Hydrogeologic Investigation at the S65 Locks for the Central Florida Water Initiative

Osceola County, Florida
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EXECUTIVE SUMMARY

The South Florida Water Management District (SFWMD or District) has been working cooperatively with the Southwest Florida and St. Johns River water management districts, Florida Department of Environmental Protection, Florida Department of Agriculture and Consumer Services, and local stakeholders over the last several years to evaluate the status of traditional water supplies and plan for the future of water supply in Central Florida. As part of this Central Florida Water Initiative (CFWI; www.cfwiwater.com), the Data Monitoring and Investigations Team (DMIT) identified several areas lacking adequate monitoring and information on the hydraulic properties of the subsurface, particularly in the deeper portions of the Floridan aquifer system (FAS). Consequently, DMIT developed a work plan for the construction and testing of new data collection sites to meet future data needs within the CFWI Planning Area. This report documents one component of that work plan: the exploratory drilling and construction of monitor well OSF-113 at the S65 Locks site, located south of State Road 60, on the east bank of the Kissimmee River in Osceola County, Florida.

Exploratory drilling at this site reached a maximum depth of 2,000 feet below land surface (ft bls). Work at the S65 Locks site included wire-line coring, geophysical logging, hydraulic testing, optical borehole imaging, and water quality sampling. Data from these activities were used to identify hydrogeologic unit boundaries and evaluate variations in water quality and rock permeability with depth (**Table ES-1**).

Table ES-1. Major findings.

Hydrogeologic Unit		Unit Boundary		Mean TDS (mg/L)	Transmissivity* (ft^2/day)
		Top (ft bls)	Base (ft bls)		
Intermediate Confining Unit		81	270	--	--
Upper Floridan Aquifer	UFA-upper	270	510	313	2,500
	OCAPlpz	510	870	437	--
	APPZ	870	1,210	914	20,000 - 70,000
Middle Confining Unit	MCU_I	1,210	1,450	1,827	--
	MCU_II	Absent		--	--
Lower Floridan Aquifer	LFA-upper	1,450	1,768	3,161	50,000
	GLAUClpu	1,768	No Data	11,427	--

APPZ = Avon Park permeable zone; bls = below land surface; ft = foot; GLAUClpu = low-permeability glauconitic marker unit; LFA-upper = upper Lower Floridan aquifer; MCU = middle confining unit; mg/L = milligrams per liter; OCAPlpz = Ocala-Avon Park low-permeability zone; TDS = total dissolved solids; UFA-upper = upper permeable zone of the Upper Floridan aquifer.

* Estimated from sum of packer test results for that interval.

Major hydrostratigraphic findings from the hydrogeologic testing are summarized here:

- The base of the underground source of drinking water—where total dissolved solids (TDS) concentrations of water samples exceed 10,000 milligrams per liter (mg/L)—is approximately 1,880 ft bls.
- Hydrogeologic unit boundaries above the Lower Floridan aquifer (LFA) were very close to pre-project projections based on the most recent hydrostratigraphic interpretation.
- Three significant productive zones were identified within the LFA above 2,000 ft bls (LF1: 1,452 to 1,536 ft bls; LF2: 1,600 to 1,768 ft bls; LF3: 1,868 to 1,911 ft bls).
- There was more than 20 ft of head drop (i.e., water level decrease) between LF2 (TDS <5,000 mg/L) and LF3 (TDS >20,000 mg/L).

- OSF-113 was completed in LF1 with an open-hole interval from 1,450 to 1,580 ft bls. Long-term monitoring data from this well will represent the top of the upper permeable zone of the LFA (LFA-upper).
- Preliminary data from the OSF-113 (LFA-upper) and nearby OSF-52 (UFA-upper) monitor wells indicate an upward head gradient between these two aquifers. Water levels in OSF-113 are approximately 1 ft higher than OSF-52.
- Two highly permeable fracture zones were identified within the Avon Park permeable zone (APPZ): APhpz-1 (870 to 896 ft bls) and APhpz-2 (1,096 to 1,115 ft bls).
- There was no observed head difference between the two fractured intervals, but salinity in APhpz-1 (chloride concentration = 434 mg/L) was slightly greater than APhpz-2 (chloride concentration = 264 mg/L), indicating some vertical confinement between them and APhpz-1 may be more laterally extensive towards the coast.
- Salinity within both APhpz units is anomalously high for this location.

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ACRONYMS AND ABBREVIATIONS

APhpz	Avon Park high permeability zone
APPZ	Avon Park Permeable Zone
bls	below land surface
CFWI	Central Florida Water Initiative
CTD	conductivity, temperature, and depth
District	South Florida Water Management District
DMIT	Data Monitoring and Investigations Team
DTW	depth to water
ECFTX	East Central Florida Transient Expanded (model)
FAS	Floridan aquifer system
ft	foot
GLAUClpu	low-permeability glauconitic marker unit
gpm	gallons per minute
ICU	intermediate confining unit
k	hydraulic conductivity
LFA	Lower Floridan aquifer
MCU	middle confining unit
mg/L	milligrams per liter
OBI	optical borehole imaging
OCAPlpz	Ocala-Avon Park low-permeability zone
PVC	polyvinyl chloride
SAS	surficial aquifer system
SCADA	supervisory control and data acquisition
SFWMD	South Florida Water Management District
SPT	standard penetration test
TDS	total dissolved solids
UFA	Upper Floridan aquifer
VSMOW	Vienna standard mean ocean water
XRD	x-ray diffraction

INTRODUCTION

The South Florida Water Management District (SFWMD or District) has been working cooperatively with the Southwest Florida and St. Johns River water management districts, Florida Department of Environmental Protection, Florida Department of Agriculture and Consumer Services, and local stakeholders over the last several years to evaluate the status of traditional water supplies and plan for the future of water supply in Central Florida. As part of this Central Florida Water Initiative (CFWI; www.cfwiwater.com), the Data Monitoring and Investigations Team (DMIT) identified several areas lacking adequate monitoring and information on the hydraulic properties of the subsurface, particularly in the deeper portions of the Floridan aquifer system (FAS). Consequently, DMIT developed a work plan for the construction and testing of new data collection sites to meet future data needs within the CFWI Planning Area. This report documents one component of that work plan: the exploratory drilling and monitor well construction at the S65 Locks site (27.80115833, -81.196475).

The S65 Locks site is located in Osceola County, on the east bank of the Kissimmee River right-of-way at the southern shore of Lake Kissimmee (**Figure 1**). Land surface elevation at the site is 54.54 feet (ft) using the North American Vertical Datum of 1988 (NAVD88; 55.73 ft National Geodetic Vertical Datum of 1929 [NGVD29]).Wells OSF-52, OSS-72, and OSS-73 were present adjacent to this location (on the other side of the river) prior to this project start. OSF-52 was drilled by the SFWMD in 1982 as part of a hydrogeologic reconnaissance study of the Kissimmee Planning Area (Shaw and Trost 1984). The well was cased to 172 ft below land surface (bls), near the top of the FAS, and left open to the total drilled depth of 880 ft bls. From the time of construction until May 2009, water levels in OSF-52 were measured semiannually as part of the United States Geological Survey statewide potentiometric mapping effort for the Upper Floridan aquifer (UFA). Surficial aquifer system (SAS) wells OSS-73 (screened from 12 to 15 ft bls) and OSS-72 (screened from 105 to 120 ft bls) were constructed in 2002 as part of the SFWMD Paired Wells project, investigating interconnectivity between the SAS and FAS. After construction of the shallow wells, the site was instrumented with pressure transducers and telemetry connected to a supervisory control and data acquisition (SCADA) system and continuously monitored by the SFWMD since February 2004. DMIT plans for this site originally called for installation of an upper Lower Floridan aquifer (LFA-upper) monitor well immediately adjacent to the three existing wells, utilizing the existing SCADA site. Modern weight restrictions on the S65 structure prevented drill rig access, however, so the new well was installed as close as possible to the existing wells, approximately 800 ft southeast. A new SCADA site was installed at OSF-113 in April 2020.

Project Objectives

Hydrogeologic data collection:

1. Evaluate the lithology, productivity, and water quality of the FAS to a depth of 2,000 ft bls.

2. Identify key hydrogeologic unit boundaries from the top of the Avon Park permeable zone (APPZ) to the top of the low-permeability glauconitic marker unit (GLAUClpu).

Monitoring objectives:

1. Construct a new well (OSF-113) from the exploratory corehole to discretely monitor the LFA-upper.

2. Install an on-site SCADA system for continuous water level measurements.

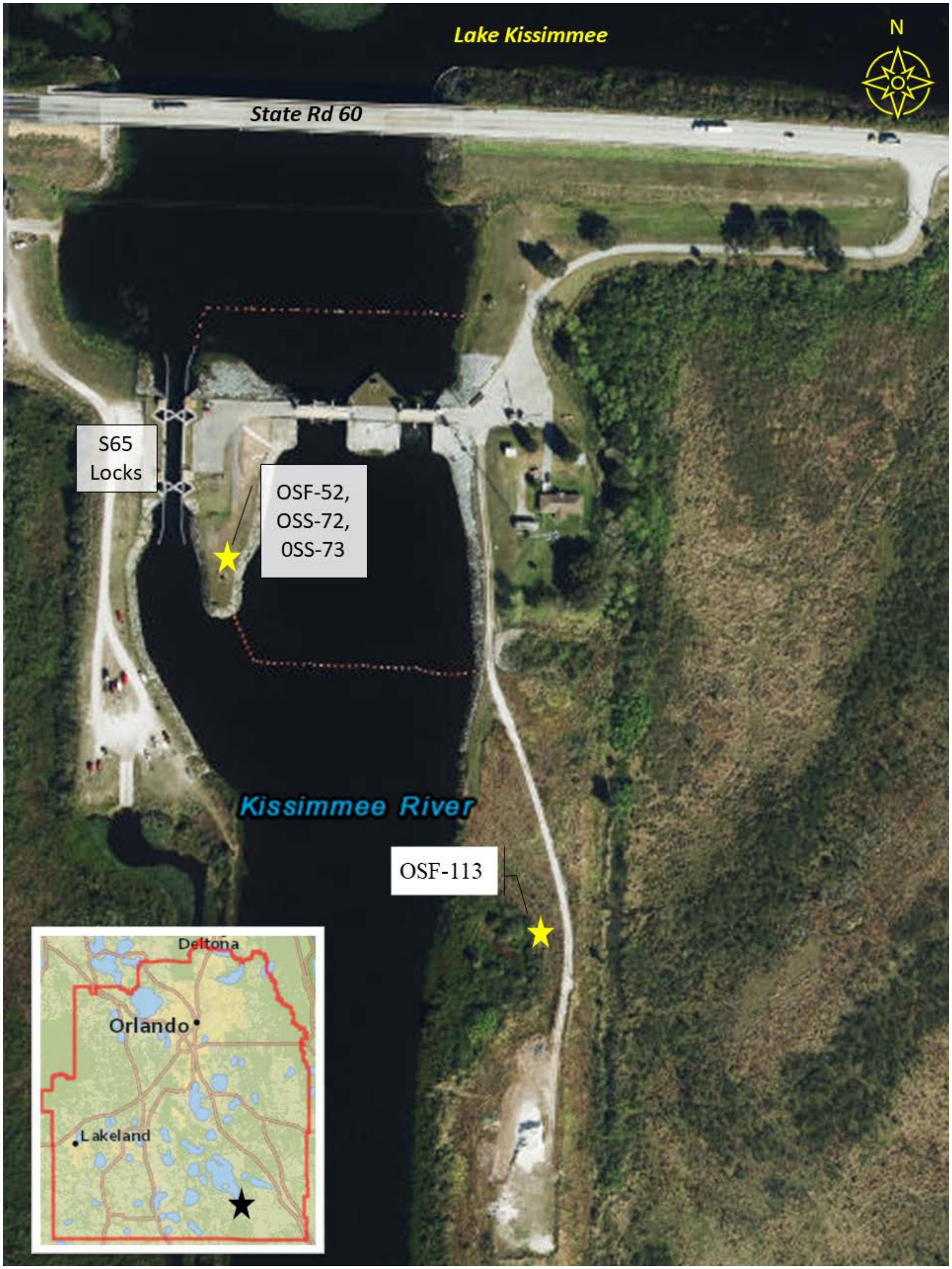

Figure 1. Location of OSF-113 and general location (inset) of the S65 Locks site within the Central Florida Water Initiative Planning Area (red boundary).

EXPLORATORY CORING AND WELL CONSTRUCTION

The SFWMD contracted with Huss Drilling, Inc. for exploratory coring, packer testing, and monitor well construction services in August 2017 (CN#4600003906-WO01). Huss mobilized a Failing 1500 Hole Master drilling rig to the S65 Locks site in January 2019 and commenced construction of exploratory well OSF-113. At a depth of 1,420 ft bls, the Failing 1500 was replaced by a Versa Drill 2000 drilling rig for deeper coring and reverse-air drilling capability.

The borehole was sampled using the ASTM D-1586-99 continuous split-barrel standard penetration test (SPT) method to a depth of 84 ft bls, near the base of the SAS. At this point, a temporary 6-inch casing was deployed in the borehole, and the rig was reconfigured for mud-rotary drilling.

A nominal 6-inch diameter pilot hole was advanced via mud-rotary drilling from the base of the temporary casing to a depth of 250 ft bls. Advanced Borehole Services ran geophysical logs (caliper, gamma, normal resistivity, and sonic porosity) on the mudded pilot hole. These were used in conjunction with the rock cuttings to verify the base of the SAS, identify correlation offsets from OSF-52, and locate a suitable casing seat for the 10-inch diameter conductor casing to prevent influx of unconsolidated material from the intermediate confining unit (ICU) during coring operations.

The temporary casing was removed, and the 20-inch diameter borehole was reamed to 81 ft bls for installation of a 16-inch steel surface casing. From 81 to 235 ft bls, the borehole was reamed to a nominal 15 inches, and a 10-inch Schedule 40 polyvinyl chloride (PVC) conductor casing was installed in the borehole and grouted to land surface. The cement plug was cleared from the borehole, and the rig was configured for coring operations.

From February 5 to June 24, 2019, a nominal 4-inch hole was advanced using wire-line core drilling in 10-ft increments to a total depth of 2,000 ft bls. The core barrel, equipped with a Boart Longyear HQ series bit, yielded 2.5-inch diameter rock cores. Fifty-eight single (off-bottom) packer tests were conducted during coring operations at 30-ft intervals. Geophysical logs (caliper, gamma, normal resistivity, fluid temperature/conductivity, down-hole video, and optical borehole imaging [OBI]) were run at multiple points during drilling operations. Based on the log and testing results, the top of the LFA-upper was identified at 1,452 ft bls and selected as the final casing depth for the well. The well was backfilled from total depth to 1,580 ft bls with a combination of neat cement and 4% bentonite grout to seal off the final monitor interval from more saline waters within the deeper portions of the LFA. Gravel was used in places to bridge more productive zones within the backfilled interval.

The interval from the top of the conductor casing to the top of the LFA-upper was reamed to a nominal 10 inches via reverse-air rotary drilling. Nominal 4.5-inch diameter Red Box 1500 fiberglass-reinforced plastic final tubing was hung in the borehole to a depth of 1,450 ft bls and grouted to 72 ft bls using cement baskets. After the grout hardened, the first two (uncemented) sticks of fiberglass-reinforced plastic tubing were backed off to provide a larger diameter for ease of pump access during regular water quality sampling. An as-built construction diagram for OSF-113 is provided in **Figure 2**. The completed well was developed until produced water was visibly free of turbidity, and pH and specific conductance were within the range determined during open borehole testing.

A complete timeline of well construction is provided in **Appendix A**. Well construction permits and completion reports are provided in **Appendix B**.

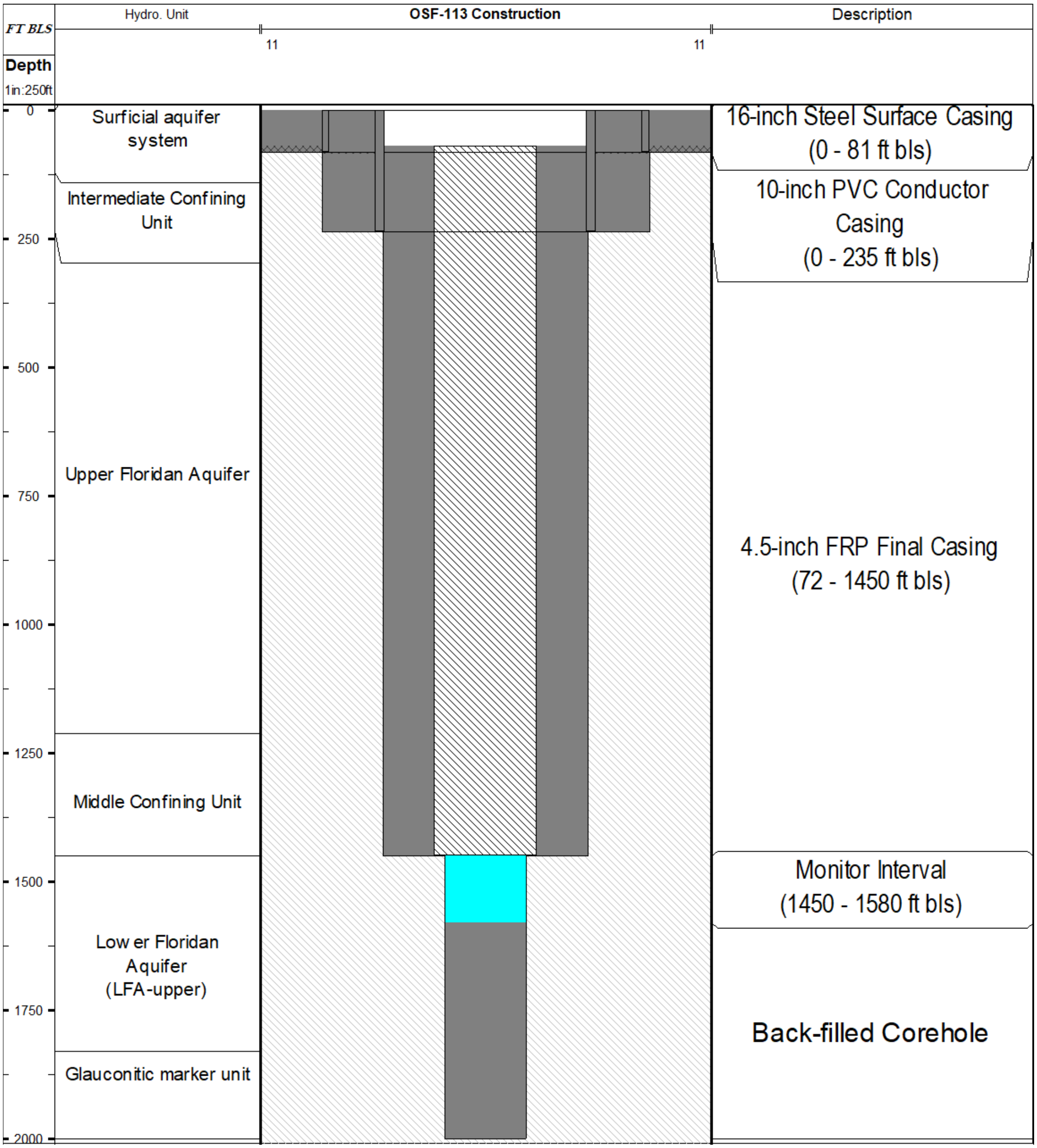

Figure 2. As-built construction diagram for monitor well OSF-113.

The completed wells were surveyed by SFWMD surveyors in September 2019 to provide precise locations and vertical references for depth-to-water (DTW) measuring points. **Figure 3** shows the reference location of surveyed measuring point elevations and the metadata for the completed monitor well.

Figure 3. Completed OSF-113 wellhead, showing surveyed horizontal and vertical positions and measuring point (reference) location for depth-to-water measurements.

STRATIGRAPHIC FRAMEWORK

The SFWMD collected geologic formation samples during pilot-hole drilling of OSF-113 and described the samples based on the dominant lithologic, textural, and porosity characteristics. Sampling methodologies included 2-ft SPT sampling at 5-ft intervals from surface to 84 ft bls, drill cuttings collection at 5-ft intervals during rotary drilling to 250 ft bls and wire-line core samples from 250 to 2,000 ft bls. SFWMD geologists described the samples (**Appendix C**) using the Expanded Dunham (Embry and Klovan 1971) classification for carbonates. Geophysical logs, OBI, video, and laboratory analysis of core samples using x-ray diffraction (XRD) and thin-section analysis helped characterize the geologic formations encountered during drilling (**Table 1**).

Table 1. Summary of site stratigraphy.

Stratigraphic Unit	From Depth (ft bls)	To Depth (ft bls)
Undifferentiated Tertiary-Quaternary Sediment	0	49
Tamiami Formation	Absent	
Hawthorn Group: Peace River Formation	49	175
Hawthorn Group: Arcadia Formation	175	275
Suwannee Limestone	Absent	
Ocala Limestone	275	370
Avon Park Formation	370	1955
Oldsmar Formation	1955	Well Depth

ft bls = feet below land surface.

Holocene, Pleistocene, and Pliocene Series

Undifferentiated sediments of Holocene, Pleistocene, and/or Pliocene age occur from land surface to approximately 49 ft bls. These undifferentiated sediments consist primarily of brownish to light gray quartz sand with small amounts of phosphatic sands that grade to yellowish gray calcilutite with small amounts of phosphatic sands. At 49 ft bls, sediments shift to a silt and clay-dominated composition and feature higher amounts of phosphatic sands, signaling the start of Miocene-age Hawthorn sediments. The group of Tertiary-Quaternary sediments generally overlies the Tamiami Formation, but in Central Florida, it lies unconformably over the Hawthorn Group.

Tamiami Formation

The Tamiami Formation was not present at this location.

Miocene Series

The Hawthorn Group is heterogeneously composed of silt, clay, calcareous sand, quartz sand, phosphatic sand, shell, silts, limestone, and dolostone. The Hawthorn Group was first elevated to group status by Scott (1988) and features two distinct formations: the Peace River Formation, which features siliciclastic sediment; and the underlying Arcadia Formation, which features primarily carbonates.

Peace River and Arcadia Formations

The Peace River Formation at OSF-113 is first observed at 49 ft bls and consists primarily of olive gray silt with very fine sand, olive gray sandy clay, and olive gray silty sand. Throughout the formation, phosphatic sand is observed (approximately 10% of the sediment matrix), a feature indicative of the Hawthorn Group. The Peace River Formation is late Miocene to early Pliocene in age, and at the S65 Locks site, is hypothesized to have formed under shallow marine, deltaic to brackish waters (Bryan et al. 2011).

At 175 ft bls, a lithologic shift from unconsolidated sediment to friable limestone is observed, marking the beginning of the Arcadia Formation. The Arcadia Formation is upper Oligocene to middle Miocene in age and is hypothesized to have formed in a carbonate bank by southward-flowing longshore currents (Scott 1988). The Arcadia Formation at OSF-113 is predominantly olive to moderate gray, poorly indurated wackestone with low intercrystalline porosity. Secondary components include clayey sand, calcilutite, and phosphatic sand. Phosphatic sand (approximately 20% of the sediment matrix) is observed throughout the formation, a feature indicative of the Hawthorn Group. The base of the Arcadia Formation is placed at approximately 271 to 275 ft bls, which corresponds with a decrease in natural gamma ray peaks and a lithology change to the Ocala Limestone. The Arcadia Formation generally overlies the Suwannee Limestone, but in Central Florida, lies unconformably over the Ocala Limestone.

Oligocene Series

Suwannee Limestone

Suwannee Limestone was not present at this location.

Eocene Series

Ocala Limestone

Ocala Limestone is the youngest of three major Eocene-age rock formations found at OSF-113, hypothesized to have been deposited in inner- to middle-shelf depths over an open marine carbonate ramp (Bryan et al. 2013). Ocala Limestone is found at a depth of 275 ft bls, and the transition from the Miocene-age Arcadia Formation to Ocala Limestone is marked by a sharp decrease in the gamma ray logs due to the lack of phosphatic sand. Ocala Limestone primarily consists of friable, poorly to moderately indurated, very pale orange foraminiferal wackestone and packstone. These beds feature predominantly moderate to high intergranular and moldic porosity. The first occurrence of *Lepidocylina*, an index foraminifera fossil for Ocala Limestone, occurs at 280 ft bls.

Avon Park Formation

The Avon Park Formation is Middle Eocene in age and is the middle rock unit of the three major Eocene-age formations found at OSF-113. The Avon Park Formation is hypothesized to have formed in a peritidal to shallow, open marine setting (Bryan et al. 2013). The top of the Avon Park Formation was correlated with the first appearance of the index foraminifera fossil *Neolagnum* at 370 ft bls (Bryan et al. 2011). The transition from Ocala Limestone to the Avon Park Formation featured a shift from non-pelleted limestone to highly pelleted limestone.

From approximately 370 to 402 ft bls, the lithology alternates between very pale orange wackestone and packstone beds with moderate intergranular and moldic porosity and poor to moderate induration. This interval was pelletel and fossiliferous, including identification of foraminifera, bivalves, gastropods, and echinoids. At approximately 402 ft bls, there is a transition to more friable, very pale orange wackestone and packstone beds, with a marked decrease in moldic porosity. Foraminifera and gastropods were found in this interval. There was no recovery from 426 to 430 ft bls and from 436 to 440 ft bls, possibly reflecting the poor induration of the sequence. From 446 to 534 ft bls, the lithology consisted of alternating very pale orange, poor to moderately indurated wackestone and packstone beds, with thin grainstone beds towards the top of the interval. These beds featured moderately to highly visible intergranular and moldic porosity. Foraminifera and bivalves were found throughout the interval. There were approximately 31 ft of no recovery along this depth interval. From 544 to 596 ft bls, the lithology consists of alternating friable, poorly to moderately indurated, very pale orange wackestone and packstone beds with minor mudstone. This interval featured generally low to moderate intergranular porosity, with thin layers of good porosity mostly associated with fossil molds. No porosity was observed in the mudstone layers. Foraminifera and bivalves were identified in this interval. There were approximately 14 ft of no recovery throughout this depth interval.

From approximately 596 through 760 ft bls, the lithology predominantly consists of very pale orange, friable, poorly to moderately indurated wackestone, mudstone, and packstone with low to moderate intergranular, vuggy, and pinpoint porosity. No porosity was observed in the mudstone layers. Fossils were predominantly foraminifera with occasional bivalves. Calcareous dolostone interbeds are present from approximately 596 to 600 ft bls and 730 to 736 ft bls and consist of dark yellow orange to pale yellowish brown sediment, poor to moderate pinpoint and vuggy porosity, and good induration. Solution fractures observed on the OBI log from 610 to 613 ft bls correspond to an interval of no core recovery.

Lithology from approximately 760 to 869 ft bls consists predominantly of moderately indurated, very pale orange to grayish orange, foraminiferous wackestone to packstone, and low to moderate intergranular porosity. The section includes abundant intraclasts, pellets, and burrows. Identified foraminifera include *Numulities* from 780 to 808 ft bls, *Fabularia* from 787 to 852 ft bls, and miliolids from 821 to 850 ft bls. A cavity was identified in the OBI log from 755 to 757 ft bls, corresponding with an interval of no core recovery. Fractures were observed on the OBI log from 731 to 735 ft bls, and brecciation was observed from 771 to 790 ft bls and 871 to 880 ft bls. Multiple sets of bedding plane fractures were observed from 833 to 869 ft bls.

From 869 to 1,025 ft bls, the lithology consists of pale to dark yellow brown and grayish orange to dark yellow orange dolostone with interbedded very pale orange wackestone. The dolostone features good induration and low pinpoint porosity, and the wackestone features moderate induration and low intergranular porosity. Well-developed secondary porosity is observed from approximately 871 to 910 ft bls on the OBI log and core, including brecciation, solution-enhanced fractures, open fractures, and cavities.

The lithology from 1,025 to 1,447 ft bls is predominantly dolostone, moderately yellow brown to grayish orange in color with low to moderate pinpoint and vuggy porosity and good induration. The evaporitic mineral celestine was identified through XRD analysis of a core sample collected at 1,030.85 ft bls, at a weight percent of 50.6, although evaporite minerals were not visually identified in this section. A picture of the core containing celestine is presented in **Figure 4**. Celestine has been observed in the Avon Park Formation in cores collected from Hernando and De Soto counties. In those cores, celestine was present as fine sand-sized grains in the limestone and dolomite (McCartan et al. 1992). If celestine is present in similar form in OSF-113, it would explain why no celestine crystals were observed in hand samples. An increase in porosity is observed from 1,224 to 1,447 ft bls, an interval that consists of very pale orange dolostone generally in the form of wackestone with high intergranular porosity and occasional mudstone beds with little to no porosity. Relatively few fractured intervals other than bedding plane fractures were observed on the OBI log and core, with the exception of a highly fractured interval from approximately 1,094 to 1,219 ft bls, which includes brecciation, solution-enhanced fractures, and fracture swarms.

The interval from approximately 1,447 to 1,900 ft bls consists primarily of well-indurated dolostone, very pale orange to dark yellow brown in color, with moderate to high pinpoint, vuggy, and moldic porosity. Limestone interbeds are present up to approximately 60 ft in thickness, consisting of well indurated, very pale orange, foraminiferal wackestone to packstone, with low to high observable intergranular porosity. Well-developed secondary porosity was observed in the OBI log and core within the following intervals:

- 1,447 through 1,536 ft bls, consisting of brecciation, solution-enhanced fractures, and fracture swarms;
- 1,605 through 1,628 ft bls, consisting of a continuous interval of brecciation;
- 1,703 through 1,730 ft bls, consisting of a continuous interval of brecciation;
- Brecciated intervals 2 to 3 ft in thickness at 1,799, 1,837, and 1,849 ft bls;
- 1,869 through 1,887 ft bls, consisting of brecciation and fractures; and
- A brecciated zone from 1,896 through 1,898 ft bls.

Glauconite was identified in hand samples from 1,955 ft bls to total cored depth and verified by petrographic thin-section analysis from samples at 1,964.15 and 1977.45 ft bls (over 4% glauconite) and a sample at 1,990.80 ft bls (1% glauconite). Duncan et al. (1994) noted a distinctive signature in the natural gamma log associated with the presence of glauconite that occurs near the contact between the Avon Park Formation and the top of the Oldsmar Formation. Duncan et al. (1994) also noted the base of the Avon Park Formation in Central Florida is characterized with cherty dolostone, which was identified in OSF-113 cores from 1,900 to 1,930 ft bls. Based on the presence of these indicators and change in lithology from dolostone to limestone, the base of the Avon Park Formation was identified at a depth of approximately 1,955 ft bls.

Figure 4. Core interval (1,030 to 1,040 ft bls) containing celestine at OSF-113. Arrow marks sampled depth.

Oldsmar Formation

The Oldsmar Formation is the lowermost Eocene formation encountered. The formation was present from 1,955 ft bls to the total depth of the well (2,000 ft bls). The sediments that compose the Oldsmar Formation were deposited in a shallow, open to marginal marine environment (Miller 1986). In OSF-113, the formation consists of very pale orange foraminiferal wackestone and occasional packstone. Little primary porosity was observed in the core, as many pore spaces were visibly filled with evaporites. The rocks are well indurated overall.

HYDROGEOLOGIC FRAMEWORK

Two major aquifer systems underlie this site within the Quaternary/Tertiary sequence, the SAS and FAS. The FAS is the primary focus of this investigation. Aquifers within the FAS are composed of multiple discrete zones of moderate to high permeability, many characterized by karst solution and fracturing. These productive zones are separated by lower-permeability units of various degrees of confinement. The sub-units of the FAS are not consistently labeled in the literature. **Figure 5** presents a comparison of commonly used nomenclature.

	Miller (1986)	SWFWMD (Horstman 2011)		SJRWMD (Davis and Boniol 2011)		SFWMD (Reese and Richardson 2008)
Floridan Aquifer System	Upper Floridan Aquifer	Upper Floridan Aquifer	Suwanee Permeable Zone	Upper Floridan Aquifer	Upper Permeable Zone	Upper Floridan Aquifer
			Ocala Low-Permeability Zone		Ocala/Avon Park Low-Permeability Zone	Middle Confining/ Semi-Confining Unit 1
			Avon Park Permeable Zone		Avon Park Permeable Zone	Avon Park Permeable Zone
	Middle Confining Unit (I, II, or VI)	Middle Confining Unit (I, II, or VI)		Middle Confining Unit I		Middle Confining Unit 2
				Middle Confining Unit II		
	Lower Floridan Aquifer	Lower Floridan Aquifer (Below Middle Confining Unit I, II, or VI)		Lower Floridan Aquifer	Upper Permeable Zone	Lower Floridan Aquifer
					Confining Unit	
					Lower Permeable Zone	
					Boulder Zone	
					Fernandina Zone	
Sub-Floridan Confining Unit						

Figure 5. A nomenclature comparison of the hydrogeologic units of within the Floridan aquifer system.

To ensure consistency within the CFWI Planning Area, the cooperating water management districts agreed on a slightly modified hydrogeologic conceptualization (**Figure 6**) as the basis for development of the East Central Florida Transient Expanded (ECFTX) groundwater model, which is being used to evaluate groundwater availability in the region. As a component of the CFWI, this report will follow the same convention for the units intersected by the exploratory drilling. A representative hydrogeologic section, with hydrogeologic units conforming to the S65 Locks site, is presented in **Figure 7**.

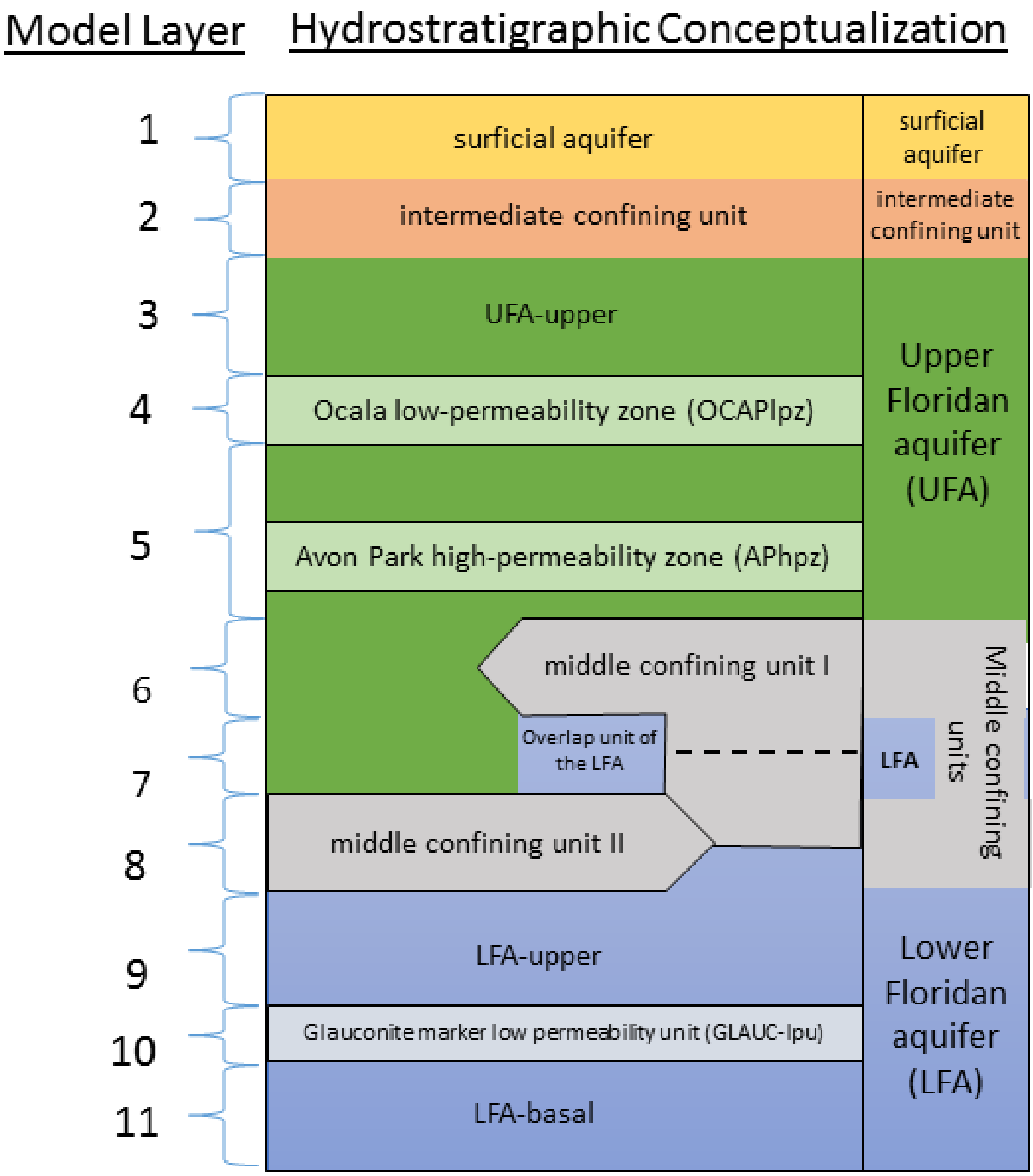

Figure 6. Hydrogeologic conceptualization and vertical discretization of the East Central Florida Transient Expanded (ECFTX) model (From: CFWI Hydrologic Assessment Team 2016).

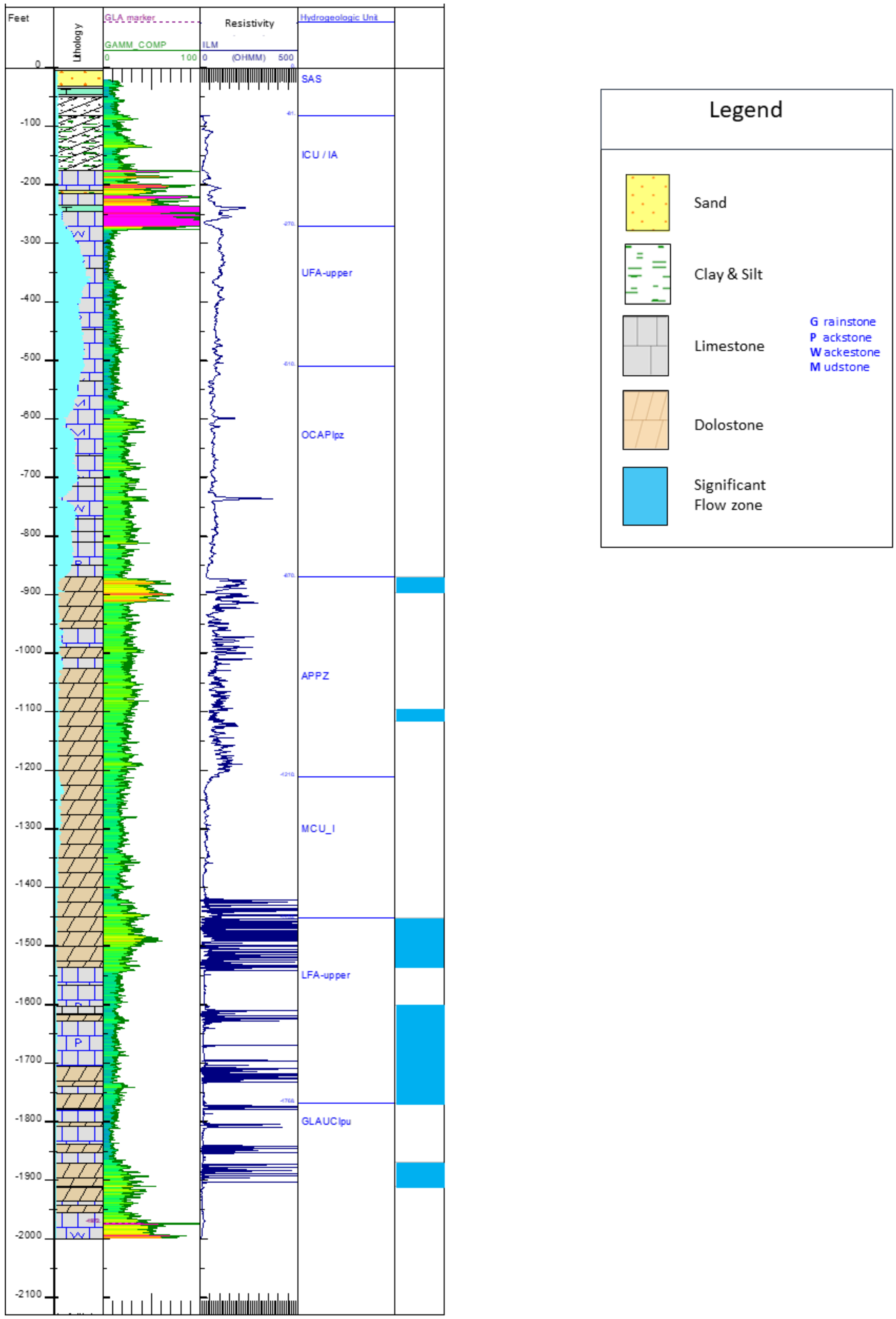

Figure 7. Representative hydrogeologic section for the S65 Locks site. Caliper log deviation from nominal bit diameter is overlain on the lithologic column.

Surficial Aquifer System (0 to 81 ft bls)

The SAS at the S65 Locks site consists of unconsolidated sediments, predominantly fine to very fine quartz sand with varying amounts of silt, clay, shell, and heavy minerals. The top of the Hawthorn Group often is selected as the base of the SAS, but lower permeability sediments frequently are found at much shallower depths, so the base of this unit is gradational. A base of 81 ft bls was selected based on sieve analysis results and persistent high silt and clay content in the samples below that point. A median hydraulic conductivity of 21 to 41 ft/day was estimated for this interval from sieve analysis results.

Intermediate Confining Unit (81 to 270 ft bls)

The ICU separates the SAS from the FAS. At the S65 Locks site, the ICU is highly heterogeneous. Silt is the dominant constituent, but a highly variable mix of olive-gray clay, fine quartz sand, phosphate, and shell fragments also is present. This unit was not expressly tested during drilling of OSF-113.

Floridan Aquifer System (270 ft bls to Total Depth)

The FAS consists of a series of Tertiary-age limestone and dolostone units. At the S65 Locks site, the FAS includes permeable sedimentary strata of the Hawthorn Group, Ocala Limestone, Avon Park Formation, and Oldsmar Formation. The base of the FAS occurs in the Paleocene Cedar Keys Formation, not penetrated at the S65 Locks site, which includes massive beds of gypsum and anhydrite (Miller 1986).

The hydrogeologic units within the FAS were delineated based on the exploratory coring, drilling, and geophysical logging of OSF-113; hydraulic and water quality analyses from 58 off-bottom packer tests conducted during coring of OSF-113 (summarized in **Figure 8**); and previously gathered lithologic, hydraulic, and geophysical log data from neighboring well OSF-52.

Upper Floridan Aquifer

The UFA generally occurs at the base of the Hawthorn Group, though it may include permeable units within the lower Arcadia Formation. It includes the Suwanee Limestone, where present; the Ocala Limestone; and portions of the Avon Park Formation. The UFA generally consists of several thin, highly permeable water-bearing zones interbedded with thicker zones of lower permeability. The CFWI Hydrologic Assessment Team (2016) used three regionally mappable units to represent the vertical heterogeneity of the UFA: UFA-upper, Ocala-Avon Park low-permeability zone (OCAPlpz), and Avon Park high-permeability zone (APhpz).

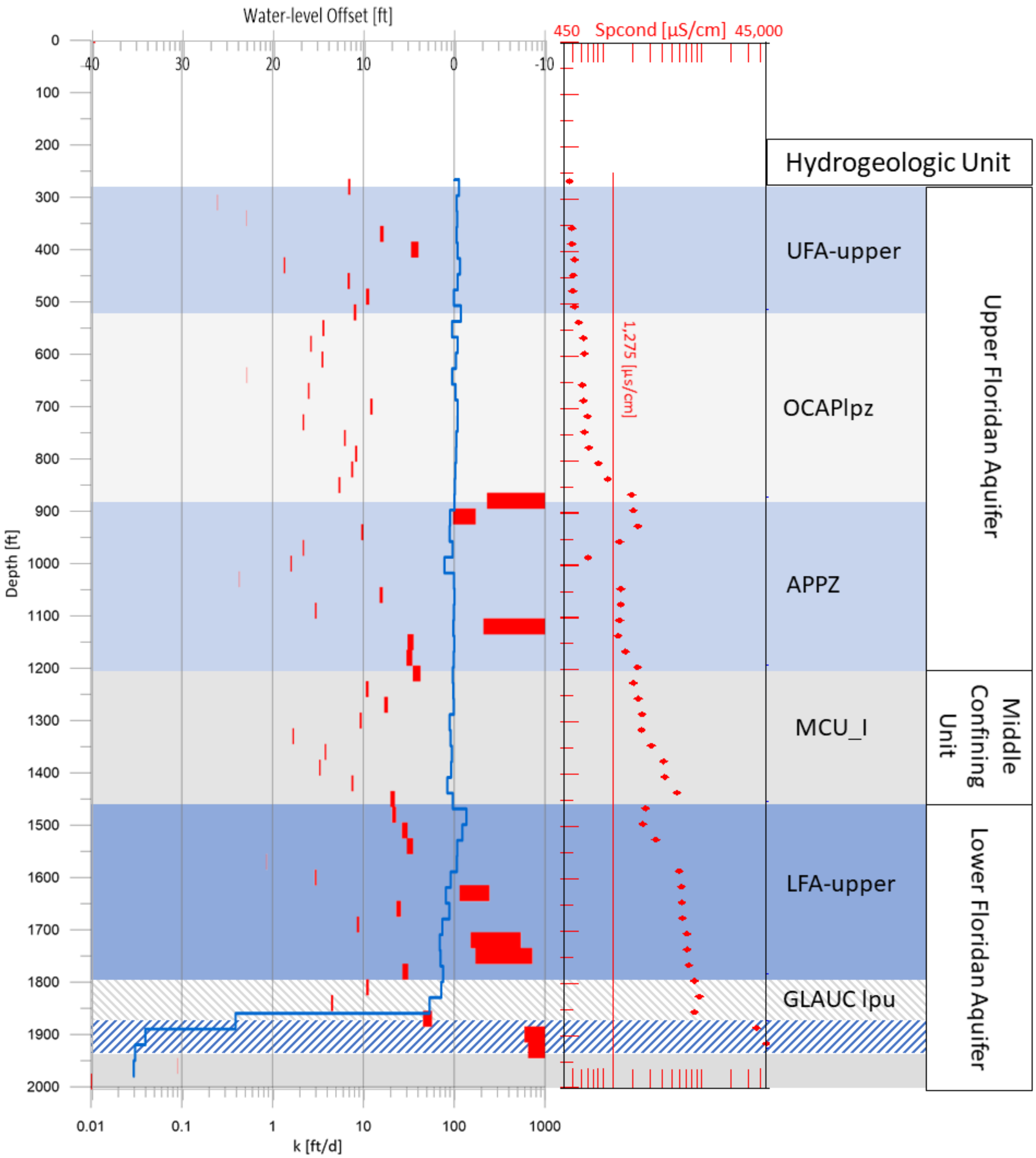

Figure 8. Variation in specific conductance (SpCond), water level offset (blue line), and hydraulic conductivity (k) with depth, from off-bottom packer testing in exploratory corehole OSF-113.

* Width of red bars in the hydraulic conductivity plot indicates range of uncertainty in the calculated value.

** Water level offset = Reference well (POF-23) water level minus packer test water level.

UFA-upper (270 to 510 ft bls)

The UFA-upper is the uppermost permeable zone of the FAS. It is predominantly limestone and characterized by intergranular, vuggy, or moldic porosity and well-developed secondary porosity (Davis and Boniol 2011). The CFWI Hydrologic Assessment Team (2016) identified the top of the UFA-upper in OSF-52 at a depth of 270 ft bls, the first occurrence of consolidated limestone below the clayey sands of the Hawthorn Group. At the S65 Locks site, the UFA-upper consists of poor to moderately consolidated limestone, predominantly wackestone-packstone. A solutioned flow zone often is observed at its upper boundary, the contact between the Hawthorn Group and Ocala Limestone. Some dissolution is visible in the OBI log at the contact in OSF-113, but it does not appear to be a significant producing zone in this location. Nine packer tests were conducted within the UFA-upper, yielding hydraulic conductivity values ranging from 0.25 to 34 ft/day. Water quality from this interval is the freshest in the corehole, with total dissolved solids (TDS) concentrations less than 350 milligrams per liter (mg/L).

The UFA-upper is highly productive in the northern portion of the CFWI Planning Area, but productivity tends to decline to the south. Reported transmissivity of the UFA-upper typically ranges from less than 10,000 to more than 100,000 ft^2/day in Central Florida (CFWI Hydrologic Assessment Team 2016). A full aquifer performance test was not conducted on this interval, but based on the packer test results, transmissivity at this site is expected to fall within the low end of the reported regional range, approximately 2,500 ft^2/day.

OCAPlpz (510 to 870 ft bls)

The OCAPlpz is distinguished from the UFA-upper by a reduction in secondary permeability. The lithology is similar to the UFA-upper, distinguished primarily by the presence of interbedded mudstone, wackestone, and packstone. Both units are largely poorly consolidated, indicated by large wash-outs on the caliper log (**Figure 7**). Based on packer test results, the OCAPlpz is of persistently lower permeability than the UFA-upper. Packer tests 10 to 19 fall wholly within the OCAPlpz unit, and these yielded hydraulic conductivity estimates of 0.5 to 12 ft/day. There is a gradual increase in TDS concentration across the OCAPlpz, from 350 to 628 mg/L, slightly more mineralized than the UFA-upper, possibly reflecting a longer formation residence time.

APhpz (870 to 896 and 1,092 to 1,115 ft bls)/APPZ (870 to 1,210 ft bls)

Reese and Richardson (2008) described the APPZ as a regionally mappable, high-permeability zone within the Avon Park Formation, characterized by dolostone or interbedded dolostone and dolomitic limestone with a high degree of secondary permeability. The permeability primarily is associated with fracturing, but cavernous or karstic, intergranular, and inter-crystalline permeability also can be present. As mapped by Reese and Richardson (2008), the APPZ included all materials from the base of the OCAPlpz to the top of the middle confining unit (MCU). The CFWI Hydrologic Assessment Team (2016) adopted the term Avon Park high-permeability zone (APhpz) to distinguish the most productive fractured intervals. Referring to **Figure 6**, the APPZ is equivalent to ECFTX model layer 5, and the APhpz is a subset of that unit.

At the S65 Locks site, the APPZ is composed of hard microcrystalline dolostone, interbedded with lesser amounts of limestone wackestone from 970 to 1,025 ft bls. On the geophysical logs, the APPZ lies within very high formation resistivity and extreme variability in sonic porosity. The upper boundary is at 870 ft bls (the first occurrence of fracture flow). Permeability in this unit is primarily through fracture flow, but between fracture sets, pinpoint vugs and bedding plane solutioning also contribute to productivity. In OSF-113, there is an increase in TDS concentration at the OCAPlpz/APPZ boundary, from 628 to 1,050 mg/L, and a shift from calcium bicarbonate ($CaHCO_3$) dominant to sodium chloride (NaCl) dominant composition.

The APhpz consists of two discrete fractured zones at 870 to 896 ft bls (APhpz-1) and 1,092 to 1,115 ft bls (APhpz-2). Estimated hydraulic conductivity (k) within the two fracture sets ranges from 100 to more than 1,000 ft/day. The uncertainty is largely due to the minimal amount of drawdown producible when testing high-permeability rock within a very small borehole. Estimated k outside of these fractured zones ranged from 0.4 to 35 ft/day. Using the mean estimate for k for the fractured intervals, a bulk transmissivity for the APPZ of 20,000 ft^2/day is calculated from the packer test data, with 50% derived from the APhpz-1, 32% derived from APhpz-2, and the remaining productivity derived from the area between the two sets and below APhpz-2. Using the high end of estimated k for the fractured intervals would put transmissivity for the APPZ in the range of 70,000 ft^2/day.

The degree of hydraulic connection between fracture sets in the APPZ is a subject of some interest and debate within the CFWI region. Some exploratory sites within the SFWMD have shown strong evidence for hydraulic connection between fracture sets, while other data have been more ambiguous. At OSF-113, there is some evidence for confinement between APhpz-1 and APhpz-2. The water levels during packer testing were not notably different, but the water chemistry in each fractured zone was distinctive. Both zones are in the transition phase between fresh and saline water, but contrary to expectation, the deeper zone (APhpz-2) contains fresher water than the shallow zone. APhpz-2 is connate water dominant and APhpz-1 is transitional seawater. Because fresher water is deeper, chloride migration into the shallow zone must have been from lateral seawater intrusion. If there were good hydraulic connection between the two fracture sets at this location, higher salinity water would be expected in APhpz-2 as well. The maximum permeability in each zone is similar, so APhpz-2 likely is less regionally extensive, not extending as far eastward as APhpz-1.

Middle Confining Unit

The MCU divides the UFA and LFA. Miller (1986) defined the MCU and subdivided it into eight regional units designated by roman numerals I to VIII. The CFWI Hydrologic Assessment Team (2016) recognized two of these units (MCU_I and MCU_II) as composing the MCU within the ECFTX model domain. MCU_I, which ranges in lithology from dolostone to micritic limestone, is the leakier of the two units. The lithologic composition of MCU_II is more distinct. MCU_II is composed of hard crystalline dolostone to dolomitic limestone, characterized by the occurrence of evaporites as beds or pore in-fillings, which greatly reduces its permeability. MCU_I, the shallower unit, is absent from the western portion of the ECFTX model domain, while MCU_II is absent from the eastern portion. Along the western reaches of the Kissimmee River valley and Lake Wales Ridge, the two units overlap each other, greatly increasing the thickness of the MCU in that region. MCU_II was not encountered at the S65 Locks site.

MCU_I (1,210 to 1,450 ft bls)

Like the APPZ, MCU_I unit at the S65 Locks site is composed almost entirely of dolostone. In comparison to the APPZ, the formation rock of MCU_I is primarily granular in texture. It tends to be more poorly indurated, as seen in the caliper and resistivity logs (**Figure 6**), and higher in porosity, but lacks significant fracturing or vuggy permeability.

Seven packer tests (33 through 39) were completed entirely within MCU_I. These yielded k estimates ranging from 1.7 to 17 ft/day and an average of 8 ft/day. Those are relatively high values for a confining unit, but somewhat misleading due to the degree of heterogeneity in the MCU_I. The packer test results represent horizontal k over 30-ft intervals, which can be easily skewed by a single bedding plane solution feature. Matrix permeability within MCU_I is very low. Five rock core samples from the lower half of the unit (1,336 to 1,440 ft bls) had an average porosity of 30%, but all yielded vertical permeabilities of less than 0.1 ft/day. As seen in **Figure 8**, there is a gradual increase in salinity across MCU_I (1,171 to 3,155 mg/L TDS) and a commensurate decreasing trend in water level. The base of MCU_I in OSF-113 is marked by a reversal in both of these trends.

Lower Floridan Aquifer

The LFA consists of a sequence of permeable zones separated by lower-permeability units. One or two of these permeable zones, such as the Boulder zone of south and east-central Florida, are regionally mapped units. In most cases, however, the availability and distribution of deep well data are not sufficient to establish the continuity of permeable zones between wells. Literature values show the LFA to be more than 1,000 ft thick within the CFWI area. This thickness includes highly productive zones and inter-aquifer confining units as well as salinities ranging from fresh to seawater. Discretizing this thickness into less hydraulically diverse subdivisions was one of the objectives of the ECFTX model.

For the ECFTX model, the LFA was subdivided into upper (LFA-upper) and basal (LFA-basal) permeable zones separated by the regionally mappable GLAUClpu (CFWI Hydrologic Assessment Team 2016). The exploratory corehole at the S65 Locks site was terminated within the GLAUClpu.

LFA-upper (1,452 to 1,768 ft bls)

The top of the LFA was identified at 1,452 ft bls, in conjunction with an increase in secondary permeability and notable changes in water chemistry and water level. Water levels in packer test 41 (1,450 to 1,480 ft bls) increased by 1.5 ft over the last MCU_I packer test, and TDS concentration decreased from 3,145 to 1,461 mg/L, a pattern that has been observed at multiple sites in eastern Osceola County. Productivity in the LFA-upper at the S65 Locks site is characterized by multiple, fairly discrete zones of fractured or highly vuggy rock within very low-permeability dolostone. Three significant productive zones were identified from the packer test data. To facilitate discussion, these zones are numbered sequentially from shallow to deep: LF1 (1,452 to 1,536 ft bls), LF2 (1,600 to 1,768 ft bls), and LF3 (1,868 to 1,911 ft bls).

Following ECFTX model mapping protocol (CFWI Hydrologic Assessment Team 2016), the base of the LFA-upper should coincide with the base of the last productive zone above the natural gamma log marker for the GLAUClpu. In OSF-113, a glauconitic horizon was identified from 1,955 to 1,990 ft bls, and the most easily correlated point in the gamma signature was found at 1,972 ft bls. By definition then, the base of the LFA-upper should be placed at 1,911 ft bls, at the base of LF3. Unfortunately, the ECFTX model protocol proved problematic at this site.

The 100 ft of rock between the base of LF2 and the top of LF3 is illustrative of the dichotomy between bulk horizontal k (packer test result) and the effective vertical k in a highly heterogeneous system. The horizontal k from packer tests in this interval did not fall below 4 ft per day, but between packer test 51 (base of LF2) and test 55 (top of LF3), there is a head drop of more than 20 ft, indicating excellent vertical confinement between these two productive zones. Likewise, the TDS concentration jumped from 4,400 to more than 17,000 mg/L. In other words, the base of the underground source of drinking water lies between LF2 and LF3. It is clear then that LF3 cannot be part of the same hydraulic unit as the overlying producing zones, so the base of the LFA-upper was placed at the bottom of LF2 (1,768 ft bls).

Estimated permeability from packer tests falling entirely within the LFA-upper (tests 41 to 51) ranged from 0.86 to 172 ft/day. Using the mean estimate for k for the fractured intervals, a bulk transmissivity for the LFA-upper of 50,000 ft^2/day was estimated from the packer test data, with approximately 5% derived from the LF1 and the remainder from LF2. There is inter-aquifer confinement between the two producing zones. LF1 is relatively freshwater (TDS less than 2,000 mg/L), but TDS steadily increase to a high of 4,400 mg/L at the base of LF2, with a commensurate density induced drop in water level. Based on the distribution of salinity and productivity from each packer test, a bulk TDS concentration of 3,920 mg/L was estimated for the LFA-upper. Fracturing is pervasive in both producing zones, but less well developed than in the APhpz horizons.

GLAUClpu (1,768 to Total Depth)

As previously discussed, the top of the GLAUClpu coincides with the top of the strong vertical confinement between LF2 and LF3. The base of the GLAUClpu was below the depth of investigation and could not be determined from the corehole information. The upper portion of this unit (1,768 to 1,868 ft bls) forms the confining unit between LF2 and LF3, which was discussed in the previous section. The base of this unit (1,911 to 2,000 ft bls) consists of microcrystalline dolostone with chert or evaporite filled vugs and dense glauconitic limestone wackestone-mudstone. This interval is represented by packer tests 57 and 58, which yielded the lowest permeability in the borehole, 0.09 and 0.005 ft/day, respectively. Sandwiched between these very low-permeability rocks is LF3 (1,868 to 1,911 ft bls).

Permeability within LF3 is derived from fractures and large vugs. Packer tests 55 and 56, which fall entirely within this interval, yielded the highest permeability estimates in the borehole, 597 and 656 ft/day, respectively. At the base of LF3, water levels were 8.5 ft NGVD29, more than 30 ft lower than the average level in the LFA-upper, and TDS concentrations were almost 24,000 mg/L. Both ion and stable isotope composition were indicative of relict seawater. These imply that this producing zone is laterally extensive eastward towards the coast or, at some distance away from OSF-113, is connected vertically with deeper zones. Examination of SFWMD test wells to the north (POF-28; approximately 16 miles away) and south (OSF-104; approximately 11 miles away) did not indicate a significant producing zone in the position of LF3, so it is assumed at this time to be of limited extent in the interior of the CFWI area.

DISCUSSION

Exploratory drilling and coring at this site reached a maximum depth of 2,000 ft bls. Work at the S65 Locks site was completed in August 2019 and included:

- Exploratory wire-line coring, geophysical logging, hydraulic testing, and water quality sampling for the purpose of:
  - identifying hydrogeologic unit boundaries, and
  - evaluating variations in water quality and rock permeability with depth; and
- Completion of the exploratory corehole as a permanent LFA-upper monitor well (OSF-113).

As a component of the CFWI DMIT project, it is important to review the results from the S65 Locks site in light of their potential impact to the understanding of the hydrogeologic framework as applied in the ECFTX groundwater model. Differences between interpreted hydrogeologic unit boundaries pre- and post-project are summarized in **Table 2**.

Predicted hydrogeologic unit boundaries are in reasonable proximity to those identified in the exploratory corehole. From the top of the ICU to the top of the LFA, unit boundaries in OSF-113 were within 50 ft of those estimated by interpolation from distant wells. The base of the LFA-upper/top of GLAUClpu is a notable exception.

A major advantage of the GLAUClpu over other sub-units of the FAS is that the criteria for identifying it are clearly defined and easily applied within the CFWI region. For the ECFTX model (CFWI Hydrologic Assessment Team 2016), the LFA was subdivided into upper (LFA-upper) and basal (LFA-basal) permeable zones. Following ECFTX model mapping protocol, the base of the LFA-upper should coincide with the base of the last productive zone above the natural gamma log marker for the GLAUClpu. Duncan et al. (1994) first noted a distinctive gamma log signature from an interbedded series of wackestone and dolostone near the top of the Oldsmar Formation. Duncan et al. (1994) associated the gamma signature with the presence of glauconite, clay, and collophane accessory minerals within that rock assemblage, and correlated the wells across the Brevard and Indian River study area. Duncan et al. (1994) referred to the gamma signature as the glauconitic marker, and the term continues to be used although the marker is identifiable in numerous wells where no glauconite was observed. Starting with the wells in Duncan et al. (1994), Reese and Richardson (2008) identified single points of correlation on the natural gamma-ray logs within the GLAUClpu. By correlation of these points on the gamma-ray signature from well to well, they mapped a glauconitic marker horizon, extending throughout Central Florida and the southeastern coast of Florida. The CFWI Hydrologic Assessment Team (2016) used the glauconitic marker horizon points from Reese and Richardson (2008) and extended the correlation to include deep wells drilled in the CFWI area after completion of that report data set.

Table 2. Hydrostratigraphic comparison at the S65 Locks site, current report versus ECFTX model layering (From: CFWI Hydrologic Assessment Team 2016).

Hydrogeologic Unit	Current Report			ECFTX Model		
	Top	Base	Thickness (feet)	Top	Base	Thickness (feet)
ICU	81	270	189	70	240	170
UFA-upper	270	510	240	240	510	270
OCAPlpz	510	870	360	510	852*	342
APPZ	870	1,210	340	852*	1,198*	346
MCU_I	1,210	1,450	240	1,198*	1,400*	202
MCU_II	*Absent*		0	*Absent*		0
LFA-upper	1,450	1,768	318	1,400*	1,830*	430
GLAUClpu	1,768	No Data	No Data	1,830*	2,116*	286

APPZ = Avon Park permeable zone; ECFTX = East Central Floridan Transient Expanded; GLAUClpu = low-permeability glauconitic marker unit; ICU = intermediate confining unit; LFA = Lower Floridan aquifer; MCU = middle confining unit; OCAPlpz = Ocala-Avon Park low-permeability zone; UFA = Upper Floridan aquifer.
Note: Top and Base values are presented in feet below land surface.
* Unit boundary interpolated from surfaces identified in deeper wells located offsite.

In OSF-113, the glauconitic marker horizon correlation point for the gamma log marker was identified at 1,972 ft bls (**Figure 7**). Like the wells in the Duncan et al. (1994) study area, the marker horizon at OSF-113 is within the interbedded series of low-permeability dolostone and limestone (mudstone/wackestone). Trace amounts of glauconite were identified in hand samples from 1,955 to 1,990 ft bls and confirmed by thin-section petrographic analysis at two points within that interval. Packer tests 57 and 58 (1,930 to 1,990 ft bls) yielded the lowest permeability in the borehole, less than 0.1 ft/day. By definition, the base of the LFA-upper should be placed at the base of the first significant producing zone above the marker horizon, 1,911 ft bls.

Based on packer testing results, three producing zones (LF1, LF2, and LF3) separated by less permeable materials were identified above the glauconitic marker horizon in OSF-113. The regional mapping protocol requires all three producing zones be included in the LFA-upper. The site data showed there is more than 20 ft of head drop between LF2 and LF3 and a major difference in water chemistry; however, hydrologic principle, dictates that those producing zones cannot all be in the same aquifer unit. Therefore, at OSF-113, there was a conflict between local observed data and regional mapping protocol. In many places, the changes that occur between two vertically stacked producing zones are subtle, and sometimes difficult to measure. The discrepancy between LF2 and LF3, however, is both obvious and extreme. Consequently, the local data must take precedence over the regional mapping criteria in this instance. Given the lateral extent of LF3 away from OSF-113 is not known, but can be definitively shown from the site data as hydraulically disconnected from the overlying producing zones, it is assumed that LF3 is a local productive zone within the GLAUClpu, and that assumption is reflected in **Table 2**.

In peninsular Florida, there is an overall trend for salinity to increase with depth, distance southward from recharge areas, and proximity to the coast. Several deviations from the tendency for salinity to increase with depth are documented in the *Water Quality and Inorganic Chemistry* section later in this report. Examining the data from OSF-113 relative to other wells in the region highlights some unusual features in the water chemistry at this location.

In OSF-113, water quality results from packer tests in the UFA-upper and LFA-upper yielded salinity concentrations consistent with regional trends, but results from the APPZ were anomalously saline. **Figure 9** shows chloride concentration and specific conductance from OSF-113 compared to equivalent SFWMD monitor wells to the north (POF-27L) and south (OSF-104M), and packer test results from a St. Johns River Water Management District exploratory corehole to the east (OS0261). Because the APPZ is highly productive, water quality samples from monitor wells completed within that unit tend to pull from the uppermost producing zone. The low pumping rates used for water quality sampling are not sufficient to stress very deeply into the aquifer, so data from APhpz-1 is displayed for equivalent comparison. The deeper fracture set is somewhat fresher (chloride concentration 264 mg/L and specific conductance 1,469 microsiemens per centimeter), but still deviating from the expected norm.

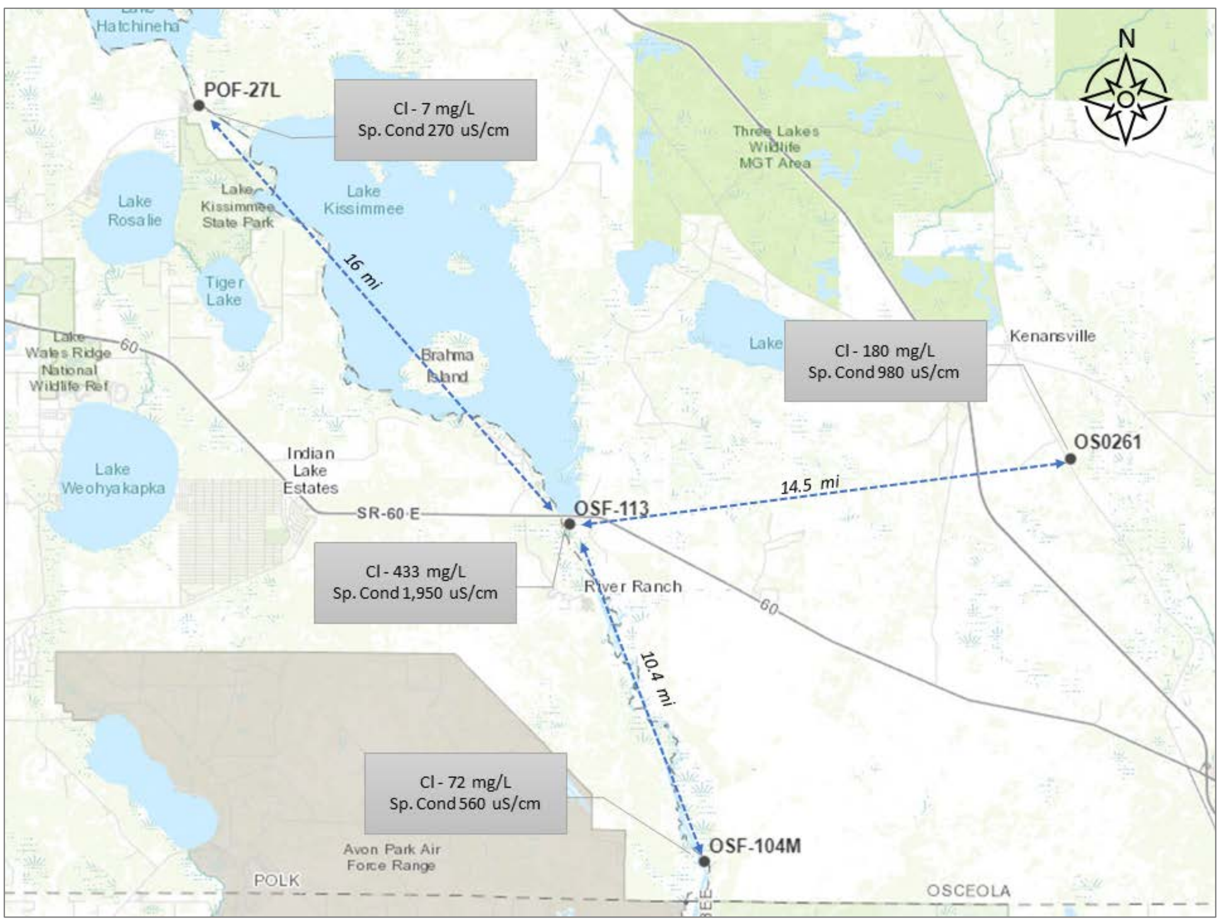

Figure 9. Comparative water chemistry at the top of the Avon Park permeable zone around OSF-113.

Chloride concentrations at OSF-113 were expected to be between those at POF-27L and OSF-104M and be considerably lower than OS0261. However, salinity at the top of the APPZ in OSF-113 was more than double that of the other three wells. The reason behind this anomaly is unknown.

Introduction of saline water into the APPZ at OSF-113 during the drilling process is not a realistic possibility. Only fresh formation water was encountered above the APPZ depths, and drilling makeup water was sourced from an adjacent SAS well, which also was fresh water. If contamination occurred via that path, it would bias salinity lower rather than higher. Because the APPZ is characterized by fracture flow conditions, it is possible that vertical fracturing connected the corehole to deeper, more saline portions of the aquifer. There is an upward head gradient from the top of the LFA that could provide the force for such a vertical migration. There was no evidence of a vertical fracture in OSF-113, but it could have occurred upgradient in the APPZ. This explanation, however, means the deeper fracture set (APhpz-2) should be more saline than APhpz-1, which is not the case. An alternate possibility is that the APPZ at OSF-113 is not anomalously saline, but rather its neighboring monitor wells to the south and east are anomalously fresh.

The APPZ in OSF-113 is not extensively fractured. It is characterized by two small fractured intervals separated by less permeable rock, with a bulk transmissivity in the 20,000 to 70,000 ft^2/day range. The APPZ near OSF-104 is one of the most highly fractured sites within the SFWMD, With measured transmissivity exceeding 400,000 ft^2/day. Because the permeability in the OSF-104 region is so much greater, it is possible that much greater volumes of fresh water from recharge areas in the Polk Highlands are reaching that area than are at OSF-113. Closer to the source of recharge, OSF-113 would be conceptually equivalent to a backwater in a river. Planned DMIT exploratory sites at SUMICA to the west and Yeehaw Junction to the east of OSF-113 should provide additional information.

An additional feature of the water chemistry at OSF-113 that merits discussion is the magnitude and distribution of strontium ions (Sr^{2+}). Strontium generally is not considered a major constituent of natural groundwater, but it does occur in trace amounts in most areas. Hem (1985) reported the median concentration of strontium in U.S. drinking water as 0.1 mg/L and used 1.0 mg/L as the division between minor and major ionic constituents. Because it is not considered a major constituent, strontium often is omitted from analysis in many sampling programs. Sprinkle (1989) reported a median strontium concentration within the upper FAS of 0.4 mg/L, but more than 25% of samples exceeded 5 mg/L. The median strontium concentration in OSF-113 was 12.7 mg/L, and all samples exceeded 3 mg/L. For comparison, a cursory review was conducted of all unflagged groundwater analyses of strontium available in the SFWMD's DBHYDRO database. The samples ranged from zero (below detection limit) to 67.65 mg/L, with a median of 2.13 mg/L. Of the highest 10 values in DBHYDRO, 7 were from OSF-113. That is a notable distinction, but it is also notable that by Hem's (1985) definition, strontium is a major ionic constituent in most South Florida groundwater. Omitting it from baseline sampling programs could lead to undesirable levels of ion-balance error.

SITE DATA

Multiple classes of data were collected and analyzed to derive the stratigraphic and hydrogeologic frameworks for the S65 Locks site. Lithologic samples were collected using SPT, mud-rotary, and wire-line coring methods, then described and analyzed. Single (off-bottom) packer testing yielded hydraulic water quality and level information. The following sections summarize the methods and results yielded by each type of data collection and analysis effort.

Standard Penetration Testing

SPT was conducted on non-lithified sediment at OSF-113 from 4 to 86 ft bls. Samples were collected in 2-ft increments with a 5-ft interval between each sample. SPT procedure provides penetration resistance of the soil and a representative soil sample for hydraulic conductivity calculations. Each sample was collected after removal of excess cuttings within the borehole.

Methodology

Following ASTM D1586 (2018) SPT standards, a 140-pound hammer was affixed to a split-spoon sampler and dropped 30 inches to measure penetration resistance of the soil down to a 2-ft interval and fill the sampler. Each strike from the hammer is a "blow" (N), and the number of blows required to move the sampler 25% of the total interval (6 inches) is a blow count (N_1, N_2, N_3, N_4). Representative N-values (N_2+N_3) were calculated for each 2-ft interval. N_1 and N_4 are disturbed by the drilling process so they were not used for N-value calculations. N-values positively correlate with penetration resistance. Overburden pressures have not been accounted for in this investigation for N counts. Split-spoon samples were extracted and examined by an on-site geologist for lithologic description. After examination, samples were bagged and transported to the SFWMD warehouse.

In accordance with ASTM C136 (2018) for mechanical sieve analysis, the interior 12 inches of each sample were weighed into a pan. Samples were dried in an oven at approximately 370°C for 3 to 4 hours, then placed in a sieve shaker for 15 minutes for optimal particle separation through each sieve. Particles passed through eight successively smaller sieves (#10 to #200), and particles smaller than 0.075 millimeters were captured in a pan at the bottom of the pan stack. The contents of each sieve and pan were carefully transferred to a tared pan and weighed. The percentage of grains finer than each subsequent sieve were calculated and plotted on a cumulative frequency graph to create a grain size distribution graph (**Figure 10**; Kasenow 1997). The grain size distribution results were used to calculate k.

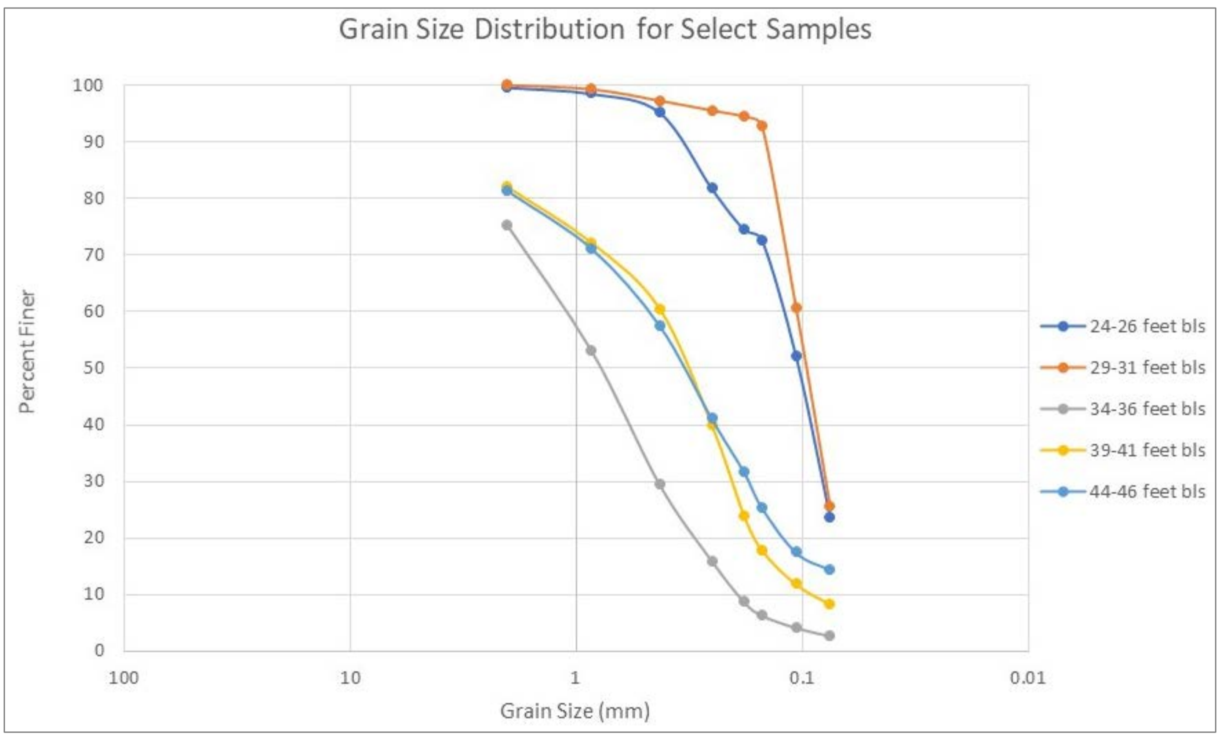

Figure 10. Grain size distribution at OSF-113 by percent finer versus grain size.

Sieve data were entered into gINT software (Bentley Systems, Incorporated 2020), and the gINT file was processed through MVASKF software (Vukovic and Soro 1992). To calculate k, MVASKF analyzes grain size distributions based on 10 empirical formulas, including Sauerbrei, Slitcher, and Zunker. The program determines which formulas are applicable for each sample, calculates k values from relevant formulas, and averages those to generate a mean k for the sample. The samples from 26 to 46 ft bls yielded a Wentworth classification of clay from the MVASKF program. Samples with large quantities of clay and silt yield inaccurate k results from MVASKF, so mean k values are null for those depths. Samples 5 (24 to 26 ft bls) and 6 (29 to 31 ft bls) were sent to Radise International for further evaluation. Hydrometer analysis from these samples (**Appendix D**) yielded a classification of silty-sand, which is more in keeping with the visual description from this interval. The gap in mean k results between 31 and 46 ft bls makes calculation of a typical value for the SAS at this location problematic. Freeze and Cherry (1979) list the range of reported k for silty-sand as 0.5 to more than 100 ft/day. Using only the samples below this data gap yielded an average k of 39 ft/day for the SAS.

Penetration Resistance and Hydraulic Conductivity Results

Mean k and SPT results are summarized in **Table 3** and graphed in **Figure 11**. N-values show a decreasing trend with depth but correlate poorly with mean k and sediment classification. From 64 to 86 ft bls, the N-values follow a similar trend to mean k but are almost contradictory at shallower depths. Sample 6 (29 to 31 ft bls) has an extremely low N-value of 2, normally associated with loose sands or pebbles, but it has a mean k of 0 and a high clay/silt content. The lack of correlation between N-values and other variables may be due to unaccounted factors such as overburden, water content, and the 5-ft centering of the SPTs.

Overall, mean k decreases slightly with depth, but the trend is variable. The 24 to 46 ft bls samples are characteristic of a confining lens, poorly sorted, with high clay/silt content. A decreasing mean k trend is more apparent below 36 ft bls but still variable. Within the analyzable interval, the SAS yielded a median k of approximately 41 ft/day. Based on the k range for silty-sands reported by Freeze and Cherry (1979), if the missing un-analyzable portion of the samples were in the low end of the range, then the median k could be as low as 21 ft/day.

Table 3. Summary results from standard penetration testing and mechanical sieve analysis of unconsolidated sediments in the surficial aquifer system.

Sample Depth (ft bls)	N-value (N2+N3)	Mean Hydraulic Conductivity (ft/day)	Folk Classification	Wentworth Classification
6	27	43.66	Extremely poorly sorted	Fine sand
11	14	43.26	Extremely poorly sorted	Fine sand
16	55	34.29	Extremely poorly sorted	Fine sand
21	15	63.85	Moderately well sorted	Fine sand
26	17	N/A	Extremely poorly sorted	Clay
31	2	N/A	Extremely poorly sorted	Clay
36	9	N/A	Extremely poorly sorted	Clay
41	17	N/A		Clay
46	17	N/A		Clay
51	15	7.50	Extremely poorly sorted	Very fine sand
56	4	80.09	Poorly sorted	Medium sand
61	7	21.16	Extremely poorly sorted	Fine sand
66	9	51.17	Extremely poorly sorted	Medium sand
71	10	56.56	Extremely poorly sorted	Medium sand
76	9	38.86		Medium sand
81	9	15.82	Extremely poorly sorted	Fine sand
86	5	8.07	Extremely poorly sorted	Fine sand

bls = below land surface; ft = foot; N/A = not available.

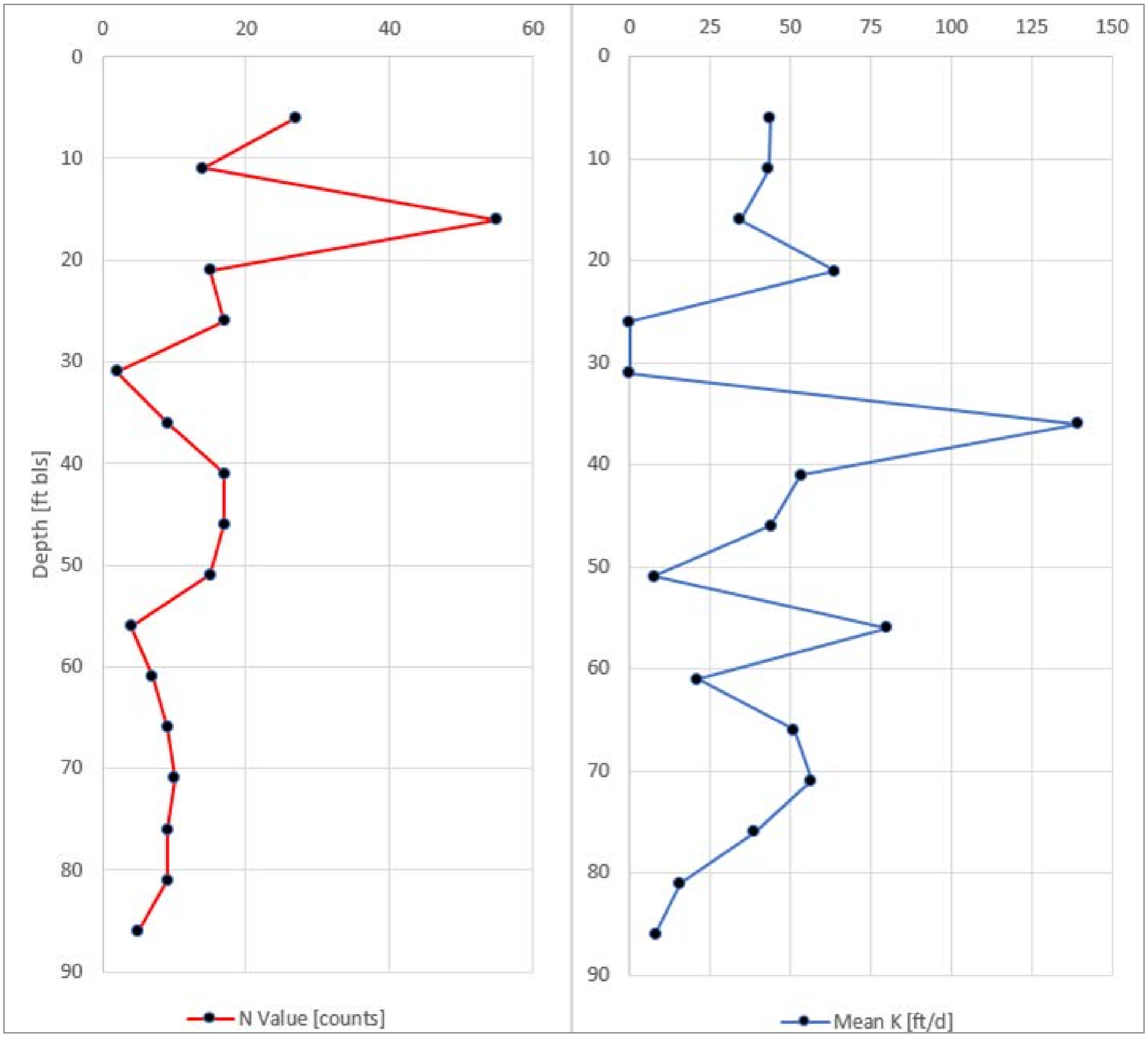

Figure 11. Comparative distribution of N-value and calculated mean hydraulic conductivity with depth.

Packer Testing

Fifty-eight packer tests were conducted during continuous coring operations of OSF-113 to determine changes in productive capacity, formation water quality, and water levels with depth. Packer testing methods, analyses, and results are summarized here. **Appendix D** provides additional details.

Methods

Figure 12 illustrates the setup used for OSF-113 packer testing operations. When the corehole was advanced to a depth selected for testing, the driller pulled up the core casing from total depth to the top of the selected test interval. The test interval was air-developed for a minimum of 1 hour to remove rock detritus and water not native to the selected test interval. After development, the packer assembly was lowered into place, followed by the submersible pump in the annular space above it. Once water levels equilibrated, the packer elements were inflated.

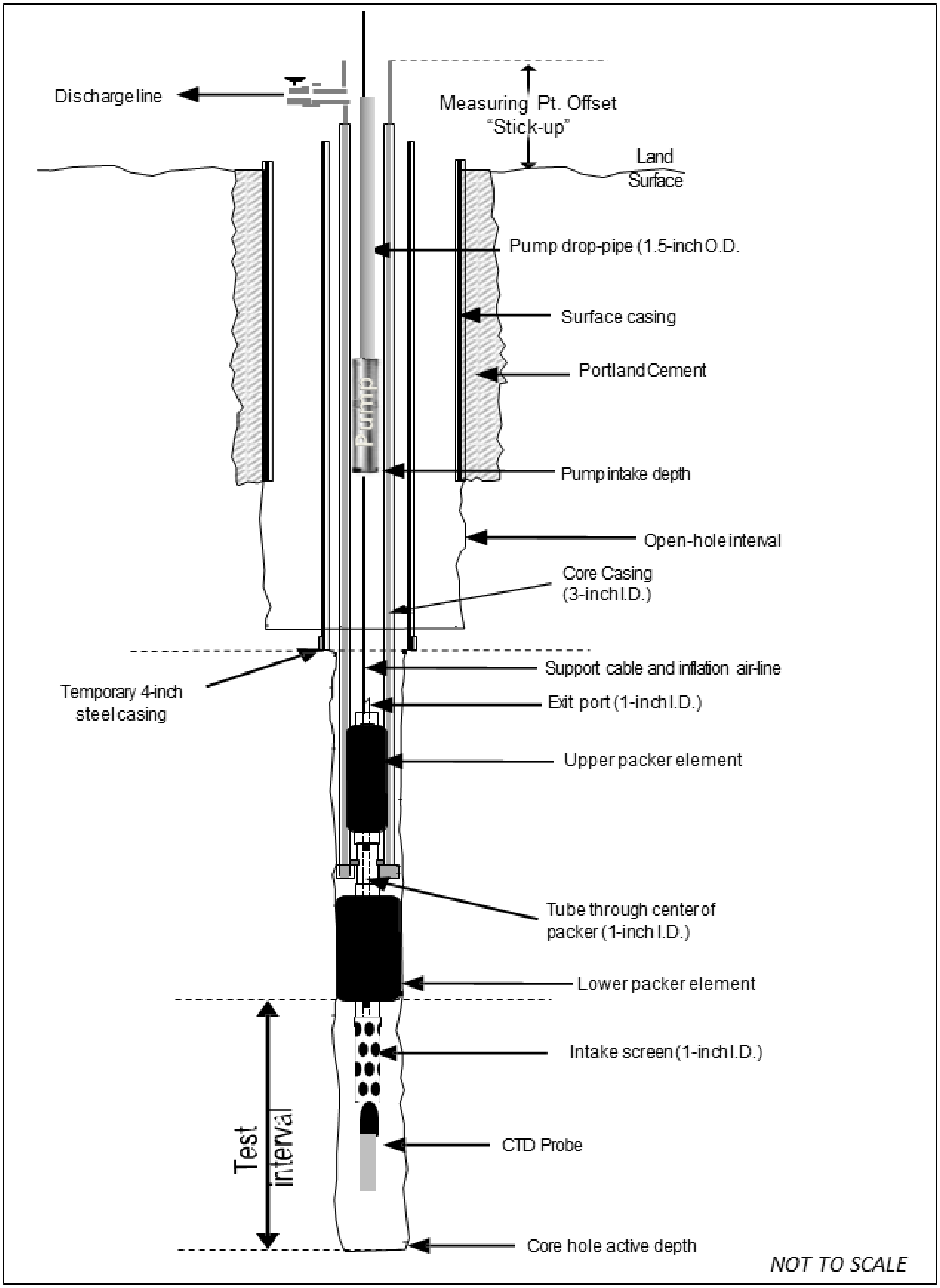

Figure 12. Generalized components of the packer test setup used in OSF-113.

The narrow (3-inch) diameter of the core casing did not allow sufficient space to accommodate a pressure transducer after the pump, drop-pipe, and associated electrical cabling were in place. Therefore, DTW readings were collected manually using a narrow-diameter electric DTW tape. Readings were collected at 1-minute intervals for the first 5 minutes of both the drawdown and recovery portions of the test, and at 5-minute intervals thereafter. The packer assembly was configured so a conductivity, temperature, and depth (CTD) probe could be attached below the bottom packer, to provide those parameters from within the tested interval.

Standard procedure for each test was to pump three complete corehole volumes at a maximum producible rate (typically 4 to 30 gallons per minute [gpm]), collect a sample for water quality analysis, then shut down the pump and monitor until water levels stabilized. For test intervals in which low-permeability rock did not allow removal of three corehole volumes of water, pumping would continue until both drawdown and water quality (temperature, pH, and specific conductance) stabilized, or until water levels declined at or near pumpable levels. Configuration specifics for each test are summarized in **Table 4**, with deviations from standard procedure noted in the comments.

Table 4. Packer test configuration summary.

Test #	Date	Water Quality Sample ID	Test Interval (ft bls)		Q (gpm)	Pumping Duration (hh:mm)	Stick-up* (ft)	Comments
			From Depth	To Depth				
1	05-Feb-19	P102211-3	250	280	23.5	0:31	4.17	
2	06-Feb-19	P102212-3	280	310	2.4	0:15	4.20	Pumped dry
3	06-Feb-19	P102212-4	310	340	4.0	0:13	4.09	Pumped dry
4	07-Feb-19	P102213-3	340	370	28.5	0:36	4.02	
5	07-Feb-19	P102213-4	370	400	30.0	0:32	4.10	
6	08-Feb-19	P102214-3	400	430	7.5	1:20	4.03	
7	11-Feb-19	P102215-3	430	460	21.0	1:15	4.09	
8	12-Feb-19	P102226-3	460	490	21.0	1:05	4.25	
9	12-Feb-19	P102226-4	490	520	20.0	1:30	4.06	
10	14-Feb-19	P102227-3	520	550	14.0	3:00	4.03	
11	14-Feb-19	P102227-4	550	580	13.5	1:27	4.02	
12	18-Feb-19	P102216-3	580	610	16.2	2:40	3.95	
13	19-Feb-19	--	610	640	12.3	0:02	3.99	Pumped dry
14	19-Feb-19	P102217-3	640	670	11.5	1:15	4.02	
15	20-Feb-19	P102218-3	670	700	35.0	0:55	3.99	
16	20-Feb-19	P102218-4	700	730	11.8	1:20	4.00	
17	22-Feb-19	P102219-3	730	760	27.7	1:05	3.99	
18	26-Feb-19	P102220-3	760	790	27.2	1:00	4.29	
19	27-Feb-19	P102221-3	790	820	26.0	1:10	3.97	
20	28-Feb-19	P102222-3	820	850	21.0	1:25	3.97	
21	28-Feb-19	P102222-4	850	880	32.0	1:05	3.90	
22	04-Mar-19	P102223-3	880	910	33.0	0:56	4.00	
23	06-Mar-19	P102224-3	910	940	30.0	1:45	3.86	
24	06-Mar-19	P102224-4	940	970	12.0	1:55	3.85	Reduced purge: 2 BV
25	07-Mar-19	P102225-3	970	1,000	10.0	1:50	3.94	Reduced purge: 1.7 BV
26	08-Mar-19	--	1,000	1,030	10.0	0:03	2.78	Pumped dry
27	11-Mar-19	P102229-3	1,030	1,060	32.8	1:10	3.82	
28	12-Mar-19	P102230-3	1,060	1,090	16.0	2:15	3.90	

Test #	Date	Water Quality Sample ID	Test Interval (ft bls)		Q (gpm)	Pumping Duration (hh:mm)	Stick-up* (ft)	Comments
			From Depth	To Depth				
29	12-Mar-19	P102230-4	1,090	1,120	32.0	1:10	3.80	
30	13-Mar-19	P102231-3	1,120	1,150	33.4	1:10	3.82	
31	14-Mar-19	P102232-3	1,150	1,180	33.0	1:10	3.82	
32	18-Mar-19	P102233-3	1,180	1,210	30.0	1:38	3.85	
33	19-Mar-19	P102234-3	1,210	1,240	26.0	2:00	3.80	
34	20-Mar-19	P102235-3	1,240	1,270	30.7	1:20	3.80	
35	21-Mar-19	P102228-3	1,270	1,300	31.0	1:49	3.75	
36	21-Mar-19	P102228-4	1,300	1,330	11.0	1:55	3.75	
37	25-Mar-19	P102229-3	1,330	1,360	20.0	2:10	3.89	
38	26-Mar-19	P102230-3	1,360	1,390	20.0	1:55	3.85	
39	26-Mar-19	P102230-4	1,390	1,420	28.8	1:50	3.85	
40	20-May-19	P104275-3	1,420	1,450	29.6	1:35	5.17	
41	21-May-19	P104275-4	1,450	1,480	34.6	1:40	5.35	
42	23-May-19	P104276-3	1,480	1,510	31.0	1:42	5.25	
43	24-May-19	P104277-3	1,510	1,540	32.0	1:40	5.35	
44	29-May-19	--	1,540	1,570	21.4	0:01	5.25	Pumped dry
45	29-May-19	P104278-3	1,570	1,600	14.6	1:30	5.30	
46	30-May-19	P104279-3	1,600	1,630	32.0	1:20	5.35	
47	03-Jun-19	P104280-3	1,630	1,660	32.0	1:45	5.43	
48	04-Jun-19	P105556-3	1,660	1,690	27.0	1:35	5.40	
49	05-Jun-10	P105557-3	1,690	1,720	31.0	1:35	5.52	
50	06-Jun-19	P105558-3	1,720	1,750	33.0	1:30	5.40	
51	07-Jun-19	P105559-3	1,750	1,780	31.0	1:35	5.45	
52	11-Jun-19	P105560-3	1,780	1,810	29.0	1:35	5.45	
53	12-Jun-19	P105561-3	1,810	1,840	16.0	2:00	5.55	
54	14-Jun-19	P105562-3	1,840	1,870	34.0	1:35	5.50	
55	18-Jun-19	P105563-3	1,870	1,900	34.0	2:50	5.47	
56	19-Jun-19	P105563-4	1,900	1,930	32.4	1:15	5.38	
57	20-Jun-19	--	1,930	1,960	11.7	0:02	5.38	Pumped dry
58	24-Jun-19	--	1,960	1,990	11.0	0:01	5.24	Pumped dry

bls = below land surface; BV = borehole volume; ft = foot; gpm = gallons per minute; hh:mm = hours:minutes; Q = rate of discharge.

* Stick-up is the offset distance (in feet) of the depth-to-water measuring point from land surface.

Hydraulic Analysis

To estimate the hydraulic properties of the geologic formation from the packer tests, well loss components of the measured drawdown, such as those caused by turbulent flow into the packer intake screen or friction losses in the packer pipe (1-inch diameter) and core casing (3-inch diameter), needed to be eliminated. The Hazen-Williams equation (Finnemore and Franzini 2002) was used to calculate the pressure loss due to friction in the pipes (**Table 5**). A conversion factor of 2.31 ft of water per pound per square inch of pressure was used to convert to consistent drawdown units.

$$P_d = L \frac{4.52Q^{1.85}}{C^{1.85}\, d^{4.865}}$$

Where:

P_d = pressure drop due to friction loss over the length of pipe (pounds per square inch)
L = length of pipe (ft)
Q = discharge rate (gpm)
C = pipe roughness coefficient
d = inside pipe diameter (inches)

Table 5. Pipe information for well-loss calculations using the Hazen-Williams equation.

Pipe Section	Inner Diameter (inches)	Length (feet)	Roughness Coefficient*
Core casing	3.00	Top of Test Interval – DTW	140
Packer assembly	1.00	9.0	150

DTW = depth to water.
* Hazen-Williams coefficients for unlined steel 140-150 sourced from Engineering ToolBox (retrieved June 6, 2018).

The intake screen below the packer assembly was fabricated by the driller to facilitate use of the CTD probe. Because this test assembly was configured in the field from various components, head losses due to changes in the flow into this custom-designed device were estimated empirically. An equation to estimate head losses due to the intake screen as a function of pumping rate was developed during the initial deployment of the component (Richardson et al. 2020).

$$\text{Screen Head Loss (ft of } H_2O) = -0.0003\text{rate}^3 + 0.0147\text{rate}^2 - 0.0993\text{rate} + 0.0532$$

Total well losses were estimated as the sum of the friction losses across the packer assembly, core casing, and intake screen.

The screen and CTD probe were deployed on multiple packer tests, but the temperature sensor on the probe failed during its first deployment in OSF-113. The pressure and conductivity sensors continued to collect data. However, those sensors must be temperature compensated to correct for density, so the CTD results were judged insufficiently reliable for use in this report.

Calculated well losses for the 58 packer tests ranged from 0.05 to 12.77 ft, depending on the pumping rate and depth of the tested interval. A similar range in well losses was observed by Richardson et al. (2020). In that study, CTD data were available to evaluate the accuracy of the well-loss calculation, yielding an error range from -0.3 to 1.3 ft. Negative values are overestimates and positive values are underestimates, with the tendency towards underestimation. Lacking the means for similar evaluation here, the maximum error of 1.3 ft was assumed to estimate the range of uncertainty in hydraulic conductivity from OSF-113 packer testing. For the most part, this range of error does not have a strong impact on the k calculations; however, when the measured drawdowns are small (i.e., in the most productive intervals), k could be significantly underestimated.

After head-loss corrections were made, hydraulic properties were estimated from the drawdown data using an empirical formula presented by Driscoll (1986). This formula estimates transmissivity in a confined aquifer based on specific capacity as:

$$T = \frac{Q}{s} * 2000$$

Where:

T = transmissivity (gallons/day/ft)
Q = pumping rate (gpm)
s = drawdown (ft)

After converting transmissivity (T) to square-feet per day units, the hydraulic conductivity was calculated as:

$$k = \left(\frac{T}{b}\right)$$

Where:

k = hydraulic conductivity (ft/day)
b = thickness of the tested interval (ft)

For seven tests (2, 3, 13, 26, 44, 57, and 58), the water levels dropped rapidly to the pump intake level. The drawdown data from these tests are not valid for analysis, as the results reflect the depth of the pump rather than the permeability of the formation. Because the drawdown was near instantaneous relative to recovery rate, these tests can be treated as slug-out or bail tests. Consequently, recovery data from these tests were analyzed in AQTESOLV Pro (v.4.5) software (Duffield 2007) using the Bouwer-Rice slug test analytical method.

Hydraulic Analysis Results and Discussion

Results from the hydraulic analysis are summarized in **Table 6**. The table shows the maximum drawdown from the manual DTW data for each test, before and after correction, for estimated head losses not related to the formation, the resultant k, and the range of uncertainty in the estimate, assuming an error in the head-loss calculation of up to 1.3 ft. Estimated k varies by up to six orders of magnitude in OSF-113, from as little as 0.01 ft/day to more than 1,000 ft/day. Tests for which uncertainty in the drawdown could have a notable effect (25% or more) on the resultant k are denoted in the table. The smaller the actual drawdown, the greater the impact of any error in the drawdown measurement.

Table 6. Summary of results from the hydraulic analysis for OSF-113.

Test #	Test Interval (ft bls)		Drawdown (ft)		Hydraulic Conductivity (ft/day)		Solution Method
	From Depth	To Depth	Raw	Corrected	Estimate	Uncertainty Range	
1	250	280	34.11	30.61	6.84	6.56 – 7.15	Driscoll (1986)
2	280	310	69.28	69.23	0.25	--	Bouwer and Rice (1976)
3	310	340	69.17	69.03	0.52	--	
4	340	370	21.81	16.56	15.33	14.22 – 16.64	Driscoll (1986)
5	370	400	15.99	7.93	33.72	28.97 – 40.33	
6	400	430	50.60	50.14	1.33	1.30 – 1.37	
7	430	460	32.59	27.80	6.73	6.43 – 7.06	
8	460	490	22.31	17.48	10.71	9.97 – 11.57	
9	490	520	27.17	22.70	7.85	7.43 – 8.33	
10	520	550	37.04	35.06	3.56	3.43 – 3.70	
11	550	580	47.92	46.13	2.61	2.54 – 2.68	
12	580	610	44.35	41.28	3.49	3.38 – 3.60	
13	610	640	69.35	67.60	0.52	--	Bouwer and Rice (1976)
14	640	670	43.17	41.65	2.46	2.39 – 2.54	Driscoll (1986)
15	670	700	36.75	26.08	11.96	11.39 – 12.59	
16	700	730	50.44	48.79	2.16	2.10 – 2.21	
17	730	760	48.25	40.09	6.16	5.96 – 6.36	
18	760	790	35.66	29.83	8.13	7.79 – 8.50	
19	790	820	36.85	31.42	7.37	7.08 – 7.69	
20	820	850	38.75	35.05	5.34	5.15 – 5.55	
21*	850	880	11.50	1.23	231	112 – >1,000	
22*	880	910	11.76	3.01	97.71	68.24 – 172	
23	910	940	35.51	28.09	9.52	9.10 – 9.98	
24	940	970	51.08	49.70	2.15	2.10 – 2.21	
25	970	1,000	57.29	56.30	1.58	1.55 – 1.62	
26	1,000	1,030	69.09	68.09	0.43	--	Bouwer and Rice (1976)
27	1,030	1,060	28.77	19.24	15.19	14.23 – 16.29	Driscoll (1986)
28	1,060	1,090	50.77	48.32	2.95	2.87 – 3.03	
29*	1,090	1,120	10.30	1.35	211	108 – >1,000	
30	1,120	1,150	19.46	9.67	30.80	27.15 – 35.58	
31	1,150	1,180	19.52	9.84	29.90	26.41 – 34.45	
32	1,180	1,210	15.79	7.59	35.24	30.08 – 42.52	
33	1,210	1,240	28.06	21.70	10.68	10.07 – 11.36	
34	1,240	1,270	26.98	16.06	17.04	15.76 – 18.54	
35	1,270	1,300	41.61	30.14	9.17	8.79 – 9.58	
36	1,300	1,330	60.03	58.70	1.67	1.63 – 1.71	
37	1,330	1,360	52.89	47.40	3.76	3.66 – 3.87	
38	1,360	1,390	59.93	54.40	3.28	3.20 – 3.36	
39	1,390	1,420	44.96	34.57	7.42	7.16 – 7.71	
40	1,420	1,450	21.89	13.21	19.96	18.18 – 22.14	
41	1,450	1,480	26.51	14.81	20.82	19.14 – 22.82	
42	1,480	1,510	20.00	10.36	26.67	23.70 – 30.50	
43	1,510	1,540	19.75	9.43	30.25	26.58 – 35.09	
44	1,540	1,570	66.95	60.27	0.86	--	Bouwer and Rice (1976)

Test #	Test Interval (ft bls)		Drawdown (ft)		Hydraulic Conductivity (ft/day)		Solution Method
	From Depth	To Depth	Raw	Corrected	Estimate	Uncertainty Range	
45	1,570	1,600	46.77	44.31	2.94	2.85 – 3.03	Driscoll (1986)
46*	1,600	1,630	15.18	2.47	115	75.62 – 243	
47	1,630	1,660	23.03	12.32	23.14	20.93 – 25.87	
48	1,660	1,690	36.10	28.21	8.53	8.15 – 8.94	
49*	1,690	1,720	12.09	1.81	152	88.79 – 540	
50*	1,720	1,750	13.35	1.71	172	97.81 – 723	
51	1,750	1,780	20.68	10.22	27.04	23.99 – 30.98	
52	1,780	1,810	33.31	23.98	10.78	10.22 – 11.40	
53	1,810	1,840	35.30	32.17	4.43	4.26 – 4.62	
54	1,840	1,870	19.38	6.64	45.64	38.17 – 56.75	
55*	1,870	1,900	13.28	0.51	597	168 – >1,000	
56*	1,900	1,930	10.89	-0.86	656	655 – >1,000	
57	1,930	1,960	51.62	49.82	0.09	--	Bouwer and Rice (1976)
58	1,960	1,990	51.71	50.09	0.01	--	

bls = below land surface; ft = foot.
* Uncertainty in the drawdown could result in a 25% or more error in the estimate of hydraulic conductivity.

Water Quality and Inorganic Chemistry

Fifty-three discrete water samples were collected during packer testing at OSF-113 to characterize the water chemistry variation in the FAS at the S65 Locks site. Field parameters (temperature, pH, and specific conductance) were recorded on site with a YSI 600XL multiprobe, and each sample was collected and submitted for laboratory analysis in accordance with the project's Water Quality Monitoring Plan (SFWMD 2017). Major cations and anions, total strontium, and stable isotopes of oxygen and hydrogen (^{18}O and ^{2}H) were analyzed in each packer test sample. A summary of the results is provided here; complete results from the testing program are available for download from the District's DBHYDRO database (www.sfwmd.gov/dbhydro). Field parameters and quality assurance data from individual samples are summarized in **Table 7**, and major ion chemistry is provided in **Table 8**. The discrete samples are organized from shallowest to deepest to allow differences between hydrogeologic units to be more easily distinguished.

Table 7. Field and laboratory water quality assessment sample summary for OSF-113. (Note: Bolded values exceed the secondary drinking water standard.)

Sampled Depth (ft bls)	Field Parameters			Laboratory Samples Ionic Balance			TDS (mg/L)	TDS to Specific Conductivity Ratio
	pH	Temp. (°C)	Specific Cond. (µS/cm)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Balance Error %		
250-280	7.6	24.50	459	4.38	4.70	3.54%	304	0.66
280-310[a]	7.6	26.80	452	4.52	4.69	1.83%	311	0.69
310-340[a]	7.4	27.50	477	4.93	4.69	-2.51%	311	0.65
340-370	7.4	24.70	482	4.71	4.73	0.16%	312	0.65
370-400	7.3	24.70	485	4.75	4.87	1.23%	311	0.64
400-430	7.4	25.10	513	4.95	5.03	0.80%	310	0.60
430-460	7.4	25.10	498	4.93	5.11	1.78%	318	0.64
460-490	7.4	25.20	494	4.87	4.84	-0.34%	317	0.64
490-520	7.3	25.50	514	5.14	5.12	-0.23%	327	0.64
520-550	7.8	25.60	564	5.56	5.58	0.22%	352	0.62
550-580	7.2	25.40	636	6.37	6.37	-0.02%	398	0.63
580-610	7.2	25.80	650	6.83	6.88	0.29%	415	0.64
640-670	7.2	25.90	617	6.49	6.67	1.34%	379	0.61
670-700	7.2	25.90	636	6.47	6.47	-0.04%	391	0.61
700-730	7.2	26.30	700	7.08	7.12	0.33%	471	0.67
730-760	7.3	26.50	650	6.08	6.10	0.15%	369	0.57
760-790	7.5	26.20	721	6.97	7.16	1.39%	445	0.62
790-820	7.5	26.40	894	8.35	8.38	0.19%	**526**	0.59
820-850	7.6	26.40	1,115	10.27	10.28	0.08%	**628**	0.56
850-880	7.4	26.70	1,949	17.57	17.28	-0.82%	**1,050**	0.54
880-910	7.3	26.60	2,036	18.18	18.47	0.79%	**1,113**	0.55
910-940	7.7	25.80	2,257	19.33	20.30	2.45%	**1,227**	0.54
940-970	7.6	24.50	1,474	12.93	13.45	1.99%	**793**	0.54
970-1,000	7.5	26.40	707	7.01	7.07	0.41%	445	0.63
1,030-1,060	7.6	27.00	1,518	13.92	14.28	1.27%	**867**	0.57
1,060-1,090	7.5	26.90	1,520	13.51	13.61	0.34%	**838**	0.55
1,090-1,120	7.2	26.90	1,469	13.89	13.93	0.16%	**848**	0.58
1,120-1,150	7.6	27.20	1,423	12.79	13.01	0.84%	**797**	0.56
1,150-1,180[b]	7.5	27.00	1,686	15.38	13.69	-5.79%	**947**	0.56
1,180-1,210	7.8	26.60	2,238	18.42	18.21	-0.59%	**1,130**	0.50
1,210-1,240	7.5	27.00	2,031	18.73	18.90	0.44%	**1,171**	0.58
1,240-1,270	7.0	26.90	2,284	21.27	20.82	-1.07%	**1,268**	0.56
1,270-1,300	7.6	27.20	2,474	22.63	22.37	-0.58%	**1,315**	0.53
1,300-1,330	7.5	26.60	2,466	22.64	22.99	0.78%	**1,297**	0.53
1,330-1,360	7.6	27.70	3,103	29.28	30.63	2.26%	**1,687**	0.54
1,360-1,390	7.5	27.20	4,118	40.14	40.52	0.47%	**2,324**	0.56
1,390-1,420	7.4	27.50	4,243	41.12	42.38	1.51%	**2,396**	0.56
1,420-1,450	7.5	27.60	5,658	53.10	51.33	-1.69%	**3,155**	0.56
1,450-1,480	7.6	27.70	2,699	24.20	24.77	1.17%	**1,461**	0.54
1,480-1,510	7.8	27.80	2,535	22.80	23.57	1.67%	**1,469**	0.58
1,510-1,540	7.8	27.70	3,448	28.83	30.35	2.57%	**1,807**	0.52
1,570-1,610	7.5	28.90	5,956	58.03	58.43	0.34%	**3,462**	0.58

Sampled Depth (ft bls)	Field Parameters			Laboratory Samples Ionic Balance			TDS (mg/L)	TDS to Specific Conductivity Ratio
	pH	Temp. (°C)	Specific Cond. (µS/cm)	Sum of Anions (meq/L)	Sum of Cations (meq/L)	Balance Error %		
1,600-1,630	7.5	28.30	6,285	57.75	59.28	1.30%	**3,482**	0.55
1,630-1,660	7.6	28.81	6,298	57.55	60.45	2.46%	**3,606**	0.57
1,660-1,690	7.4	28.23	6,408	59.79	60.26	0.39%	**3,563**	0.56
1,690-1,720	7.5	28.92	7,089	71.18	68.77	-1.73%	**4,168**	0.59
1,720-1,750	7.6	28.58	7,163	72.37	72.14	-0.16%	**4,170**	0.58
1,750-1,780	7.6	28.28	7,436	67.19	72.43	3.75%	**4,418**	0.59
1,780-1,810	7.5	27.74	8,456	76.91	77.85	0.60%	**4,846**	0.57
1,810-1,840	7.5	27.18	9,523	104.87	102.89	-0.95%	**6,260**	0.66
1,840-1,870	7.2	26.18	8,506	93.32	94.59	0.67%	**4,889**	0.57
1,870-1,900	7.4	28.85	36,095	395.28	385.62	-1.24%	**17,213**	0.48
1,900-1,930	7.6	28.20	45,252	501.41	496.63	-0.48%	**23,928**	0.53

°C = degrees Celsius; µS/cm = microsiemens per centimeter; ft bls = feet below land surface; meq/L = milliequivalents per liter; mg/L = milligrams per liter; TDS = total dissolved solids.

[a] Potentially unreliable: very low purge volume, could result in mix of formation and drilling fluids.

[b] Potentially unreliable: ion-balance error is above the threshold for acceptance.

Table 8. Major ion composition with depth. (Note: Bolded values exceed the secondary drinking water standard.)

