	90.9	68	81	14	2
174	27.87	91.5	60	73	4	2
175	27.97	91.8	27	40	2	2
176	28.17	92.4	29	42	21	2
177	28.23	92.6	194	207	71	3
178	28.32	92.9	90	103	8	2
179	28.73	94.3	7	20	5	1
180	28.84	94.6	64	77	23	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #6
NNSA/NSO
20 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
181	29.00	95.2	192	205	84	3
182	29.39	96.4	21	33	30	1
183	29.74	97.6	203	216	81	3
184	29.83	97.9	360	12	18	0
185	29.94	98.2	58	70	21	0
186	30.54	100.2	206	219	78	2
187	30.63	100.5	118	131	8	0
188	30.73	100.8	38	51	6	0
189	30.79	101.0	286	299	8	0
190	30.93	101.5	50	63	29	0
191	31.54	103.5	139	152	13	3
192	32.24	105.8	311	324	38	3
193	32.46	106.5	195	208	84	3
194	32.51	106.7	43	56	31	3
195	32.91	108.0	43	56	22	3
196	33.28	109.2	194	207	87	3
197	33.50	109.9	135	147	16	3
198	33.51	110.0	18	30	28	3
199	33.99	111.5	88	101	22	0
200	34.12	111.9	62	74	21	0
201	34.20	112.2	112	125	7	0
202	34.32	112.6	39	52	14	0
203	34.44	113.0	17	30	15	1
204	34.46	113.1	84	97	9	1
205	34.89	114.5	19	32	83	3
206	35.02	114.9	93	105	66	1
207	35.03	114.9	160	173	8	0
208	35.12	115.2	86	99	66	1
209	35.21	115.5	289	301	36	1
210	35.29	115.8	205	218	85	3
211	35.80	117.5	23	36	20	1
212	35.97	118.0	18	31	26	3
213	36.05	118.3	55	68	13	1
214	36.12	118.5	253	266	42	2
215	36.18	118.7	55	68	31	1
216	36.73	120.5	8	20	70	3
217	36.74	120.5	68	80	17	1
218	36.88	121.0	97	109	50	3
219	37.01	121.4	118	131	69	3
220	37.15	121.9	68	81	64	3
221	37.21	122.1	97	110	8	1
222	37.24	122.2	219	232	54	3
223	37.45	122.9	48	61	9	1
224	37.58	123.3	182	195	65	3
225	37.72	123.7	38	51	32	3

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #6
NNSA/NSO
20 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
226	37.74	123.8	121	134	15	3
227	37.80	124.0	181	193	74	3
228	38.33	125.8	43	56	18	3
229	38.40	126.0	110	123	44	3
230	38.43	126.1	40	53	82	3
231	38.61	126.7	69	82	19	3
232	38.72	127.0	219	232	12	3
233	38.85	127.5	81	94	20	3
234	38.97	127.9	67	80	18	3
235	39.23	128.7	197	209	51	3
236	39.36	129.1	192	205	57	3
237	39.41	129.3	30	43	76	3
238	39.53	129.7	45	58	13	2
239	39.66	130.1	22	35	36	2
240	40.31	132.3	98	111	11	1
241	40.32	132.3	24	37	85	3
242	40.45	132.7	194	207	81	3
243	40.97	134.4	164	177	82	3
244	41.00	134.5	63	76	8	1
245	41.28	135.4	274	287	67	1
246	41.33	135.6	41	54	7	1
247	41.43	135.9	195	208	60	3
248	41.71	136.8	19	32	83	3
249	41.79	137.1	18	31	83	3
250	41.97	137.7	13	26	7	1
251	42.07	138.0	160	173	62	3
252	42.11	138.1	221	234	51	2
253	42.15	138.3	196	209	78	2
254	42.43	139.2	185	198	75	1
255	42.59	139.7	29	42	17	0
256	42.67	140.0	195	208	65	2
257	42.72	140.2	48	60	15	0
258	43.12	141.5	194	207	70	3
259	43.15	141.6	2	15	37	3
260	43.27	142.0	15	28	15	2
261	43.28	142.0	190	203	55	1
262	43.52	142.8	202	215	70	3
263	43.57	143.0	198	211	4	1
264	43.86	143.9	132	145	10	1
265	43.90	144.0	101	114	11	1
266	43.98	144.3	42	55	47	0
267	44.18	145.0	26	39	33	1
268	44.86	147.2	342	355	8	2
269	44.94	147.4	62	74	25	1
270	45.20	148.3	17	30	29	1

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #6
NNSA/NSO
20 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
271	45.23	148.4	124	137	63	3
272	45.25	148.5	125	138	66	3
273	45.33	148.7	71	84	22	2
274	45.65	149.8	276	289	4	1
275	45.86	150.5	97	110	9	2
276	45.98	150.8	217	230	66	1
277	46.01	150.9	74	87	2	3
278	46.24	151.7	61	73	4	1
279	46.38	152.2	105	118	9	0
280	46.69	153.2	41	54	26	0
281	47.72	156.6	196	208	21	0
282	47.78	156.8	181	194	66	1
283	47.80	156.8	56	69	10	3
284	47.92	157.2	66	79	24	0
285	48.19	158.1	221	233	58	2
286	48.26	158.3	54	67	17	2
287	48.37	158.7	70	83	72	3
288	48.47	159.0	53	66	13	3
289	48.49	159.1	233	246	59	3
290	48.59	159.4	247	260	60	3
291	48.62	159.5	51	63	65	3
292	49.23	161.5	217	230	61	0
293	49.29	161.7	77	90	59	3
294	49.39	162.1	32	45	18	1
295	49.58	162.7	13	26	17	1
296	49.65	162.9	80	92	58	2
297	49.71	163.1	205	217	46	3
298	49.95	163.9	63	76	11	0
299	50.05	164.2	47	60	18	1
300	50.23	164.8	12	25	14	2
301	50.40	165.4	38	51	19	0
302	50.70	166.3	36	49	28	1
303	50.80	166.7	23	36	18	1
304	51.18	167.9	148	161	7	1
305	51.23	168.1	70	83	6	1
306	51.34	168.5	264	277	19	1
307	51.51	169.0	99	112	63	1
308	51.55	169.1	9	22	7	2
309	51.95	170.4	120	133	82	3
310	52.09	170.9	80	93	16	3
311	52.10	170.9	3	16	61	0
312	52.56	172.4	242	255	0	2
313	52.64	172.7	41	54	25	1
314	52.77	173.1	38	51	26	2
315	52.80	173.2	202	215	66	2

All directions have been corrected for borehole deviation, and are with respect to true north.