Sampled Depth (ft bls)	Anions (mg/L)			Cations (mg/L)				
	Chloride	Bicarbonate	Sulfate	Sodium	Magnesium	Calcium	Potassium	Strontium*
250-280	36.4	204	<1	22	20.3	38.9	2.0	4.1
280-310	35	213	1.8	22	20.2	38.6	2.3	4.1
310-340	35.1	239	1.1	21	20.3	39	2.1	3.9
340-370	37.8	222	<1	25	20.2	36.8	1.6	3.9
370-400	39.2	222	<1	27	20	38.6	1.5	3.7
400-430	39.4	234	<1	27	22.4	38.1	1.5	3.9
430-460	39.4	233	<1	26	22.8	39.2	1.4	4.6
460-490	39.5	229	<1	26	21.7	35.7	1.4	4.7
490-520	39.8	245	<1	26	23.8	36.9	1.5	6.3
520-550	39.5	271	<1	26	27.6	39.2	1.7	7.4
550-580	41.2	317	<1	28	34	41.4	2.1	11.0
580-610	42.6	343	<1	29	38.4	41.8	2.3	13.2
640-670	39.3	327	1.1	27	37.1	39.5	2.3	18.8
670-700	38.8	311	13.4	25	32.7	43.8	2.1	19.1
700-730	50.6	239	83.1	25	30.1	51.1	2.0	41.5
730-760	75.9	182	46	32	25	40.6	1.8	25.2
760-790	89.5	173	77.1	40	26.1	48.6	2.0	35.3
790-820	133	154	99.6	53	25.1	54	2.8	54.2
820-850	204	152	97.1	92	24.9	55.2	4.1	60.0
850-880	**433**	173	121	232	39	70	8.4	12.5
880-910	**438**	199	123	244	41.6	78.1	9.0	12.9
910-940	**508**	130	138	288	45.5	67.5	9.8	17.9
940-970	**290**	191	77.6	156	36.3	65	5.2	14.2

Sampled Depth (ft bls)	Anions (mg/L)			Cations (mg/L)				
	Chloride	Bicarbonate	Sulfate	Sodium	Magnesium	Calcium	Potassium	Strontium*
970-1,000	55.2	189	113	38	31.8	40.6	4.0	29.5
1,030-1,060	**327**	134	120	163	32.8	58.3	6.0	63.2
1,060-1,090	**319**	123	120	147	34.6	56	5.9	62.3
1,090-1,120	**264**	243	118	128	36	80.2	5.4	54.6
1,120-1,150	**289**	133	118	129	34.3	59.5	5.4	63.6
1,150-1,180	**379**	117	133	171	37.8	60	6.6	--
1,180-1,210	**489**	111	135	222	45.5	63.7	7.3	62.5
1,210-1,240	**500**	112	134	229	49.6	64.1	7.1	65.3
1,240-1,270	**550**	144	163	258	57.7	72.4	6.9	46.0
1,270-1,300	**608**	112	175	291	62.2	70.9	8.3	36.7
1,300-1,330	**634**	106	145	293	63.3	90.3	8.4	14.4
1,330-1,360	**843**	111	177	432	72.7	107	10.3	12.2
1,360-1,390	**1,173**	112	**251**	609	87.4	123	15.6	12.2
1,390-1,420	**1,198**	118	**260**	642	95.3	118	19.7	10.7
1,420-1,450	**1,562**	121	**339**	804	110	127	27.0	12.1
1,450-1,480	**715**	106	110	340	61	89.1	9.5	12.0
1,480-1,510	**679**	98	97.9	323	58.2	85	9.3	10.4
1,510-1,540	**905**	106	75.1	466	64.8	83.8	14.7	7.8
1,570-1,610	**1,731**	122	**346**	927	136	120	31.0	7.3
1,600-1,630	**1,687**	158	**364**	940	131	132	31.3	8.8
1,630-1,660	**1,689**	134	**370**	961	129	140	32.2	10.1
1,660-1,690	**1,756**	137	**386**	959	128	138	32.7	11.0
1,690-1,720	**2,096**	149	**462**	1,092	147	159	38.3	12.5
1,720-1,750	**2,130**	153	**470**	1,157	154	158	39.5	12.3
1,750-1,780	**1,989**	135	**426**	1,163	150	164	38.7	13.4
1,780-1,810	**2,300**	149	**460**	1,245	162	181	39.7	14.3
1,810-1,840	**3,180**	129	**627**	1,683	213	208	54.7	15.4
1,840-1,870	**2,762**	233	**557**	1,520	196	216	50.0	12.4
1,870-1,900	**12,609**	169	**1,770**	6,668	778	512	216	21.5
1,900-1,930	**16,053**	145	**2,221**	8,690	985	598	282	23.3

ft bls = feet below land surface; mg/L = milligrams per liter.

* Strontium currently is not regulated, but all recorded values exceed the United States Environmental Protection Agency's (2014) proposed health reference level for strontium of 1.5 mg/L.

Figure 13 illustrates the variations in major ion concentrations with depth. The ions are shown in milliequivalents per liter for ease of comparison. Above 790 ft bls, OSF-113 water is fresh, meeting all drinking water standards for naturally occurring ions. Bicarbonate is the dominant anion, and magnesium and calcium the dominant cations. Below 790 ft bls, there is a gradual increase in salinity with depth. Bicarbonate begins to decline, while chloride and, to a lesser extent, sulfate increase. From 790 ft bls to the total drilled depth (2,000 ft bls), only one packer test yielded water that deviated from the sodium-chloride dominant trend. Packer test #25 (970 to 1,000 ft bls) exhibited a reversal to fresher water, but with significantly higher sulfate content than observed above 790 ft bls. Packer test #26 pumped dry and could not be sampled. Although sodium-chloride dominated the remainder of the borehole, several additional inversions were observed, in which salinity briefly decreased relative to the concentration in the overlying rock unit.

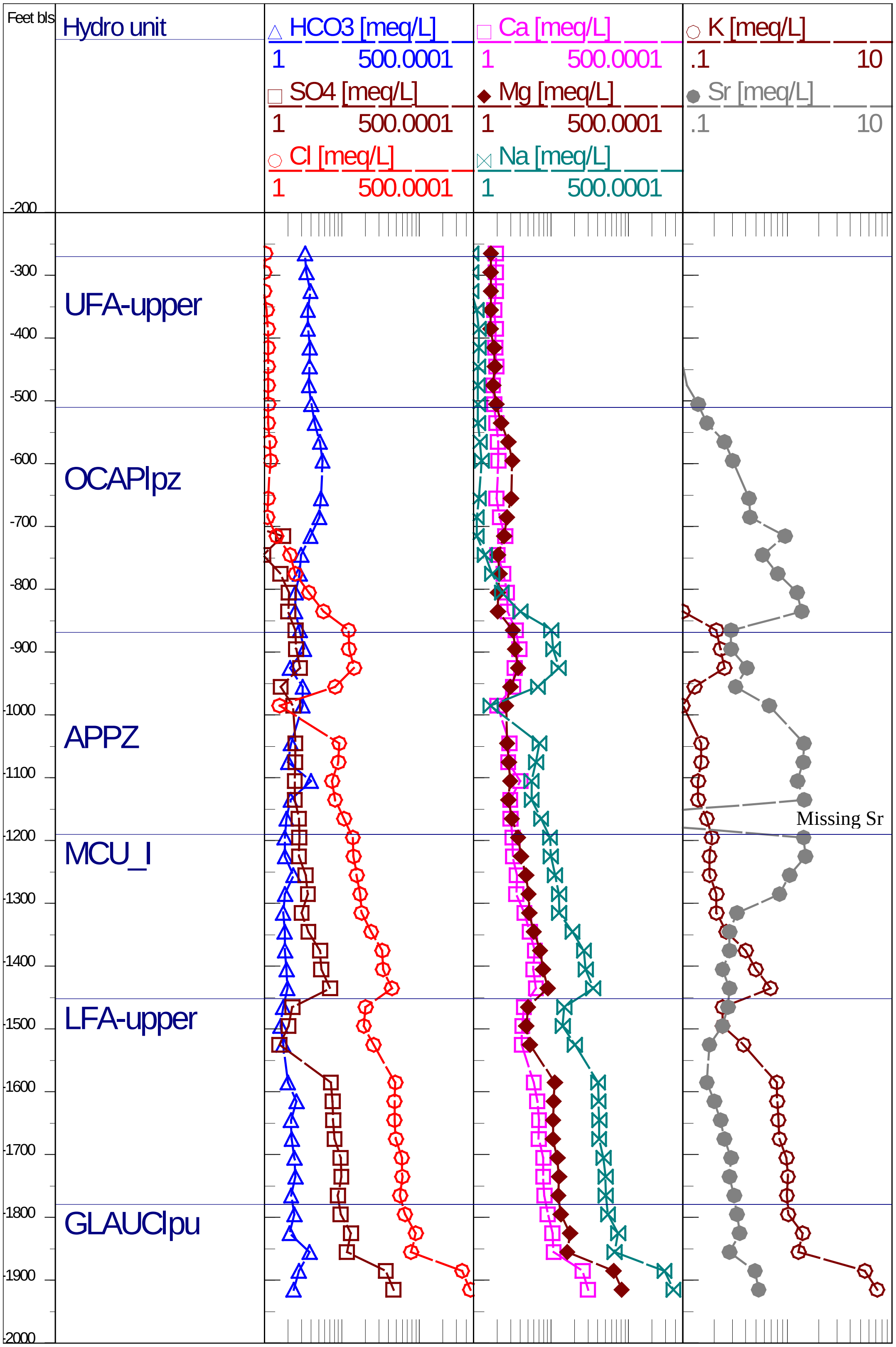

Figure 13. Variation in ion concentration (milliequivalents per liter) with depth for OSF-113. Points are positioned at the middle of the tested interval.

From 790 to 940 ft bls, TDS concentrations rose from 500 to almost 1,300 mg/L, before dropping back to 500 mg/L in packer test #25. Below 1,000 ft bls, TDS concentrations began to rise again but did not reach the previous high until 1,300 ft bls. From 1,300 to 1,450 ft bls, TDS concentrations increased steadily to more than 3,000 mg/L. A second reversal occurred from 1,450 to 1,540 ft bls, where TDS concentrations dropped back below 2,000 mg/L. Salinity begins to increase again from 1,540 to a local high of 6,260 mg/L in packer test #53 (1,810 to 1,840 ft bls). A third brief reversal occurred in packer test #54 (1,840 to 1,870 ft bls), which dropped back to a TDS concentration of 4,889 mg/L. Packer test #55 (1,870 to 1,900 ft bls) yielded a sharp increase in TDS concentrations, to more than 10,000 mg/L, indicating the boundary of the underground source of drinking water within this interval.

As seen in **Figure 13**, below 790 ft bls, most of the major ions increase and decrease in a similar pattern, differing only in the magnitude of change. The strontium ion is of particular interest because it deviates from this general pattern of behavior. With concentrations between 0 and 10 milliequivalents per liter, strontium is not a major ion, but it is of significance in OSF-113. Packer test #31, which lacked a strontium concentration due to a problem during sampling, yielded the only sample to fail the ion charge balance quality assurance test. If all the sample strontium concentrations were set to zero, three additional samples between 700 and 1,180 ft bls would fail the charge balance criteria as well, indicating the importance of strontium to the charge balance. For perspective, **Table 9** shows the abundance of strontium in the OSF-113 samples versus the UFA as a whole (Sprinkle 1989) and a nationwide survey of 12 carbonate aquifers (Lindsey et al. 2009). From these results, it appears the FAS generally yields elevated levels of strontium compared to most carbonate aquifers, and OSF-113 is in an area with higher than normal concentrations for the FAS.

Table 9. Relative abundance of strontium (mg/L) in OSF-113, the Upper Floridan aquifer, and carbonate aquifers in general.

Source	N	Maximum	75th Percentile	Median	25th Percentile	Minimum	Notes
OSF-113	52	65.31	28.4	12.7	9.1	3.72	Packer samples (170 to 1,930 ft bls)
Sprinkle (1989)	951	67	5.7	0.47	0.09	0	Samples from the Upper Floridan aquifer
Lindsey et al. (2009)	425	43.95	0.606	0.22	0.092	0	12 carbonate aquifers in the United States

ft bls = feet below land surface.

The source of this strontium abundance is unknown. Hounslow (1995) noted that aragonite is the most common source of strontium in groundwater because it substitutes for calcium in aragonite but not in calcite. The evaporite mineral celestite ($SrSO_4$), identified in the rock core at 1,030 ft bls from XRD analysis, also is a likely source of strontium in this well.

A wide range of ions and elements can become dissolved in groundwater as result of interaction with the atmosphere, soil, and rock over time and distance. Waters with very similar chemical compositions are assumed to have a similar history, so diagnostic ion chemistry (i.e., hydrochemical facies) of a sample can be used to learn something of its age, flowpath, and water-rock interactions. At a single location, differences in hydrochemical facies between samples at different depths are an indication of hydraulic separation between those depths. Numerous hydrochemical facies classification schemes have been developed. The OSF-113 packer samples were evaluated using the geochemical pattern analysis method developed for the FAS by Frazee (1982) to relate the chemical signature to recharge source, residence time, and saltwater intrusion. The Frazee water types are defined in **Table 10**. **Figure 14** shows how the packer test samples conform to the water types on Frazee's pattern overlay of the classic Piper trilinear diagram.

Table 10. Description of Frazee (1982) water types.

Abbreviation	Description	Characteristics
FW-I	Fresh Recharge Water Type I	Rapid infiltration through sands, high calcium bicarbonate ($CaHCO_3$).
FW-II	Fresh Recharge Water Type II	Infiltration through sands and clay lenses, $CaHCO_3$ with sodium (Na), sulfate (SO_4), and chloride (Cl). Marginal type II waters are beginning to transition toward FW-IV.
FW-III	Fresh Recharge Water Type III	Infiltration through clay-silt estuarine depositional environment, high sodium bicarbonate ($NaHCO_3$).
FW-IV	Fresh Formation Water Type IV	Fresh water, low calcium (Ca), magnesium (Mg), SO_4, and Cl. Vertical infiltration insignificant. Older form of FW-II or FW-III.
TW-I	Transitional Water Type I	Seawater begins to dominate source water; Cl begins to dominate bicarbonate (HCO_3) with increasing sodium chloride (NaCl) percentage.
TW-II	Transitional Water Type II	Transitional water with source water still dominant, $HCO_3 – SO_4$ mixing zone with increasing Cl.
TCW	Transitional Connate Water	Connate water dominates source water, SO_4 begins to dominate HCO_3 with increasing Cl.
TRSW	Transitional Seawater	Transitional water with seawater dominating source water.
CW	Connate Water	Highly mineralized fresh water with high total dissolved solids and calcium sulfate ($CaSO_4$) dominance. Presence of highly soluble minerals; hydrogen sulfide (H_2S) gas prevalent.
RSW*	Relict Seawater	Unflushed seawater with NaCl.

* Strongly NaCl-dominant waters may plot in this category even if the overall salinity is substantially less than seawater.

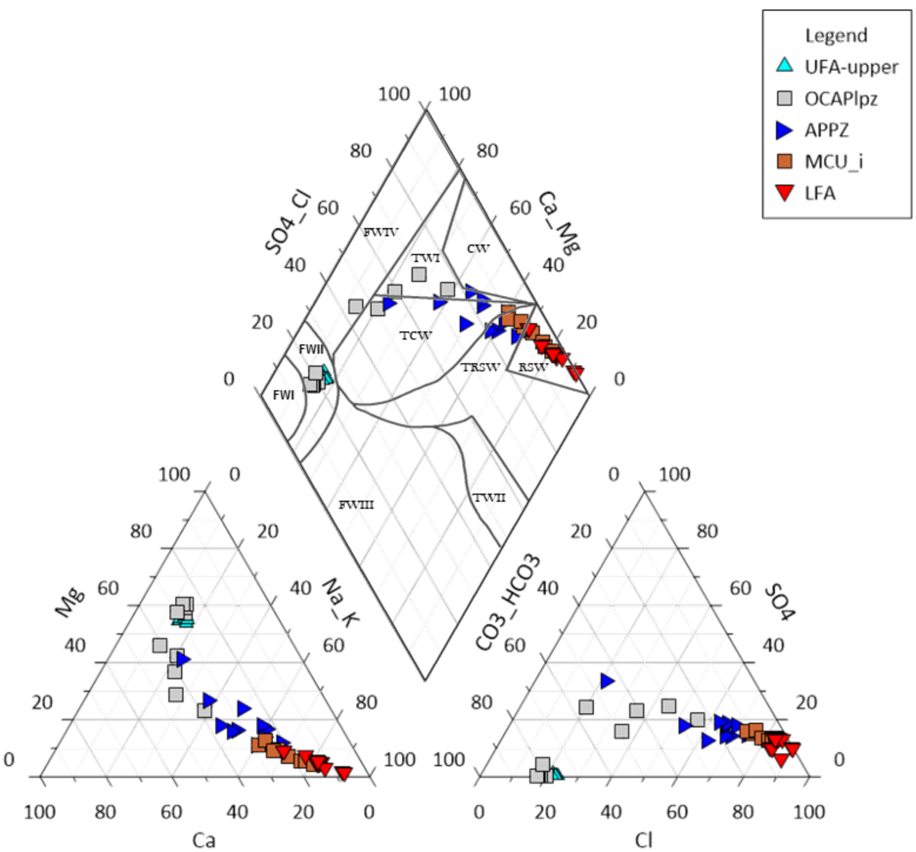

Figure 14. Water-type classification of packer test sample data for OSF-113, illustrating distinctions between hydrogeologic units (Modified from: Frazee 1982).

The UFA-upper and upper part of the OCAPlpz, through packer test #15 (670 to 700 ft bls), fall within the freshwater category in Frazee's (1982) classification scheme. Below this depth, the diagram illustrates a relatively smooth depth transition from fresh to connate water dominance to seawater dominance to relict seawater in the LFA. An interesting deviation within the APPZ is not obvious from this figure. The APPZ at this site consisted of two significant producing zones, separated by less permeable rock. These two producing zones plot backwards of expectations, the deeper zone being connate water dominant (TCW) and the upper zone transitional seawater (TRSW). Because fresher water is deeper, chloride migration into the shallow zone must have been from lateral seawater intrusion, and significant confinement is implied between the two zones. The maximum permeability in each zone is very similar, so the lower zone likely is fresher because it does not extend as far eastward towards the ocean as the shallow zone.

Stable isotopes of oxygen and hydrogen (^{18}O and ^{2}H) were analyzed to identify distinctions between source waters and the hydrogeologic units penetrated during coring and packer testing operations (**Figure 15**). These values represent the deviation in the isotope ratio of the sample from the reference standard, in this case Vienna standard mean ocean water (VSMOW). Negative values indicate the sample is depleted in the rare isotope (^{2}H or ^{18}O) relative to VSMOW, and positive values that the sample is enriched relative to VSMOW. Except for packer test #56, which yielded hydrogen isotope (^{2}H) concentrations close to zero, all the OSF-113 samples were slightly depleted relative to VSMOW. Craig (1961) first noted a linear relationship between ^{18}O and ^{2}H isotope values measured in precipitation from all over the world. This relationship $^{2}H = 8\ ^{18}O + 10$ parts per thousand has become known as the global meteoric water line.

Compared to the wide range of ^{18}O and ^{2}H observed in modern rainfall around the world, the samples from OSF-113 are very similar: ^{18}O ranging from -2 to -0.2 parts per thousand, and ^{2}H from -8.9 to -0.1 parts per thousand. Despite this relatively narrow range of absolute values, the stable isotope results clearly cluster by hydrogeologic unit, indicating conditions during recharge to each unit were not identical. The clustering of the APPZ in the lower left quadrant of the plot possibly indicate environmental conditions were slightly cooler when those waters initially were recharged into the aquifer than conditions under which the UFA-upper and LFA were recharged.

Most OSF-113 samples plot relatively close to the global meteoric water line, implying their source water did not experience a prolonged period of evaporation prior to recharge. However, as illustrated in **Figure 16**, the distance of each point from the global meteoric water line is not evenly distributed with depth. The deviation of each sample result from the global meteoric water line can be calculated using the standard formula for the distance between an x,y point and a line.

$$distance = \frac{abs(Ax + By + C)}{\sqrt{A^2 + B^2}}$$

In this case, x is ^{18}O, y is ^{2}H, and the line is the global meteoric water line $y = 8x + 10$. Re-writing the line formula as $-8x + y - 10 = 0$ yields the constants; A = -8, B = 1 and C = -10. In the plot, the more heterogeneous units (APPZ and LFA) are further discretized using a numeric suffix to indicate a contiguous flow zone, and the letter C to indicate lower-permeability materials. For example, APPZ_1 and APPZ_2 are the two significant production zones within the APPZ unit, and APPZ_1C is the lower-permeability rock underlying APPZ_1. The OSF-113 samples are an average distance of 0.3 per mil from the global meteoric water line, and 90% of the samples are within 0.46 per mil of the global meteoric water line. The two samples from the deepest producing interval penetrated within the LFA (1,870 to 1,930 ft bls) are significant outliers. These two samples, which were below the underground source of drinking water, experienced considerably more evaporation prior to recharge than the rest of the data set and approach 100% seawater. It also is noteworthy that APPZ_1, the uppermost permeable zone of the APPZ, experienced greater evaporative effects than the deeper zone.

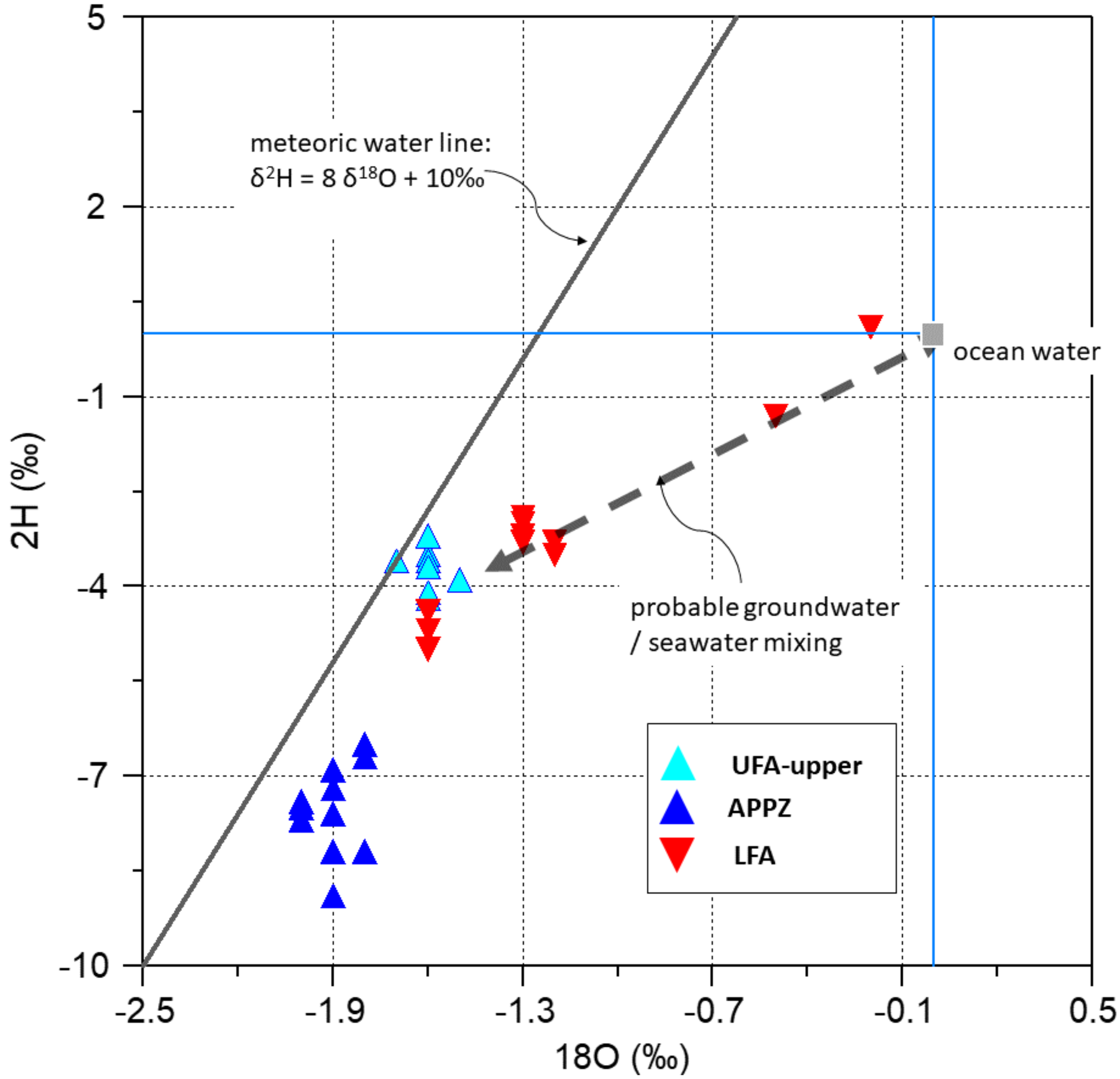

Figure 15. Stable isotopic ratios of ^{2}H and ^{18}O from OSF-113 aquifers.

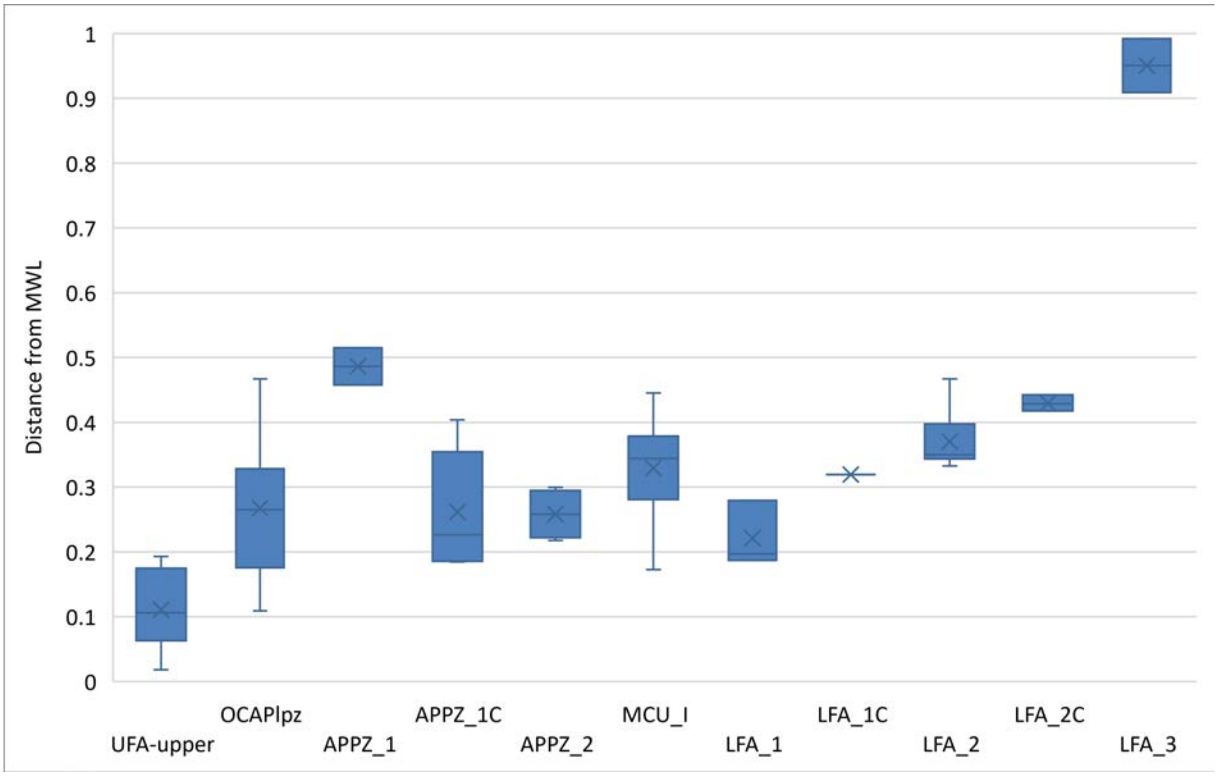

Figure 16. Range of deviation between measured ^{18}O and ^{2}H isotope ratios and the global meteoric water line as a function of hydrogeologic unit within OSF-113.

Geophysical Logging

Borehole geophysical logs collected during the construction of OSF-113 and earlier construction of OSF-52 are listed in **Table 11**. Geophysical logging was conducted in the corehole after each stage of OSF-113 drilling and following reaming of the borehole prior to casing installations. The logs provide a continuous record of physical properties of the subsurface formations and the fluids they contain. The log data were used to assist with casing seat selection and lithologic determination, to identify potential production and confining zones, and to assist in correlation among the wells. All log depth intervals are recorded as feet below land surface. A complete data set of the logs collected at this site is provided in **Appendix C**. Brief descriptions of the key information provided by the logging program are in the following subsections.

Table 11. Geophysical log inventory for the S65 Locks site.

	OSF-52		OSF-113					
Date	10-Jun-82	15-Feb-18	21-Jan-19	28-Mar-19	07-May-19	02-May-19	02-Jul-19	02-Jul-19
Logging Company	SFWMD	Baker	ABS	Baker	Baker	USGS	Baker	USGS
Interval (ft bls)	0-851	174-880	0-250	0-1,417	0-1,417	235-1,420	1,383-2,000	1,383-2,000
Caliper	✓	✓	✓	✓	✓		✓	
Natural Gamma	✓	✓	✓	✓	✓		✓	
Normal Resistivity	✓	✓	✓	✓	✓		✓	
Dual Induction/ Spontaneous Potential		✓		✓	✓		✓	
Neutron Porosity	✓							
Sonic Porosity		✓	✓		✓			
Flow Meter	✓							
Temperature	✓	✓		✓	✓		✓	
Fluid Resistivity	✓	✓		✓	✓		✓	
Downhole Video		✓			✓			
Optical Borehole Imaging						✓		✓

ABS = Advanced Borehole Services; Baker = RMBaker LLC; ft bls = feet below land surface; SFWMD = South Florida Water Management District; USGS = United States Geological Survey.
✓ Collected under pumped flow conditions.
✓ Collected under static flow conditions.

Logging of OSF-52

When the S65 Locks site was selected as a potential CFWI LFA drill site, existing well OSF-52 was logged to confirm its construction, assess the condition of the casing, and determine whether the open-hole interval intersected the APPZ as well as the UFA-upper. This well had not been entered since it was logged in 1982, over 35 years previously. The well casing was found to be in good condition, but downhole video showed a curious phenomenon. The well was entirely unobstructed during the original logging event in 1982, but during video logging in 2018, massive tubular mineral growths were found to be blocking the borehole near the base of the casing (**Figure 17**). The minerals were fragile and broke easily under the weight of the camera. A small piece of the unknown mineral was caught in the camera light fixture and returned to the surface with that instrument. The sample (**Figure 18**) was sent to the Florida Geological Survey for identification. The sample was examined via scanning electron microscope energy dispersive x-ray spectroscopy and identified as a strontian aragonite with various amounts of magnesium, chlorine, calcium, and zinc (**Appendix G**). At the time of the analysis, the Florida Geological Survey qualified the result that it might be falsely identifying silica as strontium, as the first energy dispersive x-ray spectroscopy peaks of those two elements overlap. Strontium was judged to be more likely because of the association with calcium and magnesium, which were common in the sample (C. Albritton, Florida Geological Survey, personal communication, April 1, 2020). The unusually high levels of strontium found in water samples from OSF-113 support the energy dispersive x-ray spectroscopy interpretation.

Figure 17. Tubular mineral growth crisscrossing the borehole below the base of the casing during downhole video logging of OSF-52 in February 2018.

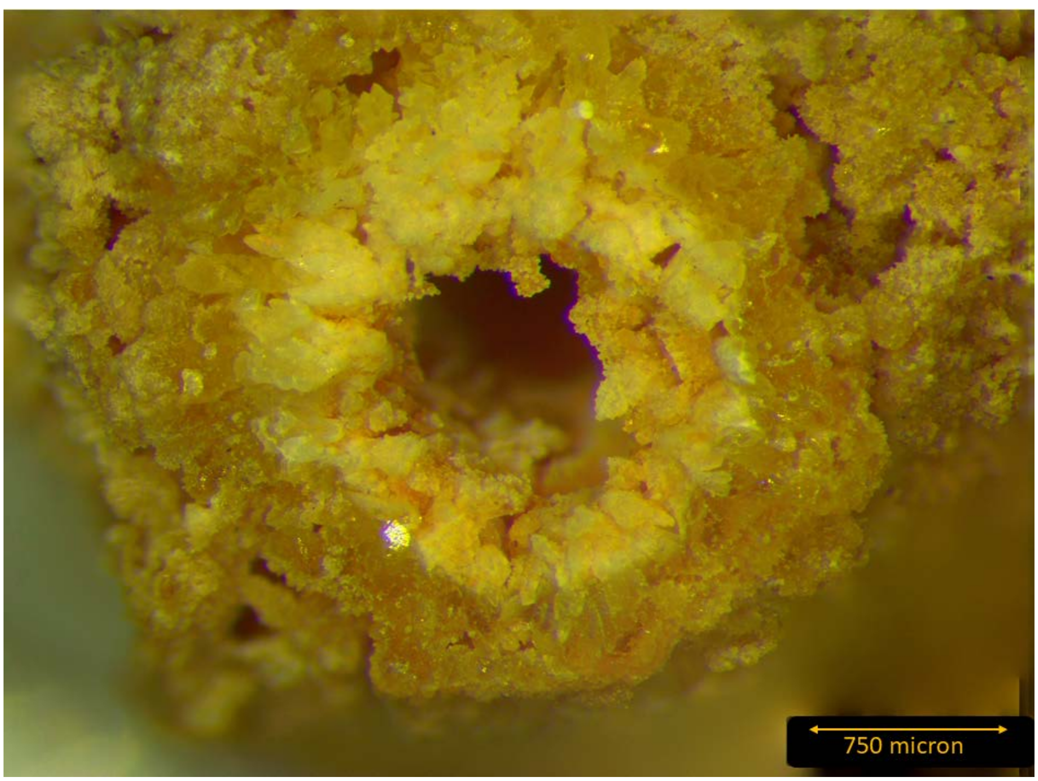

Figure 18. Overlaid color microscope image of the OSF-52 mineral sample showing tubular structure (Photo courtesy of Casey Albritton, Florida Geologic Survey).

Logging of OSF-113

High levels of radioactive phosphate in the Hawthorn Group produced large spikes on the natural gamma log in OSF-113 from 174 to approximately 275 ft bls. Gamma readings in the region average 128 counts per second, with spikes up to 585 counts per second. Below 275 ft bls, there is an abrupt downshift in the natural gamma associated with the clean limestones of the Ocala Formation. This drop in gamma is accompanied by large rounded deviations in the caliper log indicative of poorly indurated rock. The pattern of low gamma and wallowed caliper persists to a depth of 869 ft bls. In contrast to the Hawthorn Group, the mean gamma in this region is 14 counts per second, with a maximum of only 40 counts per second.

At 869 ft bls, there are abrupt shifts in multiple logs. The gamma increases by 160%, while the caliper indicates a gauge borehole. The dual induction log shows a 250% increase in formation resistivity. There is a major drop in sonic porosity as well, but it is not continuous here. Sonic velocity switches from continuous slow returns to a cycle-skipping pattern indicative of fractured, low-porosity rock. These changes correspond to the top of the “upper dolostone unit” of Williams and Kuniansky (2015), a distinct high-resistivity, low-porosity unit near the top of the Avon Park Formation throughout the CFWI area. This unit is an important log correlation marker in the FAS. At OSF-113, it coincides with the top of the APPZ. This pattern of high resistivity and low porosity extends from 869 to 1,210 ft bls. Between 869 and 898 ft bls, the conductance log increases abruptly from 1,300 to 3,900 microsiemens per centimeter.

From 1,210 to 1,417 ft bls, the overlying pattern is inverted to one of low resistivity and high porosity. The caliper log is slightly enlarged through this interval, and specific conductance begins to climb as well. Below 1,417 ft bls, porosity logs are not available due to the small diameter of the corehole, which prohibited use of the sonic porosity tool. From 1,420 to 1,540 ft bls, there is a major jump in formation resistivity from a mean of 27 to 93 ohm-meters on the dual induction log, and a 54% increase in gamma activity as well. Some fracturing is visible in the caliper log, and there is a slight freshening in the conductance log.

From 1,540 to approximately 1,900 ft bls, the borehole is characterized by alternating massive low-resistivity units with thinner beds of higher-resistivity rock. Between 1,880 and 1,890 ft bls, the conductance log increases from 12,000 to >40,000 microsiemens per centimeter. The induction log resistivity is suppressed below this point due to saline water occupying the formation. Duncan et al. (1994) first noted a distinctive gamma log signature from an interbedded series of wackestone and dolostone near the top of the Oldsmar Formation. That study associated the gamma signature with the presence of glauconite, clay, and collophane accessory minerals within the rock assemblage and made use of it to correlate the wells across the Brevard and Indian River counties study area. Duncan et al. (1994) referred to the gamma signature as the glauconitic zone marker. This gamma signature is present near the base of OSF-113, the most consistently recognizable point is found at a depth of 1,972 ft bls.

Core Analysis

Thirteen cores were shipped to Core Lab in Houston, Texas, for conventional core analysis. Samples were analyzed for porosity, permeability, and grain density (**Table 12**).

Table 12. Core Lab results.

Sample Number	Depth (ft bls)	Porosity (%)	Permeability		Grain Density (g/cm^3)
			Klinkenberg (ft/day)	Kair (ft/day)	
1V	821.52 – 821.80	42.39	5.03	5.33	2.705
1H	821.86	44.50	10.26	12.70	2.706
2V	835.58 – 835.86	43.41	3.85	4.02	2.704
2H	835.50	43.26	4.18	4.33	2.708
3V	845.66 – 845.80	36.50	2.50	3.44	2.699
3H	845.62	34.06	1.69	2.34	2.700
4V	1,030.80 – 1,031.10	7.55	N/A	N/A	2.816
4H	1,030.85	36.20	2.49	2.71	3.478
5V	1,032.72 – 1,033.00	40.28	5.35	6.64	2.823
5H	1,032.67	41.40	10.99	12.95	2.823
6V	1,040.73 – 1,040.90	30.12	0.04	0.06	2.817
6H	1,040.68	42.56	35.11	35.39	2.885
7V	1,336.00 – 1,336.40	31.92	0.07	0.09	2.841
7H	1,336.17	27.90	0.07	0.08	2.838
8V	1,366.33 – 1,366.70	13.23	0.00	0.01	2.811
8H	1,366.28	13.70	0.12	0.15	2.792
9V	1,369.60 – 1,369.80	30.81	0.01	0.01	2.833
9H	1,396.83	29.60	0.01	0.01	2.835
10V	1,422.35 – 1,422.60	30.71	0.09	0.10	2.828
10H	1,422.20	33.55	0.26	0.31	2.823
11V	1,439.50 – 1,440.00	29.29	0.02	0.02	2.841
11H	1,439.80	30.17	0.01	0.02	2.841
12V	1,782.72 – 1,783.00	18.68	0.01	0.01	2.798
12H	1,782.68	25.18	0.12	0.15	2.778
13V	1,788.20 – 1,788.50	28.16	0.46	0.62	2.754
13H	1,788.10	27.60	0.60	0.86	2.747

bls = below land surface; ft = foot; g/cm^3 = grams per cubic centimeter; N/A = not available.

Porosity was high (25% to 45%) in most of the measured core samples. Lower porosity values (13% to 19%) were found in samples from 1,366.28 to 1,366.70 ft bls and from 1,782.72 to 1,783.00 ft bls. Permeability was higher than 1 ft/day in all core samples between 821.52 and 1040.68 ft bls and lower than 1 ft/day in all samples between 1,040.73 and 1,788.50 ft bls.

Both porosity (**Figure 19**) and permeability (**Figure 20**) decreased with depth in the cores. None of the core samples sent to Core Lab were associated with flow zones identified during packer tests (**Figure 8**), which may explain the lower permeability found within the core samples, particularly deeper than the APPZ, where permeability generally is associated with secondary porosity rather than primary porosity, a common feature in the dolomites and dolomitic limestones in the FAS (Duerr 1995). The decrease in porosity and permeability occurs as the rock units shift from being primarily limestone around 820 to 850 ft bls to primarily dolostone throughout the rest of the formation.

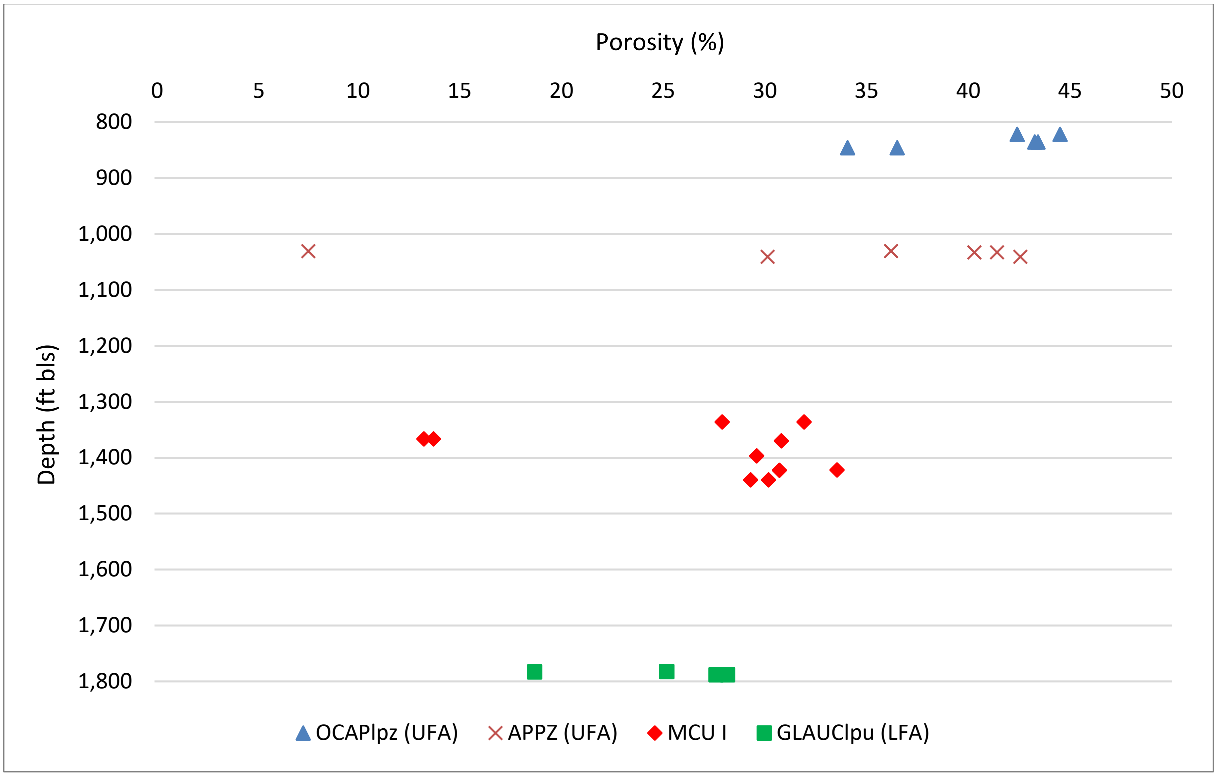

Figure 19. Core Lab porosity data.

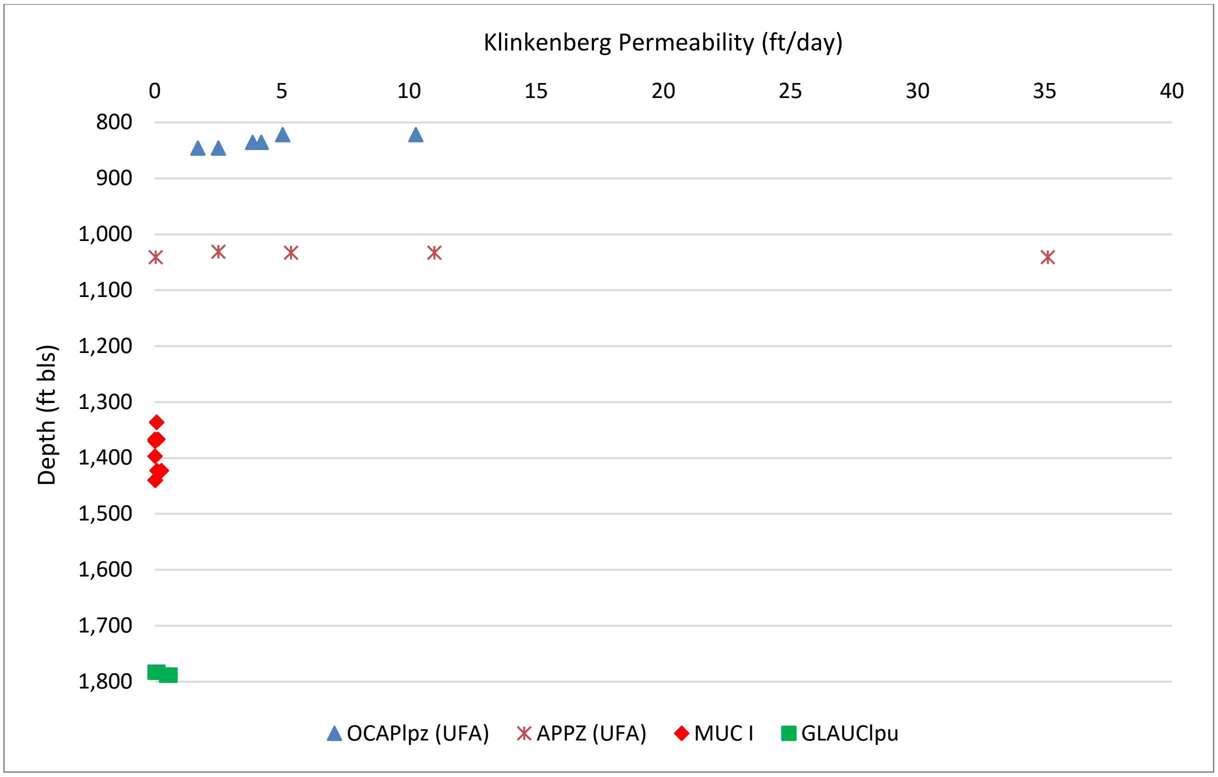

Figure 20. Core Lab permeability data.

In addition to the samples shown in **Table 12**, several samples were selected for XRD and petrographic analysis with specific geochemical objectives. Water quality samples taken at OSF-113 showed strontium levels from 700 to 1,300 ft bls were more than three times greater, on average, than the rest of the core (39.9 mg/L compared to 10.7 mg/L, respectively). Celestine, a strontium sulfate mineral found in buried marine carbonates, was hypothesized to be the primary factor behind the high strontium values observed. Celestine has been observed in the Avon Park Formation in other cores taken in Florida (McCartan et al. 1992; Richardson et al. 2020). Thin-sections were taken from two core samples within the interval with high strontium concentrations and further analyzed via XRD for celestine presence.

The top of the Oldsmar Formation often is characterized by the presence of a glauconitic horizon and a distinctive gamma log signature that provides a helpful marker for correlating between wells. Glauconite was identified in trace amounts in multiple hand samples from OSF-113. Because of the small size of the grains, this visual identification was primarily based on color, making a more quantitative confirmation of this identification desirable. Glauconite is not readily distinguished by XRD. To determine presence of glauconite and quantify the approximate location of the glauconitic marker, three petrographic thin-sections were taken from basal core depths and analyzed for the presence of glauconite. Celestine was identified in an XRD sample at 1,030.85 ft bls at 50.6% by weight. Glauconite was identified in petrographic thin-sections, with samples at 1,964.15 and 19,77.45 ft bls having more than 4% glauconite by area of thin-section and a sample at 1,990.80 ft bls having 1% glauconite by area of thin-section. A complete report of the Core Lab analyses is provided in **Appendix F**.

Water Levels

Changes in water level with depth are the most reliable indication that there has been a breach of confinement during drilling. Referenced water levels generated from static DTW measured during packer testing are presented in **Figure 21** and **Table 13**. The blue points show the absolute water level from OSF-113 packer testing. Because these measurements were recorded over approximately 5 months (February 5 to June 24, 2019), it is necessary to differentiate between regional changes in water level over this time, which affect all units of the FAS, and those related solely to changes in depth, which should be discernable from the packer test data.

To this end, a nearby offsite FAS monitor well, POF-23, was used as a control well, indicating regional influences on FAS water levels. The orange points are water level readings from POF-23 at the same date and time of each OSF-113 packer test reading. POF-23, located 3.7 miles southwest of OSF-113, is open to the UFA-upper. This is the same hydrogeologic unit to which OSF-113 was open at the beginning of coring operations. The difference between the two water levels (black squares) best reflects depth-related change. There is a median difference of 0.975 ft for all the packer test results.

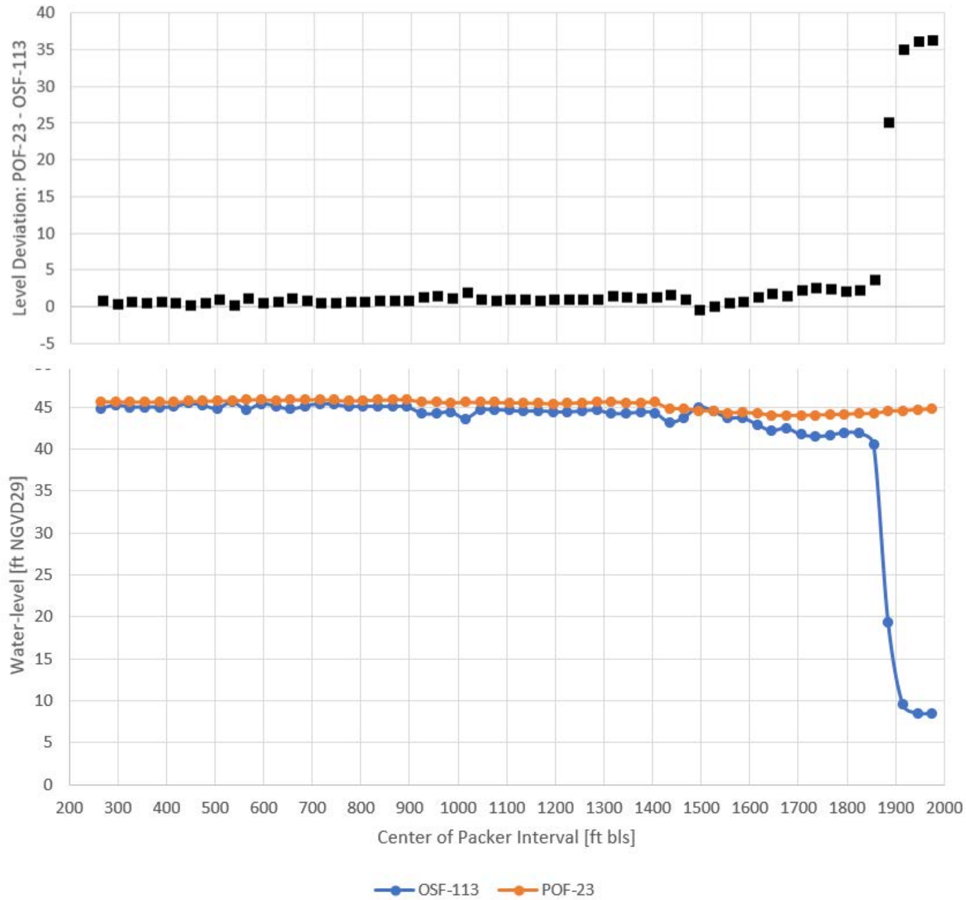

Figure 21. Depth-specific water levels from packer testing in OSF-113, relative to time-variant changes in water level from offsite monitor well POF-23. The black squares represent the deviation (in feet) between the two water level data sets (POF-23 minus OSF-113).

Table 13. Water level variation with depth in OSF-113 from off-bottom packer testing.
[Δ Median (ft) = Level Deviation – 0.975 ft (median of Level Deviation)]

Packer #	Center Depth (ft bls)	Water Level (ft NGVD29)			Level Deviation ■ (ft)	Δ Median (ft)*
		● OSF-113	● POF-23	OSF-52		
1	265	44.81	45.69	45.48	0.9	-0.10
2	295	45.22	45.61	45.40	0.4	-0.59
3	325	45.00	45.65	--	0.6	-0.32
4	355	45.00	45.60	45.37	0.6	-0.37
5	385	44.97	45.63	45.42	0.7	-0.32
6	415	45.02	45.57	45.36	0.5	-0.43
7	445	45.42	45.70	45.48	0.3	-0.69
8	475	45.18	45.72	45.49	0.5	-0.43
9	505	44.80	45.76	45.50	1.0	-0.02
10	535	45.60	45.78	45.55	0.2	-0.79
11	565	44.69	45.85	45.62	1.2	0.18
12	595	45.39	45.93	45.70	0.5	-0.43
13	625	45.08	45.81	45.54	0.7	-0.25
14	655	44.75	45.90	45.66	1.2	0.18

Packer #	Center Depth (ft bls)	Water Level (ft NGVD29)			Level Deviation ■ (ft)	Δ Median (ft)*
		● OSF-113	● POF-23	OSF-52		
15	685	45.09	45.87	45.62	0.8	-0.20
16	715	45.39	45.93	45.68	0.5	-0.43
17	745	45.28	45.83	45.57	0.5	-0.43
18	775	45.05	45.74	45.47	0.7	-0.29
19	805	45.09	45.81	45.56	0.7	-0.25
20	835	45.07	45.87	45.61	0.8	-0.18
21	865	45.04	45.89	45.63	0.8	-0.13
22	895	45.02	45.92	45.63	0.9	-0.07
23	925	44.25	45.63	45.12	1.4	0.41
24	955	44.19	45.61	45.10	1.4	0.44
25	985	44.42	45.52	45.13	1.1	0.13
26	1,015	43.61	45.61	--	2.0	1.03
27	1,045	44.61	45.56	--	0.9	-0.03
28	1,075	44.67	45.56	45.30	0.9	-0.08
29	1,105	44.59	45.55	45.20	1.0	-0.02
30	1,135	44.48	45.50	45.12	1.0	0.04
31	1,165	44.54	45.46	45.20	0.9	-0.06
32	1,195	44.43	45.41	45.16	1.0	0.00
33	1,225	44.39	45.47	45.23	1.1	0.11
34	1,255	44.52	45.54	45.26	1.0	0.04
35	1,285	44.62	45.59	45.32	1.0	0.00
36	1,315	44.23	45.65	45.38	1.4	0.44
37	1,345	44.23	45.55	45.17	1.3	0.34
38	1,375	44.37	45.55	45.23	1.2	0.20
39	1,405	44.30	45.56	45.28	1.3	0.29
40	1,435	43.15	44.83	44.55	1.7	0.70
41	1,465	43.74	44.82	44.53	1.1	0.11
42	1,495	44.99	44.56	44.24	-0.4	-1.41
43	1,525	44.49	44.51	44.22	0.0	-0.96
44	1,555	43.69	44.28	43.95	0.6	-0.39
45	1,585	43.70	44.33	44.03	0.6	-0.35
46	1,615	42.92	44.23	43.93	1.3	0.33
47	1,645	42.15	43.99	43.62	1.8	0.86
48	1,675	42.49	43.94	43.57	1.5	0.47
49	1,705	41.71	43.94	43.60	2.2	1.26
50	1,735	41.49	44.01	43.70	2.5	1.55
51	1,765	41.62	44.05	43.73	2.4	1.45
52	1,795	41.95	44.10	43.80	2.2	1.18
53	1,825	41.84	44.19	43.90	2.3	1.38
54	1,855	40.57	44.21	43.88	3.6	2.67
55	1,885	19.39	44.47	44.18	25.1	24.11
56	1,915	9.53	44.58	44.25	35.1	34.08
57	1,945	8.49	44.67	44.38	36.2	35.21
58	1,975	8.44	44.77	44.49	36.3	35.36

bls = below land surface; ft = foot; NGVD29 = National Geodetic Vertical Datum of 1929.
* Blue intensity increases with distance below the median, and red intensity increases with distance above the median.

In **Table 13**, the last column notes the difference between the median water level deviation between the packer test value and the control well (POF-23) for all tests and the level deviation from an individual test. This field is colored to highlight trends in the data with depth; white fields are closest to the median, blue intensity marks distance below the median, and red intensity distance above.

Above 1,480 ft bls (packer test #42), water levels are consistently within 0.5 ft of the median. Within this interval, there is a trend in the data. The shallower tests (1 to 22) tend to be slightly below the median (closer to POF-23 levels), while the deeper tests (23 to 41) are at or slightly above the median (farther from POF-23 levels). When packer testing penetrates the LFA, there is an abrupt reversal in this trend, with test #42 showing a 1.5-ft increase in head. There is a gradual decline in head below this point (packer tests #43 to #54), with a commensurate increase in salinity. The deepest tests (55 to 58) are notable outliers in the data set. Between packer tests #54 and #55, there is a 20-ft drop in head and an additional 10-ft drop between tests #55 and #56). Water levels in tests #56 and #57 are more than 35 ft lower than POF-23.

OSF-113 was completed with an open interval from 1,450 to 1,580 ft bls, represented by packer tests #41 to #45. The largest negative difference in median head (-1.41 ft) was at 1,495 ft bls, corresponding to the uppermost portion of the open interval of OSF-113 in the LFA-upper. While awaiting permanent SCADA installation, a temporary data logger was deployed in OSF-113 for approximately 5 months (September 11, 2019 to February 3, 2020). The data were compared with the same period of record at OSF-52 and adjacent SAS well OSS-72 to evaluate the vertical head gradients at the site (**Figure 22**). Based on the packer test data, water levels in the completed well were expected to be very similar, within 0.5 ft OSF-52, but the difference was slightly greater. Results from the temporary data logger deployment indicate an upward head gradient, with a median difference of 1.1 ft between the UFA (OSF-52) and LFA-upper (OSF-113).

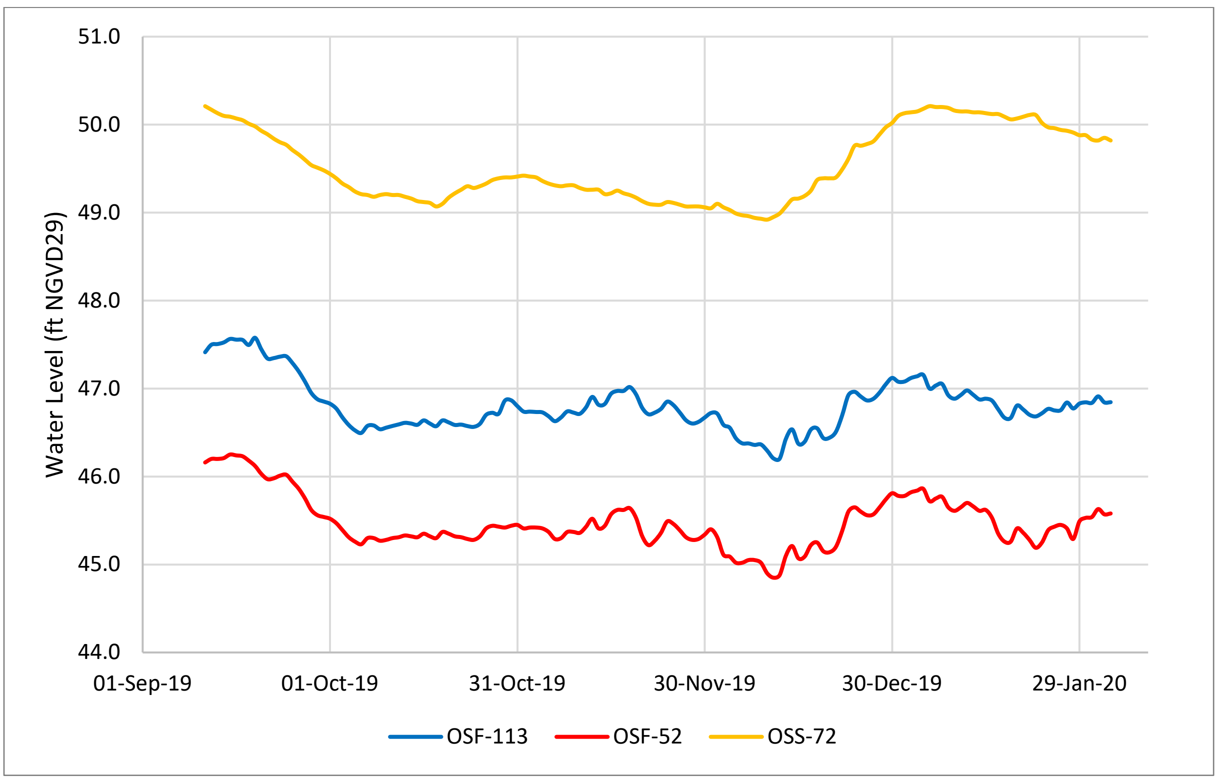

Figure 22. Mean daily water levels from monitored aquifers at the S65 Locks site after completion of OSF-113 (LFA-upper; 1,450 to 1,580 ft bls), OSS-72 (SAS 105 to 120 ft bls), and OSF-52 (UFA-upper; 172 to 880 ft bls).

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APPENDICES

APPENDIX A:
WELL CONSTRUCTION SUMMARY

Date From	Date To	Activity	Site Geologist
14-Jan-19	17-Jan-19	Huss Drilling rig mobilization. Install temporary water supply well. Standard penetration test to 84 ft bls and set temporary 6-inch casing. Drill 6-inch mud-rotary pilot hole from 84 to 250 ft bls. Condition borehole for logging.	J. Janzen
21-Jan-19	24-Jan-19	Advanced Borehole Services log 6-inch pilot hole to 250 ft bls. Ream 20-inch borehole to 81 ft bls and install 16-inch steel surface casing and grout to land surface.	E. Richardson
28-Jan-19	31-Jan-19	Ream 15-inch nominal borehole to 235 ft bls. Install 235 ft of 10-inch polyvinyl chloride (PVC) conductor casing and grout to land surface.	L. Lindstrom
4-Feb-19	8-Feb-19	Drill out cement plug, and ream from 235 ft to previously drilled depth of 250 ft bls. Beginning of coring operations. Core and packer test from 250 to 430 ft bls.	K. Smith
11-Feb-19	14-Feb-19	Core and packer test from 430 to 580 ft bls.	S. Krupa
18-Feb-18	22-Feb-19	Core and packer test from 580 to 760 ft bls. At 740 ft bls, begin to have trouble with plugging of the annular space. Core casing pulled and corehole air-lifted to remove fallen cuttings material. Note: Kevin says lost circulation below 690 ft bls.	E. Richardson
25-Feb-19	1-Mar-19	Install nominal 4-inch temporary casing to 600 ft bls. Core and packer test from 760 to 880 ft bls, complete partial core to 899 ft bls.	K. Smith
4-Mar-19	8-Mar-19	Core and packer test from 889 to 1,060 ft bls.	L. Lindstrom
11-Mar-19	15-Mar-19	Core and packer test from 1,060 to 1,210 ft bls.	K. Smith
18-Mar-19	22-Mar-19	Core and packer test from 1,210 to 1,360 ft bls. Complete core from 1,360 to 1,390 ft bls and air-lift in preparation for packer testing.	S. Krupa
25-Mar-19	29-Mar-19	Packer test from 1,360 to 1,390 ft bls, then core and packer test from 1,390 to 1,420 ft bls, base of Phase I of coring operations. Huss pulls the core casing and prepares the borehole for geophysical logging. RM Baker mobilizes to the site to run narrow-gauge geophysical logs. Fluid logs ran from the temporary casing (600 ft) to total depth without incident, but the resistivity tool was blocked from advancement at 1,095 ft bls. No other tools could pass this point. To clear the borehole, Huss tripped back in with the core casing to total depth, then pulled back to just below the blocked portion of the borehole. Induction resistivity logs were run through the core casing to total depth to provide a complete resistivity profile of the corehole.	E. Richardson
1-Apr-19	5-Feb-19	Huss pulls the temporary 4-inch casing from the borehole and mobilizes to the site with the Versadrill rig for reverse-air reaming of the corehole from 4-inch to 10-inch diameter.	--

Date From	Date To	Activity	Site Geologist
7-May-19	8-May-19	RM Baker logged the 10-inch borehole from 250 to 1,420 ft bls, with standard logging suite. Static spinner flowmeter was conducted, but it was later determined the flowmeter was malfunctioning, so the log was discarded. Following this, Mike Wacker of the United States Geological Survey mobilized to the site and conducted an optical borehole imaging log on the borehole.	S. Krupa
9-May-19	17-May-19	Huss installs temporary 5-inch and interior 4-inch casing to total reamed depth (1,420 ft bls)	--
20-May-19	24-May-19	Core and packer tests (tests 40-43) from 1,420 to 1,540 ft bls.	J. Janzen
27-May-19	31-May-19	Core and packer tests (tests 44-46) from 1,450 to 1,640 ft bls.	E. Richardson
3-Jun-19	7-Jun-19	Core and packer tests (tests 47-51) from 1,640 to 1,780 ft bls.	K. Smith
10-Jun-19	14-Jun-19	Core and packer tests (tests 52-54) from 1,780 to 1,870 ft bls.	S. Krupa
17-Jun-19	18-Jun-19	Core and packer test (test 55) from 1,870 to 1,900 ft bls. Continue coring to 1,930 ft bls and air-develop. Significant head drop below 1,870 ft bls.	L. Lindstrom
19-Jun-19	21-Jun-19	Complete packer tests 56 and 57, and continue coring to 1,990 ft bls.	E. Richardson
24-Jun-19	25-Jun-19	Packer test from 1,960 to 1,990 ft bls, continue coring to total depth of 2,000 ft bls. Huss develops borehole in preparation for logging. The logger was not available until July 1, 2019, so work on hold until then.	E. Richardson
1-Jul-19	2-Jul-19	RM Baker logged the 4-inch corehole from 1,420 to 2,000 ft bls, with narrow-gauge logging suite. Following this, Mike Wacker of the United States Geological Survey mobilized to the site and conducted an optical borehole imaging log on the borehole.	S. Coonts
3-Jul-19		Huss re-installed core casing in preparation for borehole backfill, then broke for Independence Day holiday.	--
4-Jul-19	5-Jul-19	NO WORK - INDEPENDENCE DAY HOLIDAY BREAK	
7-Aug-19	11-Jul-19	Backfill corehole from 2,000 to 1,580 ft bls. 1.5 yards of gravel plus 49 sacks of neat cement grout.	K. Smith
15-Jul-19	26-Jul-19	Huss removed temporary 5-inch and 4-inch casings, and ream 10-inch nominal borehole from 1,420 to 1,454 ft bls. Borehole was cleared out from the ream and conditioned for casing installation. Work halted to await availability of fiberglass-reinforced plastic installers.	--

Date From	Date To	Activity	Site Geologist
30-Jul-19	2-Aug-19	1,450 ft of nominal 4.5-inch Red Box 1500 fiberglass-reinforced plastic tubing (3.98-inch inner diameter) installed in OSF-113. Cement baskets opened with 5 bags of pea gravel and 20 sacks of neat cement.	S. Krupa
5-Aug-19	9-Aug-19	Tremie grout fiberglass-reinforced plastic tubing from 1,424 to 835 ft bls.	E. Geddes
12-Aug-19	20-Aug-19	Tremie grout fiberglass-reinforced plastic tubing from 835 to 85 ft bls, then gravel to 72 ft bls.	K. Smith
21-Aug-19	21-Aug-19	Well development (2.5 hours) and complete well pad installation.	S. Coonts

APPENDIX B:
WELL COMPLETION REPORTS

49WP 19148556

STATE OF FLORIDA PERMIT APPLICATION TO CONSTRUCT, REPAIR, MODIFY, OR ABANDON A WELL

☐ Southwest
☐ Northwest
☐ St. Johns River
☐ South Florida
☐ Suwannee River
☐ DEP
☒ Delegated Authority (If Applicable) Osceola

PLEASE FILL OUT ALL APPLICABLE FIELDS
(*Denotes Required Fields Where Applicable)

The water well contractor is responsible for completing this form and forwarding the permit application to the appropriate delegated authority where applicable.

Permit No.
Florida Unique ID
Permit Stipulations Required (See Attached)
62-524 Quad No. ______ Delineation No. ______
CUP/WUP Application No. ______
ABOVE THIS LINE FOR OFFICIAL USE ONLY

1. SFWMD 600 Brickell Ave Ste 1570 Miami FL 33131
*Owner, Legal Name if Corporation *Address *City *State *ZIP Telephone Number
2. 26000 E SR 60 Okeechobee, FL 34972
*Well Location - Address, Road Name or Number, City
3. 131310000003 0000
*Parcel ID No. ☒ (PIN) or ☐ Alternate Key Lot Block Unit
4. ______ Check if 62-524: ☐ Yes ☐ No
*Section or Land Grant *Township *Range *County Subdivision
5. Stephanie Stallsmith 9342 352-567-9500 Stephanie@hessdrilling.com
*Water Well Contractor *License Number *Telephone Number E-mail Address
6. 35920 State Road 52 Dade City FL 33525
*Water Well Contractor's Address City State ZIP
7. *Type of Work: ☒ Construction ☐ Repair ☐ Modification ☐ Abandonment ______
*Reason for Repair, Modification, or Abandonment
8. *Number of Proposed Wells 1
9. *Specify Intended Use(s) of Well(s):
☐ Domestic ☐ Landscape Irrigation ☐ Agricultural Irrigation ☐ Site Investigations
☐ Bottled Water Supply ☐ Recreation Area Irrigation ☐ Livestock ☐ Monitoring
☐ Public Water Supply (Limited Use/DOH) ☐ Nursery Irrigation ☒ Test
☐ Public Water Supply (Community or Non-Community/DEP) ☐ Commercial/Industrial ☐ Earth-Coupled Geothermal
☐ Class I Injection ☐ Golf Course Irrigation ☐ HVAC Supply
☐ HVAC Return
Class V Injection: ☐ Recharge ☐ Commercial/Industrial Disposal ☐ Aquifer Storage and Recovery ☐ Drainage
Remediation: ☐ Recovery ☐ Air Sparge ☐ Other (Describe) ______
☐ Other (Describe)

Date Stamp

Official Use Only

10. *Distance from Septic System if ≤ 200 ft. ______ 11. Facility Description Dam for River 12. Estimated Start Date 1/2K/19
13. *Estimated Well Depth 1850 *Estimated Casing Depth 1400 ft. Primary Casing Diameter 4 in. Open Hole: From 1400 To 1850 ft.
14. Estimated Screen Interval: From ______ To ______ ft.
15. *Primary Casing Material: ☐ Black Steel ☐ Galvanized ☒ PVC ☐ Stainless Steel
☐ Not Cased ☐ Other ______
16. Secondary Casing: ☐ Telescope Casing ☐ Liner ☒ Surface Casing Diameter 16, 10 in.
17. Secondary Casing Material: ☒ Black Steel ☐ Galvanized ☒ PVC ☐ Stainless Steel ☐ Other ______
18. *Method of Construction, Repair, or Abandonment: ☐ Auger ☐ Cable Tool Jetted ☒ Rotary ☐ Sonic
☐ Combination (Two or More Methods) ☐ Hand Driven (Well Point, Sand Point) ☐ Hydraulic Point (Direct Push)
☐ Horizontal Drilling ☐ Plugged by Approved Method ☐ Other (Describe) ______
19. Proposed Grouting Interval for the Primary, Secondary, and Additional Casing:
From 0 To 1400 Seal Material (☐ Bentonite ☒ Neat Cement ☐ Other ______)
From ______ To ______ Seal Material (☐ Bentonite ☐ Neat Cement ☐ Other ______)
From ______ To ______ Seal Material (☐ Bentonite ☐ Neat Cement ☐ Other ______)
From ______ To ______ Seal Material (☐ Bentonite ☐ Neat Cement ☐ Other ______)
20. Indicate total number of existing wells on site ______ List number of existing unused wells on site Ø
21. *Is this well or any existing well or water withdrawal on the owner's contiguous property covered under a Consumptive/Water Use Permit (CUP/WUP) or CUP/WUP Application? Yes (No) If yes, complete the following: CUP/WUP No. ______ District Well ID No. ______
22. Latitude ______ Longitude ______
23. Data Obtained From: ☐ GPS ☐ Map ☐ Survey Datum: ______ NAD 27 ______ NAD 83 ______ WGS 84

I hereby certify that I will comply with the applicable rules of Title 40, Florida Administrative Code, and that a water use permit or artificial recharge permit, if needed, has been or will be obtained prior to commencement of well construction. I further certify that all information provided in this application is accurate and that I will obtain necessary approval from other federal, state, or local governments, if applicable. I agree to provide a well completion report to the District within 30 days after completion of the construction, repair, modification, or abandonment authorized by this permit, or the permit expiration, whichever occurs first.

I certify that I am the owner of the property, that the information provided is accurate, and that I am aware of my responsibilities under Chapter 373, Florida Statutes, to maintain or properly abandon this well; or, I certify that I am the agent for the owner, that the information provided is accurate, and that I have informed the owner of their responsibilities as stated above. Owner consents to allowing personnel of the WMD or Delegated Authority access to the well site during the construction, repair, modification, or abandonment authorized by this permit.

[signature] 9342 [signature] 1/9/19
*Signature of Contractor *License No. *Signature of Owner or Agent *Date

Approval Granted By [signature] Issue Date 1-9-19 Expiration Date 7-9-19 Hydrologist Approval ______ Initials
Fee Received $ 175 — Receipt No. ______ Check No. CC

THIS PERMIT IS NOT VALID UNTIL PROPERLY SIGNED BY AN AUTHORIZED OFFICER OR REPRESENTATIVE OF THE WMD OR DELEGATED AUTHORITY. THE PERMIT SHALL BE AVAILABLE AT THE WELL SITE DURING ALL CONSTRUCTION, REPAIR, MODIFICATION, OR ABANDONMENT ACTIVITIES.

STATE OF FLORIDA WELL COMPLETION REPORT

☐ Southwest
☐ Northwest
☐ St. Johns River
☐ South Florida
☐ Suwannee River
☐ DEP
☒ Delegated Authority (If Applicable) Osceola

PLEASE, FILL OUT ALL APPLICABLE FIELDS
(*Denotes Required Fields Where Applicable)

Date Stamp

Official Use Only

1.*Permit Number 49WP1914856 *CUP/WUP Number ______ *DID Number ______ 62-524 Delineation No. ______

2.*Number of permitted wells constructed, repaired, or abandoned 1 *Number of permitted wells not constructed, repaired, or abandoned Ø

3.*Owner's Name SFWMD 4.*Completion Date 8/23/19 5. Florida Unique ID ______

6. 2600 E SR 60 Okeechobee, Fl. 34972
*Well Location - Address, Road Name or Number, City, ZIP

7. *County Osceola *Section ______ Land Grant ______ *Township ______ *Range ______

8. Latitude ______ Longitude ______

9. Data Obtained From: ___GPS ___Map ___Survey Datum: ___NAD 27 ___NAD 83 ___WGS 84

10.*Type of Work: X Construction ___Repair ___Modification ___Abandonment

11.*Specify Intended Use(s) of Well(s):
___Domestic ___Landscape Irrigation ___Agricultural Irrigation ___Site Investigation
___Livestock ___Monitoring
___Bottled Water Supply ___Recreation Area Irrigation ___Nursery Irrigation X Test
___Public Water Supply (Limited Use/DOH) ___Commercial/Industrial ___Earth-Coupled Geothermal
___Public Water Supply (Community or Non-Community/DEP) ___Golf Course Irrigation ___HVAC Supply
___Class I Injection ___HVAC Return
Class V Injection: ___Recharge ___Commercial/Industrial Disposal ___Aquifer Storage and Recovery ___Drainage
Remediation: ___Recovery ___Air Sparge ___Other (Describe) ______
___Other (Describe) ______

12.*Drill Method: ___Auger ___Cable Tool X Rotary ___Combination (Two or More Methods) ___Jetted ___Sonic ___Horizontal Drilling ___Hydraulic Point (Direct Push) ___Other ______

13.*Measured Static Water Level ______ ft. Measured Pumping Water Level ______ ft. After ______ Hours at ______ GPM

14.*Measuring Point (Describe) ______ Which is ___ft. ___Above ___Below Land Surface *Flowing: ___Yes ___No

15.*Casing Material: ___Black Steel ___Galvanized ___PVC ___Stainless Steel ___Not Cased X Other Fiberglass

16.*Total Well Depth 560 ft. Cased Depth 454 ft. *Open Hole: From 454 To 560 ft. *Screen: From ___ To ___ ft. Slot Size ___

17.*Abandonment: ___Other (Explain) ______
From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___

18.*Surface Casing Diameter and Depth:
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___

19.*Primary Casing Diameter and Depth:
Dia 4 in. From 0 ft. To 454 ft. No. of Bags 790 Seal Material (Check One): X Neat Cement ___Bentonite ___Other ___
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___

20.*Liner Casing Diameter and Depth:
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___

21.*Telescope Casing Diameter and Depth:
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___
Dia ___in. From ___ft. To ___ft. No. of Bags ___ Seal Material (Check One): ___Neat Cement ___Bentonite ___Other ___

22. Pump Type (If Known):
___Centrifugal ___Jet ___Submersible ___Turbine
Horsepower ______ Pump Capacity (GPM) ______
Pump Depth ___ft. Intake Depth ___ft.

23. Chemical Analysis (When Required):
Iron ___ppm Sulfate ___ppm Chloride ___ppm
___Laboratory Test ___Field Test Kit

24. Water Well Contractor:
*Contractor Name Stephanie Stallsmith License Number 9342 E-mail Address stephanie@hossdrilling.com
*Contractor's Signature [signature] *Driller's Name (Print or Type) Eddie Palmer
(I certify that the information provided in this report is accurate and true.)

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
2379 BROAD STREET, BROOKSVILLE, FL 34604-6899
PHONE: (352) 796-7211 or (800) 423-1476
WWW.SWFWMD.STATE.FL.US

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
4049 REID STREET, PALATKA, FL 32178-1429
PHONE: (386) 329-4500
WWW.SJRWMD.COM

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT
152 WATER MANAGEMENT DR., HAVANA, FL 32333-4712
(U.S. Highway 90, 10 miles west of Tallahassee)
PHONE: (850) 539-5999
WWW.NWFWMD.STATE.FL.US

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
P.O. BOX 24680
3301 GUN CLUB ROAD
WEST PALM BEACH, FL 33416-4680
PHONE: (561) 686-8800
WWW.SFWMD.GOV

SUWANNEE RIVER WATER MANAGEMENT DISTRICT
9225 CR 49
LIVE OAK, FL 32060
PHONE: (386) 362-1001 or (800) 226-1066 (Florida only)
WWW.MYSUWANNEERIVER.COM

***DRILL CUTTINGS LOG** (Examine cuttings every 20 ft. or at formation changes. Note cavities and depth to producing zone. Grain Size: F=Fine, M=Medium, and C=Coarse)

From (ft.)	To (ft.)	Color	Grain Size (F, M, C)	Material
0	10	Brown	F	Sand
10	20	Grey & Brown	F	Sand
20	60	grey	M	Sand
60	75	grey	m	Sand w/ shell
75	95	green	m	Clay
95	105	green	M	Clay w/ sand stringers
105	110	green		Rock w/ clay phosphate
110	130	green	m	clay & shell
130	175	green	H	clay
175	180	white	H	rock
180	230	green	H	clay
230	1424	white	H	Rock

Comme

FORM LEG-

APPENDIX C:
LITHOLOGIC DESCRIPTION

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
4.0	6.0	Fine quartz sand, brownish gray (5yr4/1); subangular; calcareous; non-cohesive
9.0	11.0	Fine quartz sand, brownish gray (5yr4/1); subangular; calcareous; non-cohesive; 30% silt; 5% phosphatic sand
14.0	16.0	Fine quartz sand, brownish gray (5yr4/1); subangular; calcareous; non-cohesive; 10% silt; 5% phosphatic sand
19.0	21.0	Fine quartz sand, brownish gray (5yr4/1); subangular; calcareous; non-cohesive; 10% silt; 5% phosphatic sand
24.0	26.0	Fine quartz sand, light olive gray (5yr6/1); subangular; calcareous; non-cohesive; 30% silt; 5% phosphatic sand
29.0	31.0	Fine quartz sand, brownish gray (5yr4/1); 10% silt; non-cohesive; phosphatic sand
34.0	36.0	Calcilutite, yellowish gray (5y8/1); non-cohesive; with quartz sand, shell, and phosphate
39.0	41.0	Calcilutite, yellowish gray (5y8/1); non-cohesive; with quartz sand, shell, and phosphate
44.0	46.0	Calcilutite, yellowish gray (5y8/1); non-cohesive; with quartz sand, shell, and phosphate
49.0	51.0	Silt and very fine sand; olive gray (5y4/1); calcareous with shell and phosphatic sand; non-cohesive
54.0	56.0	Silt and very fine sand; olive gray (5y4/1); calcareous with shell and phosphatic sand; non-cohesive
59.0	61.0	Silt and very fine sand; olive gray (5y4/1); calcareous with shell and phosphatic sand; non-cohesive
64.0	66.0	Silt and very fine sand; olive gray (5y4/1); calcareous with shell and phosphatic sand; non-cohesive
69.0	71.0	Sandy clay, olive gray (5y4/1); low plasticity; with quartz and phosphatic sand and shell fragments
74.0	76.0	Sandy clay, olive gray (5y4/1); low plasticity; with quartz and phosphatic sand and shell fragments
79.0	81.0	Silt and very fine sand; olive gray (5y4/1); calcareous with shell and phosphatic sand; non-cohesive
84.0	86.0	Very fine silty sand; olive gray (5y4/1); calcareous with shell, quartz and phosphatic sand; non-cohesive
86.0	90.0	Very fine silty sand; olive gray (5y4/1); calcareous with shell, quartz and phosphatic sand; non-cohesive
90.0	105.0	Very fine silty sand; olive gray (5y4/1); calcareous with shell, quartz and phosphatic sand; non-cohesive
105.0	125.0	Shell; light olive gray (5yr6/1); sand and gravel sized shell fragments with quartz and phosphatic sand
125.0	145.0	Silt and very fine sand; olive gray (5y4/1); calcareous with shell and phosphatic sand; low plasticity
145.0	175.0	Sandy clay, olive gray (5y4/1); moderate plasticity; with phosphatic sand and shell fragments
175.0	190.0	Limestone (wackestone); light olive gray (5yr6/10); low intergranular porosity; poor induration; with calcilutite, quartz, shells and phosphatic sand
190.0	200.0	Limestone (wackestone); olive gray (5y4/1); low intergranular porosity; poor induration; with calcilutite, quartz, shells, and phosphatic sand; 30% clayey sand
200.0	210.0	Limestone (wackestone); yellowish gray (5y4/1); low intergranular porosity; poor induration; with quartz, shells, and phosphatic sand; 30% clayey sand
210.0	215.0	Clayey sand; light olive gray (5yr6/10); 40% wackestone with shell and phosphatic sand
215.0	220.0	Limestone (wackestone); light olive gray (5yr6/10); low intergranular porosity; poor induration; with quartz, shells, and phosphatic sand; 30% clayey sand
220.0	235.0	Limestone (wackestone); yellowish gray (5y4/1); low intergranular porosity; poor induration; with quartz, shells, and phosphatic sand; 30% clayey sand
235.0	245.0	Calcilutite, yellowish gray (5y8/1); non-cohesive; with limestone, shell, and phosphate

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
245.0	250.0	Limestone (wackestone); medium gray (n5); low intergranular porosity; poor induration; with shell and phosphatic sand
250.0	265.7	Limestone (wackestone); medium gray (n5); moderate intergranular porosity, pinpoint vugular and moldic porosity; poor induration; with quartz and phosphatic sand; gastropods and bivalves
265.7	272.1	Limestone (wackestone); medium gray (n5); good intergranular porosity, vugular and moldic porosity; moderate induration; with quartz and phosphatic sand; gastropods and bivalves
271.1	280.0	No recovery
280.0	299.4	Limestone (wackestone); very pale orange (10yr 8/2); very pale orange (10yr 6/2); moderate intergranular and moldic porosity; poor induration; with *Lepidocyclina*
299.4	300.0	Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; poor induration; with *Lepidocyclina* and other forams
300.0	308.4	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; with *Lepidocyclina* and other forams
308.4	310.0	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; with *Lepidocyclina* and other forams
310.0	320.0	Limestone (wackestone); very pale orange (10yr 8/2) moderate intergranular porosity; poor induration; with *Lepidocyclina* and other forams
320.0	330.0	Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; poor induration; with *Lepidocyclina* and other forams
330.0	342.3	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; with *Lepidocyclina* and other forams
342.3	350.0	Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; poor induration; with *Lepidocyclina* and other forams
350.0	354.0	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; with *Lepidocyclina* and other forams
354.0	360.0	No recovery
370.0	380.7	Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; moderate induration; pelletal; with *Lepidocyclina*, *Neolagnum*, undifferentiated forams, bivalves, echinoids
380.7	386.4	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pelletal
386.4	390.0	No recovery
390.0	397.2	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; moderate induration; undifferentiated forams, gastropods
397.2	400.0	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets
400.0	401.3	Limestone (packstone); very pale orange (10yr 8/2); good intergranular porosity; moderate induration; undifferentiated forams
401.3	411.2	Limestone (wackestone); very pale orange (10yr 8/2) moderate intergranular porosity; poor induration; some lamination; pellets; undifferentiated forams, some gastropods
411.2	417.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; undifferentiated forams
417.8	426.4	Limestone (wackestone); very pale orange (10yr 8/2) low intergranular porosity; poor induration; some lamination; pellets
426.4	430.0	No recovery
430.0	433.7	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; gastropods
433.7	434	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
434.4	436.2	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; some lamination; pellets
436.2	440.0	No recovery
440.0	440.7	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets
440.7	442.0	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; moderate induration; pellets
442.0	446.0	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets
446.0	446.4	Limestone (grainstone); very pale orange (10yr 8/2); good intergranular porosity and moldic; poor induration; pellets; undifferentiated forams
446.4	450.0	No recovery
450.0	450.3	Limestone (grainstone); very pale orange (10yr 8/2); good intergranular porosity and moldic; poor induration; pellets; undifferentiated forams
450.3	454.7	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; moderate induration; undifferentiated forams
454.7	460.0	No recovery
460.0	461.9	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; undifferentiated forams
461.9	462.4	Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; moderate induration; pellets and undifferentiated forams
462.4	470.0	No recovery
470.0	472.4	Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; moderate induration; pellets; bivalves and undifferentiated forams
472.4	474.2	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets
474.2	480.0	No recovery
490.0	492.0	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; undifferentiated forams
492.0	499.4	Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; moderate induration; undifferentiated forams and bivalves
499.4	500.0	No recovery
500.0	503.4	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; moderate induration; undifferentiated forams; pellets
503.4	506.3	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets
506.3	510.0	No recovery
510.0	520.0	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; undifferentiated forams
520.0	522.6	Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; moderate induration; undifferentiated forams and bivalves
522.6	525.4	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets
525.4	530.0	No recovery
530.0	533.8	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; lamination; pellets
533.8	535.3	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
535.3	538.7	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; some lamination

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
538.7	540.0	No recovery
540.0	540.8	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
540.8	546.7	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; bivalves; pellets
546.7	550.0	No recovery
550.0	550.4	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; undifferentiated forams
550.4	551.8	Limestone (packstone); very pale orange (10yr 8/2); good intergranular and moldic porosity; poor induration; *Fallotella*, undifferentiated forams and bivalves
551.8	553.0	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; lamination; pellets
553.0	554.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; undifferentiated forams
554.8	556.7	Limestone (grainstone); very pale orange (10yr 8/2); good intergranular porosity; moderate induration; *Fallotella* and undifferentiated forams
556.7	557.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; moderate induration; undifferentiated forams
557.8	559.1	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; pellets
559.1	559.6	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
559.6	560.0	No recovery
560.0	564.2	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; pellets; undifferentiated forams
564.2	566.0	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and pinpoint vuggy porosity; moderate induration; undifferentiated forams
566.0	567.5	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
567.5	570.0	No recovery
570.0	571.5	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; pellets
571.5	576.4	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
576.4	580.0	No recovery
580.0	584.3	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; moderate induration; pellets, gastropods
584.3	588.4	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; pellets and undifferentiated forams, burrows
588.4	590.0	No recovery
590.0	591.6	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; bivalves; lamination
591.6	595.4	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
595.4	597.0	Calcareous dolostone; dark yellow orange (10yr6/6); low pinpoint porosity; well indurated
597.0	599.5	Calcareous dolostone; dark yellow orange (10yr6/6); good pinpoint and vuggy porosity; well indurated
599.5	600.0	Limestone (wackestone); grayish orange (10yr 7/4); moderate intergranular porosity; moderate induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
600.0	600.8	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets; lamination
600.8	602.9	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; pellets and undifferentiated forams
602.9	606.4	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; lamination
606.4	609.1	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
609.1	610.0	No recovery
610.0	610.7	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; moderate induration
610.7	612.5	Limestone (wackestone); very pale orange (10yr 8/2); no observable porosity; moderate induration; lamination
612.5	615.9	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular and vuggy porosity; poor induration; pellets
615.9	618.0	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
618.0	624.0	No recovery
620.0	634.0	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets
634.0	634.4	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
634.4	636.0	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular and vuggy porosity; poor induration; pellets
636.0	636.4	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
636.4	637.4	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular and vuggy porosity; poor induration; pellets
637.4	638.0	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
638.0	638.8	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular and vuggy porosity; poor induration; pellets
638.8	640.0	No recovery
640.0	641.6	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; undifferentiated forams; lamination
641.6	642.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; pellets and undifferentiated forams
642.8	644.1	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; undifferentiated forams; lamination
644.1	644.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; pellets and undifferentiated forams
644.8	649.6	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; undifferentiated forams; lamination
649.6	650.0	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
650.0	650.6	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets
650.6	650.8	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
650.8	651.4	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
651.4	651.6	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
651.6	651.8	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets
651.8	652.7	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
652.7	653.2	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets
653.2	653.9	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor to moderate induration
653.9	654.3	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; intraclasts, pellets and undifferentiated forams
654.3	655.9	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
655.9	657.3	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets
657.3	658.5	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; intraclasts, pellets; and undifferentiated forams and echinoids
658.5	659.3	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
659.3	661.1	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; pellets
661.1	662.0	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
662.0	663.7	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and pinpoint porosity; poor induration; pellets
663.7	670.0	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; pellets
670.0	674.3	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and pinpoint porosity; moderate induration; bivalves, gastropods, undifferentiated forams, and burrows
674.3	676.9	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and pinpoint porosity; moderate induration; undifferentiated forams
676.9	684.4	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; poor induration; some lamination, some interclasts lampellets
684.4	687.3	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and pinpoint porosity; moderate induration; pellets; undifferentiated forams
687.3	688.0	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
688.0	688.6	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration
688.6	690.0	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
690.0	700.0	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration
700.0	700.8	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; pellets; undifferentiated forams, echinoids, and burrows
700.8	709.4	Limestone (packstone); very pale orange (10yr 8/2); good intergranular, pinpoint and vuggy porosity; poor induration; pellets; undifferentiated forams
709.4	710.0	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; laminated; pellets; undifferentiated forams

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
710.0	710.6	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
710.6	713.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity; poor induration; pellets; and undifferentiated forams, gastropods
713.8	715.8	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; pellets
715.8	717.7	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
717.7	720.8	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; pellets, undifferentiated forams
720.8	721.8	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
721.8	730.2	Limestone (wackestone); very pale orange (10yr 8/2); l0w intergranular porosity; poor induration; pellets
730.2	732.7	Calcareous dolostone; pale yellowish brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; well indurated
732.7	734.1	Limestone (wackestone); pale yellowish brown (10yr 6/2); moderate intergranular porosity; moderate induration
734.1	736.2	Calcareous dolostone; pale yellowish brown (10yr6/2); moderate pinpoint and vuggy porosity; well indurated
736.2	740.0	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; moderate induration; pellets; foraminifera
740.0	742.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; pellets; undifferentiated forams
742.8	743.3	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; moderate induration; foraminifera
743.3	743.7	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; undifferentiated forams
743.7	744.2	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; moderate induration; foraminifera
744.2	746.7	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; poor induration; undifferentiated forams
746.7	749.2	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; pellets
749.2	751.1	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and pin pint vuggy porosity; moderate induration; foraminifera
751.1	751.7	Limestone (wackestone); very pale orange (10yr 8/2); good moldic, intergranular and pinpoint vuggy porosity; moderate induration; foraminifera
751.7	755.3	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration
755.3	756.0	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
756.0	760.0	No recovery
760.0	764.6	Limestone (packstone); grayish orange (10yr7/4); moderate intergranular and moldic porosity, moderate induration, pellets; intraclasts; undifferentiated forams
764.6	767.2	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; pellets
767.2	767.6	Limestone (wackestone); very pale orange (10yr 8/2); good moldic, intergranular and moldic porosity; moderate induration; foraminifera
767.6	769.6	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; pellets

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
769.6	771.6	Limestone (wackestone); grayish orange (10yr7/4); moderate pinpoint and moldic porosity, moderate induration; intraclasts; undifferentiated forams
771.6	771.8	Limestone (wackestone); grayish orange (10yr7/4); low intergranular porosity; moderate induration; intraclasts; forams
771.8	772.3	Limestone (grainstone); grayish orange (10yr7/4); good intergranular and vuggy porosity; moderate induration; intraclasts; foraminifera
772.3	774.0	Limestone (packstone); grayish orange (10yr7/4); moderate intergranular and moldic porosity, moderate induration; intraclasts; undifferentiated forams
774.0	776.7	Limestone (wackestone); grayish orange (10yr7/4); moderate pinpoint and intergranular porosity, moderate induration; intraclasts; undifferentiated forams
776.7	778.0	Limestone (grainstone); grayish orange (10yr7/4); good intergranular and vuggy porosity; moderate induration; intraclasts; foraminifera
778.0	780.0	Limestone (wackestone); grayish orange (10yr7/4); moderate pinpoint and intergranular porosity, moderate induration; intraclasts; undifferentiated forams
780.0	782.8	Limestone (packstone); grayish orange (10yr7/4); moderate intergranular porosity; moderate induration; undifferentiated forams; *Numulities*
782.8	785.6	Limestone (wackestone); grayish orange (10yr7/4); moderate pinpoint and intergranular porosity, moderate induration; undifferentiated forams; *Numulities*
785.6	786.7	Limestone (packstone); grayish orange (10yr7/4); moderate intergranular and moldic porosity, moderate induration; intraclasts; undifferentiated forams *Numulities*
786.7	787.0	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; poor induration
787.0	791.8	Limestone (packstone); grayish orange (10yr7/4); moderate intergranular and moldic porosity, moderate induration; intraclasts; undifferentiated forams; *Numulities*; *Fabularia*
791.8	795.2	Limestone (wackestone); grayish orange (10yr7/4); low intergranular porosity; moderate induration; forams; *Fabularia*
795.2	800.0	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity; moderate induration; some lamination; foraminifera; organics
800.0	800.7	Limestone (packstone); grayish orange (10yr7/4); moderate intergranular and moldic porosity, moderate induration; intraclasts; undifferentiated forams, *Numulities*
800.7	806.8	Limestone (wackestone); very pale orange (10yr 8/2); low to moderate intergranular, vuggy, and moldic porosity; moderate induration; foraminifera
806.8	807.6	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular, vuggy and moldic porosity, moderate induration; intraclasts; undifferentiated forams, *Numulities*
807.6	808.8	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; pellets
808.8	809.1	Limestone (mudstone); dusky yellowish brown (10yrr2/2); no observable porosity; poor induration; organics
809.1	810.0	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; pellets
810.0	810.1	Clay; pale yellow brown (10yr6/2); unconsolidated; low plasticity; no observable porosity
810.1	811.8	Limestone (wackestone); very pale orange (10yr 8/2); moderate to good vuggy and intergranular porosity, moderate induration; pellets; undifferentiated forams
811.8	812.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; moderate induration; pellets; undifferentiated forams
812.8	817.8	Limestone (wackestone); grayish orange (10yr7/4); good intergranular porosity, moderate induration; some lamination; pellets; undifferentiated forams
817.8	820.5	Limestone (wackestone); grayish orange (10yr7/4); moderate intergranular and vuggy porosity, moderate induration; some lamination; undifferentiated forams

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
820.5	824.0	Limestone (packstone); grayish orange (10yr7/4); good intergranular, pinpoint, and vuggy porosity; moderate induration; undifferentiated forams, miliolids
824.0	827.6	Limestone (packstone); grayish orange (10yr7/4); moderate intergranular and vuggy porosity; moderate induration; intraclasts; undifferentiated forams, miliolids
827.6	831.3	Limestone (wackestone); grayish orange (10yr7/4); moderate intergranular and pinpoint porosity, moderate induration; undifferentiated forams
831.3	833.0	Limestone (packstone); grayish orange (10yr7/4); good intergranular and porosity; moderate induration; intraclasts; undifferentiated forams
833.0	836.8	Limestone (packstone); grayish orange (10yr7/4); moderate intergranular porosity, moderate induration; undifferentiated forams
836.8	838.9	Limestone (packstone); grayish orange (10yr7/4); good intergranular, pinpoint and vuggy porosity; some lamination; moderate induration; undifferentiated forams
838.9	842.0	Limestone (wackestone); grayish orange (10yr7/4); moderate intergranular and pinpoint porosity, moderate induration; undifferentiated forams
842.0	842.4	Limestone (wackestone); grayish orange (10yr7/4); moderate intergranular and pinpoint porosity, moderate induration; intraclasts; organic lamination; undifferentiated forams
842.4	844.4	Limestone (wackestone); grayish orange (10yr7/4); moderate intergranular and pinpoint porosity, moderate induration; undifferentiated forams
844.4	845.2	Limestone (wackestone); grayish orange (10yr7/4); moderate intergranular porosity, moderate induration; organic lamination; undifferentiated forams
845.2	845.8	Limestone (packstone); grayish orange (10yr7/4); high intergranular porosity; intraclasts; organic lamination; moderate induration; undifferentiated forams, miliolids, gastropods
845.8	850.0	Limestone (packstone); grayish orange (10yr7/4); moderate intergranular porosity, moderate induration; undifferentiated forams, miliolids
850.0	852.4	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular and pin pint vuggy porosity; moderate induration; foraminifera, *Fabularia*
852.4	865.3	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration
865.3	866.7	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; lamination
866.7	868.3	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration
868.3	869.4	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration; lamination
869.4	870.8	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration
870.8	874.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; fractured; good induration
874.0	878.3	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration
878.3	879.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration
879.0	880.0	No recovery
880.0	889.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; fractured; good induration
889.0	890.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration
890.0	893.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration; fractured
893.0	897.7	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
897.7	910.4	Dolostone; moderate yellow brown (10yr 5/4); low pinpoint porosity; good induration; fractured
910.4	912.8	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; moderate induration.
912.8	914.4	Dolostone; grayish orange (10yr 7/4); moderate vuggy, pinpoint and moldic porosity; good induration; fractured
914.4	915.2	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; moderate induration
915.2	917.4	Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate vuggy, pinpoint and moldic porosity; good induration; fractured
917.4	922.6	Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; moderate Induration; some lamination
922.6	923.7	Dolostone; dark yellow brown (10yr 4/2); l0w pinpoint porosity; fractured; good induration
923.7	927.3	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration
927.3	928.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; fractured; good induration
928.0	928.4	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration
928.4	929.6	Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; no observed porosity; good induration
929.6	930.0	Dolostone; pale yellowish brown (10yr 6/2); microcrystalline; no observed porosity; good induration; fractured
930.0	930.4	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; good pinpoint and vuggy porosity; good induration
930.4	940.0	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration
940.0	941.4	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration; fractured
941.4	942.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
942.0	942.9	No recovery
942.9	949.3	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; moderate induration
949.3	950.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, moldic, and vuggy porosity; good induration; bivalves
950.0	950.6	Dolostone; dark yellow orange (10yr 6/6); microcrystalline; low pinpoint porosity; poor induration
950.6	957.5	Dolostone; dark yellow orange (10yr 6/6); microcrystalline; low pinpoint and moldic porosity; good induration; bivalves
957.5	967.0	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration
967.0	971.7	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
971.7	973.6	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration
973.6	975.6	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; good induration
975.6	976.3	Dolostone; grayish orange (10yr 7/4); moderate pinpoint, vuggy and moldic porosity; good induration; bivalves
976.3	976.9	Dolostone; grayish orange (10yr 7/4); no observable porosity; good induration; some lamination
976.9	979.2	Limestone (wackestone); very pale orange (10yr 8/2); low pinpoint porosity; good induration; lamination

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
979.2	982.2	Dolomitic limestone (wackestone); dark yellow orange (10yr 6/6); moderate vuggy, moldic and intergranular porosity; good induration; bivalves
982.2	983.0	Limestone (wackestone); dark yellow orange (10yr 6/6); moderate vuggy, moldic and intergranular porosity; good induration; bivalves
983.0	984.1	Limestone (wackestone); very pale orange (10yr8/2); no observable porosity; moderate induration
984.1	988.3	Calcareous dolostone; dark yellow orange (10yr 6/6); l0w pinpoint porosity; good induration
988.3	989.4	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration
989.4	990.0	Calcareous dolostone; dark yellow orange (10yr 6/6); l0w pinpoint porosity; good induration
990.0	992.3	Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration
992.3	998.2	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; l0w pinpoint porosity; good induration
998.2	1,000.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; l0w pinpoint porosity; good induration
1,000.0	1,001.8	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; good induration
1,001.8	1,005.3	Calcareous dolostone; grayish orange (10yr 7/4); low pinpoint porosity; good induration; lamination
1,005.3	1,008.4	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; l0w pinpoint porosity; good induration
1,008.4	1,013.2	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration
1,013.2	1,014.7	Calcareous dolostone; pale yellow brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration
1,014.7	1,017.1	Limestone (wackestone); grayish orange (10yr7/4); low intergranular porosity; moderate induration; lamination; undifferentiated forams
1,017.1	1,018.1	Limestone (wackestone); grayish orange (10yr7/4); moderate pinpoint and vugular porosity; moderate induration; undifferentiated forams
1,018.1	1,020.0	Limestone (wackestone); grayish orange (10yr7/4); low intergranular porosity; moderate induration; undifferentiated forams
1,020.0	1,024.7	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; moderate induration
1,024.7	1,026.5	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,026.5	1,027.4	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; good induration
1,027.4	1,031.7	Dolostone; dark yellow orange (10yr 6/6); microcrystalline; low pinpoint porosity; good induration; lamination
1,031.7	1,039.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration
1,039.0	1,040.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; good pinpoint, vuggy, and moldic porosity; good induration
1,040.0	1,041.2	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration; lamination
1,041.2	1,044.1	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,044.1	1,046.1	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration; lamination

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,046.1	1,052.3	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; good pinpoint and vuggy porosity; good induration; lamination
1,052.3	1,053.8	Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration
1,053.8	1,055.4	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; low pinpoint porosity; intraclasts; good induration
1,055.4	1,056.1	Dolostone; very pale orange (10yr 8/2); high pinpoint, vuggy, and moldic porosity; good induration
1,056.1	1,062.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration; lamination
1,062.0	1,063.3	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,063.3	1,068.1	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration; lamination
1,064.6	1,267.8	Dolostone; very pale orange (10yr 8/2); fractured; low pinpoint and moldic porosity; good induration
1,067.8	1,068.1	Dolostone; white (n9); no observable porosity; good induration
1,068.1	1,072.3	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,072.3	1,074.0	Dolostone; dark yellow orange (10yr 6/6); low pinpoint porosity; good induration; lamination
1,074.0	1,076.6	Dolostone; dark yellow orange (10yr 6/6); microcrystalline; moderate pinpoint and vuggy porosity; good induration: lamination
1,076.6	1,080.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration; lamination
1,080.0	1,080.8	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; high pinpoint and vuggy porosity; good induration
1,080.8	1,091.1	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration; lamination
1,091.1	1,092.7	Dolostone; dark yellow orange (10yr 6/6); low pinpoint porosity and vuggy; good induration; lamination
1,092.7	1,094.4	Dolostone; grayish orange (10yr 7/4); moderate pinpoint and vuggy porosity; good induration
1,094.4	1,096.0	Dolostone; grayish orange (10yr 7/4); fractured; low pinpoint and vuggy porosity; good induration
1,096.0	1,098.4	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; good induration
1,098.4	1,100.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,100.0	1,109.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, moldic and vuggy porosity; good induration
1,109.0	1,110.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; low pinpoint porosity; good induration
1,110.0	1,117.2	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration; lamination
1,117.2	1,118.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint, vuggy, and moldic porosity; good induration
1,118.6	1,121.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,121.0	1,122.2	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, moldic and vuggy porosity; good induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,122.2	1,130.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,130.0	1,132.8	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,132.8	1,134.7	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,134.7	1,135.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration
1,135.6	1,141.4	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,141.4	1,142.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration
1,142.0	1,144.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, moldic, and vuggy porosity; good induration
1,144.0	1,144.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration
1,144.6	1,146.9	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,146.9	1,148.1	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, moldic, and vuggy porosity; good induration
1,148.1	1,150.0	Dolostone; dark yellow orange (10yr 6/6); microcrystalline; low pinpoint porosity; good induration; lamination
1,150.0	1,154.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,154.6	1,155.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, moldic, and vuggy porosity; good induration
1,155.6	1,157.3	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; low pinpoint porosity; good induration
1,157.3	1,158.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, moldic, and vuggy porosity; good induration
1,158.6	1,159.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,159.0	1,160.0	Calcareous dolostone; very pale orange (10yr 8/2); microcrystalline; fractured; low pinpoint porosity; good induration
1,160.0	1,165.3	Dolostone; microcrystalline; grayish orange (10yr 7/4); low pinpoint porosity; good induration; some lamination
1,165.3	1,169.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration; lamination
1,169.6	1,172.1	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,172.1	1,172.8	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration
1,172.8	1,177.5	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,177.5	1,178.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; low pinpoint porosity; good induration
1,178.0	1,180.2	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,180.2	1,186.0	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration
1,186.0	1,188.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; low pinpoint porosity; good induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,188.0	1,198.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint and vuggy porosity; good induration; lamination
1,198.0	1,198.7	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; good pinpoint, moldic and vuggy porosity; good induration; lamination
1,198.7	1,204.3	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,204.3	1,205.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,205.6	1,207.2	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; good induration
1,207.2	1,209.6	Dolostone; grayish orange (10yr 7/4); fractured; low pinpoint porosity; good induration; lamination
1,209.6	1,210.0	Dolostone; pale yellow brown (10yr 6/2); fractured; moderate pinpoint and vuggy porosity; good induration
1,210.0	1,212.3	Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration
1,212.3	1,213.0	Dolostone; grayish orange (10yr 7/4); microcrystalline; fractured; low pinpoint porosity; good induration
1,213.0	1,216.4	Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration
1,216.4	1,218.5	Dolostone; grayish orange (10yr 7/4); microcrystalline; fractured; low pinpoint porosity; good induration
1,218.5	1,220.0	Dolostone; grayish orange (10yr 7/4); microcrystalline; low pinpoint porosity; good induration
1,220.0	1,223.9	Dolostone; grayish orange (10yr 7/4); moderate pinpoint and vuggy porosity; good induration
1,223.9	1,225.8	Dolostone; very pale orange (10yr 8/2); no observable porosity; good induration
1,225.8	1,234.8	Dolostone; very pale orange (10yr 8/2); moderate pinpoint porosity; good induration
1,234.8	1,236.5	Dolostone; very pale orange (10yr 8/2); high pinpoint, vuggy, and moldic porosity; good induration
1,236.5	1,238.3	Dolostone; very pale orange (10yr 8/2); no observable porosity; good induration
1,238.3	1,241.4	Dolostone; very pale orange (10yr 8/2); moderate pinpoint porosity; good induration
1,241.4	1,242.1	Dolostone; very pale orange (10yr 8/2); no observable porosity; good induration
1,242.1	1,244.0	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration
1,244.0	1,246.4	Dolostone; very pale orange (10yr 8/2); no observable porosity; good induration
1,246.4	1,250.0	Dolostone; very pale orange (10yr 8/2); fractured; low pinpoint porosity; moderate induration
1,250.0	1,254.4	Dolostone; very pale orange (10yr 8/2); good pinpoint, vuggy, and moldic porosity; good induration
1,254.4	1,255.6	Dolostone; very pale orange (10yr 8/2); fractured; moderate pinpoint porosity; moderate induration
1,255.6	1,256.2	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,256.2	1,258.6	Dolostone; very pale orange (10yr 8/2); good pinpoint, vuggy, and moldic porosity; good induration
1,258.6	1,259.1	Dolostone; very pale orange (10yr 8/2); fracture; no observable porosity; good induration
1,259.1	1,260.8	Dolostone; very pale orange (10yr 8/2); no observable porosity; good induration
1,260.8	1,262.8	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,262.8	1,263.3	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration
1,263.3	1,264.6	Dolostone; very pale orange (10yr 8/2); fractured; good pinpoint and vuggy porosity; good induration
1,270.0	1,271.3	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,271.3	1,272.5	Dolostone; very pale orange (10yr 8/2); moderate pinpoint, vuggy, and moldic porosity; good induration
1,272.5	1,274.2	Dolostone; very pale orange (10yr 8/2); no observable porosity; good induration
1,274.2	1,275.7	Dolostone; very pale orange (10yr 8/2); good pinpoint, vuggy, and moldic porosity; good induration; fossil fragments
1,275.7	1,276.7	Dolostone; very pale orange (10yr 8/2); good pinpoint, vuggy, and moldic porosity; good induration
1,276.7	1,280.4	Dolostone; very pale orange (10yr 8/2); moderate pinpoint porosity; good induration
1,280.4	1,282.0	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration
1,282.0	1,282.4	Dolostone; very pale orange (10yr 8/2); fractured; moderate pinpoint and vuggy porosity; good induration
1,282.4	1,282.9	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration
1,282.9	1,283.4	Dolostone; very pale orange (10yr 8/2); fractured; moderate pinpoint and vuggy porosity; good induration
1,283.4	1,284.0	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration
1,284.0	1,288.0	Dolostone; very pale orange (10yr 8/2); moderate pinpoint porosity; good induration
1,288.0	1,288.8	Dolostone; very pale orange (10yr 8/2); fractured; low pinpoint porosity; good induration
1,288.8	1,290.0	Dolostone; very pale orange (10yr 8/2); fractured; good pinpoint porosity; moderate induration
1,290.0	1,291.9	Dolostone; very pale orange (10yr 8/2); no observable porosity; moderate induration
1,291.9	1,294.2	Dolostone; very pale orange (10yr 8/2); good pinpoint, vuggy, and moldic porosity; good induration
1,294.2	1,295.8	Dolostone; grayish orange (10yr 7/4); microcrystalline; moderate pinpoint, moldic and vuggy porosity; moderate induration; organic lamination; bivalves
1,295.8	1,300.0	Dolostone; very pale orange (10yr 8/2); moderate pinpoint, vuggy, and moldic porosity; good induration; organic lamination; burrows
1,300.0	1,310.9	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration; laminated
1,310.9	1,313.8	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration
1,313.8	1,315.4	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,315.4	1,316.5	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration; some lamination
1,316.5	1,316.8	Dolostone; very pale orange (10yr 8/2); fractured; moderate pinpoint and vuggy porosity; good induration
1,316.8	1,317.4	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration
1,317.4	1,317.6	Dolostone; very pale orange (10yr 8/2); fractured; moderate pinpoint and vuggy porosity; good induration
1,317.6	1,318.2	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration
1,318.2	1,319.4	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,319.4	1,319.6	Dolostone; very pale orange (10yr 8/2); fractured; low pinpoint porosity; good induration
1,319.6	1,320.0	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,320.0	1,326.2	Dolostone; very pale orange (10yr 8/2); good pinpoint porosity; good induration; some lamination
1,326.2	1,326.9	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration
1,326.9	1,328.0	Dolostone; very pale orange (10yr 8/2); moderate pinpoint porosity; good induration
1,328.0	1,330.0	Dolostone; very pale orange (10yr 8/2); moderate pinpoint, moldic and vuggy porosity; good induration; some organic lamination
1,330.0	1,334.1	Dolostone; very pale orange (10yr 8/2); moderate pinpoint porosity; good induration
1,334.1	1,339.7	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; good induration
1,339.7	1,341.3	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,341.3	1,341.6	Dolostone; very pale orange (10yr 8/2); fractured; low pinpoint porosity; good induration
1,341.6	1,342.0	Dolostone; very pale orange (10yr 8/2); fractured; no observable porosity; moderate induration
1,342.0	1,343.1	Dolostone; very pale orange (10yr 8/2); no observable porosity; moderate induration
1,343.1	1,343.8	Dolostone; very pale orange (10yr 8/2); fractured; no observable porosity; moderate induration
1,343.8	1,344.1	Dolostone; very pale orange (10yr 8/2); no observable porosity; moderate induration
1,344.1	1,346.4	Dolostone; very pale orange (10yr 8/2); fractured; low pinpoint porosity; good induration
1,346.4	1,347.1	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,347.1	1,347.9	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration
1,347.9	1,348.7	Dolostone; very pale orange (10yr 8/2); fractured; no observable porosity; moderate induration
1,348.7	1,350.0	Dolostone; very pale orange (10yr 8/2); fractured; no observable porosity; moderate induration; some lamination;
1,350.0	1,350.7	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,350.7	1,351.9	Dolostone; very pale orange (10yr 8/2); good pinpoint, moldic and vuggy porosity; good induration
1,351.9	1,353.5	Dolostone; very pale orange (10yr 8/2); no observable porosity; moderate induration
1,353.5	1,354.5	Dolostone; very pale orange (10yr 8/2) to grayish orange (10yr7/4); fractured; no observable porosity; moderate induration
1,354.5	1,355.5	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; good induration
1,355.5	1,357.4	Dolostone; grayish orange (10yr 7/4); no observable porosity; good induration
1,357.4	1,362.3	Dolostone; grayish orange (10yr 7/4); moderate pinpoint porosity; good induration; laminated
1,362.3	1,364.1	Dolostone; very pale orange (10yr 8/2); good pinpoint porosity; good induration; laminated
1,364.1	1,365.4	Dolostone; very light gray (n8); moderate pinpoint porosity; good induration
1,365.4	1,366.1	Dolostone; medium dark gray (n4); good intergranular, pinpoint, vuggy, and moldic porosity; good induration; organics
1,366.1	1,367.0	Dolostone; medium light gray (n6); good pinpoint, vuggy, and moldic porosity; good induration; organics
1,367.0	1,367.9	Dolostone; very pale orange (10yr 8/2); good pinpoint, moldic and vuggy porosity; good induration; laminated
1,367.9	1,370.0	Dolostone; white (n9); no observable porosity; good induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,370.0	1,374.0	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration; laminated
1,374.0	1,377.4	Dolostone; very pale orange (10yr 8/2); good pinpoint, moldic and vuggy porosity; good induration
1,377.4	1,378.0	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration; laminated
1,378.0	1,378.8	Dolostone; very pale orange (10yr 8/2); good pinpoint, moldic and vuggy porosity; good induration
1,378.8	1,379.6	Dolostone; very pale orange (10yr 8/2); moderate pinpoint porosity; good induration; laminated
1,379.6	1,380.0	No recovery
1,380.0	1,381.6	Dolostone; very pale orange (10yr 8/2); good pinpoint porosity; good induration; laminated
1,381.6	1,383.0	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration
1,383.0	1,385.1	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration; laminated
1,385.1	1,388.3	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration; some lamination
1,388.3	1,389.6	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,389.6	1,390.0	Dolostone; very pale orange (10yr 8/2); no observable porosity; good induration
1,390.0	1,395.8	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,395.8	1,396.6	Dolostone; very pale orange (10yr 8/2); fractured; low pinpoint porosity; good induration
1,396.6	1,397.7	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration; organic lamination
1,397.7	1,399.2	Dolostone; medium light gray (n6); good pinpoint and vuggy porosity; good induration
1,399.2	1,401.4	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,401.4	1,403.2	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration; some organic lamination
1,403.2	1,403.6	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,403.6	1,405.2	Dolostone; very pale orange (10yr 8/2); good pinpoint, moldic and vuggy porosity; good induration; burrows
1,405.2	1,407.7	Dolostone; very pale orange (10yr 8/2); moderate pinpoint porosity; good induration
1,407.7	1,408.5	Dolostone; very pale orange (10yr 8/2); fractured; low pinpoint porosity; good induration
1,408.5	1,409.0	Dolostone; very pale orange (10yr 8/2); no observable porosity; good induration
1,409.0	1,410.0	No recovery
1,410.0	1,412.3	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration; some organic lamination
1,412.3	1,413.6	Dolostone; very pale orange (10yr 8/2); fractured; moderate pinpoint porosity; good induration
1,413.6	1,414.1	Dolostone; very light gray (n8); fractured; good pinpoint and vuggy porosity; good induration
1,414.1	1,415.5	Dolostone; very light gray (n8); moderate pinpoint porosity; good induration
1,415.5	1,416.2	Dolostone; very light gray (n8); moderate pinpoint and vuggy porosity; good induration
1,416.2	1,419.6	Dolostone; very pale orange (10yr 8/2); fractured; moderate pinpoint porosity; good induration; lamination
1,419.6	1,420.0	No recovery
1,420.0	1,421.6	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,421.6	1,425.3	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration
1,425.3	1,428.0	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,428.0	1,429.7	Dolostone; very pale orange (10yr 8/2); no observable porosity; good induration; chalky
1,429.7	1,431.3	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,431.3	1,431.7	Dolostone; very pale orange (10yr 8/2); good pinpoint, vuggy, and moldic porosity; good induration; gastropods
1,431.7	1,436.6	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration; gastropods
1,436.6	1,440.0	Dolostone; very pale orange (10yr 8/2); moderate pinpoint porosity; good induration
1,440.0	1,447.8	Dolostone; grayish orange (10yr 7/4); moderate pinpoint porosity; good induration
1,447.8	1,449.8	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,449.8	1,452.3	Dolostone; very pale orange (10yr 8/2); good pinpoint and vuggy porosity; good induration; gastropods
1,452.3	1,452.8	Dolostone; very pale orange (10yr 8/2); fractured; moderate pinpoint and vuggy porosity; good induration; gastropods
1,452.8	1,454.4	Dolostone; very pale orange (10yr 8/2); fractures; good pinpoint, vuggy, and moldic porosity; vertical vugs; good induration; gastropods, worm tubes?
1,454.4	1,456.4	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration
1,456.4	1,456.9	Dolostone; very pale orange (10yr 8/2); fractured; moderate pinpoint and vuggy porosity; good induration
1,456.9	1,458.6	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,458.6	1,460.0	No recovery
1,460.0	1,460.9	Dolostone; grayish orange (10yr 7/4); fractures; moderate pinpoint and vuggy porosity; good induration
1,460.9	1,464.7	Dolostone; grayish orange (10yr 7/4); moderate pinpoint porosity; good induration
1,464.7	1,466.0	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,466.0	1,466.6	Dolostone; very pale orange (10yr 8/2); fractures; low pinpoint porosity; good induration
1,466.6	1,467.3	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,467.3	1,469.0	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration; organic vug filling
1,469.0	1,469.4	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,469.4	1,470.0	No recovery
1,470.0	1,472.7	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,472.7	1,475.6	Dolostone; very pale orange (10yr 8/2); moderate pinpoint and vuggy porosity; good induration; organic vug filling
1,475.6	1,477.0	Dolostone; grayish orange (10yr 7/4); fractures; good pinpoint, moldic and vuggy porosity; good induration
1,477.0	1,479.1	Dolostone; grayish orange (10yr 7/4); good pinpoint, moldic and vuggy porosity; good induration; some organic vug fill
1,479.1	1,480.0	Dolostone; pale yellow brown (10yr 6/2); fractures; good pinpoint and vuggy porosity; good induration; organic vug fill
1,480.0	1,482.0	Dolostone; pale yellow brown (10yr 6/2); moderate pinpoint and vuggy porosity; good induration
1,482.0	1,482.8	Dolostone; pale yellow brown (10yr 6/2); fractures; moderate pinpoint and vuggy porosity; good induration; organic vug fill
1,482.8	1,485.4	Dolostone; pale yellow brown (10yr 6/2); moderate pinpoint and vuggy porosity; good induration