Orientation Summary Table - Image Features
Nevada Test Site
Source Physics Experiment
U-15N #6
NNSA/NSO
20 Sept 2010

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Direction (deg. TN)	Dip Angle (degrees)	Feature Rank (0 to 5)
316	52.92	173.6	45	58	28	1
317	52.92	173.6	213	226	64	2
318	53.10	174.2	209	222	62	0
319	53.17	174.4	11	24	4	1
320	53.25	174.7	45	58	28	1
321	53.32	174.9	61	74	14	1
322	53.35	175.0	62	75	12	1
323	53.69	176.2	43	56	29	1
324	53.78	176.5	56	69	29	2
325	53.79	176.5	68	81	76	3
326	53.96	177.1	202	214	49	3
327	53.99	177.1	28	41	28	1
328	54.28	178.1	79	91	39	1
329	54.46	178.7	42	55	27	0
330	54.73	179.6	31	44	26	1
331	54.77	179.7	222	235	59	0
332	54.87	180.0	28	41	32	1
333	54.87	180.0	230	243	46	3
334	55.02	180.5	174	187	40	0
335	55.20	181.1	189	202	44	3
336	55.26	181.3	27	40	20	1
337	55.46	181.9	218	231	56	0
338	55.60	182.4	216	228	57	2
339	55.82	183.1	209	222	65	3
340	56.00	183.7	221	234	74	3
341	56.05	183.9	79	92	74	1
342	56.38	185.0	208	221	73	3
343	56.46	185.2	26	39	83	3
344	56.47	185.3	211	224	78	3
345	56.58	185.6	12	24	70	3
346	56.59	185.7	49	62	17	2
347	56.63	185.8	161	174	71	2
348	56.96	186.9	176	189	36	2
349	57.02	187.1	194	207	45	0
350	57.22	187.7	175	188	20	3
351	57.37	188.2	167	180	26	1
352	57.45	188.5	34	47	21	0

All directions have been corrected for borehole deviation, and are with respect to true north.

APPENDIX K

Information Regarding Weathering at the U15n Source Physics Experiment Site

Table K-1
Visual Weathering Characteristics of U-15n Core

Depth (feet)	USBR Weathering Category [a]	Comment
7–20	W3	About 90% of observable core is relatively unweathered (W3) quartz monzonite and 10% is relatively weathered (W4)
20–45	W4	About 65% of observable core is relatively weathered (W4); 35% (minor zones) is relatively unweathered (W3).
45–75	W3	Core is mostly hard, stained granodiorite (USBR category W3, slightly weathered)
75–88.5	Fault zone	Shows low resistivity and low density on logs. Feldspars are altered to clay, and biotite is surrounded by alteration holes of bronze biotite. This sheared material is not considered in the determination of weathering and alteration categories by USBR procedure.
88.5–104	W3	Core is mostly hard, stained quartz monzonite (W3).
104–107	Fault zone	Fault zone, similar to fault zone at 75–88.5 ft.
107–138	W3	Core is mostly hard, stained quartz monzonite (W3).
138–148	W3	Relatively unweathered quartz monzonite with little staining and few fractures (W3)
148–196.5	W3	Core is mostly hard, stained quartz monzonite (W3), with minor areas of W4 adjacent to faults or fractures at 155.5–156.5, 168–171, and 194.8–196.5 ft.

a U.S. Bureau of Reclamation Weathering Categories. See Table K-2. Information about the International Society of Rock Mechanics (ISRM) Weathering Classification system is provided in Table K-3 for comparison.

Table K-2
U.S. Bureau of Reclamation Weathering Categories

Name Sy	mbol	Description
Decomposed	W9	Body of rock is discolored or oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and ferromagnesian minerals are completely altered to clay; complete separation of grain boundaries (disaggregated), partial or complete remnant rock structure may be preserved, but resembles a soil.
Very Intensely Weathered [a]	W8	
Intensely Weathered	W7	Body of rock is discolored or oxidized throughout; all feldspars and ferromagnesian minerals are altered to clay to some extent. All fracture surfaces are discolored or oxidized, surfaces friable; partial separation of grain boundaries, rock is friable; in situ disaggregation of grantics common in semi-arid regions; texture altered and leaching of soluble minerals may be complete. Rock has dull sound when struck with hammer; rock is weakened, usually can be broken with moderate to heavy manual pressure or by light hammer blow without reference to planes of weakness.
Intensely to Moderately Weathered [a]	W6	
Moderately Weathered	W5	Discoloration or oxidation extends from fractures, usually throughout body of rock; ferromagnesian minerals are "rusty," feldspar crystals area "cloudy'" all fracture surfaces are discolored or oxidized; partial opening of grain boundaries visible; texture generally preserved by soluble minerals may be mostly leached. Hammer does not ring when rock is struck; body of rock is slightly weakened.
Moderately to Slightly Weathered [a]	W4	
Slightly Weathered	W3	Discoloration or oxidation is limited to surface of, or short distance from fractures; some feldspar crystals are dull; fracture surfaces have minor to complete discoloration or oxidation; no visible separation of grain boundaries; texture preserved and minor leaching of soluble minerals may be present. Hammer rings when crystalline rocks are struck; body of rock is not weakened by weathering.
Slightly Weathered to Fresh [a]	W2	
Fresh	W1	Body of rock is not oxidized or discolored; fracture surface are not oxidized or discolored [b]; no separation of grain boundaries; no change of texture and no solutioning. Hammer rings when crystalline rocks are struck.

Taken from U.S. Bureau of Reclamation, 2007. *Engineering Geology Field Manual*, Figure 4-6, page 67. www.usbr.gov/pmts/geology/geolman/. Accessed on October 17, 2011.

a. Combination of descriptors is used where equal distribution of both weathering characteristics are present over significant intervals or where characteristics noted are "in between" the diagnostic characteristics.
b. Characteristics of fractures surfaces do not include directional weathering along shears or faults and their associated fracture zones. For example, a shear that carries weathering to great depths in a fresh rock mass would not require the whole rock mass to be classified as weathered.

Table K-3
International Society of Rock Mechanics Weathering Classification

Term G	rade	Description
Residual Soil		All rock material is converted to soil; the mass structure and material fabric are destroyed; there is a large change in volume but the soil has not been significantly transported.
Completely Weathered	W5	All rock material is decomposed and/or disintegrated to soil; the original mass structure is still largely intact.
Highly Weathered	W4	More than half of the rock material is decomposed and/or disintegrated to soil; fresh or discolored rock is present either as a discontinuous framework or as core stones.
Moderately Weathered	W3	Less than half of the rock material is decomposed and/or disintegrated to soil; fresh or discolored rock is present either as a discontinuous framework or as core stones.
Slightly Weathered	W2	Discoloration indicates weathering of rock material and discontinuity surfaces; weathering may discolor all the rock material.
Fresh Rock	W1	No visible sign of rock material weathering; perhaps slight discoloration on major discontinuity surfaces.

International Society for Rock Mechanics, 1981. “Basic Geotechnical Description of Rock Masses.” *International Journal of Rock Mechanics, Mining Sciences, and Geomechanics Abstracts*, vol. 18, pp. 85–110.

APPENDIX L

Water in the SPE Holes

Email from Margaret Townsend, UGTA/Boreholes Geology Group, National Security Technologies, LLC

To Source Physics Experiment Subject Matter Experts

December 29, 2010

From:	Townsend, Margaret
To:	Barker, Dennis; Ortego, Paul; Schuette, Robert; Snelson-Gerlicher, Catherine; Graves, Tom; "Antoun, Tarabay H."; "lomov1@llnl.gov"; "Wendee Brunish"; "Chris Bradley"; "Aviva Sussman"; "reabbott@sandia.gov"; "Corbell, Bobby H"; "Kiran Shah (kiran.shah@dtra.mil)"; "Barbara Harris-West"; "Mike Giltrud"
Cc:	Lee, Ping; Drellack, Sigmund
Subject:	water in the SPE holes
Date:	Wednesday, December 29, 2010 4:54:38 PM
Attachments:	U-15n#5_water_chem.pdf U15n_Borehole_Groundwater_Elevations_mod2.xls

SPE Team,

As you know, we have found that the holes drilled at the U-15n site contain water. This was a surprise to me, and at first I thought this must be water from the drilling operation seeping back into the open holes after being forced into natural fractures during drilling. However, subsequent investigations indicate that it is natural groundwater. Here is an update, first the chemistry analysis, then the water levels.

Water Chemistry

On October 21, 2010, the NSTec Ecological and Environmental Monitoring Group collected one water sample from hole U-15n#5 and one from the water truck that delivered water for making up the foam used as a drilling fluid (source is Water Well 8 in Area 18). The samples were analyzed at a commercial laboratory for metals (Calcium, Magnesium, Potassium, Silica [Silicon], Sodium) and four other routinely monitored stable chemistry parameters:

- Alkalinity, Bicarbonate (HCO3) as CaCO3
- Alkalinity, Carbonate (CO3) as CaCO3
- Chloride, Fluoride, Sulfate as SO4
- Total Dissolved Solids (TDS)

The sampling crew also used a meter to measure pH, temperature, specific conductance, and turbidity of the borehole water at the time of sampling.

The lab data package is about an inch thick, but I scanned the summary sheet and attached it to this message (I wrote the borehole meter readings at the bottom). The results indicate that only bicarbonate alkalinity and total dissolved solids were detectable in the sample from the water truck, while in the sample from the borehole they also measured chloride, fluoride, and sulfate. The lab also reported that due to very high sodium levels in the truck sample they had to dilute the sample 12-fold.

It is hard to make a definitive statement about the source of the borehole water based on only these two samples, but the significant difference between the two samples seems to indicate that they are from two different sources. Given the composition of the granite, and some mineralization not far away, the presence of chloride, fluoride and sulfate appears to indicate that the sample from U-15n#5 is formation water.

Water Levels

Water level depths tagged during geophysical logging (September 20, 2010) ranged from 57.3 to 77 ft, as reported on the daily drilling report:

- Hole #1 Fluid at 58.3'
- Hole #2 Fluid at 77'
- Hole #3 Fluid at 58'
- Hole #4 Fluid at 61'
- Hole #5 Fluid at 57.3'
- Hole #6 Fluid at 61.5'

On the same day that they collected the water sample from U-15n#5 (October 21, 2010), the Ecological Monitoring folks measured recharge of water in hole #5 during pumping: while pumping at 1.3 GPM, they measured the recharge rate at approximately 1.306 gal/ft every 10 minutes.

An NSTec crew measured the water levels on December 9, 2010, and reported a fluid level depth of 58 ft in all five open instrument holes and the 36-in. hole, which was 112 ft deep at the time. This seemed to indicate that the holes are communicating through the fracture system, allowing the fluid levels to equilibrate in all holes.

NSTec geologists measured the water levels in all six open holes twice on December 23 and twice on December 28, 2010. The measured water level depths below ground surface were very similar to those measured two weeks before, ranging from about 57 to 60 ft. I’ve attached an Excel spreadsheet that lists these latest measurements and shows a graphical plot of the data. We plan to measure the water levels again next week, to try to determine if the slight rise seen in some of the holes continues, following the rains we’ve been having.

I hope to send out next week some preliminary interpretations of the fracture data from the instrument holes.

Let me know if there are any questions.
Maggie

Margaret Townsend
702-295-6521
NSTec Environmental Restoration
Contractor to the United States Department of Energy

Rec'd 12-09-2010

264 Welsh Pool Road
Exton, PA 19341
Phone: 610-280-3000
Fax: 610-280-3041

National Security Technologies, LLC 2621 Losee Road, Mail Stop NTS273 North Las Vegas NV, 89030	Project: BOA Project Number: V3513 Project Manager: Ted Redding	**Reported:** 11/16/2010 17:22

Wet Chemistry
Lionville Laboratory

Analyte	Result and Qualifier	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method
U-15N-5 (1010109-01) Water								
Carbonate Alkalinity	2.0 U	2.0	mg/L	1	L011059	10/29/2010	10/29/2010	SM 2320B
Bicarbonate Alkalinity	245	2.0	mg/L	1	L011059	10/29/2010	10/29/2010	SM 2320B
Total Dissolved Solids	383	5.0	mg/L	1	L010402	10/27/2010	10/27/2010	SM 2540C
Chloride	10.6	2.50	mg/L	10	L011245	11/10/2010	11/11/2010	EPA 300.0 (1993)
Fluoride	0.52	0.25	mg/L	1	L011245	11/10/2010	11/11/2010	EPA 300.0 (1993)
Sulfate	42.3	2.50	mg/L	10	L011245	11/10/2010	11/11/2010	EPA 300.0 (1993)
U-15N-T (1010109-02) Water								
Carbonate Alkalinity	10.0 U	10.0	mg/L	1	L011059	10/29/2010	10/29/2010	SM 2320B
Bicarbonate Alkalinity	202	10.0	mg/L	1	L011059	10/29/2010	10/29/2010	SM 2320B
Total Dissolved Solids	15.0	5.0	mg/L	1	L010402	10/27/2010	10/27/2010	SM 2540C
Chloride	1250 U	1250	mg/L	5000	L011245	11/10/2010	11/11/2010	EPA 300.0 (1993)
Fluoride	1250 U	1250	mg/L	5000	L011245	11/10/2010	11/11/2010	EPA 300.0 (1993)
Sulfate	1250 U	1250	mg/L	5000	L011245	11/10/2010	11/11/2010	EPA 300.0 (1993)

Measured in U-15n#5 by ETS, 21 Oct 2010

pH = 7.25
Temp = 17.4°C
Spc. Conductance = 566 μS/cm
Turbidity = 1.03 (NTU)

U15n Borehole Groundwater Elevations

Date	Time	Baro	U-15n (36")			U-15n #1			U-15n #2			U-15n #3			U-15n #4			U-15n #5		
			GS Elevation:		5003.12	GS Elevation:		5003.19	GS Elevation:		5003.28	GS Elevation:		5003.85	GS Elevation:		5003.79	GS Elevation:		5003.27
			TOC Stickup AGS:		2.56	TOC Stickup AGS:		0.60	TOC Stickup AGS:		0.65	TOC Stickup AGS:		0.60	TOC Stickup AGS:		0.75	TOC Stickup AGS:		0.65
			Time	DTW	GW Elev	Time	DTW	GW Elev	Time	DTW	GW Elev	Time	DTW	GW Elev	Time	DTW	GW Elev	Time	DTW	GW Elev
12/23/2010	7:15	867.6	9:10	59.89	4945.79	9:05	58.05	4945.74	9:00	57.69	4946.24	8:50	57.57	4946.88	8:55	58.77	4945.77	8:41	57.35	4946.57
12/23/2010			15:25	59.89	4945.79	15:20	58.06	4945.73	15:19	57.72	4946.21	15:15	57.60	4946.85	15:17	58.80	4945.74	15:10	57.37	4946.55
12/28/2010			8:29	59.89	4945.79	8:17	57.78	4946.01	8:27	57.69	4946.24	8:22	57.42	4947.03	8:24	58.76	4945.78	8:20	57.17	4946.75
12/28/2010	15:45	862.9	16:06	59.87	4945.81	15:45	57.76	4946.03	15:59	57.78	4946.15	15:54	57.38	4947.07	15:57	58.75	4945.79	15:39	57.10	4946.82