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,485.4	1,487.0	Dolostone; dark yellow brown (10yr 4/2); fractures; moderate pinpoint and vuggy porosity; good induration; some organic vug fill
1,487.0	1,488.0	Dolostone; moderate yellow brown (10yr 5/4); moderate pinpoint and vuggy porosity; good induration
1,488.0	1,489.3	Dolostone; moderate yellow brown (10yr 5/4); good pinpoint and vuggy porosity; good induration
1,489.3	1,491.7	Dolostone; dark yellow brown (10yr 4/2); moderate pinpoint and vuggy porosity; good induration
1,491.7	1,493.3	Dolostone; moderate yellow brown (10yr 5/4); fractures; good pinpoint; moldic, and vuggy porosity; good induration
1,493.3	1,494.5	Dolostone; moderate yellow brown (10yr 5/4); good pinpoint; moldic, and vuggy porosity; good induration
1,494.5	1,495.8	Dolostone; moderate yellow brown (10yr 5/4); very good pinpoint; moldic, and vuggy porosity; good induration; vesicular texture
1,495.8	1,497.3	Dolostone; moderate yellow brown (10yr 5/4); fractures; good pinpoint; moldic, and vuggy porosity; good induration
1,497.3	1,498.7	Dolostone; moderate yellow brown (10yr 5/4); good pinpoint; moldic, and vuggy porosity; good induration
1,498.7	1,499.6	Dolostone; very pale orange (10yr 8/2); low pinpoint porosity; good induration
1,499.6	1,500.0	No recovery
1,500.0	1,509.5	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration; vesicular texture
1,509.5	1,510.0	No recovery
1,510.0	1,522.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,522.0	1,526.8	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint; moldic; and vuggy porosity; good induration
1,526.8	1,530.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,530.0	1,535.6	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,535.6	1,536.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; fractures; moderate pinpoint and vuggy porosity; good induration
1,536.0	1,536.6	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,536.6	1,539.5	Limestone (wackestone); very pale orange (10yr 8/2) no observable porosity; poor induration
1,539.5	1,540.6	Dolostone; dark yellow orange (10yr 6/6); microcrystalline; fractured; low pinpoint porosity; good induration; lamination
1,540.6	1,546.6	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; undifferentiated forams
1,546.6	1,552.7	Limestone (packstone); very pale orange (10yr 8/2); low intergranular porosity; good induration; undifferentiated forams
1,552.7	1,561.8	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration; friable; undifferentiated forams
1,561.8	1,563.0	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; good induration; undifferentiated forams
1,563.0	1,566.2	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity; good induration
1,566.2	1,569.5	Limestone (packstone); very pale orange (10yr 8/2); moderate to good intergranular, vuggy, and moldic porosity; good induration; gastropods and undifferentiated forams

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,569.5	1,600.0	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; good induration; undifferentiated forams
1,600.0	1,602.0	Limestone (packstone); pale yellow brown (10yr 6/2); lo1 intergranular porosity; good induration; undifferentiated forams
1,602.0	1,603.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; good induration
1,603.6	1,607.0	Limestone (packstone); very pale orange (10yr 8/2); low intergranular porosity; good induration; undifferentiated forams
1,607.0	1,609.5	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint porosity; good induration
1,609.5	1,610.0	No recovery
1,610.0	1,610.3	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity; good induration; undifferentiated forams
1,610.3	1,611.7	Dolomitic limestone; very pale orange (10yr 8/2); microcrystalline; fractured; good vuggy, moldic, intercrystalline and pinpoint porosity; good induration; undifferentiated forams
1,611.7	1,615.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration; undifferentiated forams
1,615.0	1,616.2	Limestone (packstone); pale yellow brown (10yr 6/2); lo1 intergranular porosity; good induration
1,616.2	1,618.0	Dolostone; dark yellow orange (10yr 6/6); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration; friable
1,618.0	1,620.0	Dolostone; dark yellow orange (10yr 6/6); microcrystalline; moderate pinpoint and vuggy porosity; good induration; friable
1,620.0	1,628.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate to high pinpoint vuggy, and moldic porosity; good induration
1,628.0	1,650.0	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity, good induration; undifferentiated forams
1,650.0	1,660.0	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity, good induration
1,660.0	1,662.0	Limestone (packstone); very pale orange (10yr 8/2); good intergranular porosity, good induration
1,662.0	1,664.0	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity, good induration
1,664.0	1,671.0	Limestone (packstone); very pale orange (10yr 8/2); good intergranular porosity, good induration
1,671.0	1,671.1	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity, good induration
1,671.1	1,680.0	Limestone (packstone); very pale orange (10yr 8/2); good intergranular porosity, good induration
1,680.0	1,682.0	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity, good induration
1,682.0	1,686.0	Limestone (wackestone); very pale orange (10yr 8/2); moderate intergranular porosity, good induration; undifferentiated forams
1,686.0	1,692.0	Limestone (packstone); very pale orange (10yr 8/2); low intergranular porosity, good induration; undifferentiated forams
1,692.0	1,700.0	Limestone (packstone); dark yellow orange (10yr 6/6); low intergranular porosity, good induration; undifferentiated forams
1,700.0	1,703.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, vuggy, and moldic porosity; good induration; undifferentiated forams
1,703.0	1,704.6	Limestone (packstone); very pale orange (10yr 8/2); low intergranular porosity, good induration; undifferentiated forams

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,704.6	1,707.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,707.6	1,710.0	Dolostone; grayish orange (10yr 7/4); good pinpoint and vuggy porosity; good induration; some organic vug fill
1,710.0	1,716.4	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,716.4	1,716.8	Dolostone; pale yellow brown (10yr 6/2); fractures; microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,716.8	1,718.6	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,718.6	1,720.0	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration
1,720.0	1,729.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,729.0	1,730.0	No recovery
1,730.0	1,736.0	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration; undifferentiated forams; healed fractures
1,736.0	1,736.5	Dolostone; pale yellow brown (10yr 6/2); fractures; microcrystalline; moderate pinpoint and vuggy porosity; good induration; undifferentiated forams
1,736.5	1,740.0	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration; undifferentiated forams
1,740.0	1,752.3	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity, good induration; large undifferentiated forams, bivalves
1,752.3	1,770.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate to good pinpoint, moldic and vuggy porosity; good induration; undifferentiated forams
1,770.0	1,778.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint, moldic and vuggy porosity; good induration
1,778.0	1,779.3	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; good pinpoint, moldic and vuggy porosity; good induration
1,779.3	1,800.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity, good induration; undifferentiated forams, bivalves, algae
1,800.8	1,801.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate to good pinpoint, moldic and vuggy porosity; good induration; undifferentiated forams
1,801.6	1,803.7	Dolostone; pale yellow brown (10yr 6/2); fractures; microcrystalline; very good vuggy and cavity porosity; good induration
1,803.7	1,808.1	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,808.1	1,808.9	Limestone (packstone); dark yellow orange (10yr 6/6); moderate intergranular porosity; brecciated; good induration; algae, undifferentiated forams; organics
1,808.9	1,809.5	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity, good induration; undifferentiated forams, bivalves, algae
1,809.5	1,810.0	No recovery
1,810.0	1,814.5	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity, good induration; undifferentiated forams, algae
1,814.5	1,815.6	Limestone (packstone); dark yellow orange (10yr 6/6); moderate intergranular porosity; good induration; algae, undifferentiated forams
1,815.6	1,820.0	Limestone (packstone); very pale orange (10yr 8/2); low intergranular porosity, good induration; undifferentiated forams
1,820.0	1,827.8	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular porosity, good induration; undifferentiated forams, bivalves, algae

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,827.8	1,830.0	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular and vuggy porosity; poor induration; organic wave-like structures
1,830.0	1,837.4	Limestone (packstone); very pale orange (10yr 8/2); low intergranular porosity, good induration; undifferentiated forams, bivalves, algae
1,837.4	1,841.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration, some lamination
1,841.0	1,841.5	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration, some lamination
1,841.5	1,844.6	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,844.6	1,846.4	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration
1,846.4	1,848.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,848.0	1,849.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration
1,849.0	1,850.5	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,850.5	1,851.1	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; high vuggy porosity; good induration
1,851.1	1,851.8	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration
1,851.8	1,859.2	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity, good induration; undifferentiated forams
1,859.2	1,860.0	No recovery
1,860.0	1,863.2	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity, good induration; undifferentiated forams
1,863.2	1,864.2	Dolomitic limestone; dark yellow brown (10yr 4/2); moderate vuggy porosity; good induration; undifferentiated forams
1,864.2	1,864.9	Dolomitic limestone; dark yellow brown (10yr 4/2); fractures; high vuggy and moldic porosity; poor induration; algae, undifferentiated forams; organics
1,864.9	1,865.0	Limestone (packstone); very pale orange (10yr 8/2); moderate intergranular and moldic porosity, good induration; algae, undifferentiated forams
1,865.0.	1,870.0	Limestone (packstone); very pale orange (10yr 8/2); low intergranular and moldic porosity, good induration; algae, undifferentiated forams
1,870.0	1,8720	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate to high pinpoint and vuggy porosity; good induration
1,872.0	1,874.3	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate to good pinpoint and vuggy porosity; good induration
1,874.3	1,875.4	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; good pinpoint and vuggy porosity; good induration
1,875.4	1,876.3	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; low pinpoint porosity; good induration
1,876.3	1,878.0	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration
1,878.0	1,889.5	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; fractured; moderate pinpoint and vuggy porosity; good induration; some organic lamination
1,889.5	1,890.0	No recovery
1,890.0	1,890.8	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; moderate pinpoint and vuggy porosity; good induration; evaporite vug infilling

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,890.8	1,891.7	Limestone (wackestone); pale yellow brown (10yr 6/2); low intergranular porosity, good induration; organics
1,891.7	1,893.4	Dolostone; dark yellowish orange (10yr 6/6); microcrystalline; good pinpoint and vuggy porosity; good induration
1,893.4	1,894.6	Limestone (wackestone); very pale orange (10yr 8/2); low intergranular porosity, good induration; lamination
1,894.6	1,897.7	Dolostone; moderate yellow brown (10yr 5/4); microcrystalline; moderate pinpoint and vuggy porosity; good induration
1,897.7	1,898.8	Dolostone; moderate yellow brown (10yr 5/4); good pinpoint and vuggy porosity, larger vugs; good induration
1,898.8	1,900.0	Dolostone; moderate yellow brown (10yr 5/4); moderate pinpoint and vuggy porosity; good induration
1,900.0	1,902.0	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; no observed porosity; good induration; evaporite vug filling
1,902.0	1,902.8	Dolostone; very pale orange (10yr 8/2); microcrystalline; no observed porosity; good induration; evaporite vug filling; organic flakes
1,902.8	1,905.0	Dolostone; grayish orange (10yr 7/4); low pinpoint and vuggy porosity; good induration; some organics
1,905.0	1,907.3	Dolostone; moderate yellow brown (10yr 5/4); low pinpoint and vuggy porosity; good induration; some organics
1,907.3	1,910.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; good vuggy porosity, large vugs; good induration; chert nodules
1,910.0	1,911.7	Dolostone; very pale orange (10yr 8/2); microcrystalline; low pinpoint porosity; good induration
1,911.7	1,912.0	Evaporite; moderate gray (n5); no observable porosity
1,912.0	1,916.2	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration
1,916.2	1,917.0	Dolostone; dark yellow brown (10yr 4/2); microcrystalline; fractured; good vuggy porosity; good induration; chert nodules
1,917.0	1,918.7	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; good induration; some evaporite vug filling; chert nodules
1,918.7	1,919.5	Dolostone; grayish orange (10yr 7/4); good vuggy porosity; good induration; chert nodules
1,919.5	1,920.0	No recovery
1,920.0	1,922.8	Dolostone; very pale orange (10yr 8/2); microcrystalline; no observable porosity; good induration
1,922.8	1,924.3	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity, poor induration
1,924.3	1,928.0	Dolostone; very pale orange (10yr 8/2); microcrystalline; low vuggy porosity; good induration
1,928.0	1,930.6	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; no observed porosity; good induration; chert nodules
1,930.6	1,935.7	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration; partial evaporite vug filling
1,935.7	1,942.3	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; good induration; evaporite vug filling
1,942.3	1,949.7	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; good induration; some evaporite vug filling; organic flecks
1,949.7	1,950.0	Limestone (mudstone); very pale orange (10yr 8/2); no observable porosity; good induration; trace evaporite fracture filling; organic flecks

From Depth (ft bls)	To Depth (ft bls)	Lithologic Description
1,950.0	1,951.7	Limestone (wackestone); grayish orange (10yr 7/4); low intergranular porosity; good induration; undifferentiated forams; some lamination
1,951.7	1,955.3	Dolostone; grayish orange (10yr 7/4); low pinpoint porosity; good induration; some evaporite vug filling; organic flecks; undifferentiated forams
1,955.3	1,956.0	Limestone (wackestone); grayish orange (10yr 7/4); low intergranular porosity; good induration; with glauconite and evaporites; undifferentiated forams; some lamination
1,956.0	1,958.1	Dolostone; grayish orange (10yr 7/4); no observable porosity; good induration; evaporite vug filling; undifferentiated forams
1,958.1	1,960.0	Limestone (wackestone); very pale orange (10yr 8/2); no observable porosity; good induration; trace very fine glauconite
1,960.0	1,965.3	Limestone (wackestone); grayish orange (10yr 7/4); low intergranular porosity; good induration; with glauconite and evaporites; some lamination
1,965.3	1,966.3	Dolostone; grayish orange (10yr 7/4); moderate vugular porosity; good induration; some evaporite vug filling; very fine glauconite, trace pyrite
1,966.3	1,969.4	Dolostone; pale yellow brown (10yr 6/2); microcrystalline; low pinpoint porosity; good induration; partial evaporite vug filling
1,969.4	1,990.0	Limestone (wackestone); very pale orange (10yr 8/2); 10% intergranular porosity; good induration; up to 5% glauconite, trace evaporites; undifferentiated forams
1,990.0	1,990.8	Limestone (packstone); very pale orange (10yr 8/2); 10% intergranular porosity; good induration; intraclasts; up to 10% fine sand to gravel sized glauconite, trace evaporites; undifferentiated forams
1,990.8	2,000.0	Limestone (wackestone); very pale orange (10yr 8/2); 10% intergranular porosity; good induration; trace very fine to medium grained glauconite; undifferentiated forams; lamination

APPENDIX D:
SIEVE HYDROMETER ANALYSIS

RADISE INTERNATIONAL

SUMMARY OF LABORATORY TEST RESULTS
SIEVE ANALYSIS
RADISE Lab ID 2019-1740
Client Name: SFWMD Hydrogeology Unit
3301 Gun Club Road, MS 4232, West Palm Beach, FL 33406

Sample Description: Grayish brown fine silty SAND (SM)
Sample Location: OSF 113 ; 24' - 26'
Sample Date: Thursday, August 29, 2019 **Test Date:** Thursday, September 05, 2019
Tested By: Chris Beyers **Report Date:** Monday, September 09, 2019

Standard Sieve No.	Sieve Size (mm)	% Retained	% Passing
3/8"	9.500	0	100
No. 4	4.750	0.1	99.9
No. 10	2.000	0.5	99.5
No. 20	0.850	1.2	98.8
No. 40	0.425	2.9	97.1
No. 50	0.300	7.6	92.4
No. 60	0.250	12.9	87.1
No. 100	0.150	22.3	77.7
No. 140	0.106	40.4	59.6
No. 200	0.075	66.3	33.7
	0.033	83.96	16.04
	0.021	85.57	14.43
	0.009	87.97	12.03
	0.006	89.58	10.42
	0.004	91.18	8.82
	0.003	91.98	8.02
	0.001	94.39	5.61

Note: Grain size analysis performed in accordance with ASTM D422

Sincerely,

RADISE International, LC
Geotechnical & Software Consultants

Lodewyk C. Beyers
Laboratory Manager

Gregory J. Stelmack, P.E.
Florida Registration No. 70556

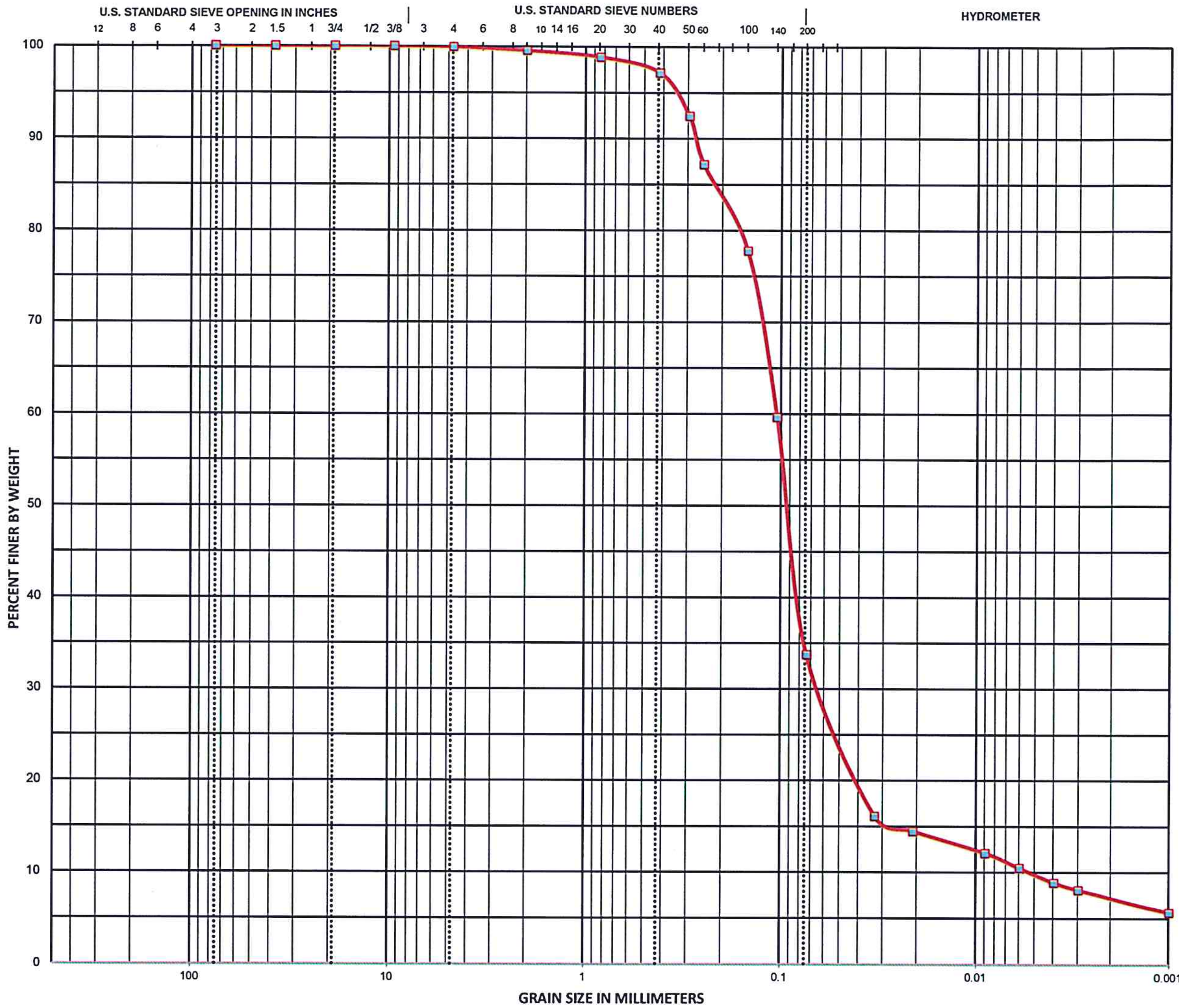
09/09/19

GREGORY J. STELMACK * LICENSE No 70556 * STATE OF FLORIDA PROFESSIONAL ENGINEER

TEST LAB LOCATION: 4152 West Blue Heron Blvd, Suite 1114, Riviera Beach, FL 33404 Ph: (561) 841-0103

GRAIN SIZE DISTRIBUTION

CLIENT NAME	SOUTH FLORIDA WATER MANAGEMENT DISTRICT 3301 Gun Club Road, MS 4232, West Palm Beach, FL 33406	PROJECT NAME	SFWMD Department of Hydrogeology - General Testing
PROJECT NUMBER	190828	SAMPLE NUMBER	2019-1740 / OSF 113 ; 24'-26'



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Year, Sample No	Classification	LL	PL	PI	Cc	Cu
2019 , 1740	Silty sand (SM)	N/A	N/A	N/A	7.07	20

Year, Sample No	D100	D60	D30	D10	% Cobble	%Gravel	%Sand	%Silt	%Clay
2019 , 1740	9.51	0.11	0.07	0.01	0	0.1	66.2	33.7	

Note: Test performed in accordance with ASTM D422

TEST LAB LOCATION: 4152 West Blue Heron Blvd, Suite 1114, Riviera Beach, FL 33404 Ph: (561) 841-0103

SUMMARY OF LABORATORY TEST RESULTS
SIEVE ANALYSIS
RADISE Lab ID 2019-1741
Client Name: SFWMD Hydrogeology Unit
3301 Gun Club Road, MS 4232, West Palm Beach, FL 33406

Sample Description: Yellowish brown fine silty SAND (SM)
Sample Location: OSF 113 ; 29' - 31'
Sample Date: Thursday, August 29, 2019 **Test Date:** Thursday, September 05, 2019
Tested By: Chris Beyers **Report Date:** Monday, September 09, 2019

Standard Sieve No.	Sieve Size (mm)	% Retained	% Passing
3/8"	9.500	0.000	100.000
No. 4	4.750	0.000	100.000
No. 10	2.000	0.1	99.9
No. 20	0.850	0.5	99.5
No. 40	0.425	0.9	99.1
No. 50	0.300	1.4	98.6
No. 60	0.250	1.7	98.3
No. 100	0.150	3.0	97.0
No. 140	0.106	34.0	66.0
No. 200	0.075	64.80	35.20
	0.032	82.25	17.75
	0.021	84.67	15.33
	0.012	87.09	12.91
	0.009	89.51	10.49
	0.006	91.93	8.07
	0.005	92.74	7.26
	0.003	93.54	6.46
	0.001	95.16	4.84

Note: Grain size analysis performed in accordance with ASTM D422

Sincerely,

RADISE International, LC
Geotechnical & Software Consultants

Lodewyk C. Beyers
Laboratory Manager

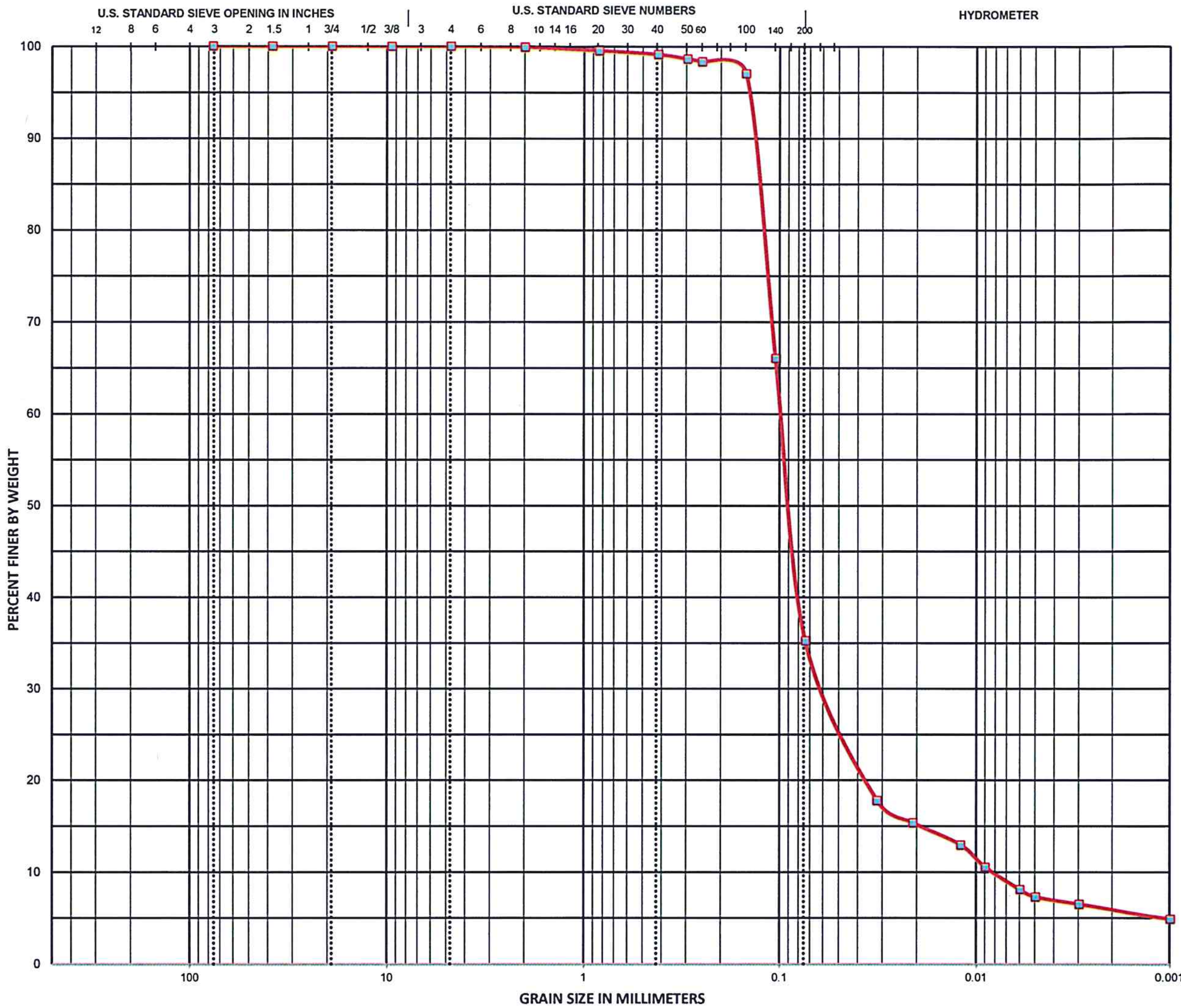
09/09/19

GREGORY J. STELMACK LICENSE No 70556 STATE OF FLORIDA PROFESSIONAL ENGINEER

Gregory J. Stelmack, P.E.
Florida Registration No. 70556

GRAIN SIZE DISTRIBUTION

CLIENT NAME	SOUTH FLORIDA WATER MANAGEMENT DISTRICT 3301 Gun Club Road, MS 4232, West Palm Beach, FL 33406	PROJECT NAME	SFWMD Department of Hydrogeology - General Testing
PROJECT NUMBER	190828	SAMPLE NUMBER	2019-1741 / OSF 113 ; 29'-31'



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Year, Sample No	Classification	LL	PL	PI	Cc	Cu
2019 , 1741	Silty sand (SM)	N/A	N/A	N/A	4.5	11.9

Year, Sample No	D100	D60	D30	D10	% Cobble	%Gravel	%Sand	%Silt	%Clay
2019 , 1741	4.76	0.1	0.06	0.01	0	0	64.8	35.2	

Note: Test performed in accordance with ASTM D422

TEST LAB LOCATION: 4152 West Blue Heron Blvd, Suite 1114, Riviera Beach, FL 33404 Ph: (561) 841-0103

APPENDIX E:
GEOPHYSICAL LOGS

ABS

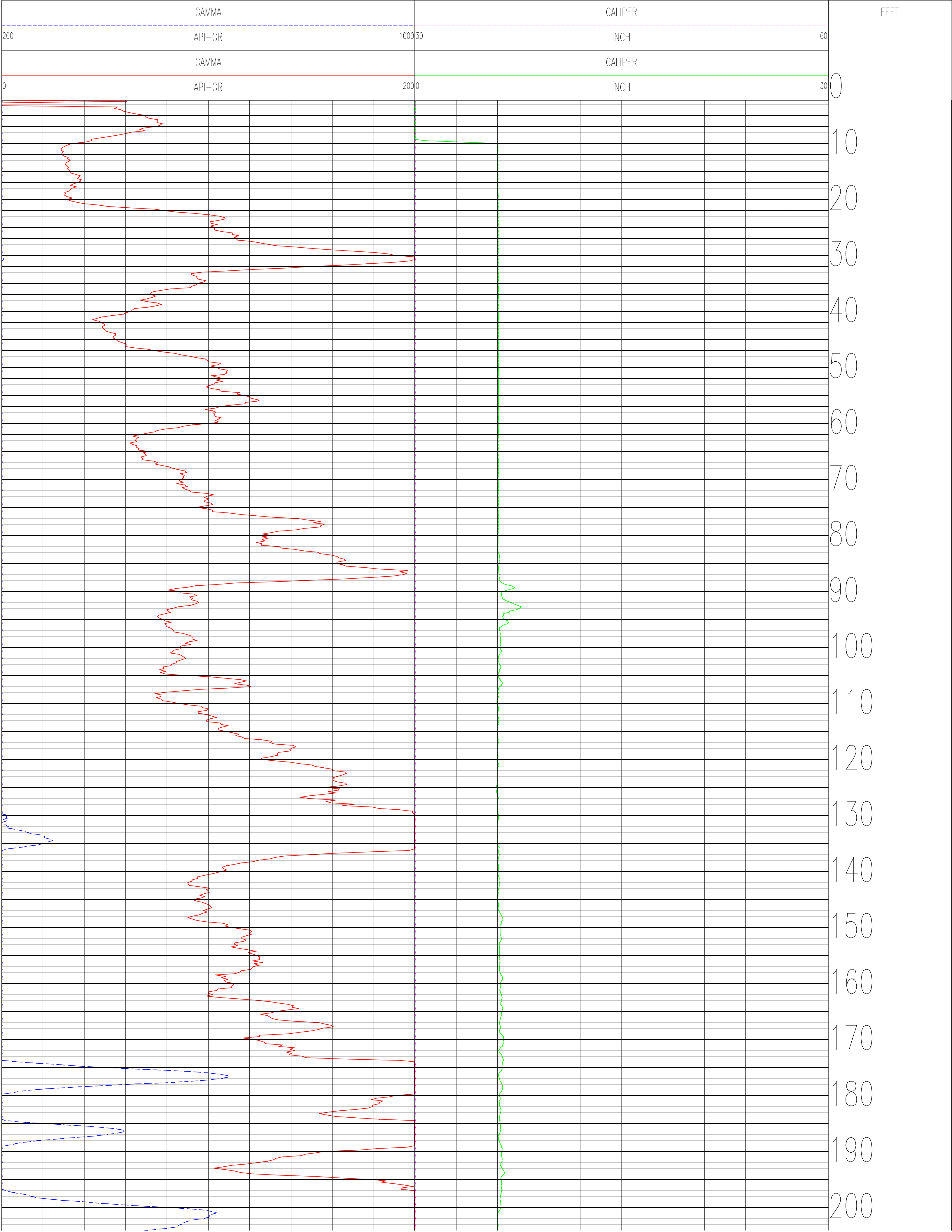
Advanced Borehole Services

GAMMA RAY (API)-CALIPER

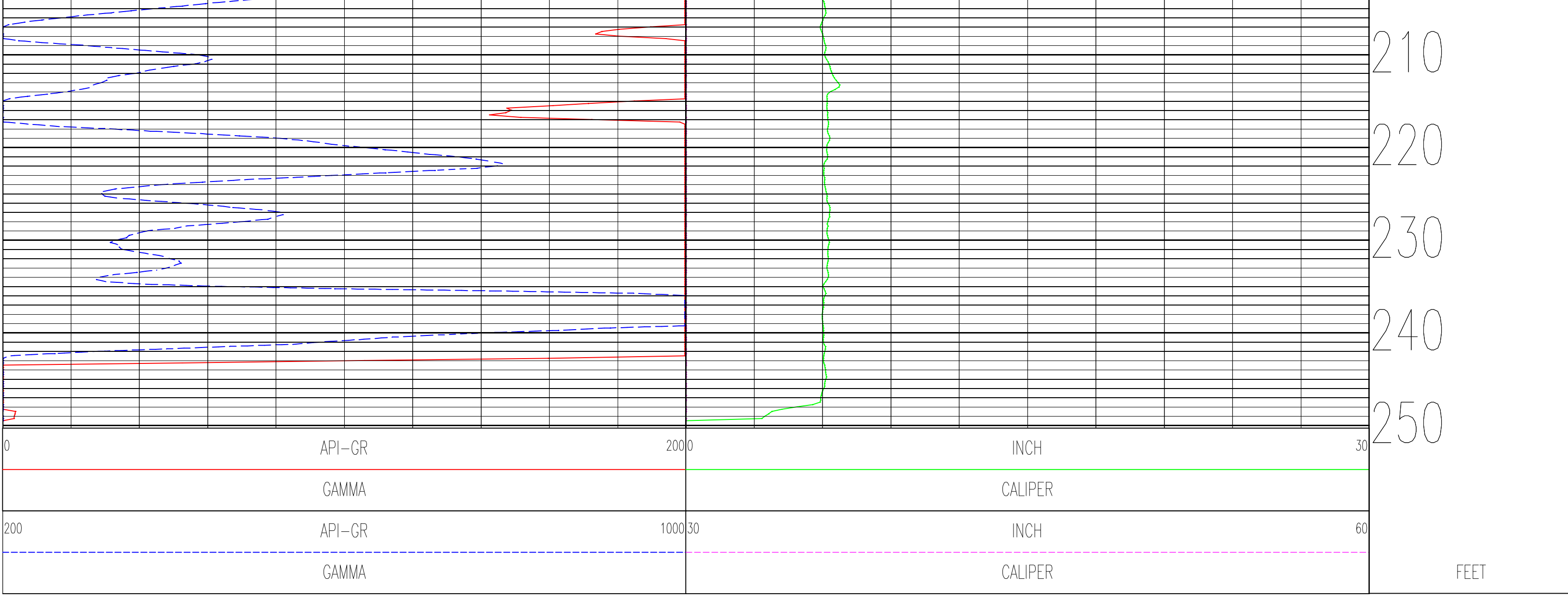
OSF-113

COMPANY	: HUSS DRILLING		OTHER SERVICES: PILOT
WELL	: OSF-113		
FIELD	: SITE S65		
COUNTY	: OSCEOLA		
STATE	: FLORIDA		
LOCATION	:		
SECTION	: None		
TOWNSHIP	: None		
RANGE	: None		
API NO.	:		
UNIQUE WELL ID.	:		
PERMANENT DATUM	: MSL	ELEVATION KB:	None
LOG MEASURED FROM:	GND SUR	ELEVATION DF:	None
DRL MEASURED FROM:	NA	ELEVATION GL:	None
DATE	: 01/21/19		
DEPTH DRILLER	: 250		
BIT SIZE	: 6		
LOG TOP	: 2.25		
LOG BOTTOM	: 250.00		
CASING OD	:		
CASING BOTTOM	: 82		
CASING TYPE	: STEEL		
BOREHOLE FLUID	: MUD		
RM TEMPERATURE	: 0		
MUD RES	: 0		
MUD WEIGHT	:		
WITNESSED BY	:		
RECORDED BY	: AFB		
REMARKS 1	:		
REMARKS 2	:		

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS



GAMMA
API-GR
200
1000
CALIPER
INCH
30
60
FEET
GAMMA
API-GR
0
200
CALIPER
INCH
0
30
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
0
API-GR
200
GAMMA
200
API-GR
1000
GAMMA
0
INCH
30
CALIPER
30
INCH
60
CALIPER
FEET

TOOL CALIBRATION OSF−113 01/21/19 11:24
TOOL 9074A1 TM VERSION 0
SERIAL NUMBER 857

	DATE	TIME	SENSOR	STANDARD		RESPONSE	
1	Dec02,18	17:23:05	GAMMA	Default	[CPS]	Default	[CPS]
	Dec02,18	14:23:05	GAMMA	180.000	[API−GR]	185.00	[CPS]
2	Jan09,18	14:50:00	CALIPER	3.000	[INCH]	157313.00	[CPS]
	Jan09,18	14:50:00	CALIPER	5.000	[INCH]	150790.00	[CPS]
3	Jan12,19	20:41:48	CALIPERL	5.000	[INCH]	121812.00	[CPS]
	Jan12,19	20:41:48	CALIPERL	10.000	[INCH]	113224.00	[CPS]
4	Dec13,00	22:19:45	CALIPERX	Default	[CPS]	Default	[CPS]
	Dec13,00	22:19:45	CALIPERX	Default	[CPS]	Default	[CPS]

GAMMA RAY-RESISTIVITY (16-64)

OSF-113

ABS
Advanced Borehole Services

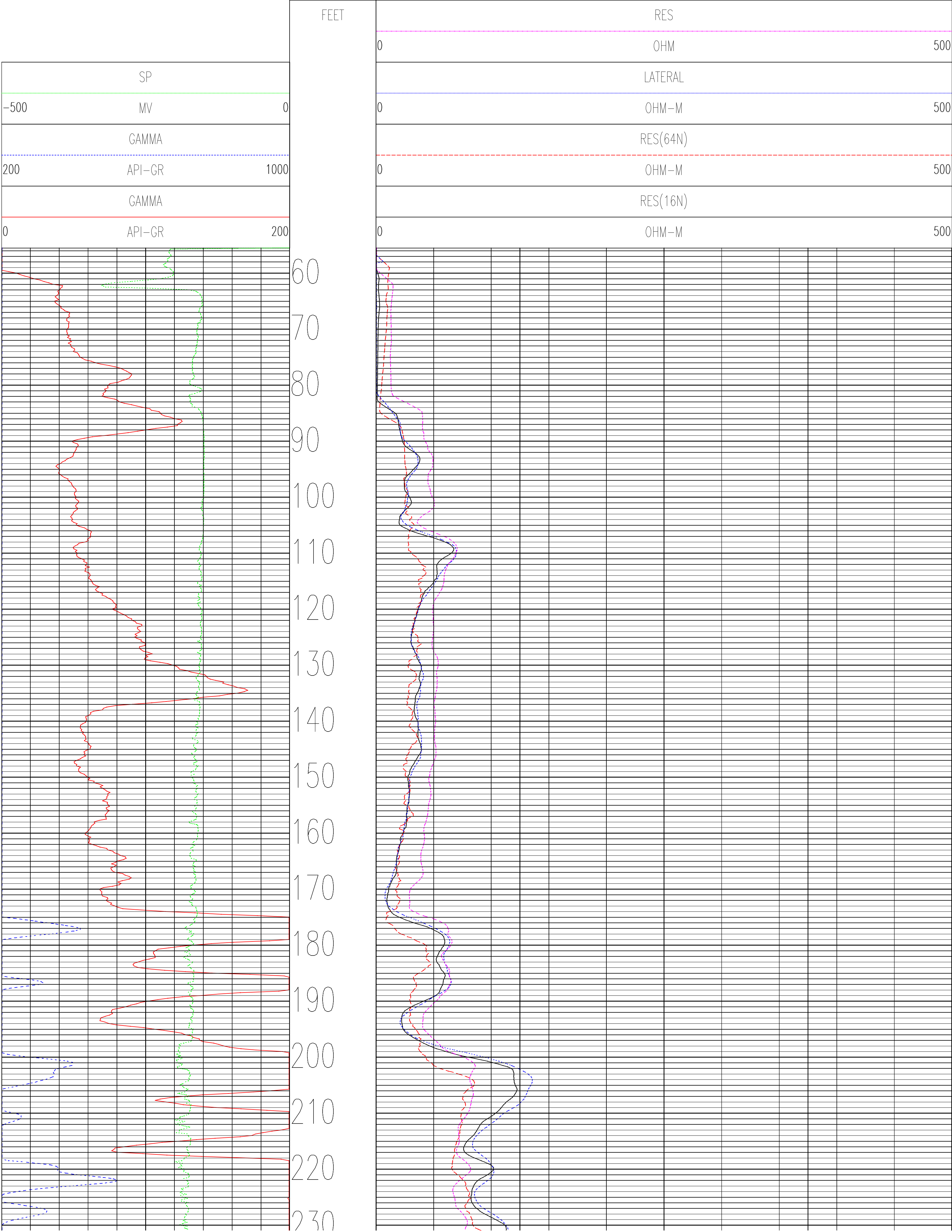
COMPANY	:	HUSS DRILLING
WELL	:	OSF-113
FIELD	:	SITE S65
COUNTY	:	OSCEOLA
STATE	:	FLORIDA

OTHER SERVICES:
PILOT

LOCATION	:	
SECTION	:	None
TOWNSHIP	:	None
RANGE	:	None
API NO.	:	
UNIQUE WELL ID.	:	

PERMANENT DATUM	: MSL	ELEVATION KB:	None
LOG MEASURED FROM:	GND SUR	ELEVATION DF:	None
DRL MEASURED FROM:	NA	ELEVATION GL:	None

DATE	:	01/21/19
DEPTH DRILLER	:	250
BIT SIZE	:	6
LOG TOP	:	55.50
LOG BOTTOM	:	248.00
CASING OD	:	
CASING BOTTOM	:	82
CASING TYPE	:	STEEL
BOREHOLE FLUID	:	MUD
RM TEMPERATURE	:	0
MUD RES	:	0
MUD WEIGHT	:	
WITNESSED BY	:	
RECORDED BY	:	AFB
REMARKS 1	:	
REMARKS 2	:	


FEET
RES
0 OHM 500
SP
-500 MV 0
LATERAL
0 OHM-M 500
GAMMA
200 API-GR 1000
RES(64N)
0 OHM-M 500
GAMMA
0 API-GR 200
RES(16N)
0 OHM-M 500
60
70
80
90
100
110
120
130
140
150
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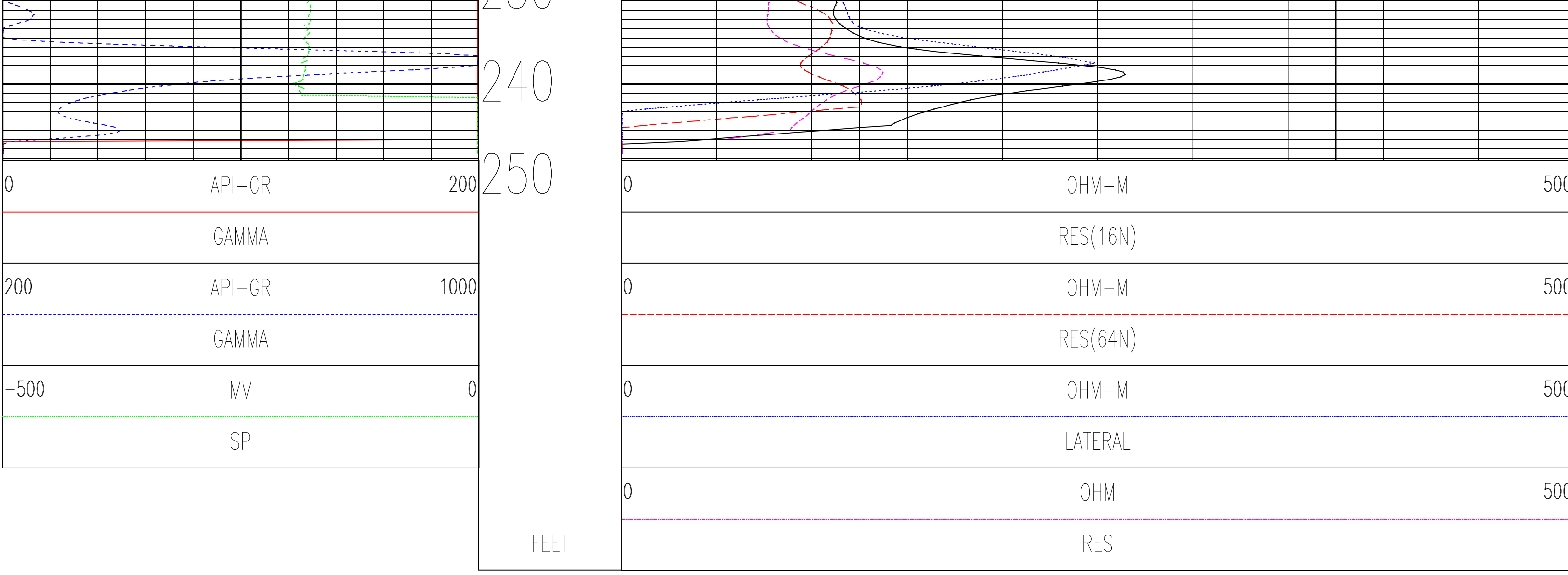
190
200
210
220
230


240
250
0 API-GR 200
GAMMA
200 API-GR 1000
GAMMA
-500 MV 0
SP
FEET
0 OHM-M 500
RES(16N)
0 OHM-M 500
RES(64N)
0 OHM-M 500
LATERAL
0 OHM 500
RES

TOOL CALIBRATION OSF-113 01/21/19 12:13
TOOL 8044A TM VERSION 0
SERIAL NUMBER 938

	DATE	TIME	SENSOR	STANDARD		RESPONSE	
1	Jan03,03	10:49:05	GAMMA	0.001	[API-GR]	0.00	[CPS]
	Jan03,03	07:49:05	GAMMA	180.000	[API-GR]	169.00	[CPS]
2	Jun26,18	13:37:10	RES(FL)	43.100	[OHM-M]	50053.00	[CPS]
	Jun26,18	13:37:10	RES(FL)	4.400	[OHM-M]	14979.00	[CPS]
3	Aug17,14	17:00:23	SP	0.000	[MV]	59670.00	[CPS]
	Aug17,14	17:00:23	SP	395.000	[MV]	23612.00	[CPS]
4	Jun25,18	17:12:44	RES(16N)	0.000	[OHM-M]	4101.00	[CPS]
	Jun25,18	17:12:44	RES(16N)	1996.000	[OHM-M]	103689.00	[CPS]
5	Jun25,18	17:13:03	RES(64N)	0.000	[OHM-M]	4430.00	[CPS]
	Jun25,18	17:13:03	RES(64N)	1990.000	[OHM-M]	102814.00	[CPS]
6	Aug17,14	17:19:05	TEMP	71.700	[DEG F]	63355.00	[CPS]
	Aug17,14	17:19:05	TEMP	81.500	[DEG F]	58740.00	[CPS]
7	Aug17,14	15:39:11	RES	0.000	[OHM]	9855.00	[CPS]
	Aug17,14	15:39:11	RES	988.000	[OHM]	58788.00	[CPS]

ABS
Advanced Borehole Services

FULL WAVE BHC ACOUSTIC-VDL

OSF-113

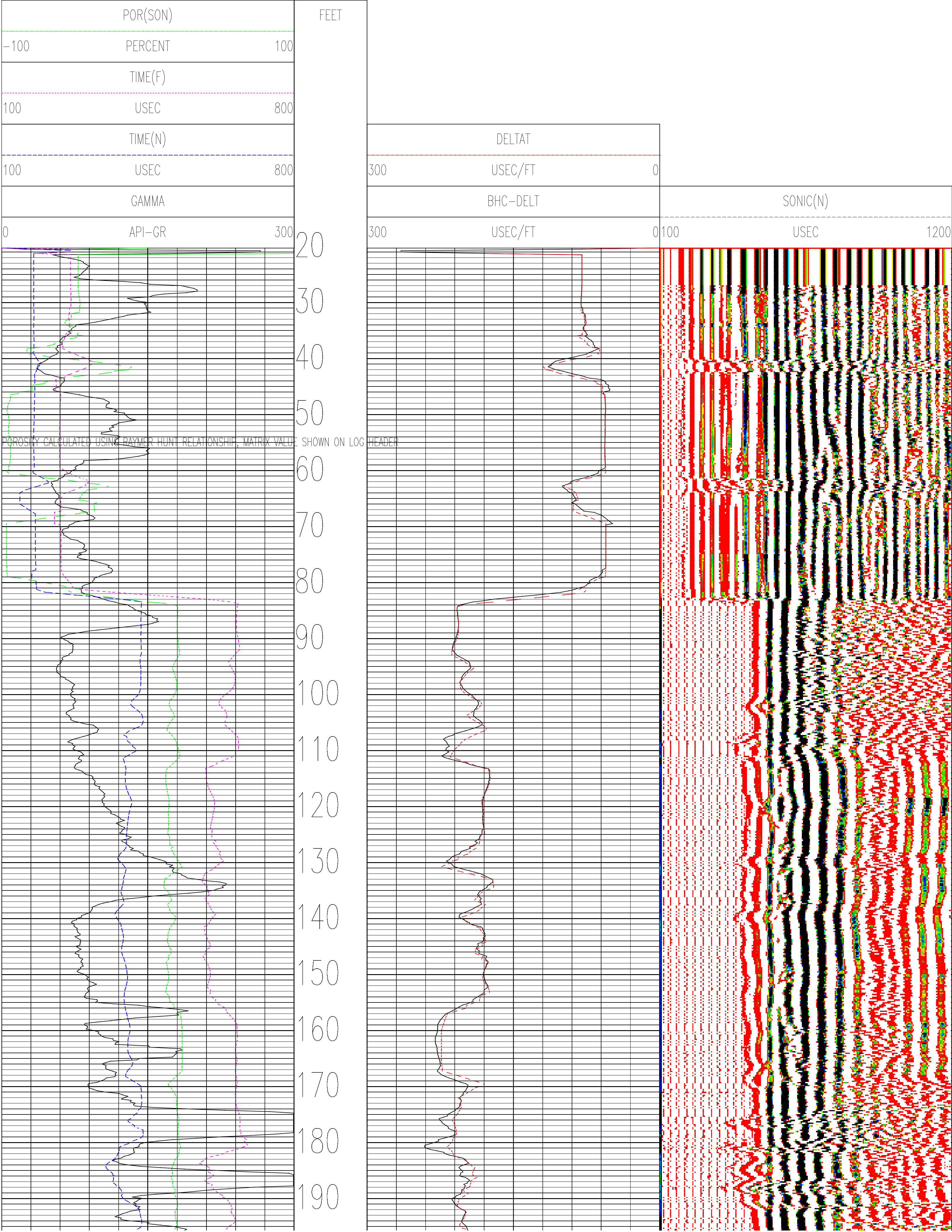
COMPANY	:	HUSS DRILLING
WELL	:	OSF-113
FIELD	:	SITE S65
COUNTY	:	OSCEOLA
STATE	:	FLORIDA

OTHER SERVICES:
PILOT

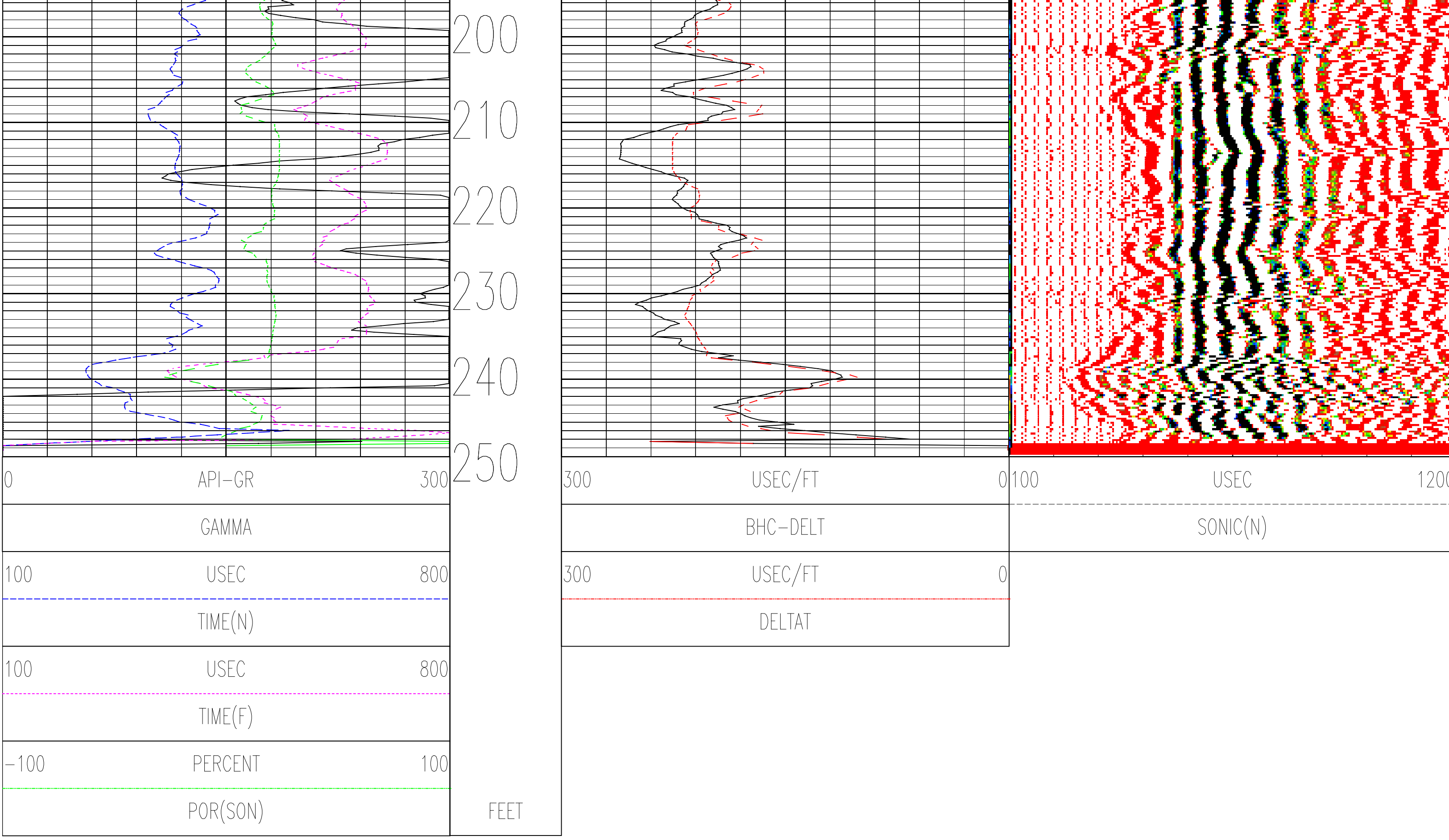
LOCATION	:	
SECTION	:	None
TOWNSHIP	:	None
RANGE	:	None
API NO.	:	
UNIQUE WELL ID.	:	

PERMANENT DATUM	: MSL	ELEVATION KB:	None
LOG MEASURED FROM:	GND SUR	ELEVATION DF:	None
DRL MEASURED FROM:	NA	ELEVATION GL:	None

DATE	:	01/21/19
DEPTH DRILLER	:	250
BIT SIZE	:	6
LOG TOP	:	20.25
LOG BOTTOM	:	248.75
CASING OD	:	
CASING BOTTOM	:	82
CASING TYPE	:	STEEL
BOREHOLE FLUID	:	MUD
RM TEMPERATURE	:	0
MUD RES	:	0
MUD WEIGHT	:	
WITNESSED BY	:	
RECORDED BY	:	AFB
REMARKS 1	:	
REMARKS 2	:	



POR(SON)
-100 PERCENT 100
TIME(F)
100 USEC 800
TIME(N)
100 USEC 800
GAMMA
0 API-GR 300
FEET
DELTAT
300 USEC/FT 0
BHC-DELT
300 USEC/FT 0
SONIC(N)
100 USEC 1200
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
POROSITY CALCULATED USING RAYMER HUNT RELATIONSHIP, MATRIX VALUE SHOWN ON LOG HEADER


200
210
220
230
240
250
0 API-GR 300
GAMMA
100 USEC 800
TIME(N)
100 USEC 800
TIME(F)
-100 PERCENT 100
POR(SON)
FEET
300 USEC/FT 0
BHC-DELT
300 USEC/FT 0
DELTAT
100 USEC 1200
SONIC(N)

TOOL CALIBRATION OSF-113 01/21/19 12:40
TOOL 9320A2 TM VERSION 0
SERIAL NUMBER 667

	DATE	TIME	SENSOR	STANDARD		RESPONSE	
1	Apr12,99	23:12:30	GAMMA	Default	[CPS]	Default	[CPS]
	Apr12,99	20:12:30	GAMMA	Default	[CPS]	Default	[CPS]

RMBAKER LLC
Geology and Geophysics
8600 Oldbridge Lane
Orlando, FL 32819
mobile ph 407-733-8958
rob@rmbaker.com
www.rmbaker.com

WELL OSF113
UWI OSF113
LOG STAGE PILOT HOLE 1420 FT

HEADER NOTES:

COMP	SFWMD		
LOC	26000 SR 60		
FLD	S65		
CNTY	OSCEOLA		
STAT	FL		
PROV	FL		
CTRY	USA		
LATI		X	
LONG		Y	
GDAT	WGS84	H DAT	
SEC		ELEV	
TWP		V DAT	
RGE			

ALL SERVICES:
CALIPER
NATURAL GAMMA
WATER QUALITY
ELECTRIC
DUAL INDUCTION

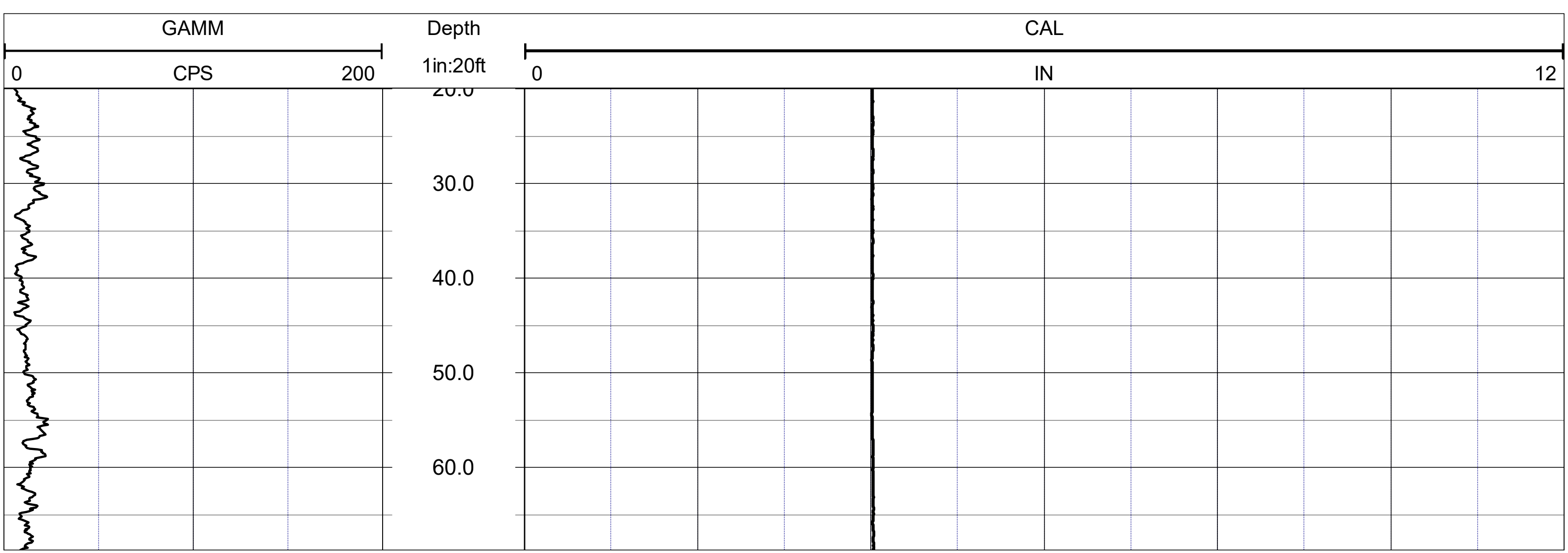
PERMANENT DATUM:
LOG MEASURED FROM: GROUND SURFACE
DRILLING MEASURED FROM:

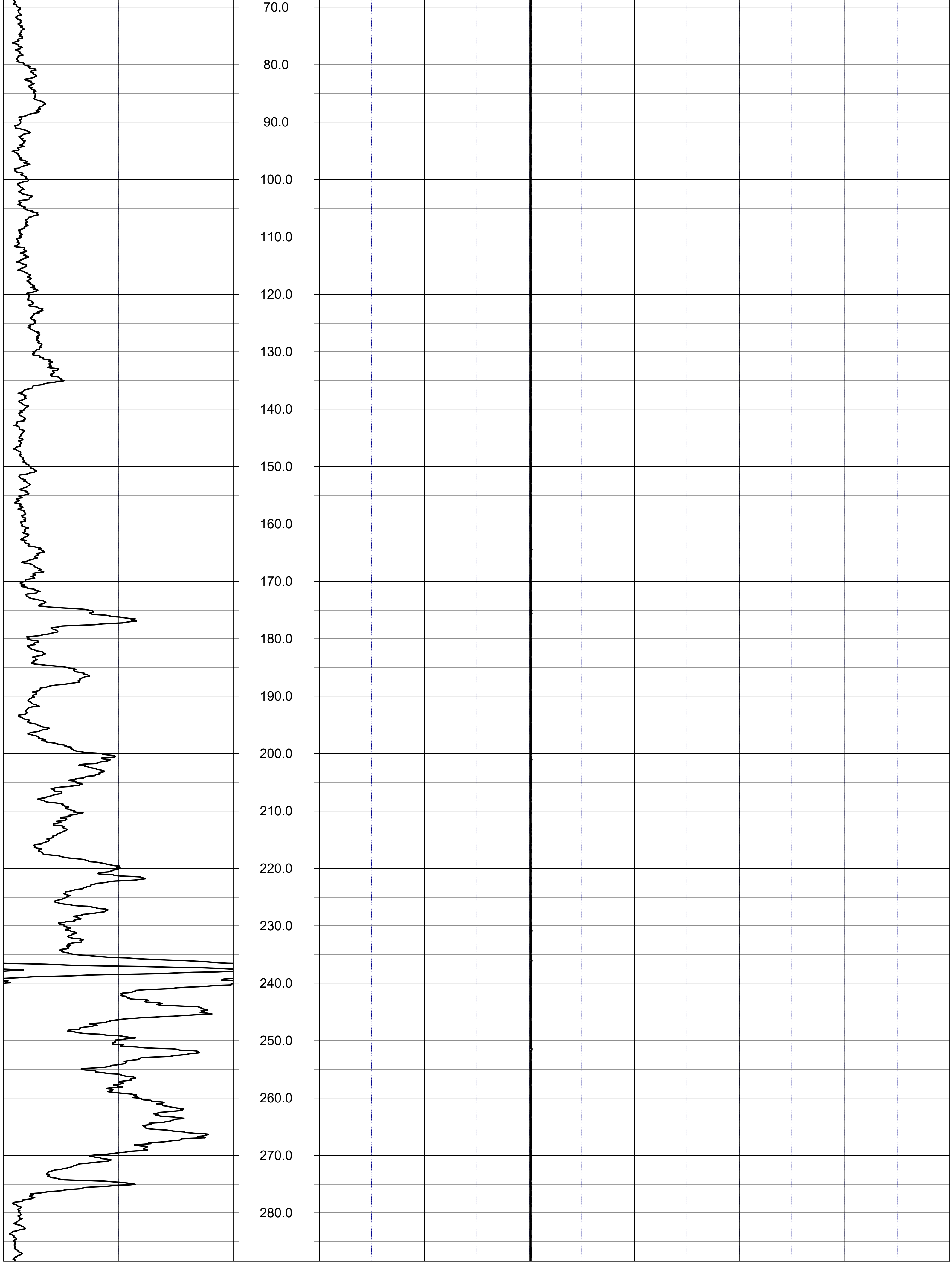
DATE	28 Mar 19	TYPE FLUID IN HOLE	WATER
RUN No	1	LOGGING SPEED (FT/MIN)	30
TYPE LOG	**CALIPER**	TROLLING DIRECTION	UP
		PUMPING RATE (GPM)	N/A
DEPTH-DRILLER	1420		
DEPTH-LOGGER	1416.75		
DRILLER	HUSS DRILLING		
RECORDED BY	RMB		
SRVC	RMBAKER LLC	API	N/A
WITNESSED BY	SFWMD	LIC	N/A

BOREHOLE RECORD				CASING RECORD			
RUN NO.	BIT	FROM	TO	SIZE	MAT.	FROM	TO
1	3.9	598	1420	4	STEEL	0	598

LOG CODES

3-arm caliper	**CAL**	long normal resistivity	**RLN**	deep induction conductivity	**IDC**
natural gamma (CPS)	**GAMM**	8 inch resistivity	**R8**	shallow induction conductivity	**ISC**
spontaneous potential	**ESP**	32 inch resistivity	**R32**	sonic interval velocity	**DT**
single point resistance	**RES**	deep induction resistivity	**ILD**	sonic porosity (RHG method)	**SPHI**
short normal resistivity	**RSN**	shallow induction resistivity	**ILM**	repeat designation	**R**

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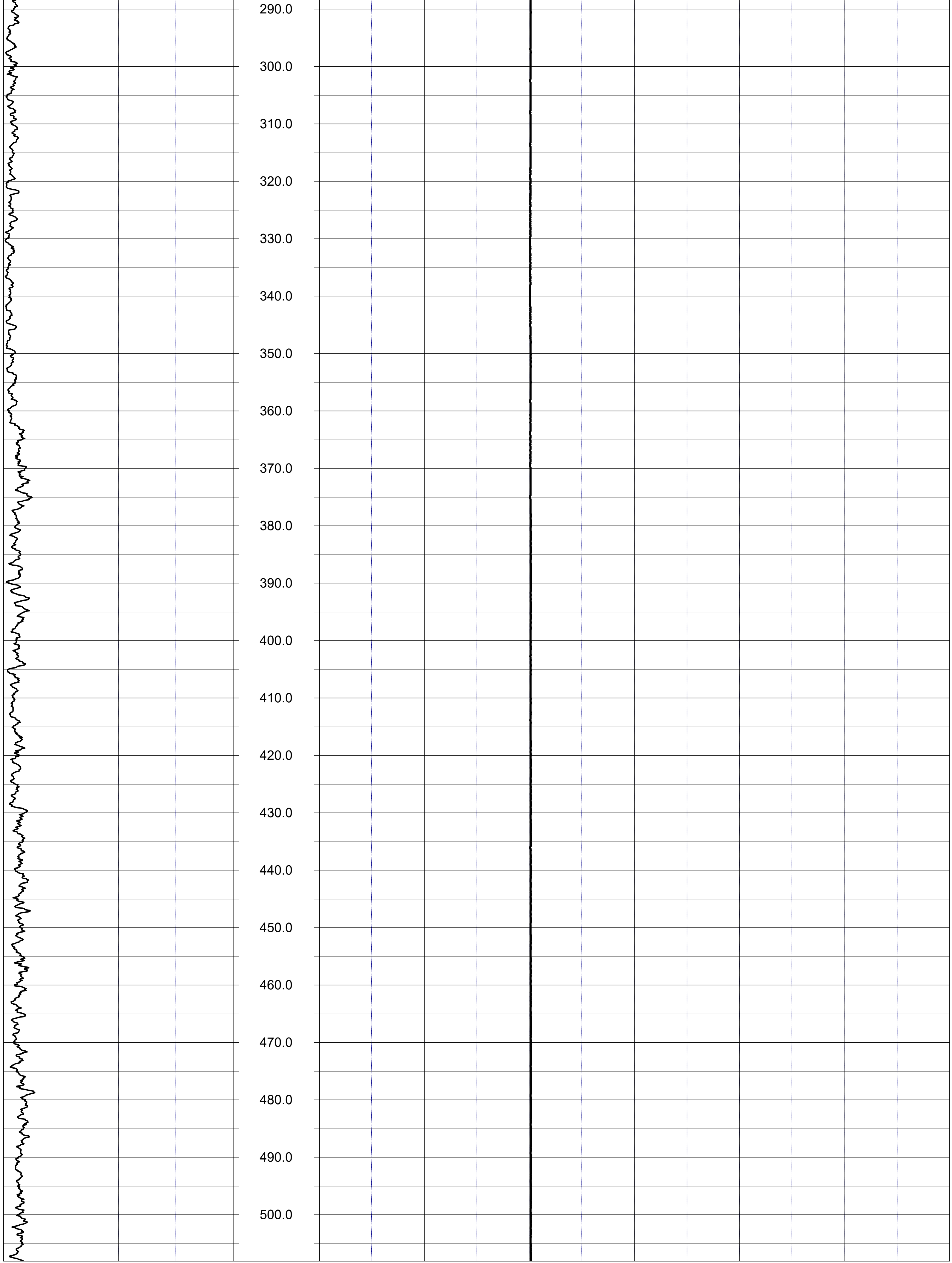
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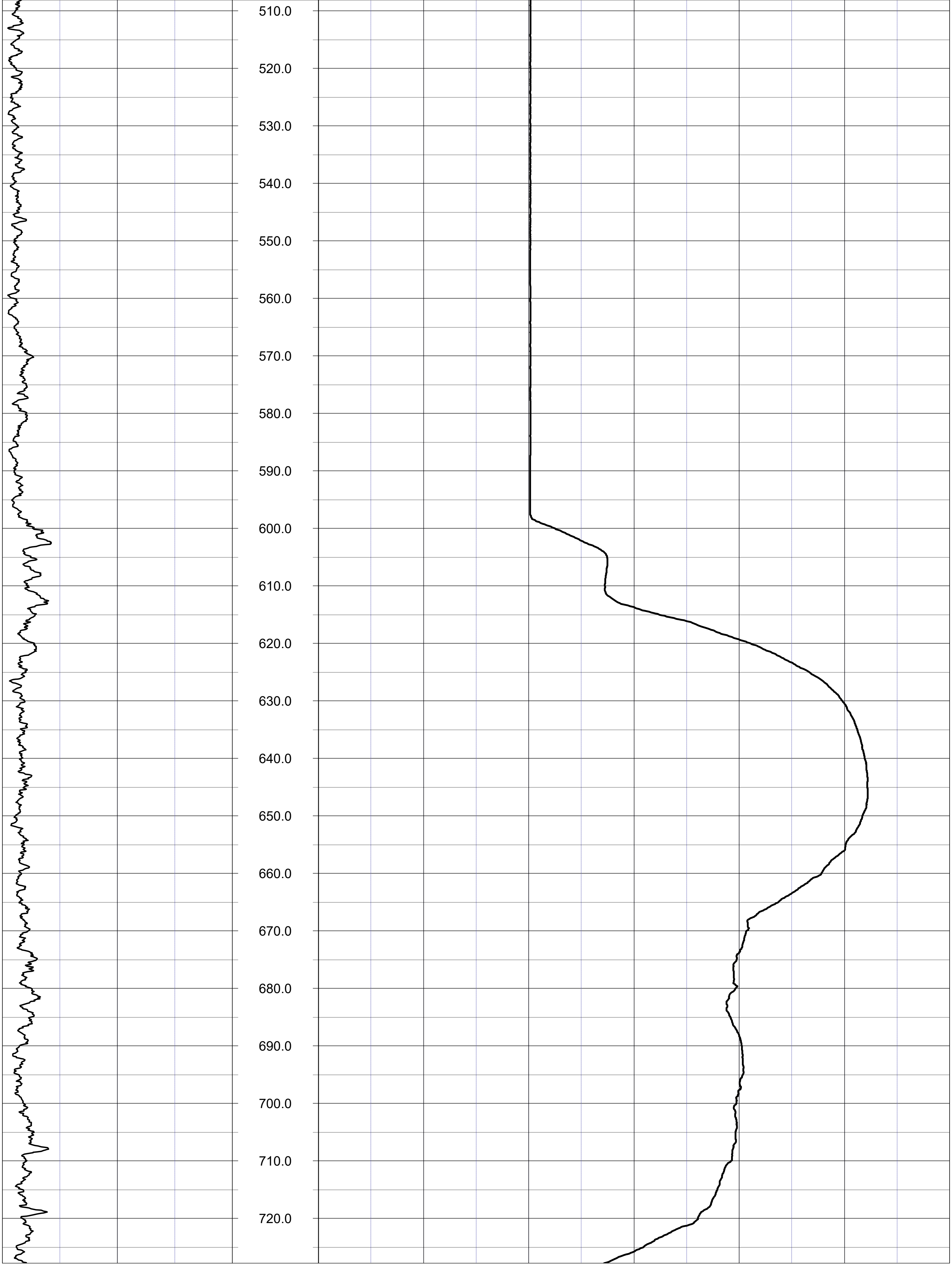
480.0
490.0
500.0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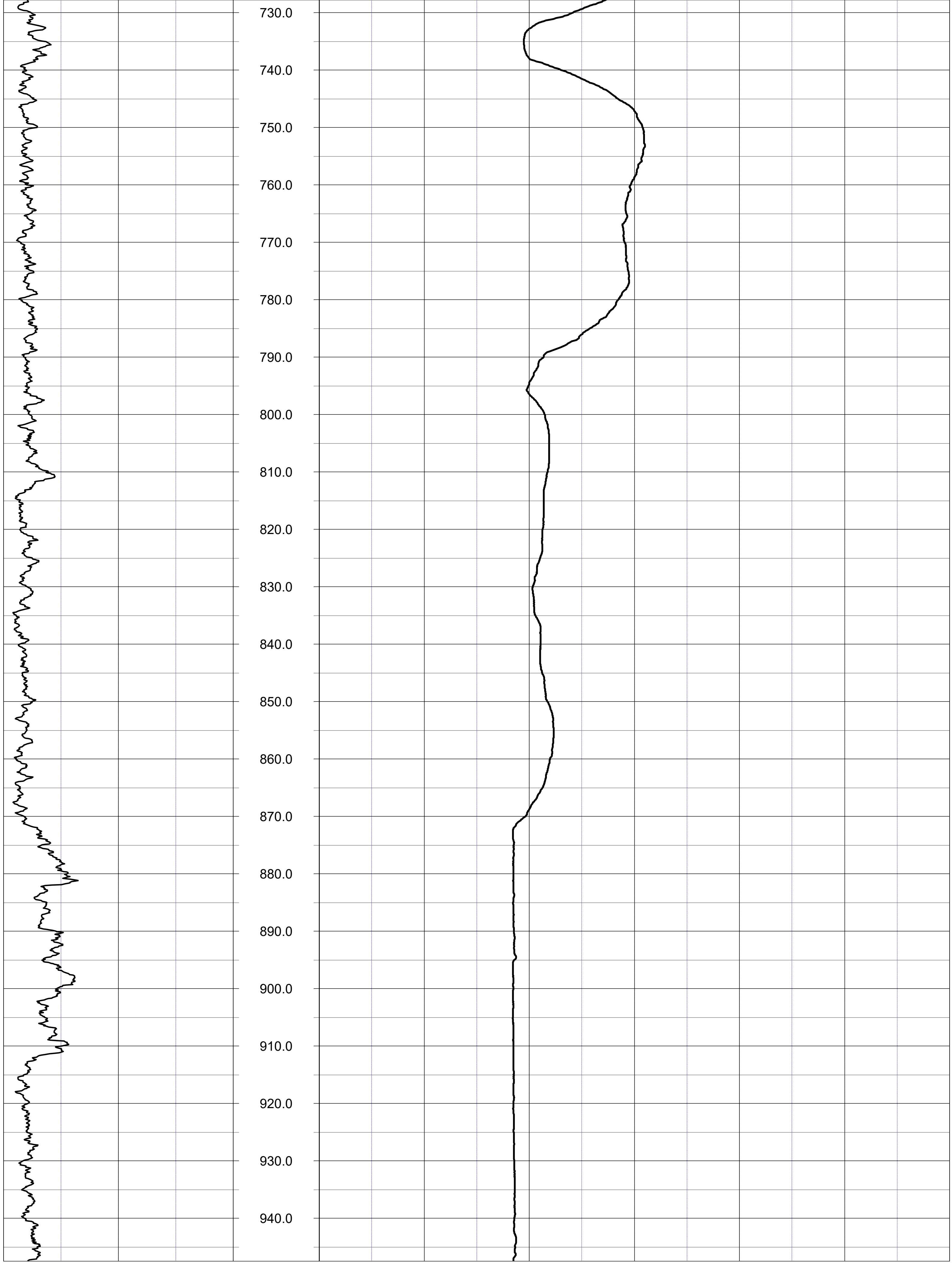
700.0
710.0
720.0


730.0
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760.0
770.0
780.0
790.0
800.0
810.0
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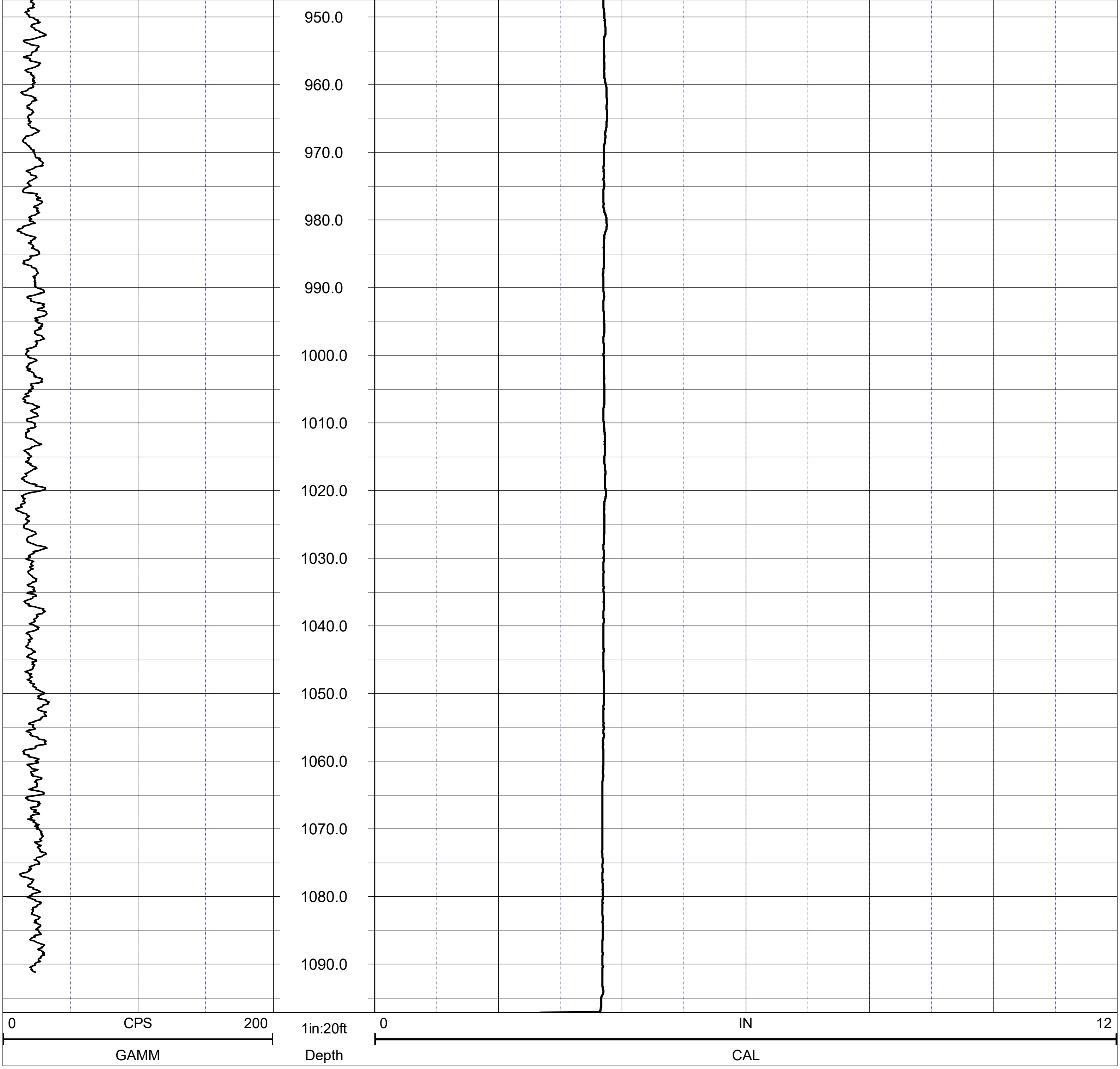
920.0
930.0
940.0



NOTES:
While due care has been exercised in the performance of these measurements and observations, in accordance with methodologies utilized by the general practitioner, RMBAKER LLC can make no representations, warranties, or guarantees with respect to latent or concealed conditions that may exist, which may be beyond the detection capabilities of the methodologies used, or that may extend beyond the areas and depths surveyed.
The geophysical well logs show subsurface conditions as they existed at the dates and locations shown, and it is not warranted that they are representative of subsurface conditions at other locations and times.
If, at any time, different subsurface conditions from those observed are determined to be present, we must be advised and allowed to review and revise our observations if necessary.

Florida Licensed Geology Business GB 458

END OF LOG

RMBAKER LLC

Geology and Geophysics
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Orlando, FL 32819
mobile ph 407-733-8958
rob@rmbaker.com
www.rmbaker.com

WELL OSF113
UWI OSF113
LOG STAGE PILOT HOLE 1420 FT

HEADER NOTES:
BOTH SETS OF LOGS WERE COLLECTED IN MULTIPLE STAGES; A DEVIATION IN THE BOREHOLE AT 1100 FEET NECESSITATED SHALLOW AND DEEP DUAL INDUCTION RUNS

COMP	SFWMD
LOC	26000 SR 60
FLD	S65
CNTY	OSCEOLA
STAT	FL
PROV	FL
CTRY	USA

LATI		X	
LONG		Y	
GDAT	WGS84	H DAT	
SEC		ELEV	
TWP		V DAT	
RGE			

ALL SERVICES:
CALIPER
NATURAL GAMMA
WATER QUALITY
ELECTRIC
DUAL INDUCTION

PERMANENT DATUM:
LOG MEASURED FROM: GROUND SURFACE
DRILLING MEASURED FROM:

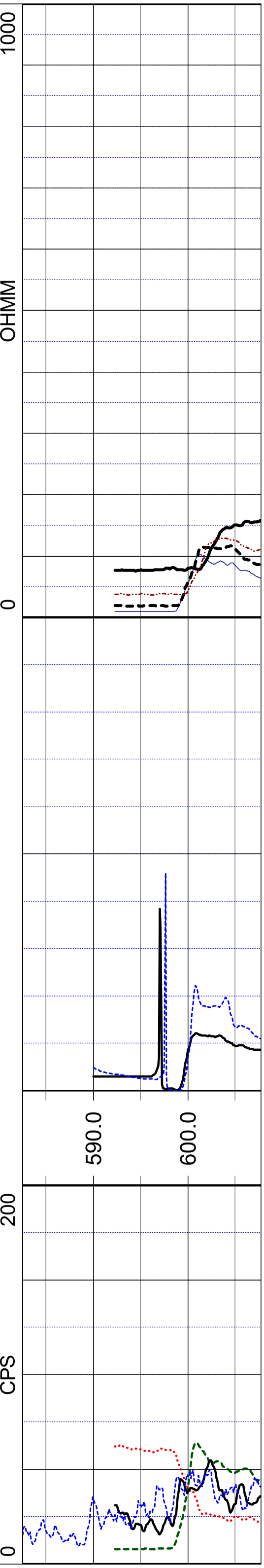
DATE	28 Mar 19	TYPE FLUID IN HOLE	WATER
RUN No	1	LOGGING SPEED (FT/MIN)	25
TYPE LOG	ELECTRIC + DUIN	TROLLING DIRECTION	UP
		PUMPING RATE (GPM)	N/A
DEPTH-DRILLER	1420		
DEPTH-LOGGER	1416.75		
DRILLER	HUSS DRILLING		
RECORDED BY	RMB		
SRVC	RMBAKER LLC	API	N/A
WITNESSED BY	SFWMD	LIC	N/A

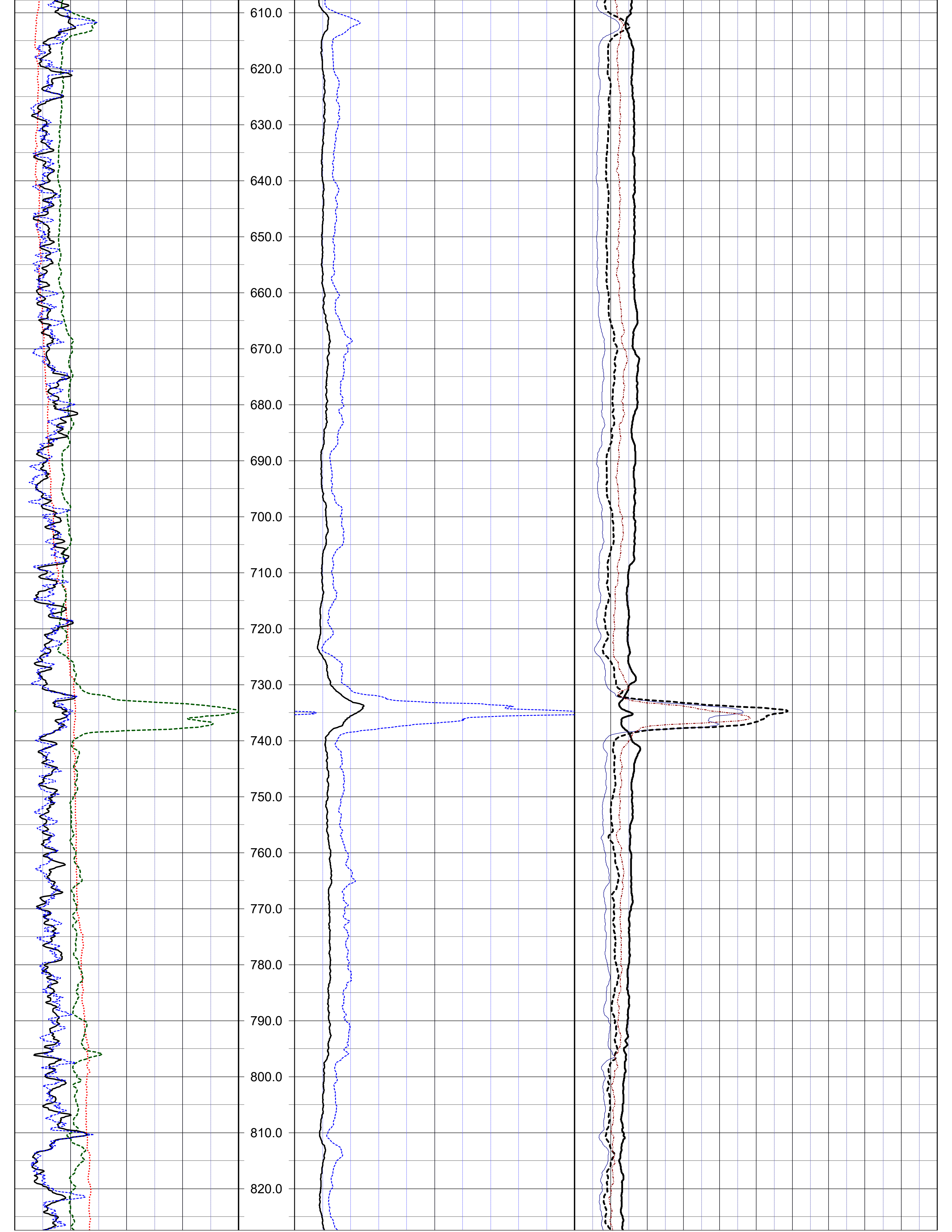
RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	MAT.	FROM	TO
1	3.9	598	1420	4	STEEL	0	598

LOG CODES

3-arm caliper	**CAL**	long normal resistivity	**RLN**	deep induction conductivity	**IDC**
natural gamma (CPS)	**GAMM**	8 inch resistivity	**R8**	shallow induction conductivity	**ISC**
spontaneous potential	**ESP**	32 inch resistivity	**R32**	sonic interval velocity	**DT**
single point resistance	**RES**	deep induction resistivity	**ILD**	sonic porosity (RHG method)	**SPHI**
short normal resistivity	**RSN**	shallow induction resistivity	**ILM**	repeat designation	**R**

ESP	Depth	ILD	RLN
0 mV 1000	1in:20ft	0 OHMM 500	0 OHMM 1000
RES		ILM	R8
0 OHM 220		0 OHMM 500	0 OHMM 1000
EGAMM			RSN
0 CPS 200			0 OHMM 1000
DGAMM			R32
0 CPS 200			0 OHMM 1000

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620.0
630.0
640.0
650.0
660.0
670.0
680.0
690.0
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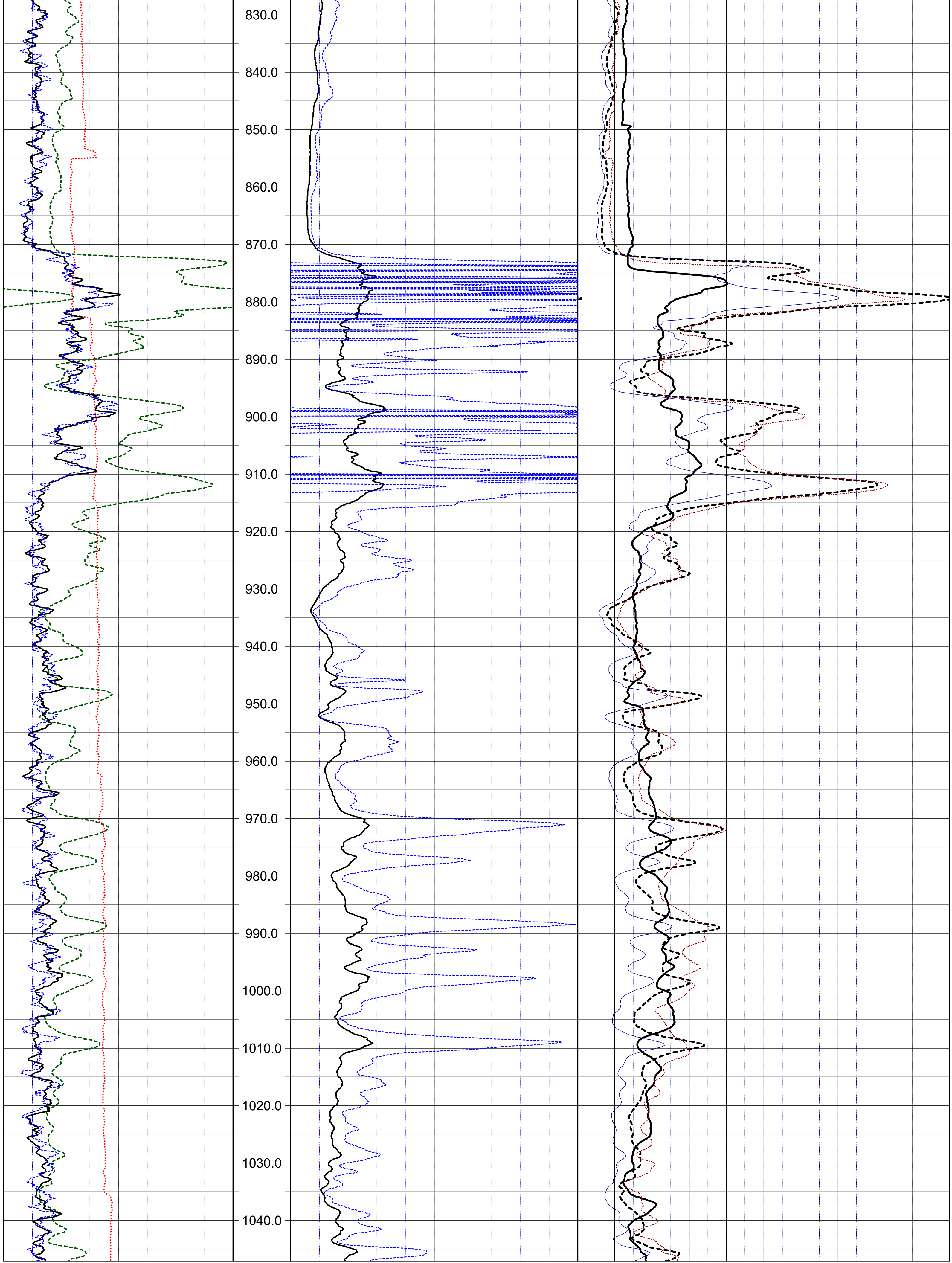

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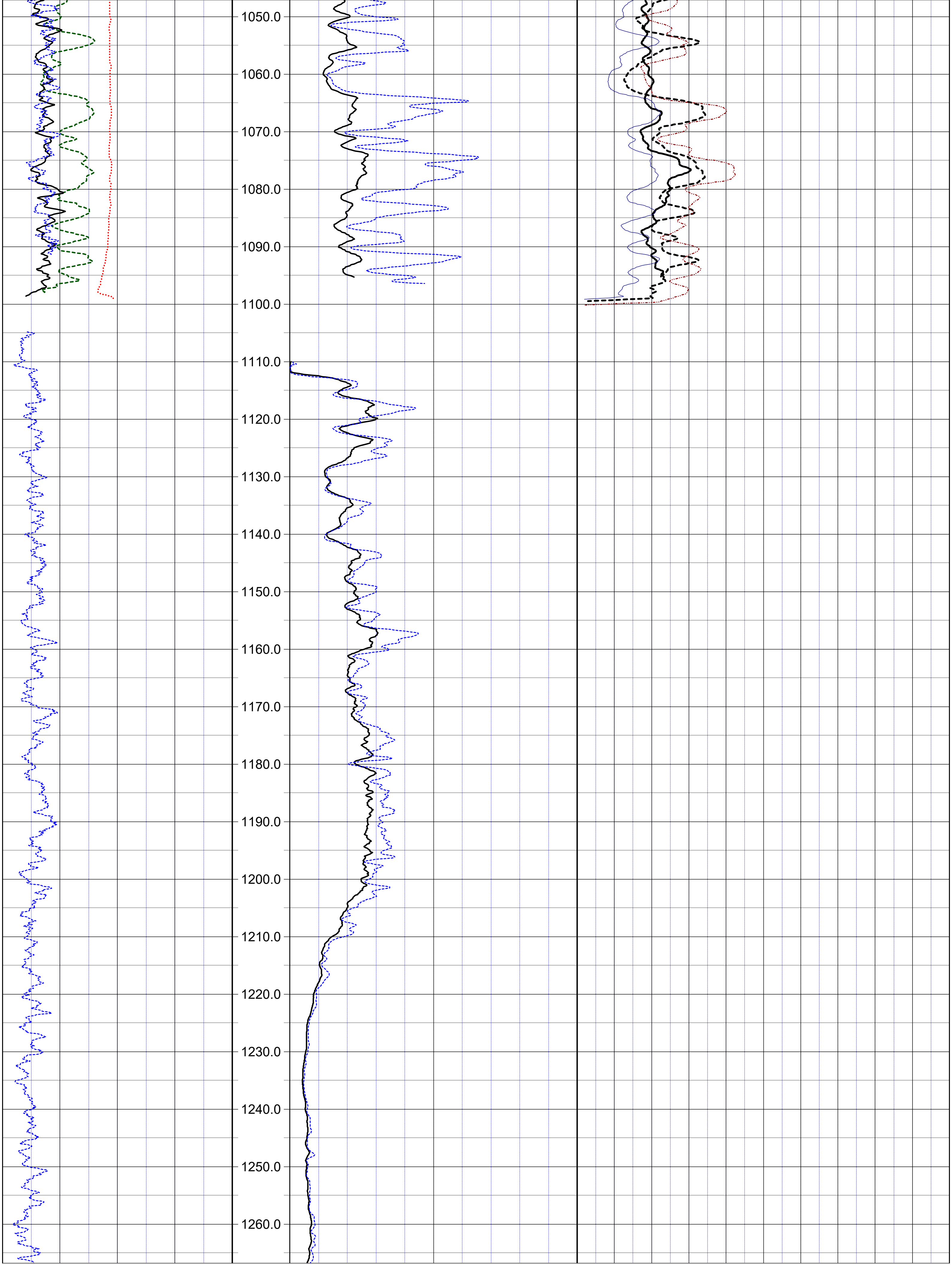
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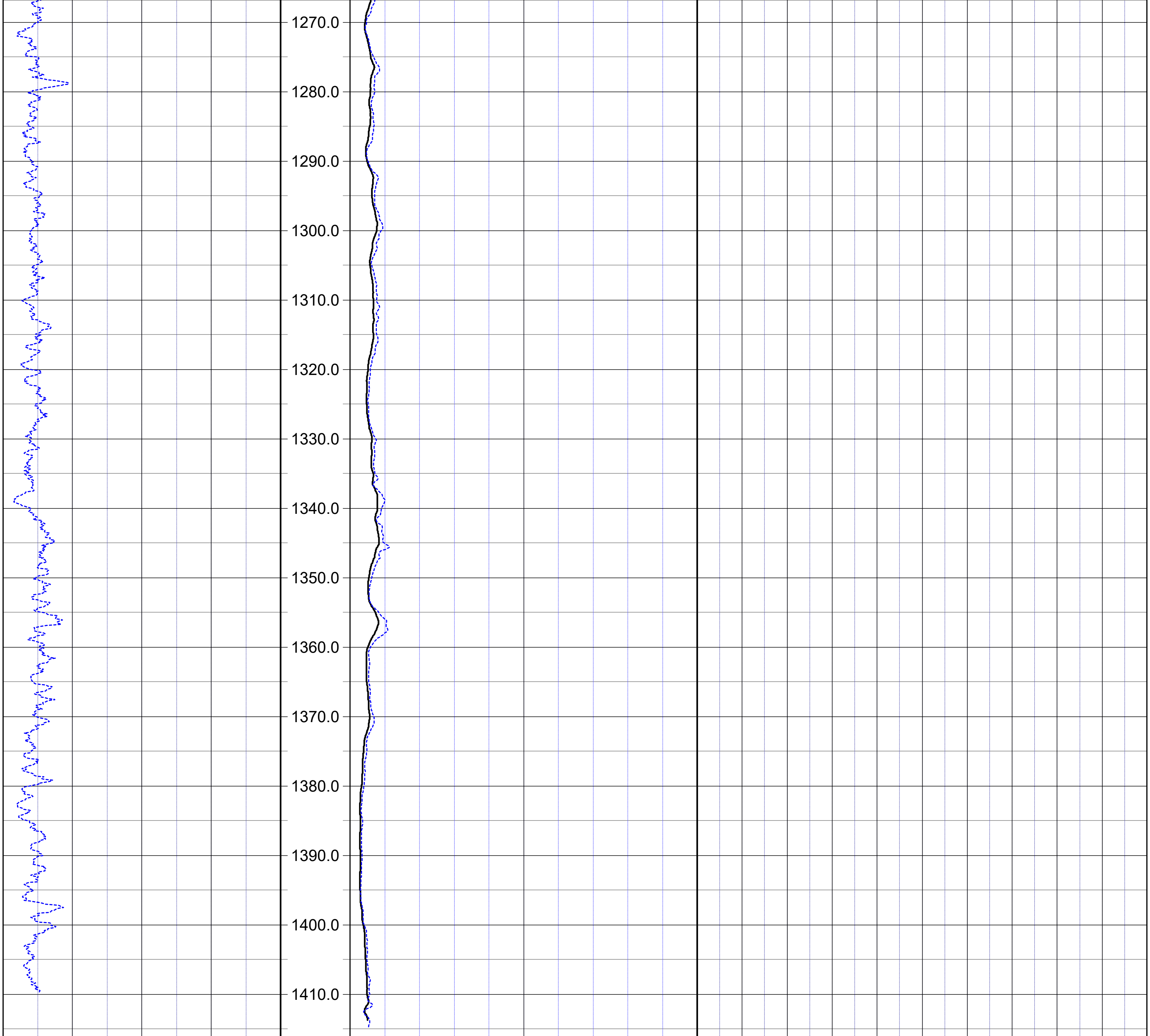

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0 CPS 200 EGAMM			0 OHMM 1000 RSN
0 OHM 220 RES		0 OHMM 500 ILM	0 OHMM 1000 R8
0 mV 1000 ESP	1in:20ft Depth	0 OHMM 500 ILD	0 OHMM 1000 RLN

NOTES:

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Florida Licensed Geology Business GB 458

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Geology and Geophysics
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mobile ph 407-733-8958
rob@rmbaker.com
www.rmbaker.com

WELL OSF113
UWI OSF113
LOG STAGE PILOT HOLE 1420 FT

HEADER NOTES:

COMP	SFWMD
LOC	26000 SR 60
FLD	S65
CNTY	OSCEOLA
STAT	FL
PROV	FL
CTRY	USA

LATI		X	
LONG		Y	
GDAT	WGS84	H DAT	
SEC		ELEV	
TWP		V DAT	
RGE			

ALL SERVICES:
CALIPER
NATURAL GAMMA
WATER QUALITY
ELECTRIC
DUAL INDUCTION

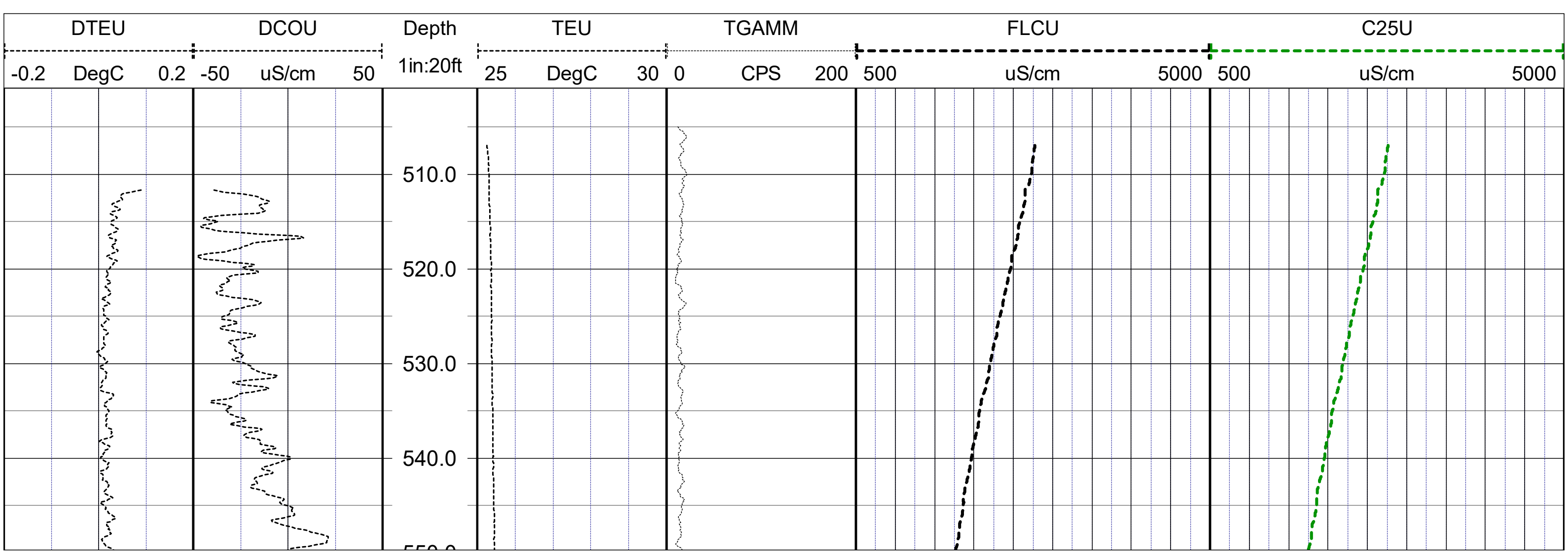
PERMANENT DATUM:
LOG MEASURED FROM: GROUND SURFACE
DRILLING MEASURED FROM:

DATE	28 Mar 19	TYPE FLUID IN HOLE	WATER
RUN No	1	LOGGING SPEED (FT/MIN)	15
TYPE LOG	**WATER QUALITY**	TROLLING DIRECTION	DOWN
DEPTH-DRILLER	1420	PUMPING RATE (GPM)	N/A
DEPTH-LOGGER	1416.75		
DRILLER	HUSS DRILLING		
RECORDED BY	RMB		
SRVC	RMBAKER LLC	API	N/A
WITNESSED BY	SFWMD	LIC	N/A

BOREHOLE RECORD				CASING RECORD			
RUN NO.	BIT	FROM	TO	SIZE	MAT.	FROM	TO
1	3.9	598	1420	4	STEEL	0	598

WATER QUALITY LOG CODES

static fluid temperature	**TEU**	dynamic fluid conductivity	**FLCP**	caliper	**CAL**
dynamic fluid temperature	**TEP**	static differential cond.	**DCOU**	repeat designation	**R**
static differential temperature	**DTEU**	dynamic differential cond.	**DCOP**	natural gamma	**GAMM**
dynamic differential temp.	**DTEP**	static specific conductance	**C25U**	calibration correction	**C**
static fluid conductivity	**FLCU**	dynamic specific conductance	**C25P**		

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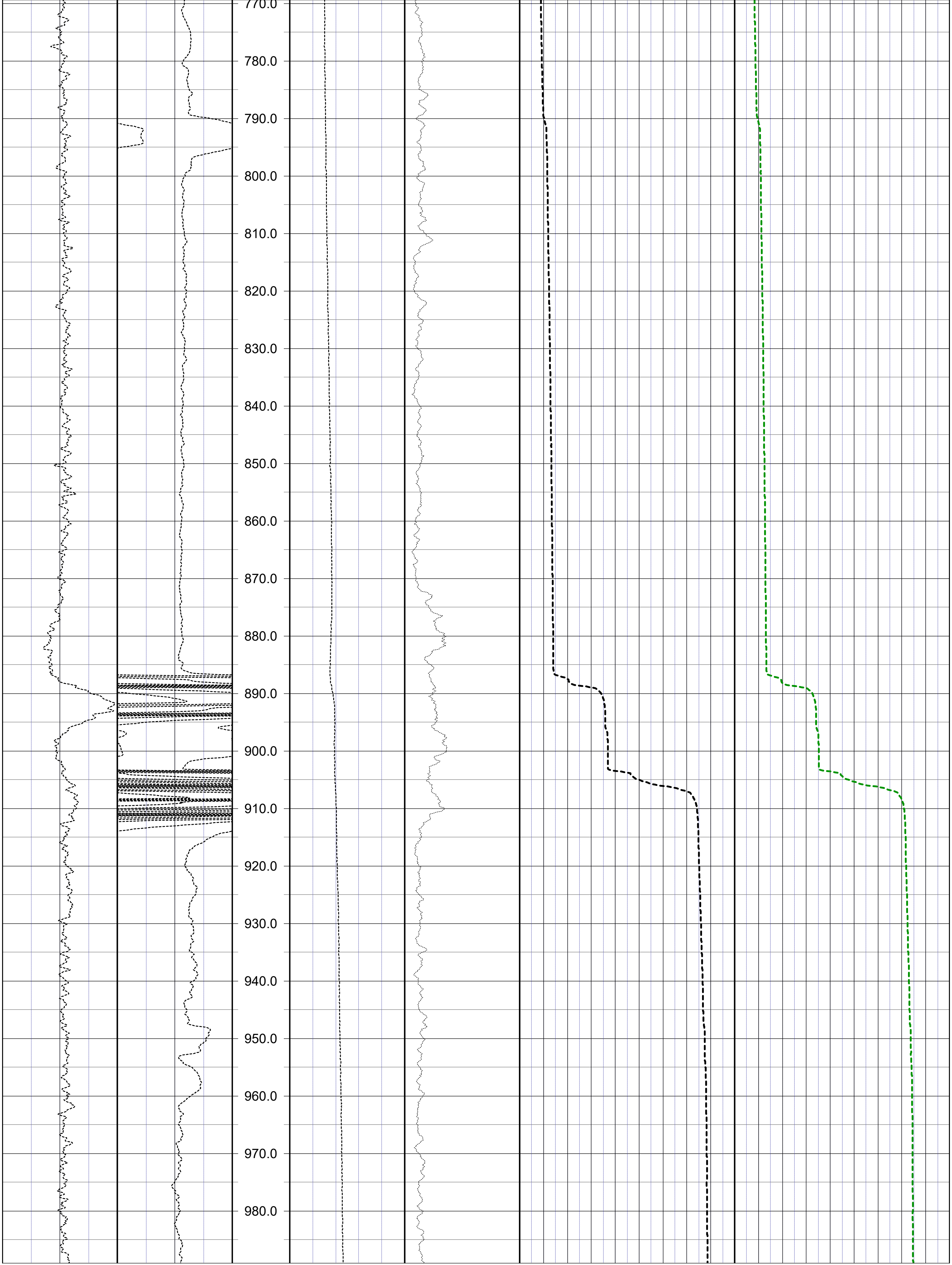
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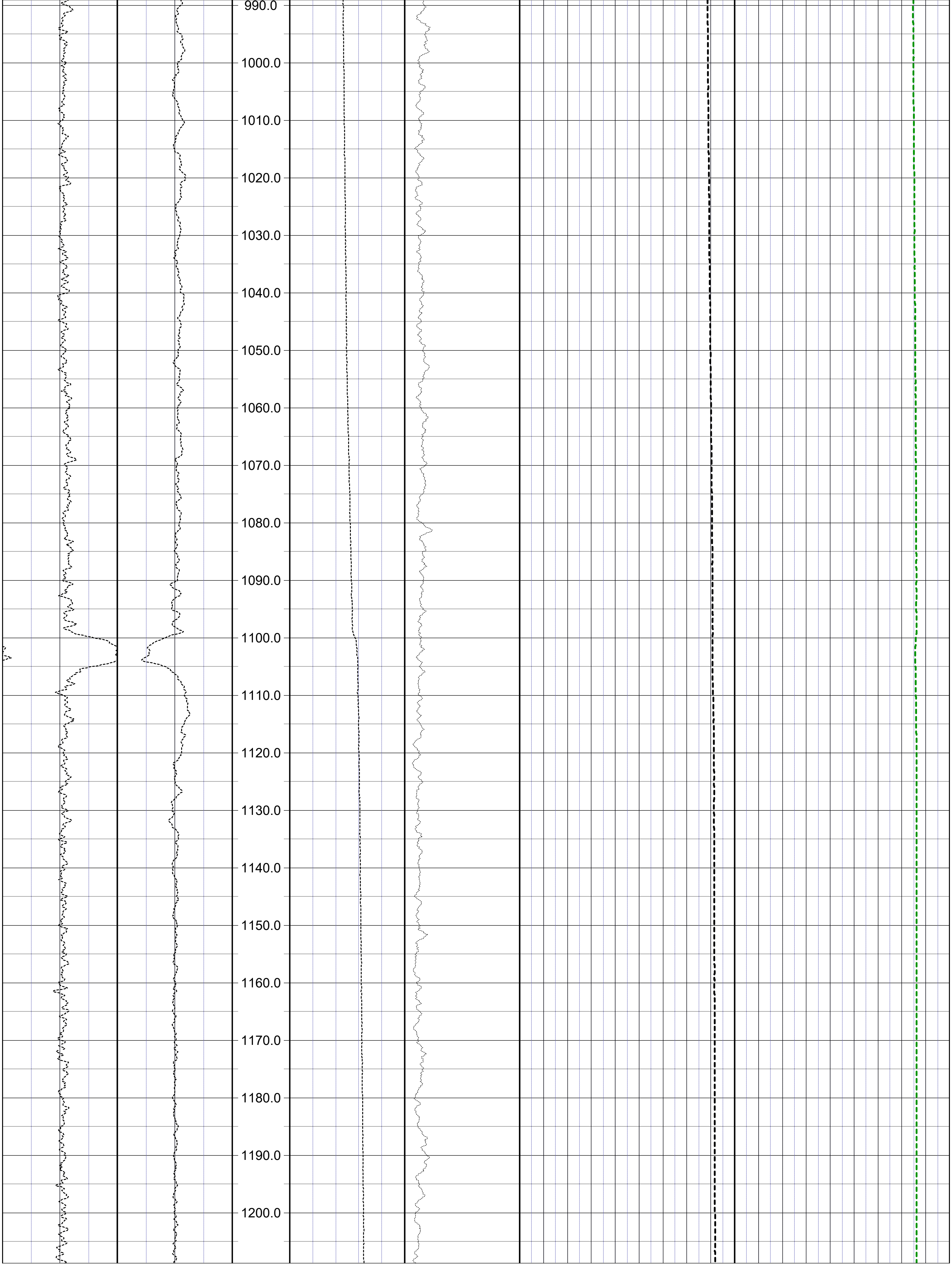
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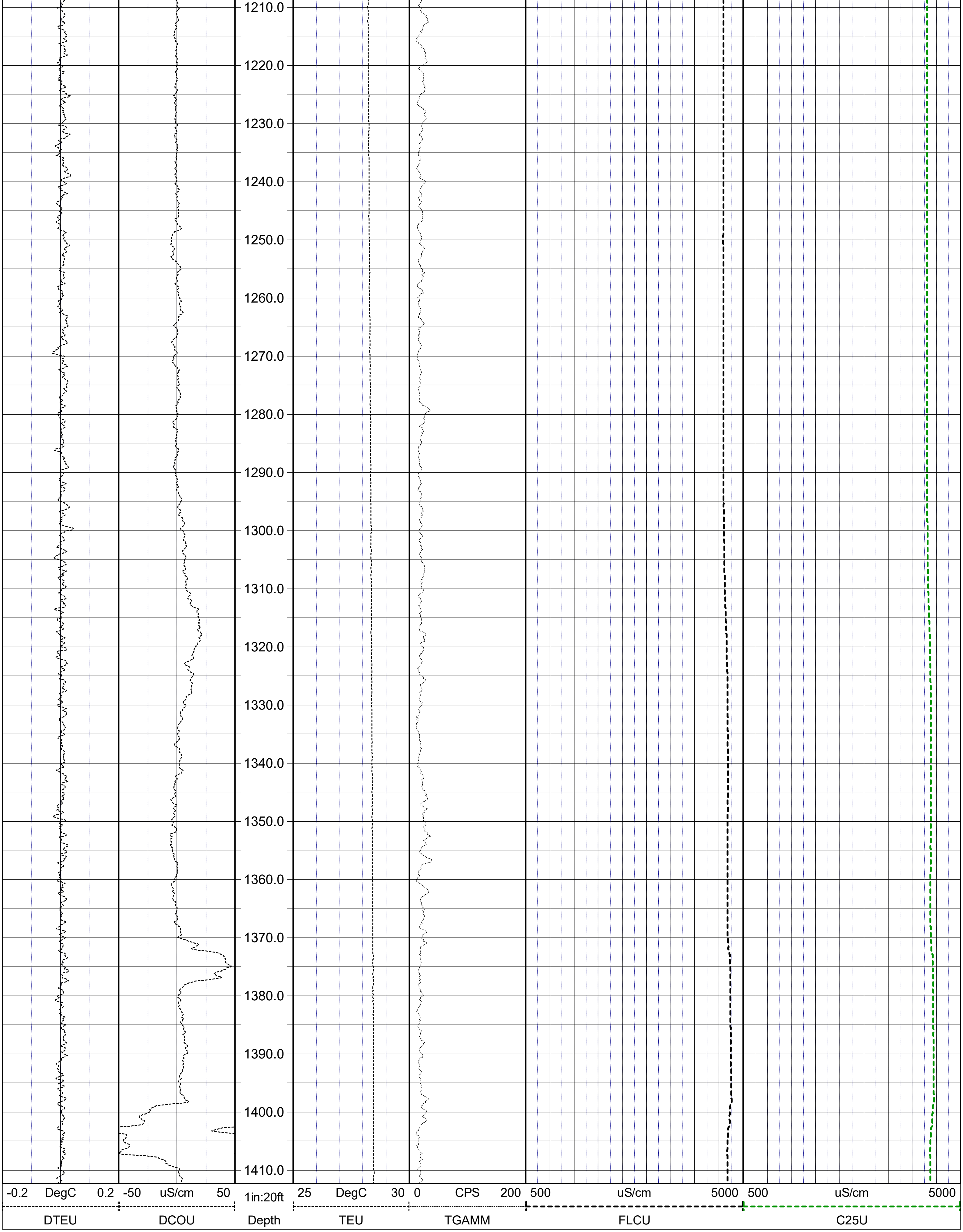
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DCOU
1in:20ft
Depth
25 DegC 30
TEU
0 CPS 200
TGAMM
500 uS/cm 5000
FLCU
500 uS/cm 5000
C25U