AGS = Above Ground Surface, stickup height of TOC in feet, approximate due to uneven ground surface
Baro = Barometric Pressure, in millibars, at Station 2, reported from the NOAA ARL SORD MEDA Data website
DTW = Depth To Water, in feet measured with electronic sounding tape from top of casing
GS = Ground Surface, elevation in feet, approximate due to uneven ground surface
GW = Ground Water, elevation in feet, approximate due to uneven ground surface
TOC = Top Of Casing, measurement point
Measurements made by NSTec UGTA/Boreholes geologists

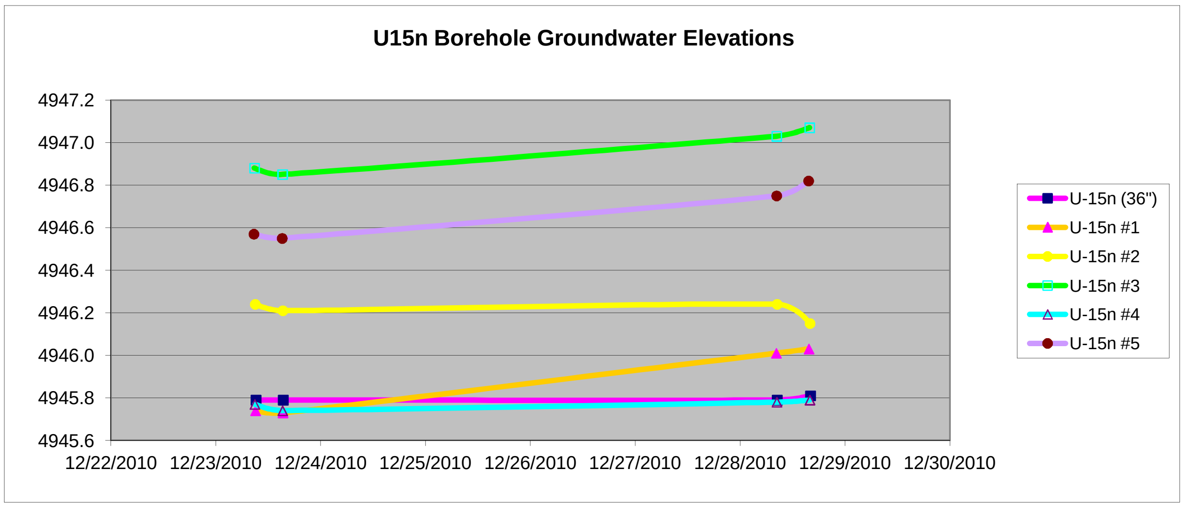
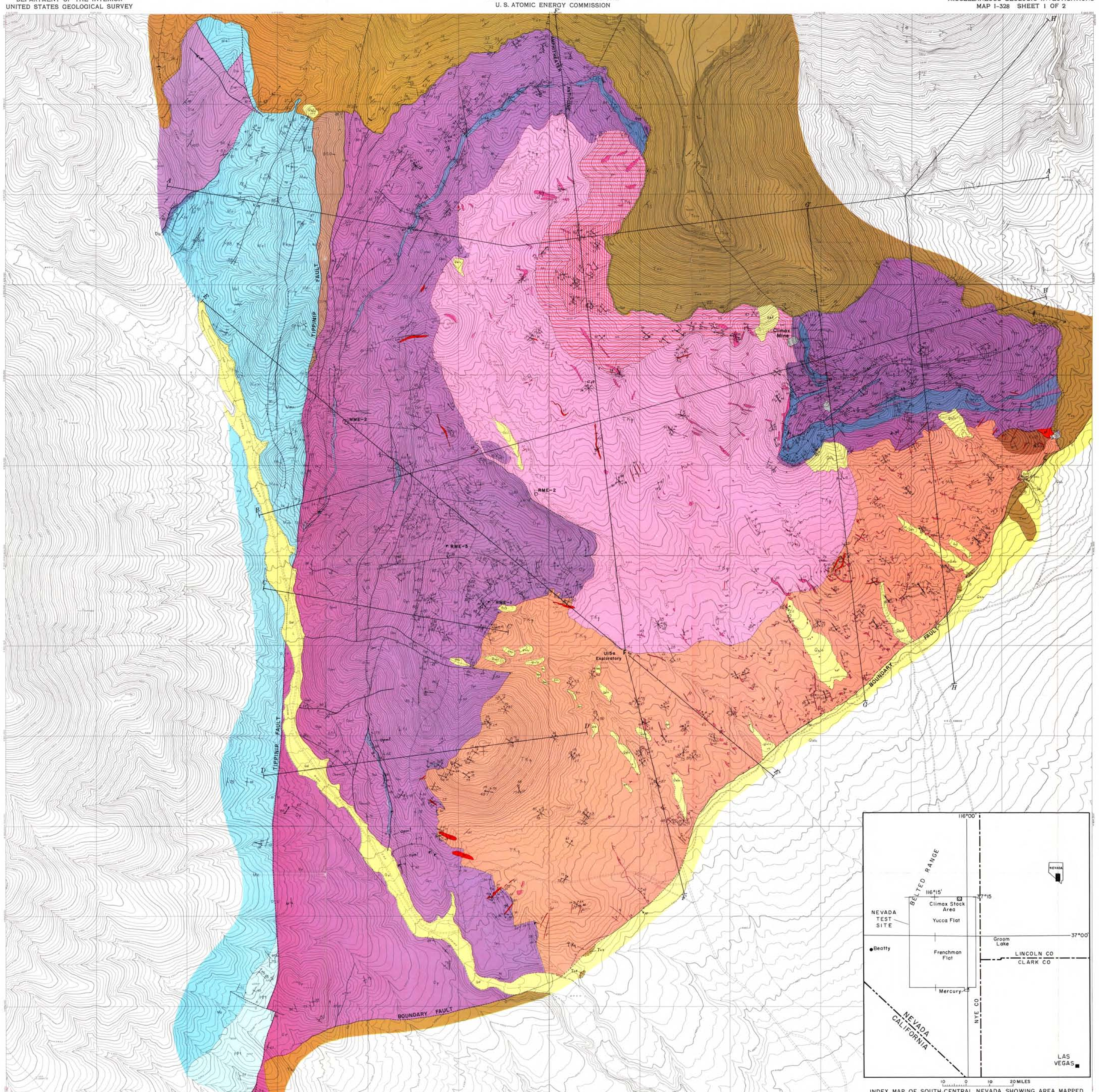


Plate 1

Houser, F. N., and F. G. Poole, 1960. Preliminary Geologic Map of the Climax Stock and Vicinity, Nye County, Nevada. U.S. Geological Survey, Miscellaneous Geologic Investigations Map I-328



INDEX MAP OF SOUTH-CENTRAL NEVADA SHOWING AREA MAPPED

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—61026

Topography by American Aerial Surveys, Inc., Covina, California by stereophotogrammetric (Kelsh) methods from photographs taken in September 1959