NOTES:

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WELL OSF113
UWI OSF113

LOG STAGE REAMED HOLE 1420 FT

HEADER NOTES:

COMP	SFWMD
LOC	26000 SR 60
FLD	S65
CNTY	OSCEOLA
STAT	FL
PROV	FL
CTRY	USA

LATI		X	
LONG		Y	
GDAT	WGS84	H DAT	
SEC		ELEV	
TWP		V DAT	
RGE			

ALL SERVICES:
CALIPER
NATURAL GAMMA
WATER QUALITY
ELECTRIC
DUAL INDUCTION
FLOWMETER
SONIC
VIDEO

PERMANENT DATUM:

LOG MEASURED FROM: GROUND SURFACE

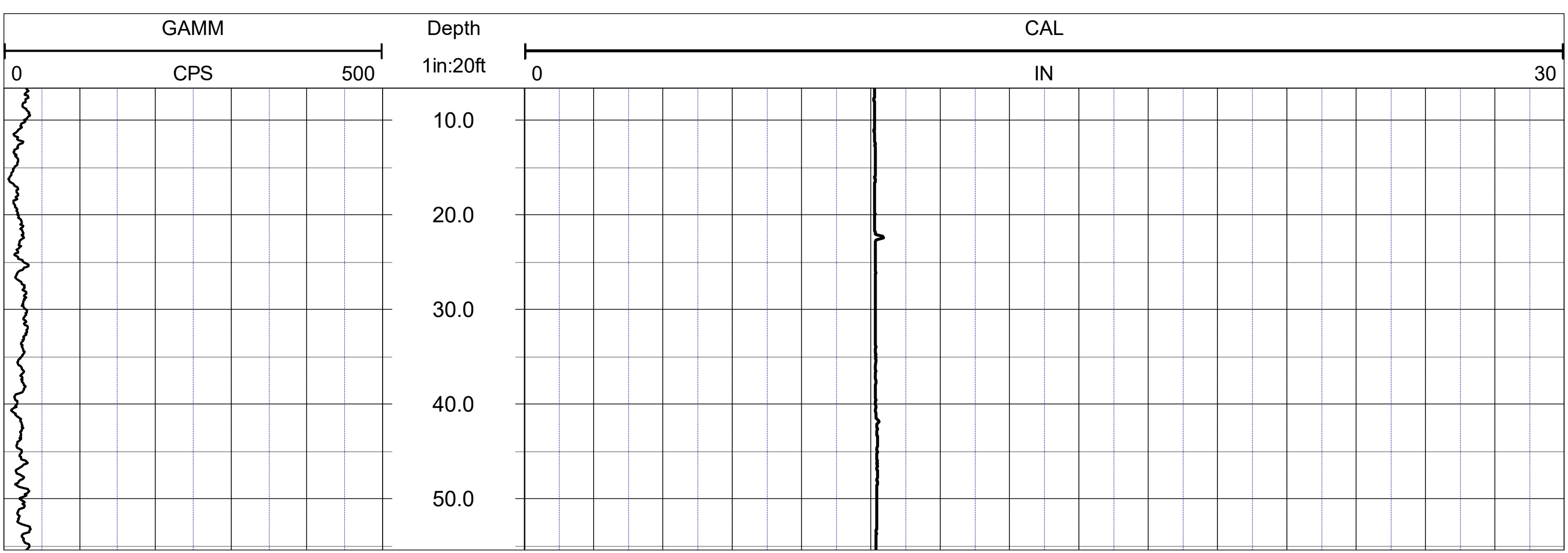
DRILLING MEASURED FROM:

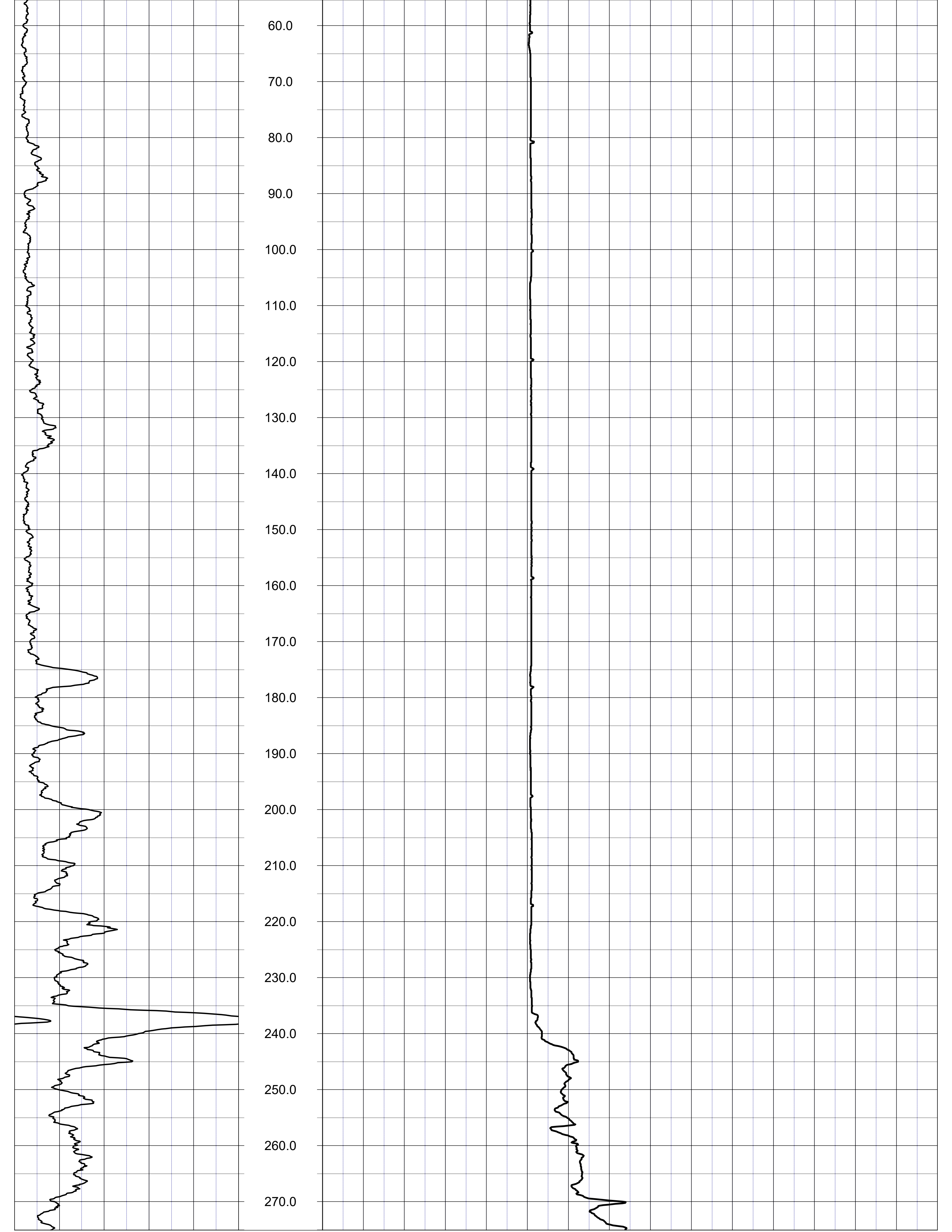
DATE	06 May 19	TYPE FLUID IN HOLE	WATER
RUN No	1	LOGGING SPEED (FT/MIN)	40
TYPE LOG	**CALIPER**	TROLLING DIRECTION	UP
		PUMPING RATE (GPM)	N/A
DEPTH-DRILLER	1420		
DEPTH-LOGGER	1420		
DRILLER	HUSS DRILLING		
RECORDED BY	RMB		
SRVC	RMBAKER LLC	API	N/A
WITNESSED BY	SFWMD	LIC	N/A

BOREHOLE RECORD				CASING RECORD			
RUN NO.	BIT	FROM	TO	SIZE	MAT.	FROM	TO
1	9.875	237.5	1420	10	PVC	0	237.5

LOG CODES

3-arm caliper	**CAL**	long normal resistivity	**RLN**	deep induction conductivity	**IDC**
natural gamma (CPS)	**GAMM**	8 inch resistivity	**R8**	shallow induction conductivity	**ISC**
spontaneous potential	**ESP**	32 inch resistivity	**R32**	sonic interval velocity	**DT**
single point resistance	**RES**	deep induction resistivity	**ILD**	sonic porosity (RHG method)	**SPHI**
short normal resistivity	**RSN**	shallow induction resistivity	**ILM**	repeat designation	**R**





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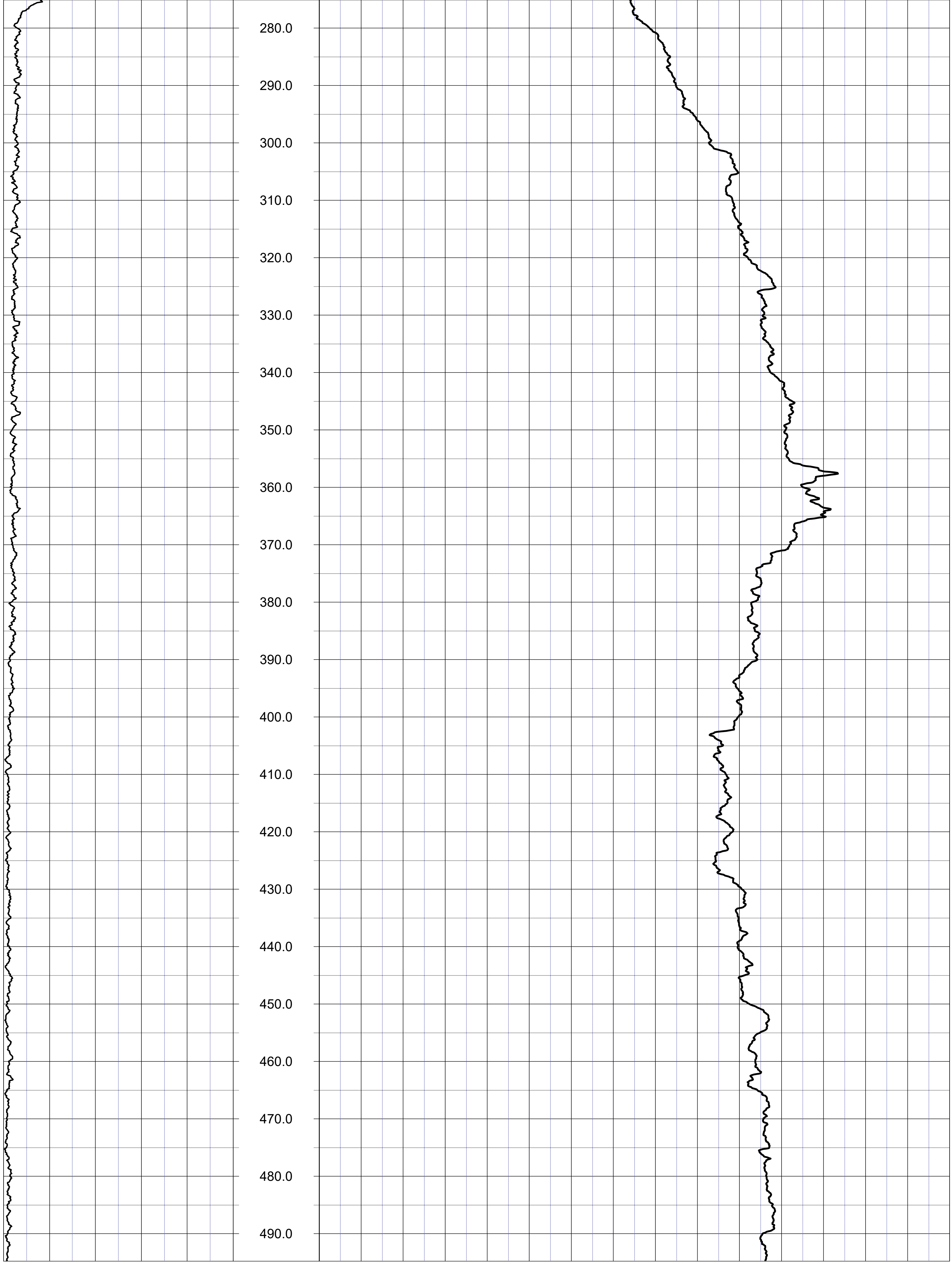
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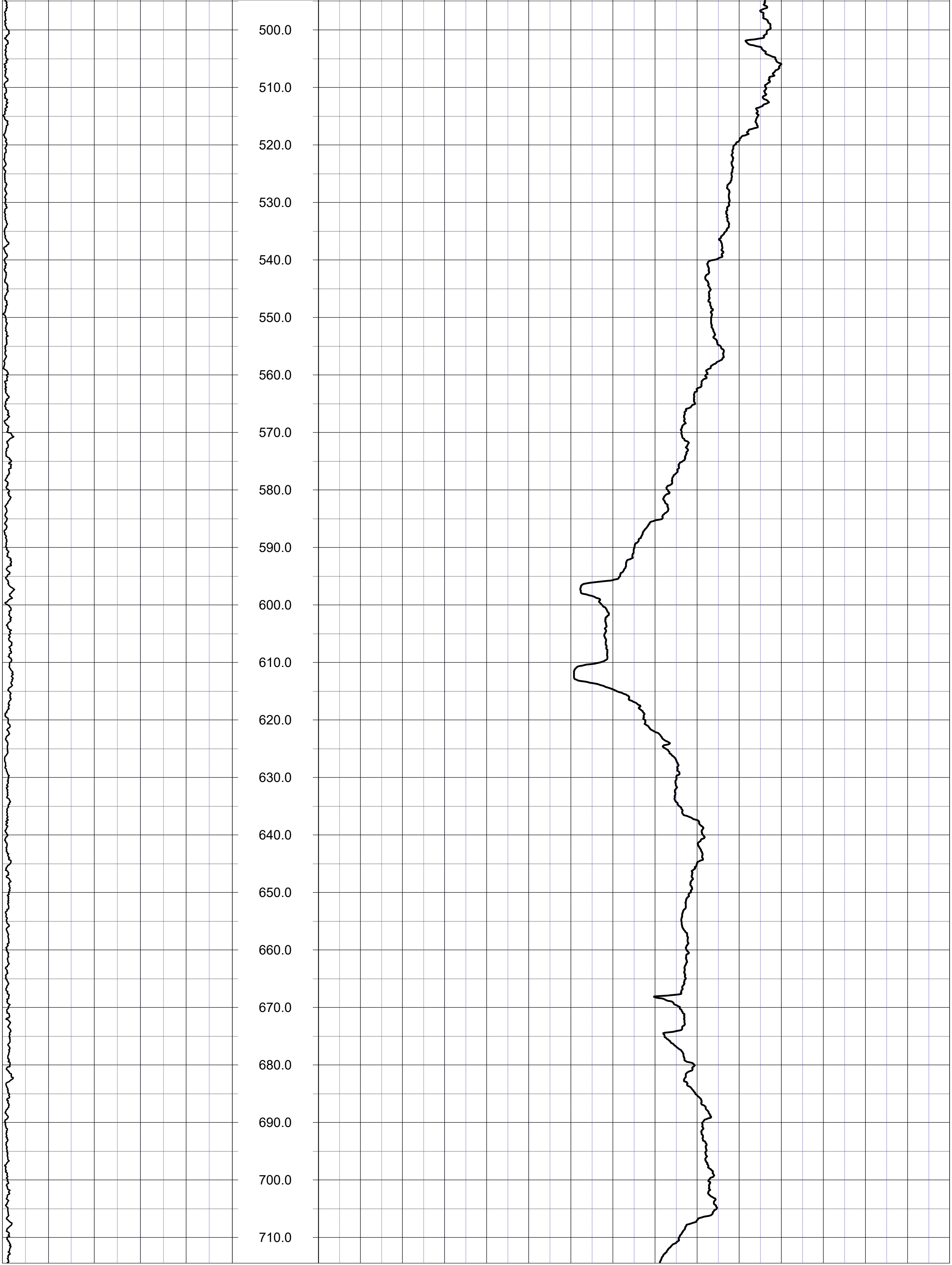

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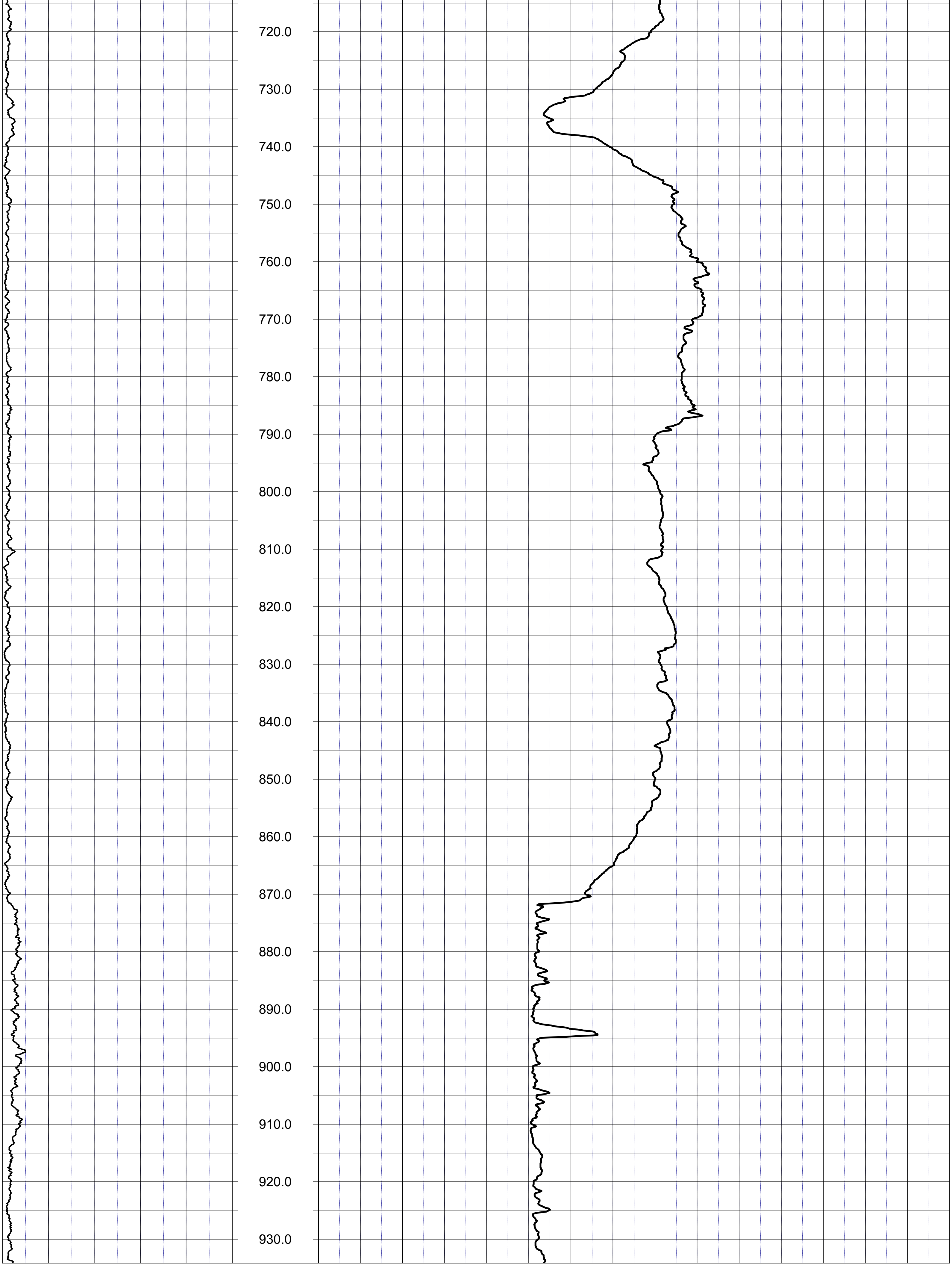
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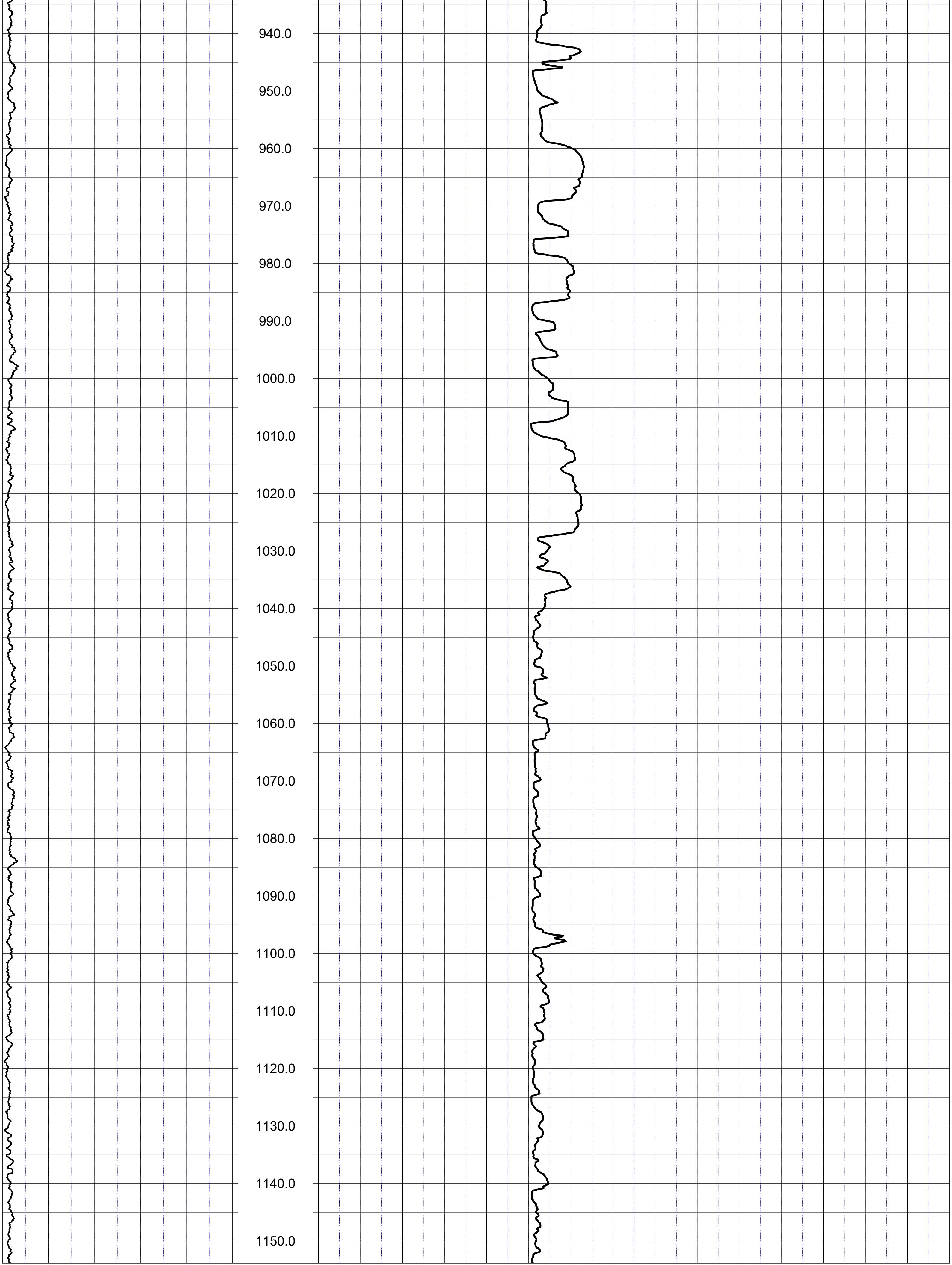
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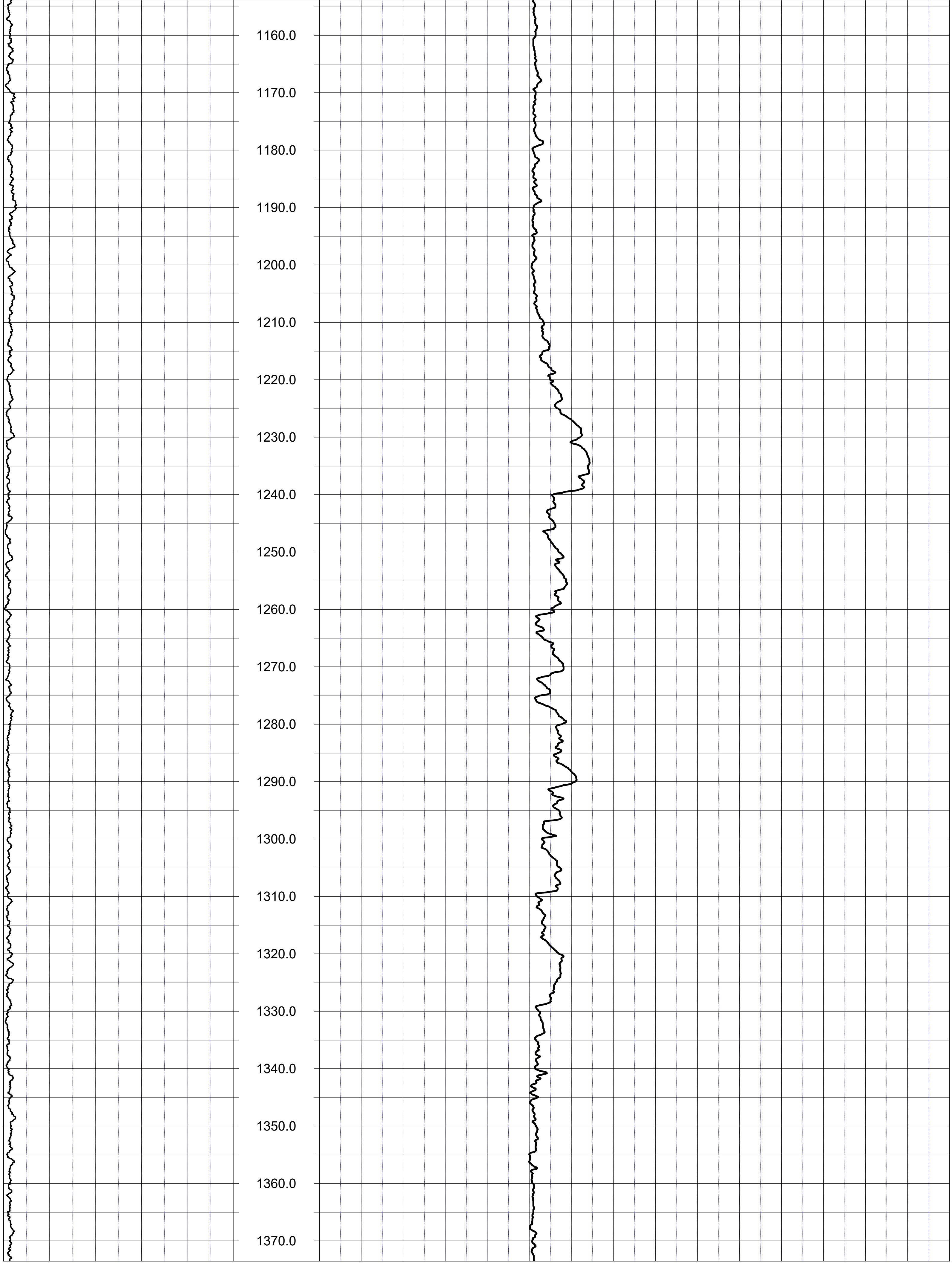
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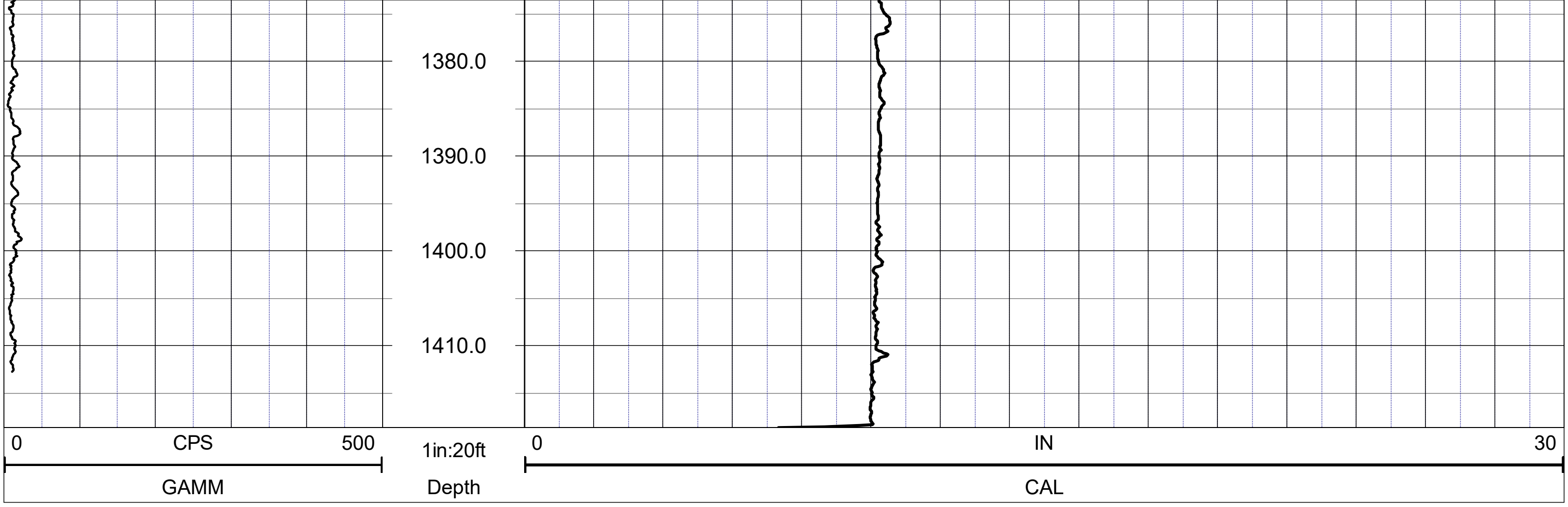

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WELL	OSF113
UWI	OSF113
LOG STAGE	REAMED HOLE 1420 FT

HEADER NOTES:

COMP	SFWMD
LOC	26000 SR 60
FLD	S65
CNTY	OSCEOLA
STAT	FL
PROV	FL
CTRY	USA

LATI		X	
LONG		Y	
GDAT	WGS84	H DAT	
SEC		ELEV	
TWP		V DAT	
RGE			

ALL SERVICES:
CALIPER
NATURAL GAMMA
WATER QUALITY
ELECTRIC
DUAL INDUCTION
FLOWMETER
SONIC
VIDEO

PERMANENT DATUM:
LOG MEASURED FROM: GROUND SURFACE
DRILLING MEASURED FROM:

DATE	06 May 19	TYPE FLUID IN HOLE	WATER
RUN No	1	LOGGING SPEED (FT/MIN)	30
TYPE LOG	FLOWMETER	TROLLING DIRECTION	BOTH
		PUMPING RATE (GPM)	N/A
DEPTH-DRILLER	1420		
DEPTH-LOGGER	1420		
DRILLER	HUSS DRILLING		
RECORDED BY	RMB		
SRVC	RMBAKER LLC	API	N/A
WITNESSED BY	SFWMD	LIC	N/A

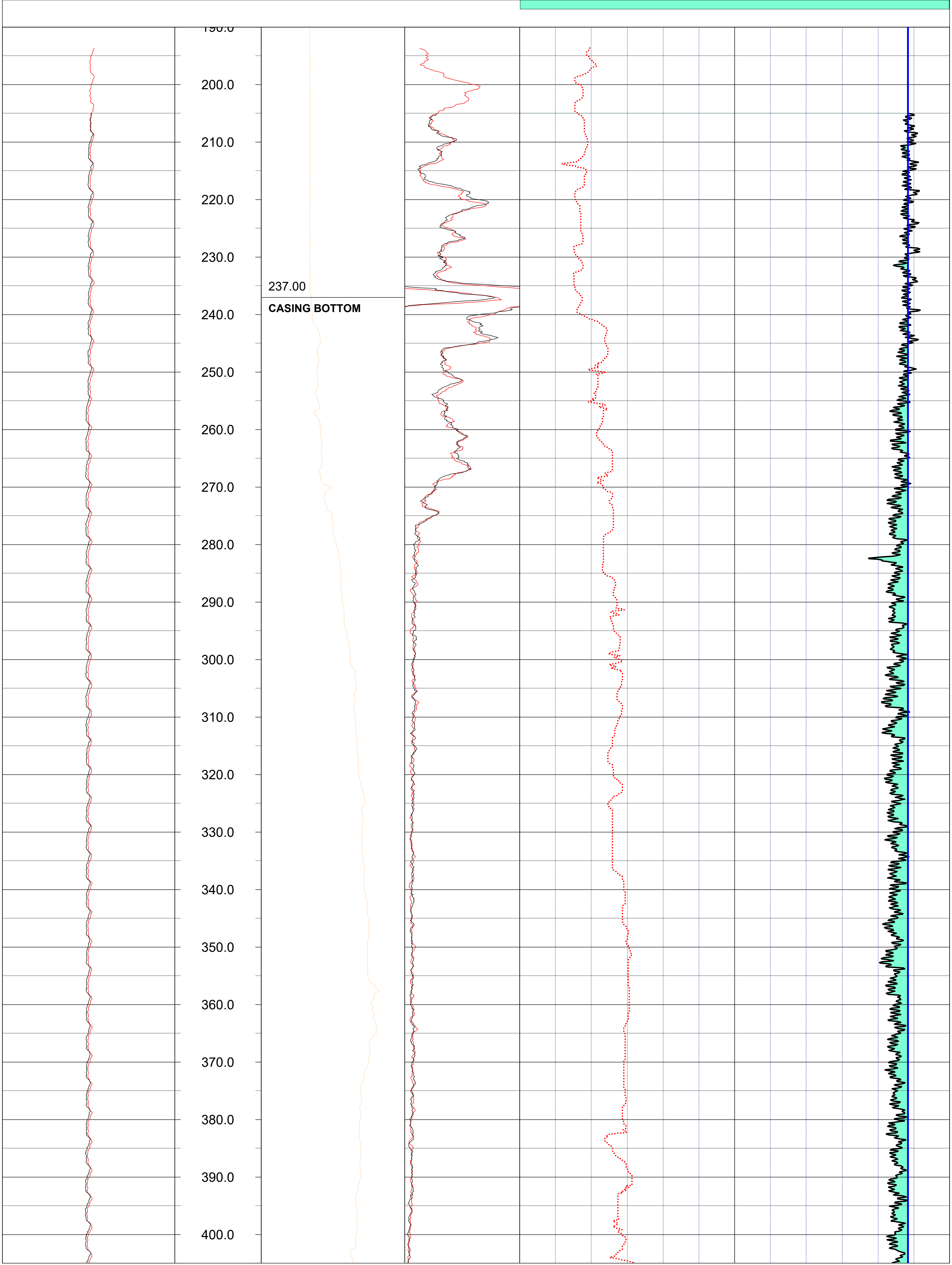
BOREHOLE RECORD				CASING RECORD			
RUN NO.	BIT	FROM	TO	SIZE	MAT.	FROM	TO
1	9.875	237.5	1420	10	PVC	0	237.5

PROJECT NOTES:
-The spinner rate curves deflect to the positive direction with increasing flow from the well.
-The spinner rate curves are not corrected for borehole diameter.
-Silts and debris throughout the water column and dredged into the water column caused jamming of the impeller and often a reversal.

FLOWMETER LOG CODES

down static spinner rate	**FSD**	down static line speed	**LSSD**	natural gamma (w/annot.)	**GAMM**
up static spinner rate	**UTS**	up static line speed	**LSSU**	caliper	**CAL**
down dynamic spinner rate	**DYND**	down dynamic line speed	**LSDD**	repeat designation	**R**
up dynamic spinner rate	**DYNU**	up dynamic line speed	**LSDU**	percent flow	**PFLO**
static station spinner rate	**FSU**	dynamic station spinner rate	**FSP**	GPM flow	**GPMFLO**

LSSU: 0 – 60 ft/min	Depth 1in:20ft	COMMENTS	US GAMM: 0 – 500 CPS	UTS: -600 – 600 RPM
LSSD: 0 – 60 ft/min		CAL: 0 – 30 IN	DS GAMM: 0 – 500 CPS	FSD: -600 – 600 RPM
				DOWN NO-FLOW BASELINE: -600 – 600 RPM
				REGIONS OF DOWNWARD FLOW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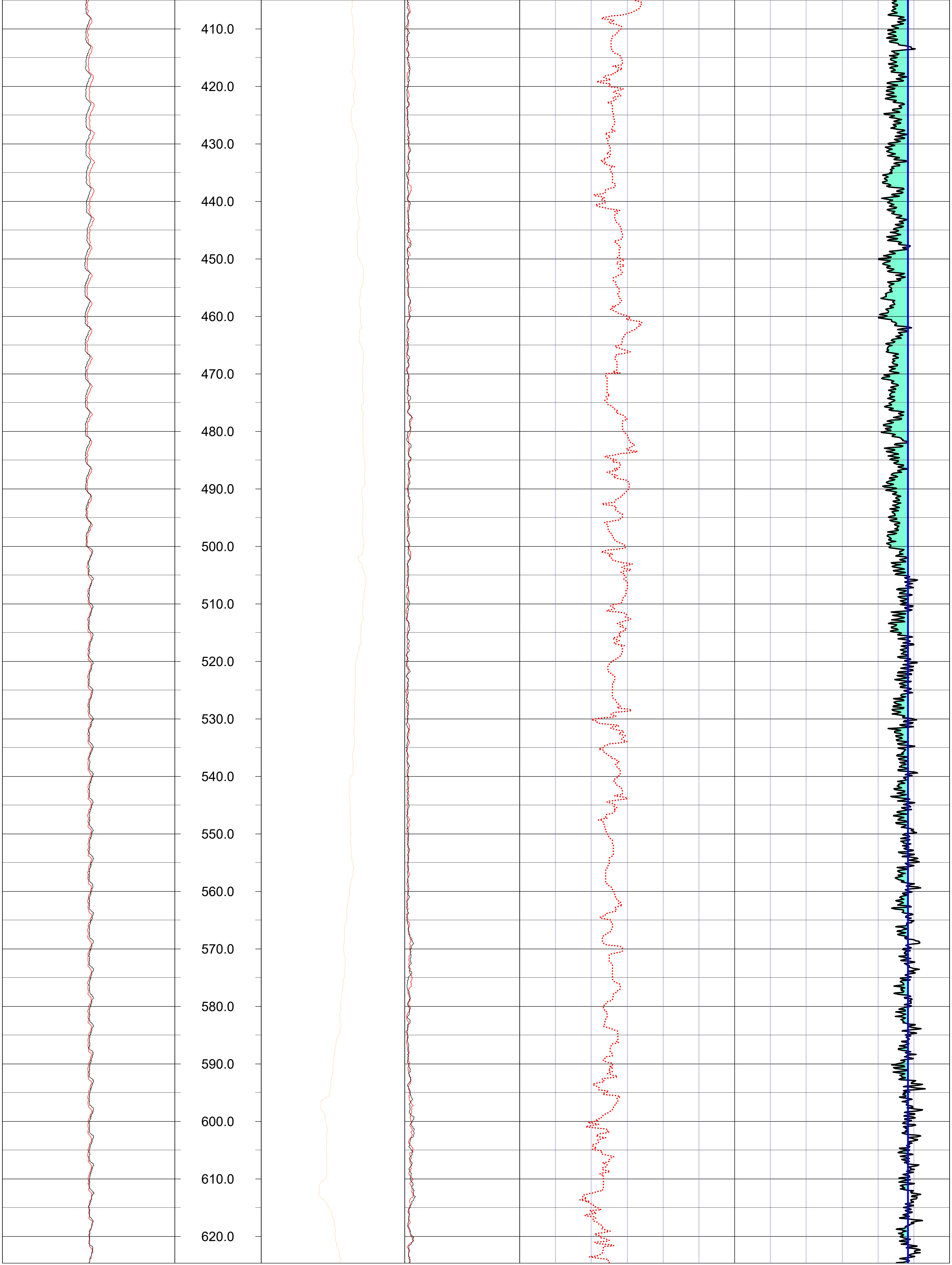
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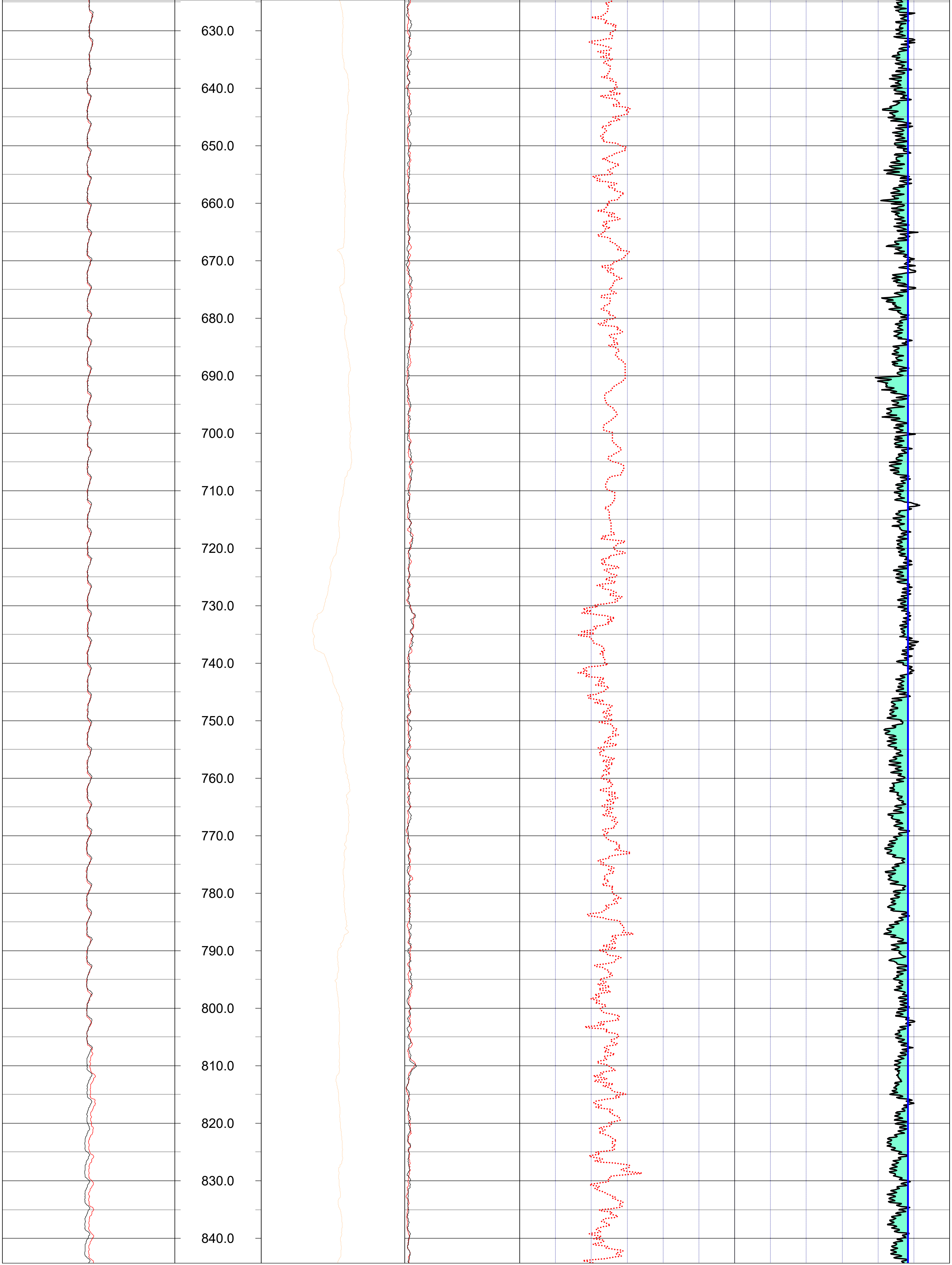
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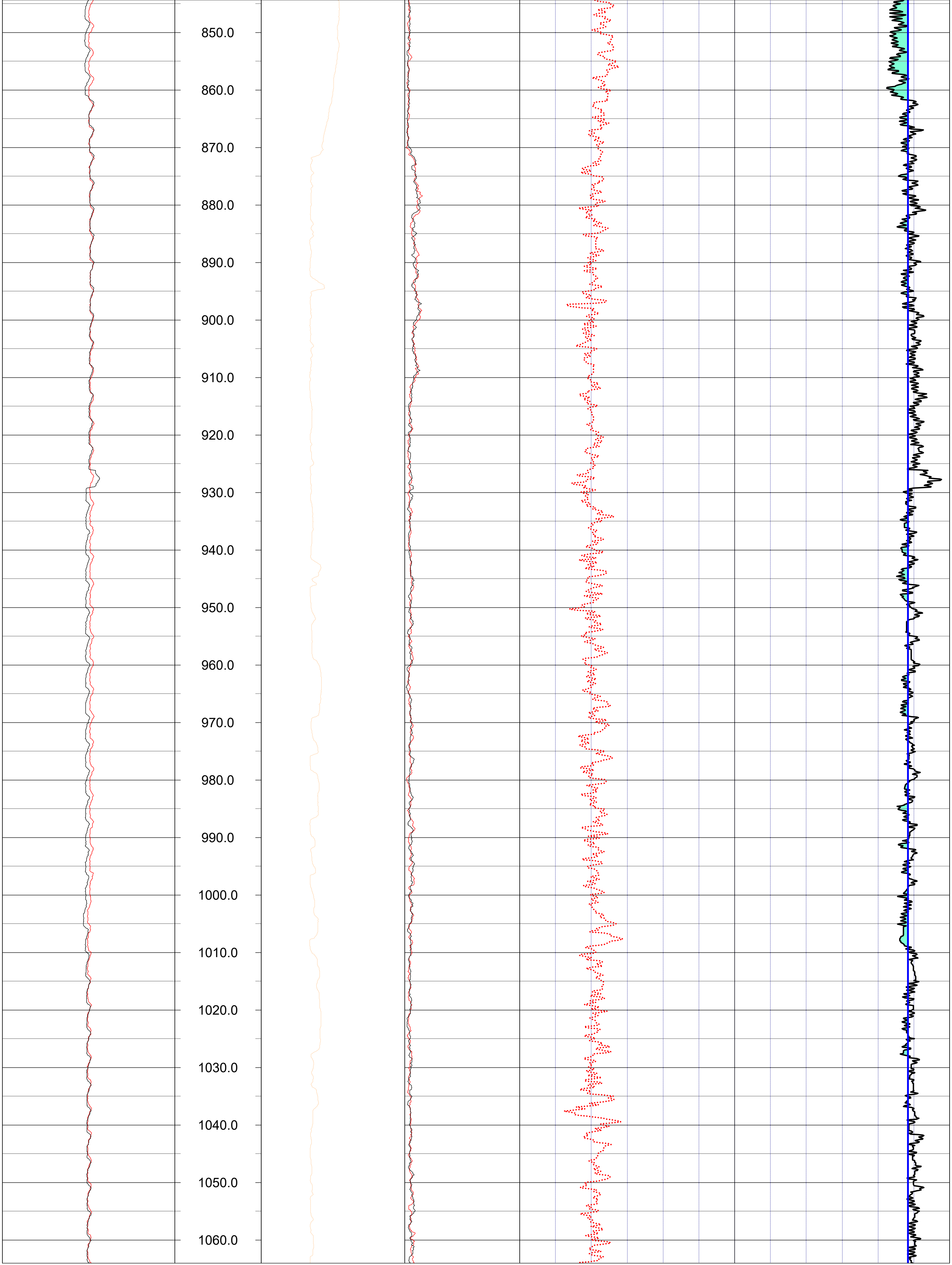
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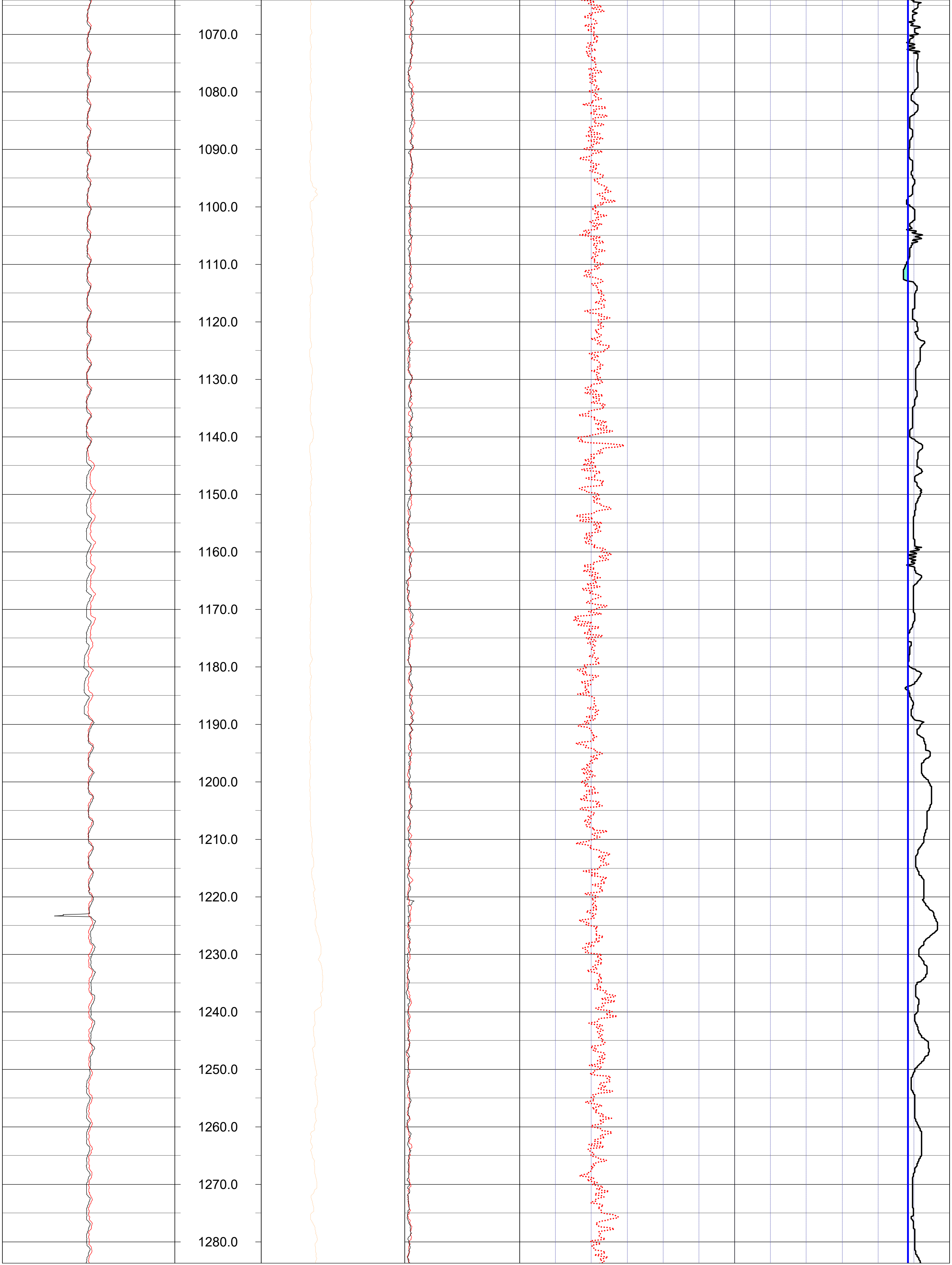
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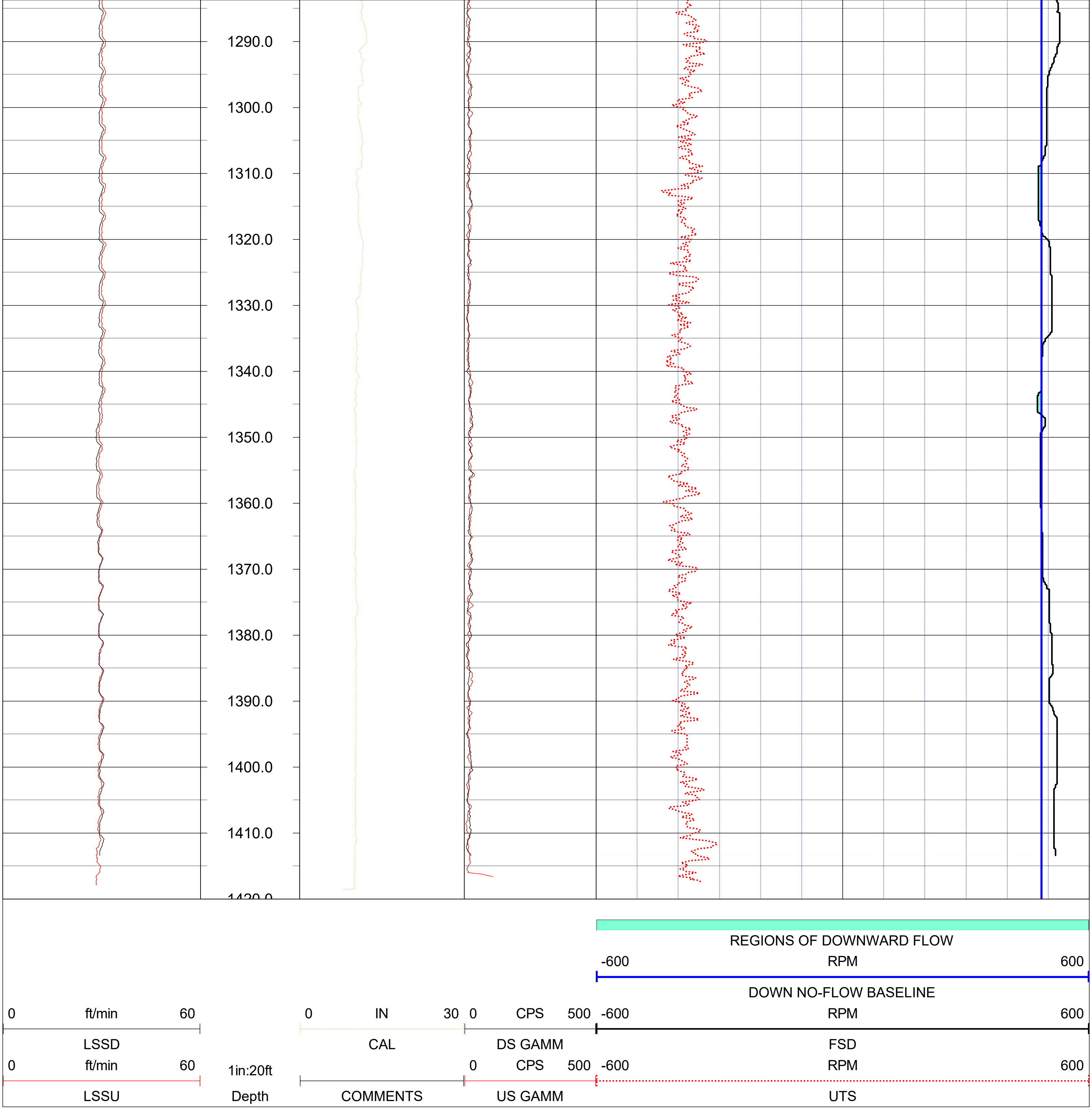

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WELL OSF113
UWI OSF113
LOG STAGE REAMED HOLE 1420 FT

HEADER NOTES:

COMP	SFWMD
LOC	26000 SR 60
FLD	S65
CNTY	OSCEOLA
STAT	FL
PROV	FL
CTRY	USA

LATI		X	
LONG		Y	
GDAT	WGS84	H DAT	
SEC		ELEV	
TWP		V DAT	
RGE			

ALL SERVICES:
CALIPER
NATURAL GAMMA
WATER QUALITY
ELECTRIC
DUAL INDUCTION
FLOWMETER
SONIC
VIDEO

PERMANENT DATUM:
LOG MEASURED FROM: GROUND SURFACE
DRILLING MEASURED FROM:

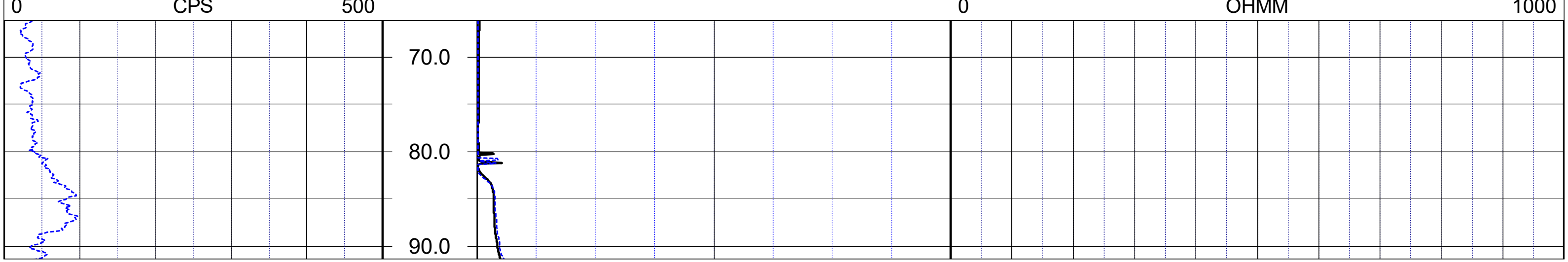
DATE	07 May 19	TYPE FLUID IN HOLE	WATER
RUN No	1	LOGGING SPEED (FT/MIN)	35
TYPE LOG	ELECTRIC + DUIN	TROLLING DIRECTION	UP
DEPTH-DRILLER	1420	PUMPING RATE (GPM)	N/A
DEPTH-LOGGER	1420		
DRILLER	HUSS DRILLING		
RECORDED BY	RMB		
SRVC	RMBAKER LLC	API	N/A
WITNESSED BY	SFWMD	LIC	N/A

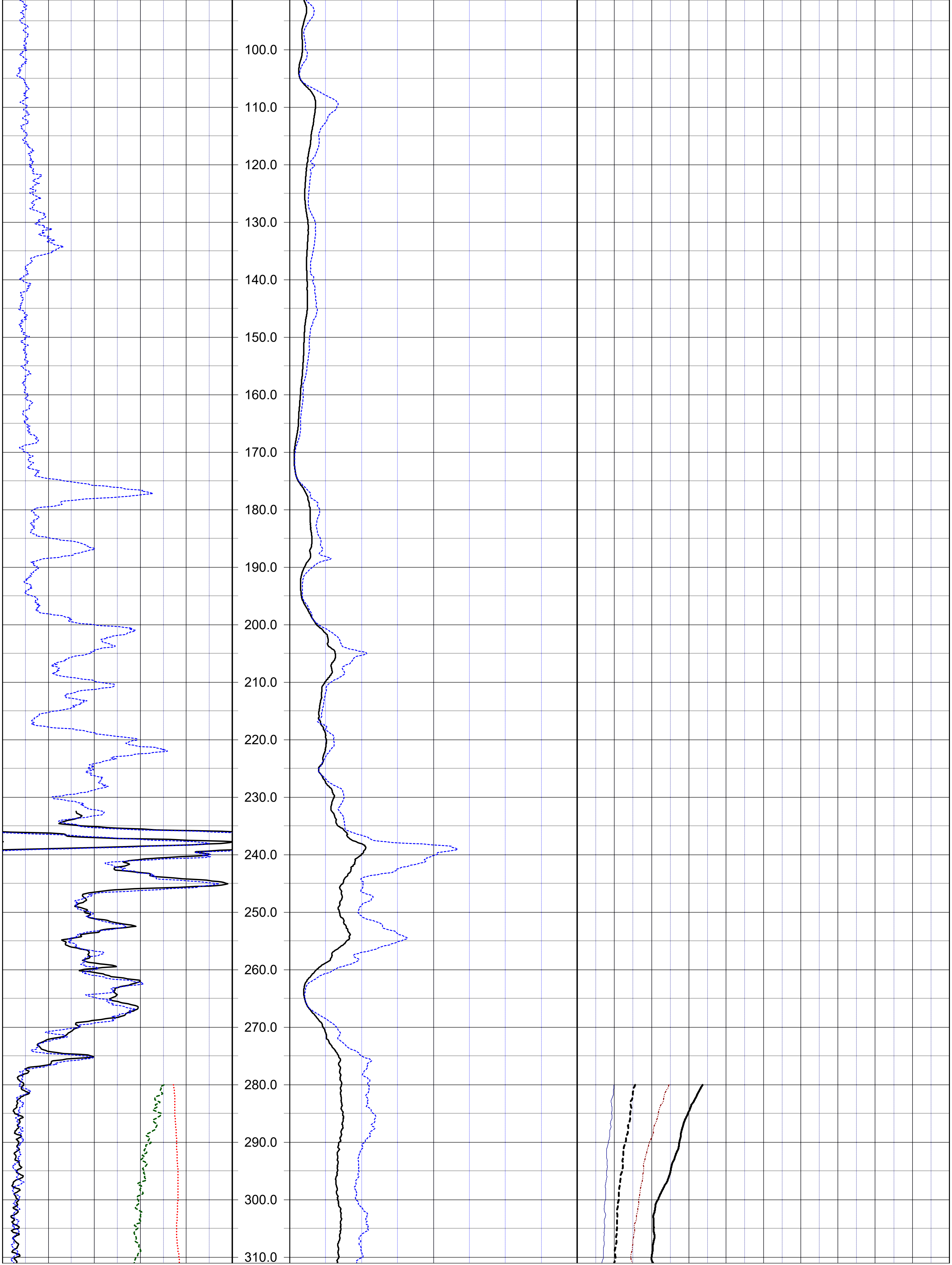
RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	MAT.	FROM	TO
1	9.875	237.5	1420	10	PVC	0	237.5

LOG CODES

3-arm caliper	**CAL**	long normal resistivity	**RLN**	deep induction conductivity	**IDC**
natural gamma (CPS)	**GAMM**	8 inch resistivity	**R8**	shallow induction conductivity	**ISC**
spontaneous potential	**ESP**	32 inch resistivity	**R32**	sonic interval velocity	**DT**
single point resistance	**RES**	deep induction resistivity	**ILD**	sonic porosity (RHG method)	**SPHI**
short normal resistivity	**RSN**	shallow induction resistivity	**ILM**	repeat designation	**R**

ESP	Depth	ILD	R8
-1000 mV 1000	1in:20ft	0 OHMM 400	0 OHMM 1000
RES		ILM	RSN
0 OHM 100		0 OHMM 400	0 OHMM 1000
EGAMM			R32
0 CPS 500			0 OHMM 1000
DGAMM			RLN
0 CPS 500			0 OHMM 1000

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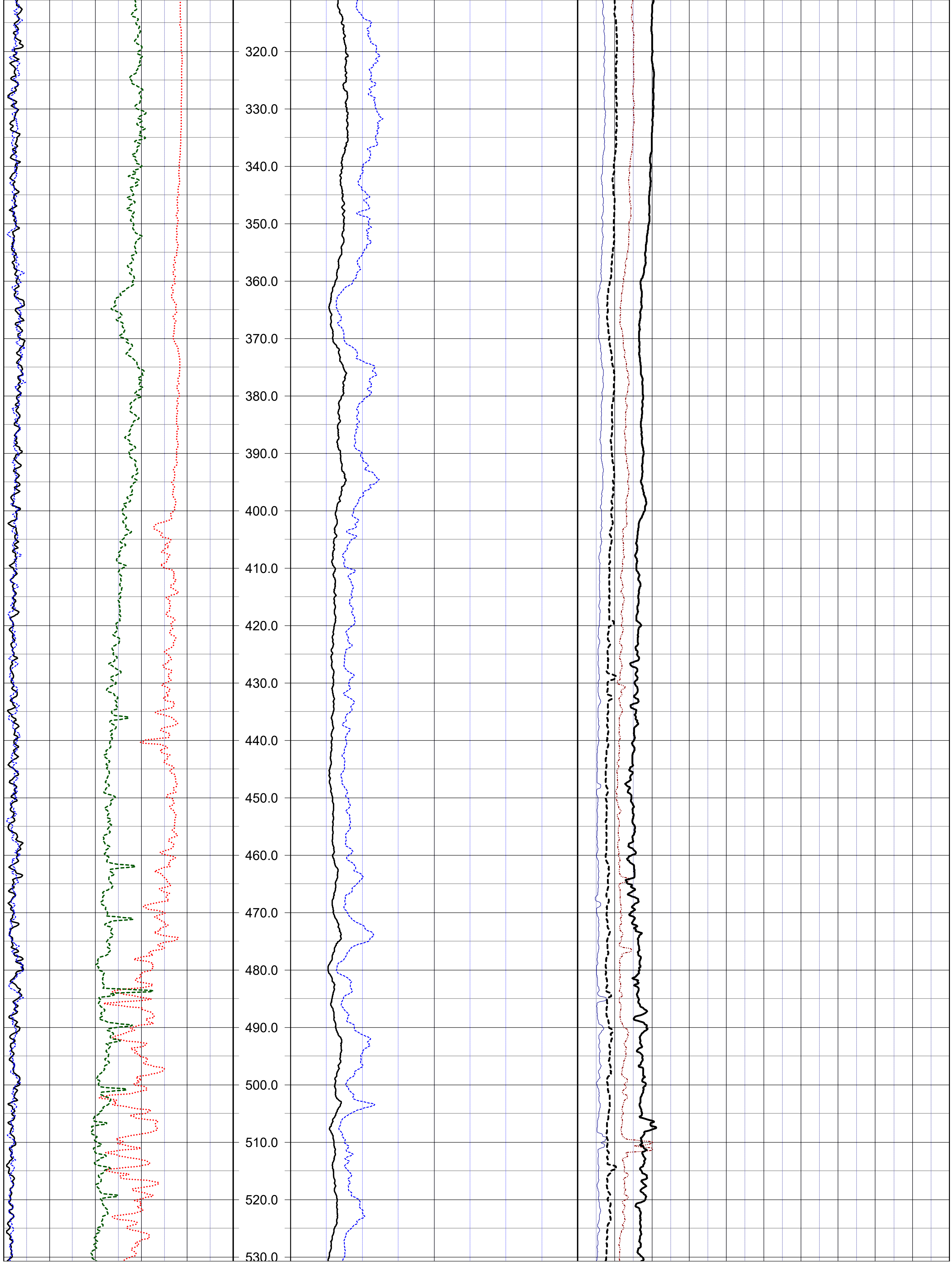
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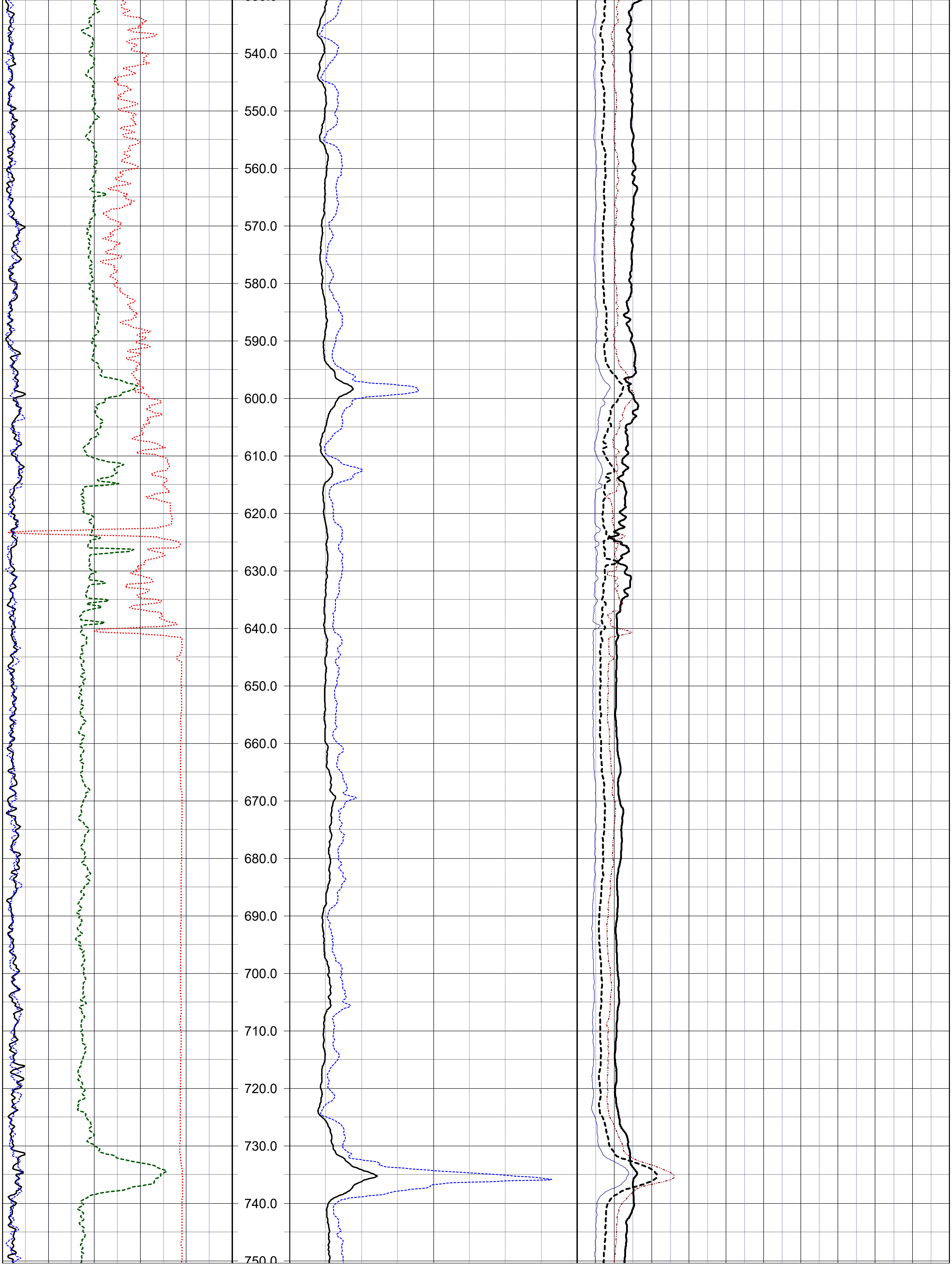
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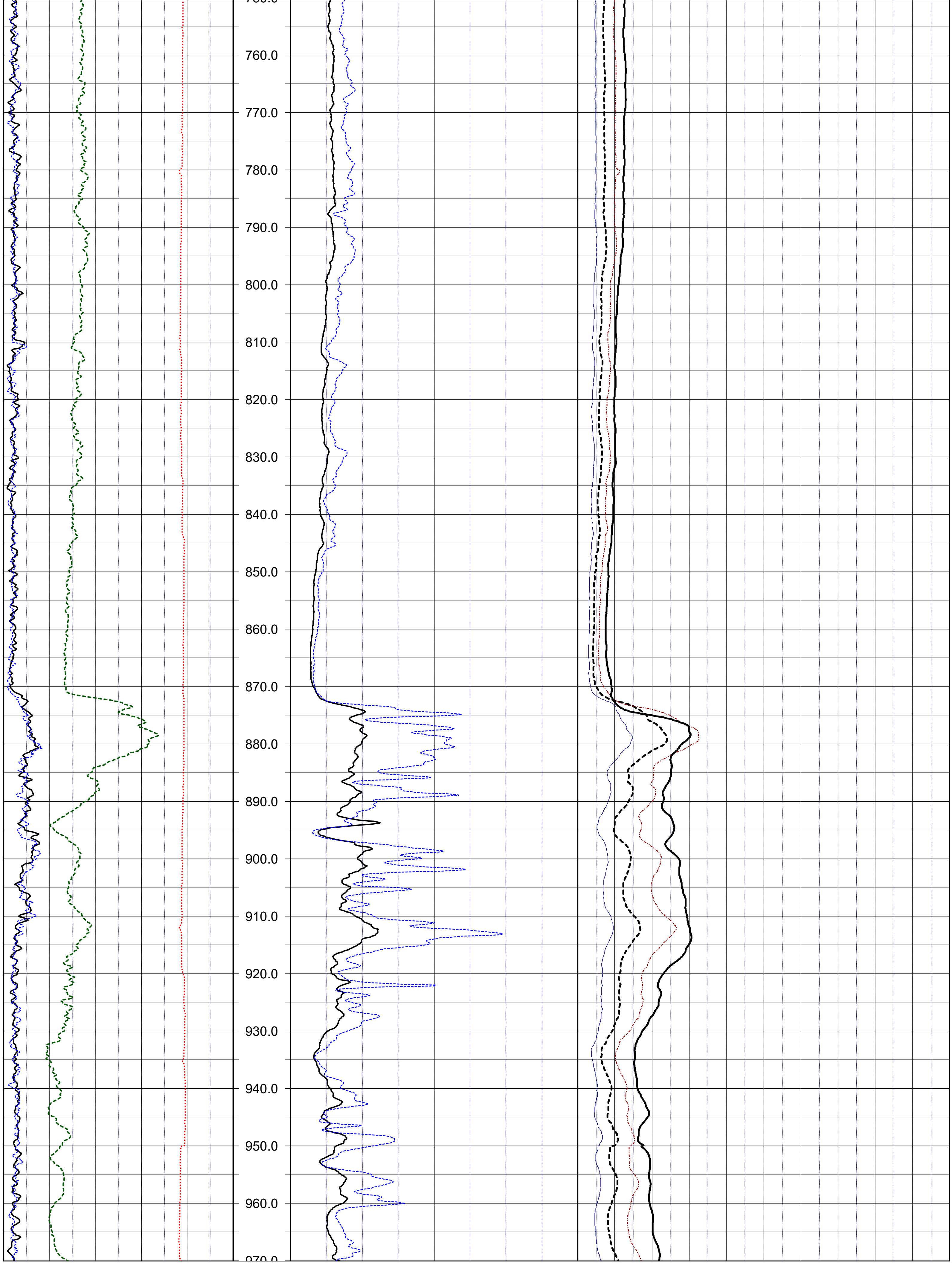

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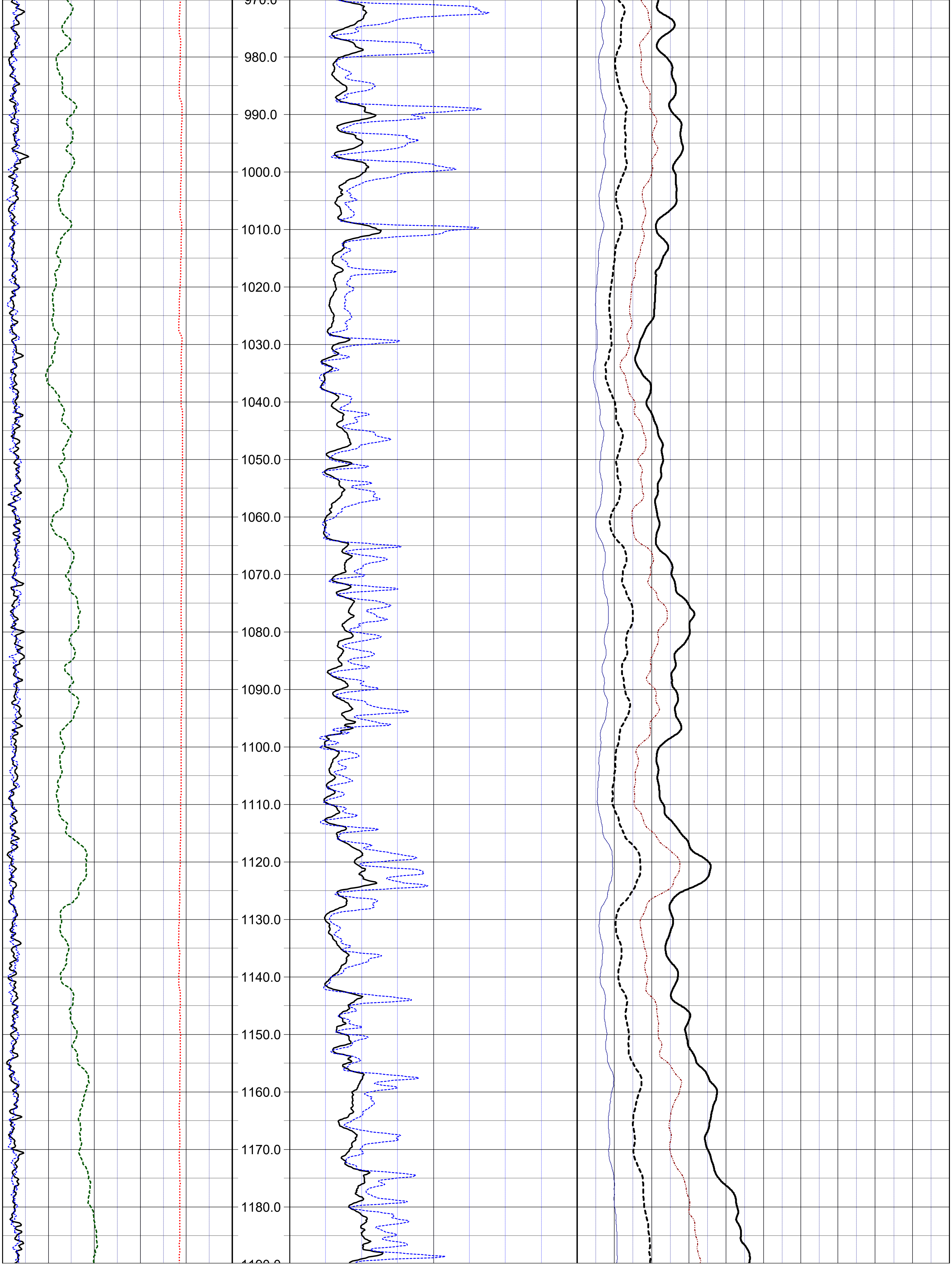
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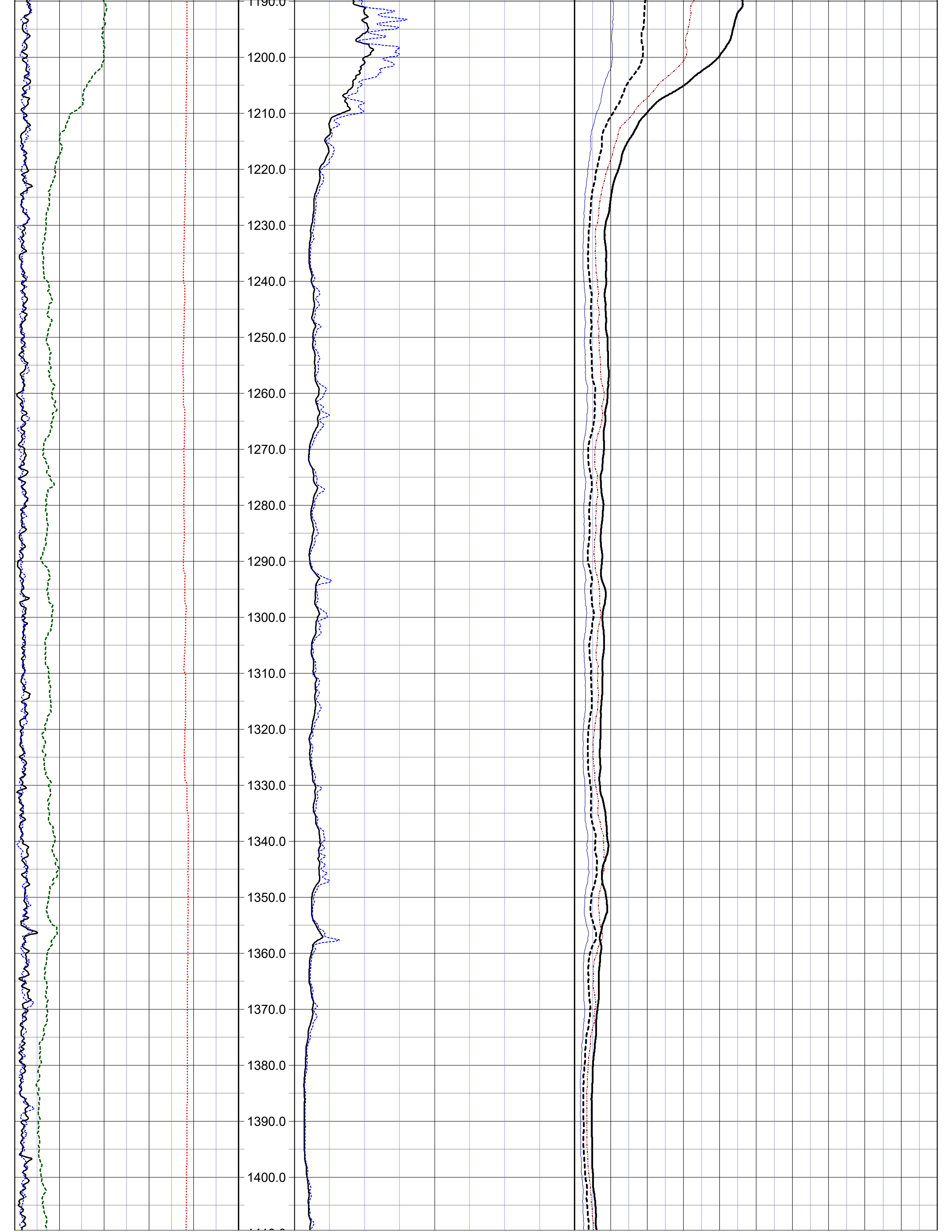
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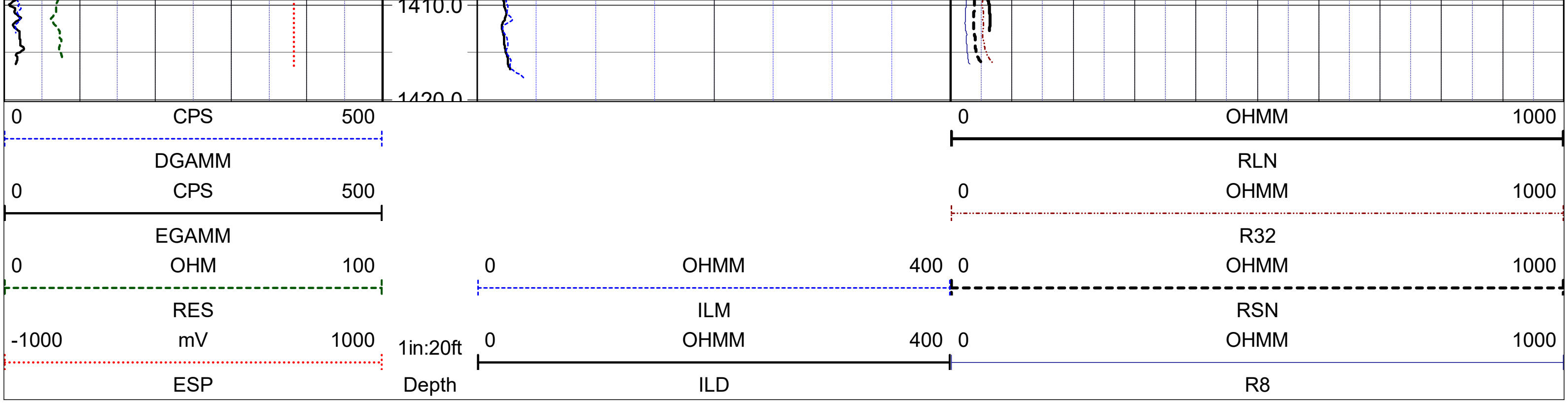

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mobile ph 407-733-8958
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WELL OSF113
UWI OSF113
LOG STAGE REAMED HOLE 1420 FT

HEADER NOTES:

COMP	SFWMD
LOC	26000 SR 60
FLD	S65
CNTY	OSCEOLA
STAT	FL
PROV	FL
CTRY	USA

LATI		X	
LONG		Y	
GDAT	WGS84	H DAT	
SEC		ELEV	
TWP		V DAT	
RGE			

ALL SERVICES:
CALIPER
NATURAL GAMMA
WATER QUALITY
ELECTRIC
DUAL INDUCTION
FLOWMETER
SONIC
VIDEO

PERMANENT DATUM:
LOG MEASURED FROM: GROUND SURFACE
DRILLING MEASURED FROM:

DATE	07 May 19	TYPE FLUID IN HOLE	WATER
RUN No	1	LOGGING SPEED (FT/MIN)	12
TYPE LOG	**SONIC**	TROLLING DIRECTION	UP
		PUMPING RATE (GPM)	N/A
DEPTH-DRILLER	1420		
DEPTH-LOGGER	1420		
DRILLER	HUSS DRILLING		
RECORDED BY	RMB		
SRVC	RMBAKER LLC	API	N/A
WITNESSED BY	SFWMD	LIC	N/A

BOREHOLE RECORD				CASING RECORD			
RUN NO.	BIT	FROM	TO	SIZE	MAT.	FROM	TO
1	9.875	237.5	1420	10	PVC	0	237.5

LOG CODES

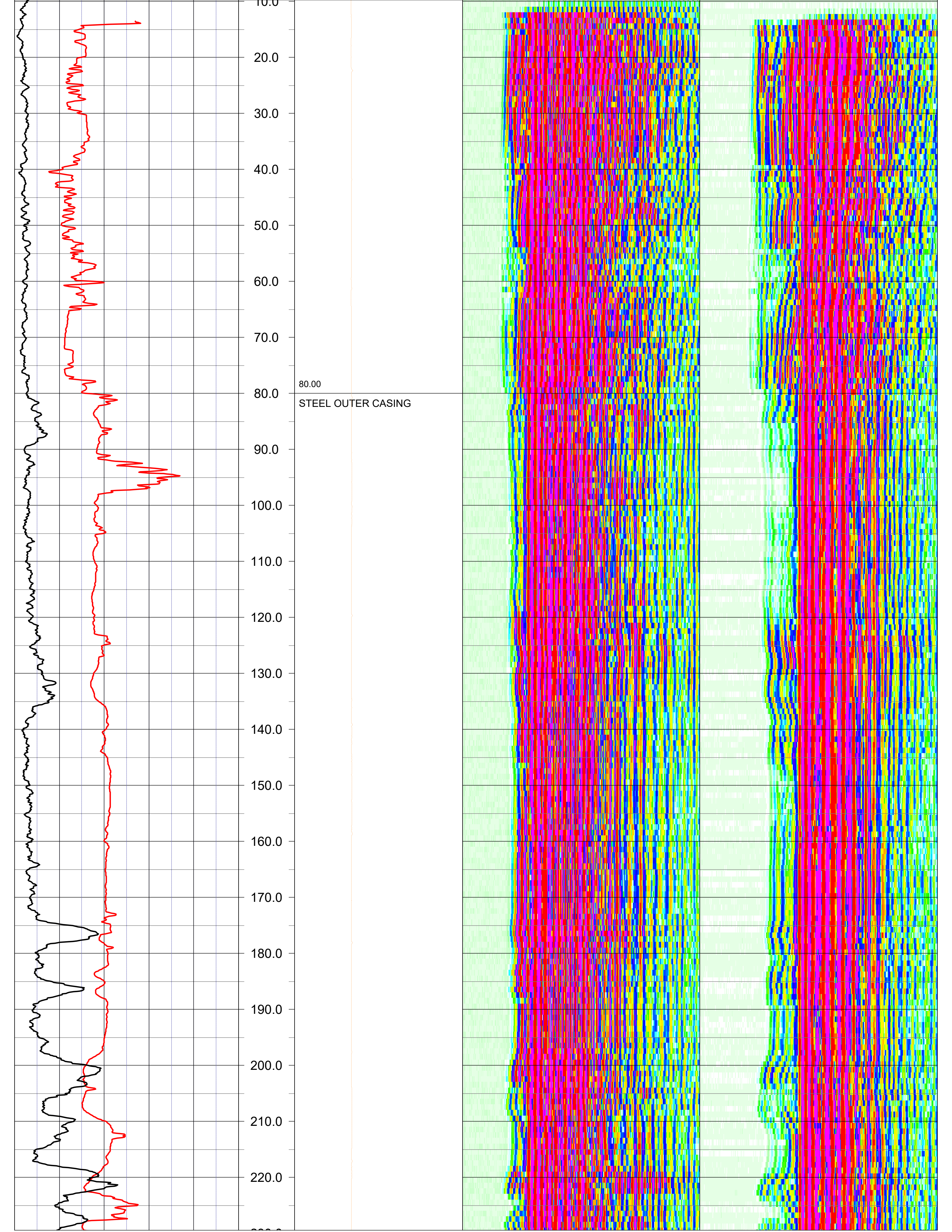
3-arm caliper	**CAL**	long normal resistivity	**RLN**	deep induction conductivity	**IDC**
natural gamma (CPS)	**GAMM**	8 inch resistivity	**R8**	shallow induction conductivity	**ISC**
spontaneous potential	**ESP**	32 inch resistivity	**R32**	sonic interval velocity	**DT**
single point resistance	**RES**	deep induction resistivity	**ILD**	sonic porosity (RHG method)	**SPHI**
short normal resistivity	**RSN**	shallow induction resistivity	**ILM**	repeat designation	**R**

SONIC POROSITY:
Assuming a carbonate formation, the porosity can be calculated using the Raymer-Hunt-Gardner (RHG) equation:

porosity= 5/8 x ([TT of log - TT of matrix] / TT of log), where "TT of log" is the measured sonic value and the "TT of matrix" is a constant.

The TT of matrix for dolostone is 43.5 microseconds per foot, and for limestone is 47.5 microseconds per foot.

SVEL	Depth	COMMENT	RX-3	RX-5
0 µs/ft 250	1in:20ft		0 1916	0 1916
SPHI - 47.5		CAL		
0 POR 1		0 IN 30		
GAMM				
0 CPS 500				



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30.0
40.0
50.0
60.0
70.0
80.00
80.0
STEEL OUTER CASING
90.0
100.0
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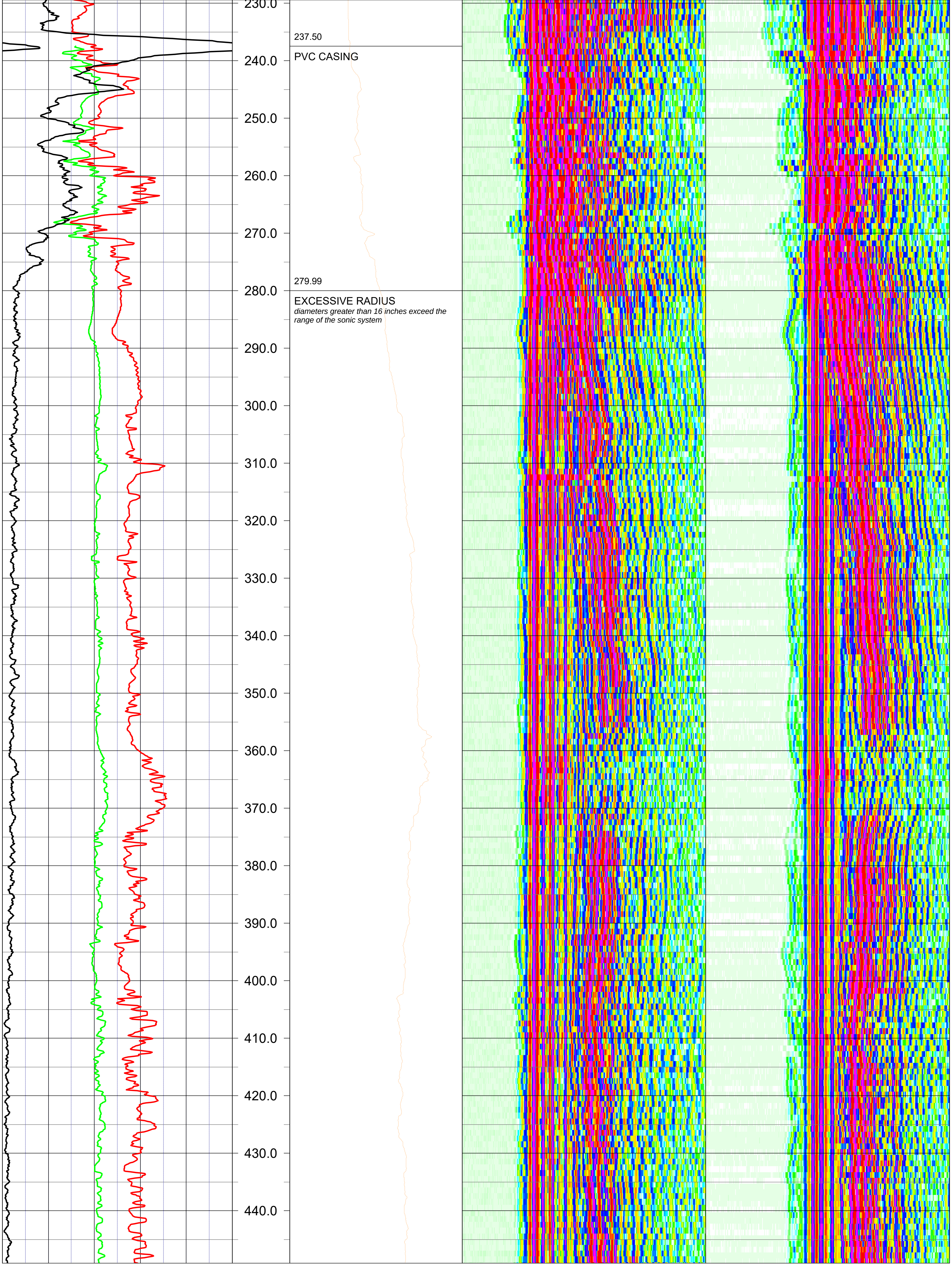
200.0
210.0
220.0


230.0
237.50
PVC CASING
240.0
250.0
260.0
270.0
279.99
280.0
EXCESSIVE RADIUS
diameters greater than 16 inches exceed the range of the sonic system
290.0
300.0
310.0
320.0
330.0
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360.0
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380.0
390.0
400.0
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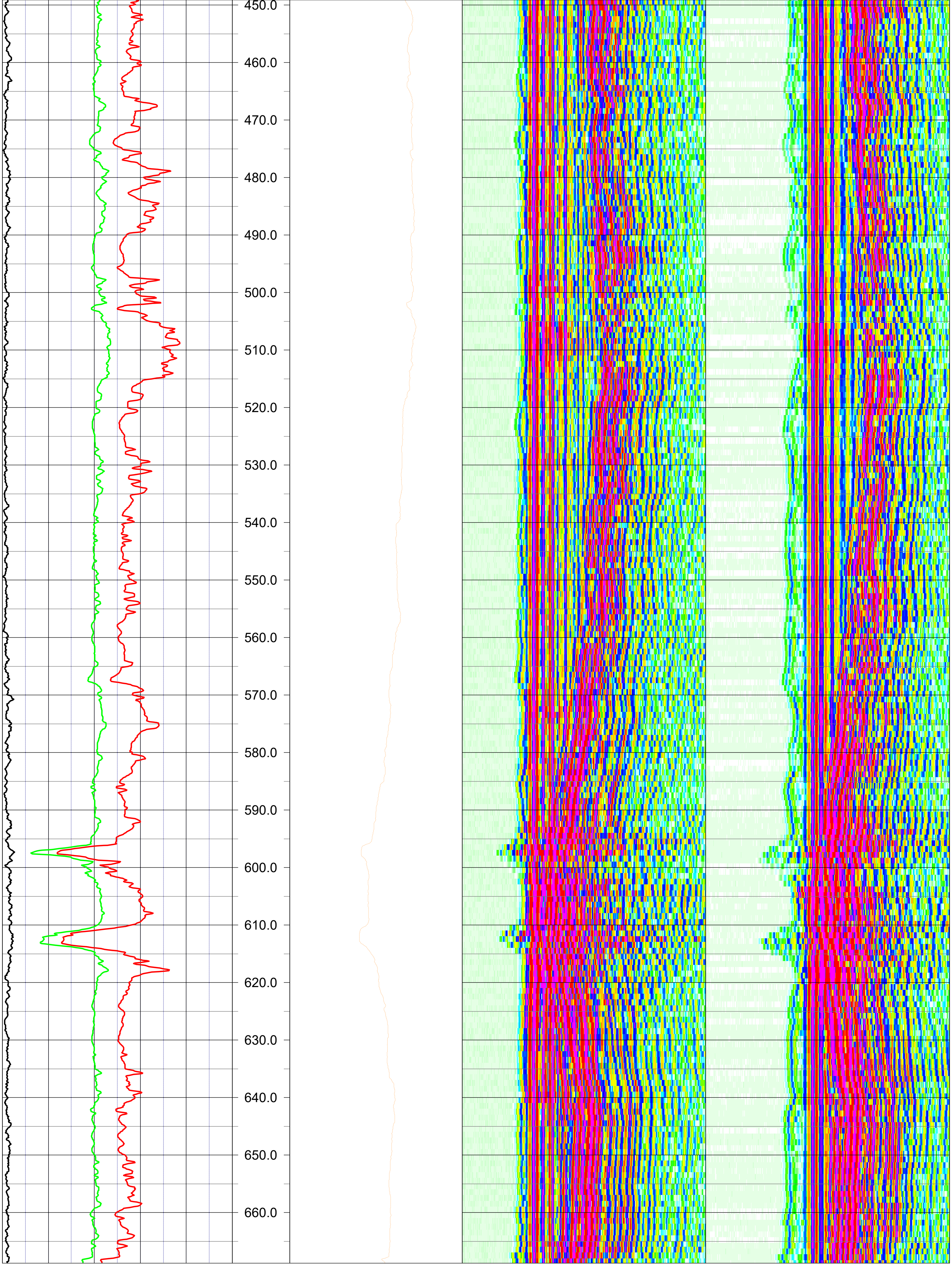
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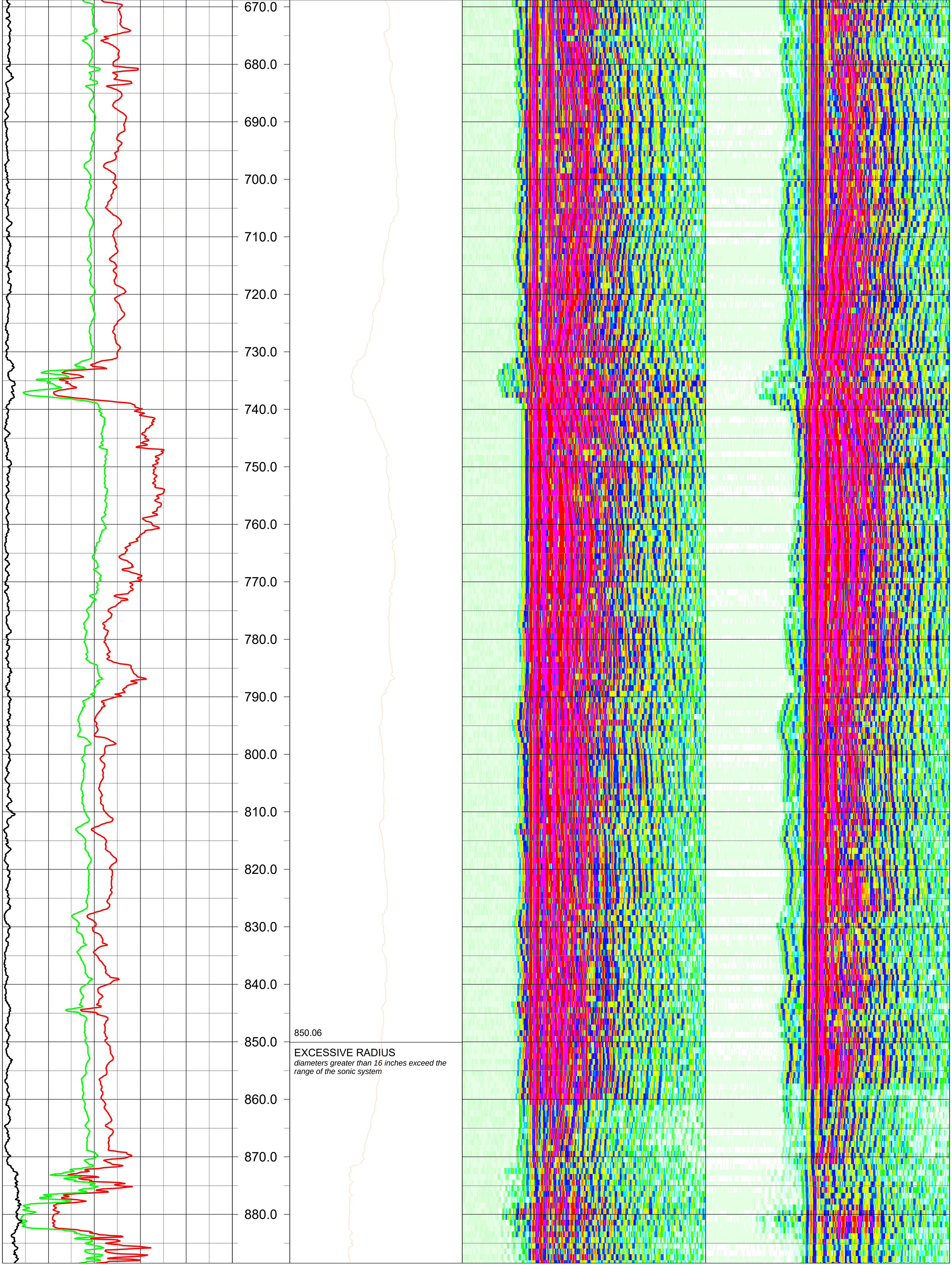
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800.0
810.0
820.0
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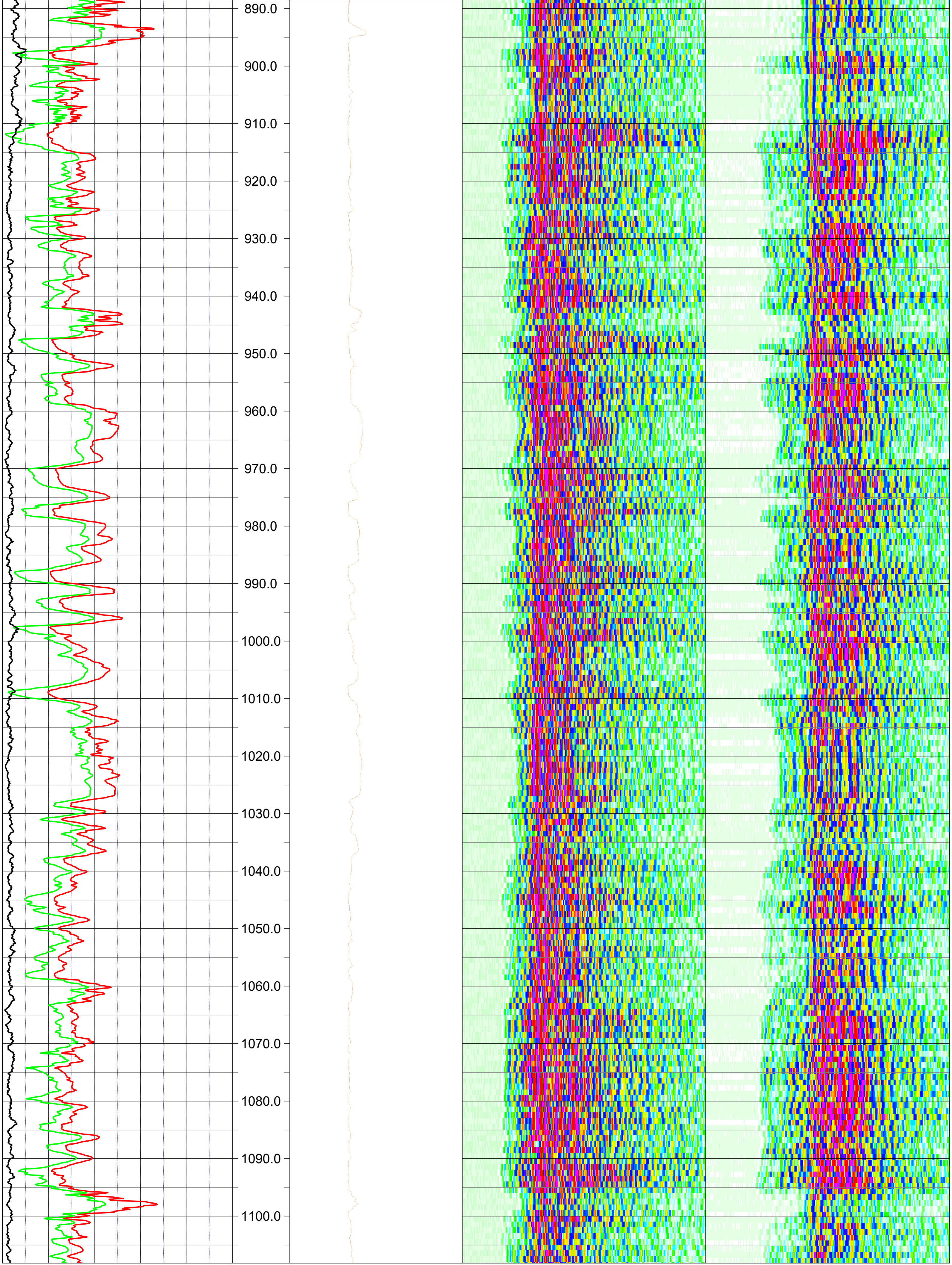
850.0
EXCESSIVE RADIUS
diameters greater than 16 inches exceed the range of the sonic system
860.0
870.0
880.0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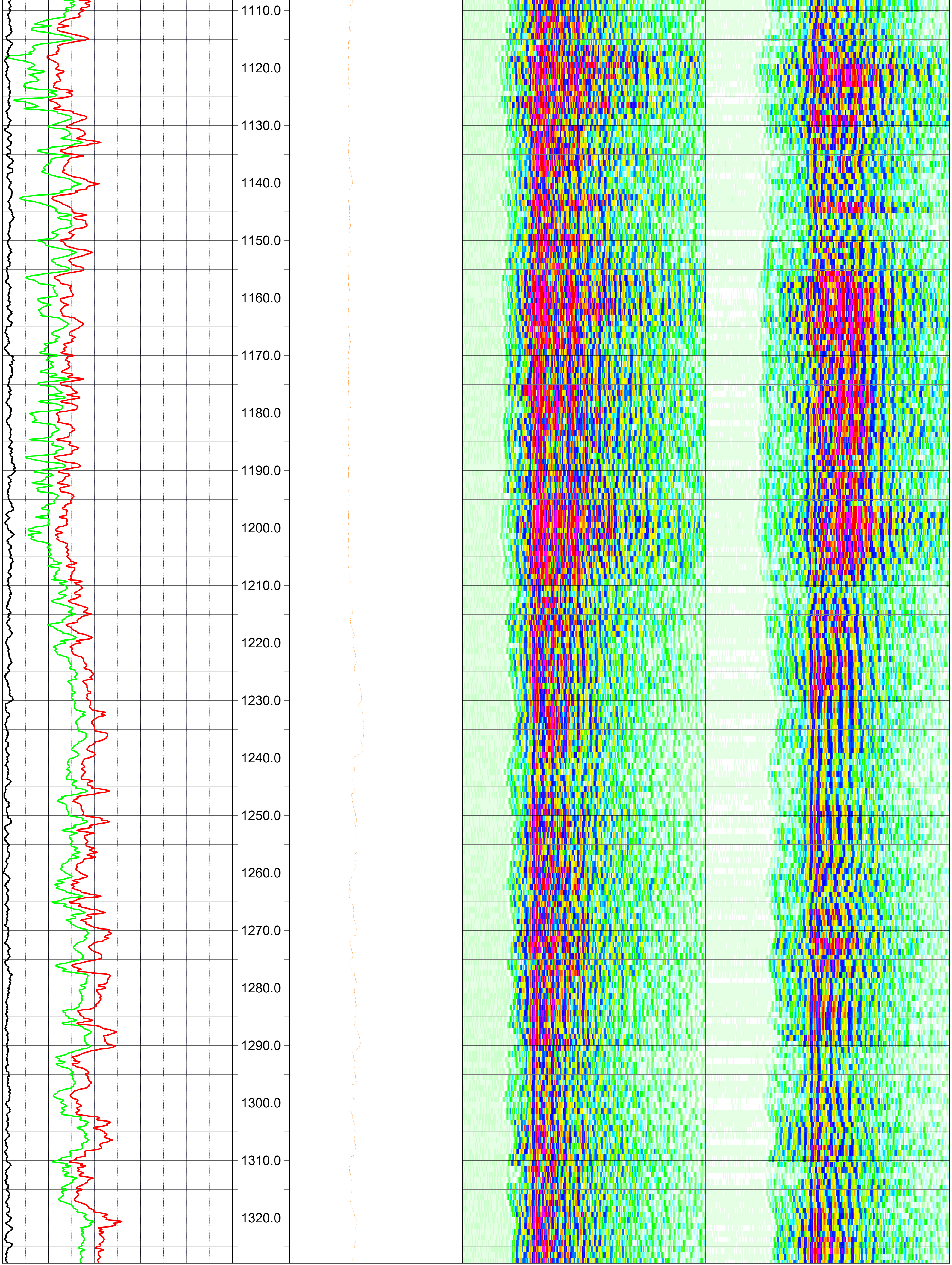
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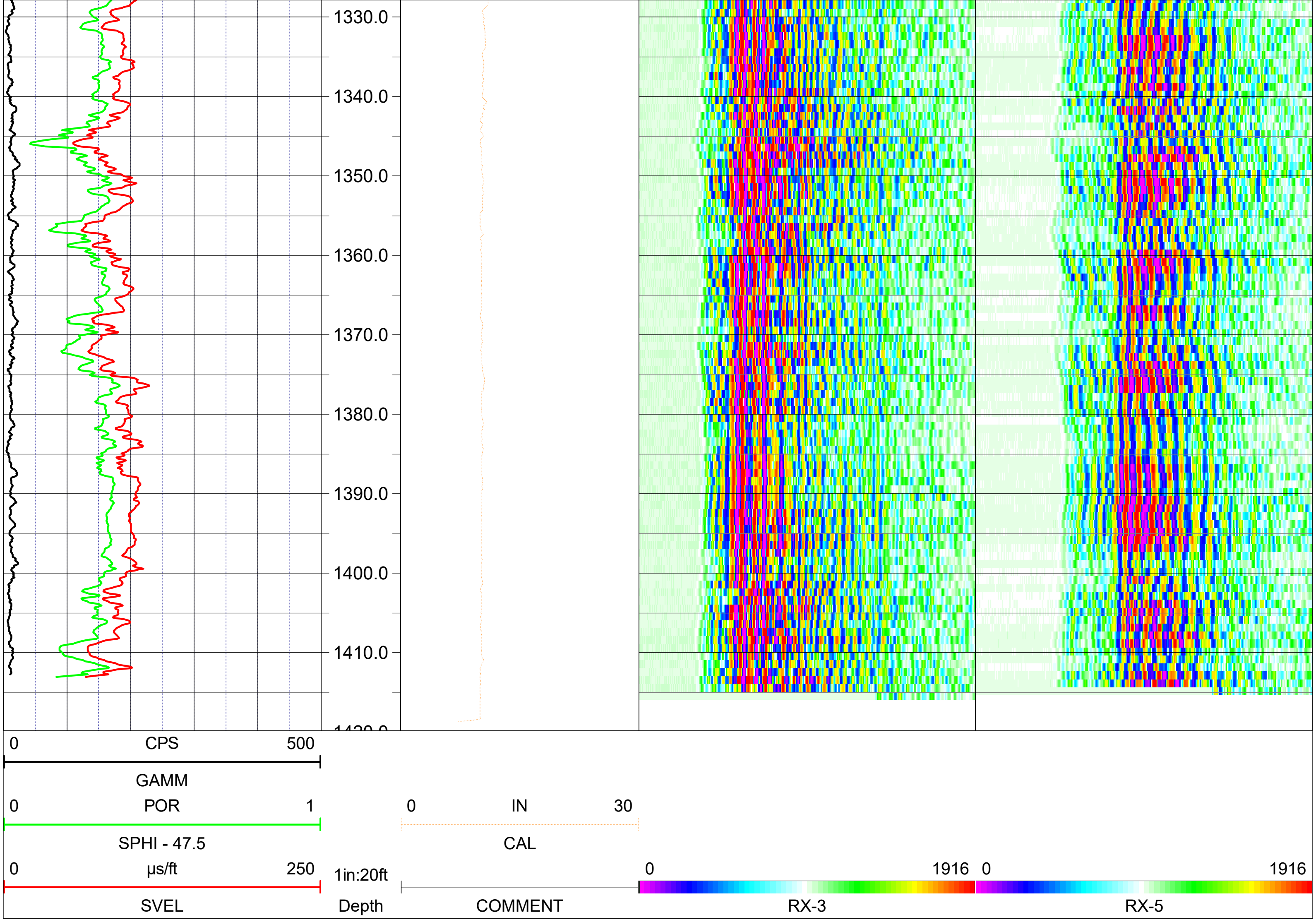