Nevada State Coordinate grid interval 1000 feet

PRELIMINARY GEOLOGIC MAP OF THE CLIMAX STOCK AND VICINITY, NYE COUNTY, NEVADA

By
F. N. Houser and F. G. Poole

400 0 400 800 1200 FEET

1960

Geology mapped in 1959 and 1960

For sale by U. S. Geological Survey, price 1.50 per set

EXPLANATION

QUATERNARY

Qal

Younger alluvium and colluvium
Unconsolidated gravel, sand, silt, and clay in main stream beds and large talus deposits on slopes

Qalo

Older alluvium and colluvium
Chiefly carbonate-cemented or unconsolidated sand and granule and pebble conglomerate

TERTIARY

Tosw / Tos / Tosb

Oak Spring formation
Tosw, gray pumiceous crystal vitric welded tuff.
Tos, white, red, yellow, pink-gray pumiceous nonwelded crystal vitric tuff, zeolitized, especially in lower part.
Tosb, widespread basal unit; reddish-brown tuffaceous rubble breccia and conglomerate, and conglomeratic tuff

CRETACEOUS(?) OR TERTIARY(?)

gd, gs, agd

Granite, light-gray, equigranular, fine- to coarse-grained; aplite to pegmatite; occurs as dikes (gd) and sills (gs); "a" prefixed to gd or gs indicates feldspathic, argillic, sericitic, or silicic alteration prominent in dike or sill

TKg

Granodiorite, light- to greenish-gray, predominantly medium grained, some fine-grained; occurs as a stock and sills

TKq

Quartz monzonite, light- to medium-gray, porphyritic, fine- to medium-grained; occurs as a stock

PENNSYLVANIAN AND PERMIAN(?)

PPt

Tippipah(?) limestone
Dolomite, medium- to dark-gray, aphanitic to finely crystalline, thick- to very thick bedded, nonfossiliferous. Estimated minimum thickness 200 feet

MISSISSIPPIAN

Me / Meu / Mem / Mel

Eleana formation
Me, undifferentiated
Meu, argillite, chiefly very dark gray, red-purple or buff, laminated to thin-bedded. Limestone, light- to very dark-gray, finely to coarsely crystalline, partly clastic, laminated to very thick bedded, common to abundant crinoids, interbedded in upper 400 feet with argillite (80 percent). Contains metamorphic silicate minerals east of Oak Spring Wash. Thickness: 970 feet.
Mem, quartzite, dark brownish-gray, very fine to fine-grained and silt, subangular to rounded grains; granule and pebble conglomerate, dark-gray; and interbedded argillite, light-gray to light-brown Thickness: 700 to 1,200 feet.
Mel, predominantly argillite, yellowish-brown to light brownish-gray with subordinate pale-red zones. Common plant remains and worm trails(?). Thickness: in excess of 2,400 feet

The Eleana formation as mapped includes the rocks of Pennsylvanian age because of the presence of Permian and Pennsylvanian corals Lophophyllidium, in the uppermost part of the formation

DEVONIAN(?)

Du

Devonian(?) rocks, undifferentiated
Limestone and dolomitic limestone, buff, very light gray to dark-gray, very finely to coarsely crystalline, in part marble. Thickness not known but is at least 300 feet

ORDOVICIAN, SILURIAN, AND DEVONIAN(?)

DSOu

Devonian(?), Silurian, and Ordovician rocks, undifferentiated
Dolomite and limy dolomite, light- to medium-gray, finely to coarsely crystalline; in part marble

ORDOVICIAN

Oe

Eureka quartzite
Quartzite, white to very light gray, yellow iron stain abundant locally, fine- to medium-grained, well-sorted, vitreous, brittle, very hard, stratification is not apparent

Op / Opmu / Opp (Oppu, Oppm, Oppl) / Opml / Opn / Opl

Pogonip group
Dolomite to dolomitic limestone, very light gray to bluish-gray, finely to coarsely crystalline, laminated to thick-bedded, common chert nodules (mostly silicated). Partly to wholly converted to marble in most places. Original stratification is absent or is indicated by poor to moderately good foliation defined mainly by color bands but partly by crystallinity. The map units differ from the general description as noted:
Op, undifferentiated.
Opmu, limy dolomite to limestone, medium light bluish-gray to medium dark-gray, finely crystalline, thin- to very thick bedded.
Opp, dolomitic limestone, white and very light bluish gray to dark-gray, aphanitic to very finely crystalline, well-laminated (foliated where converted to marble) to very thin bedded, silty (Oppl and Oppu); interbedded with dolomitic limestone and dolomite, very light gray, finely to coarsely crystalline, thin to very thick bedded (Oppm).
Opml, dolomite to dolomitic limestone, gray to blue-gray, some light-gray, massive, nonfoliated to indistinctly foliated, except locally in upper part which is moderately foliated; nodules very rare to absent in lower part but common in places in upper part.
Opn, dolomite and limy dolomite, white to bluish-gray, abundant nodules, moderately to well-foliated.
Opl, dolomite, white to medium-gray, poorly to moderately foliated; contains some nonpersistent interlayers up to 75 feet thick with numerous nodules

CAMBRIAN

Cs

Stirling(?) quartzite
Quartzite, light to medium pinkish-gray and dark-gray, medium-grained, poorly bedded with rare thin beds of dark- to medium-gray phyllite

In order to facilitate early publication of this map, some of the normal cartographic refinements have been omitted

ALTERATION

Note: Not indicated specifically are broad areas of the stock that have undergone pervasive hydrothermal pyrite mineralization and argillic alteration of plagioclase and(or) chloritic alteration of biotite Also not specifically indicated is the extensive silication of the marble along fractures near the edges of the stock The following areas of alteration have been mapped mainly in the stock except as noted

ss | sm

Silicic alteration, strong(ss) and moderate (sm). Excludes individually mappable veins or groups of veins

q

Quartz vein or group of veins

s

Sericitic
Sericite (white mica) is predominant or prominent mineral

h

Hematitic
Hematite in prominent amounts. Generally associated with masses of altered igneous rock in which quartz is prominent or along siliceous or silicate veins in the marble

agd

Feldspathic
(without letter symbol on map)
Lens-shaped feldspathized masses of igneous rock, commonly argillized and subordinately sericitized, silicified, and pyritized. The masses are commonly stained red, purple, yellow, and(or) brown by iron(?) oxides Because of the similarity of the size and shape at map scale, the granite dikes affected by the same alteration are indicated by "a"

t

Tactite
Predominantly garnet with subordinate quartz, epidote, green mica(?), limonite, calcite, sulfide, tungstate, and copper carbonate minerals

45

Contact, showing dip. Long dashed where approximately located, short dashed where gradational or inferred, dotted where concealed

U 70 58 D ? ?

Fault, showing dip and plunge of slickensides. Dashed where inferred, dotted where concealed, queried where doubtful. U, upthrown side; D, downthrown side. Arrows show relative movement

Anticline showing trace of axial plane and direction of plunge of axis. Dashed where inferred

Syncline showing trace of axial plane and direction of plunge of axis. Dashed where inferred

Overturned syncline showing trace of axial plane, direction of plunge and direction of dip of limbs. Dashed where inferred

Overturned anticline showing trace of axial plane and direction of dip of limbs. Dashed where inferred

Axis and plunge of minor anticline

75
Strike and dip of beds

90
Strike of vertical beds

Horizontal beds

65
Strike and dip of overturned beds

56
Strike and dip of joint

Strike of vertical joint

Horizontal joint

7
Strike and dip of flow layers (Tosw unit only)

80
Strike and dip of cleavage

85
Strike and dip of shear zone

RME-2 MME-2
Drill hole
RME - Reynolds Electrical & Engineering Co. marble exploration hole; MME - Minerals Engineering Co. marble exploration hole

Adit

Prospect pit

Mine dump

16°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1960

Plate 2

Barnes, H., F. N. Houser, and F. G. Poole, 1963. Geologic Map of the Oak Spring Quadrangle, Nye County, Nevada. U.S. Geological Survey Map GQ-214

PREPARED IN COOPERATION WITH THE
U.S. ATOMIC ENERGY COMMISSION

DESCRIPTION OF MAP UNITS

Qac **ALLUVIAL AND COLLUVIAL DEPOSITS** (0-1,250 ft)—largely unsorted unconsolidated deposits of boulder to sand size; includes fanglomerate locally cemented with calcium carbonate.

Tpr **PIAPI CANYON FORMATION :**

RAINIER MESA MEMBER (100-120 ft)—multiple-flow compound cooling unit. Upper part (10-40 ft)—partially welded vitric ash-flow tuff, light brownish gray; distinct eutaxitic structure; 10 to 30 percent phenocrysts of sanidine, plagioclase, quartz, biotite. Lower part (80 to 100 ft)—partially welded grading downward to nonwelded vitric ash-flow tuff, pale yellowish brown to white; abundant pumice lapilli.

Tigu **INDIAN TRAIL FORMATION :**

GROUSE CANYON MEMBER —simple cooling unit and underlying ash-fall tuff.

Upper part (40-150 ft)—densely welded devitrified ash-flow tuff, light-gray and light olive gray streaked with very light gray to white; rare phenocrysts of sanidine, quartz and clinopyroxene; lithophysal cavities conspicuous in lower part; some vitrophyre at base.

Tigl Lower part (150-400 ft)—nowelded vitric ash-flow grading downward to vitric ash-fall tuff; light-gray to white, some greenish-yellow zeolitic beds.

Tits **TUB SPRING MEMBER** (0-265 ft)—multiple-flow compound cooling unit. Upper flow (0-80 ft)—partially welded devitrified ash-flow tuff, reddish-brown; subrounded blocks of reddish devitrified pumice, also some granitoid xenoliths in upper part; 10 to 30 percent phenocrysts; basal breccia of nonwelded tuff; thins eastward overlapping older flow. Lower flow (0-190 ft)—densely welded devitrified and vitric ash-flow tuff, partially welded in lower part; light-gray to black, yellowish-green to greenish-gray; vitrophyre and perlite common in upper part, some perlite in lower part; inclusions of dense gray porphyritic volcanic rock conspicuous in upper part; 10 to 30 percent quartz and sanidine phenocrysts. Basal part (60-75 ft)—nonwelded vitric and zeolitized ash-flow tuff; vitric tuff medium gray, friable; zeolitized tuff yellow, compact.

Tiz **ZEOLITIZED TUFF** (250-1,000 ft)—largely zeolitized nonwelded tuff, white to yellowish and pinkish gray; chiefly nonbedded; locally may include vesicular lateral equivalent of red welded tuff (Tirw).

Tirw **RED WELDED TUFF** (0-60 ft)—red welded devitrified ash-flow tuff with abundant quartz and feldspar phenocrysts.

Tb **BIOTITE-RICH WELDED TUFF** (>60 ft)—simple cooling unit. Biotite-rich densely welded devitrified ash-flow tuff; brownish-red to reddish-gray; phenocrysts of biotite, plagioclase, sanidine, and quartz abundant, some hornblende; dark-gray vitrophyre in upper part locally; partially welded in lower part.

DIKES AND SILLS (20-500 ft wide)—alaskite, quartz monzonite, and syenite, light-gray to very light gray, equigranular; aplite to pegmatite; hydrothermally altered locally to vein-like masses of feldspar, sericite, quartz, minor sulfides, especially pyrite.

MzPq **QUARTZ MONZONITE STOCK**— light- to medium-gray, medium-grained, porphyritic; 40 percent intermediate plagioclase, 25 percent potassium feldspar, 28 percent quartz, 6 percent biotite. Age of 93 million years calculated by S. S. Goldick from potassium-argon in biotite

MzPg **GRANODIORITE STOCK AND SMALL SILLS** —light-gray to greenish-gray, equigranular to slightly porphyritic; 45 percent intermediate plagioclase, 16 percent potassium feldspar, 28 percent quartz, 9 percent biotite.

ELEANA FORMATION (>4,800 ft)—argillite, quartzite, conglomerite, and limestone; neither top nor base exposed.

PMei **UNIT I** (>400 ft)—interbedded limestone and argillite; limestone dominant in upper part, argillite in lower. Limestone dark to light gray, some grayish orange; largely coarse to granular crystalline; some gravel- to cobble-conglomerite; thin lenses of chert common; thin to very thick bedded, some laminated bedding; blocky splitting. Argillite similar to that in unit H.

PMeh **UNIT H** (560 ft)—argillite, some coarse clastics in lower part; gradational contacts. Argillite dark to very light gray and grayish-orange; silty and sandy; laminated to very thin bedded. Conglomerite in lower part finer and less persistent than in unit G.

PMeg **UNIT G** (1,185 ft)—quartzite, conglomerite, and argillite, interbedded; lithologic units not laterally persistent; intertonguing contact. Quartzite yellowish-brown to grayish-orange, well sorted to fairly well sorted, subrounded to rounded quartz with chert, thin to thick bedded. Conglomerite and conglomeratic quartzite light-gray, grayish-orange, yellowish-brown; granules, pebbles, and cobbles of chert, quartzite, and argillite in quartzite matrix; thick bedded to laminated. Argillite like that in unit H.

PMee **UNIT E** (2,430 ft)—argillite with some interbedded quartzite; intertonguing contacts. Argillite yellowish-brown, pale-red, greenish to dark gray; slightly metamorphosed claystone and siltstone; laminated to thin-bedded. Quartzite yellowish-brown, grayish-orange, to light-gray; very fine to fine grained, well-sorted, well-rounded to subrounded quartz, gray chert; iron-oxide minerals; laminated to thin-bedded; abundant wavy and contorted laminae and small-scale cross-strata; flaggy splitting.

PMed **UNIT D** (>200 ft)—argillite and quartzite, interbedded; similar to unit E but more quartzite.

Ddl **DOLOMITE AND LIMESTONE** (0-1,000+ft)—some thin beds of quartzite near top; very light to dark-gray, very thick to thin-bedded, locally recrystallized to marble.

DSOd **DOLOMITE AND LIMESTONE** (0-1,400+ ft)—light- to dark-gray, very thick to thin-bedded; marble in part.

Oe **EUREKA QUARTZITE** (150-200 ft)—white to very light gray, yellow to brown iron stain common; fine- to medium-grained; well-sorted, thick-bedded, locally cross-stratified.

Op **POGONIP(?) GROUP.**

Oa **ANTELOPE VALLEY LIMESTONE** (500 ft)—limestone and dolomite. Medium dark gray, very thick to thin-bedded; marble in part.

On **NINEMILE FORMATION** (500 ft)—silty dolomitic limestone with interbedded limestone, and dolomite; gradational contacts. Silty dolomitic limestone white to dark-gray, laminated to very thin bedded. Limestone and dolomite very light gray, thin to very thick bedded. Recrystallized to tactite (t) in lower part, and to marble in upper part.