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www.rmbaker.com

WELL OSF113
UWI OSF113
LOG STAGE REAMED HOLE 1420 FT

HEADER NOTES:

COMP	SFWMD
LOC	26000 SR 60
FLD	S65
CNTY	OSCEOLA
STAT	FL
PROV	FL
CTRY	USA

LATI		X	
LONG		Y	
GDAT	WGS84	H DAT	
SEC		ELEV	
TWP		V DAT	
RGE			

ALL SERVICES: CALIPER, NATURAL GAMMA, WATER QUALITY, ELECTRIC, DUAL INDUCTION, FLOWMETER, SONIC, VIDEO

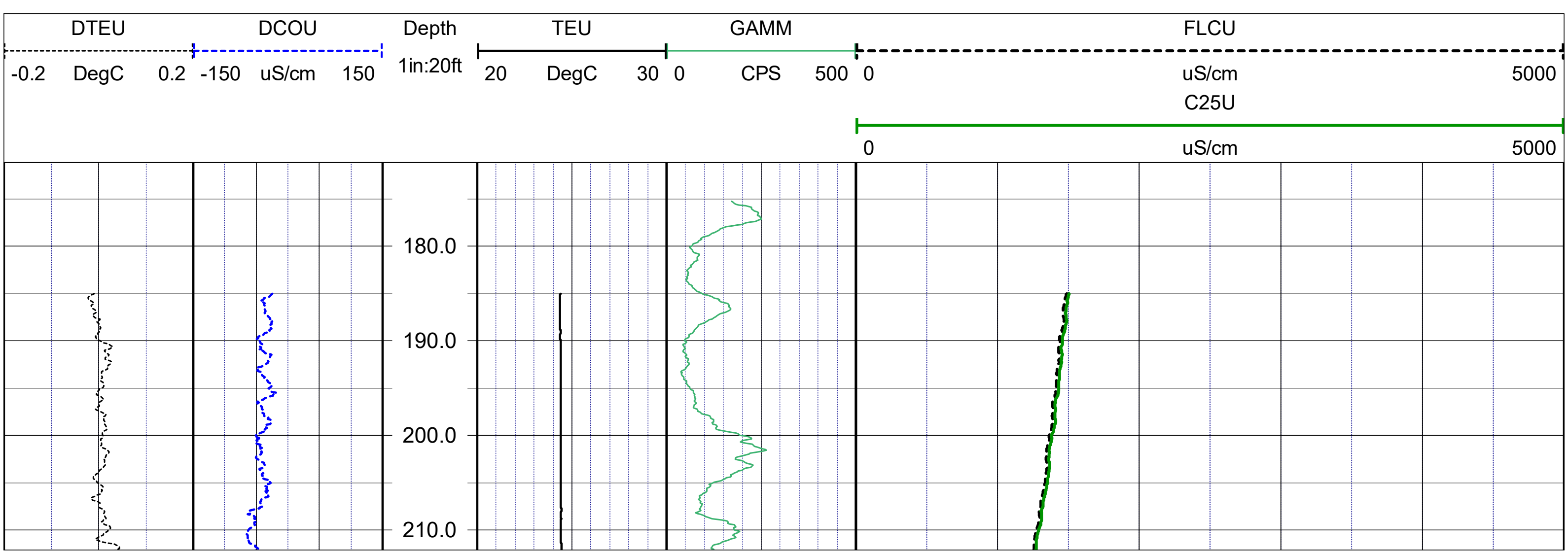
PERMANENT DATUM:
LOG MEASURED FROM: GROUND SURFACE
DRILLING MEASURED FROM:

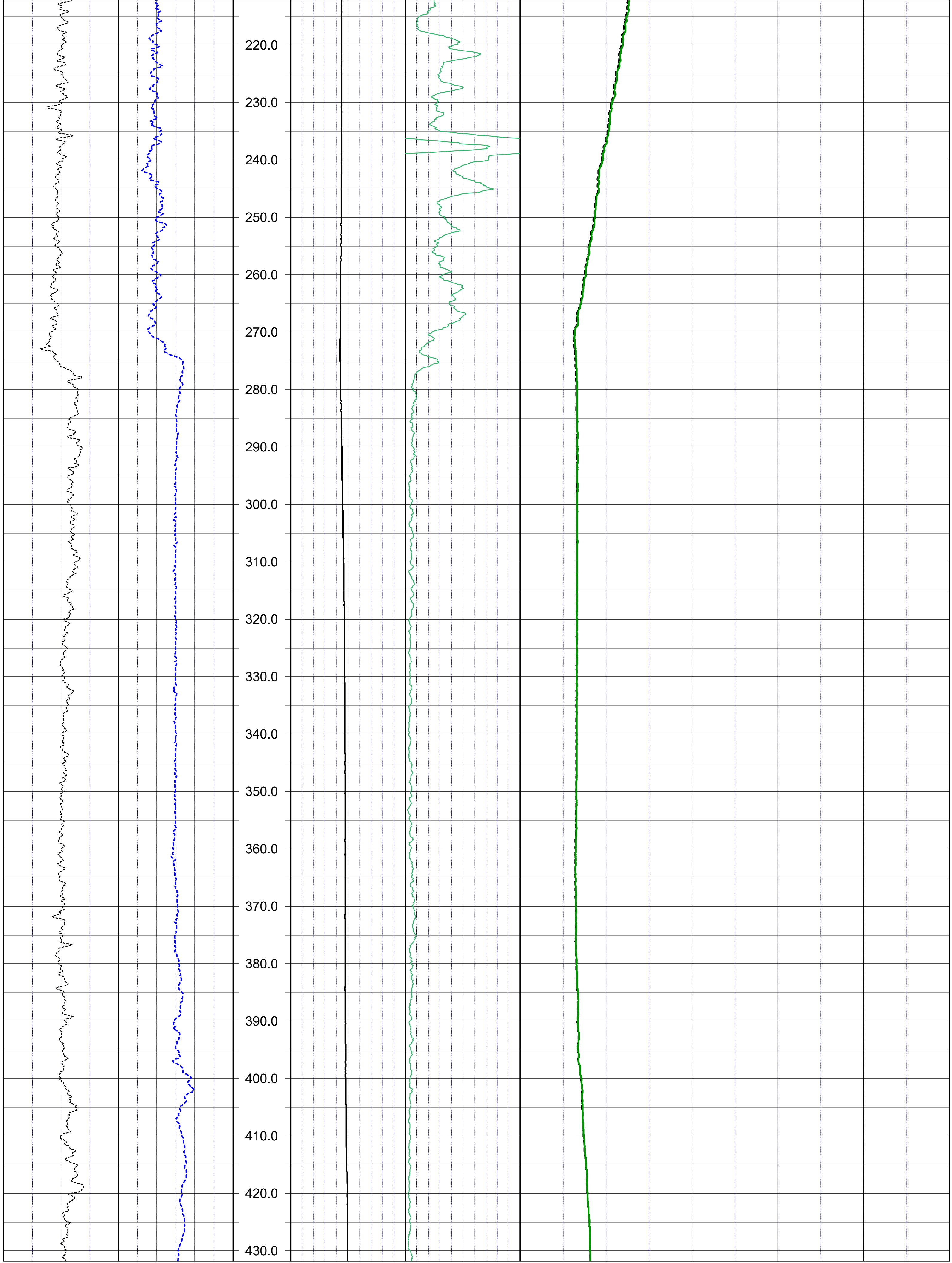
DATE	07 May 19	TYPE FLUID IN HOLE	WATER
RUN No	1	LOGGING SPEED (FT/MIN)	32
TYPE LOG	WATER QUALITY	TROLLING DIRECTION	DOWN
		PUMPING RATE (GPM)	N/A
DEPTH-DRILLER	1420		
DEPTH-LOGGER	1420		
DRILLER	HUSS DRILLING		
RECORDED BY	RMB		
SRVC	RMBAKER LLC	API	N/A
WITNESSED BY	SFWMD	LIC	N/A

BOREHOLE RECORD				CASING RECORD			
RUN NO.	BIT	FROM	TO	SIZE	MAT.	FROM	TO
1	9.875	237.5	1420	10	PVC	0	237.5

WATER QUALITY LOG CODES

static fluid temperature	**TEU**	dynamic fluid conductivity	**FLCP**	caliper	**CAL**
dynamic fluid temperature	**TEP**	static differential cond.	**DCOU**	repeat designation	**R**
static differential temperature	**DTEU**	dynamic differential cond.	**DCOP**	natural gamma	**GAMM**
dynamic differential temp.	**DTEP**	static specific conductance	**C25U**	calibration correction	**C**
static fluid conductivity	**FLCU**	dynamic specific conductance	**C25P**		

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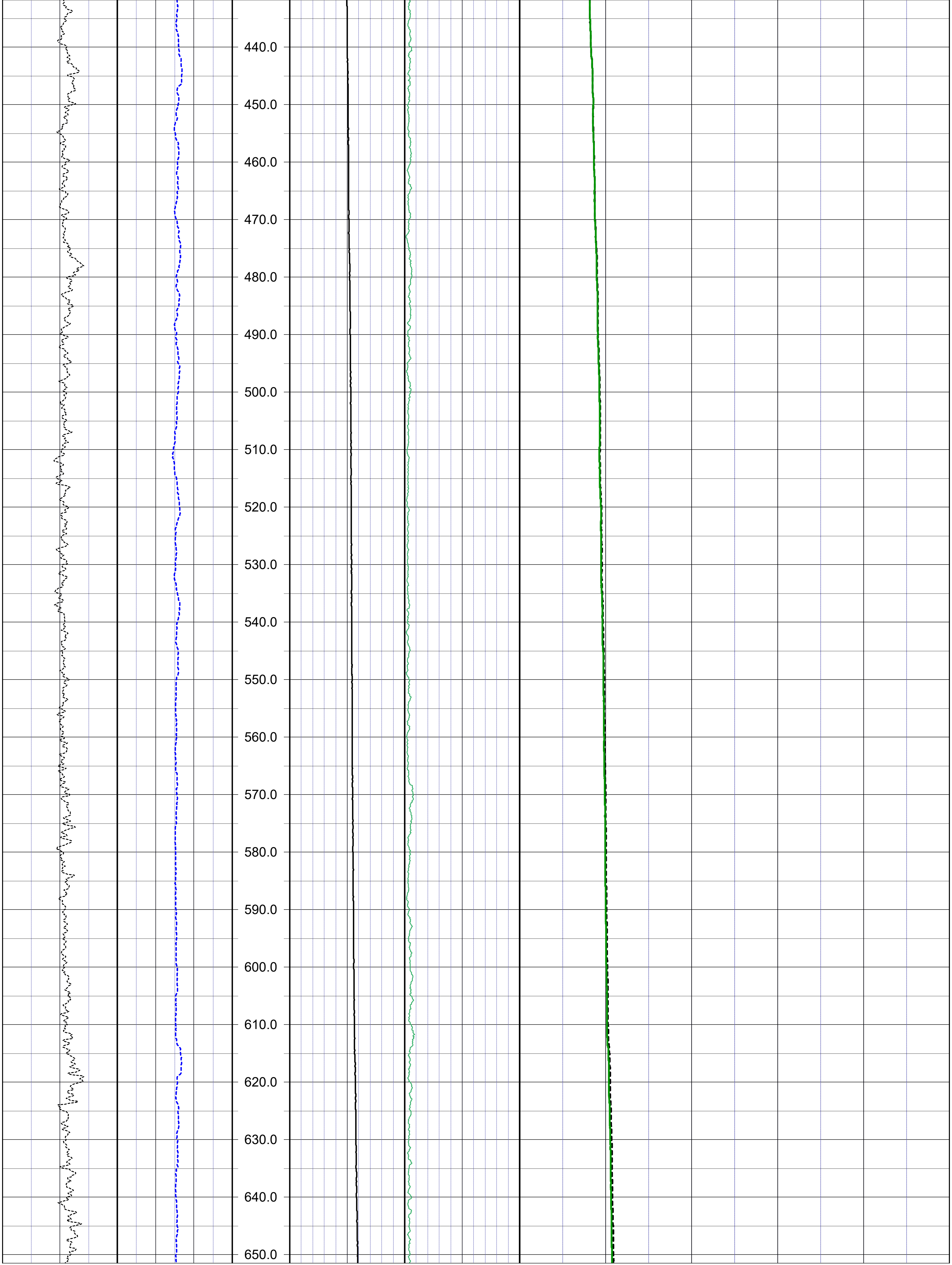
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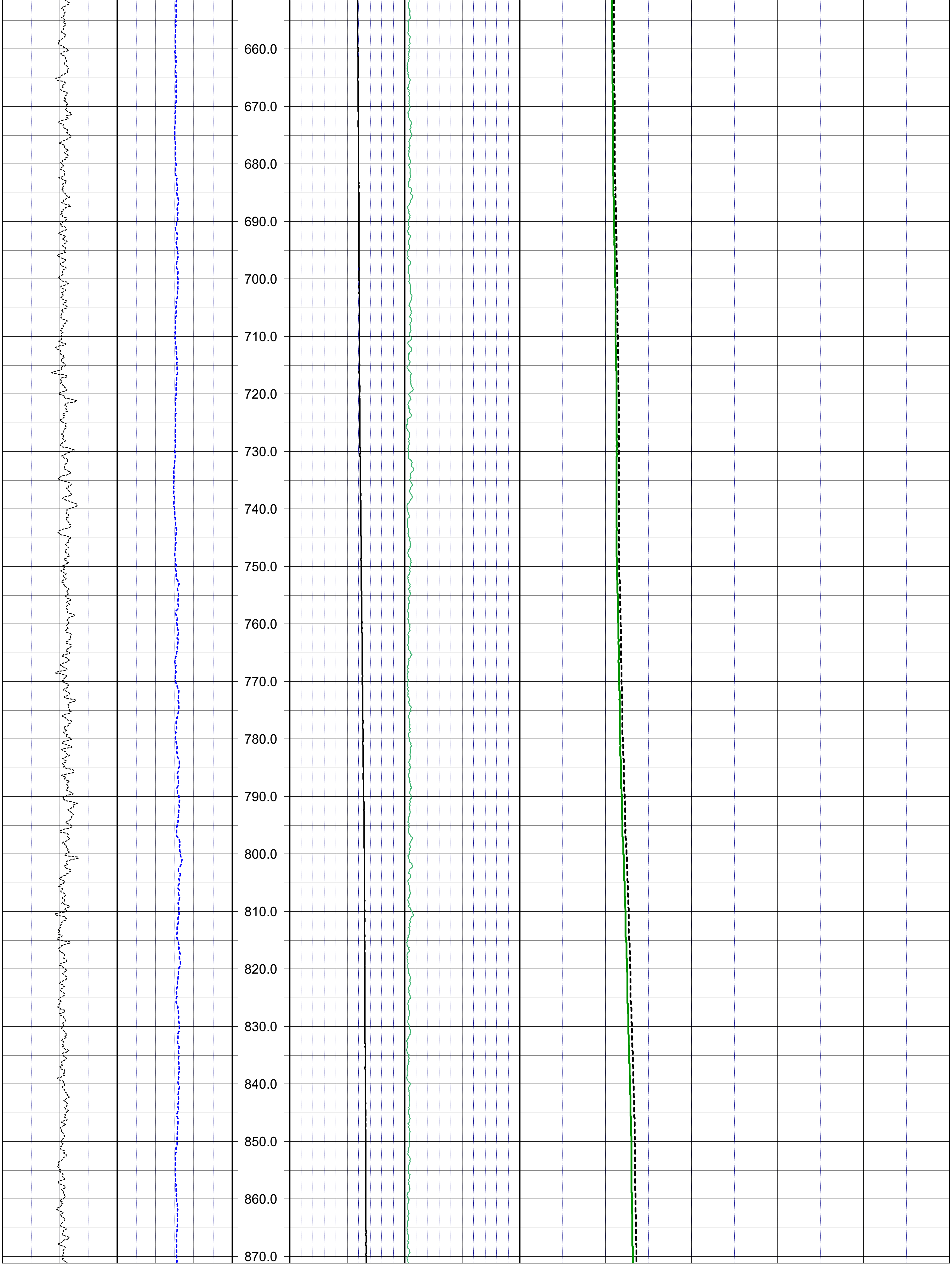
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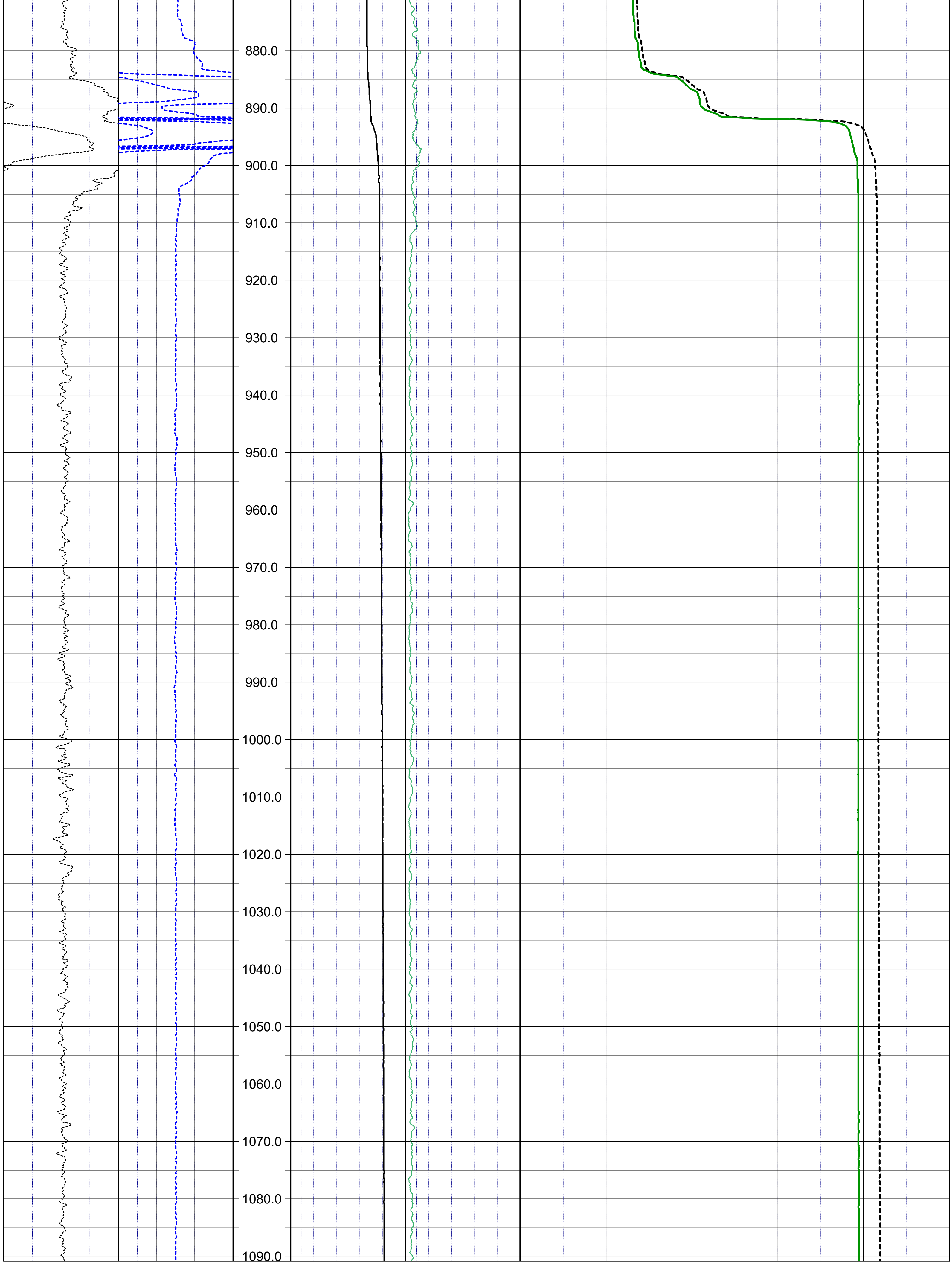
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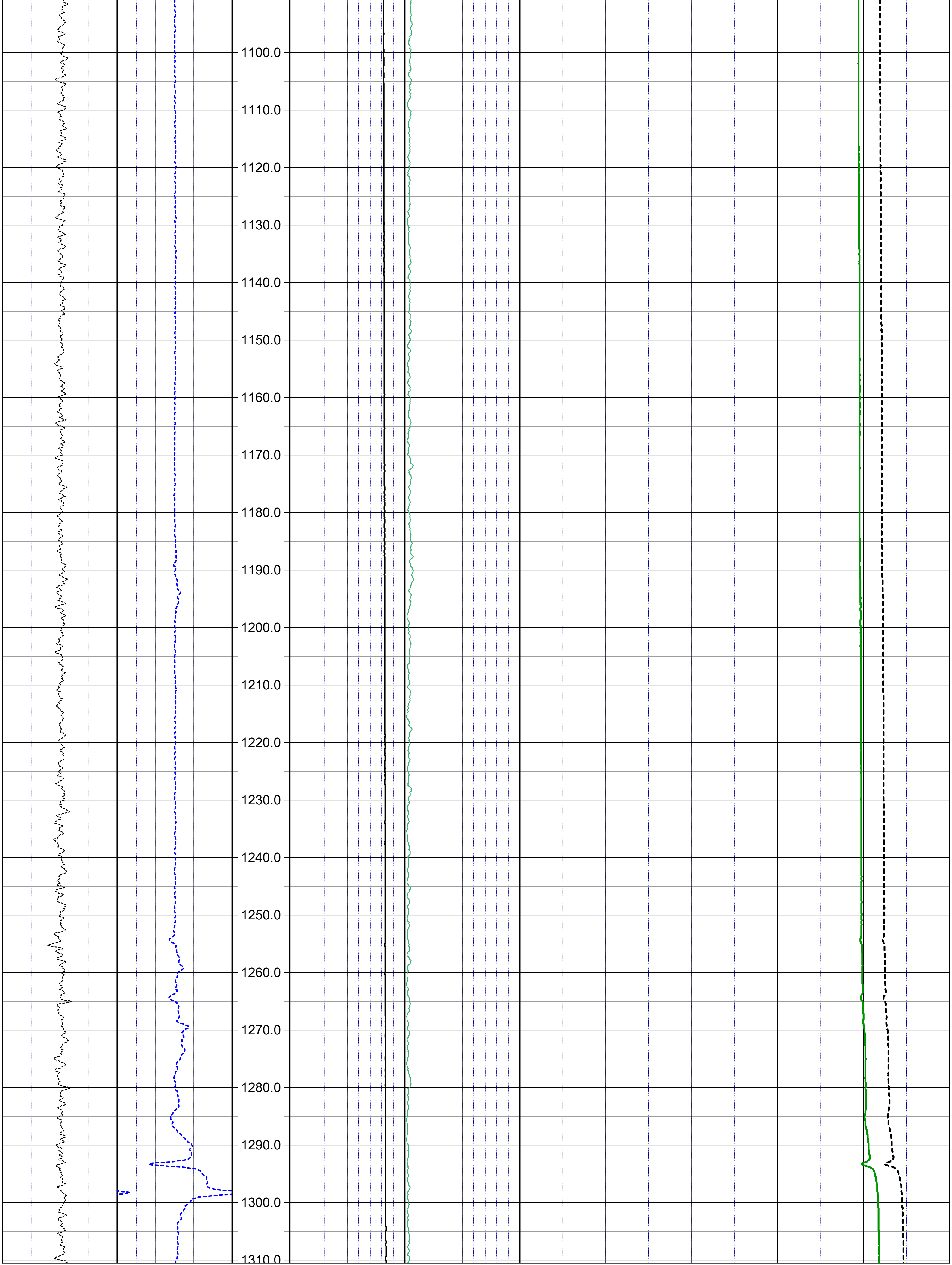
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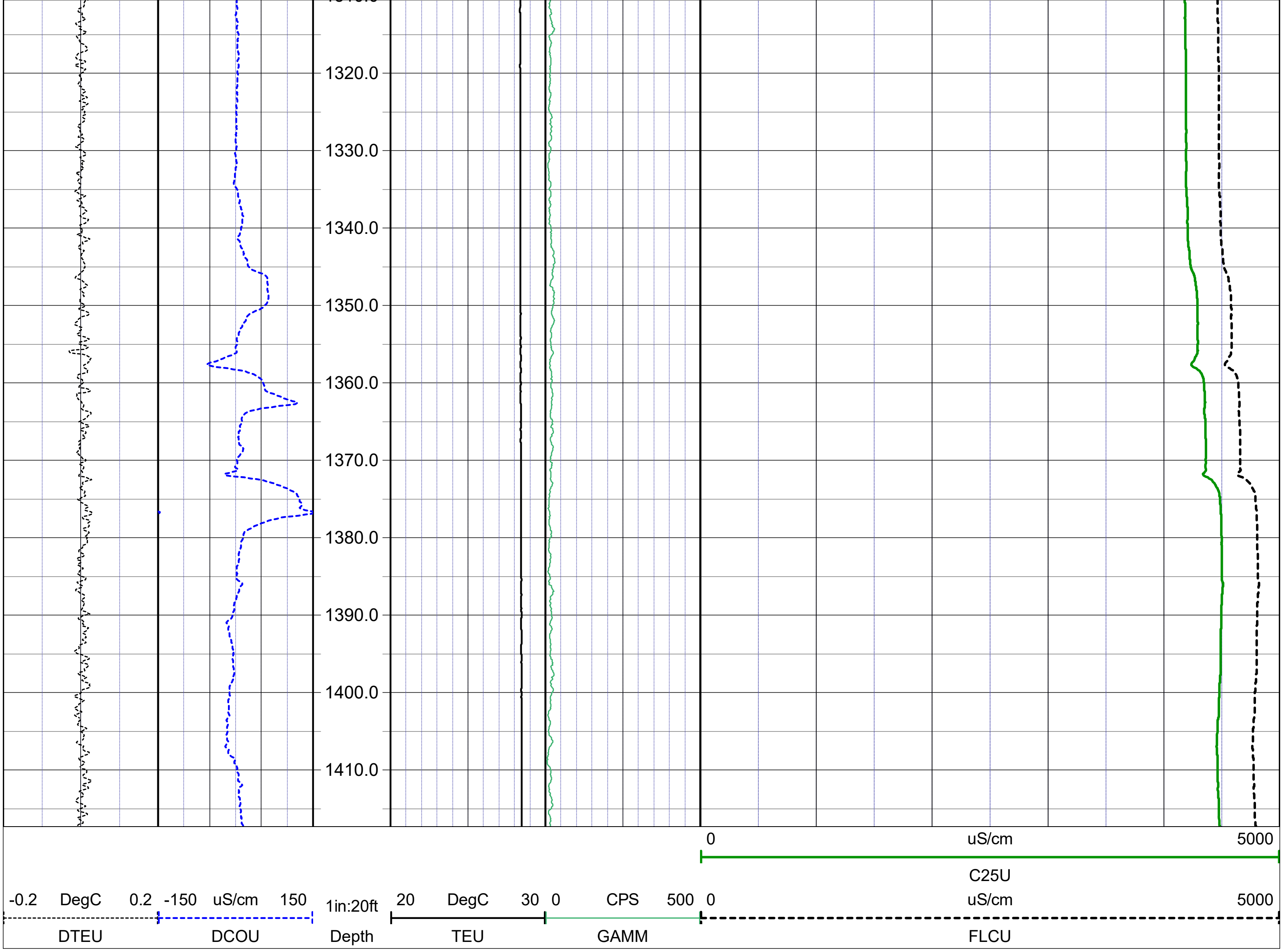

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WELL OSF113
UWI OSF113
LOG STAGE CORED TO 2000

HEADER NOTES:

COMP	SFWMD		
LOC	26000 SR 60		
FLD	S65		
CNTY	OSCEOLA		
STAT	FL		
PROV	FL		
CTRY	USA		
LATI		X	
LONG		Y	
GDAT	WGS84	H DAT	
SEC		ELEV	
TWP		V DAT	
RGE			

ALL SERVICES:
CALIPER
NATURAL GAMMA
WATER QUALITY
ELECTRIC
DUAL INDUCTION

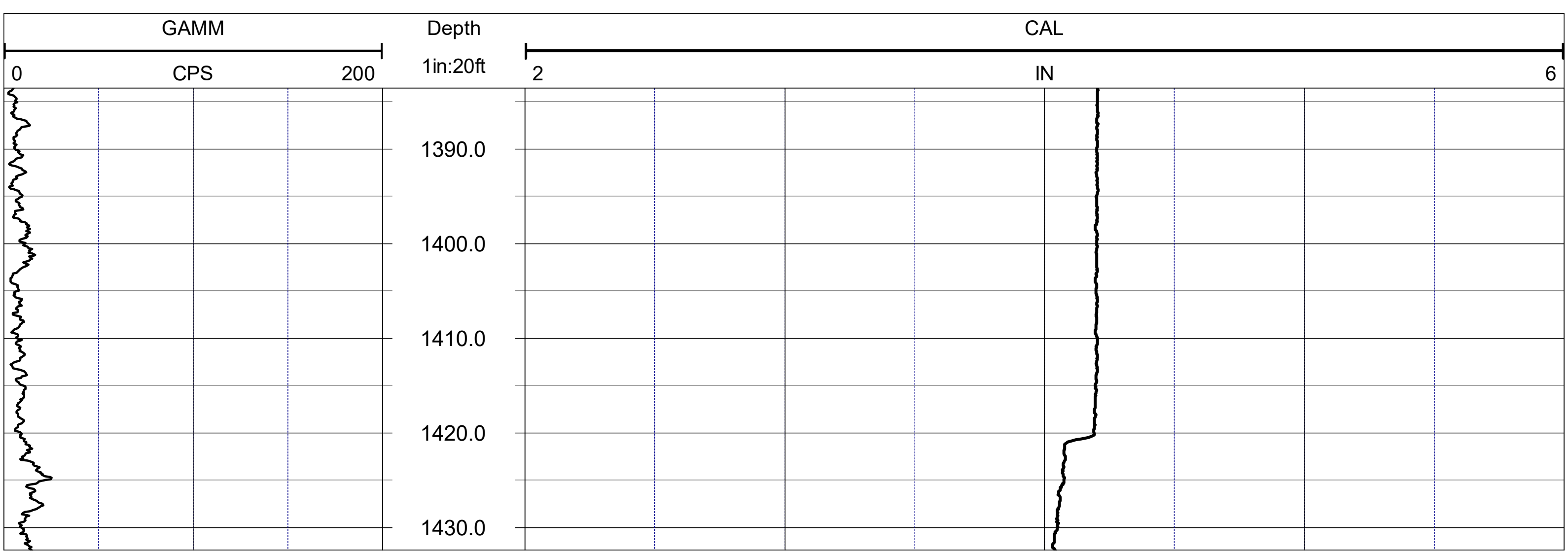
PERMANENT DATUM:
LOG MEASURED FROM: GROUND SURFACE
DRILLING MEASURED FROM:

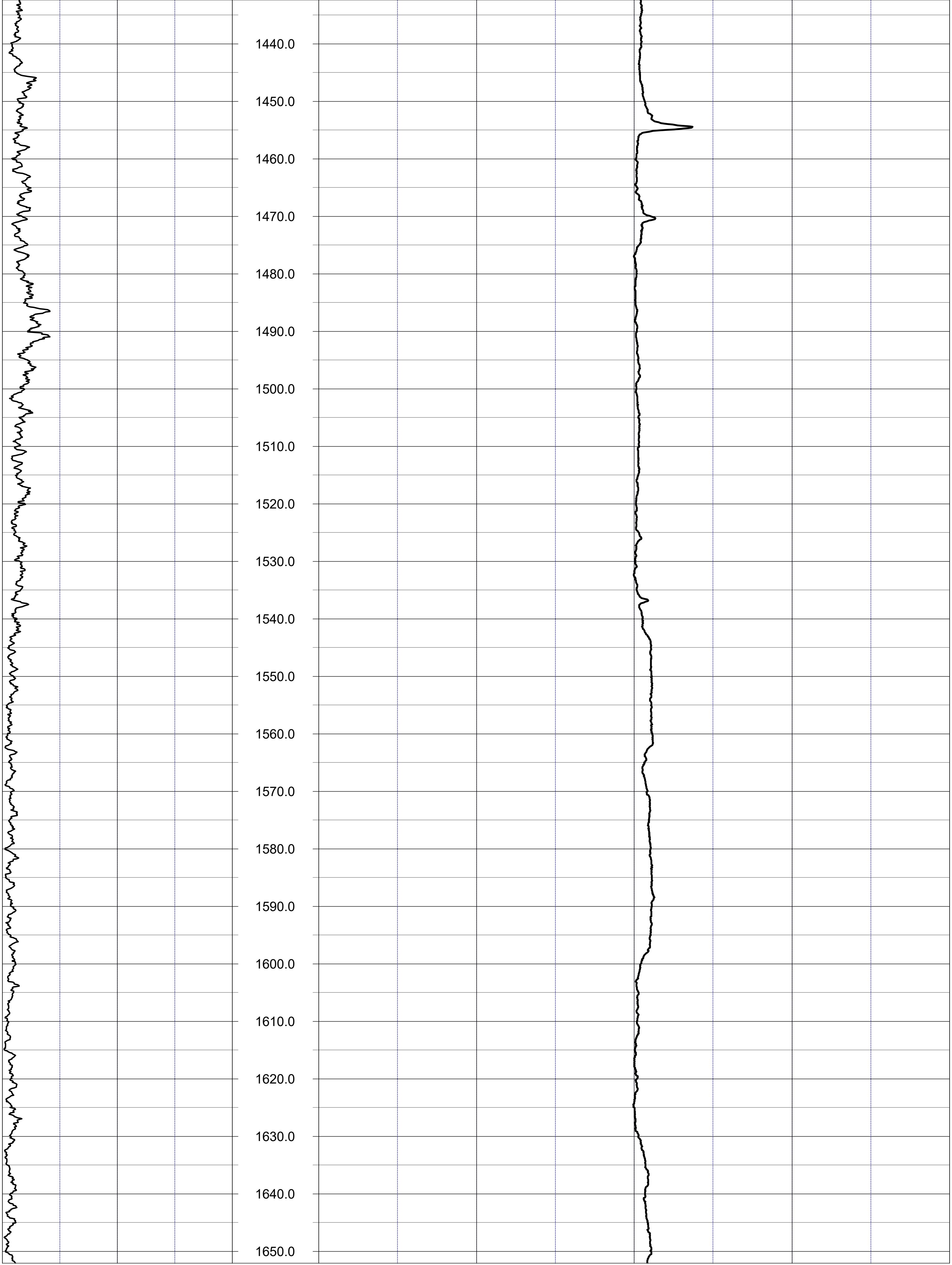
DATE	01 July 19	TYPE FLUID IN HOLE	WATER
RUN No	1	LOGGING SPEED (FT/MIN)	40
TYPE LOG	**CALIPER**	TROLLING DIRECTION	UP
		PUMPING RATE (GPM)	N/A
DEPTH-DRILLER	2000		
DEPTH-LOGGER	2002		
DRILLER	HUSS DRILLING		
RECORDED BY	RMB		
SRVC	RMBAKER LLC	API	N/A
WITNESSED BY	SFWMD	LIC	N/A

BOREHOLE RECORD				CASING RECORD			
RUN NO.	BIT	FROM	TO	SIZE	MAT.	FROM	TO
1	9.875	237.5	1420	10	PVC	0	237.5
2	3.9	1420	2000				

LOG CODES

3-arm caliper	**CAL**	long normal resistivity	**RLN**	deep induction conductivity	**IDC**
natural gamma (CPS)	**GAMM**	8 inch resistivity	**R8**	shallow induction conductivity	**ISC**
spontaneous potential	**ESP**	32 inch resistivity	**R32**	sonic interval velocity	**DT**
single point resistance	**RES**	deep induction resistivity	**ILD**	sonic porosity (RHG method)	**SPHI**
short normal resistivity	**RSN**	shallow induction resistivity	**ILM**	repeat designation	**R**

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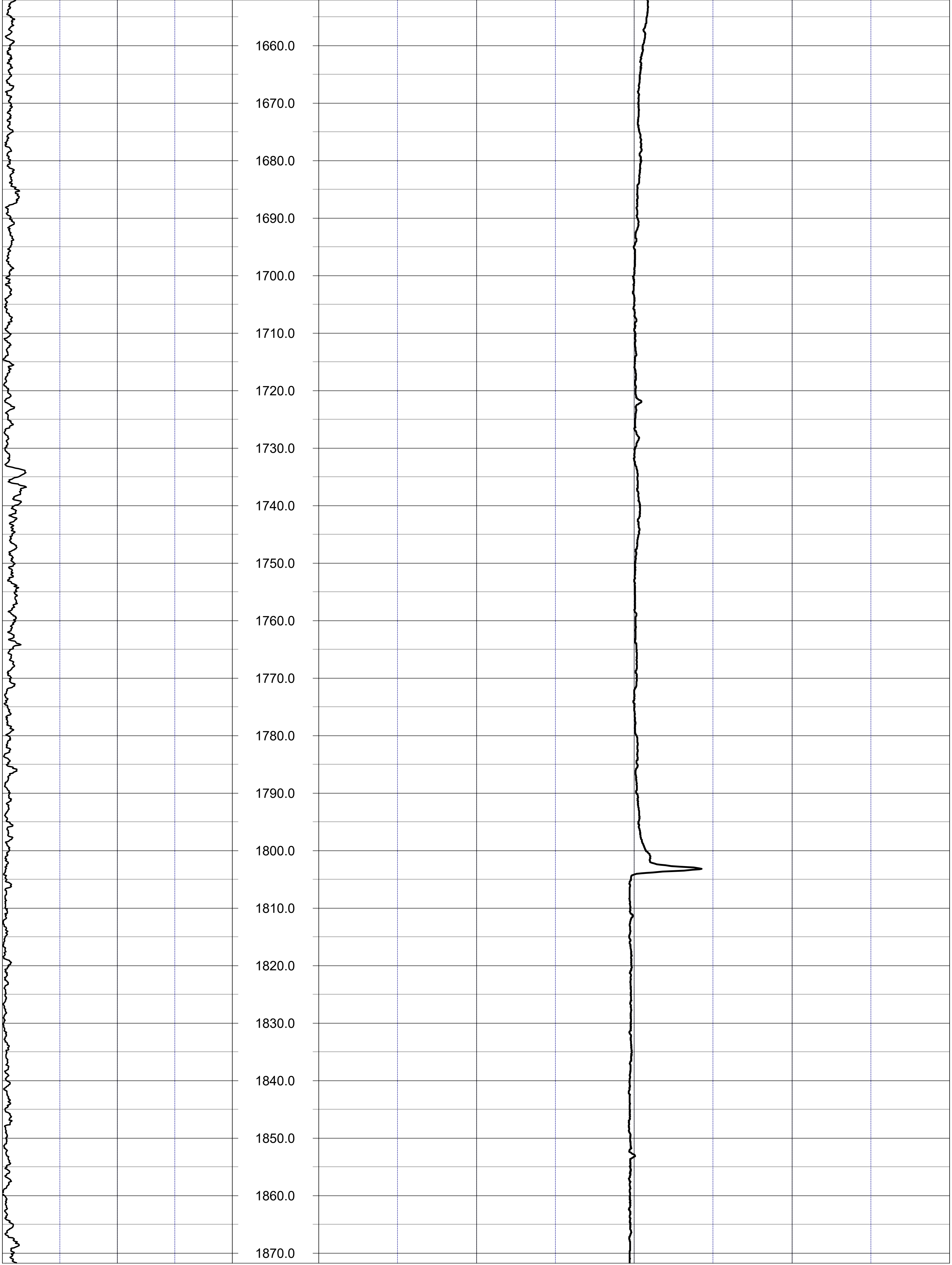
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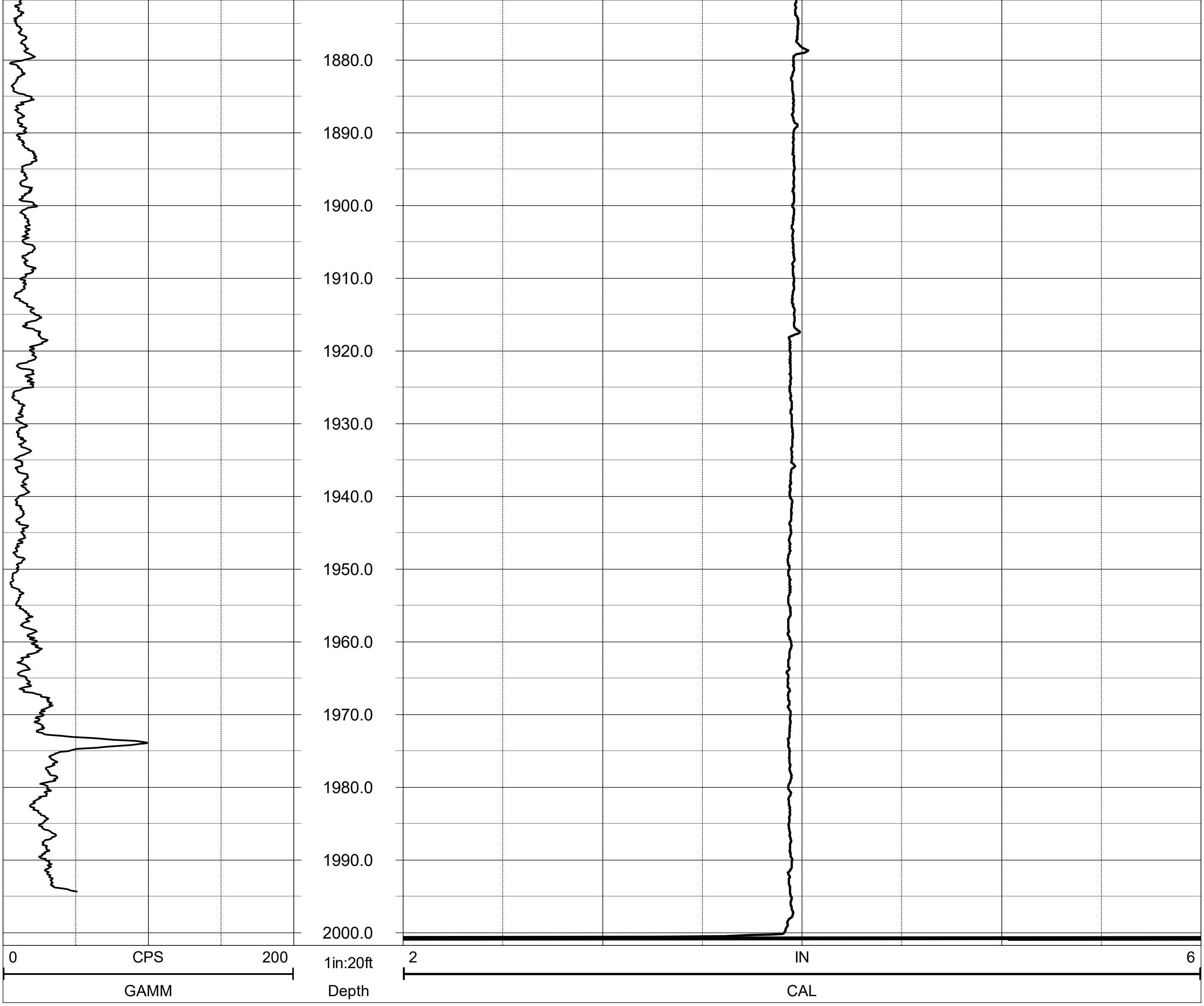

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END OF LOG

OSF-113

Depth 1ft:5ft	OBI Logs (USGS)
	Optical Borehole Image (QL40-OBI-2G)
	0° 90° 180° 270° 0°

236

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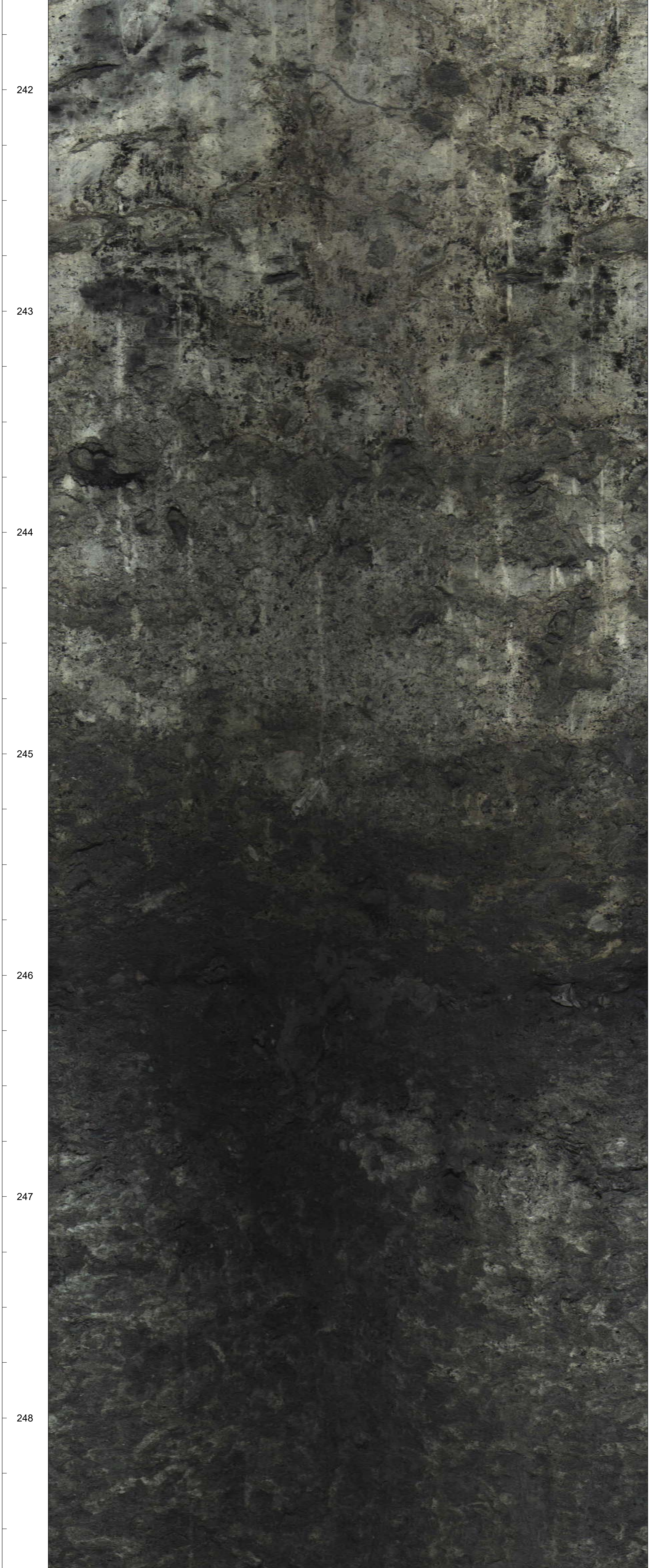
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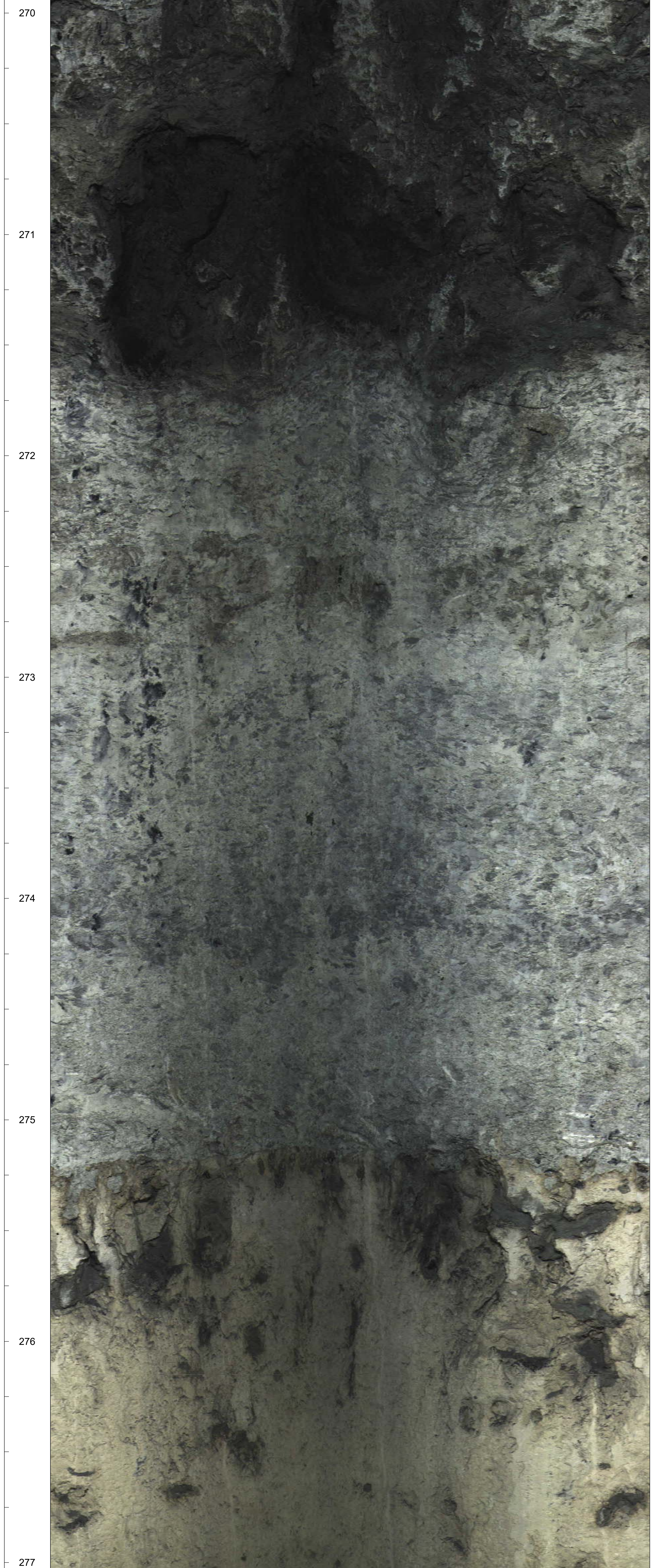
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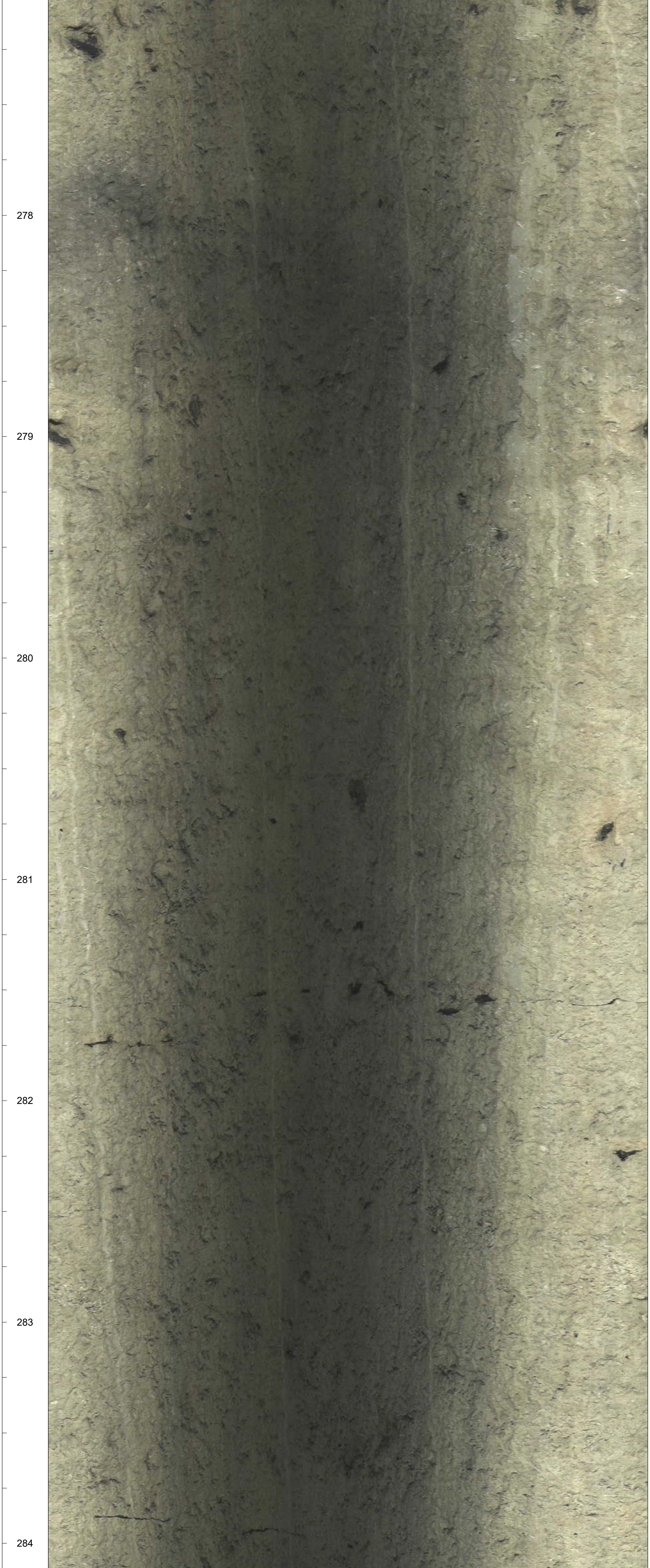
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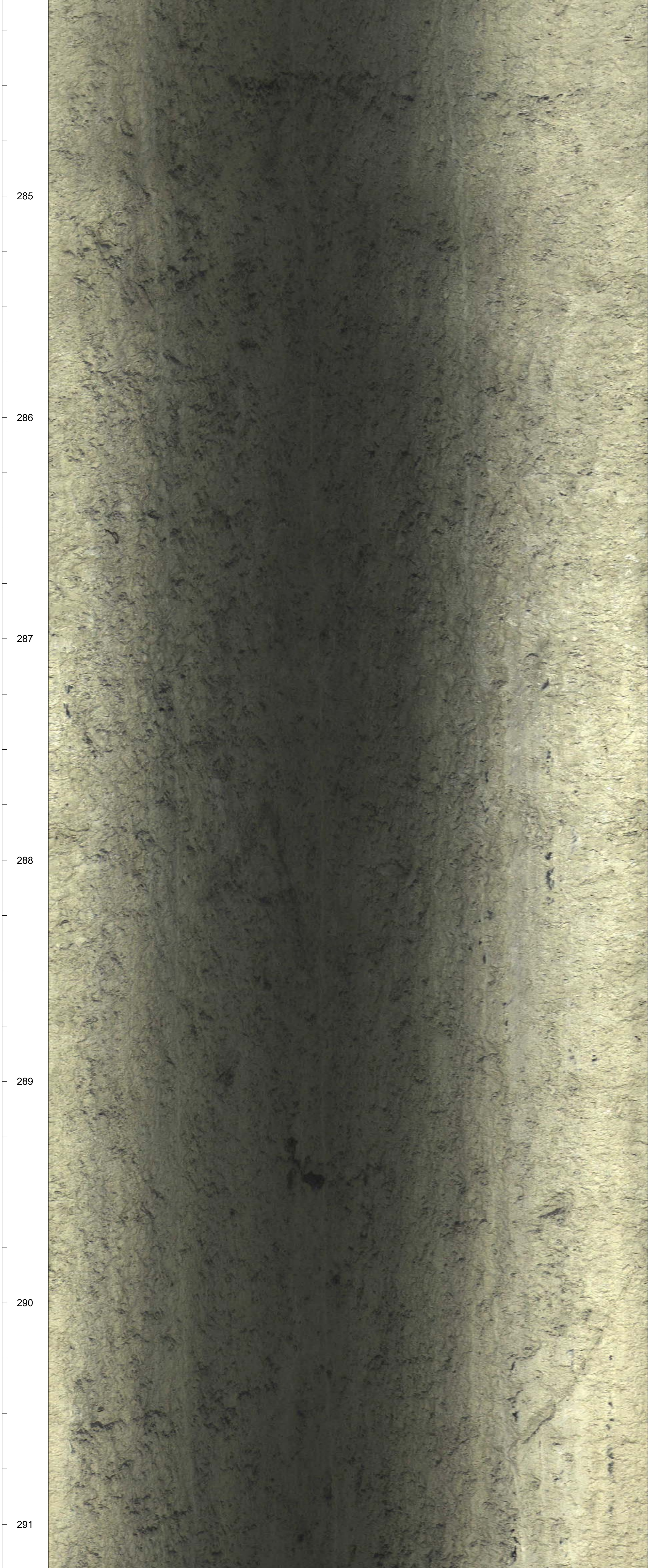
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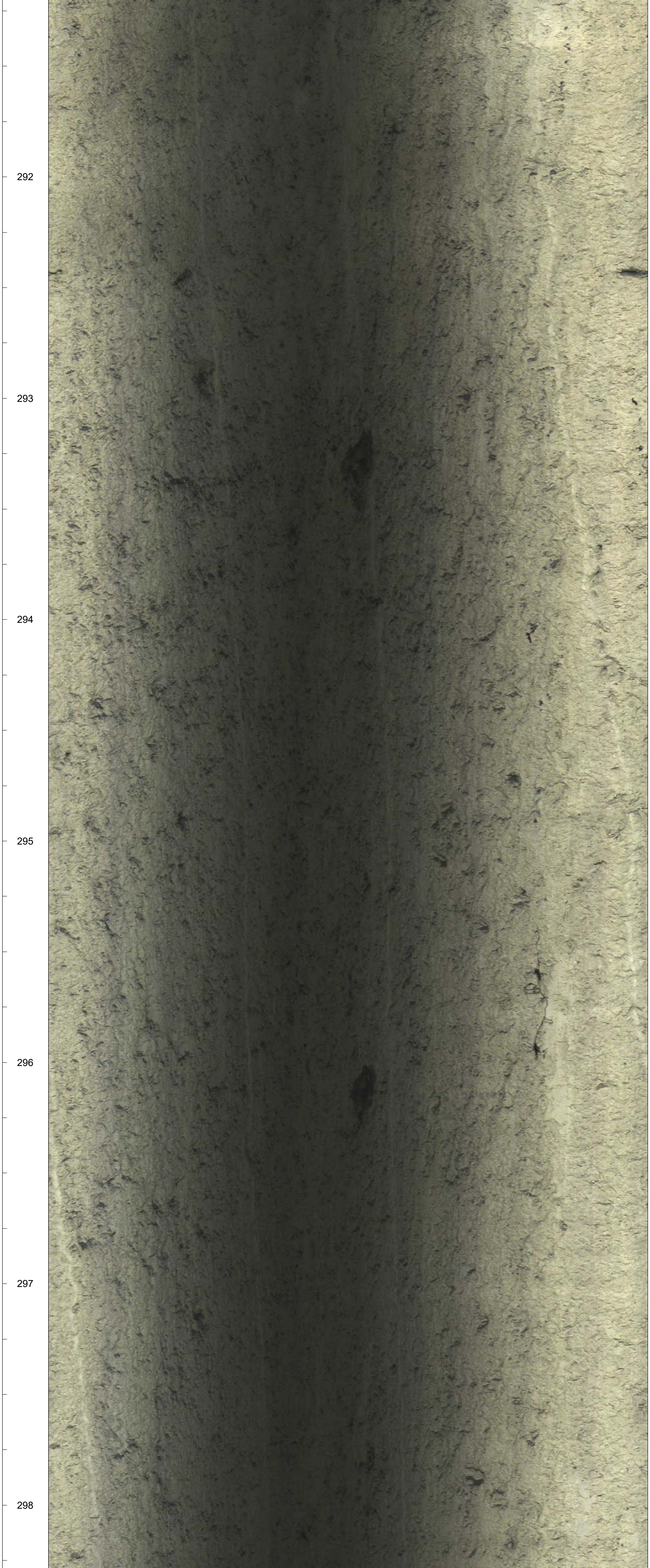
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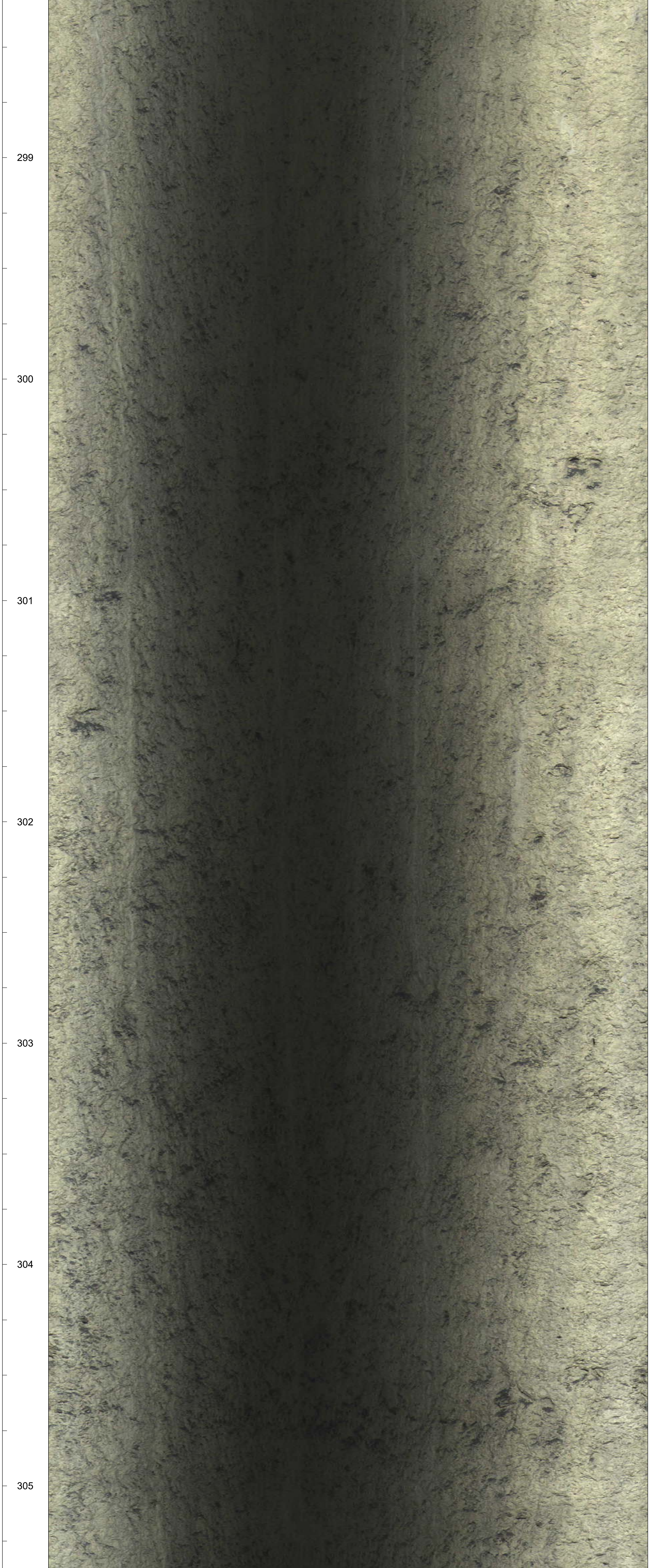

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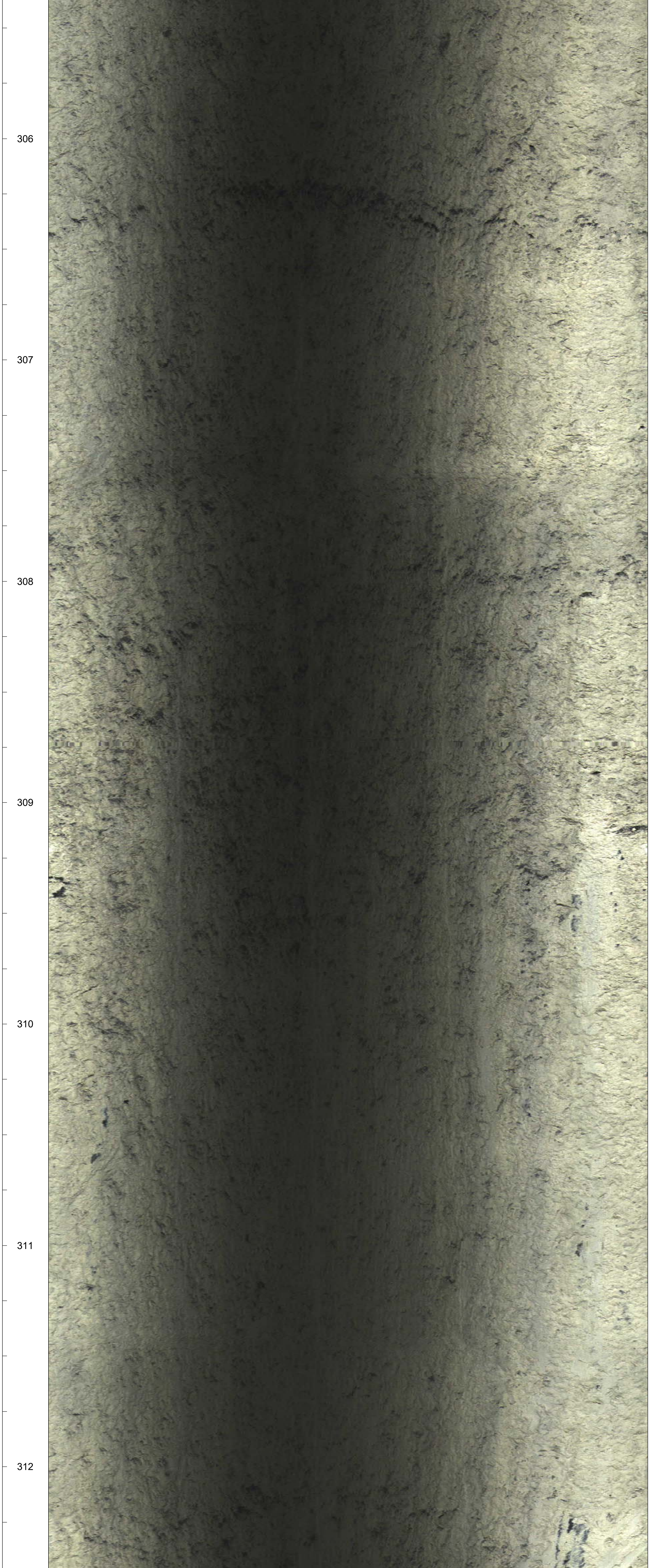
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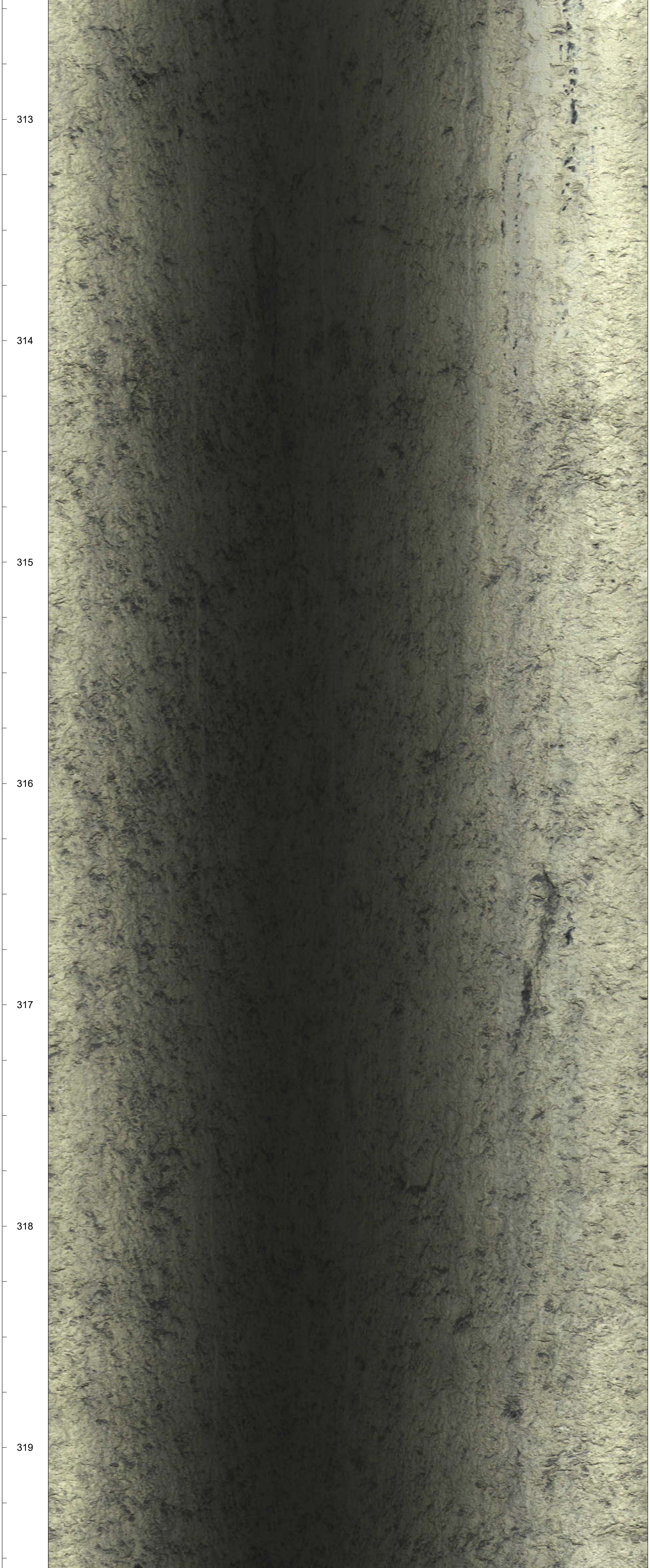
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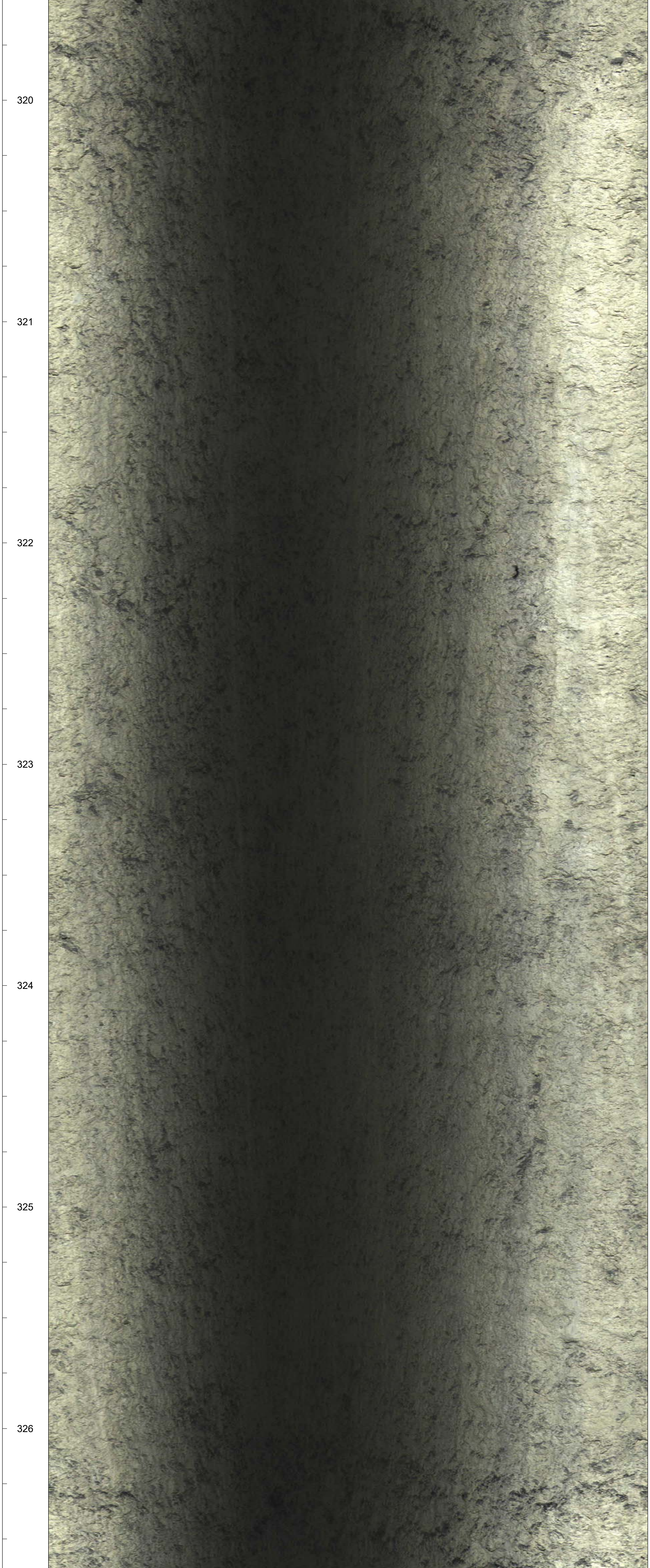
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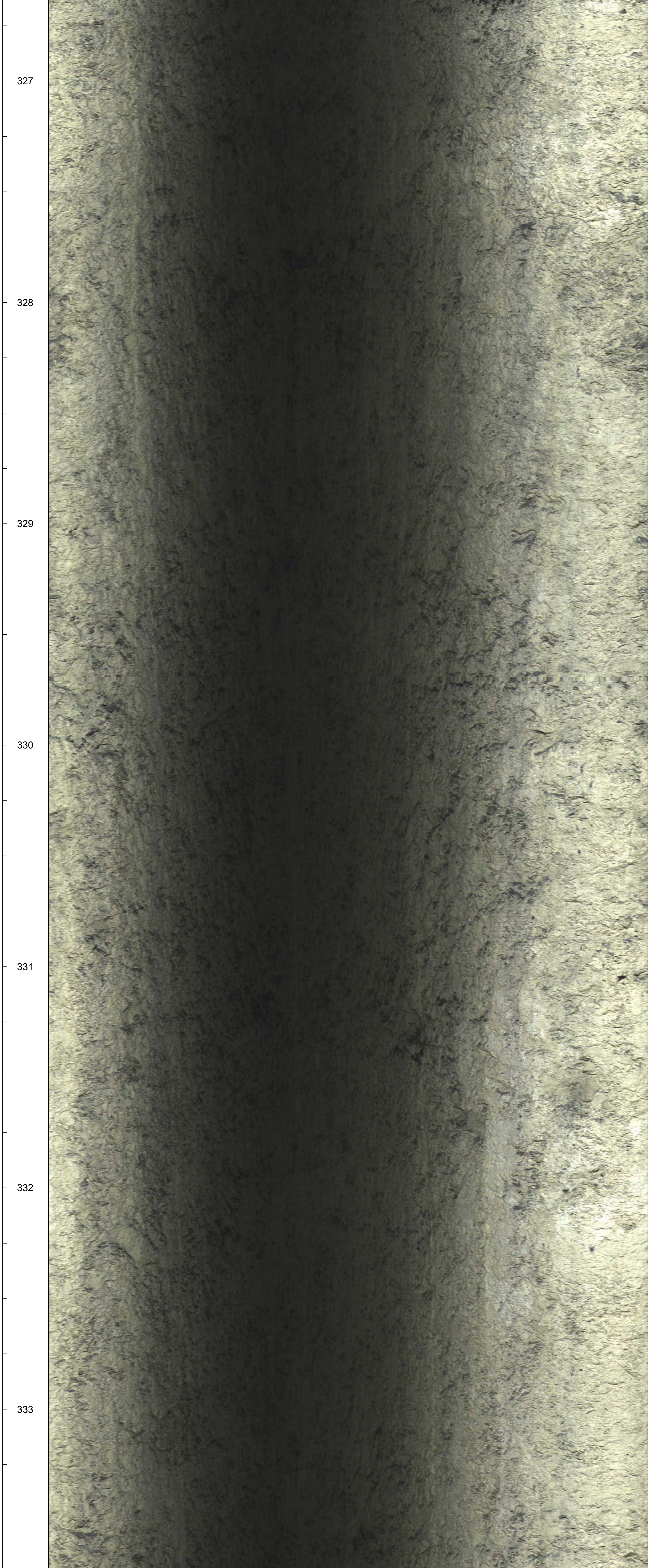
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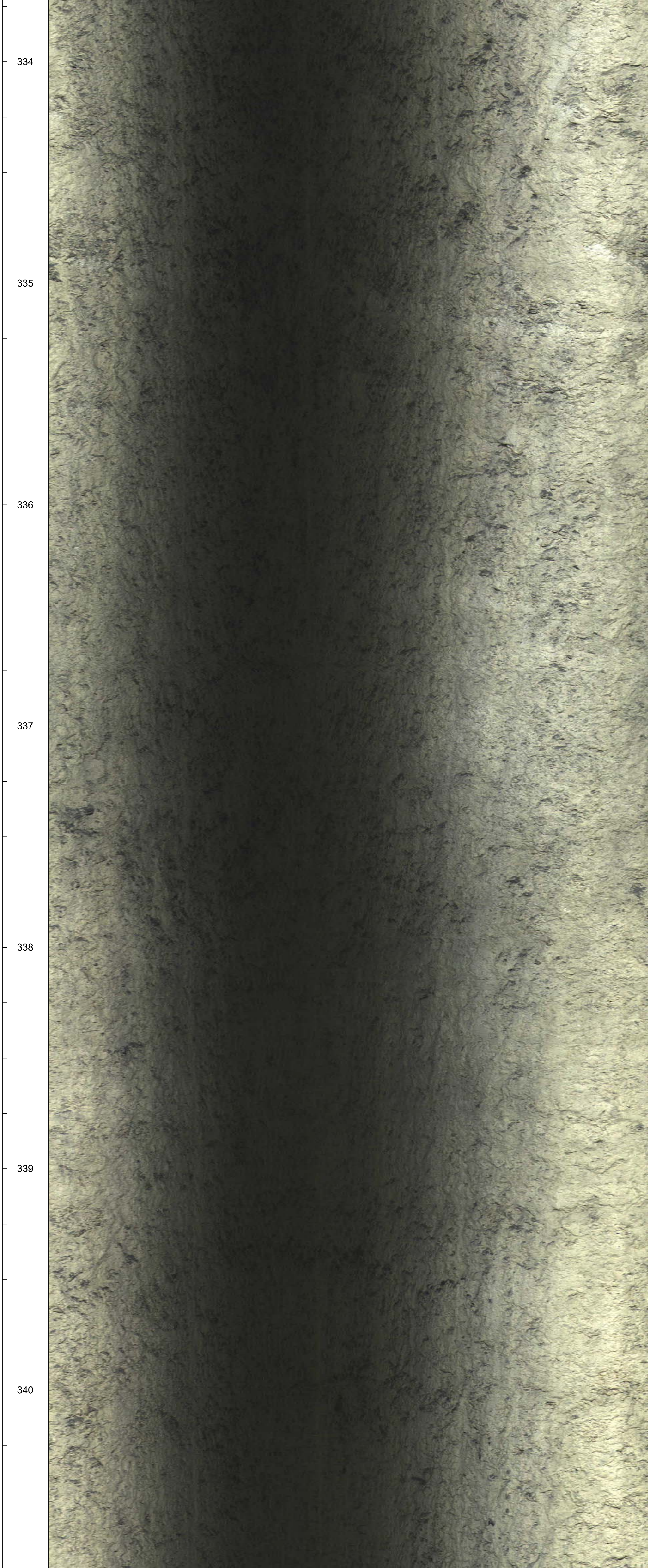
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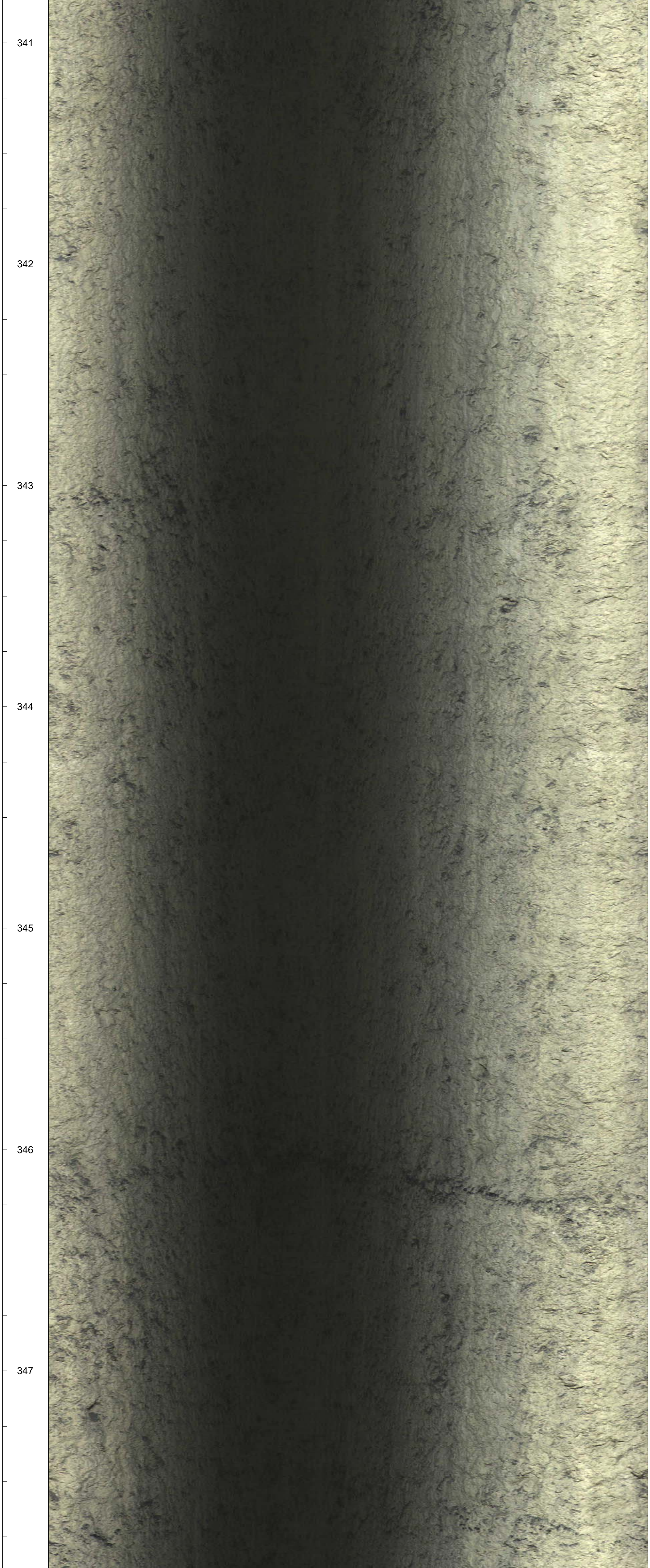
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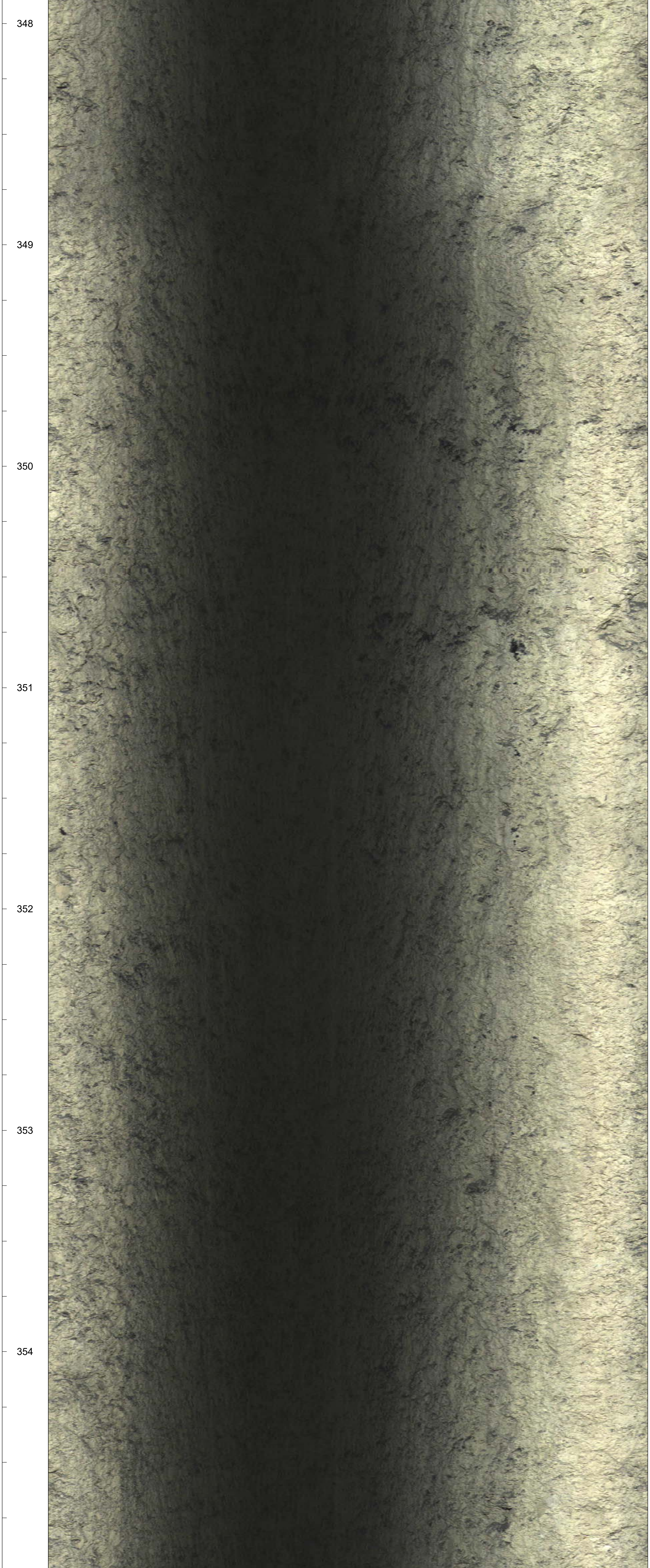
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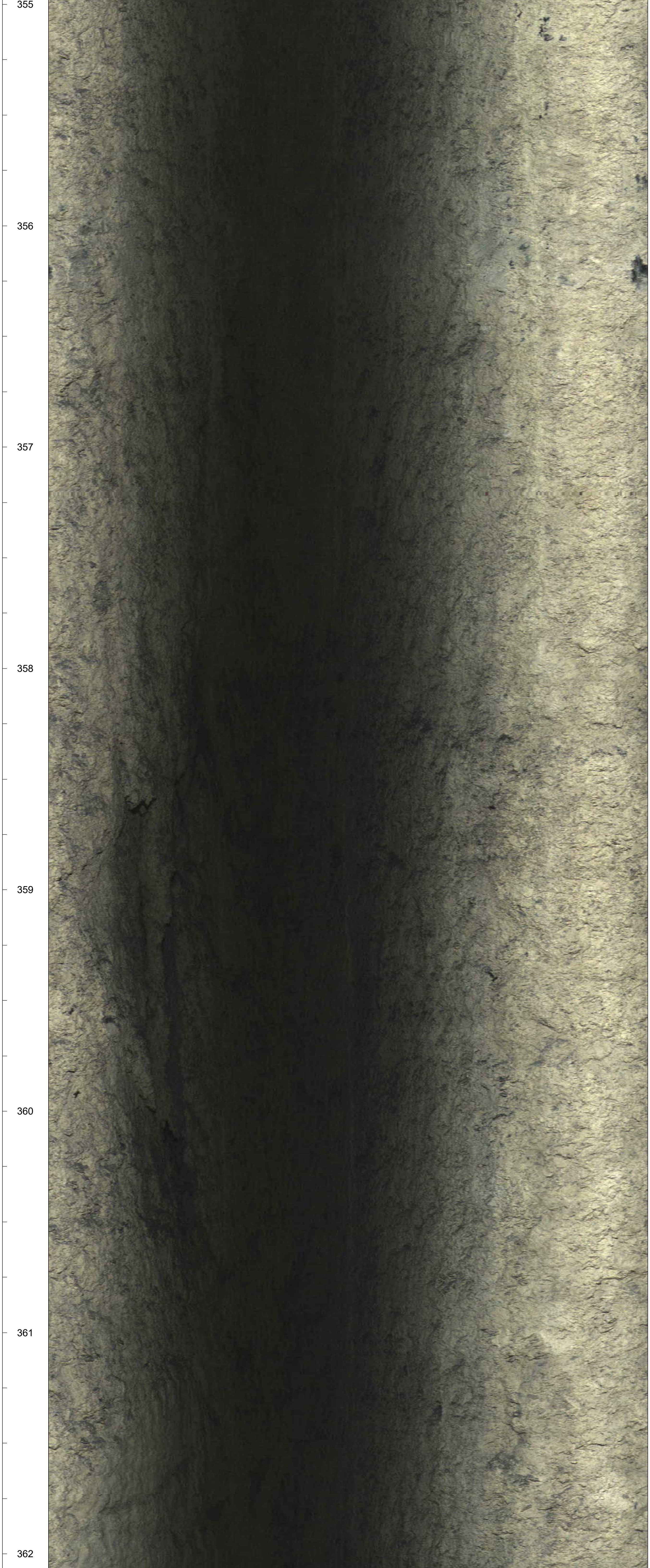
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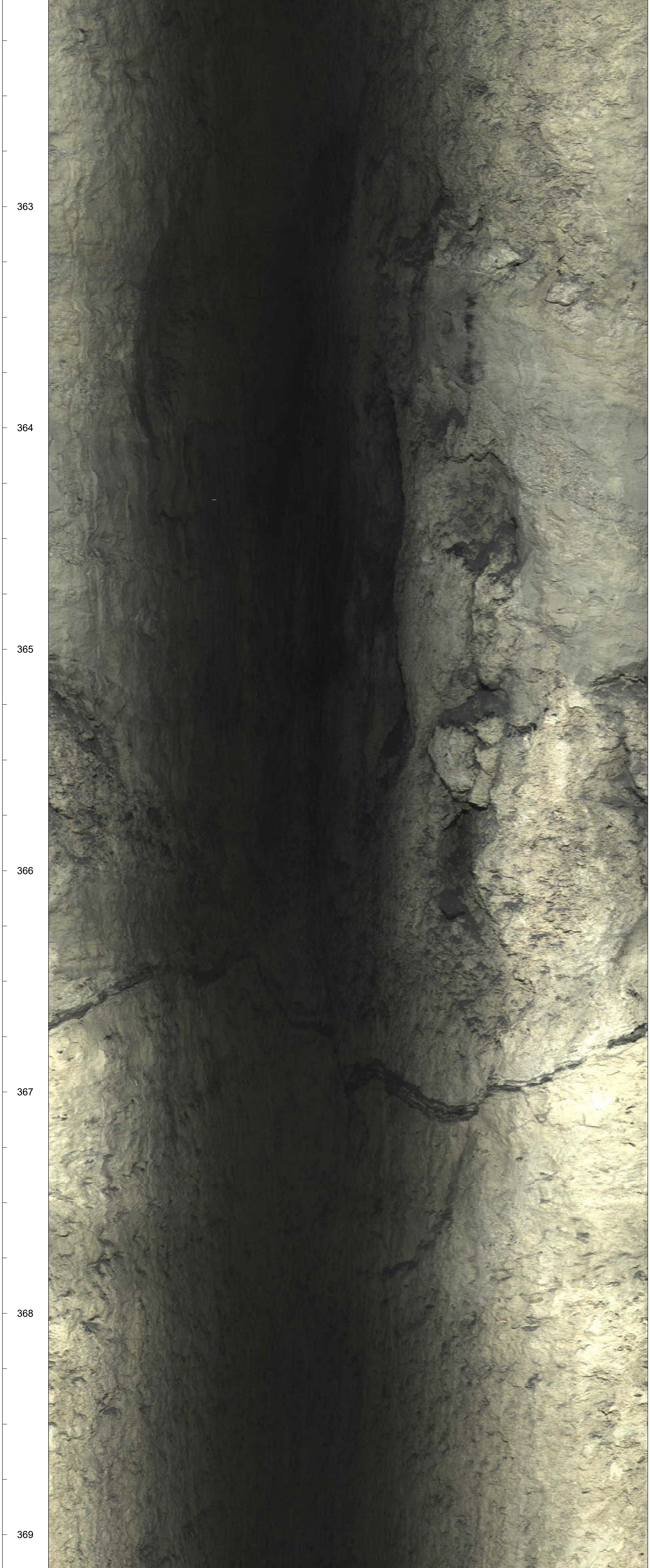
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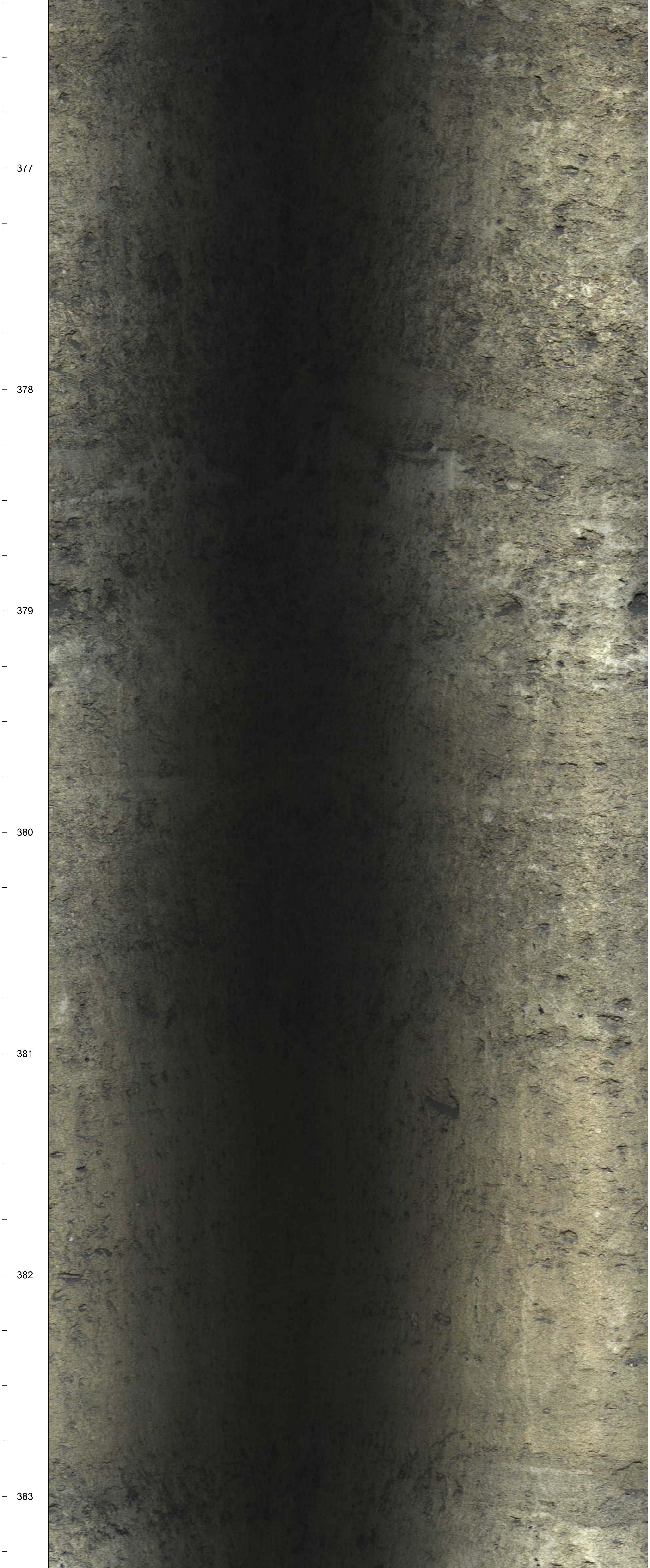
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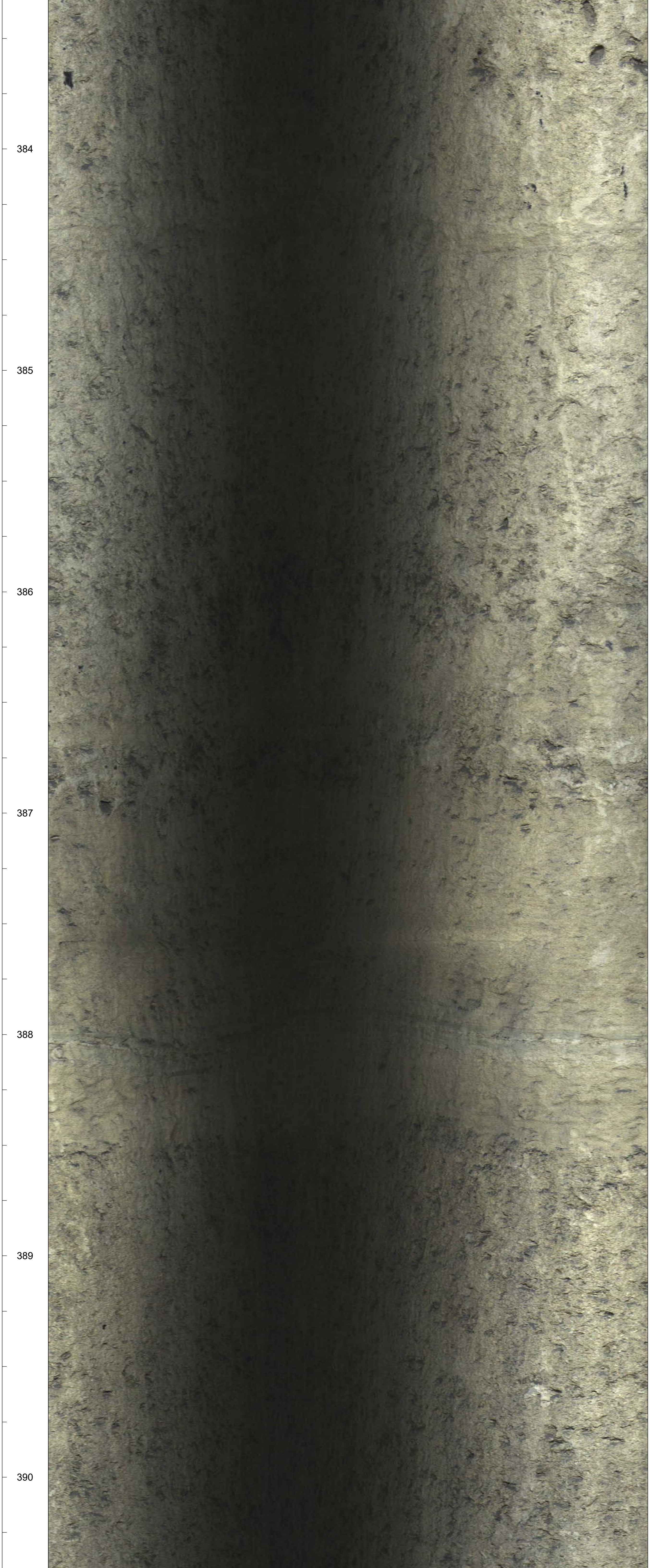
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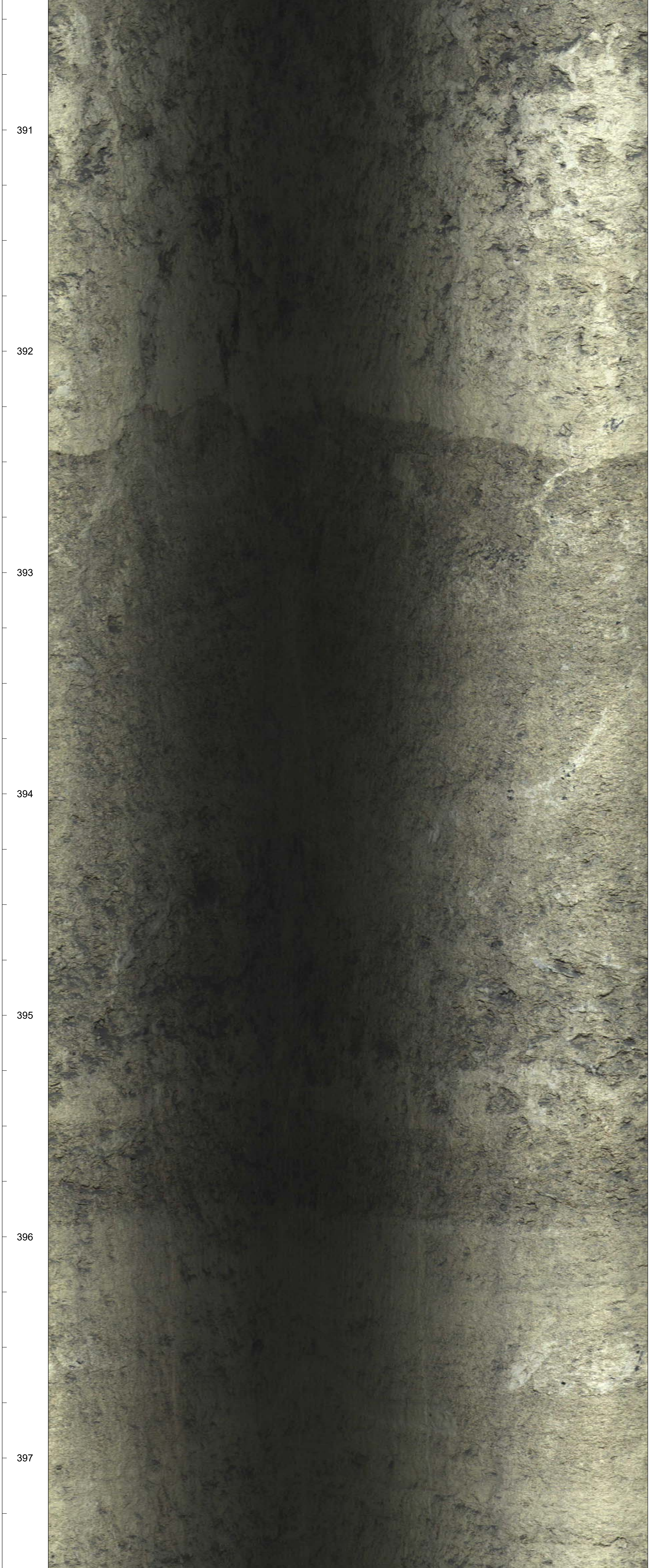
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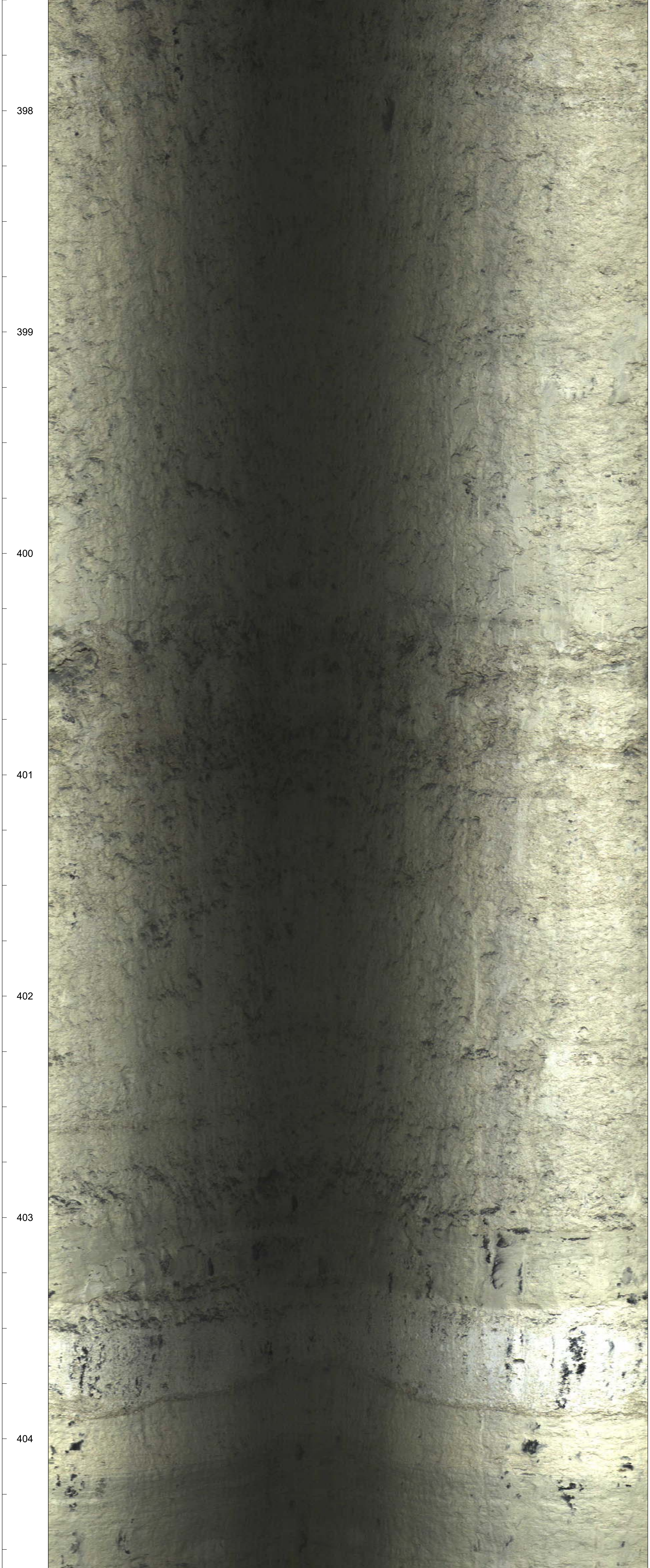
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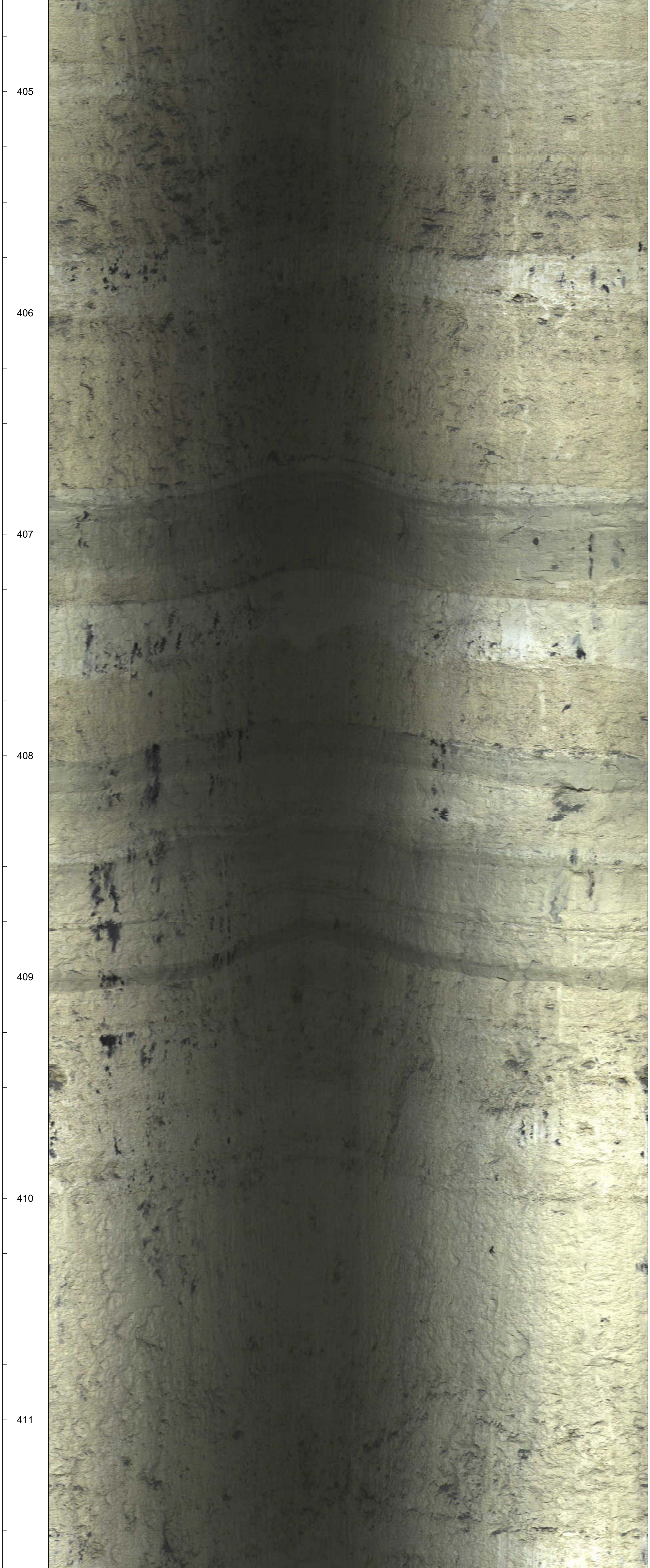
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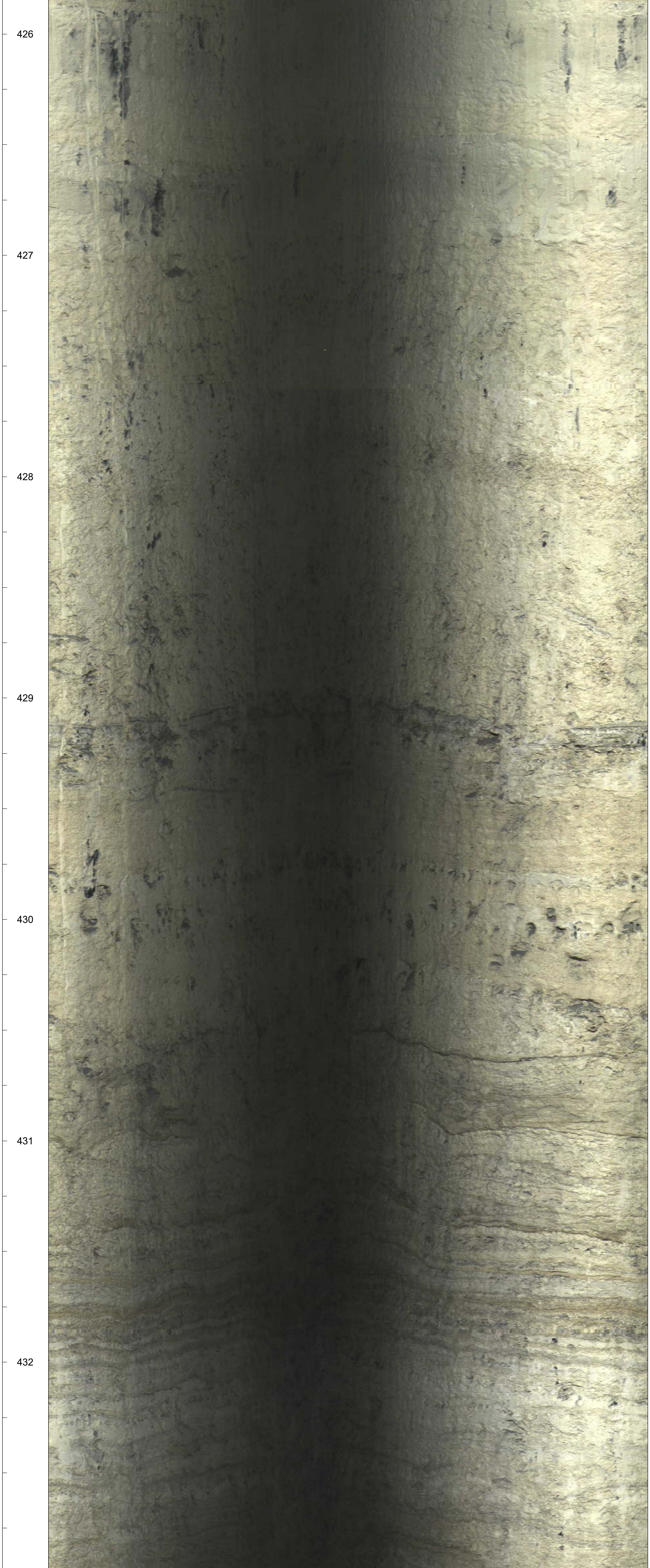
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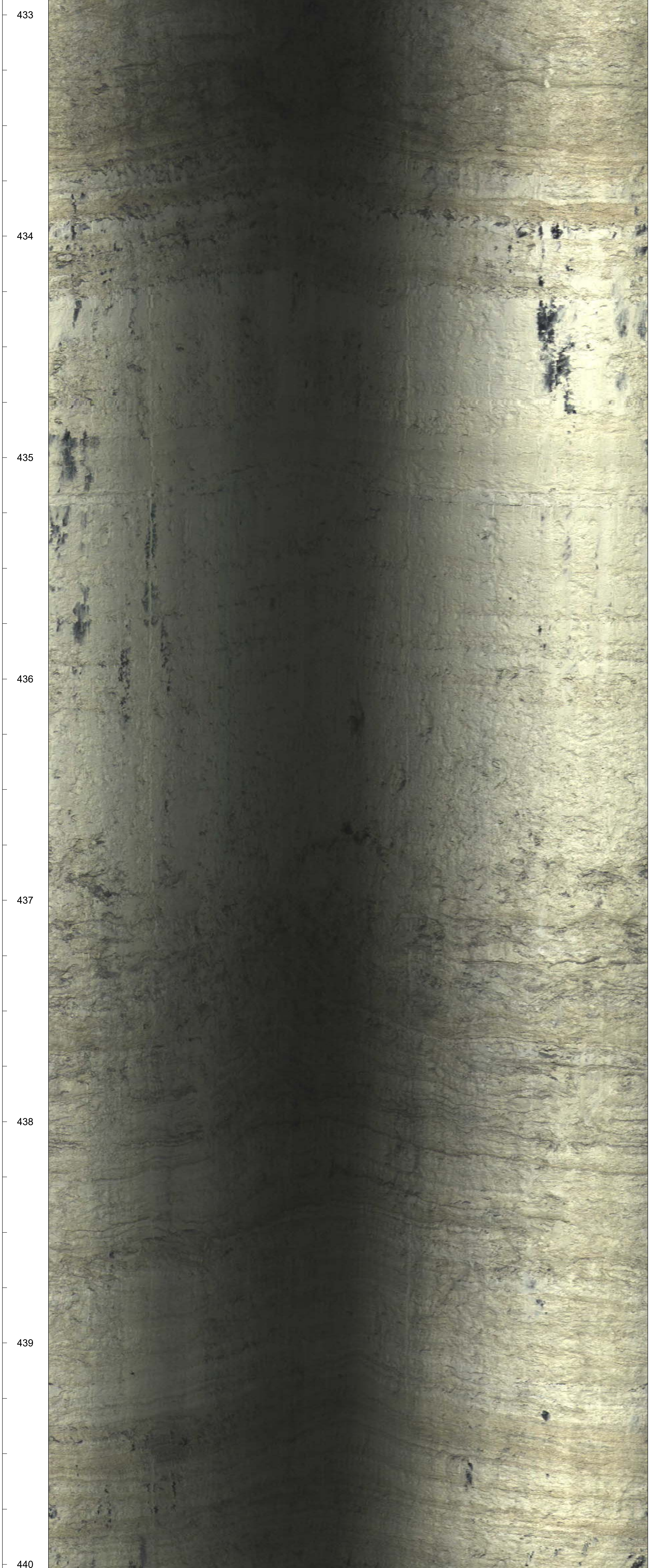
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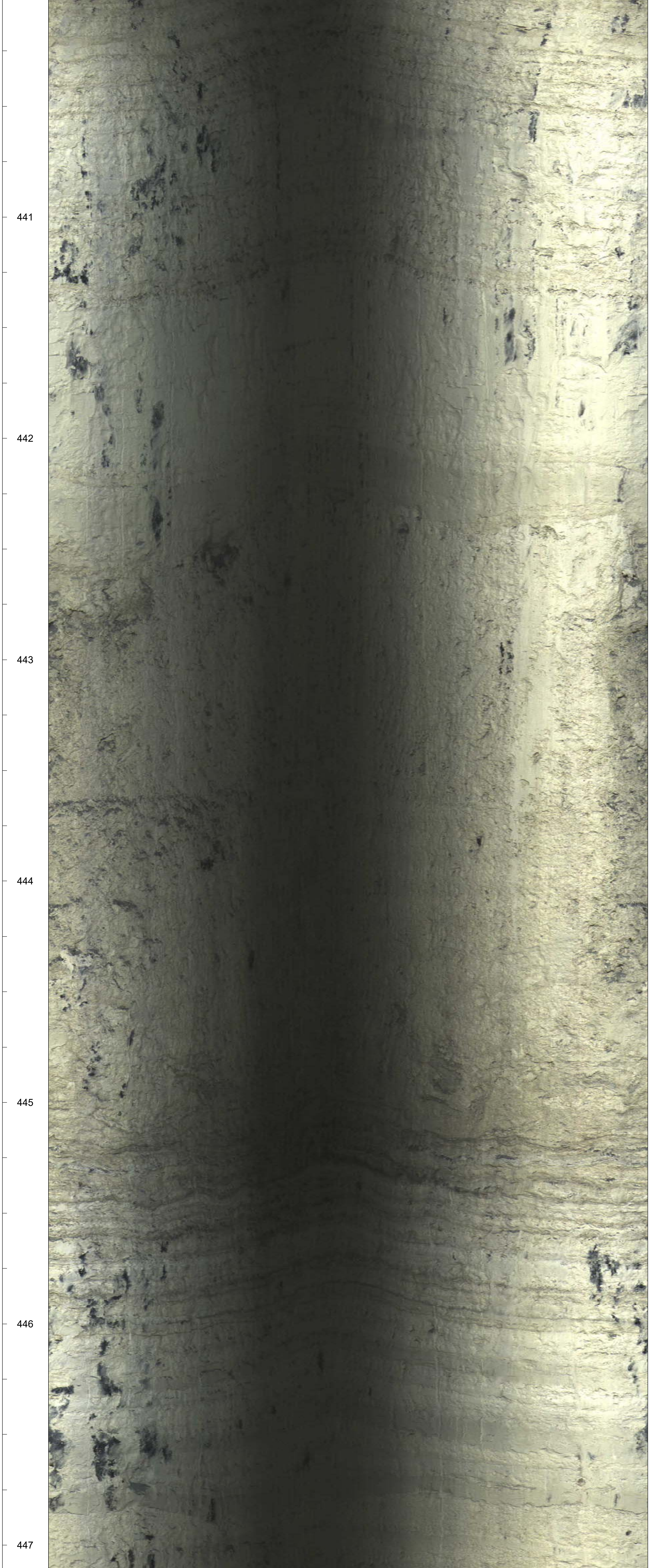
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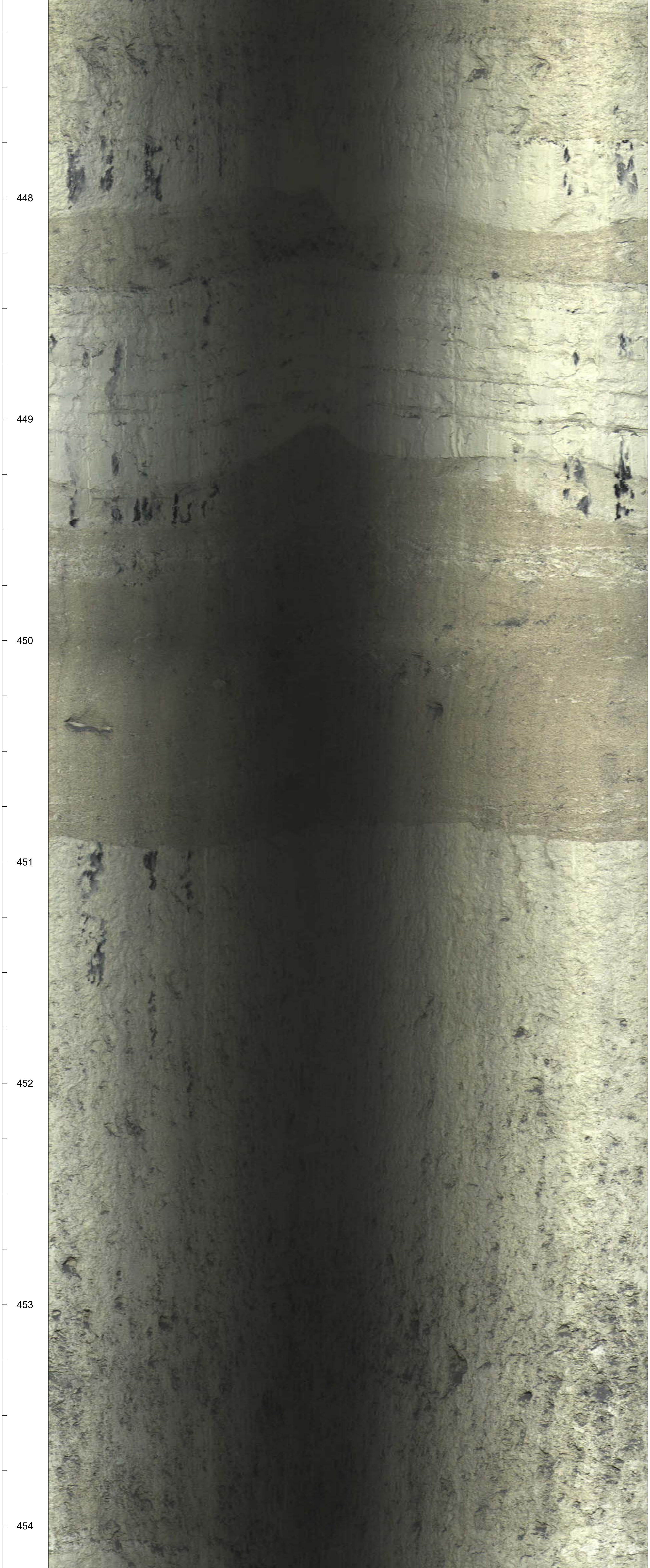
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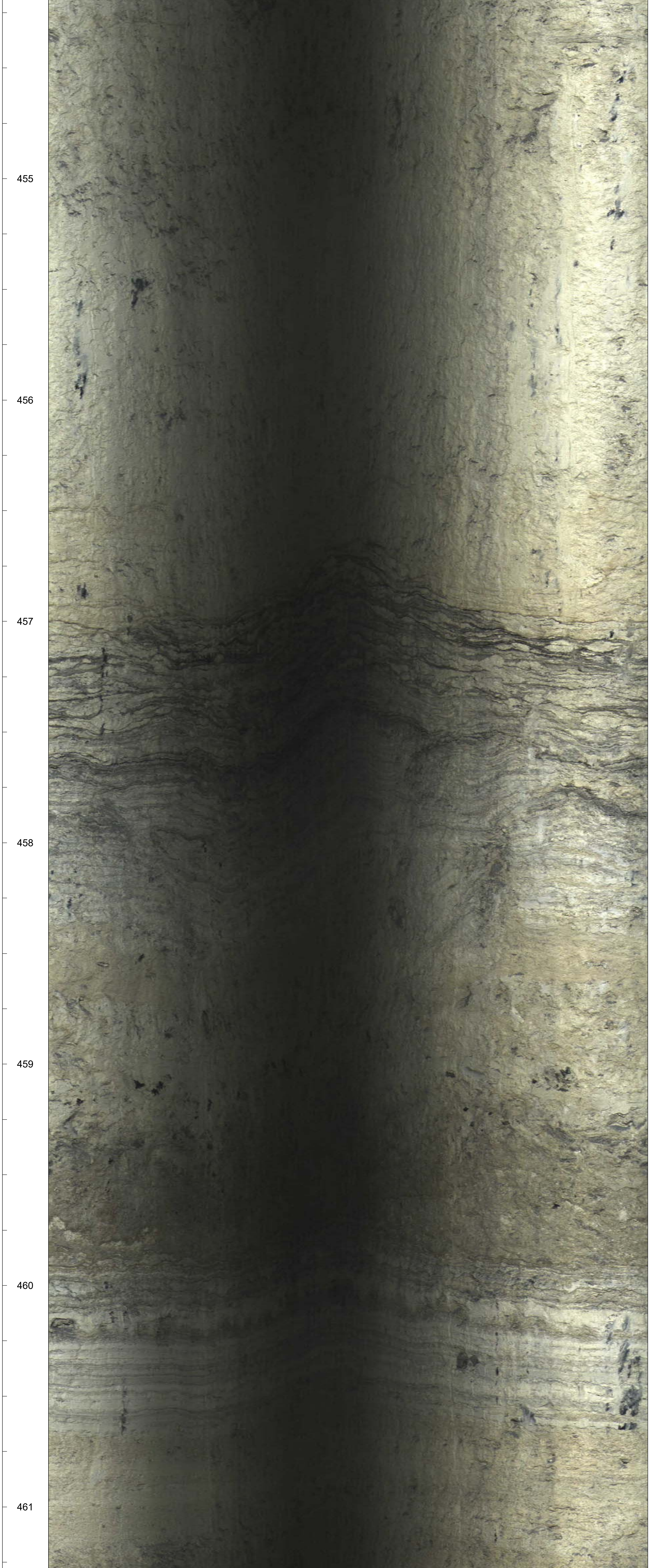
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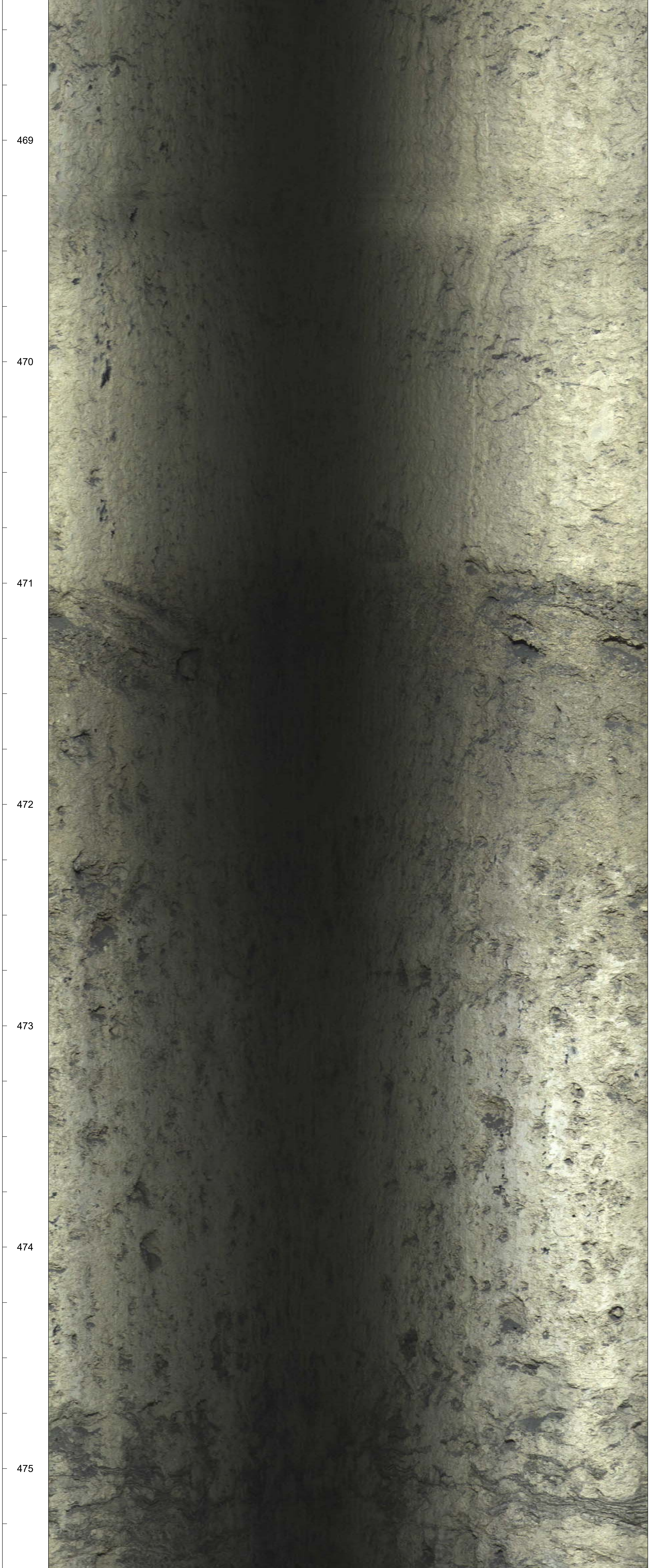
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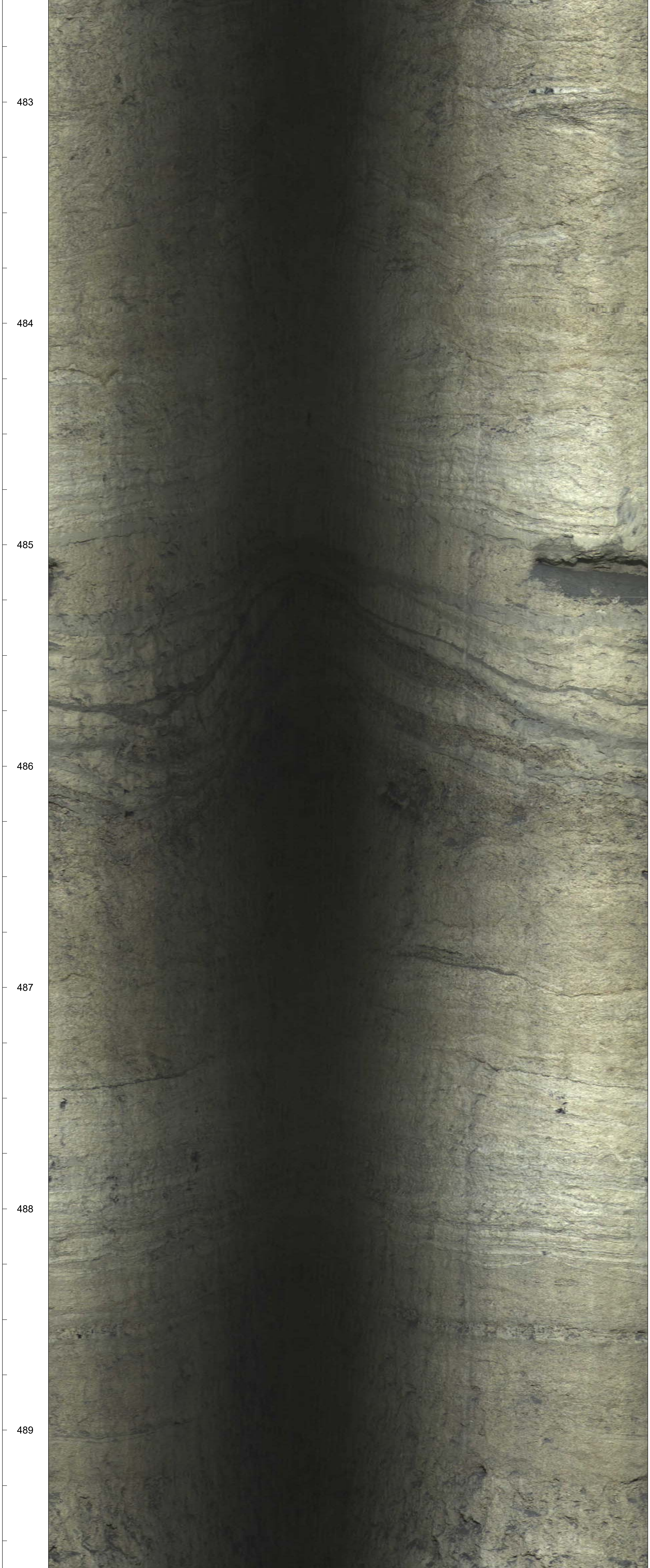
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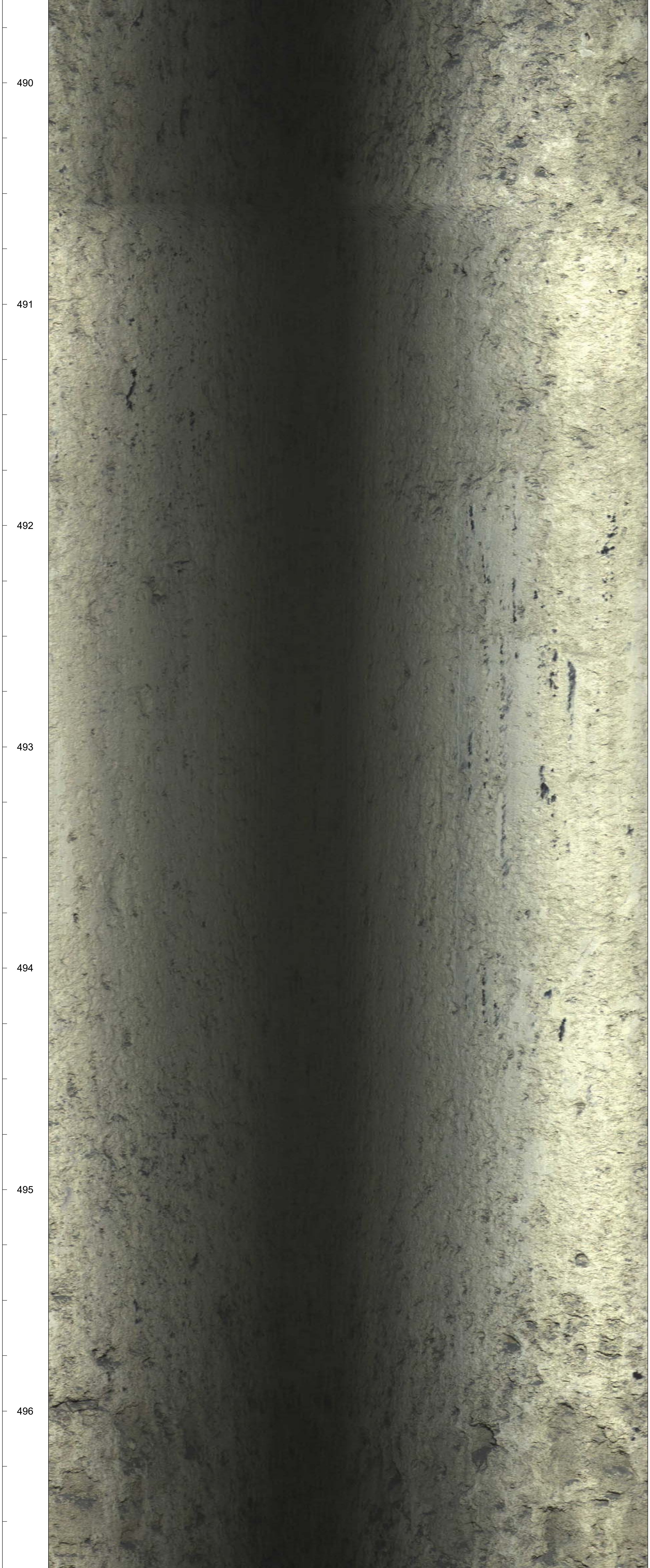
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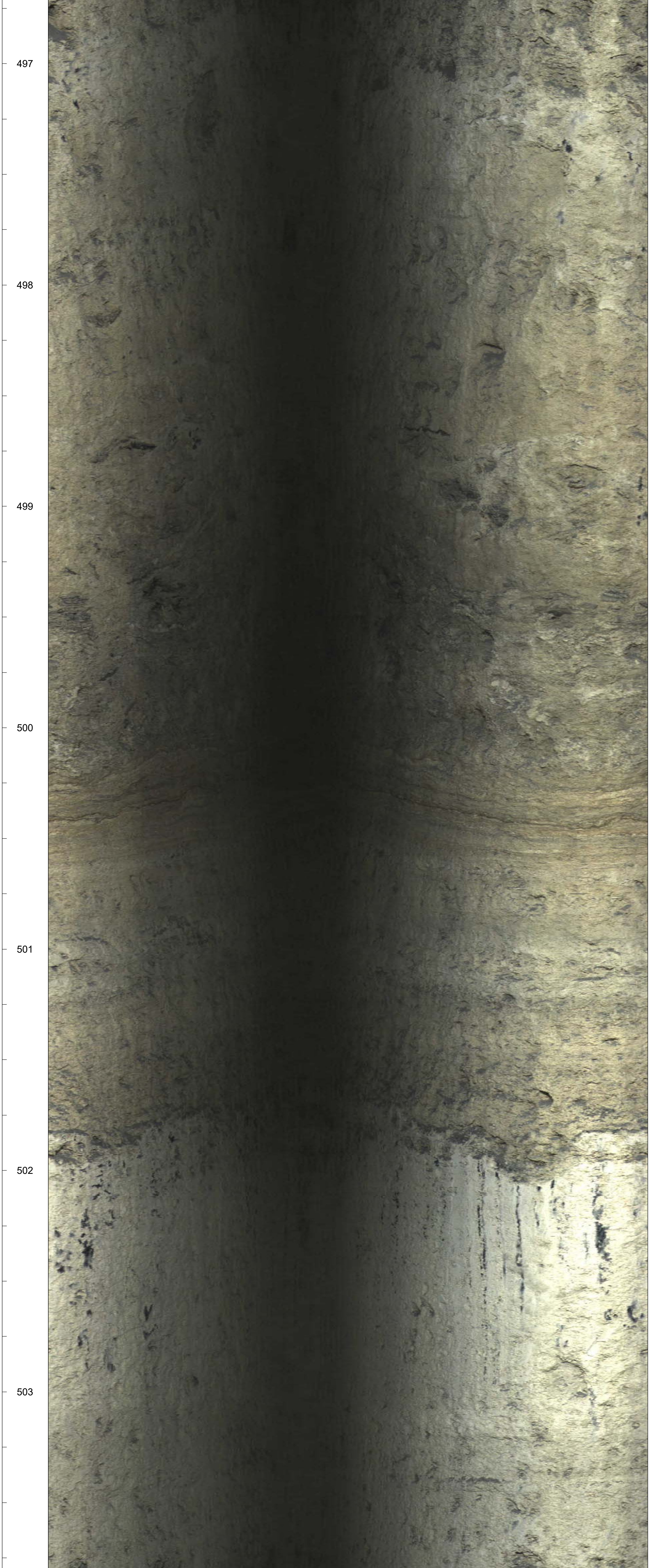
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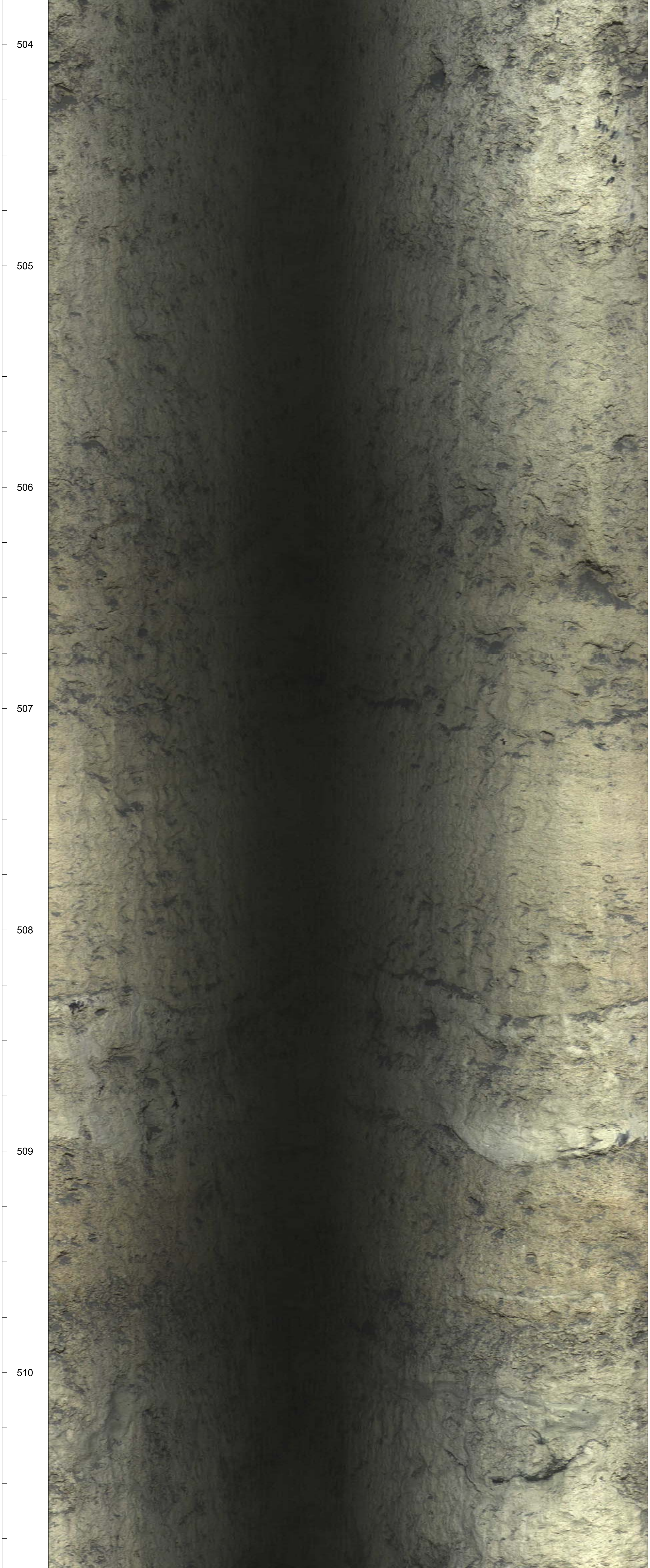
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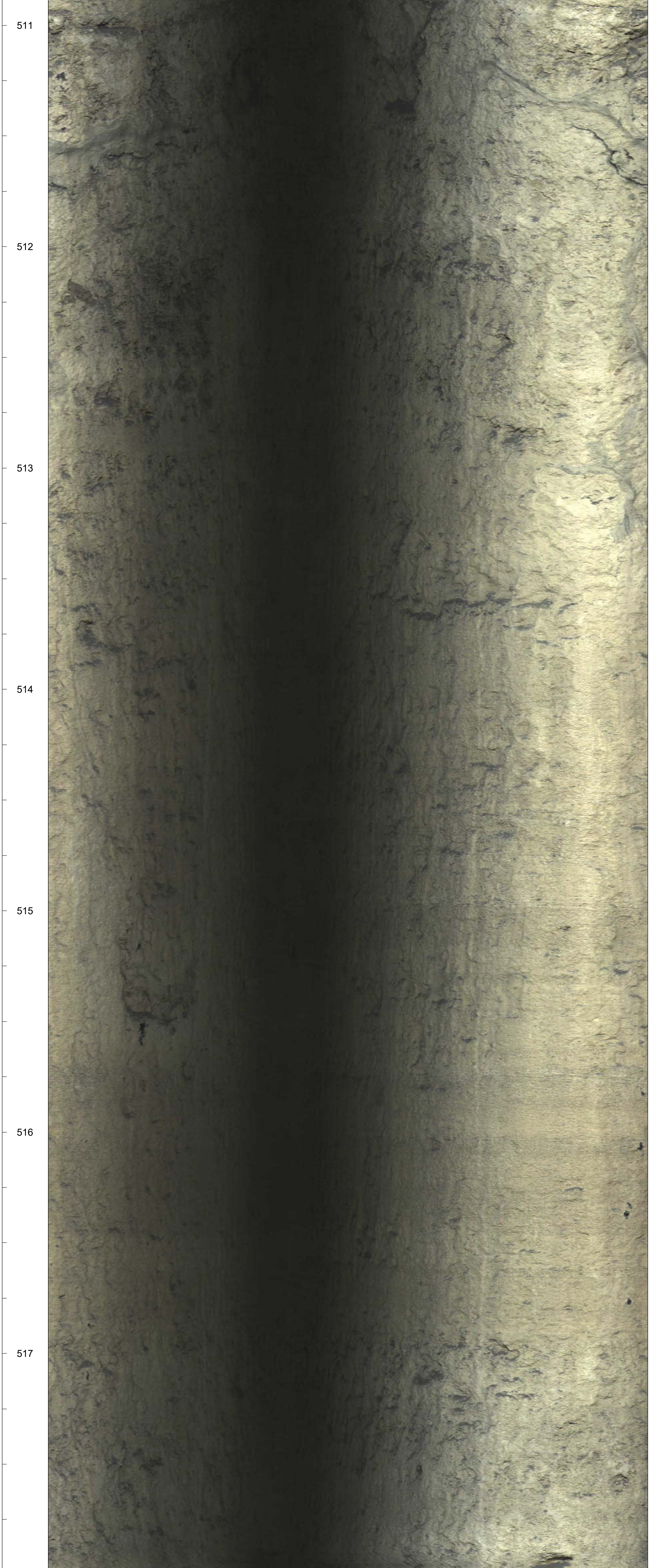
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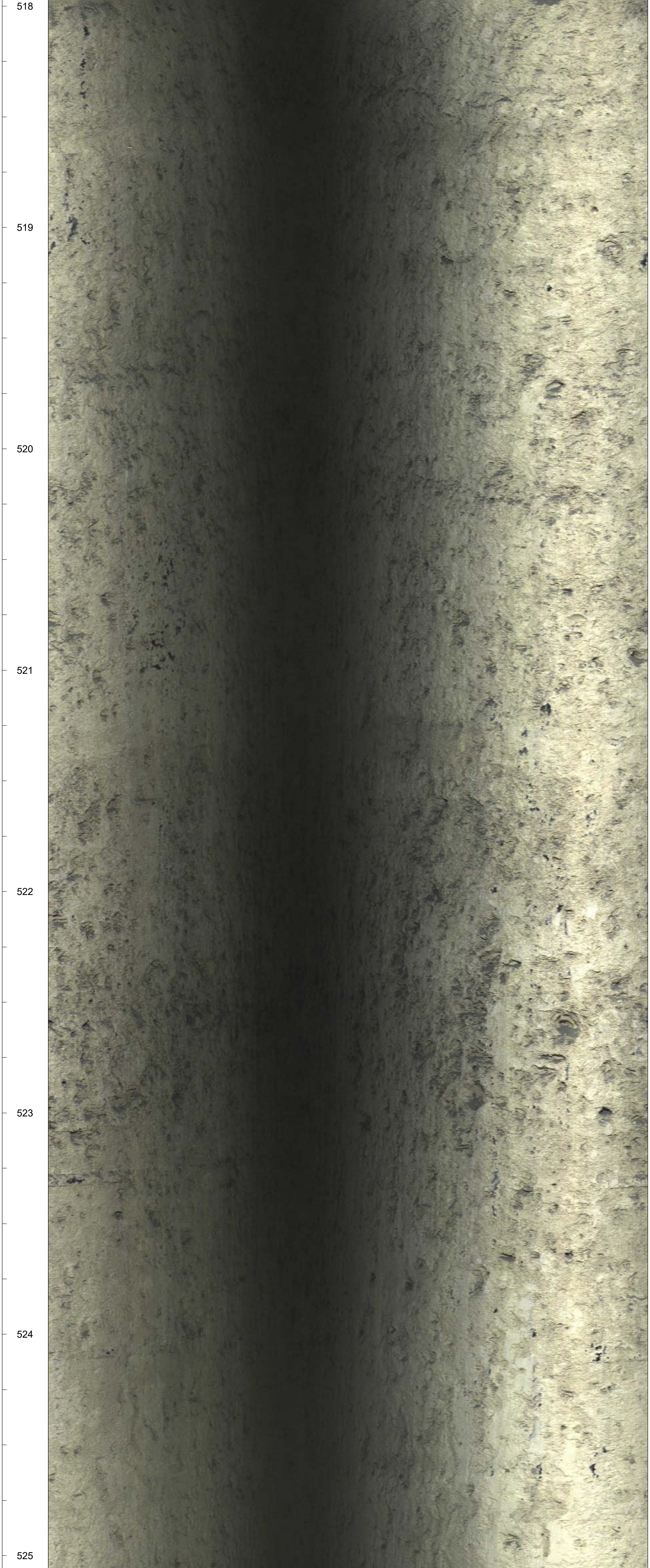
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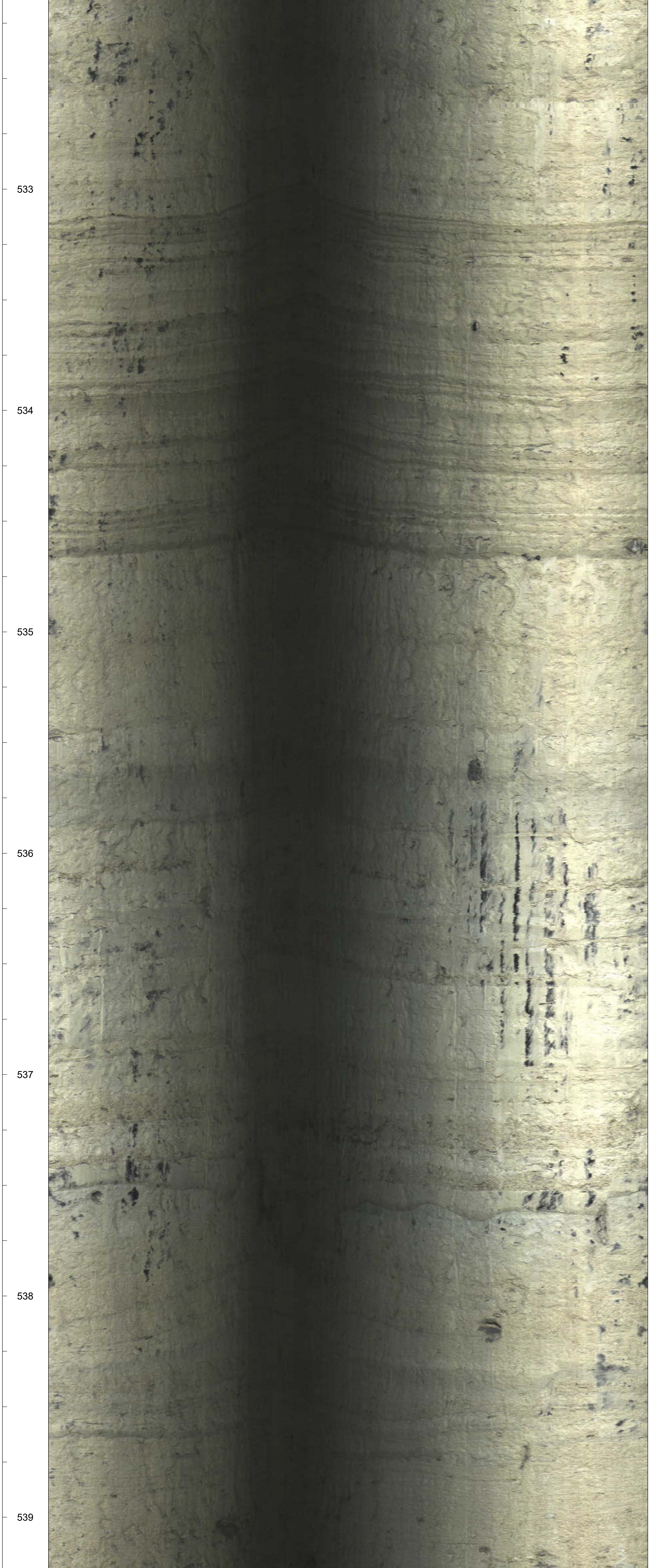
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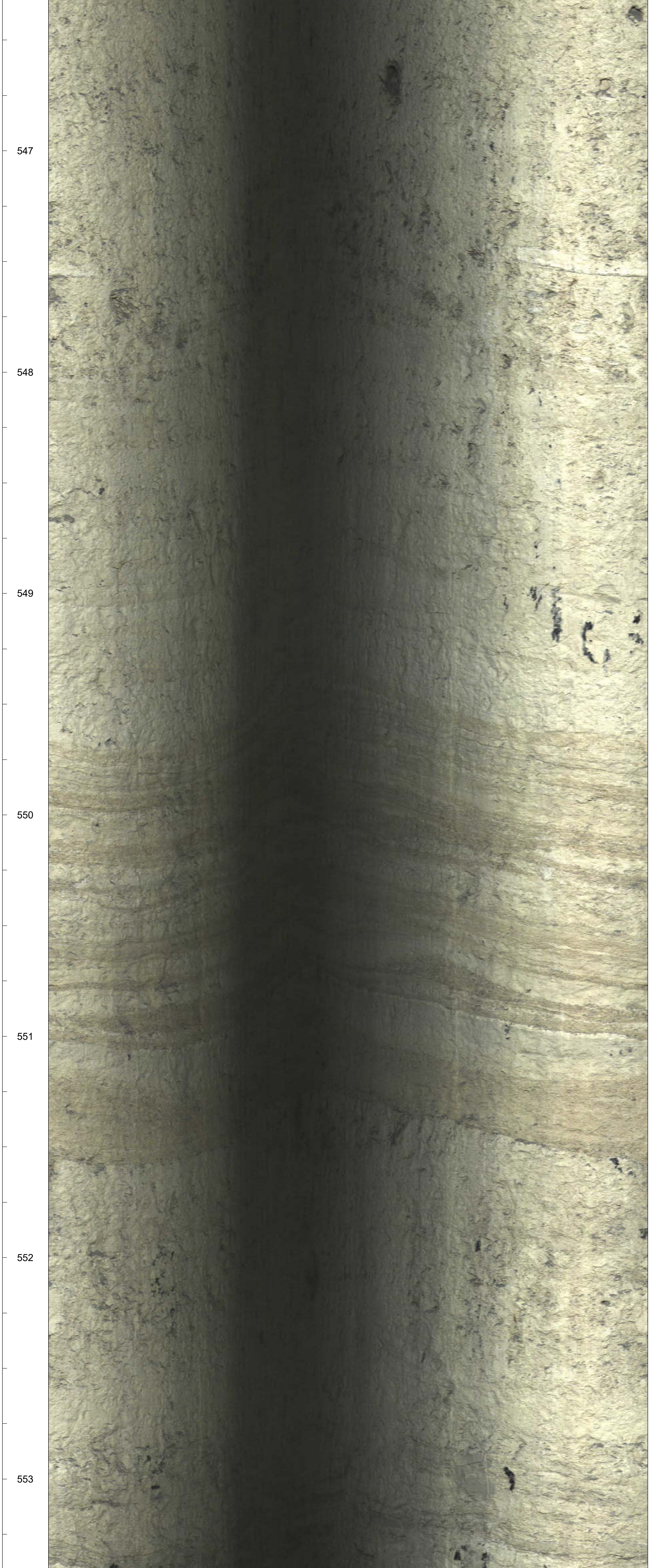
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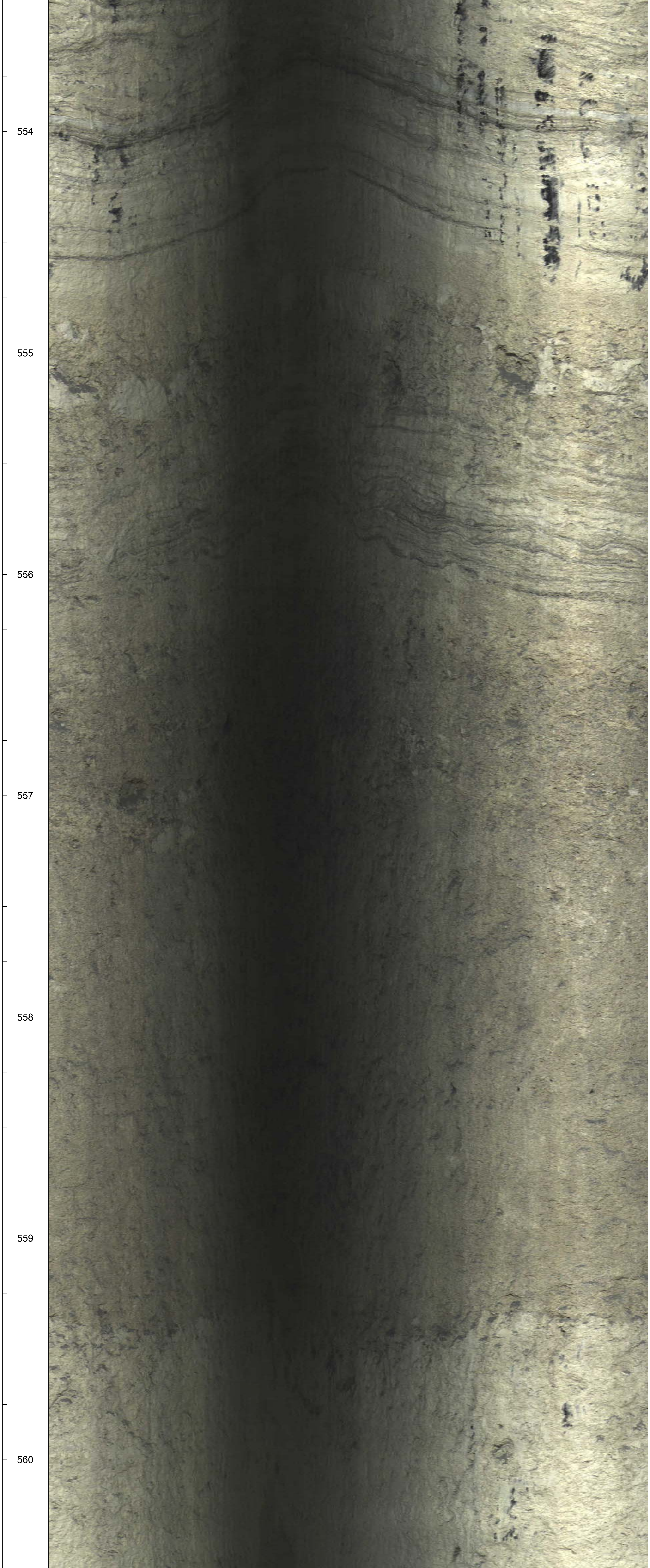
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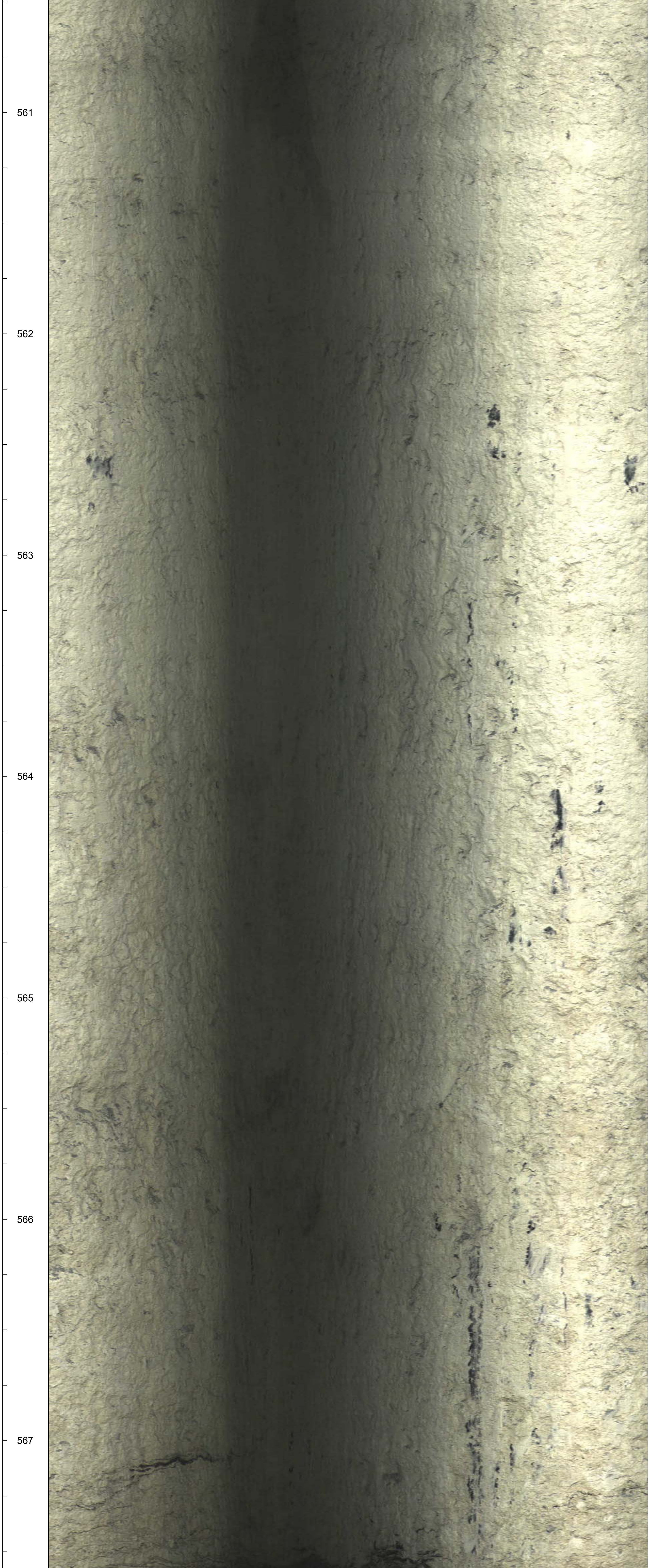
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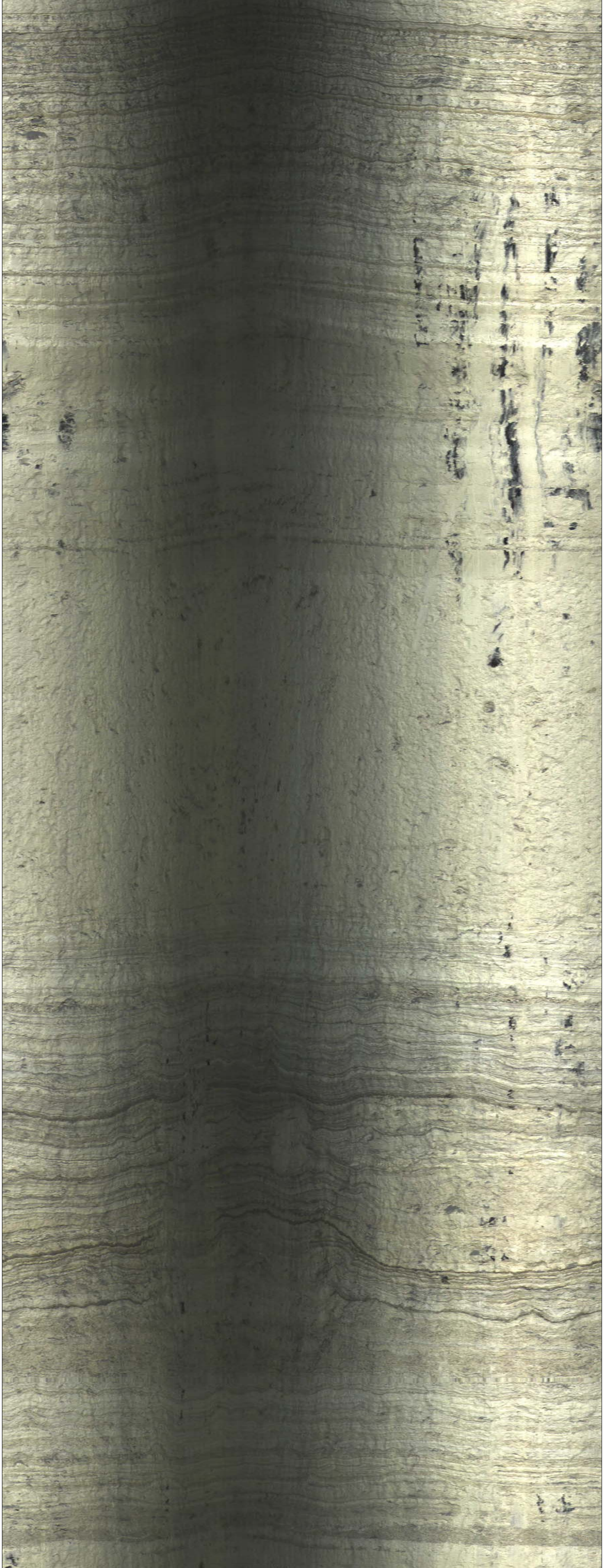

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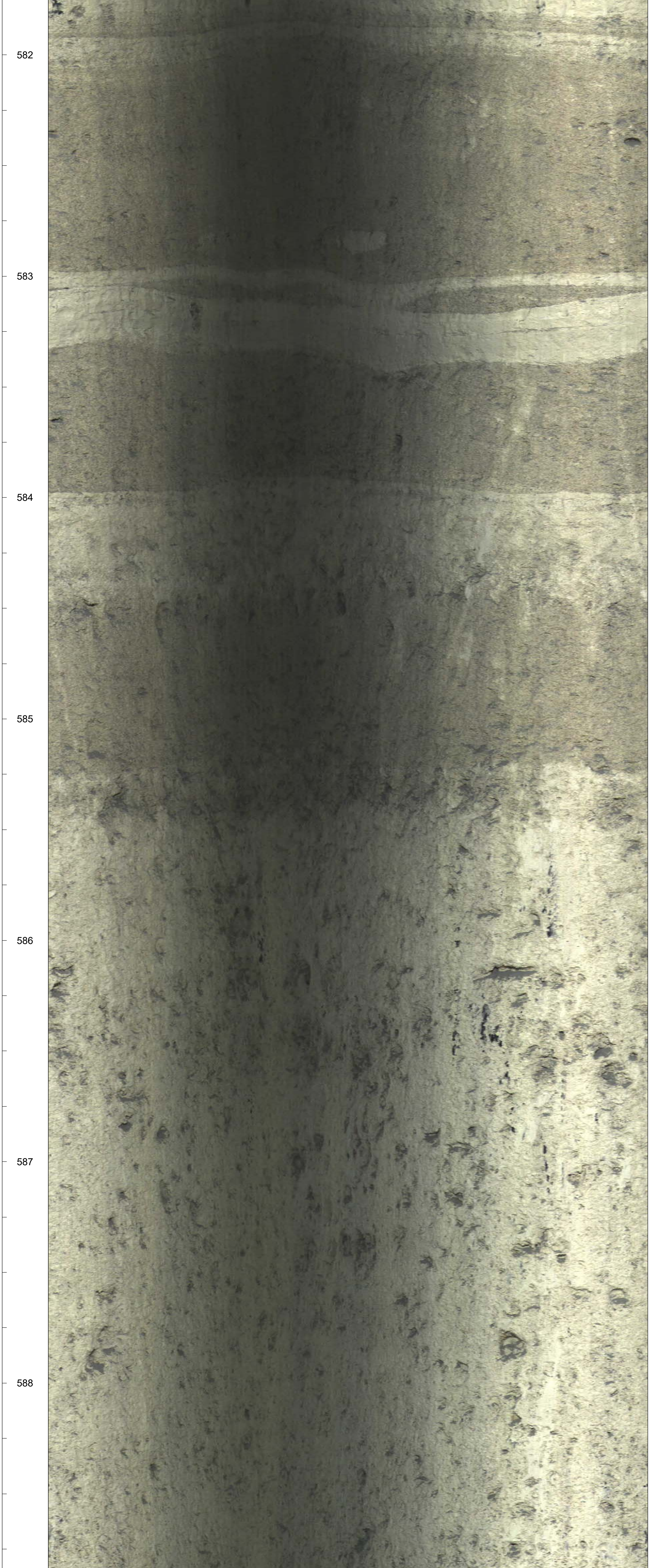
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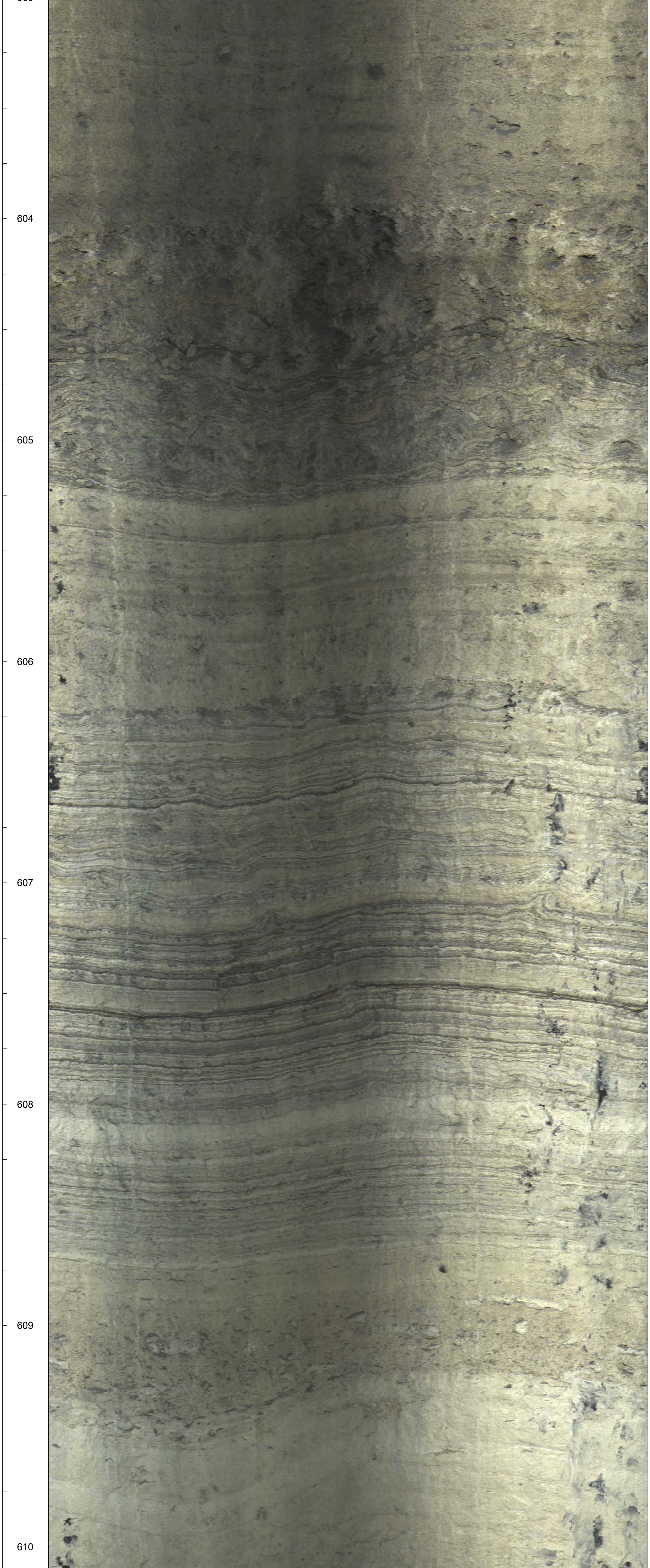
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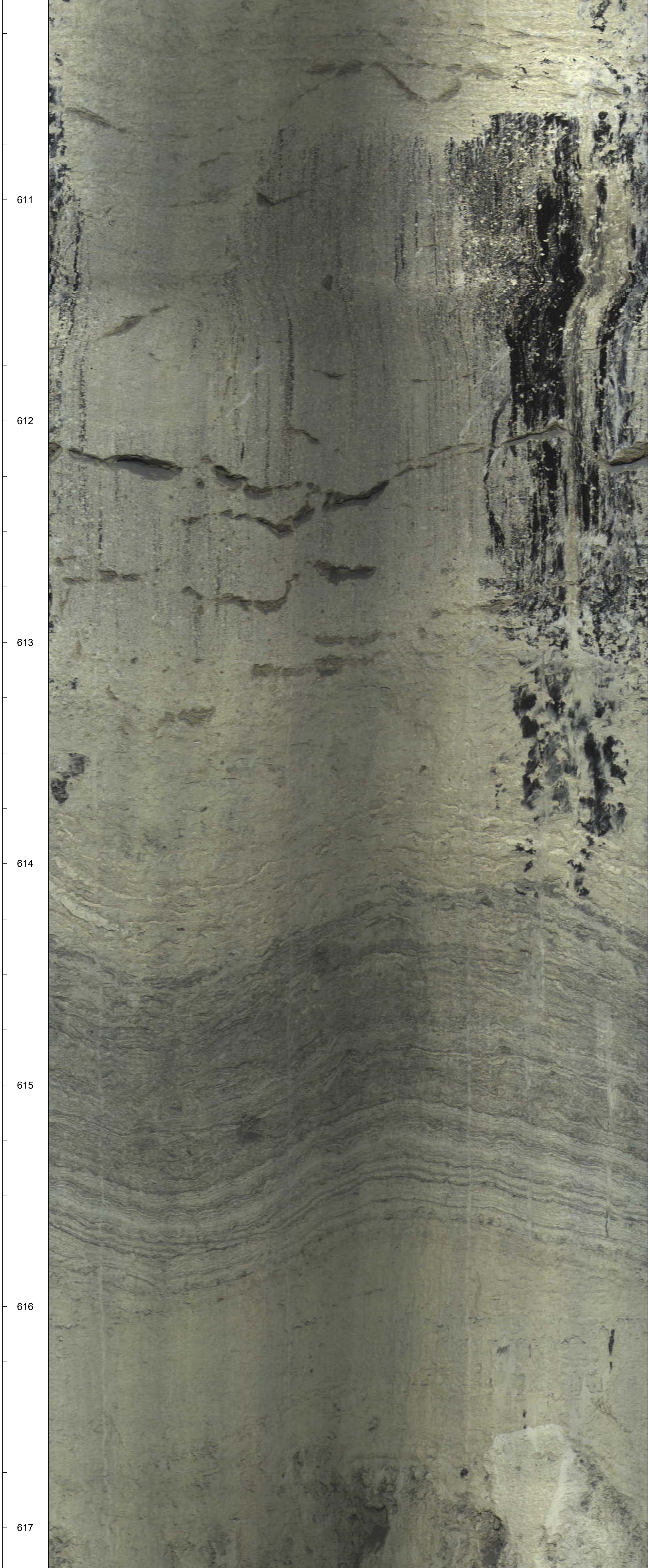
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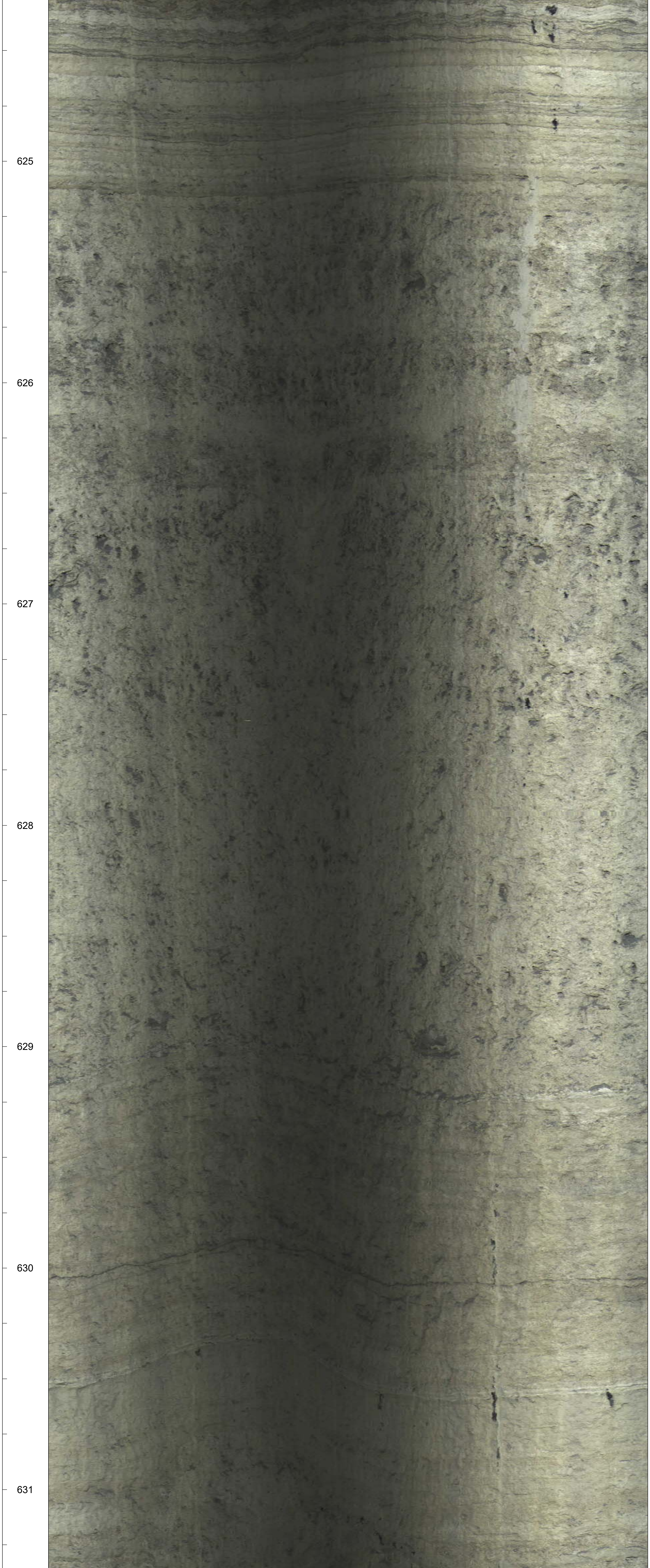
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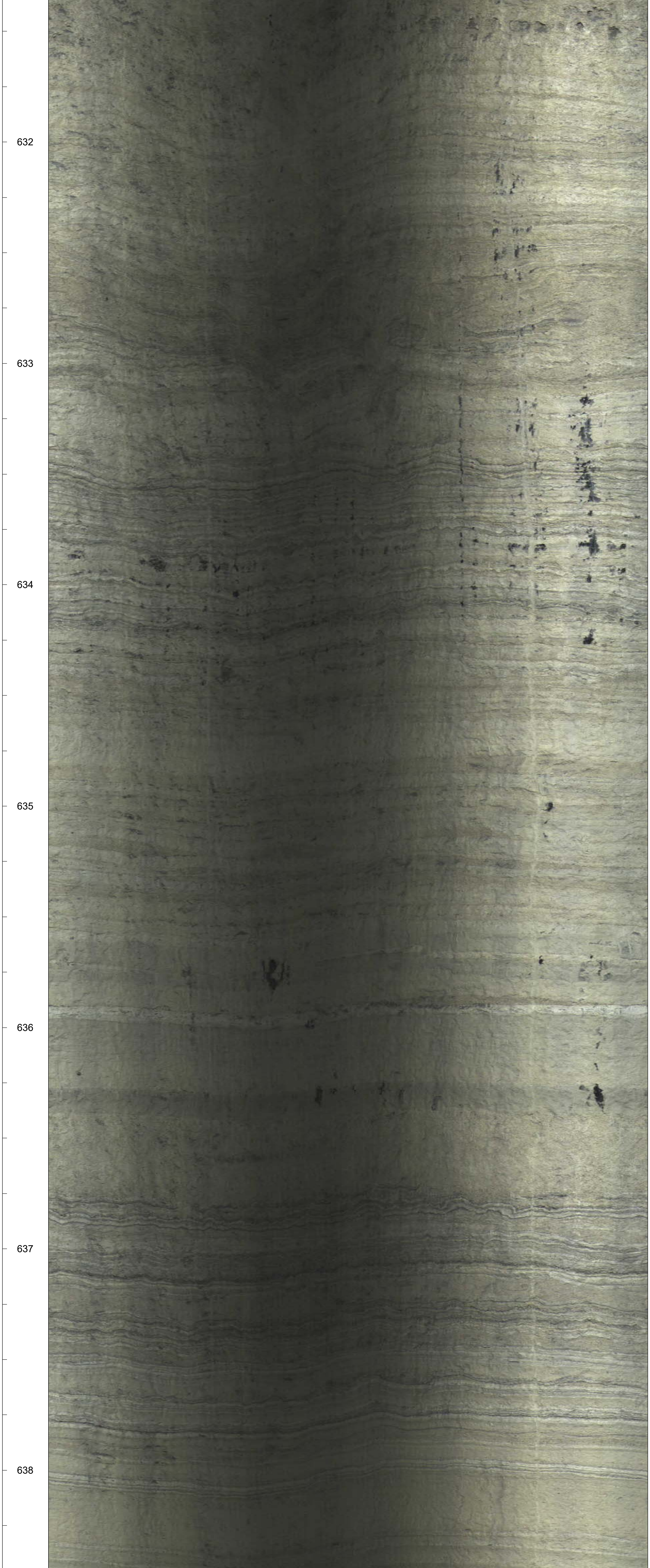
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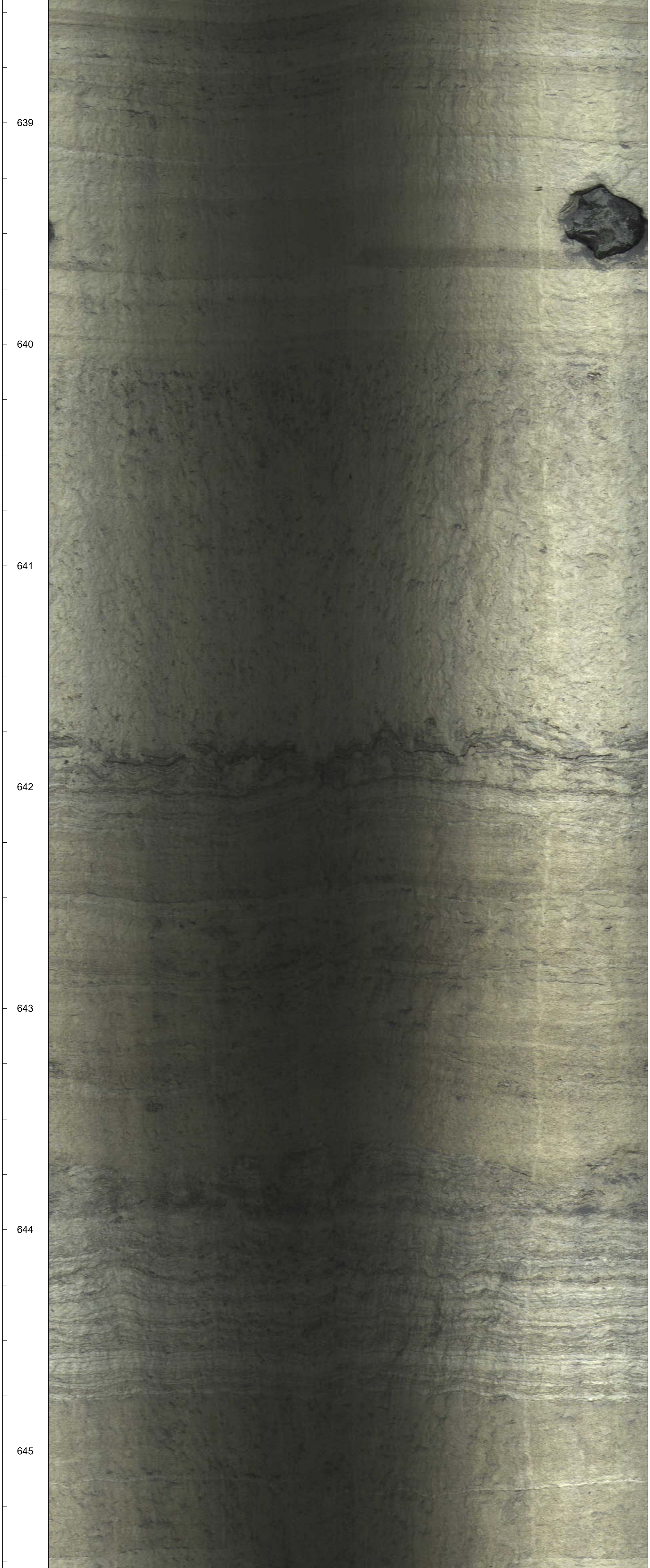
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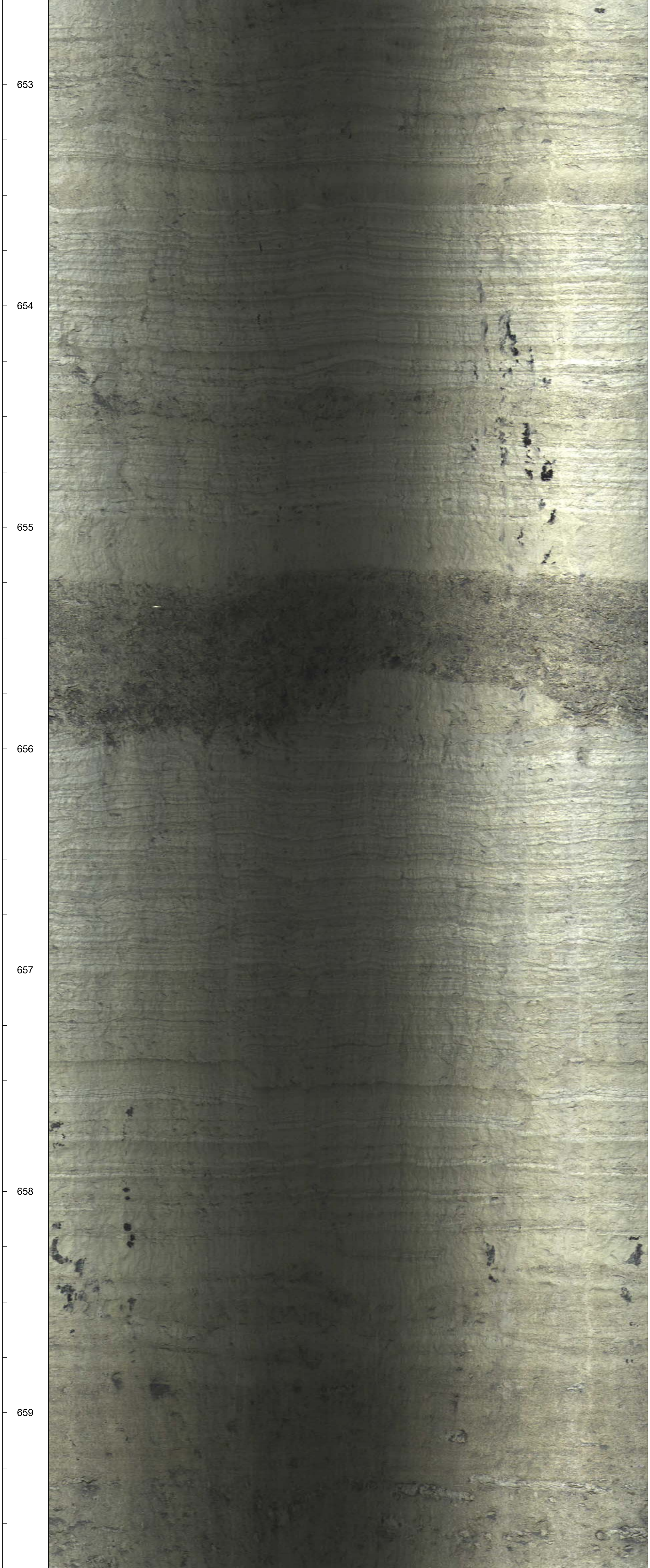
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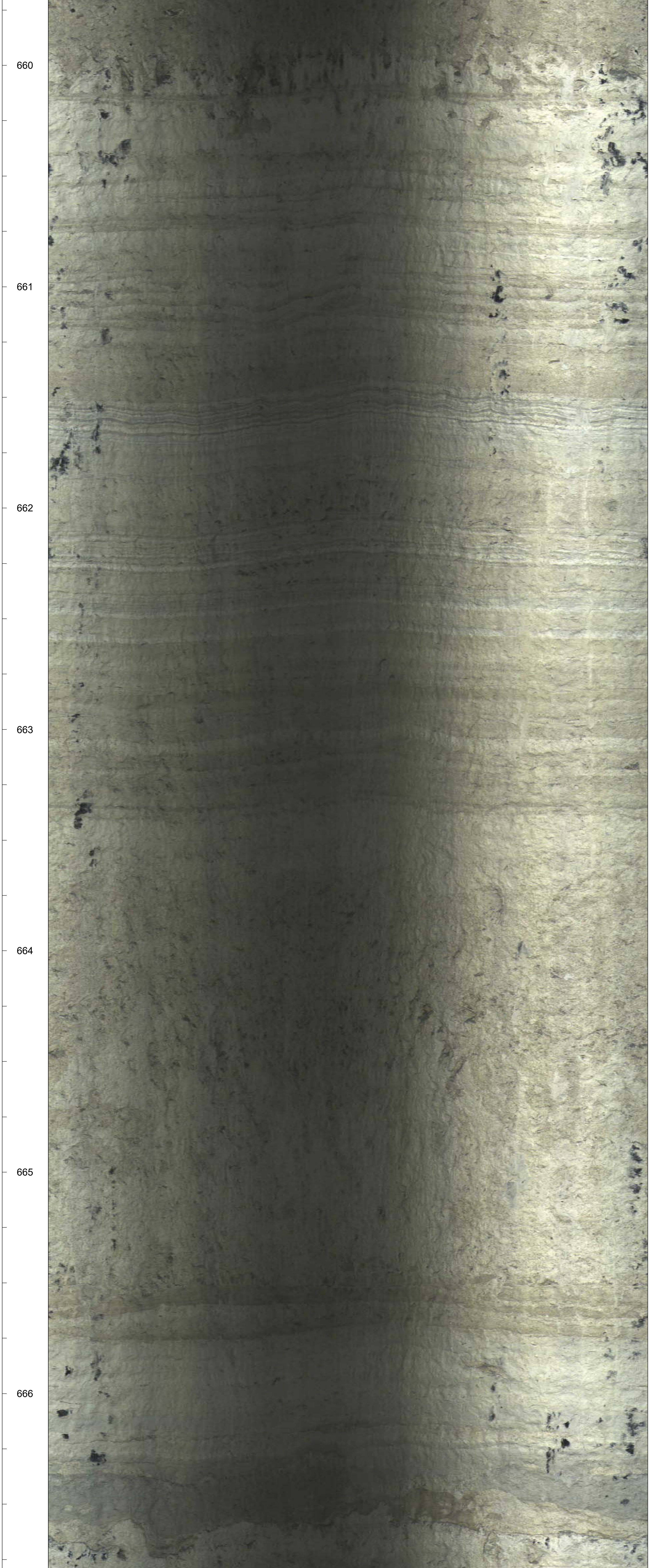

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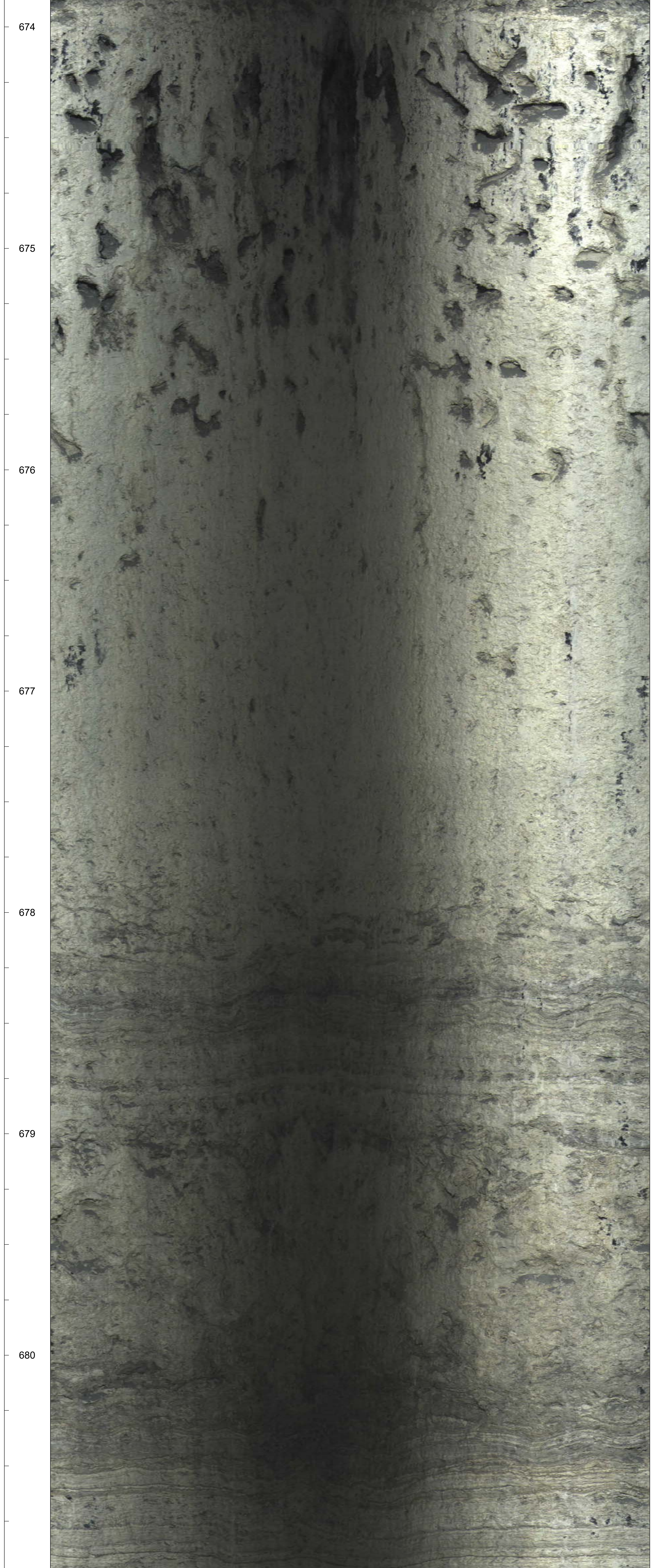
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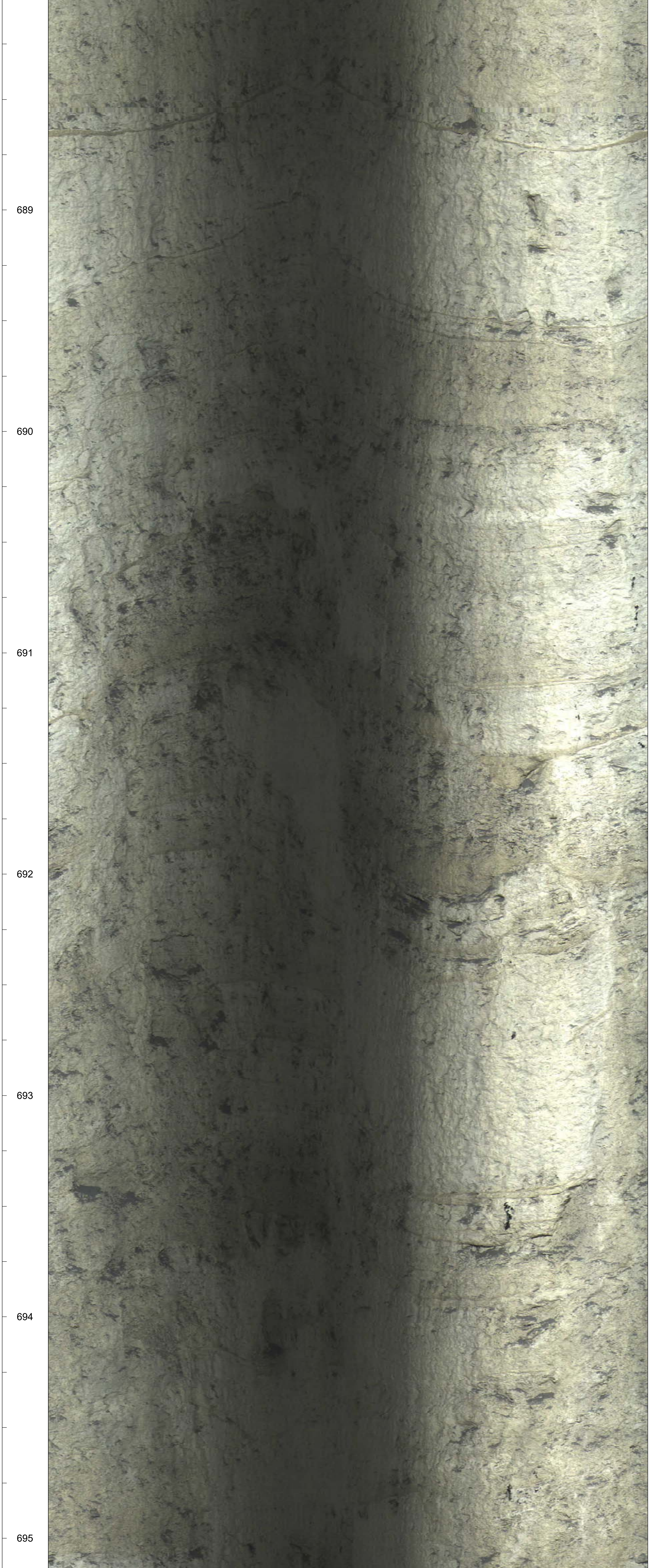
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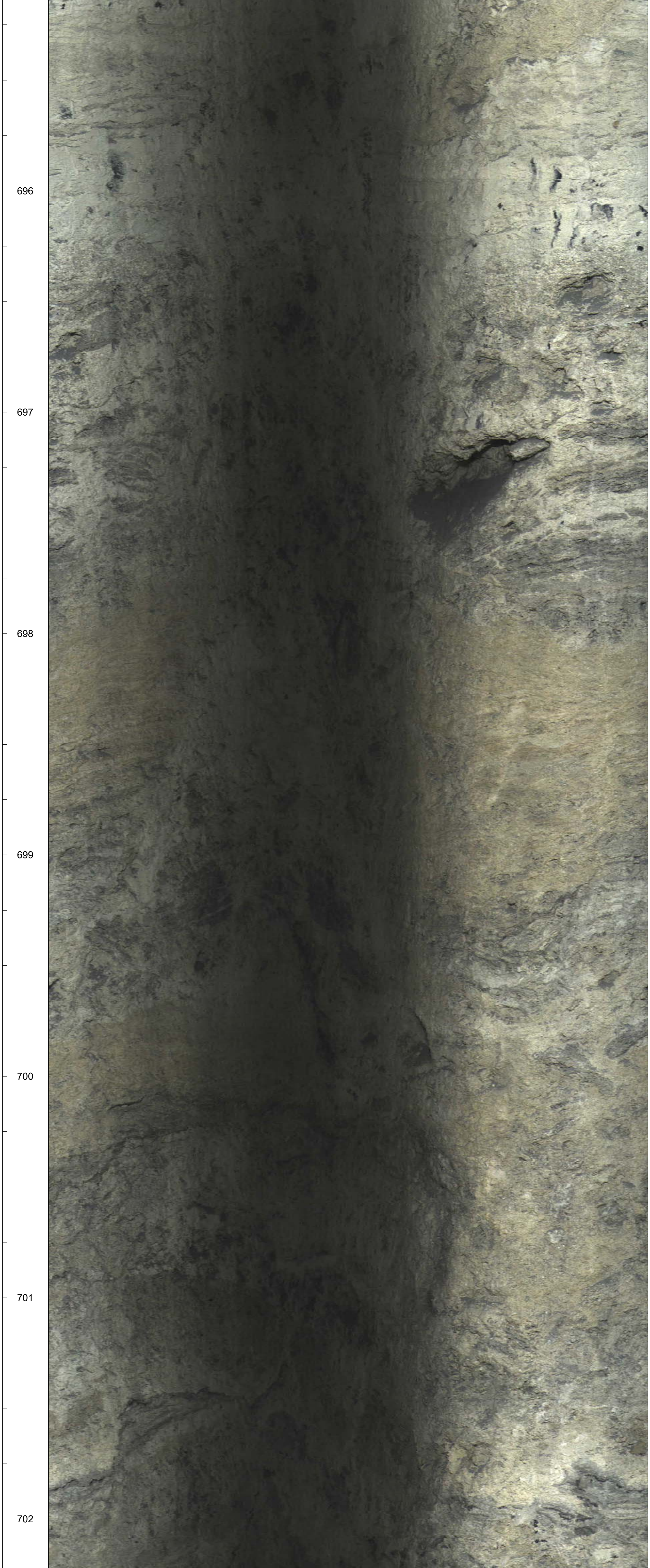
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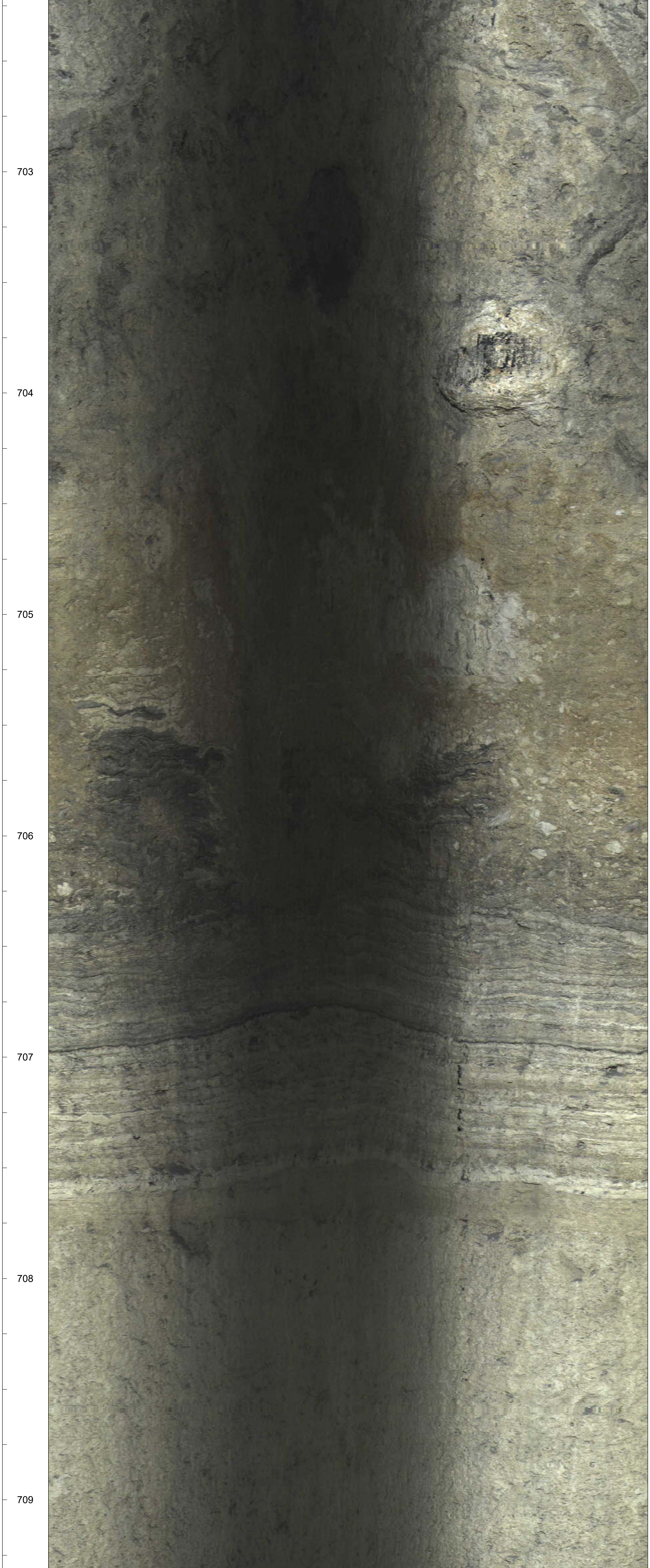
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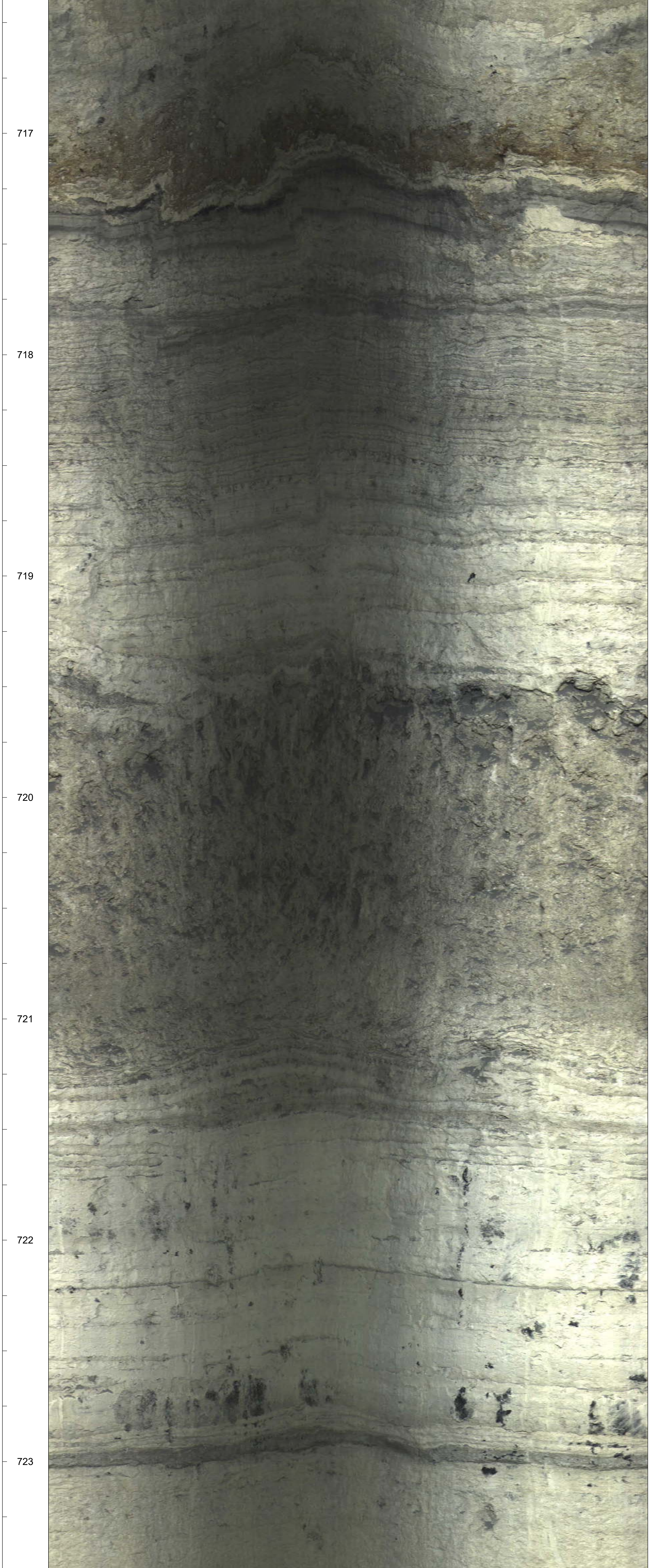
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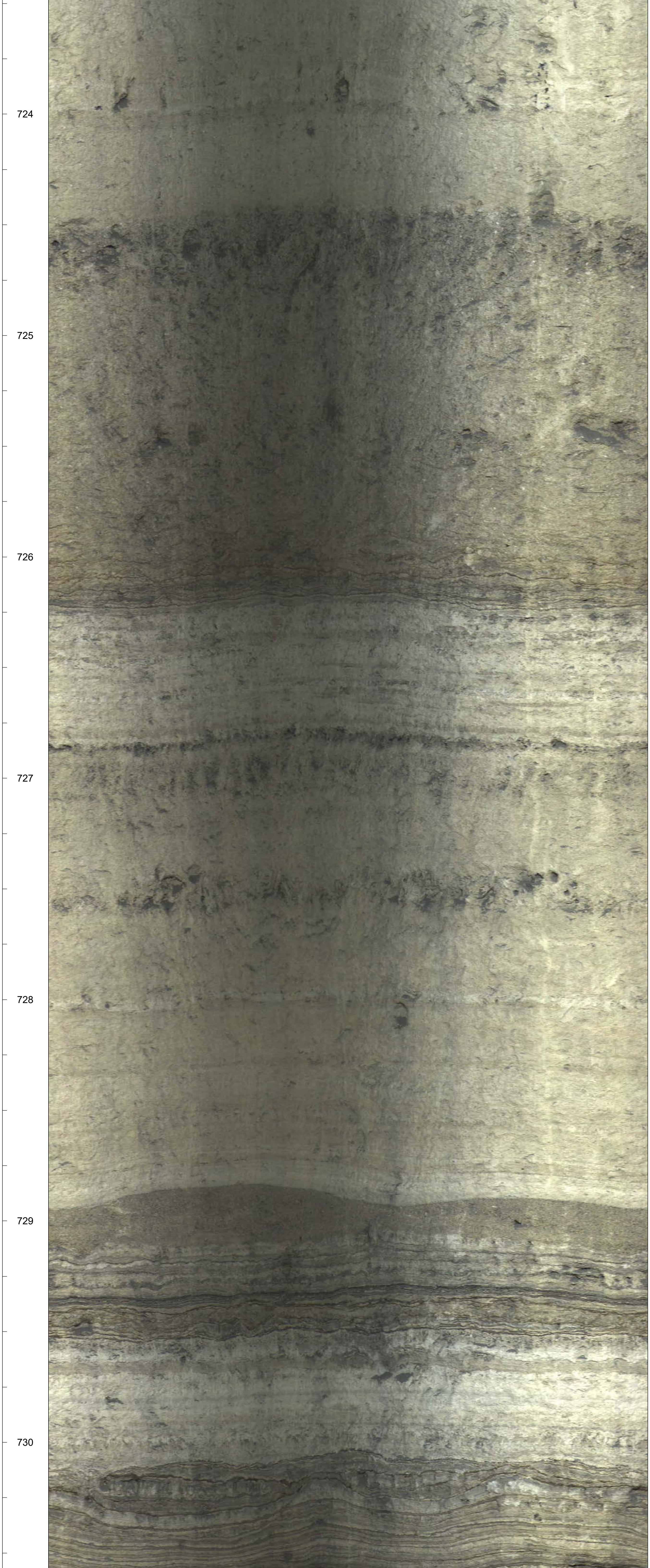
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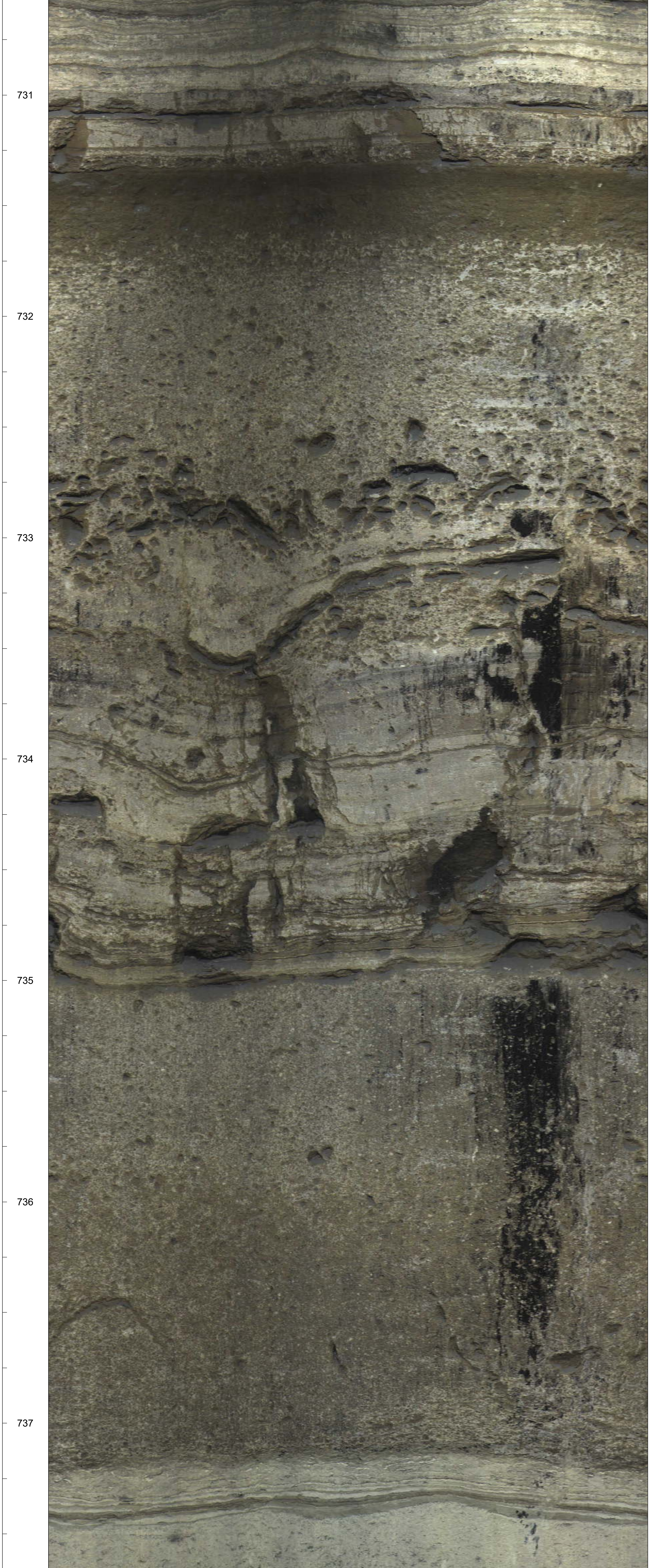
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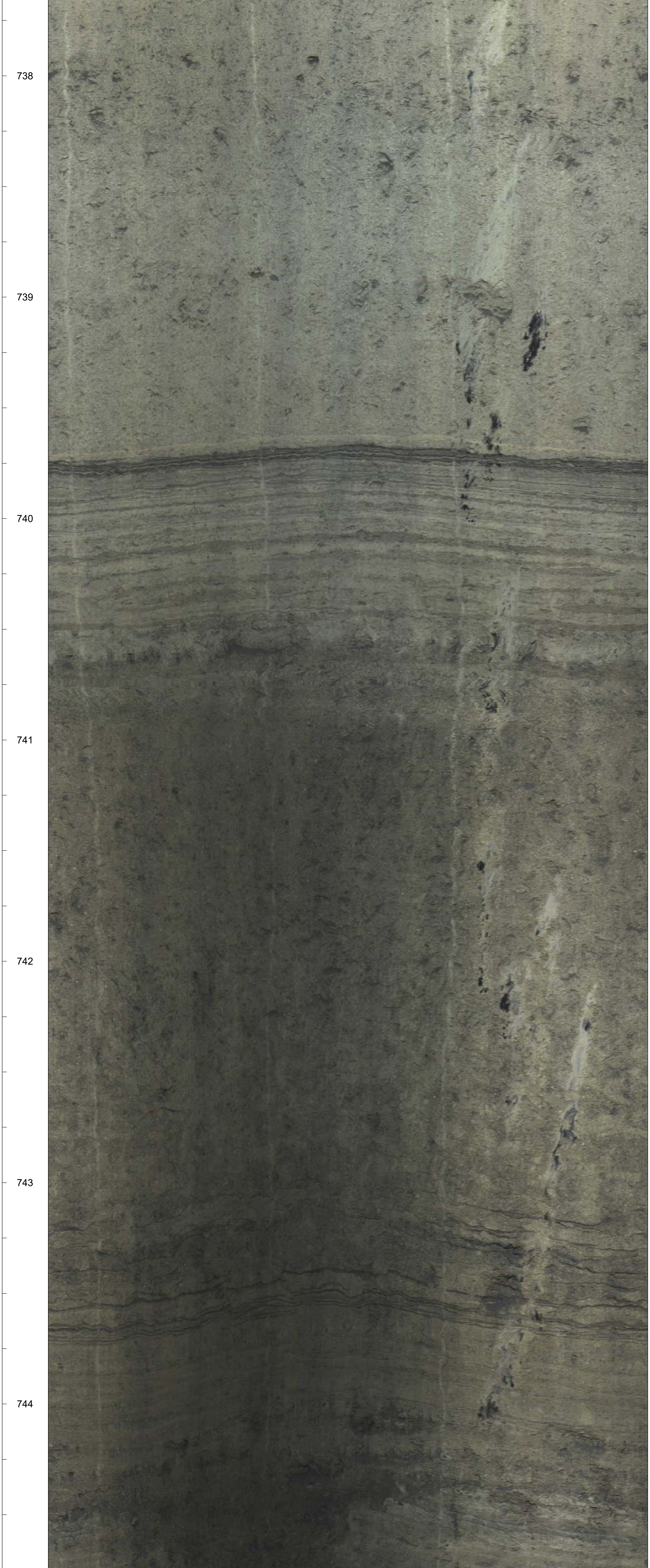

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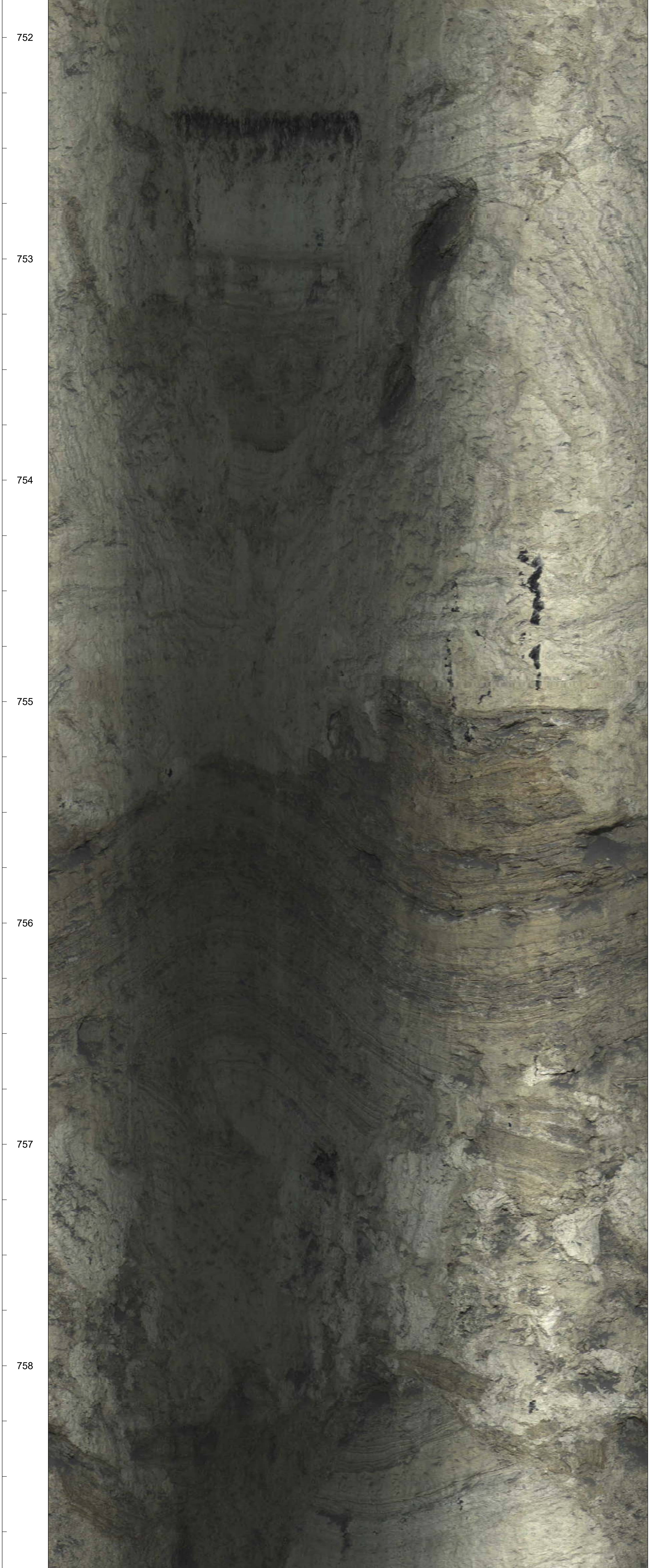
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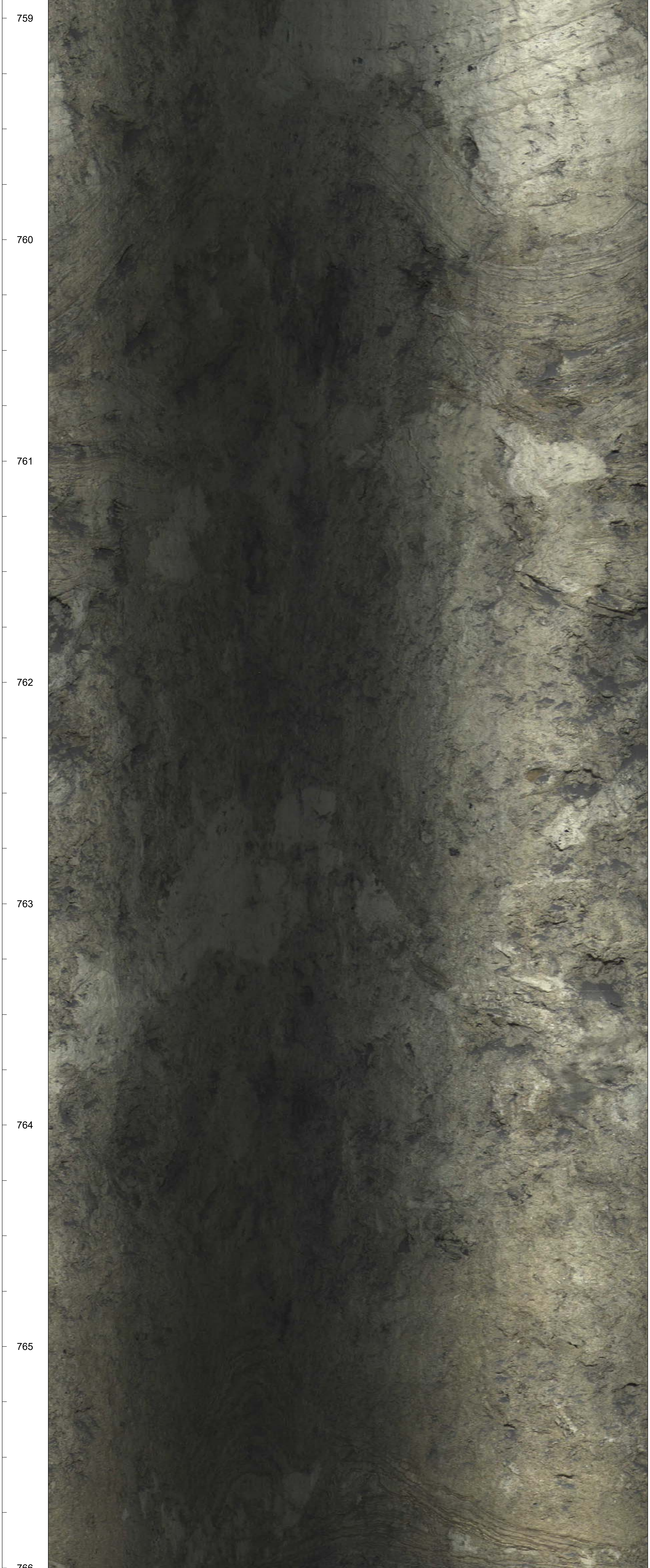
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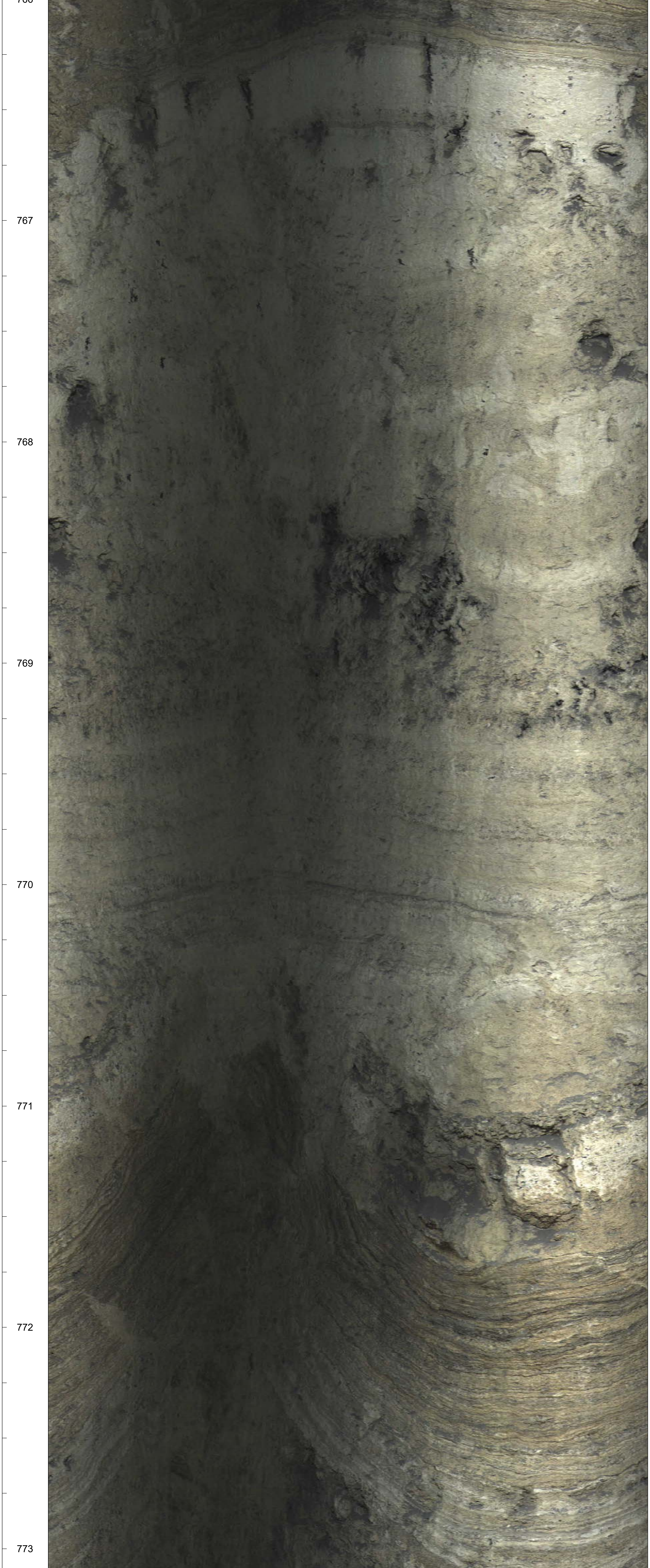
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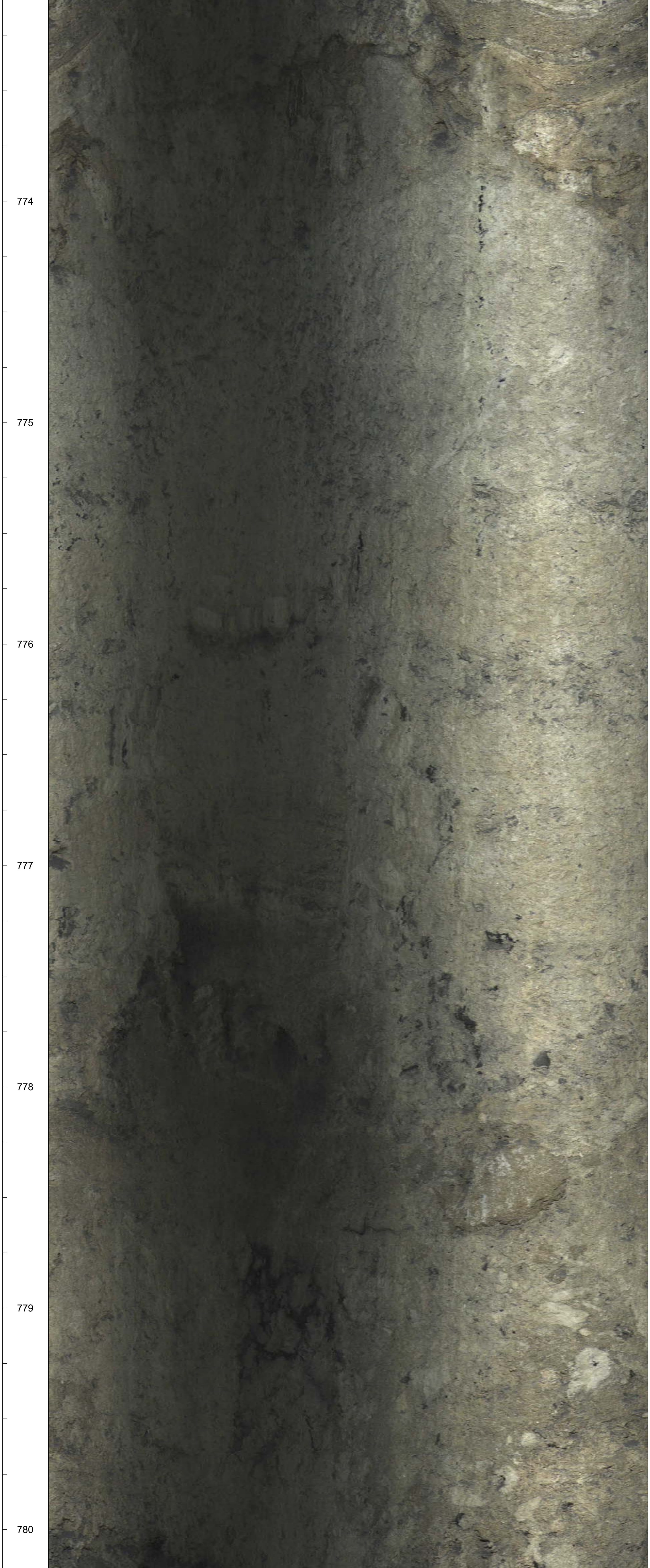
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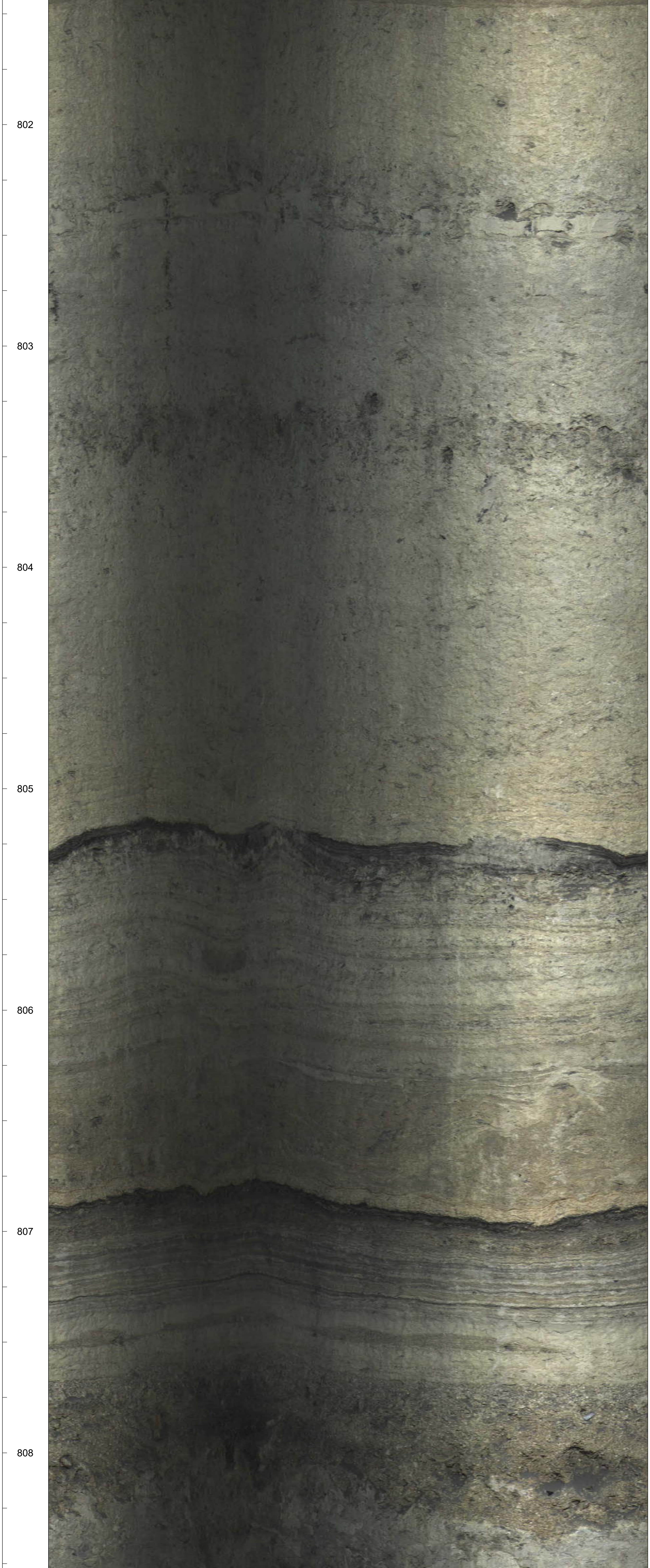
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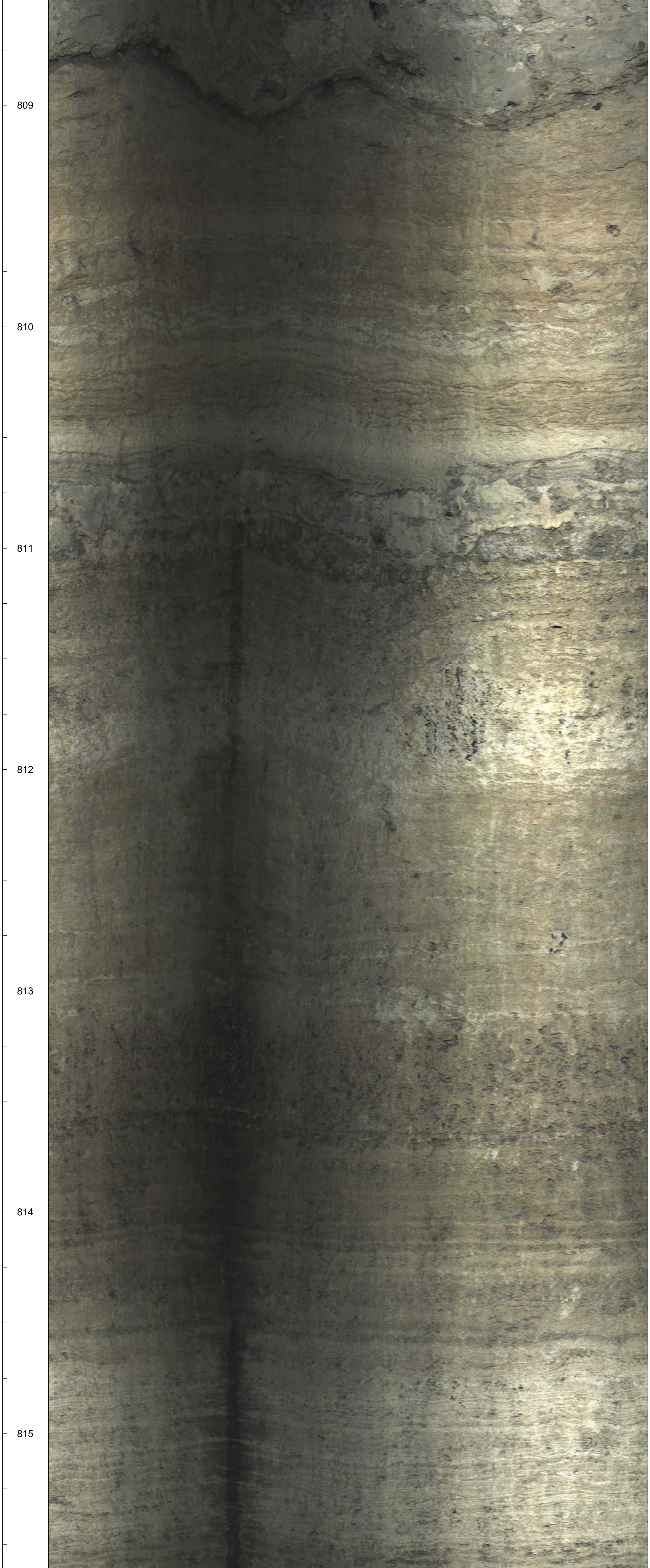
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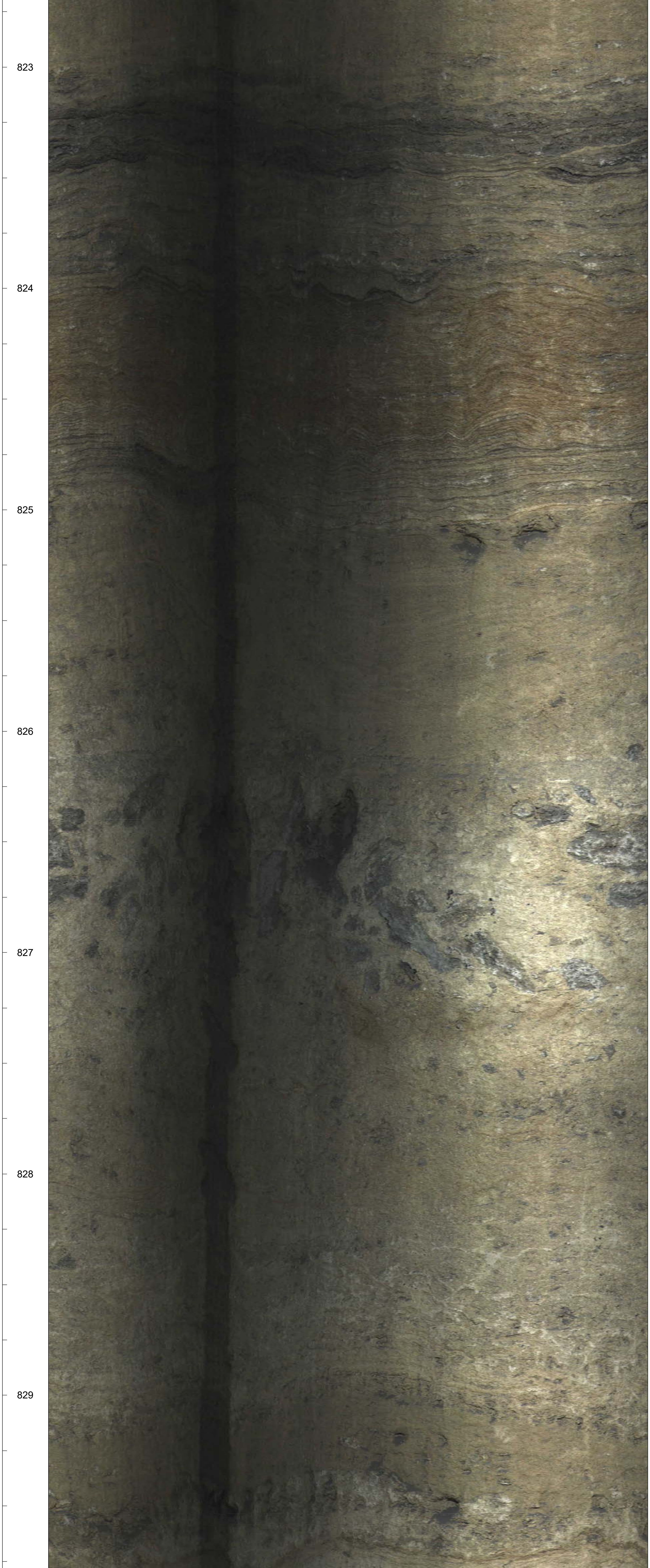