Og **GOODWIN LIMESTONE** (>1,200 ft)—limestone with some dolomite. Yellowish-gray, white to medium-gray; laminated to thick bedded; some brown-weathering siliceous carbonate and chert; locally recrystallized to marble, some tactite (t).

WINDFALL FORMATION (1,785 ft)—limestone and dolomite; gradational contacts.

Cws **SMOKY MEMBER** (1,070 ft)—thick-bedded limestone and dolomite. Very light to dark- and olive-gray, thick to very thick bedded, some thin beds and crosslaminae; scattered nodules and lenses of brownish to dark-gray weathering chert and silty dolomite. *Girvanella* in thin beds and large stromatolites in very thick beds.

Cwc **CATLIN MEMBER** (715 ft)—very thin bedded limestone and dolomite, abundant chert. Light olive to medium gray, very pale to yellowish-orange, laminated to thin bedded with intercalated lamellae of grayish-orange to pale-red silty limestone; brown-weathering siliceous carbonate and chert abundant.

Cd **DUNDERBERG SHALE** (225 ft)—shale with limestone interbeds and concretions; basal contact sharp but conformable. Shale pale reddish brown, thinly laminated, splits into papery flakes. Limestone nodules and flattened concretions in shale brownish gray to grayish-orange pink. Limestone interbeds in upper part like nodular limestone at base of Windfall; limestone interbeds in lower part like dark platy limestone at top of Bonanza King.

BONANZA KING FORMATION (4,600 ft)

Cbb **BANDED MOUNTAIN MEMBER** (2,440 ft)—dolomite and limestone; basal contact gradational.

Cbb_3 Unit 3 (300 ft)—dark-colored limestone. Light- to dark-gray, thin- to thick-bedded, weathers massively; top 10 feet dark yellowish-brown weathering brownish gray, irregularly laminated, much bituminous material, and some chert and silty limestone, platy splitting.

Cbb_2 Unit 2 (375 ft)—light-colored limestone, probably formed by alteration of darker beds. Very light to yellowish-gray, coarsely crystalline to aphanitic, thick to very thin bedded, locally crossbedded.

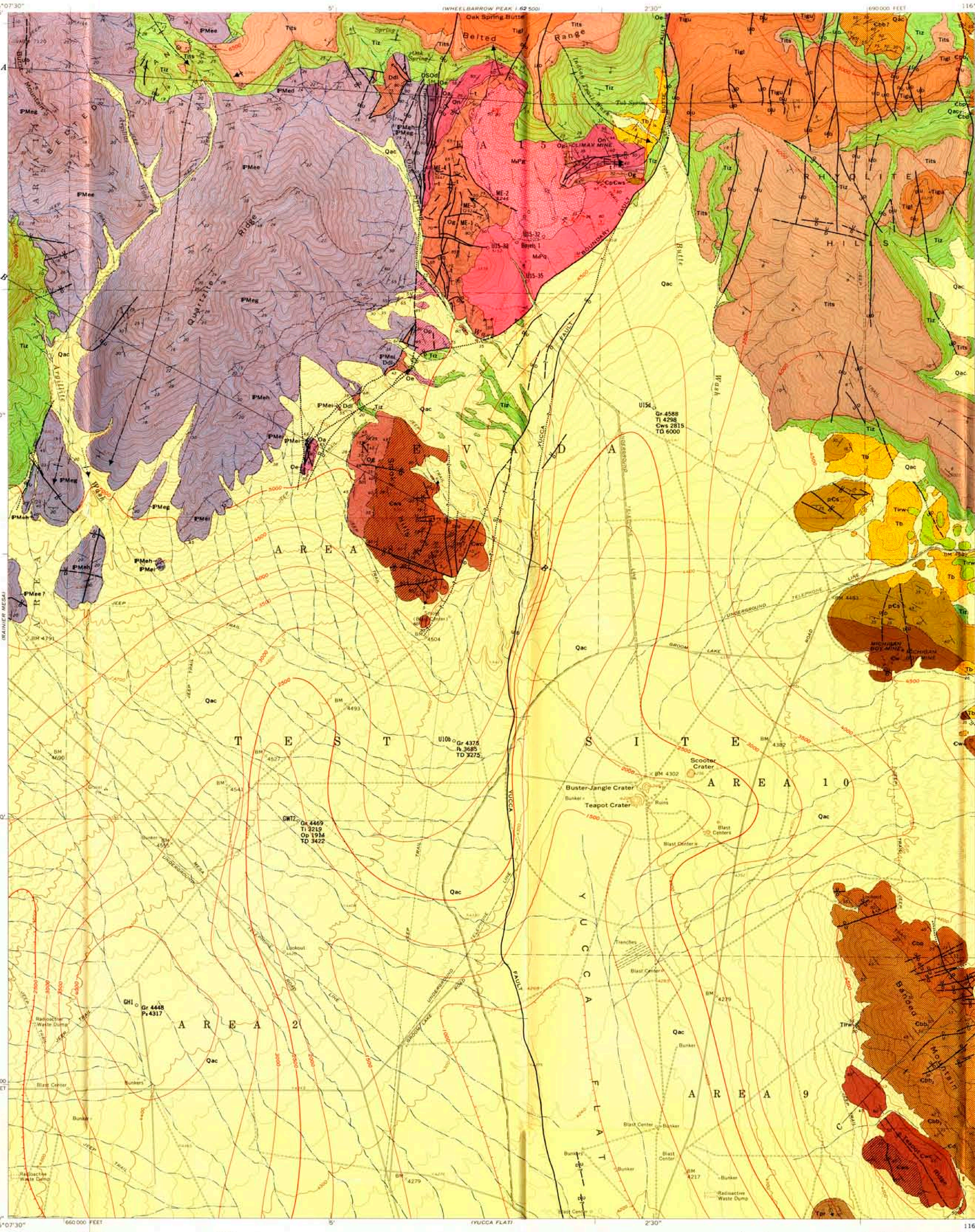
Cbb_1 Unit 1 (1,765 ft)—light- and dark-gray banded sequence of dolomite and limestone. Laminated to thin-bedded; scattered lenses of dark-brown weathering chert and silty limestone. Yellowish-orange laminated silty limestone at base.

Cbp **PAPOOSE LAKE MEMBER** (2,160 ft)—dark- to light-gray dolomite and limestone; only upper half exposed. Light- to medium-gray dolomite and limestone, laminated to thick-bedded; dark-gray dolomite in irregular and cuspate thin beds with abundant small white arcuate calcite stringers.

Cw **WOOD CANYON FORMATION** (>400 ft)—siltstone, minor shale and quartzite; only lower part exposed. Micaceous, yellowish-gray, grayish-orange, pale-brown; laminated. Some grayish-orange dolomite near top.

pCs **STIRLING QUARTZITE** (>2,000 ft)—quartzite and siltstone, minor dolomite; base not exposed. Quartzite grayish-pink to grayish-red, some micaceous, some calcareous, some with conglomeratic lenses. Siltstone micaceous, grayish-red to yellowish-gray. Dolomite yellowish-brown to pale-red.