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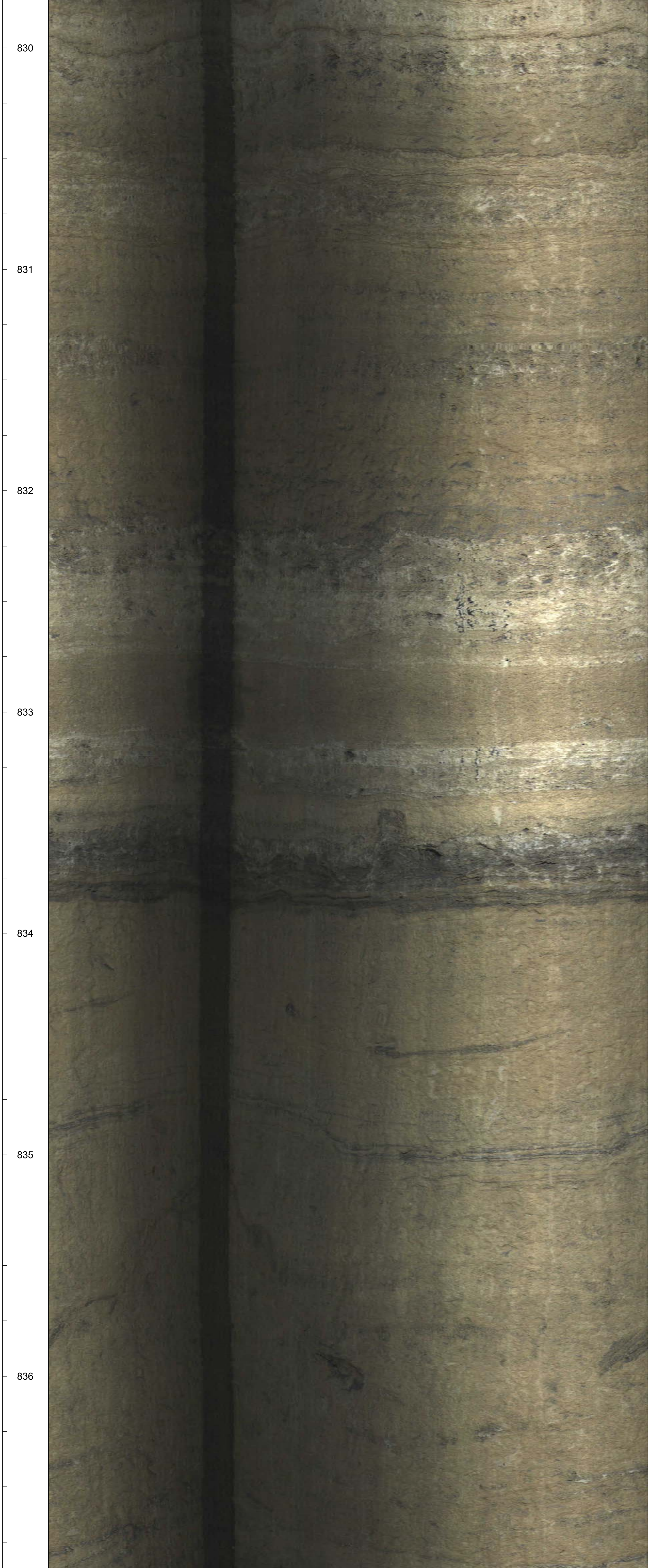
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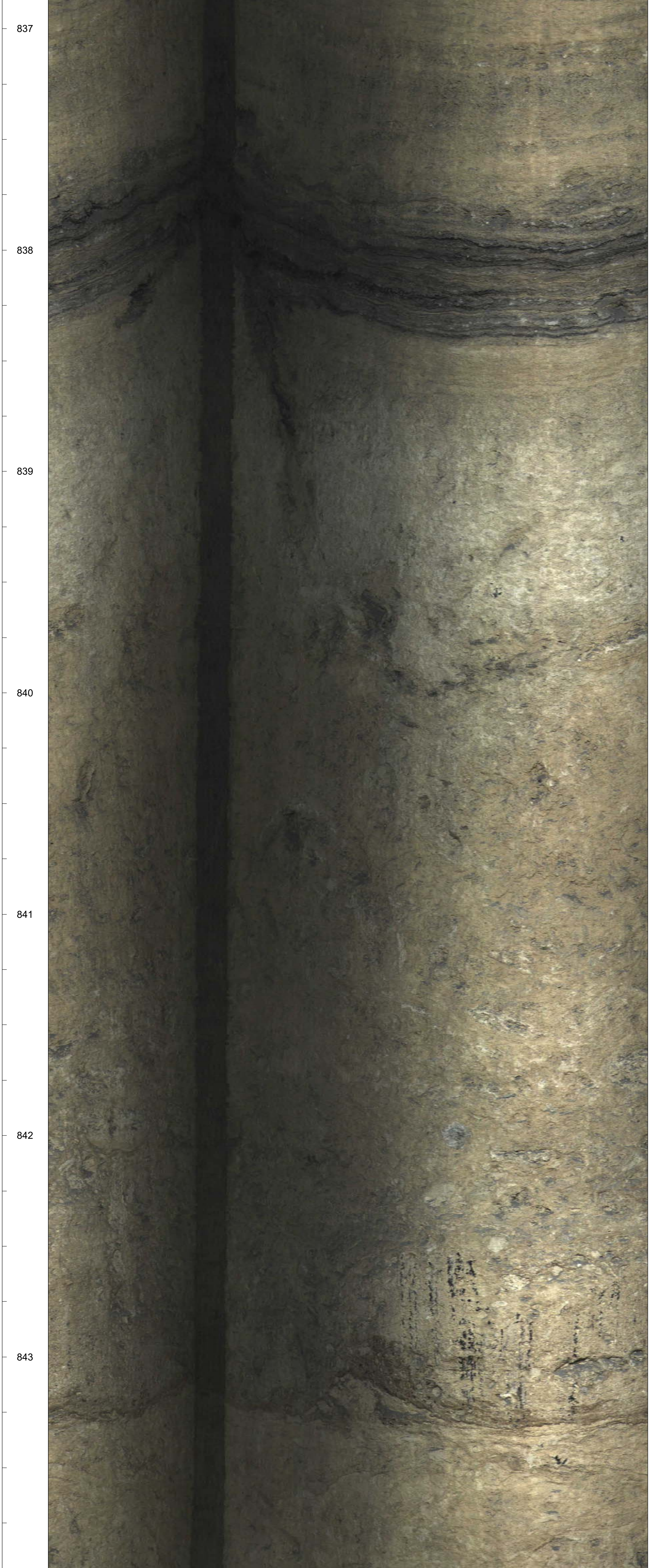
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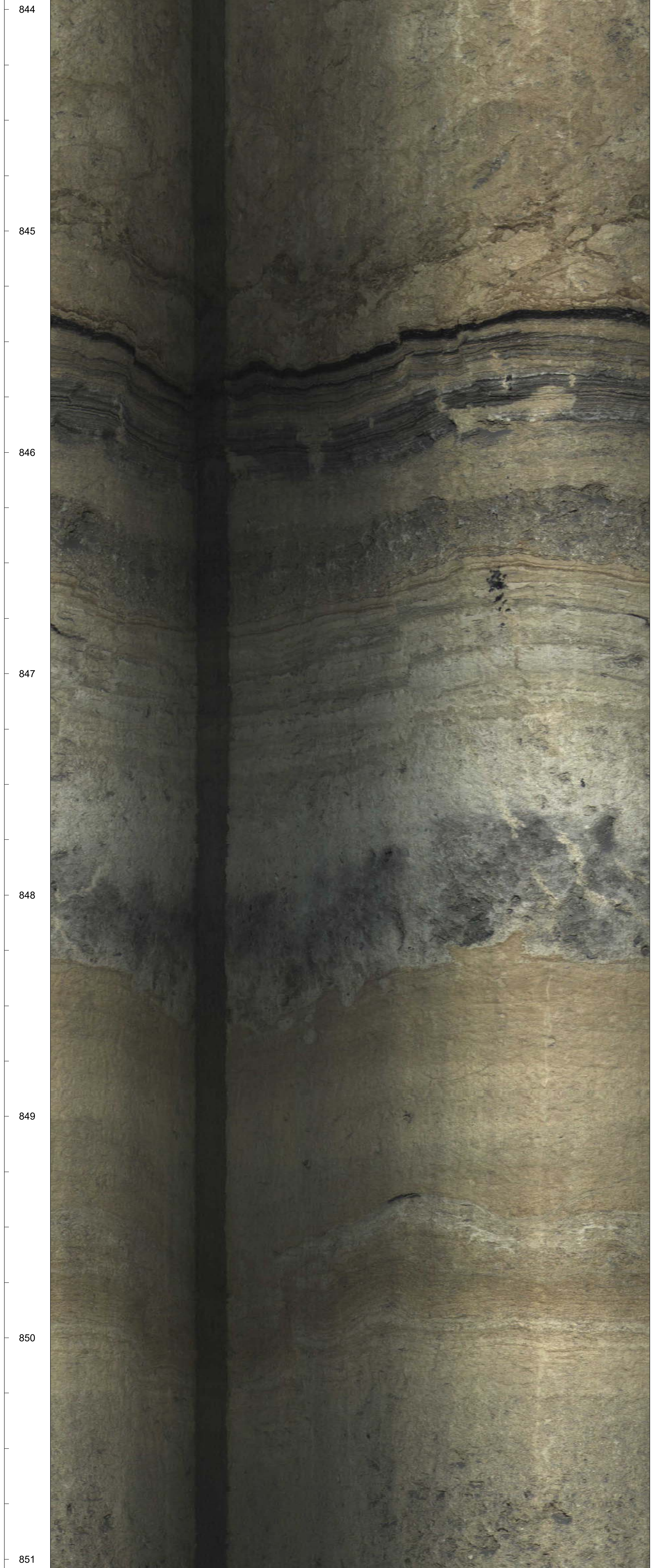
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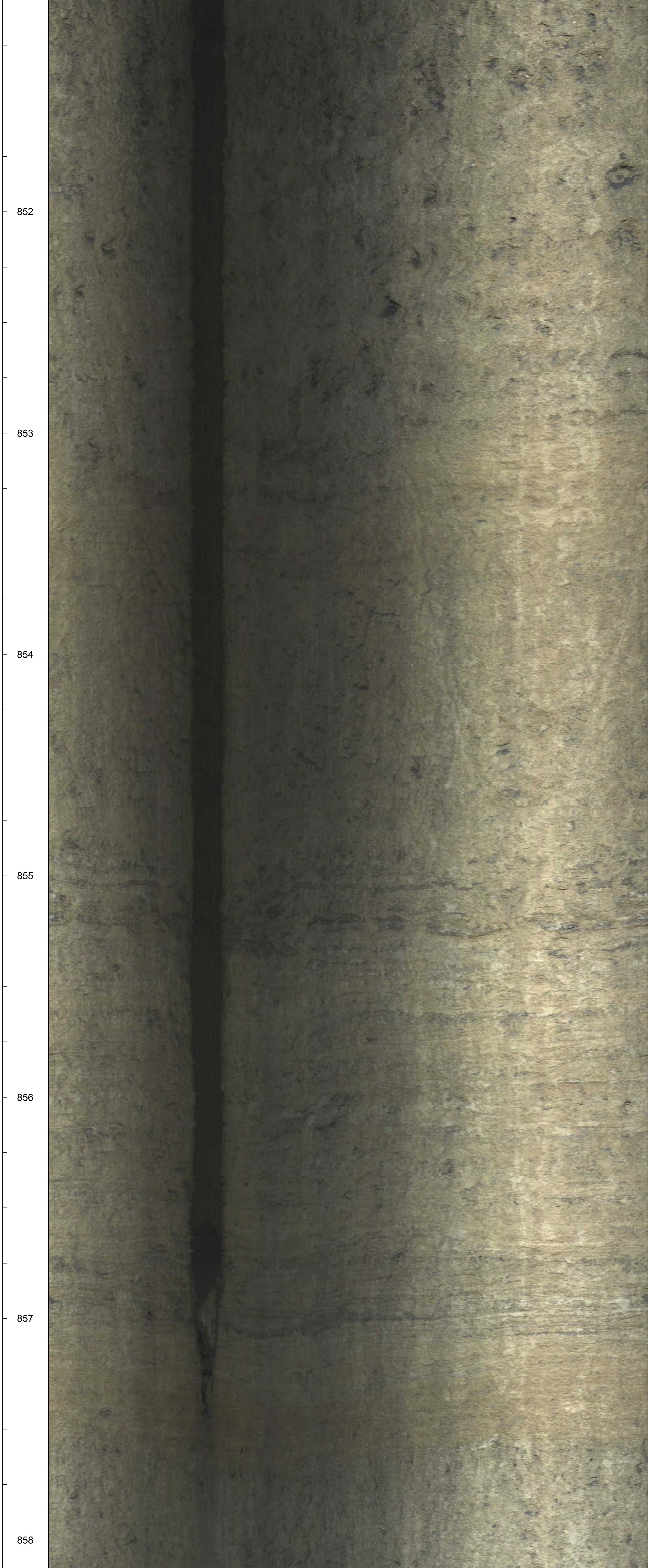
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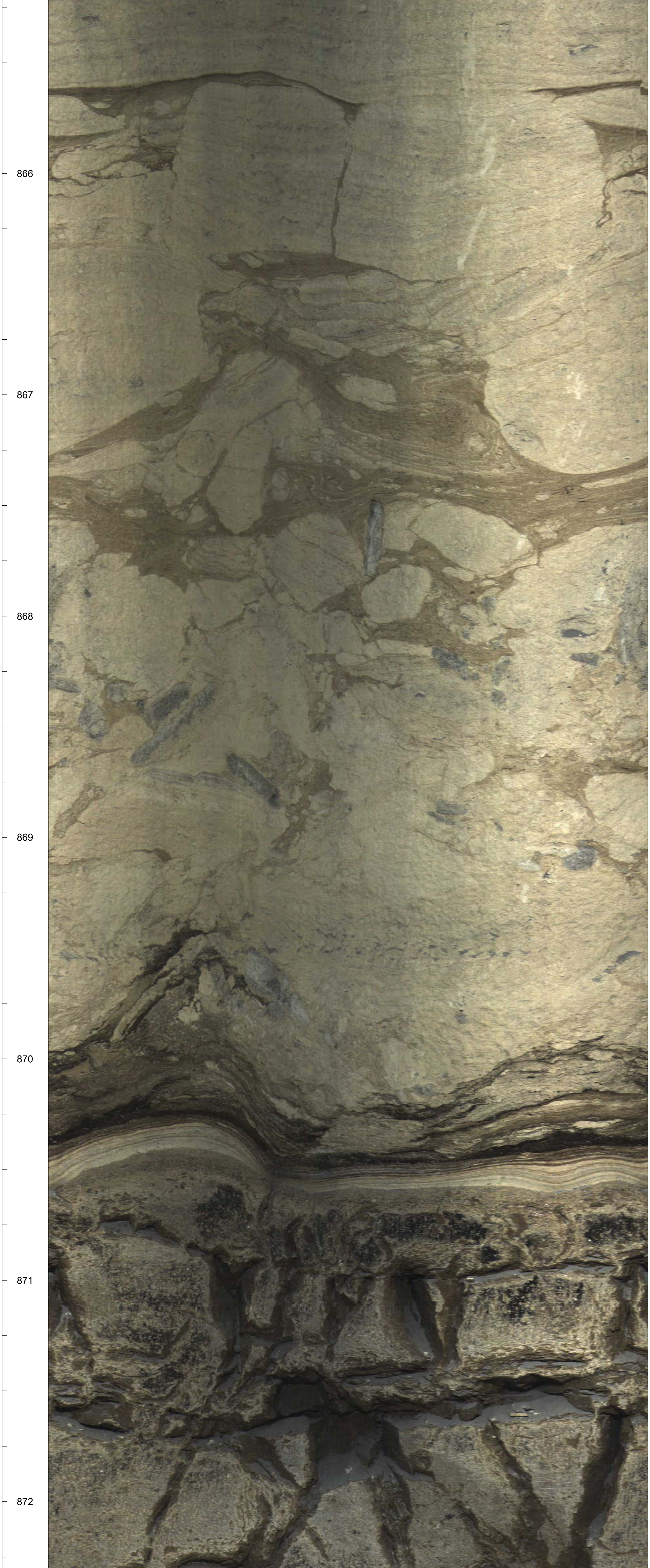
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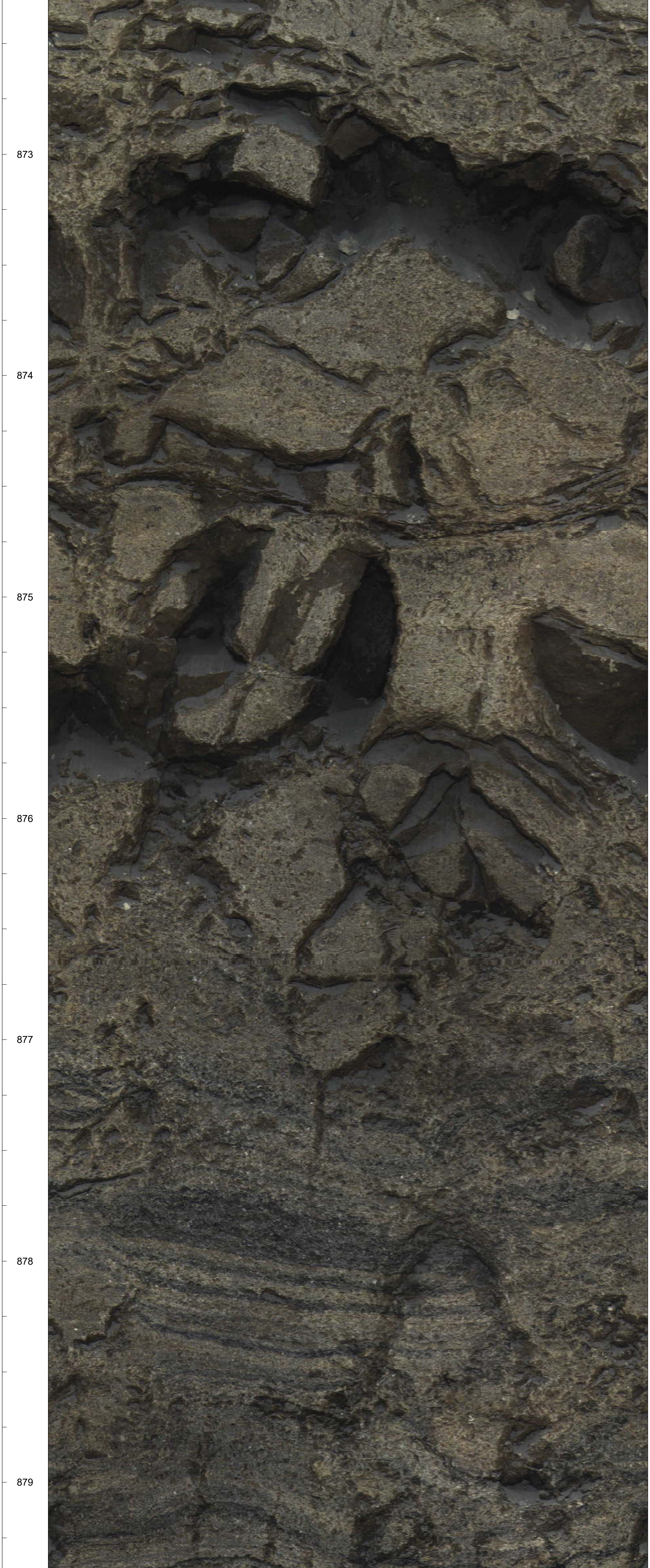
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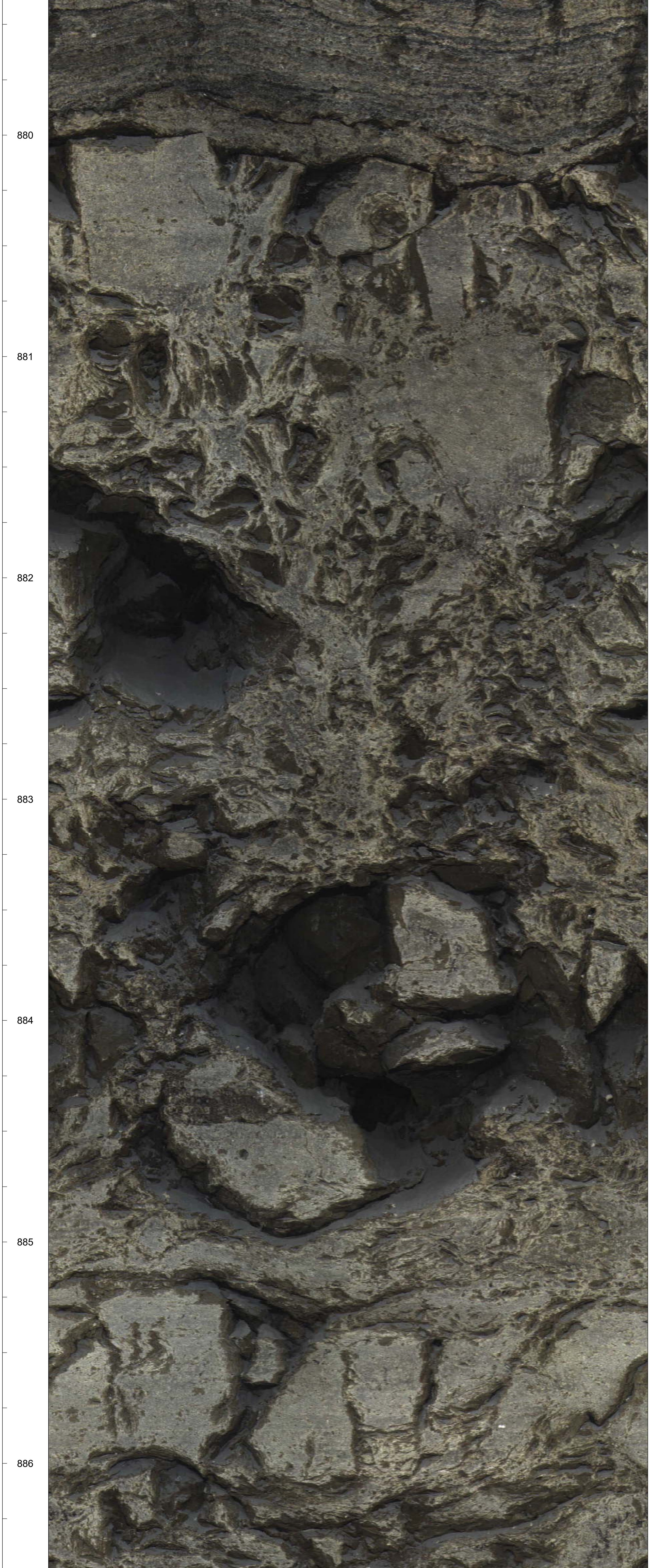
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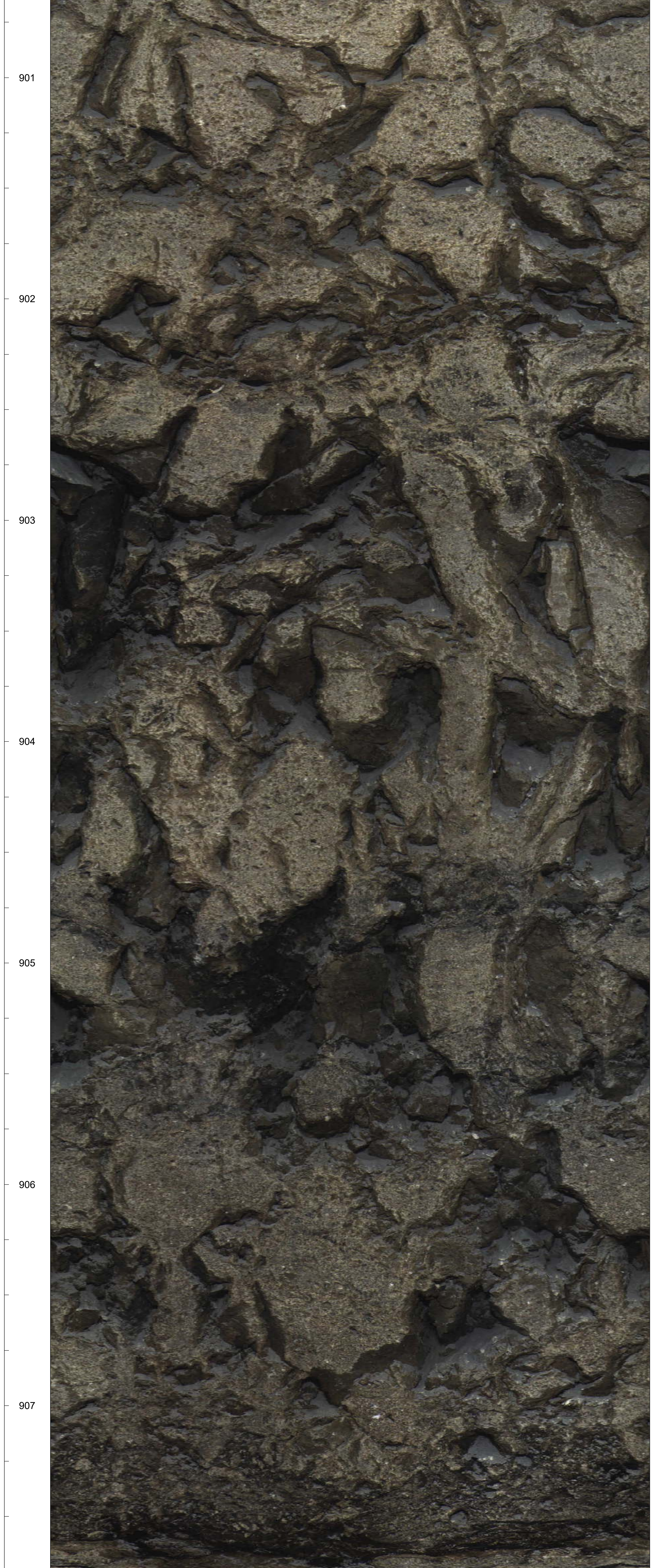
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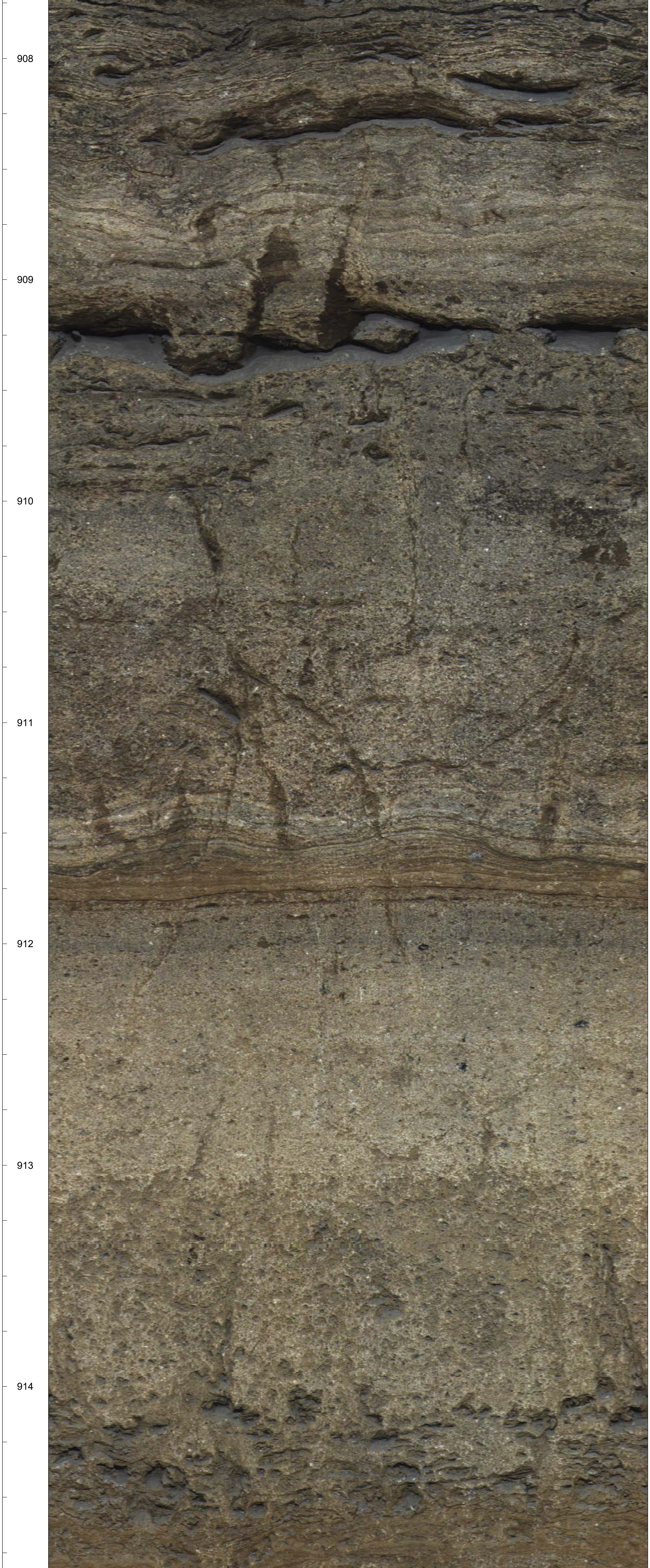
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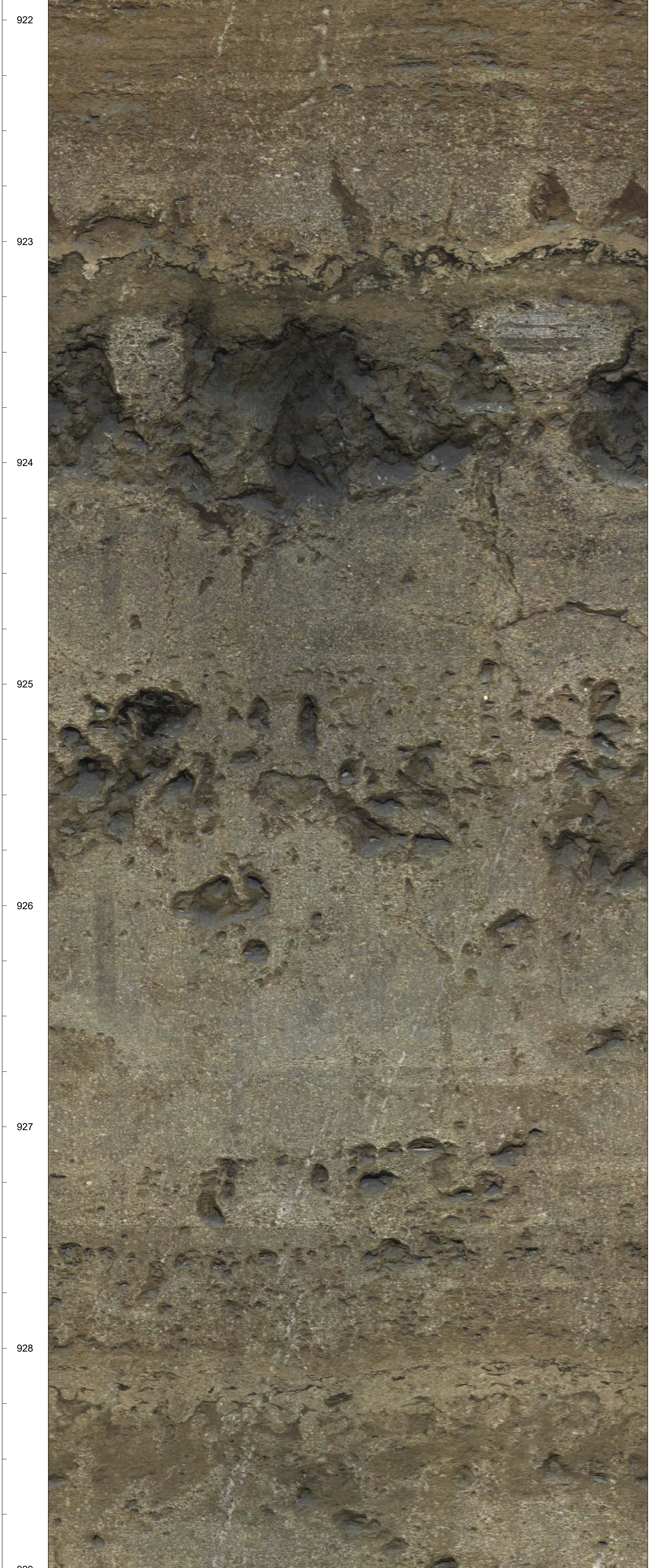
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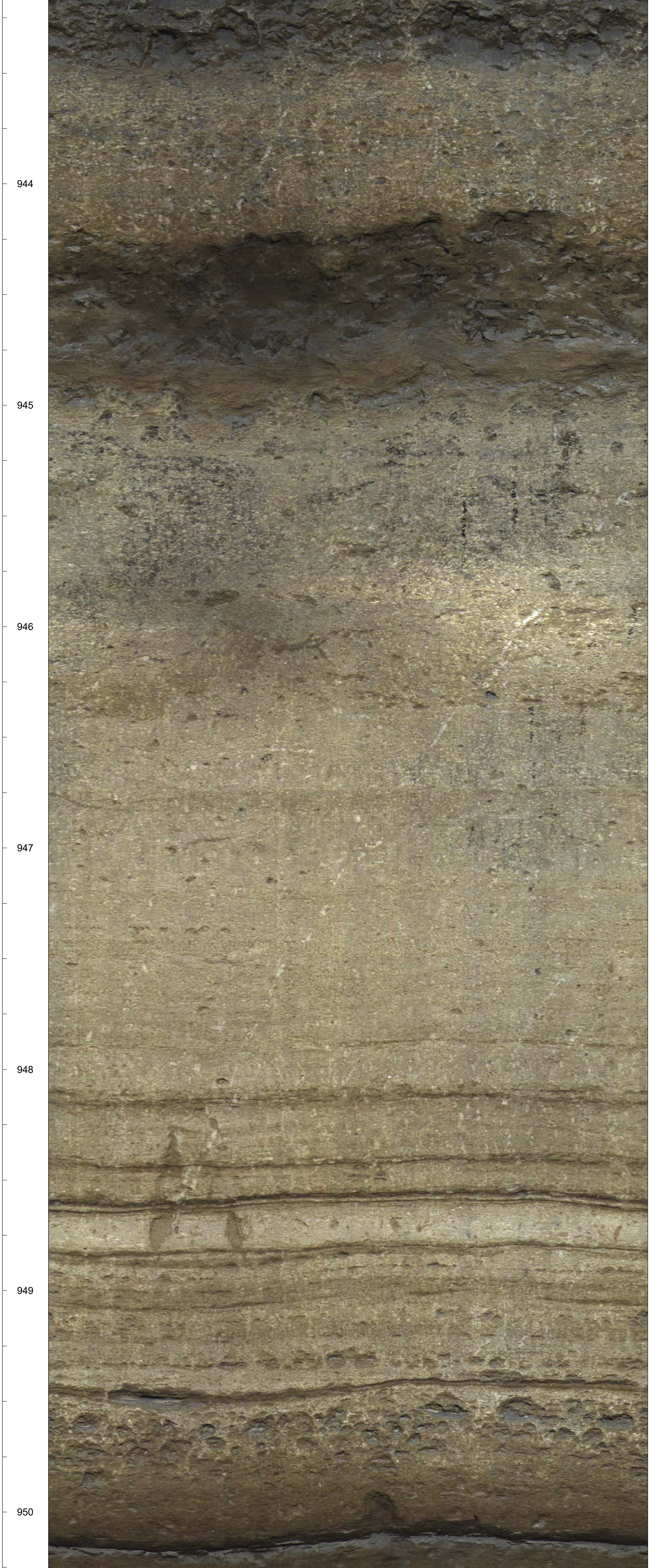
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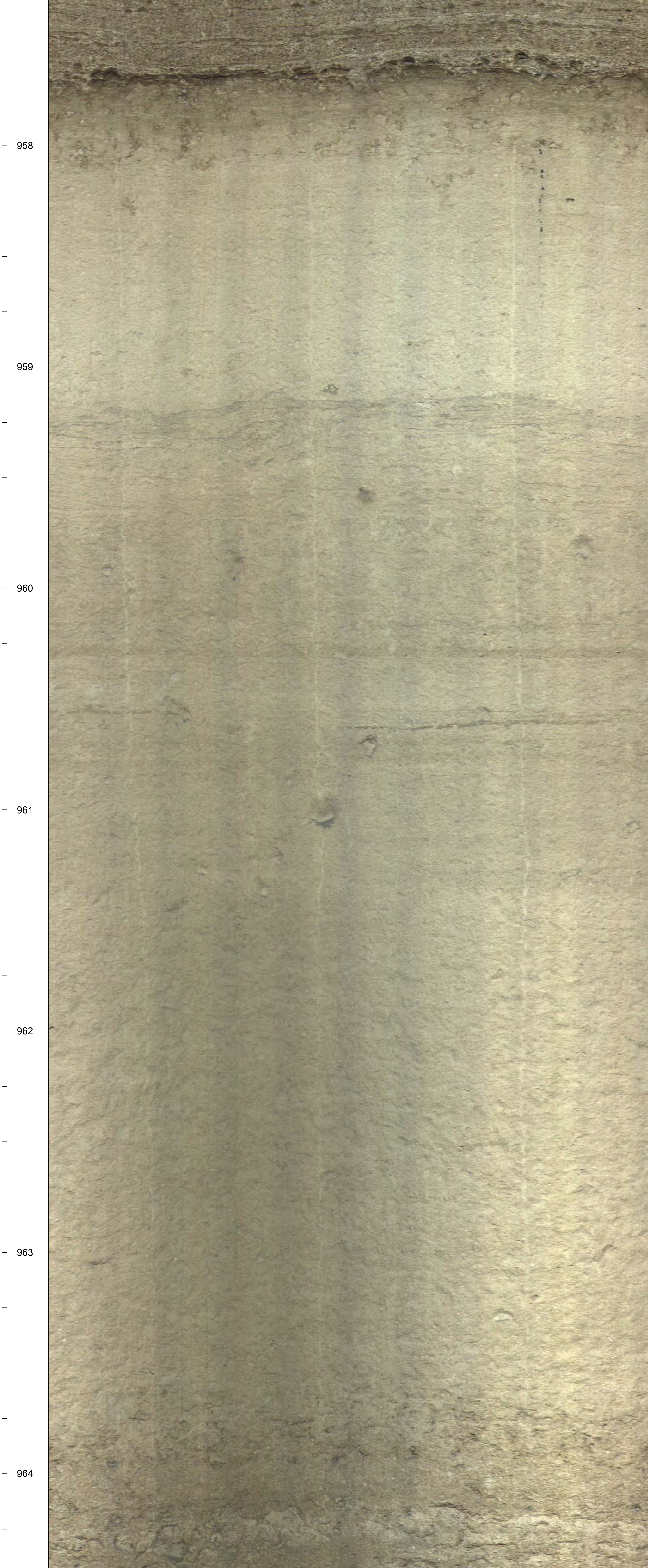
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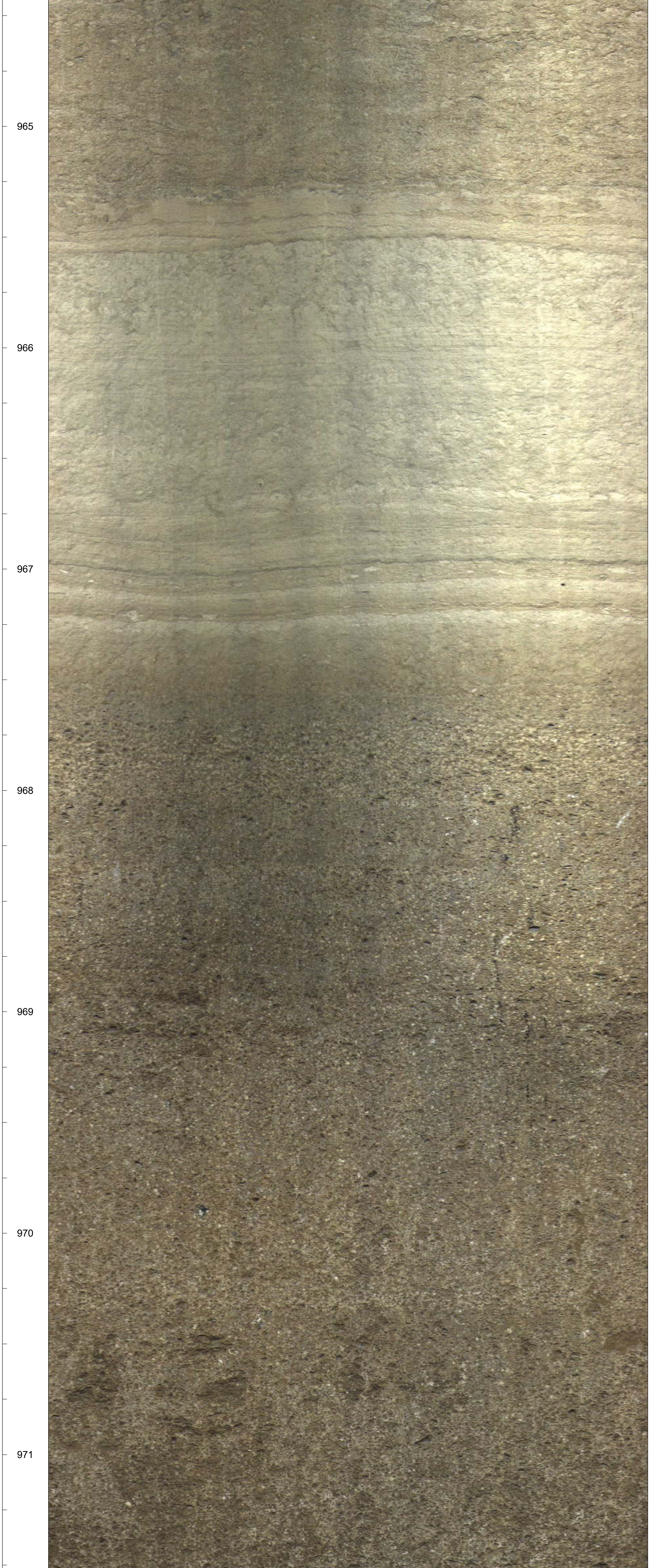
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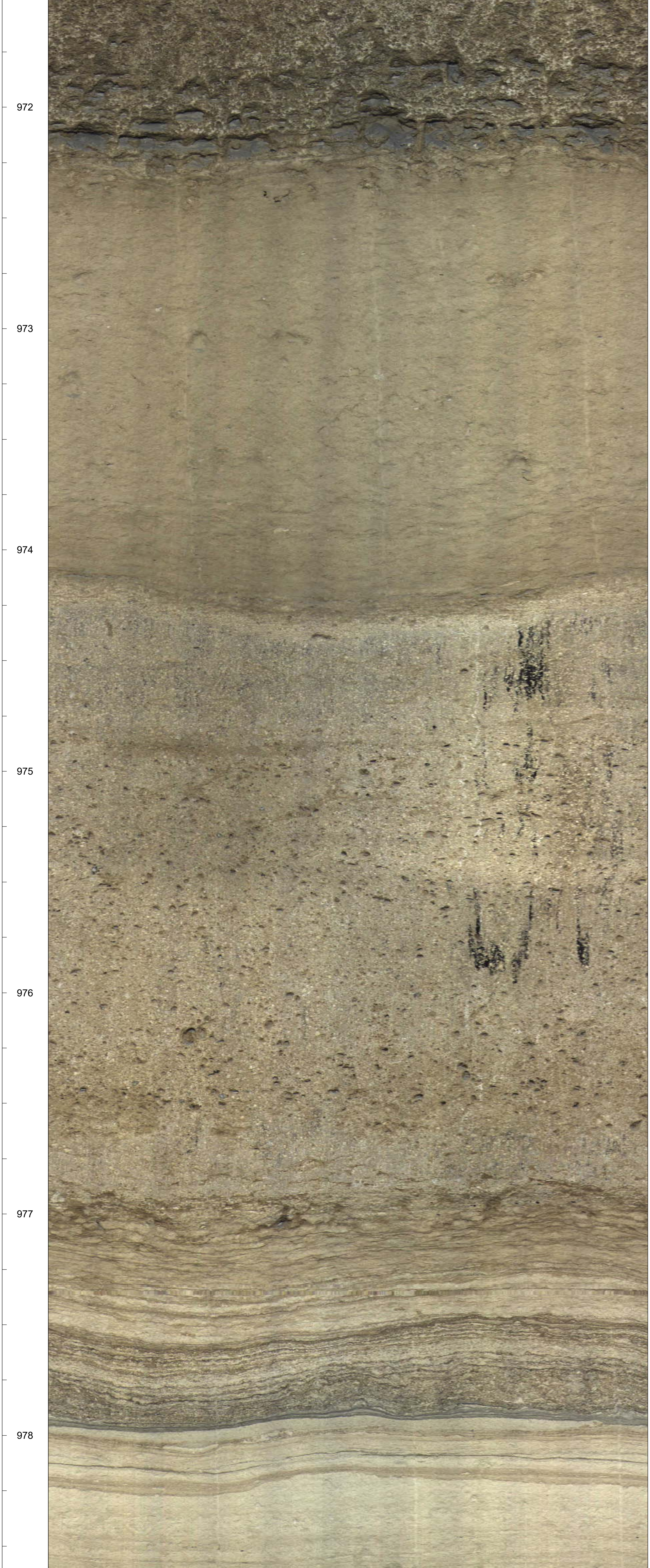
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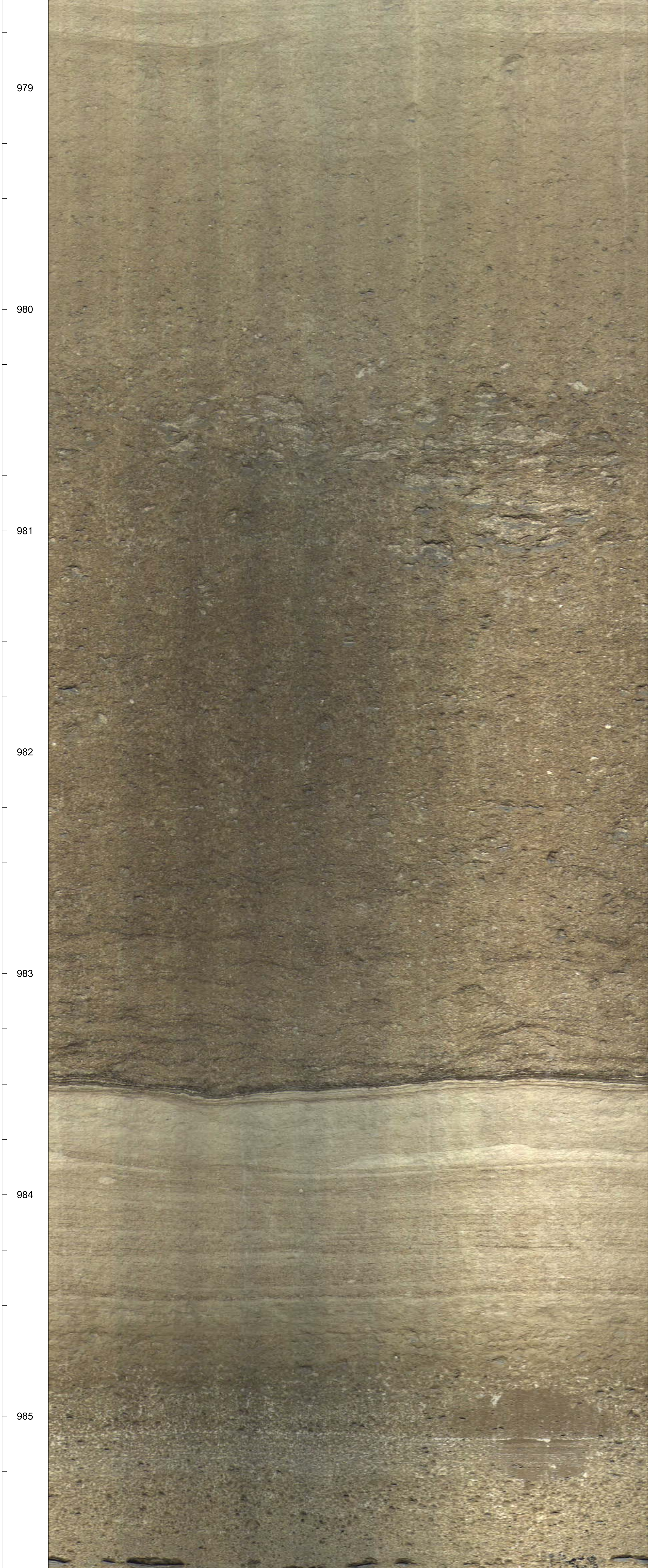
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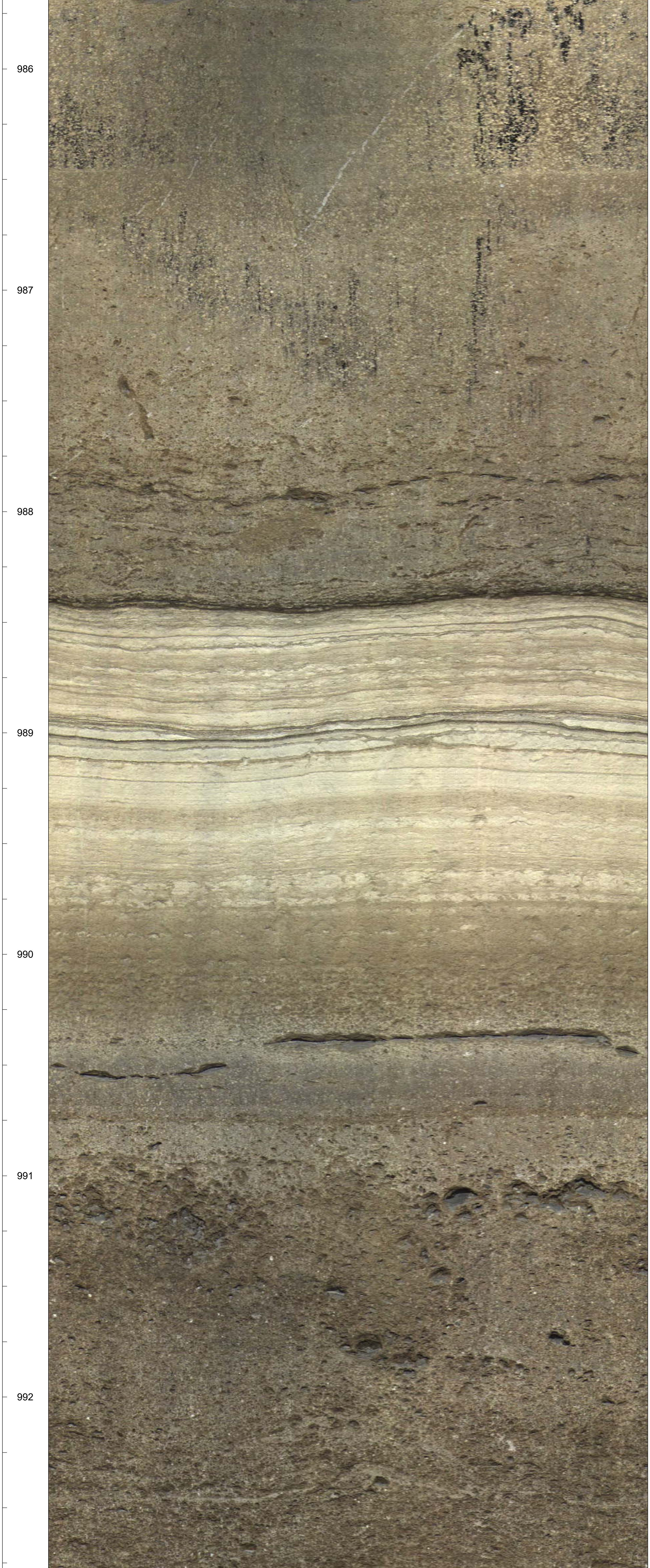
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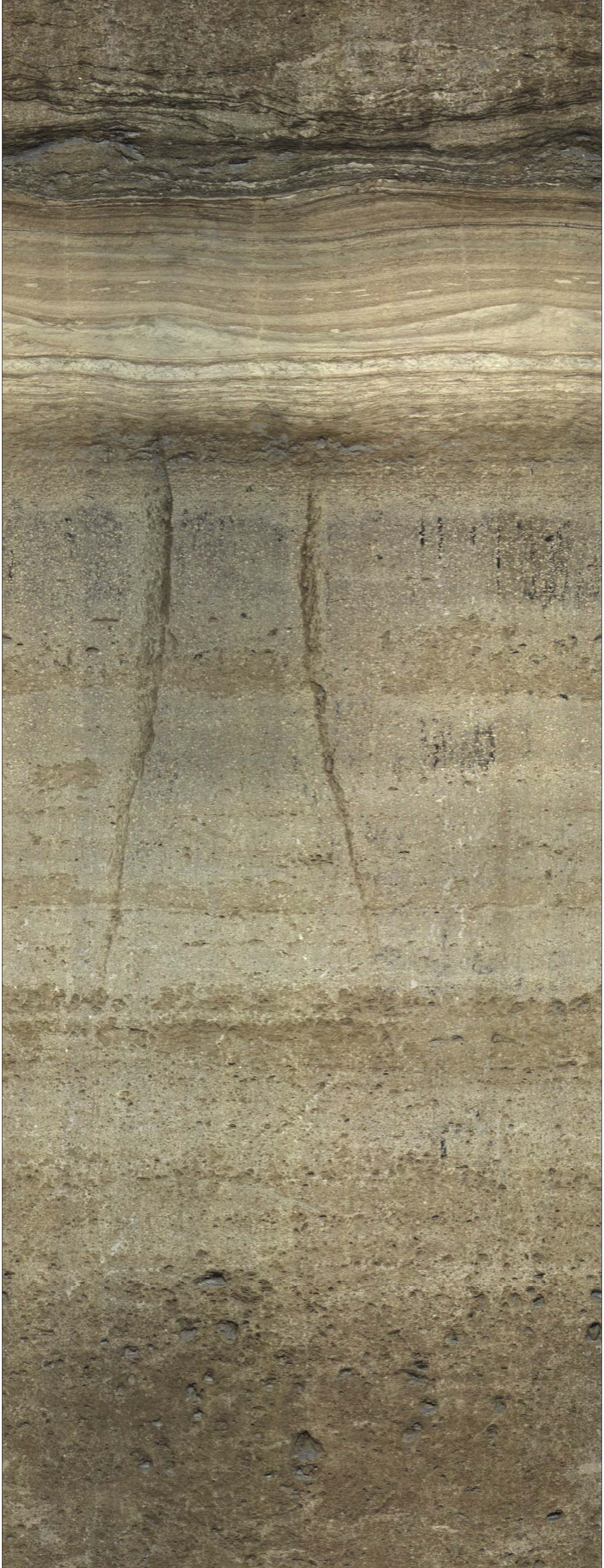

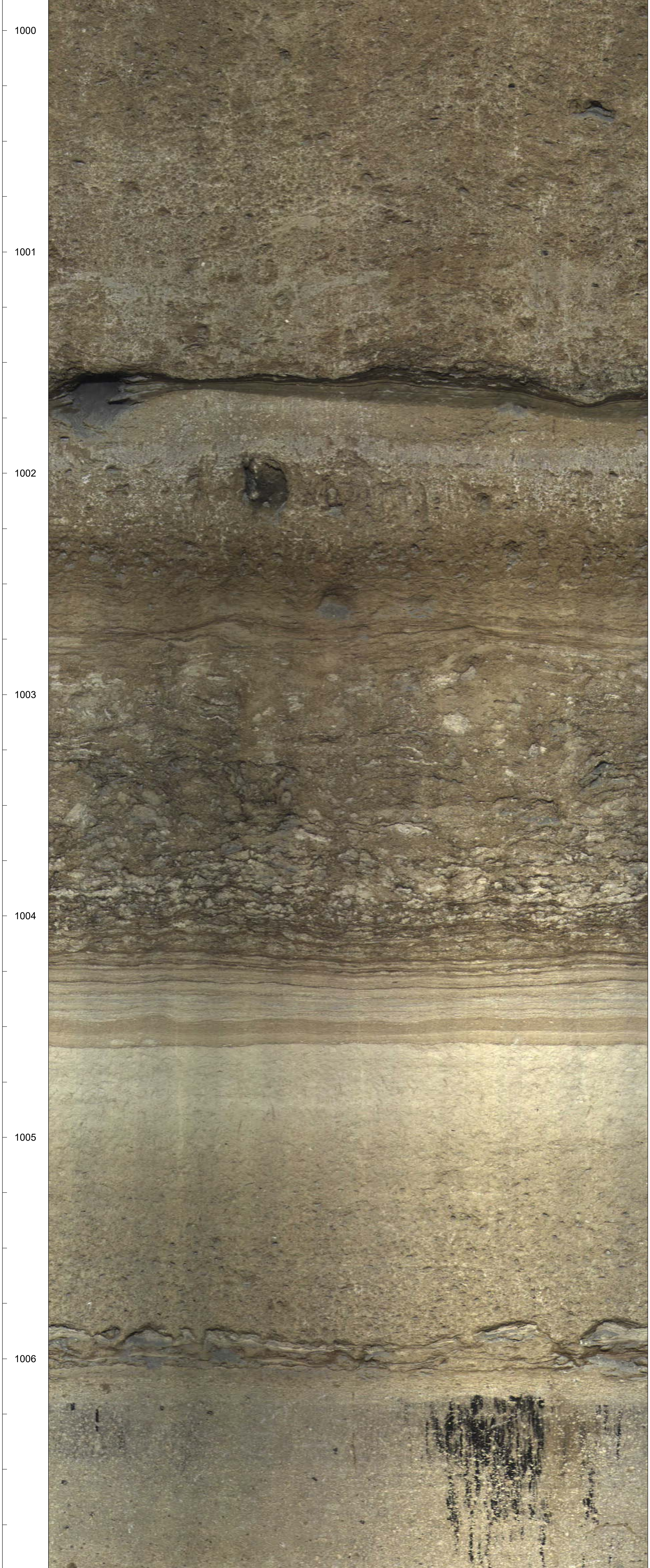
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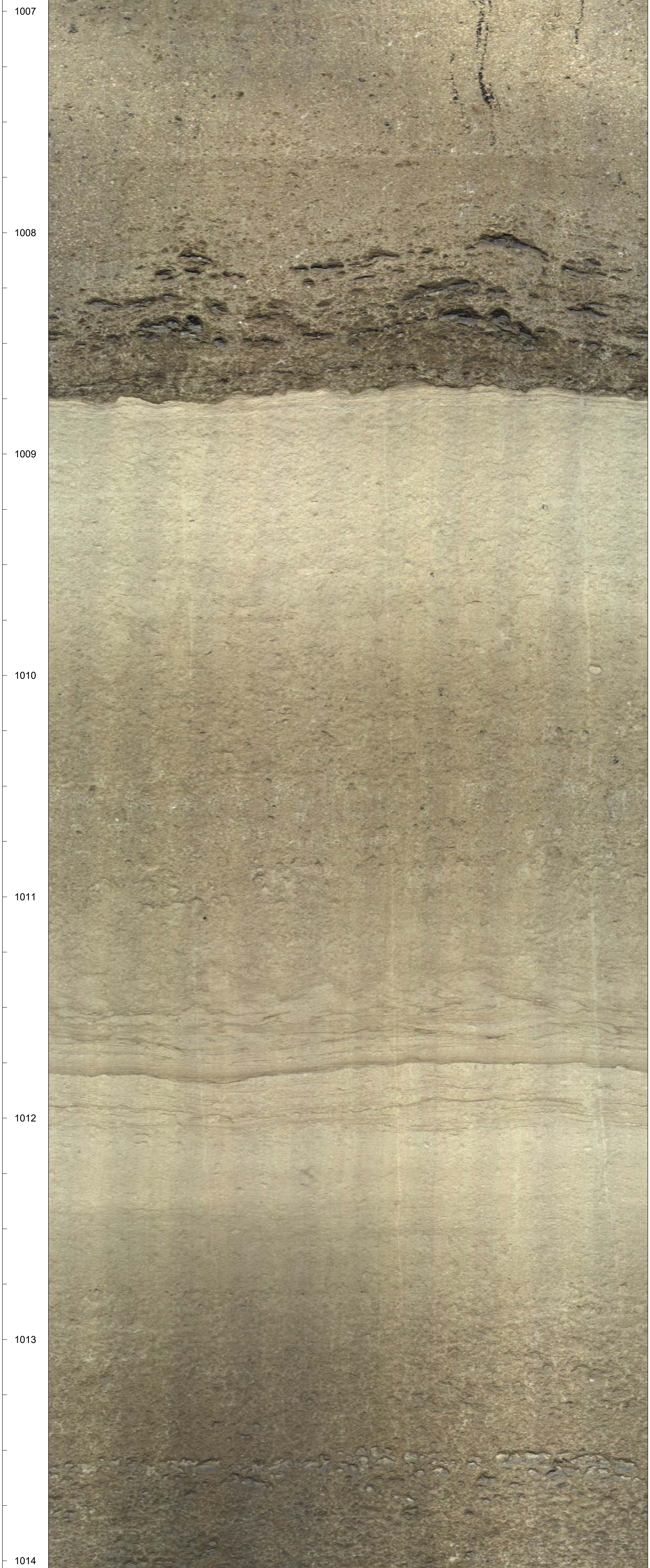
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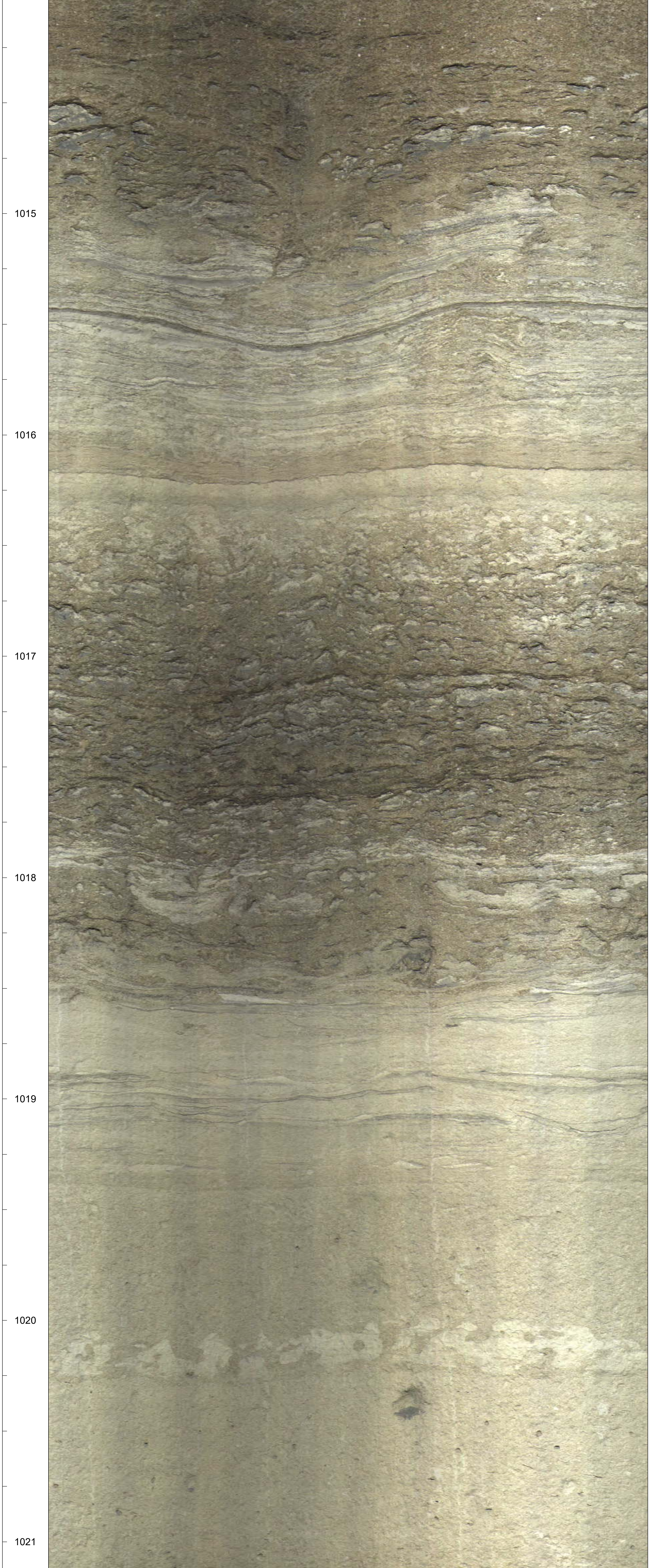
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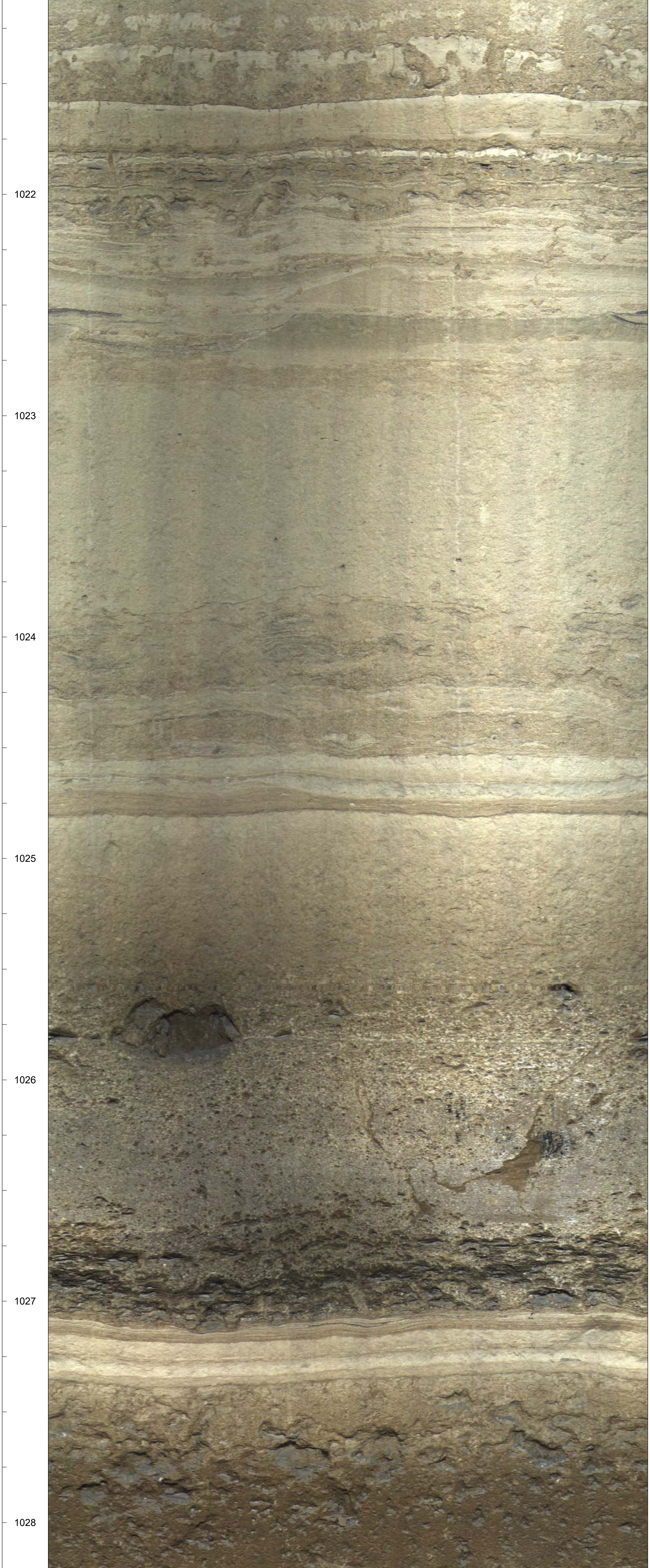
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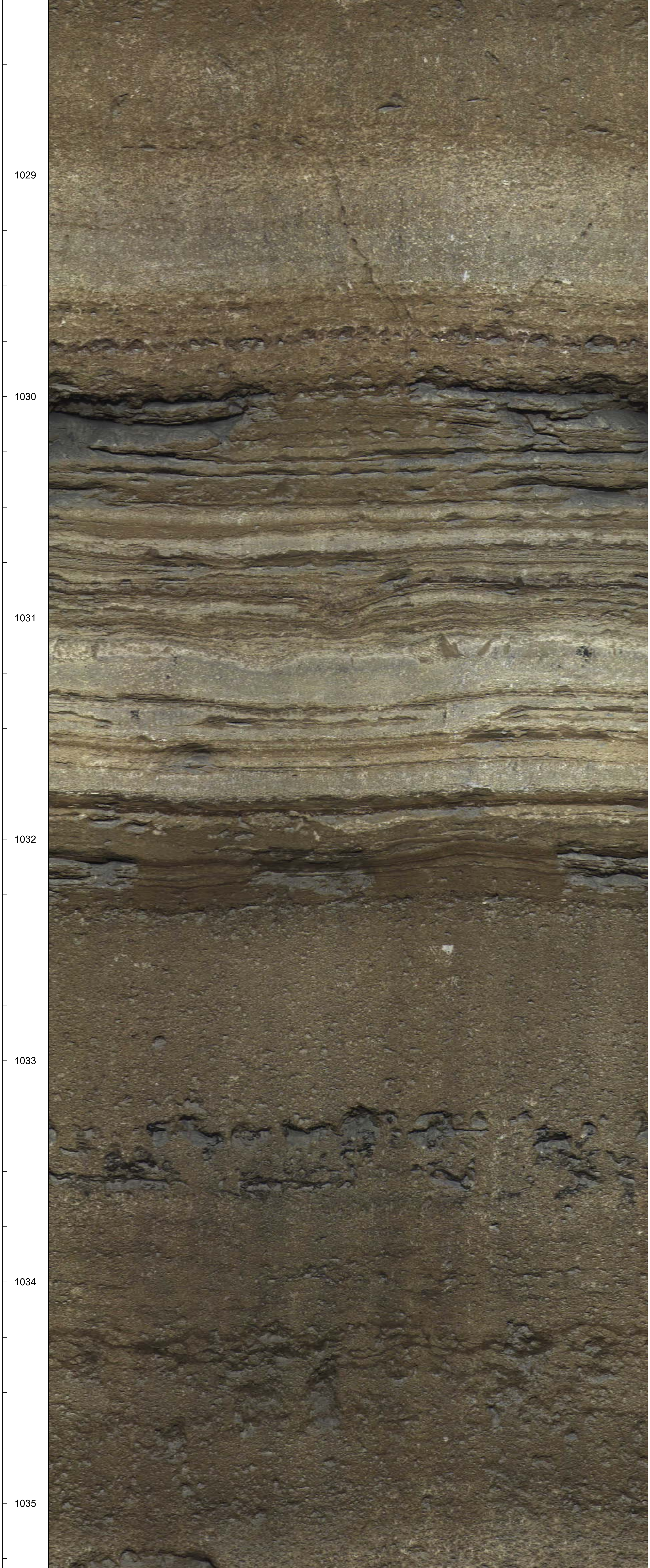
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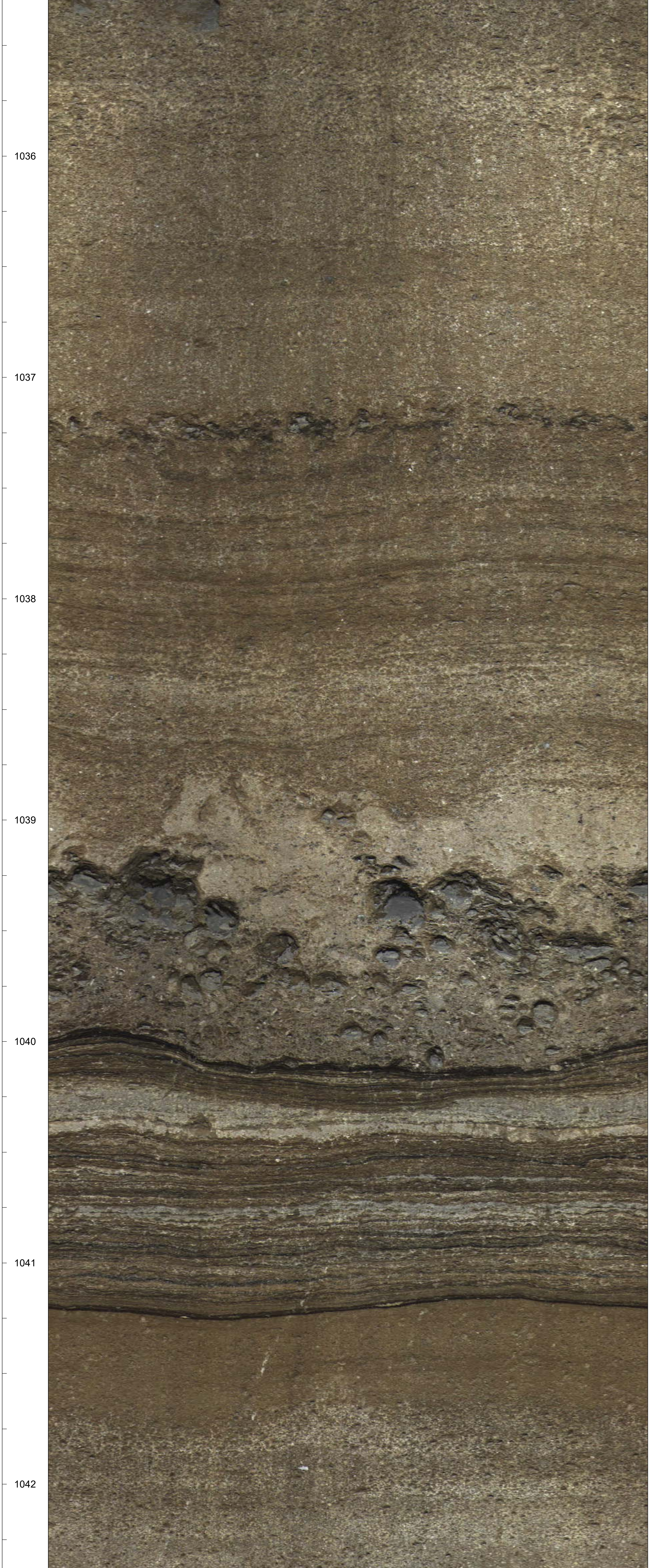
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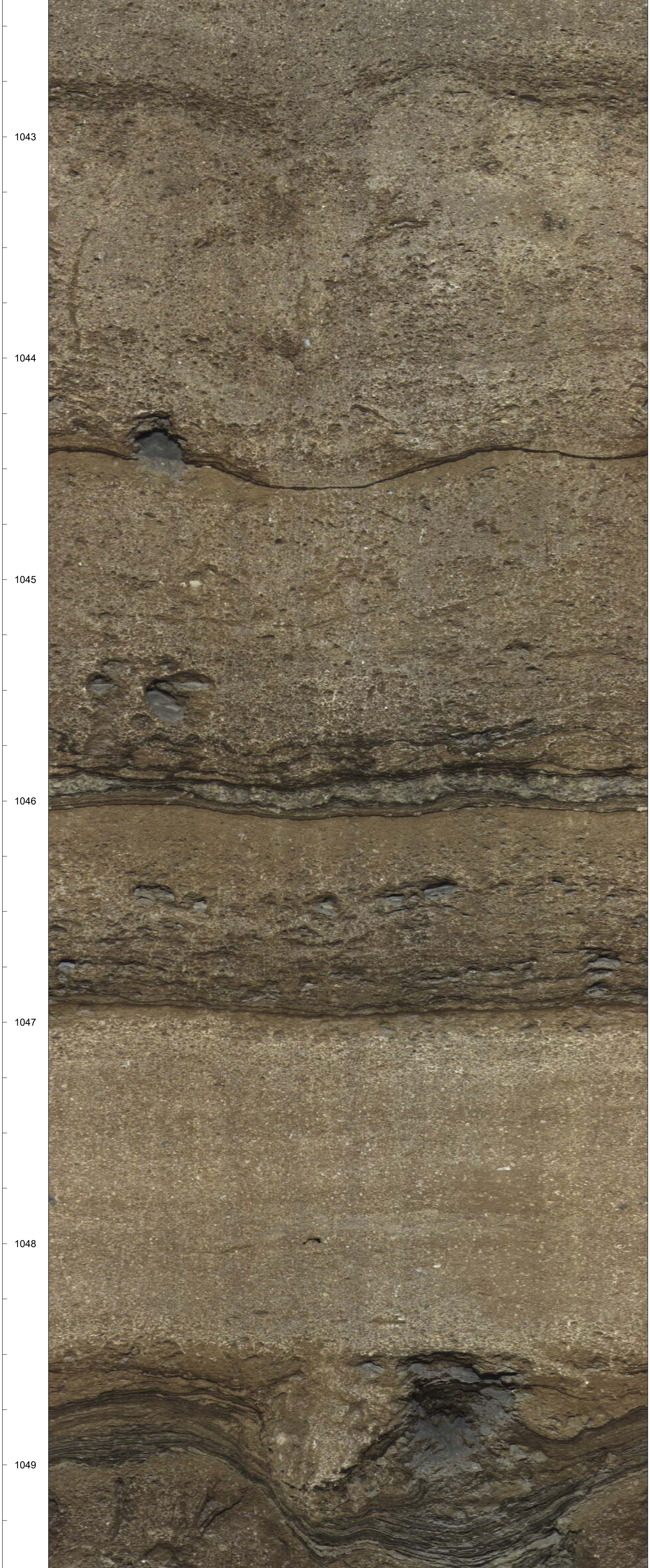
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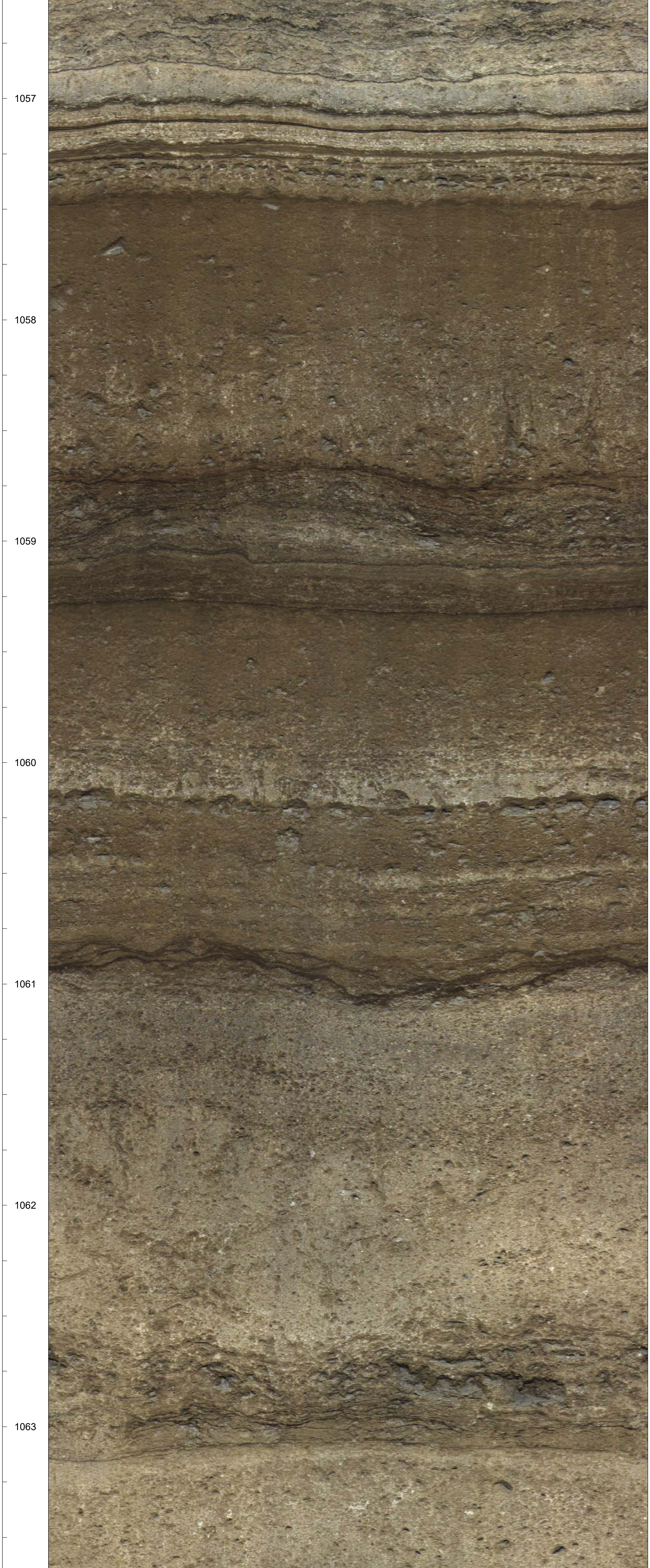
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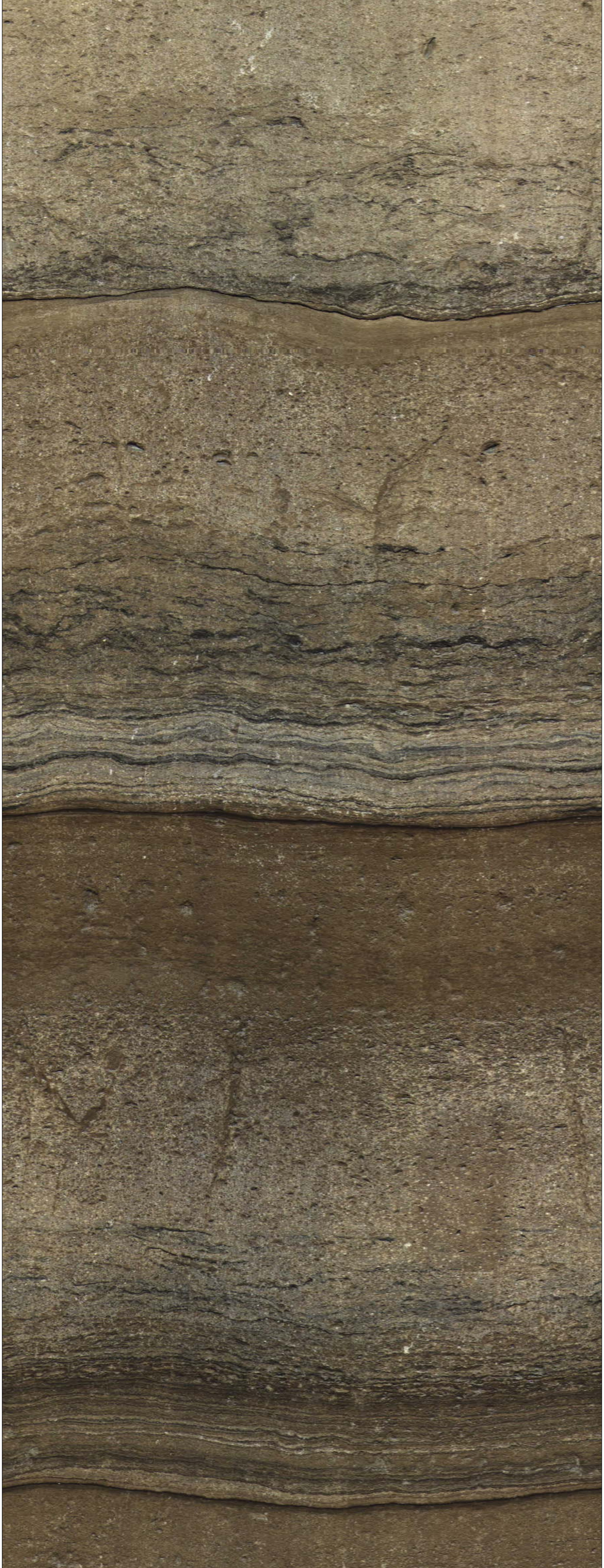

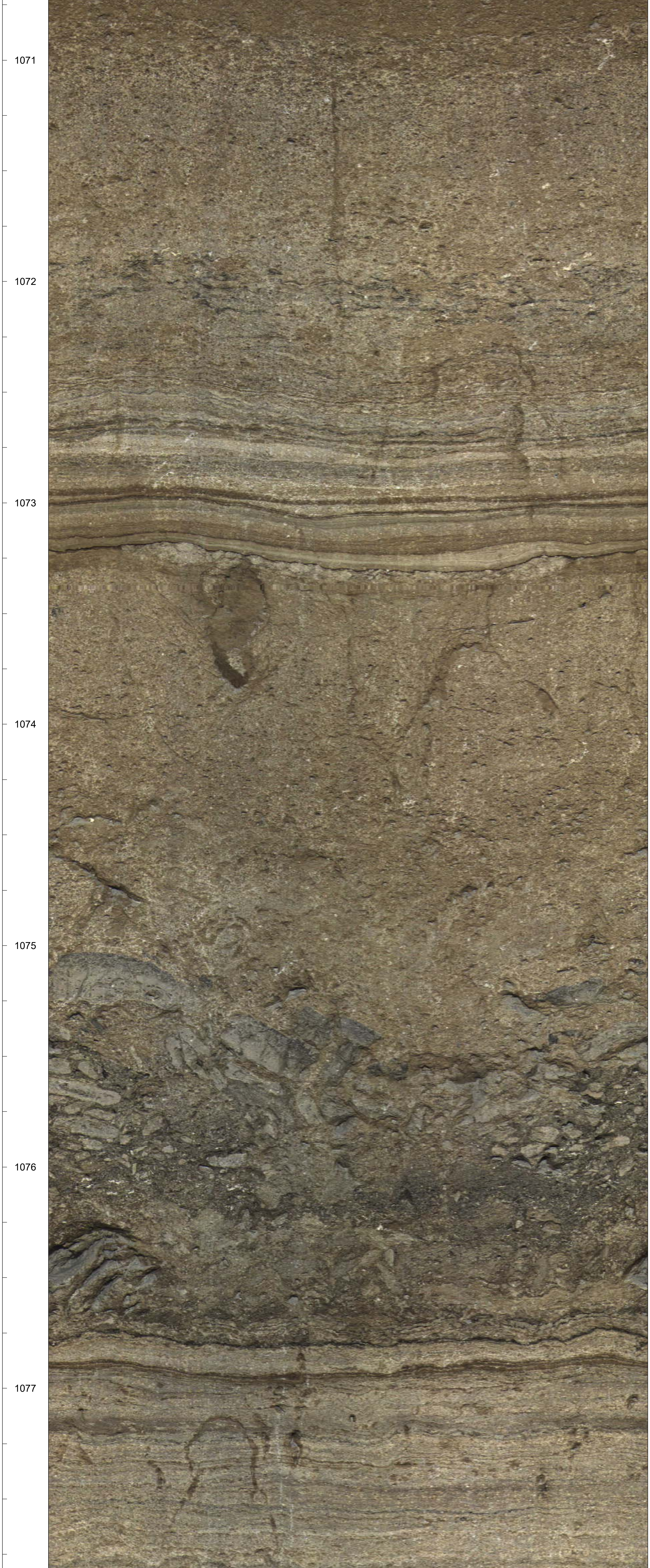
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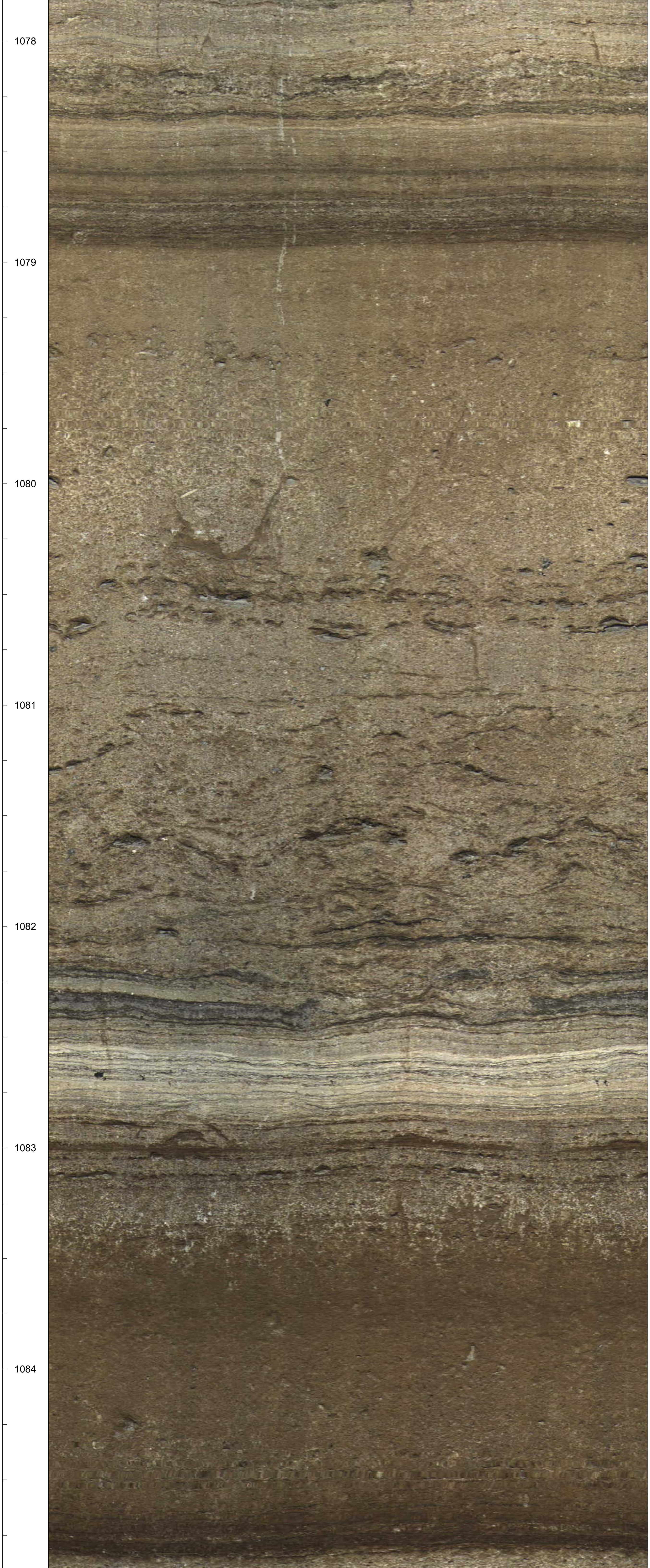