GEOLOGY OF THE
OAK SPRING QUADRANGLE
NEVADA
GQ-214



Base map by Topographic Division
U.S. Geological Survey, 1960
10,000 foot grid based on Nevada
Coordinate system, central zone

APPROXIMATE MEAN DECLINATION, 1963

SCALE 1:24 000

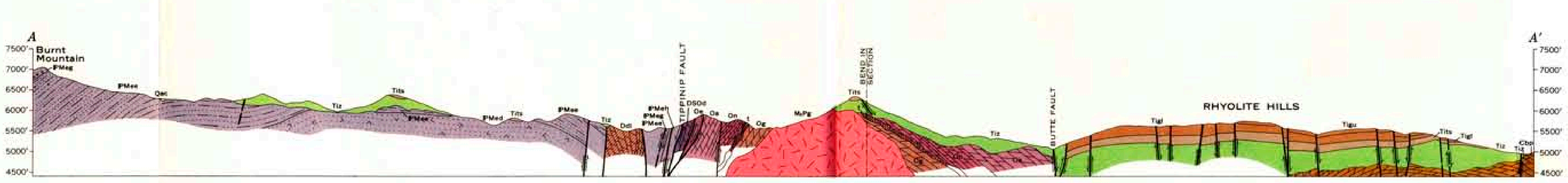
1 MILE

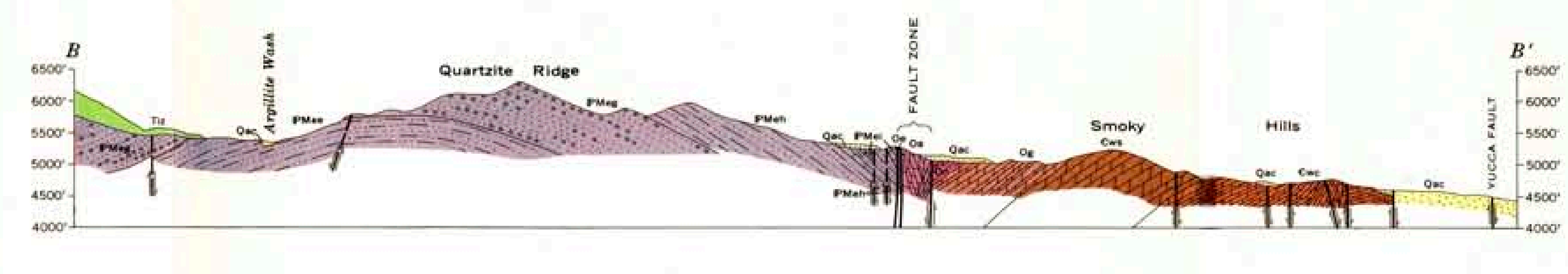
1 KILOMETER

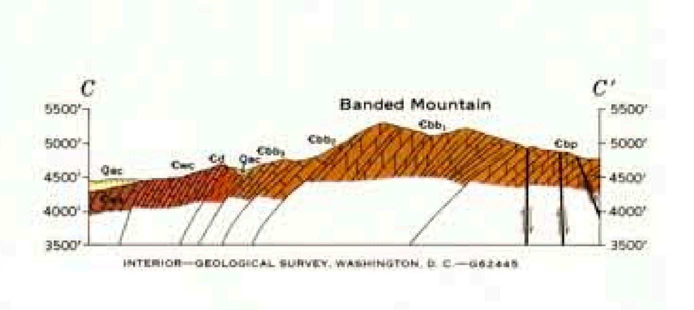
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

QUADRANGLE LOCATION

Geology by Harley Barnes, F. N. Houser
and F. G. Poole, 1960–61
Paleotopography by D. L. Healey
and C. H. Miller, 1959–60







INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—G63445

EXPLANATION

QUATERNARY

Qac — Alluvial and colluvial deposits

UNCONFORMITY

TERTIARY OR YOUNGER

Pliocene or younger

Tpr — Rainier Mesa Member of Piapi Canyon Formation

Miocene or Pliocene

Tigu, Tigl, Tits, Tiz, Tirw — Indian Trail Formation

Tigu, upper part of Grouse Canyon Member.
Tigl, lower part of Grouse Canyon Member.
Tits, Tub Spring Member.
Tiz, zeolitized tuff.
Tirw, red welded tuff

UNCONFORMITY

Tb — Biotite-rich welded tuff

UNCONFORMITY

PERMIAN TO LOWER MESOZOIC

Dikes and sills

MzPq — Quartz monzonite stock

MzPg — Granodiorite stock and small sills

UNCONFORMITY

CARBONIFEROUS — MISSISSIPPIAN TO PENNSYLVANIAN

PMei, PMeh, PMeg, PMee, PMed — Eleana Formation

PMei, *unit I.*
PMeh, *unit H.*
PMeg, *unit G.*
PMee, *unit E.* *Query indicates correlation is questionable.*
PMed, *unit D*

DEVONIAN(?)

Ddl — Dolomite and limestone

ORDOVICIAN SILURIAN AND DEVONIAN

DSOd — Dolomite and limestone

ORDOVICIAN

Middle Ordovician

Oe — Eureka Quartzite

Lower Ordovician

Op, Oa, On, t, Og — Pogonip Group

Op, *Pogonip (?) Group.*
Oa, *Antelope Valley Limestone.*
On, *Ninemile Formation; locally recrystallized to tactite, t.*
Og, *Goodwin Limestone; locally recrystallized to tactite, t*

CAMBRIAN

Upper Cambrian

Cws, Cwc — Windfall Formation

Cws, *Smoky Member.*
Cwc, *Catlin Member*

Cd — Dunderberg Shale

Middle Cambrian

Cbb, Cbb_3, Cbb_2, Cbb_1, Cbp — Bonanza King Formation

Cbb, *Banded Mountain Member. Query indicates correlation probable.*
Cbb_3, *unit 3.*
Cbb_2, *unit 2.*
Cbb_1, *unit 1.*
Cbp, *Papoose Lake Member*

CAMBRIAN(?) AND CAMBRIAN

Lower Cambrian(?) and Lower Cambrian

Cw — Wood Canyon Formation

pCCws — Wood Canyon Formation and Stirling Quartzite

PRECAMBRIAN

pCs — Stirling Quartzite

Contact
Dashed where gradational or inferred

Fault, showing dip
Dashed where approximately located; dotted where concealed; queried where doubtful. U, *upthrown side;* D, *downthrown side*

Anticline
Showing approximate trace of axial plane and direction of plunge of axis

Syncline
Showing approximate trace of axial plane and direction of plunge of axis. Dotted where concealed

Overturned anticline
Showing trace of axial plane

Plunge of minor anticline

Plunge of minor syncline

Strike and dip of beds

Strike and dip of overturned beds

Strike of vertical beds

Adit

Shaft

U15d Gr 4588 Ti 4298 Cws 2815 TD 6000
Drill hole
Showing ground elevation (Gr), and elevation of rock units shown on map (as, Cws) and other rock units (Ti, Indian Trail Formation; Pz, undifferentiated Paleozoic rocks), in feet. TD, total depth, in feet

3000 2500
Inferred paleotopographic contours
Drawn on top of buried Paleozoic rocks. Contours based on gravity data. Interval 500 feet. Datum is mean sea level

GEOLOGY OF THE OAK SPRING QUADRANGLE, NYE COUNTY, NEVADA

By

Harley Barnes, Fred N. Houser, and Forrest G. Poole

1963