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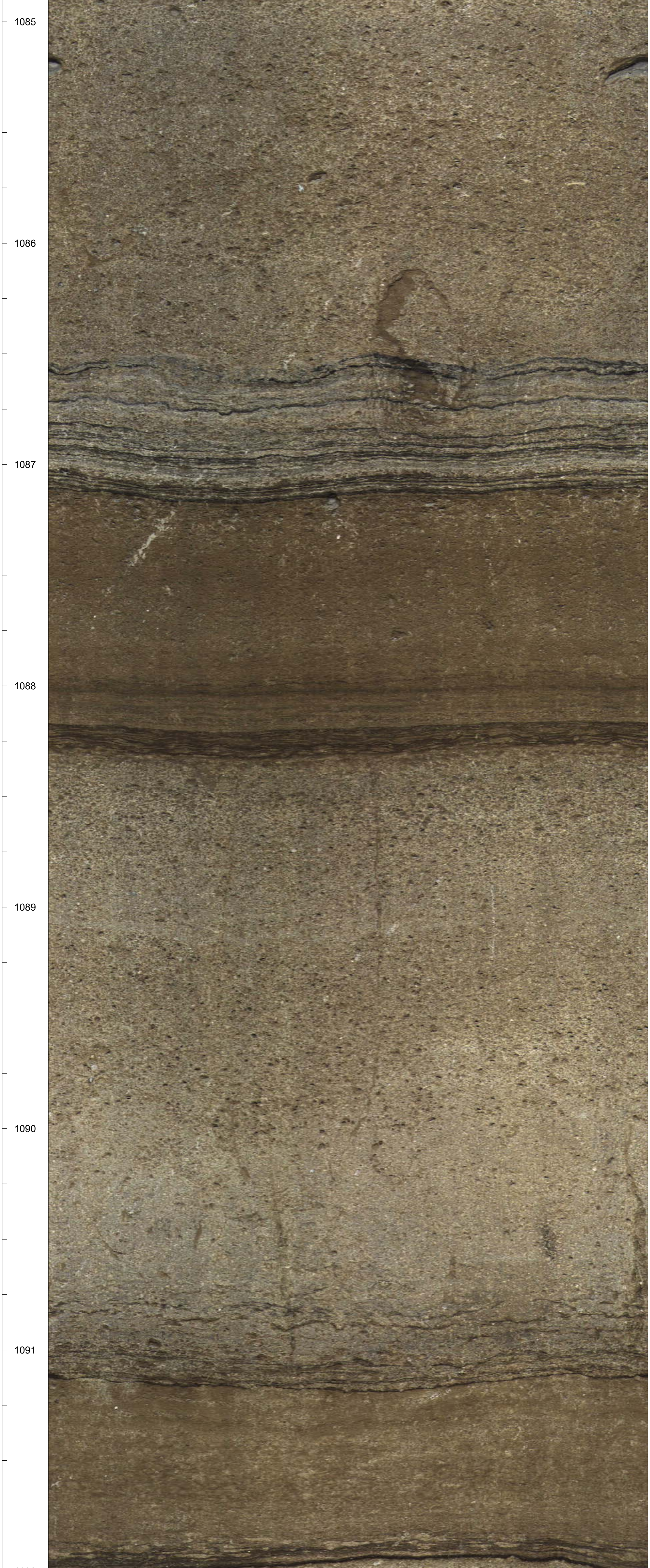
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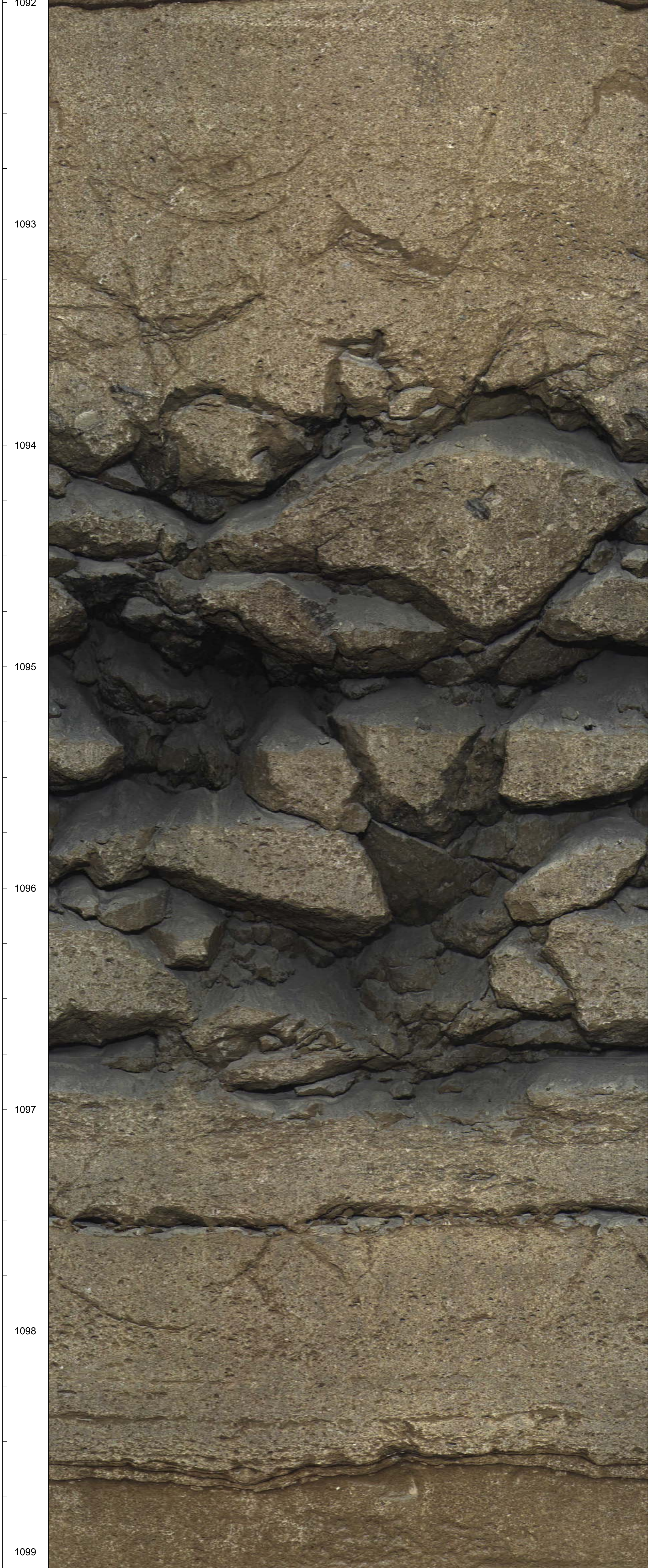
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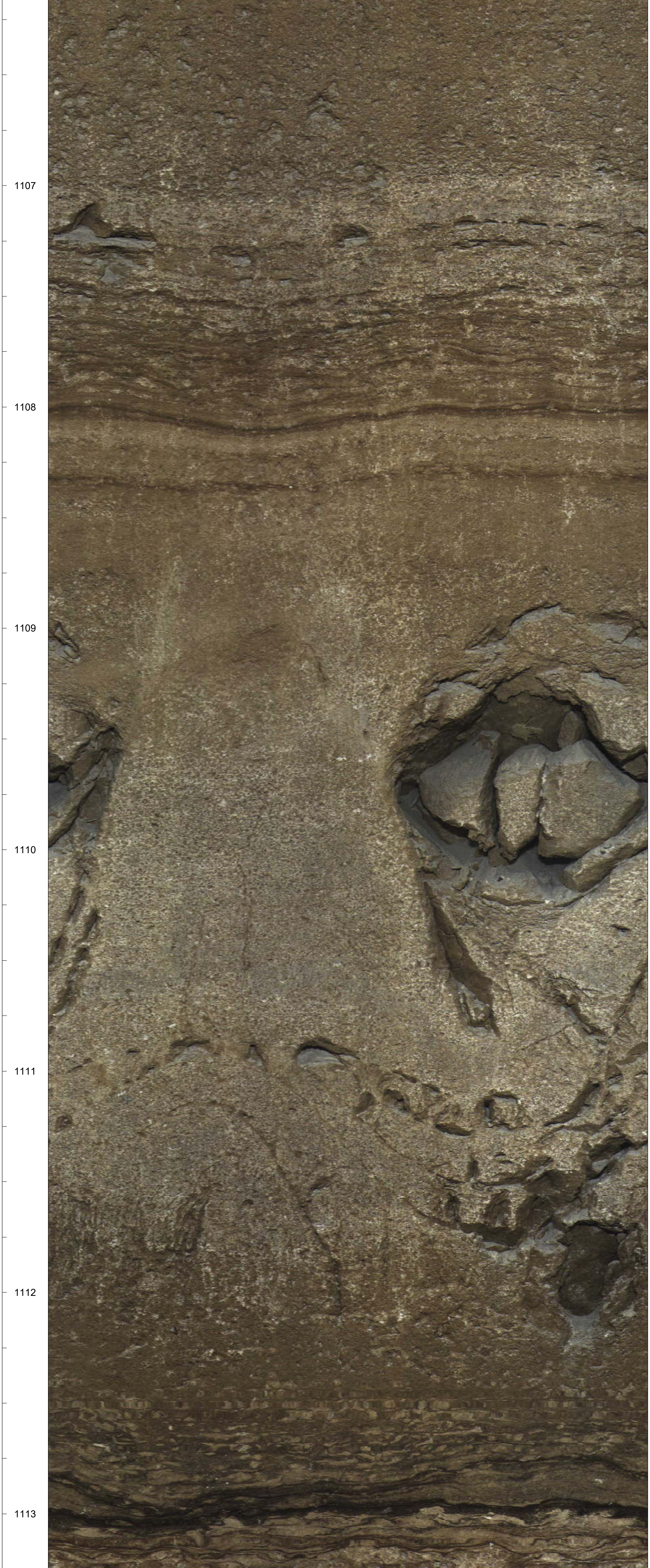
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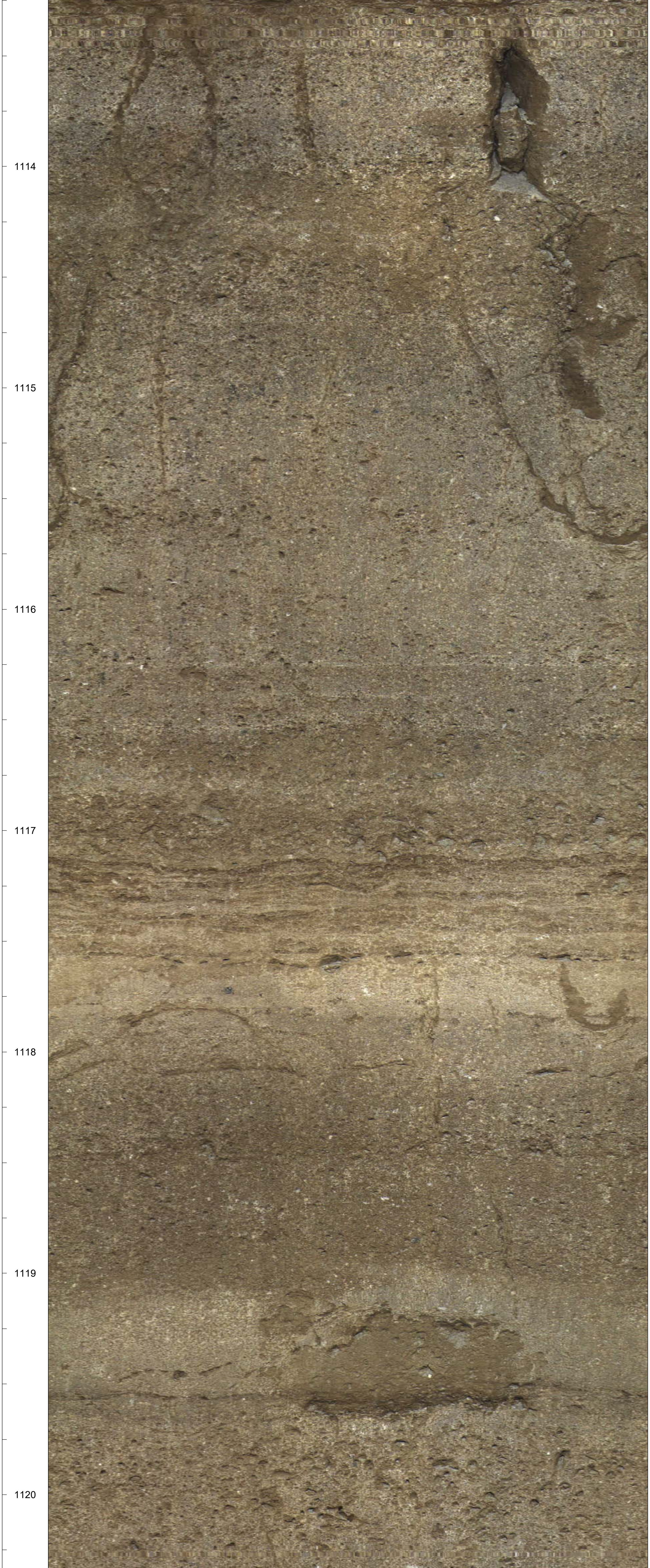
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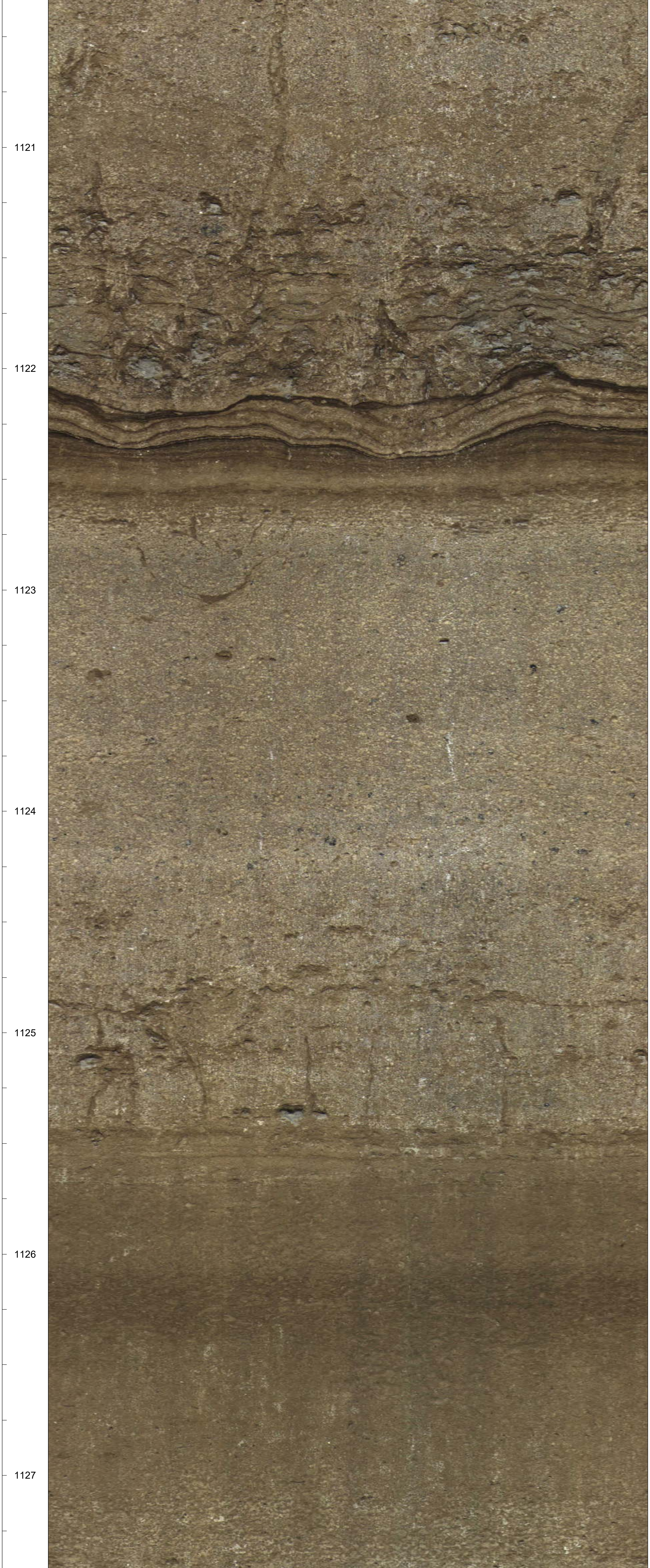
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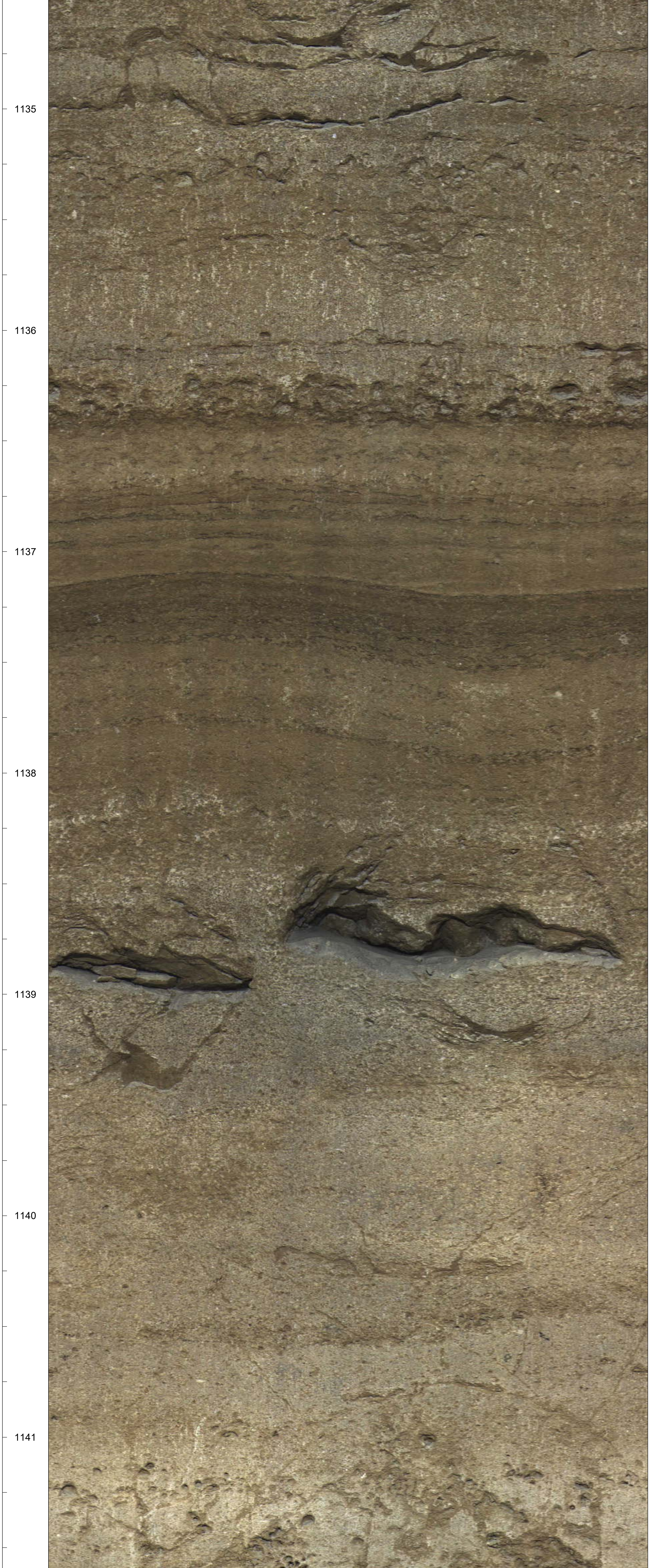
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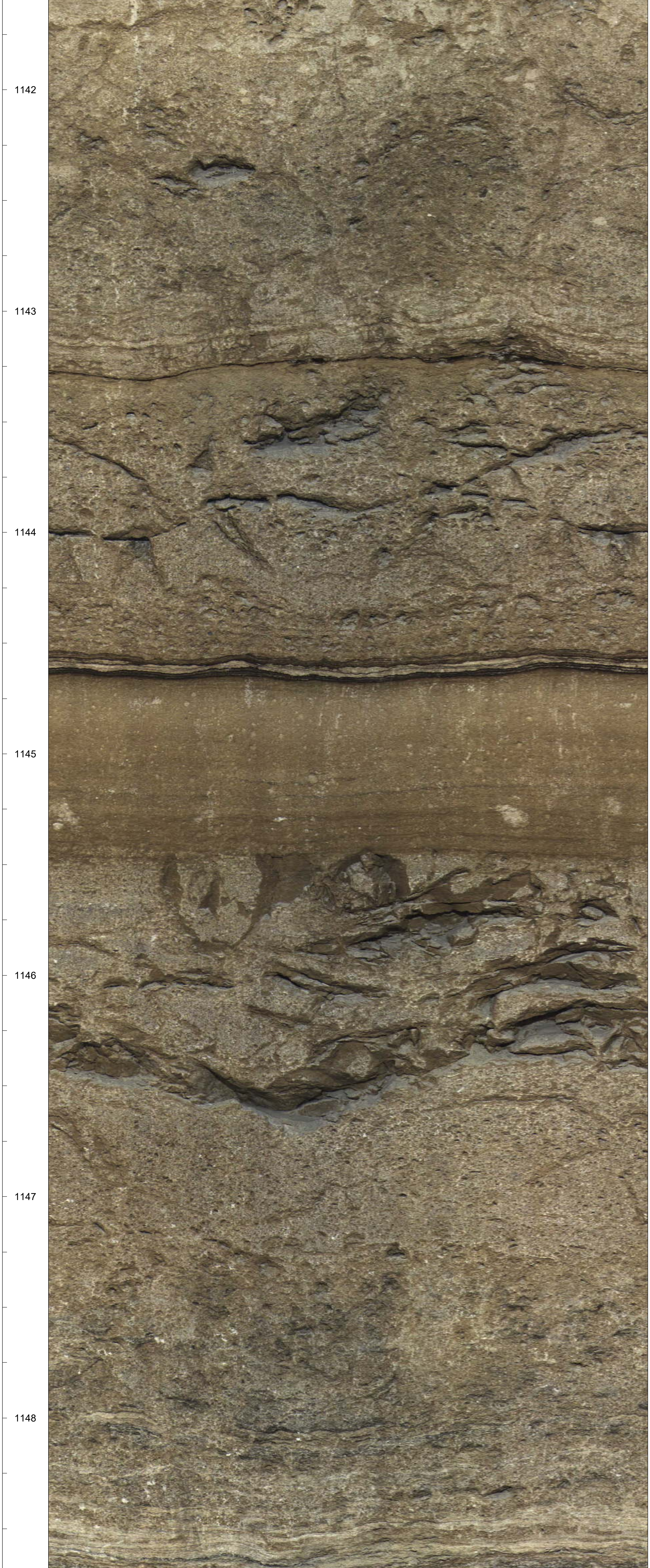
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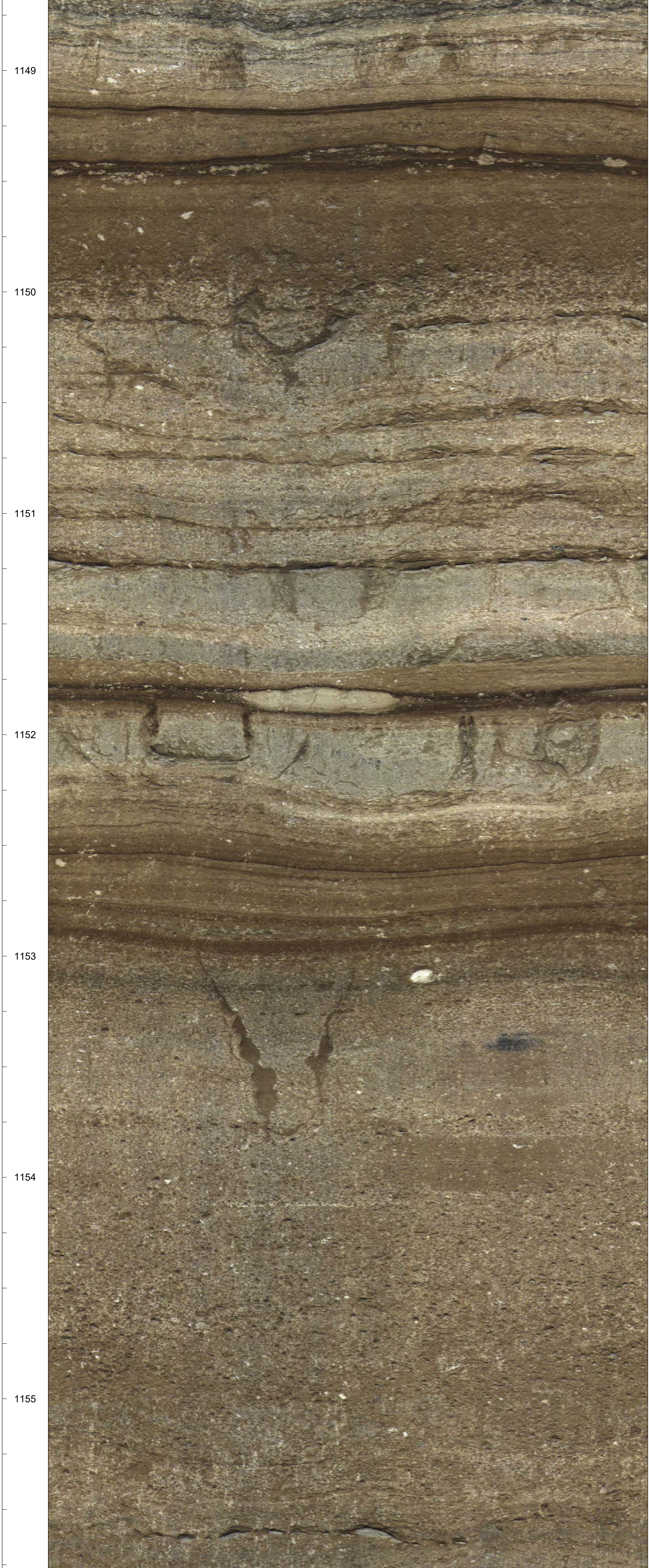
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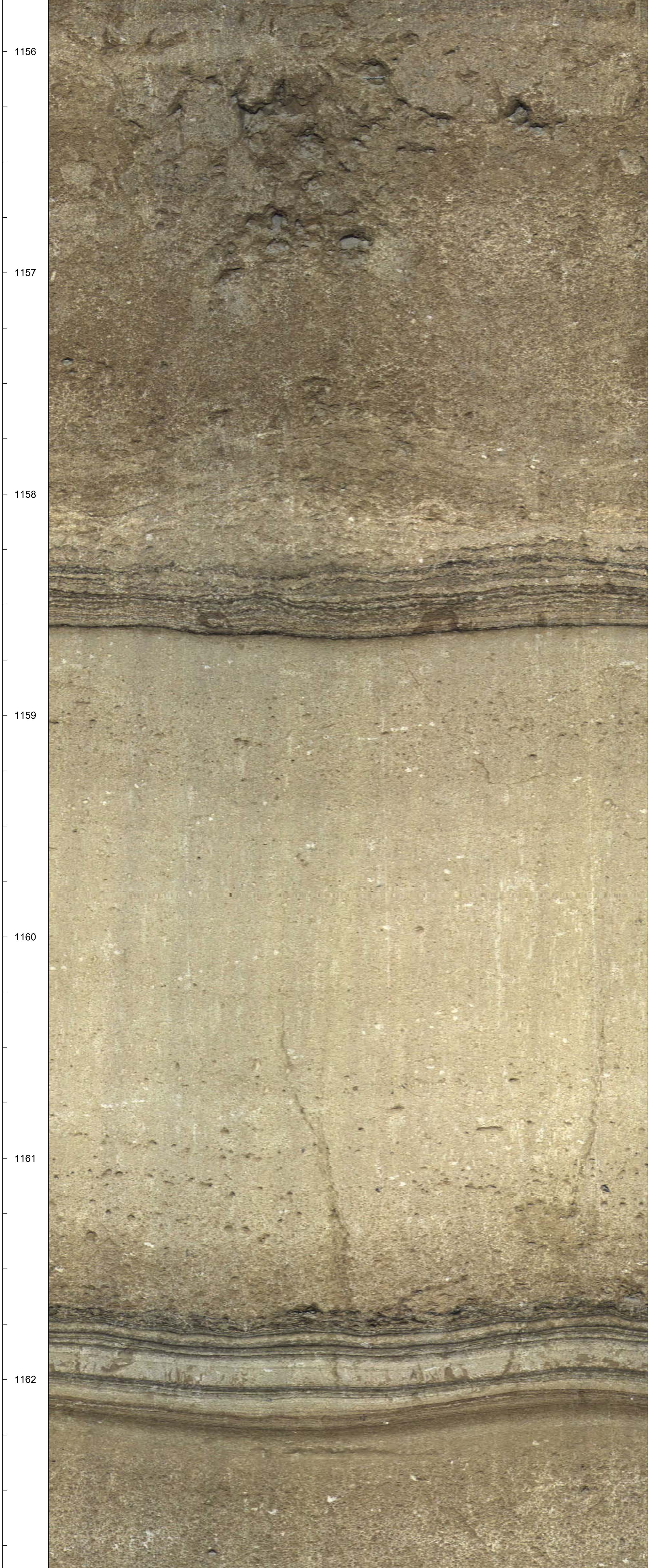
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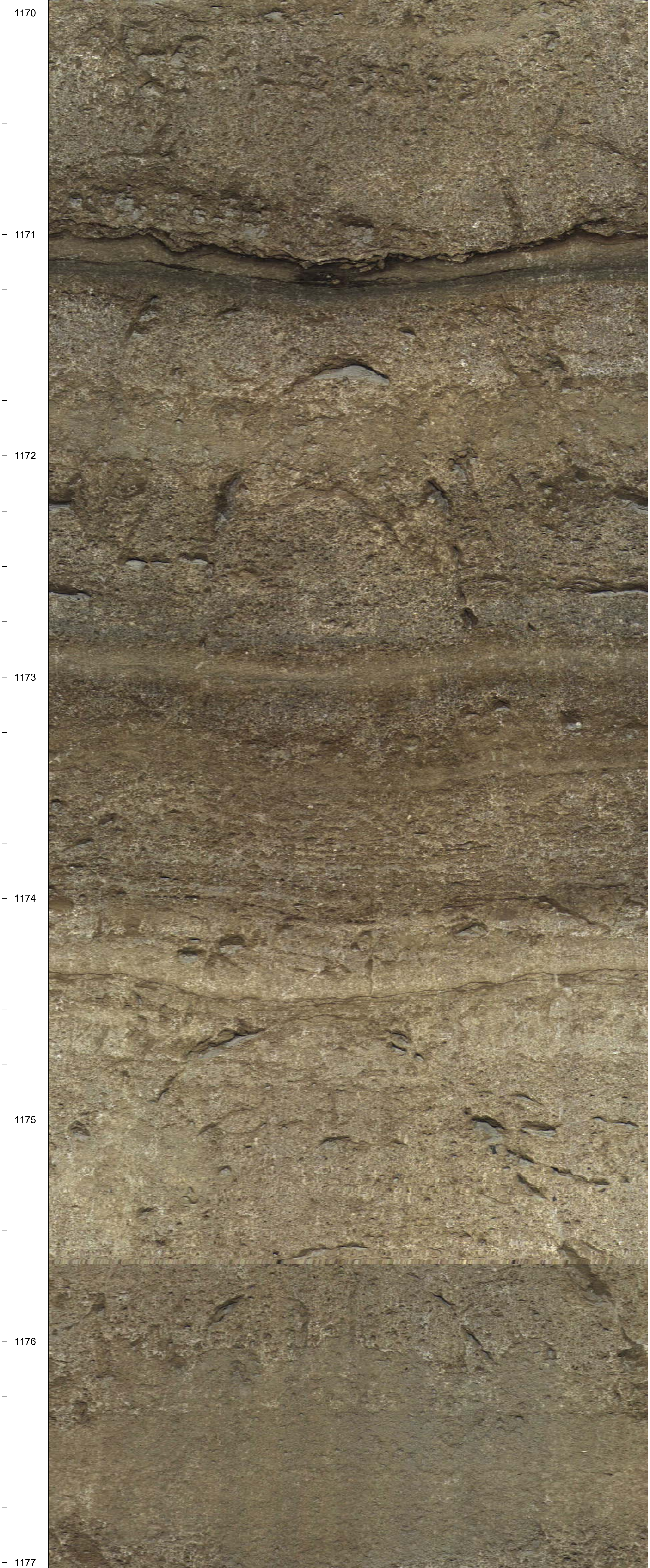
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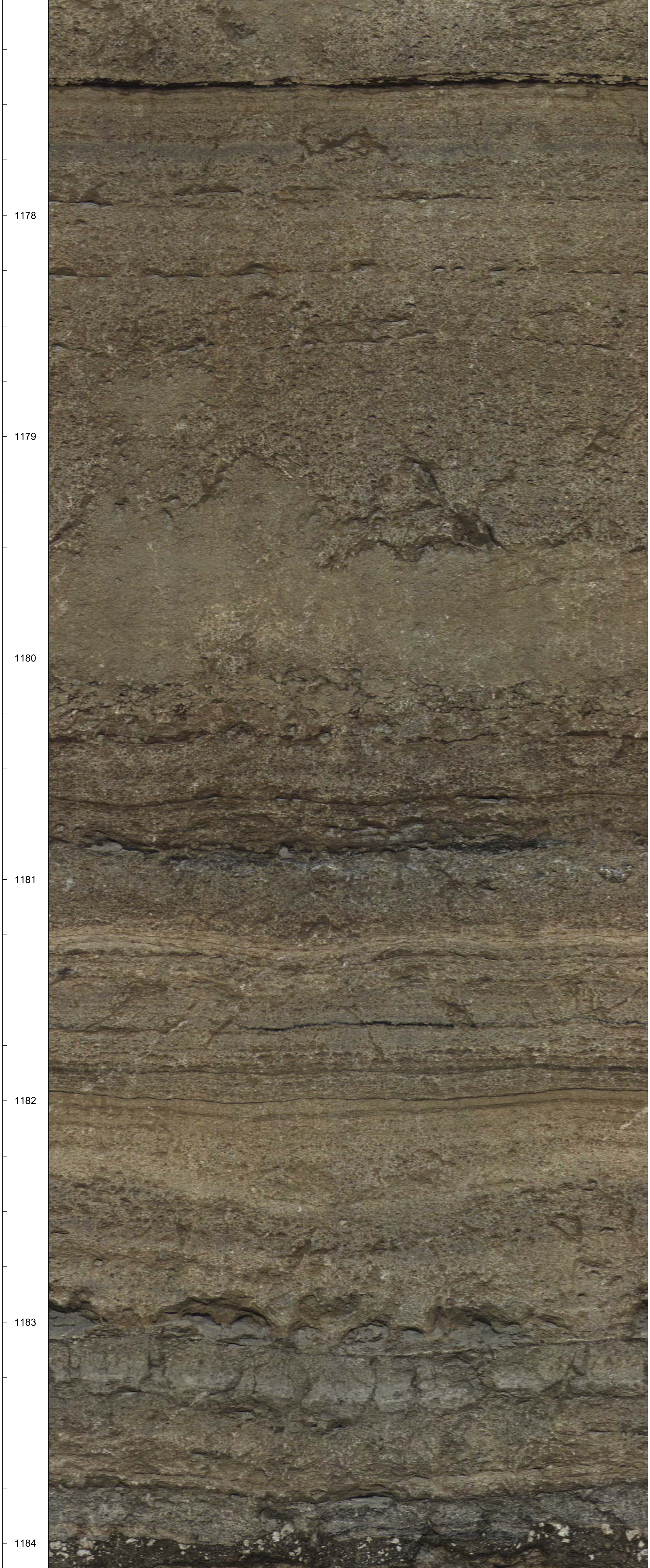
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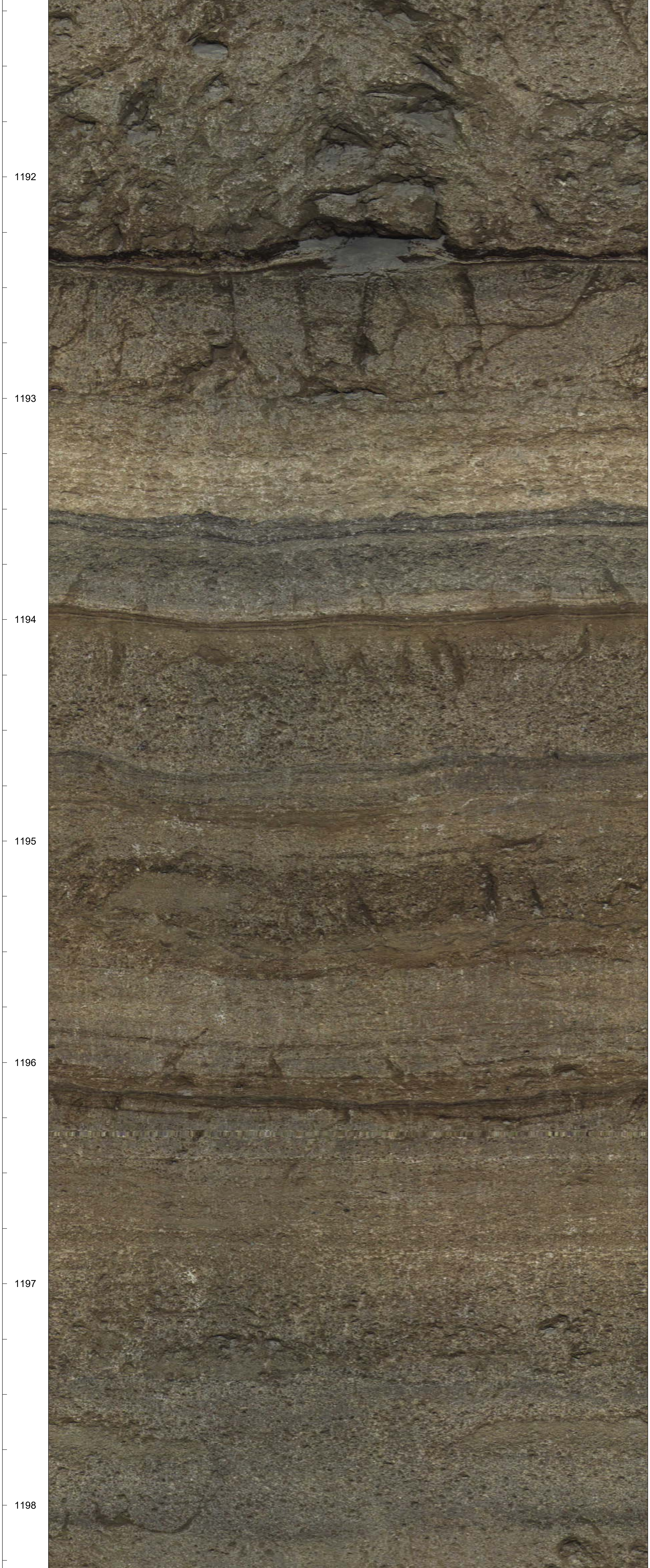
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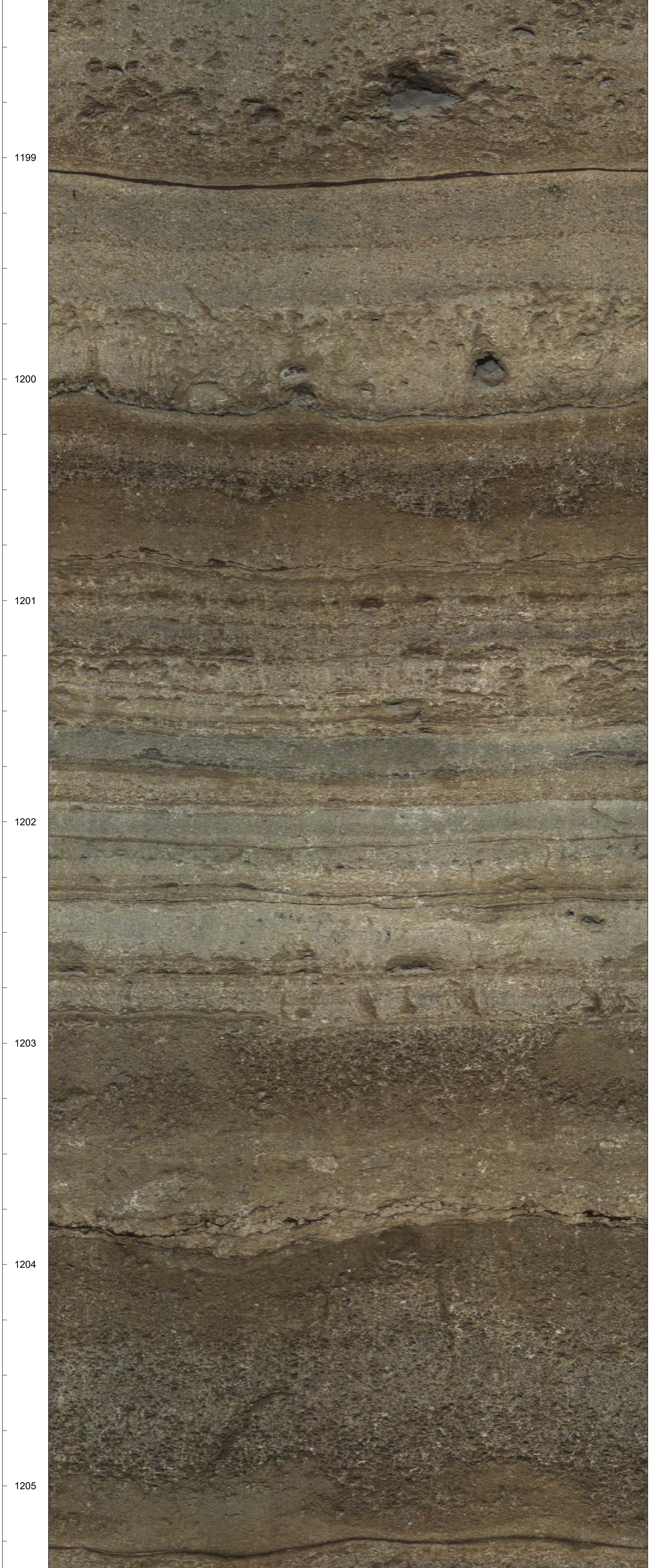
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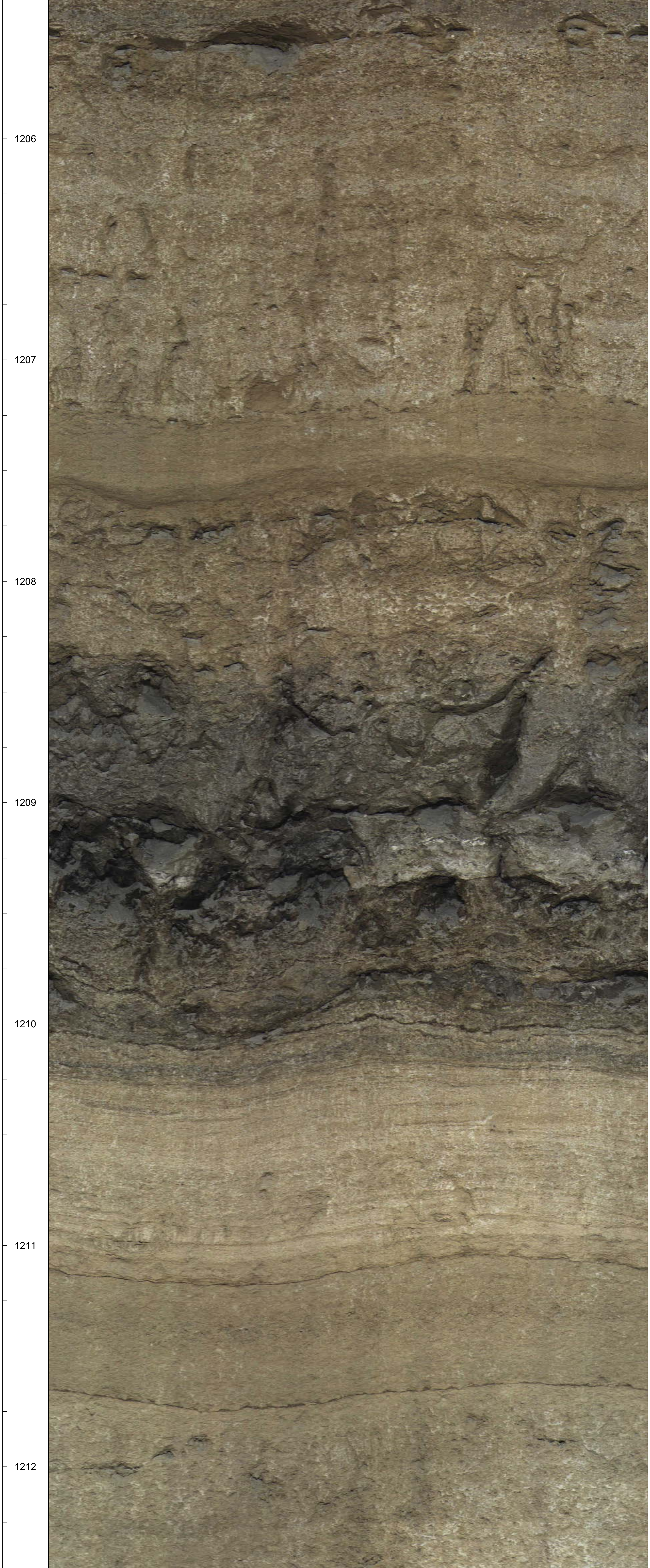

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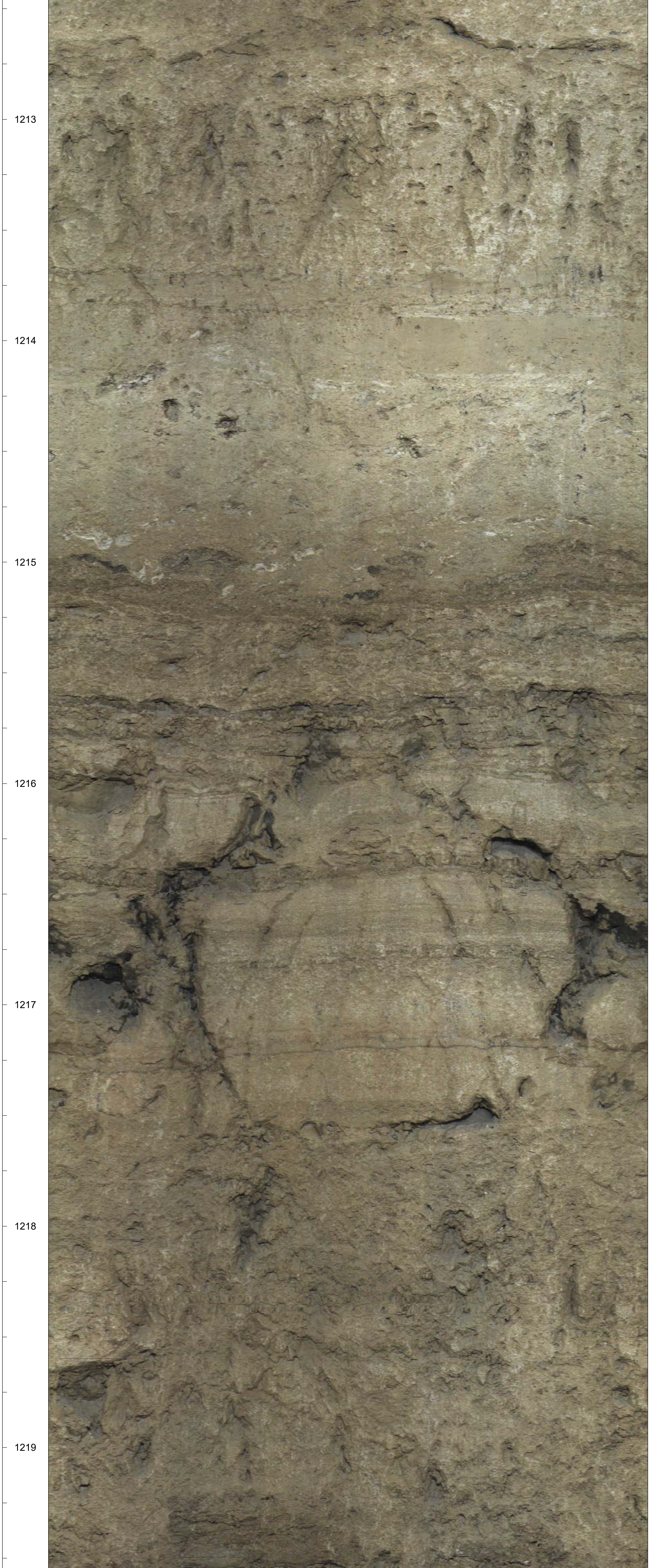
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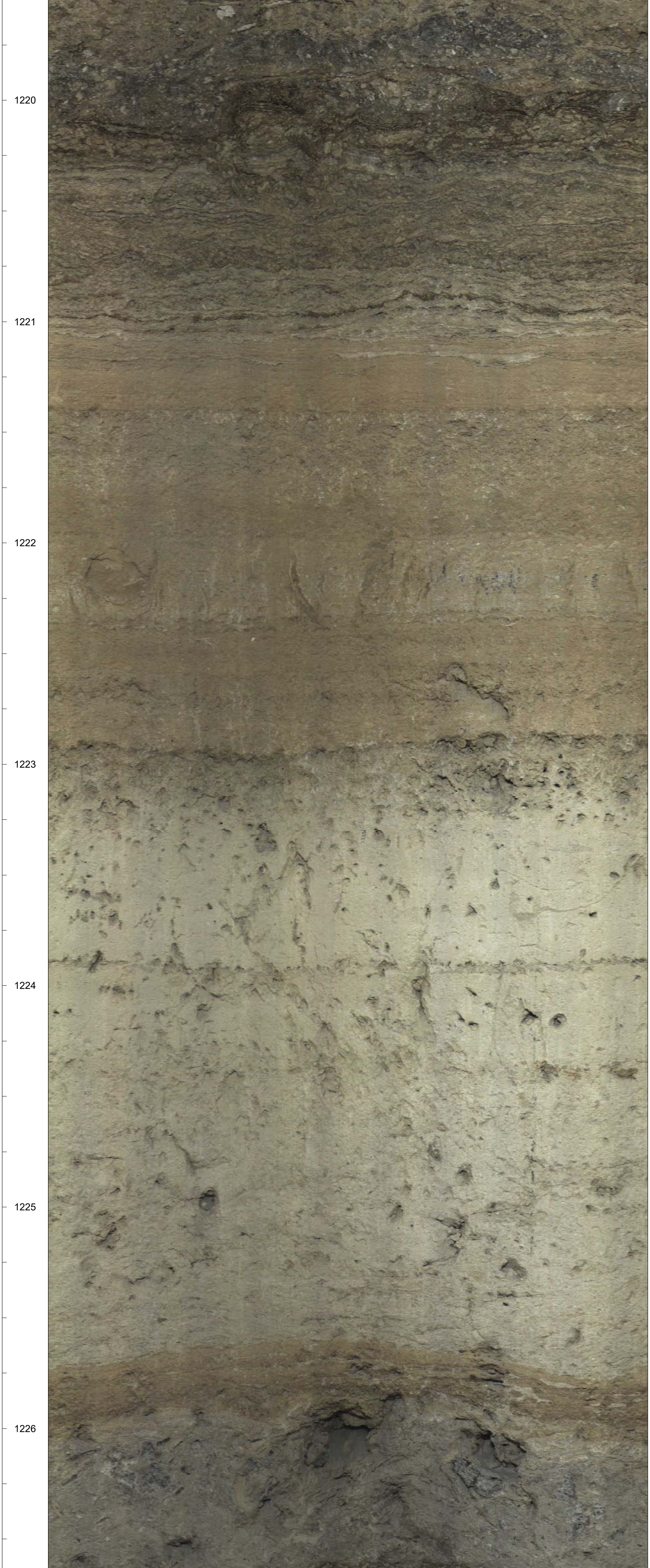
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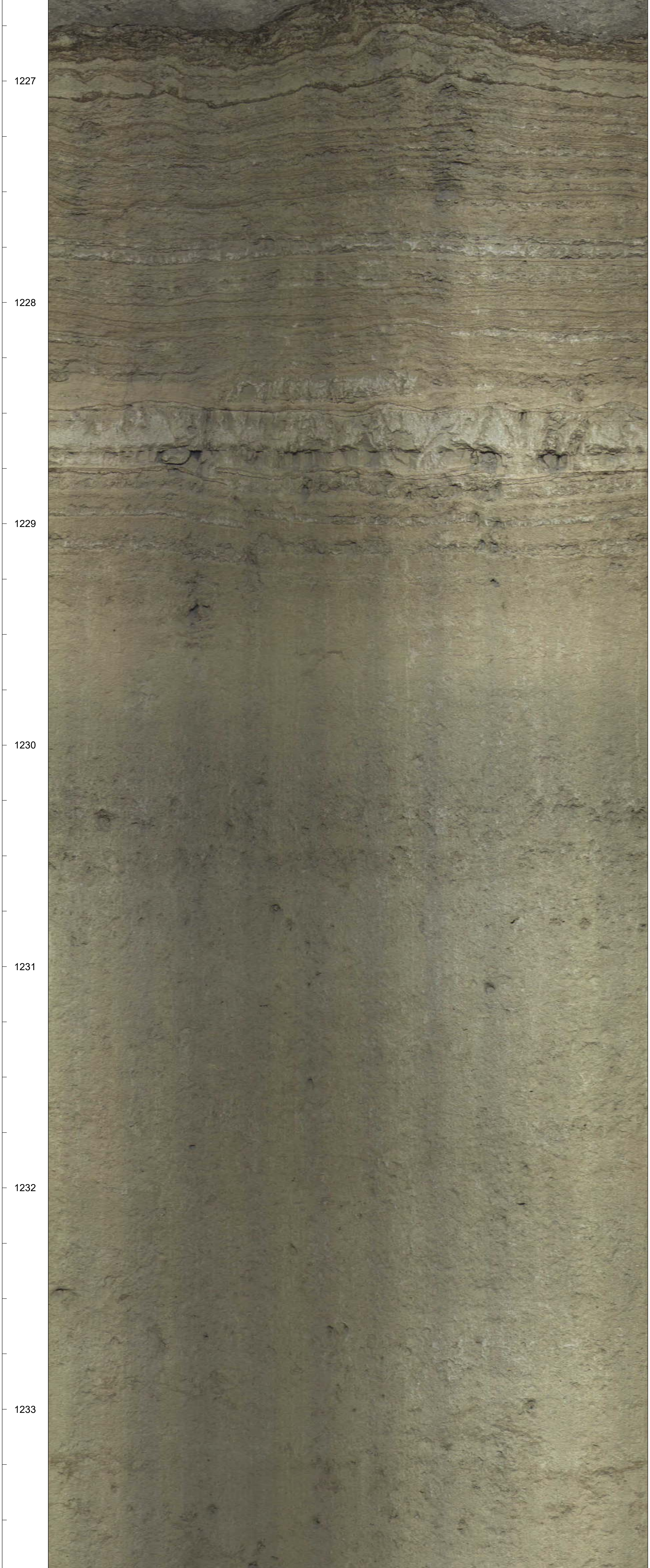
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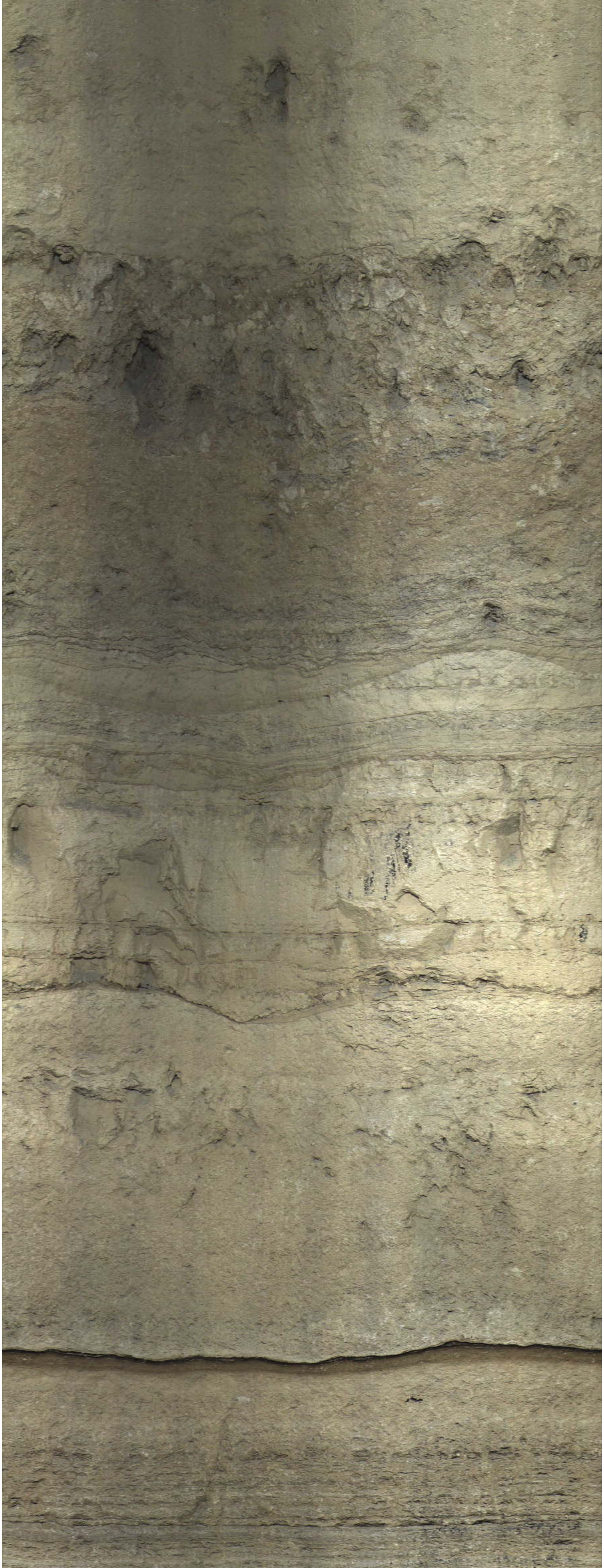

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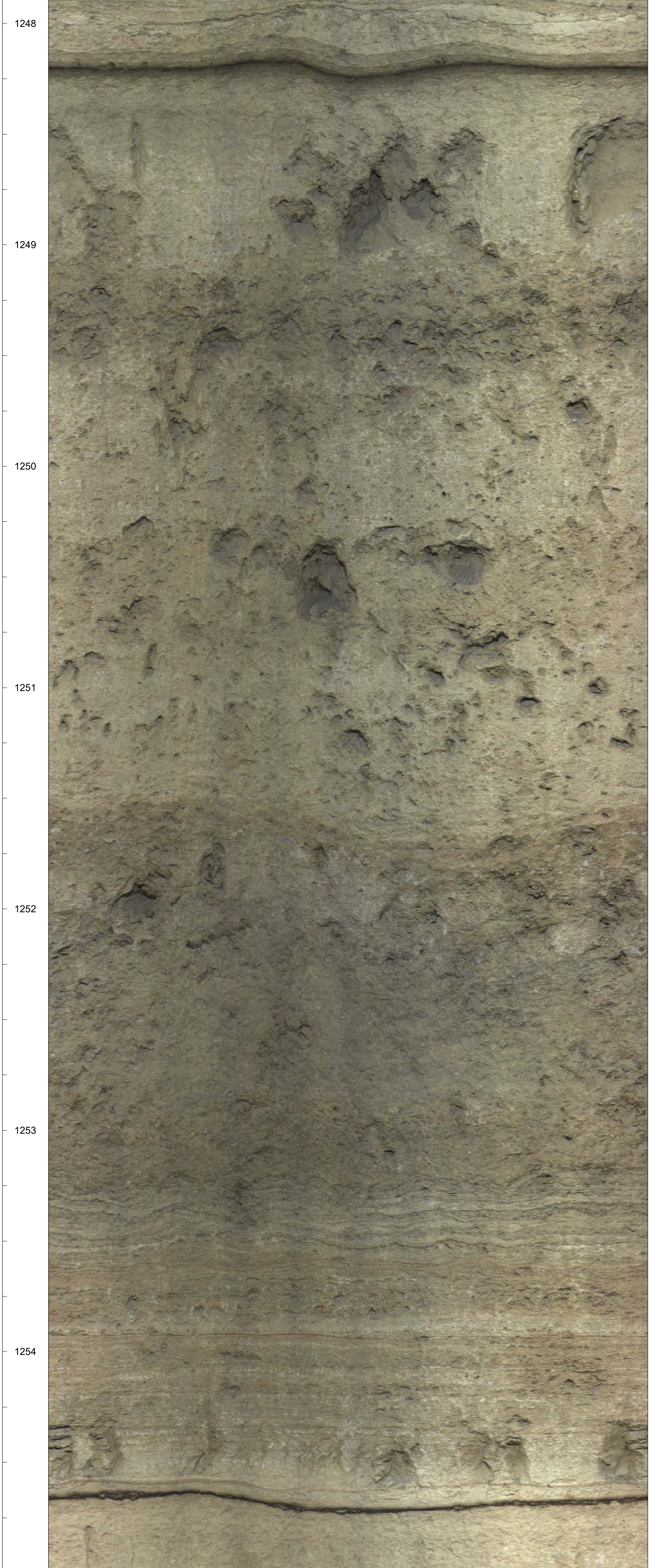
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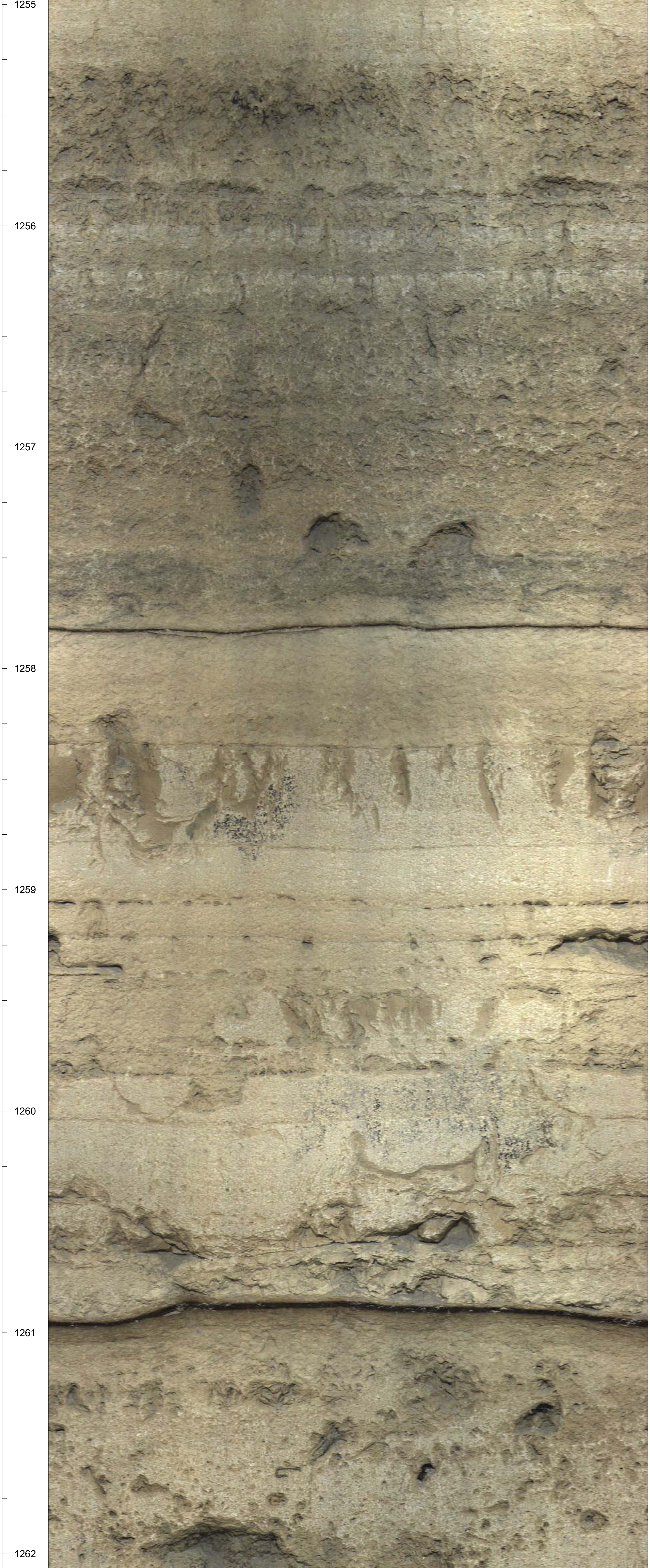
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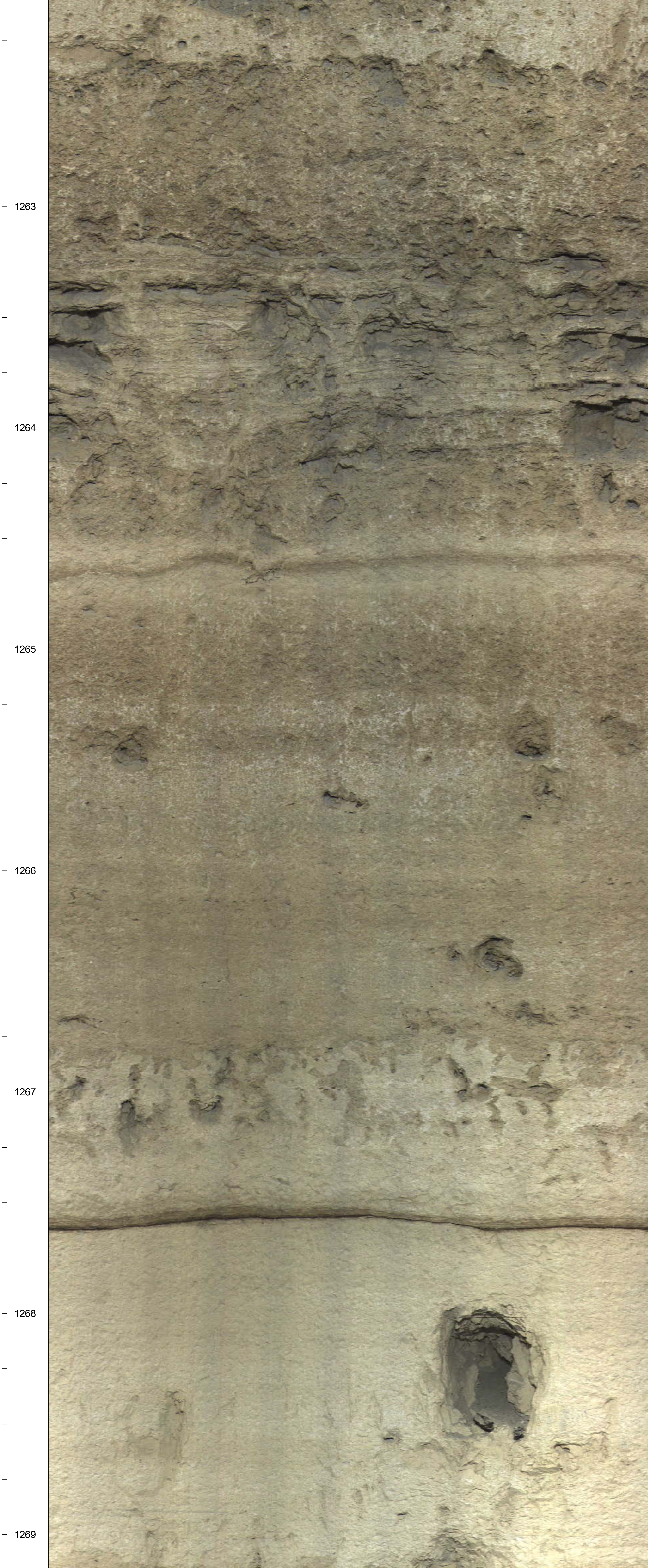
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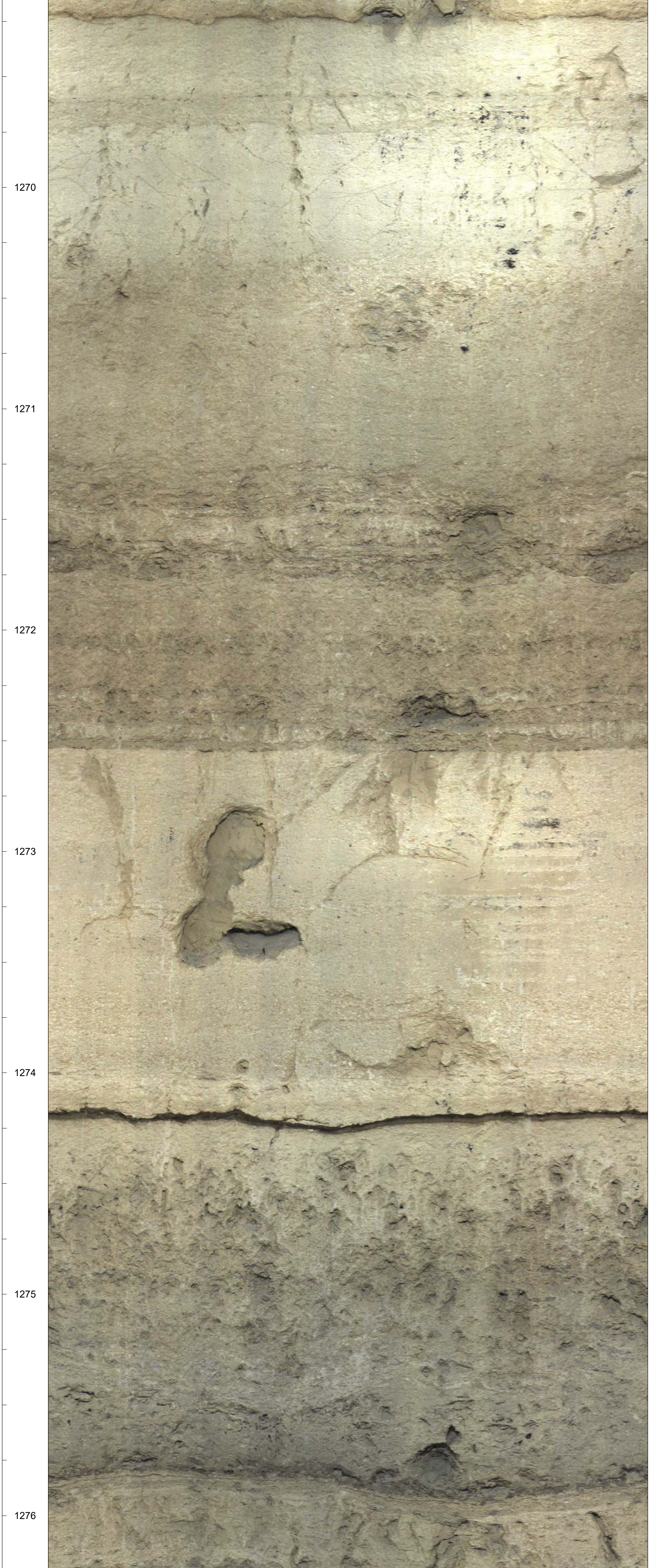
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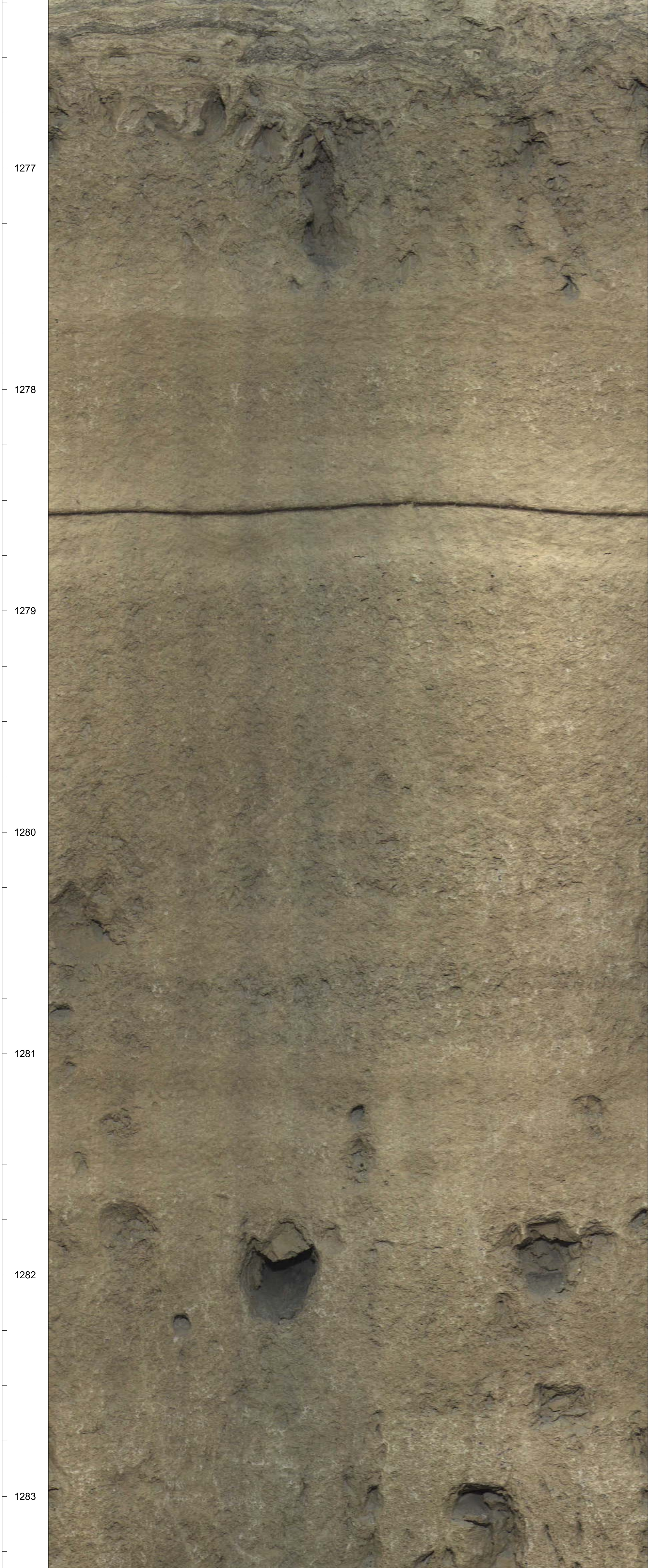
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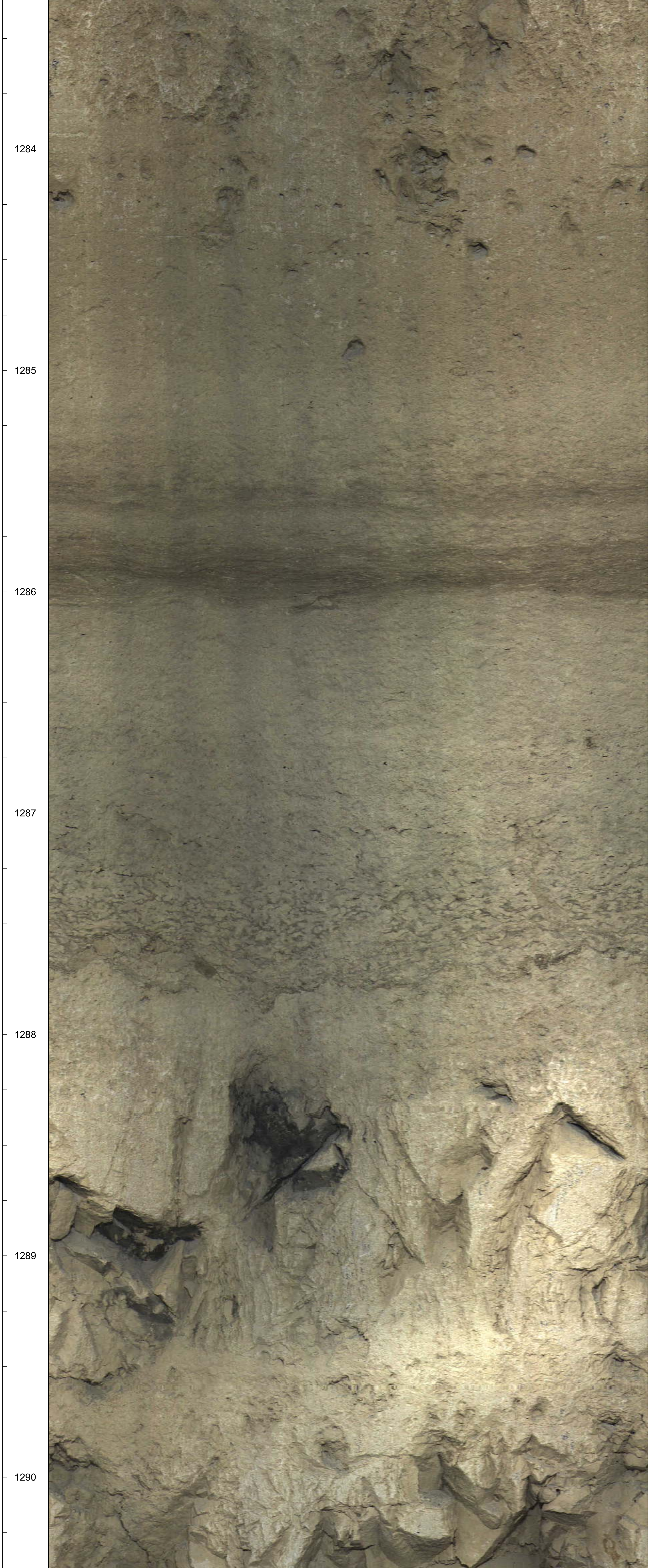
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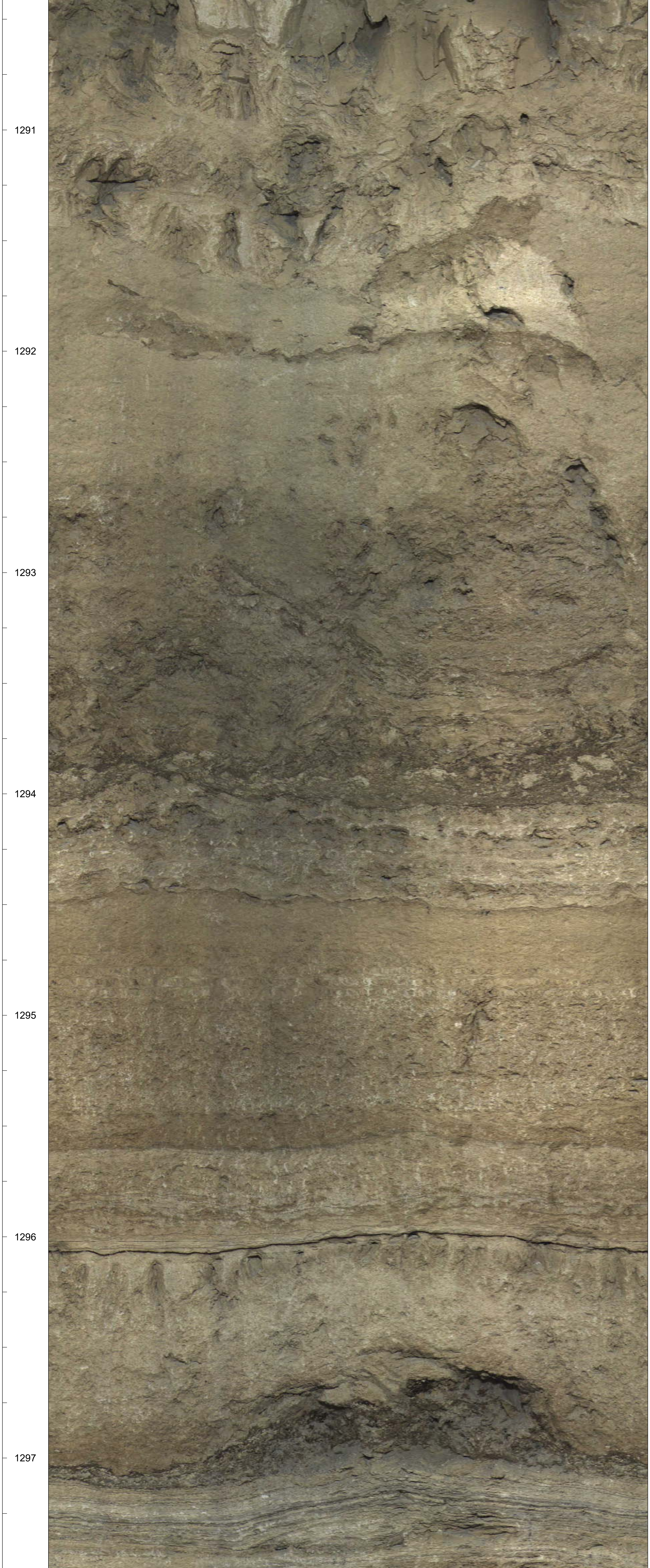
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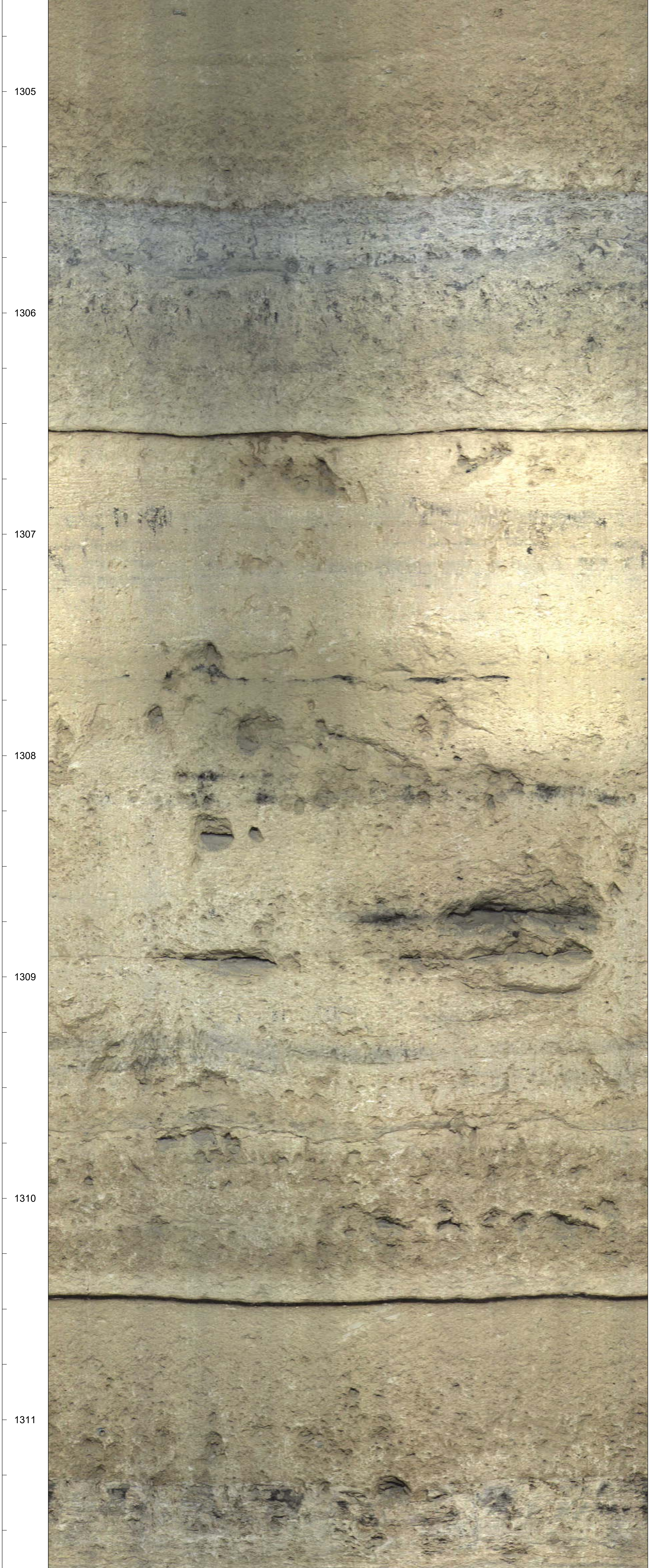
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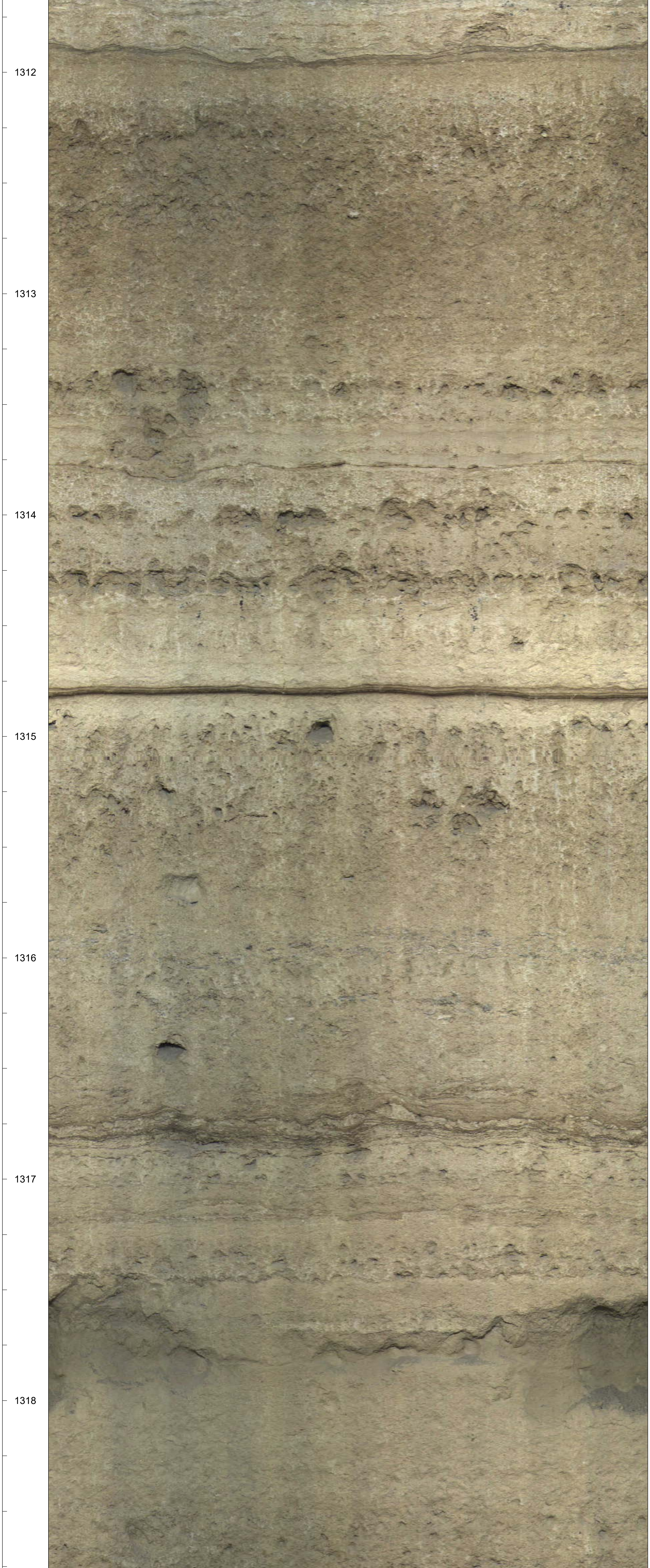
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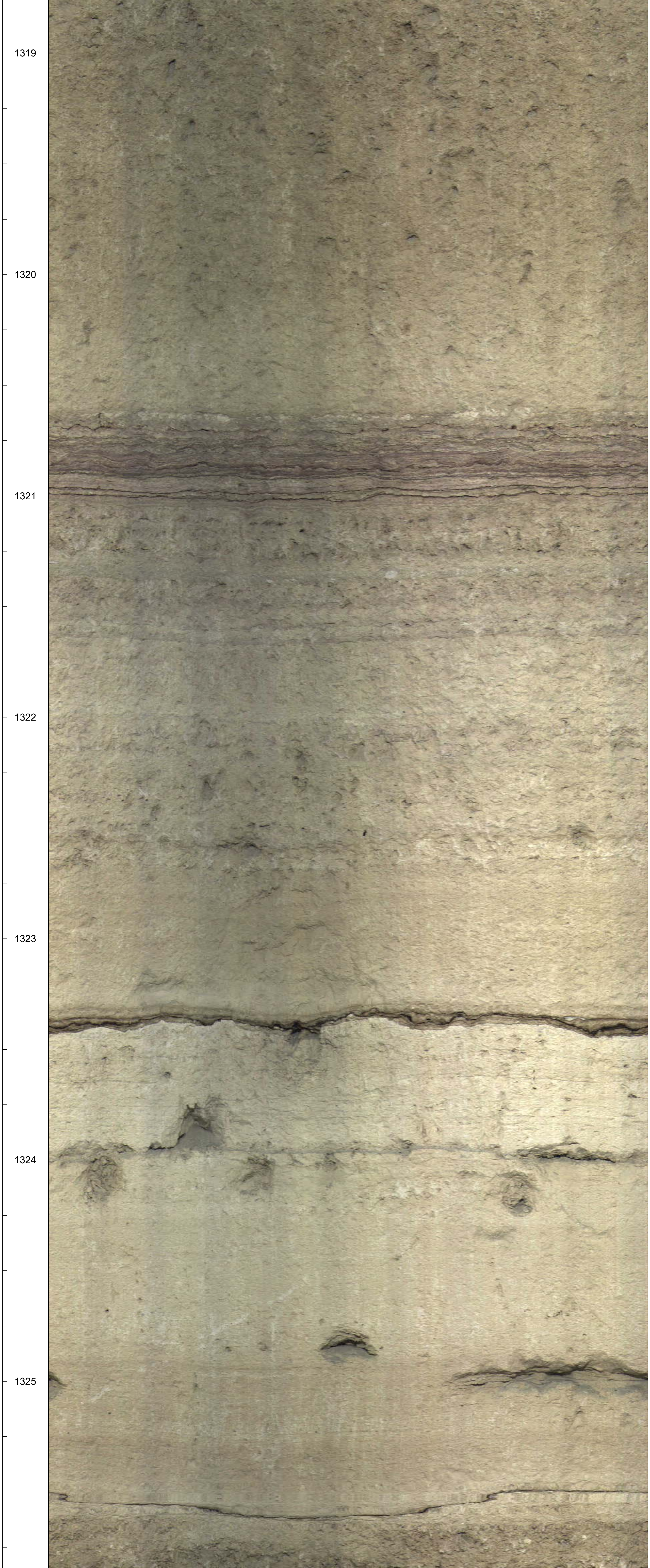
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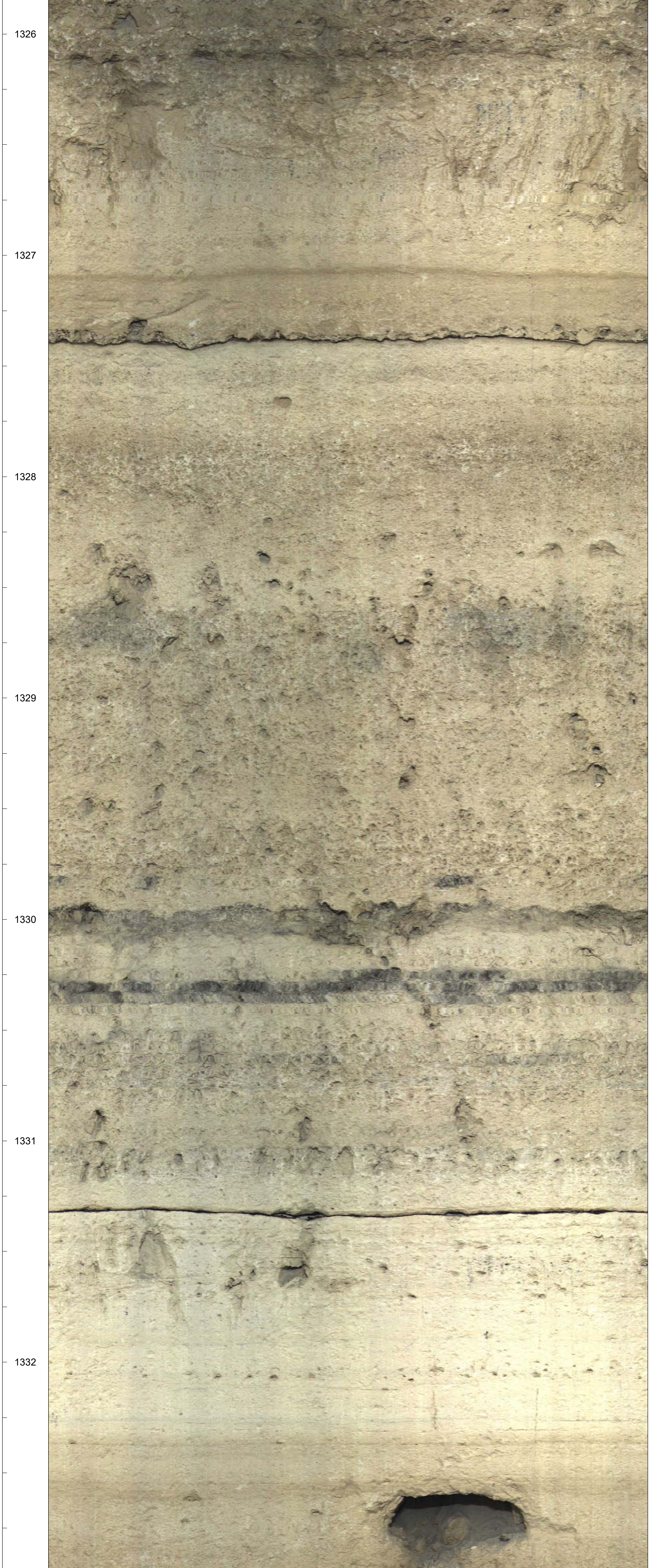
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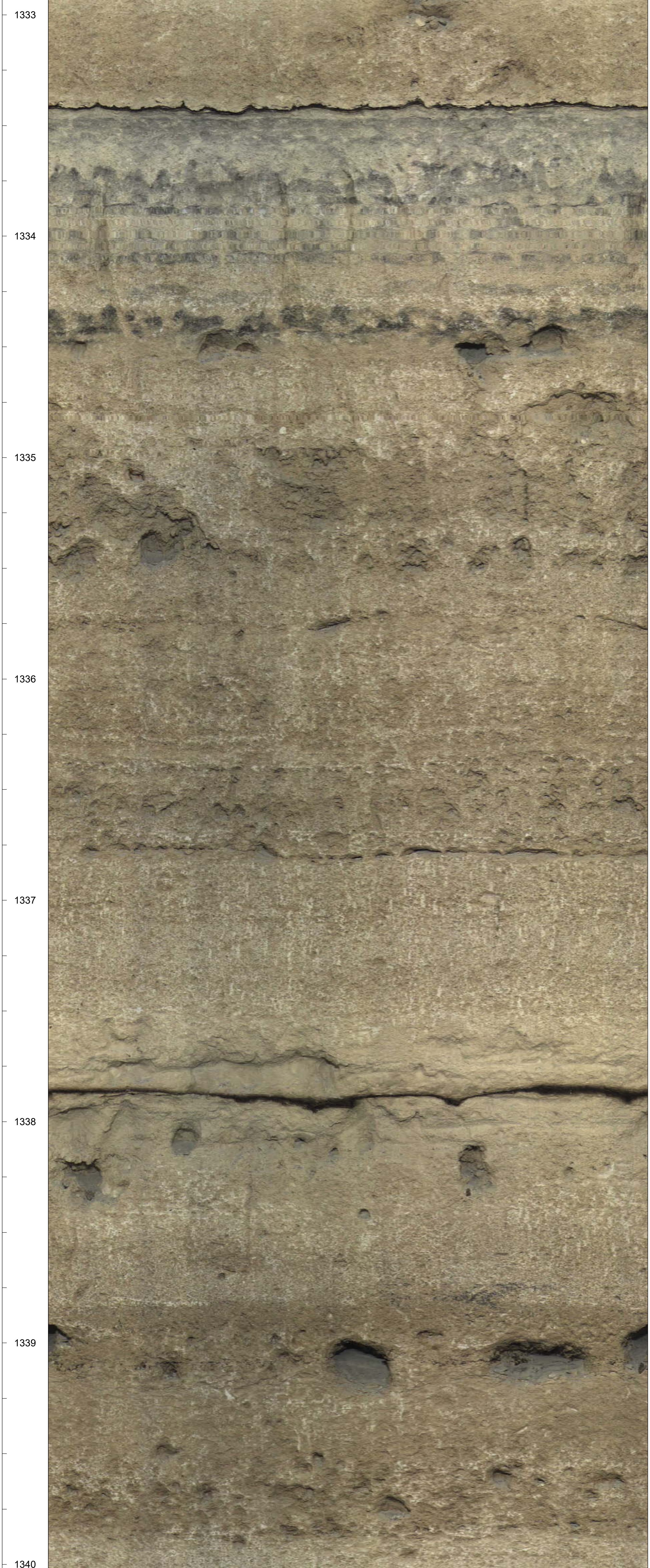
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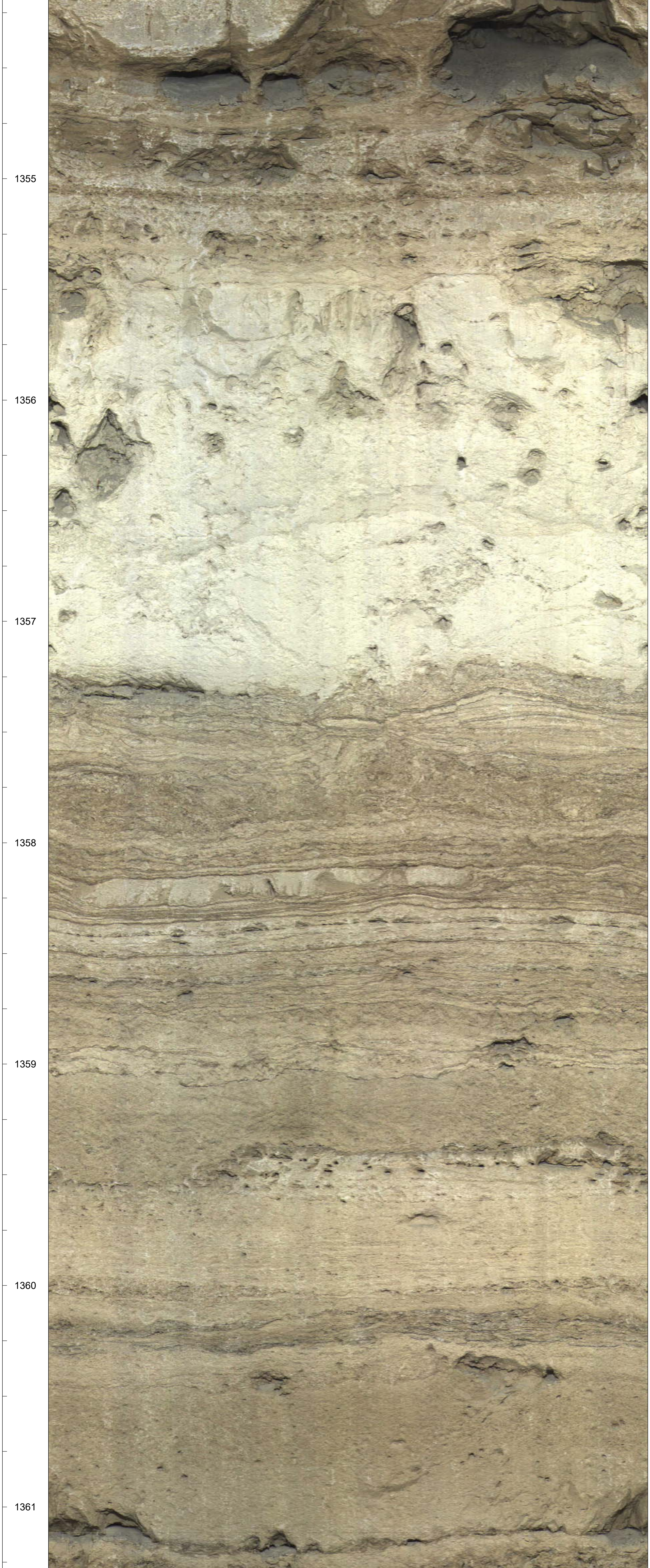
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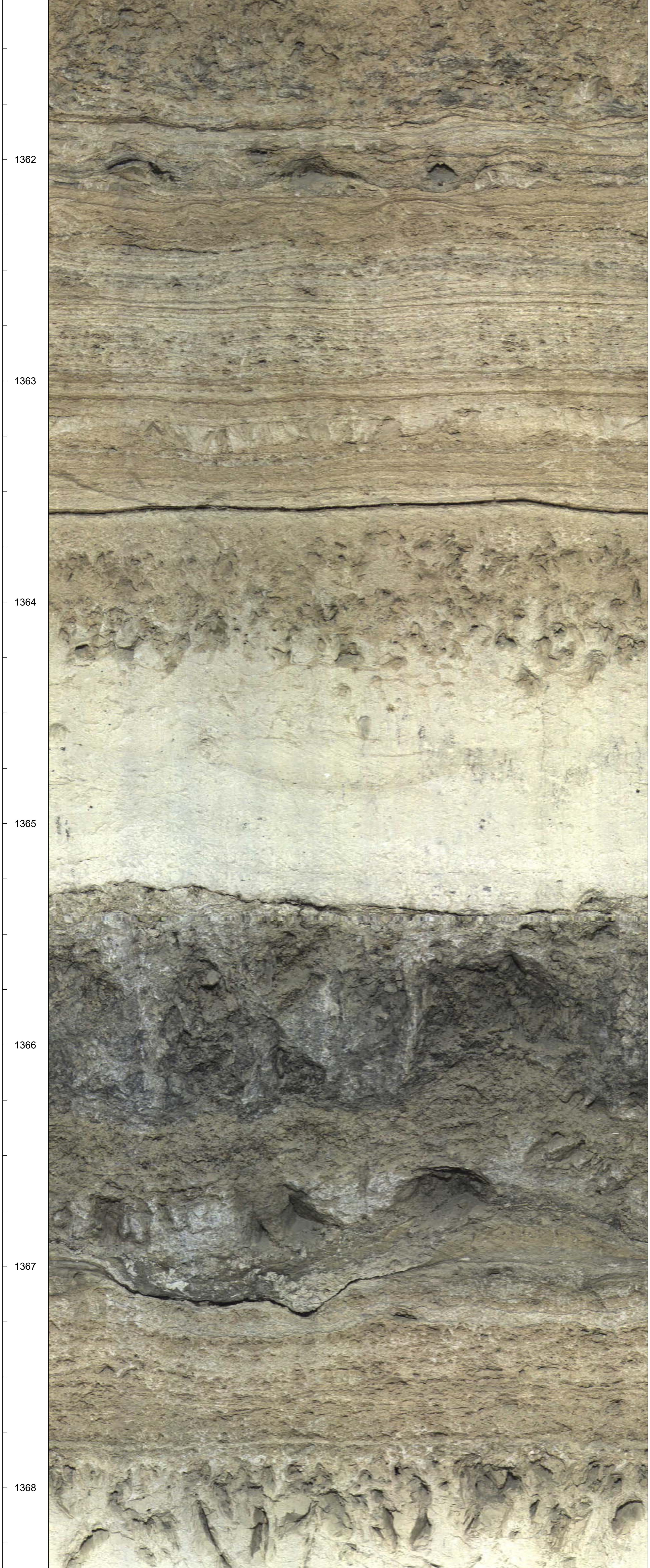
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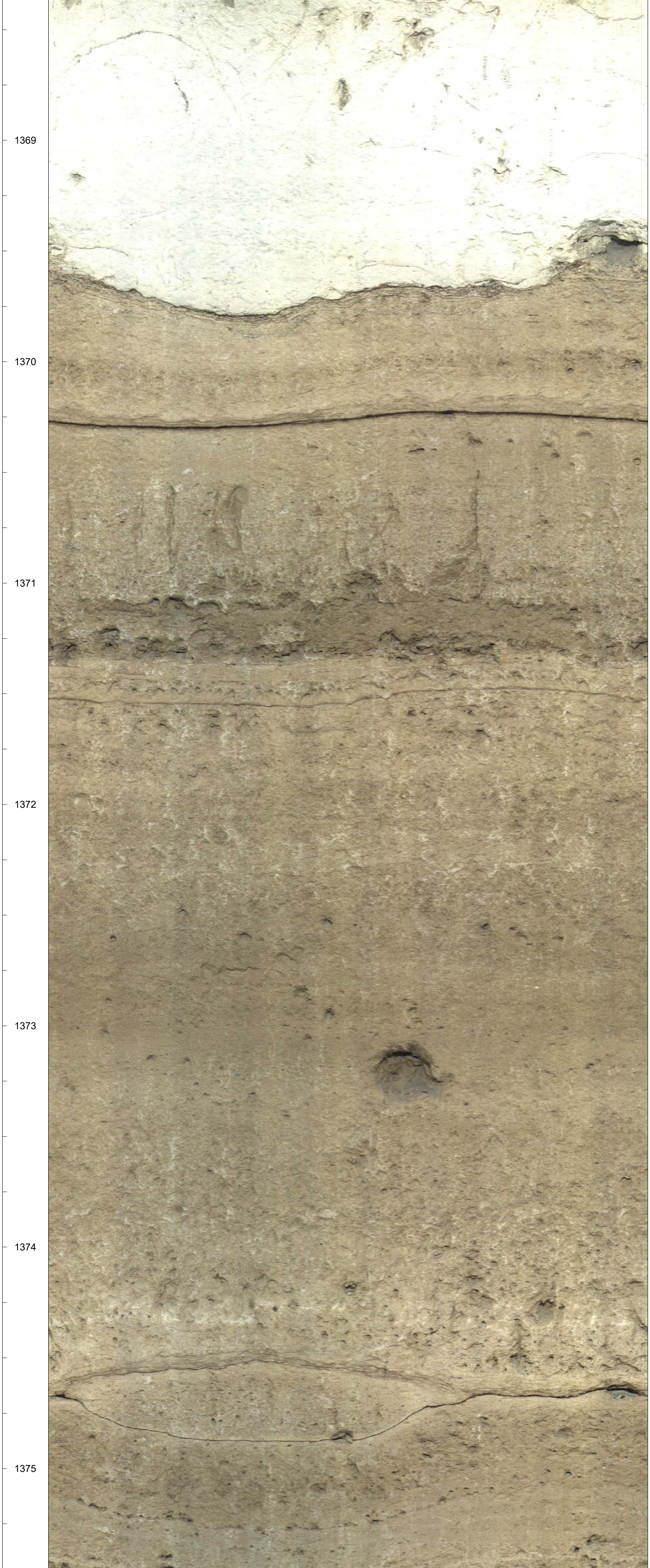
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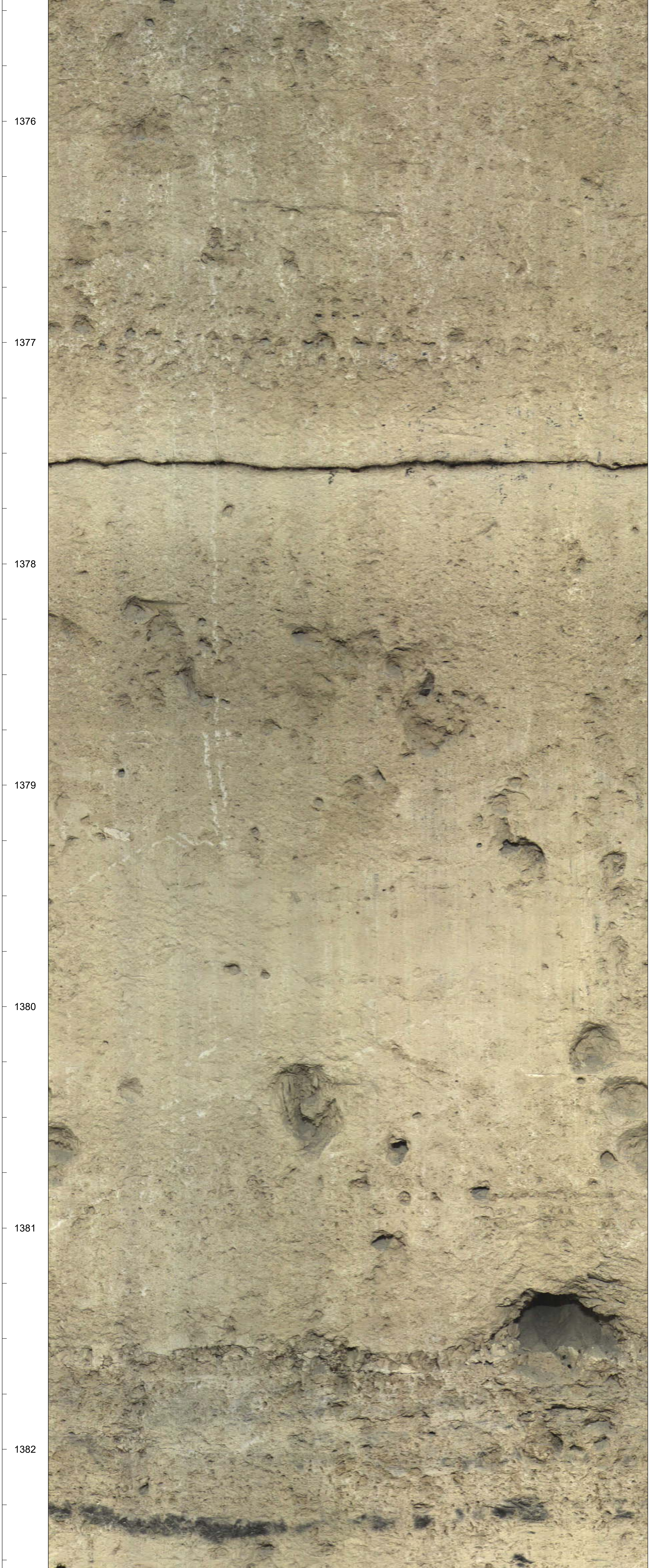
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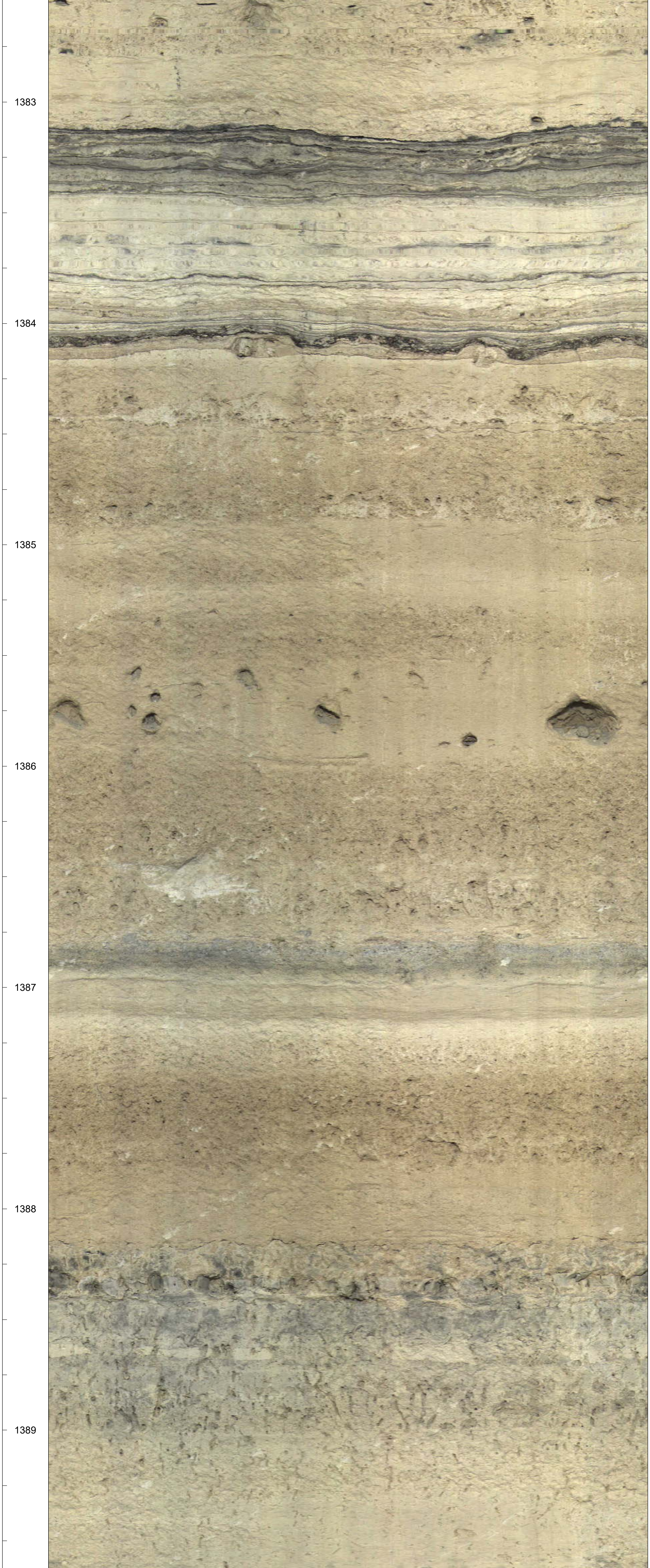
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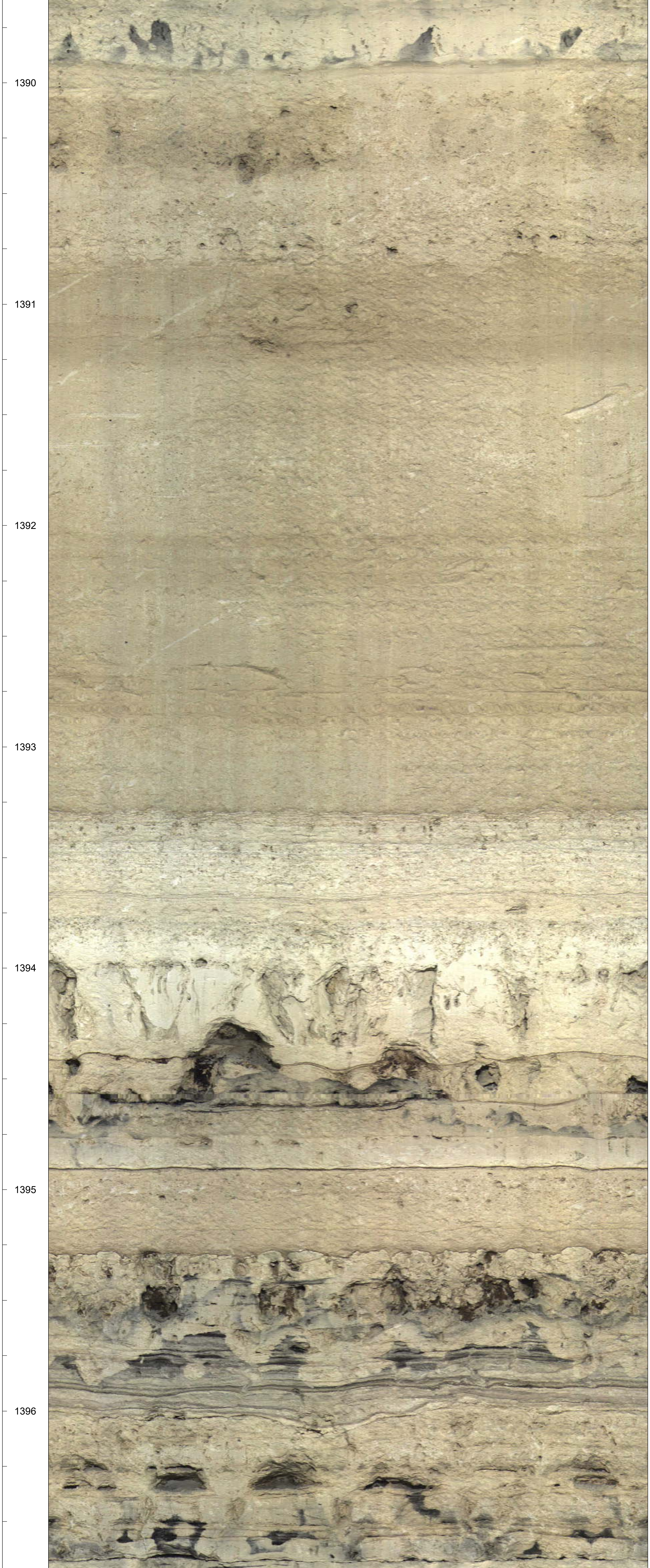
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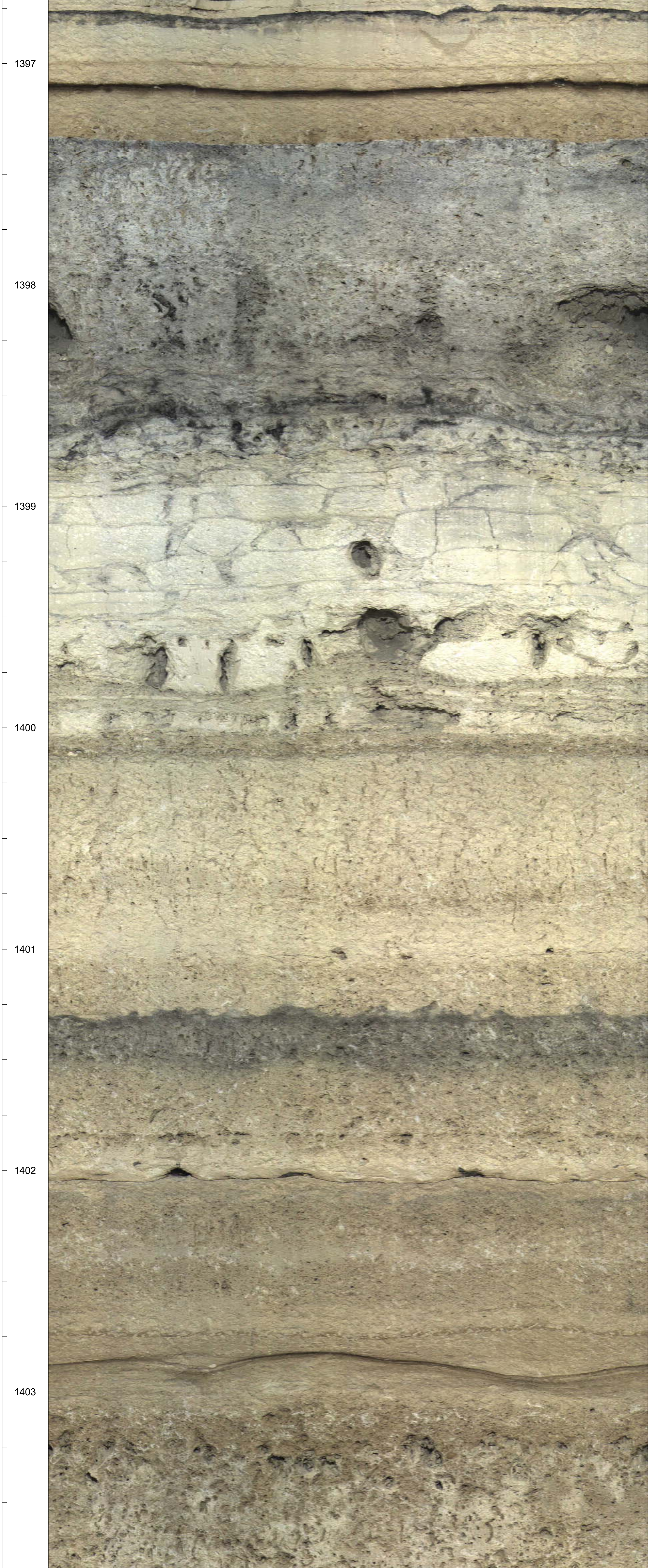

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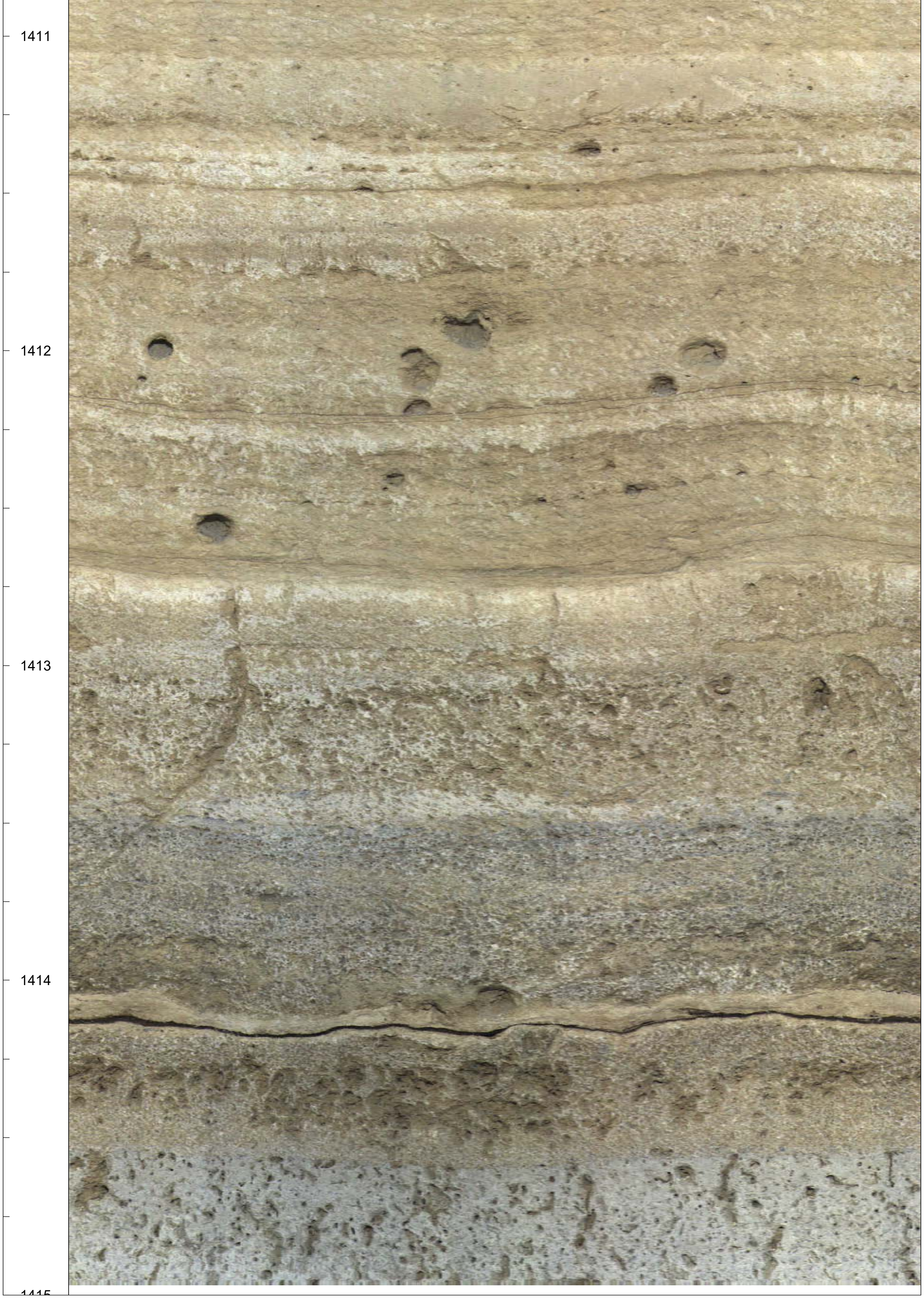
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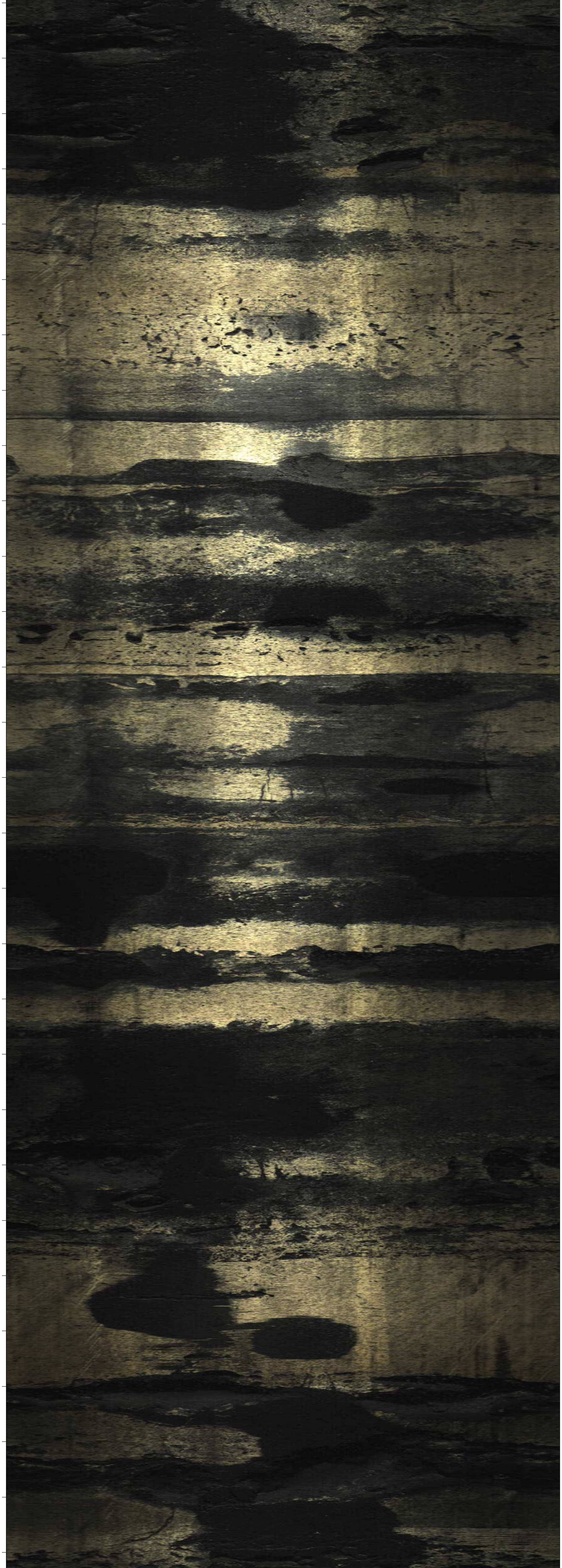

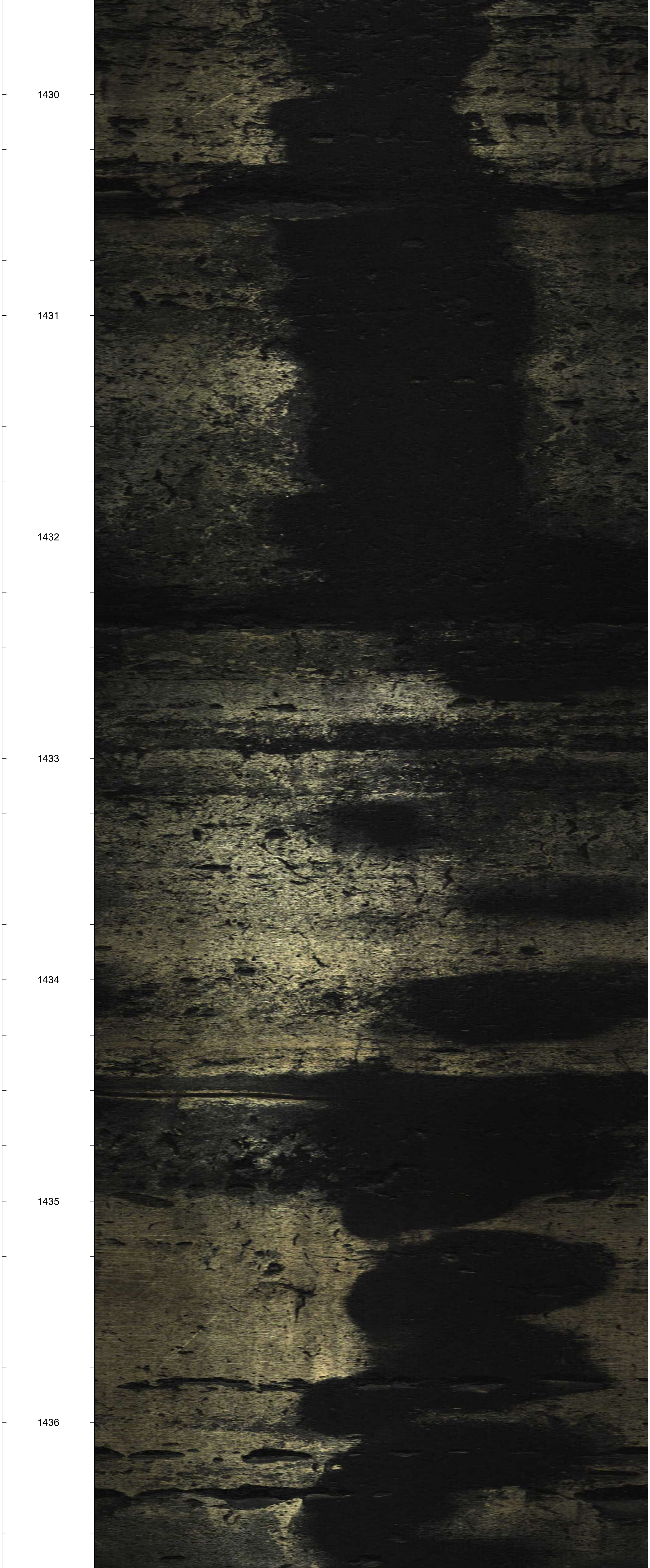
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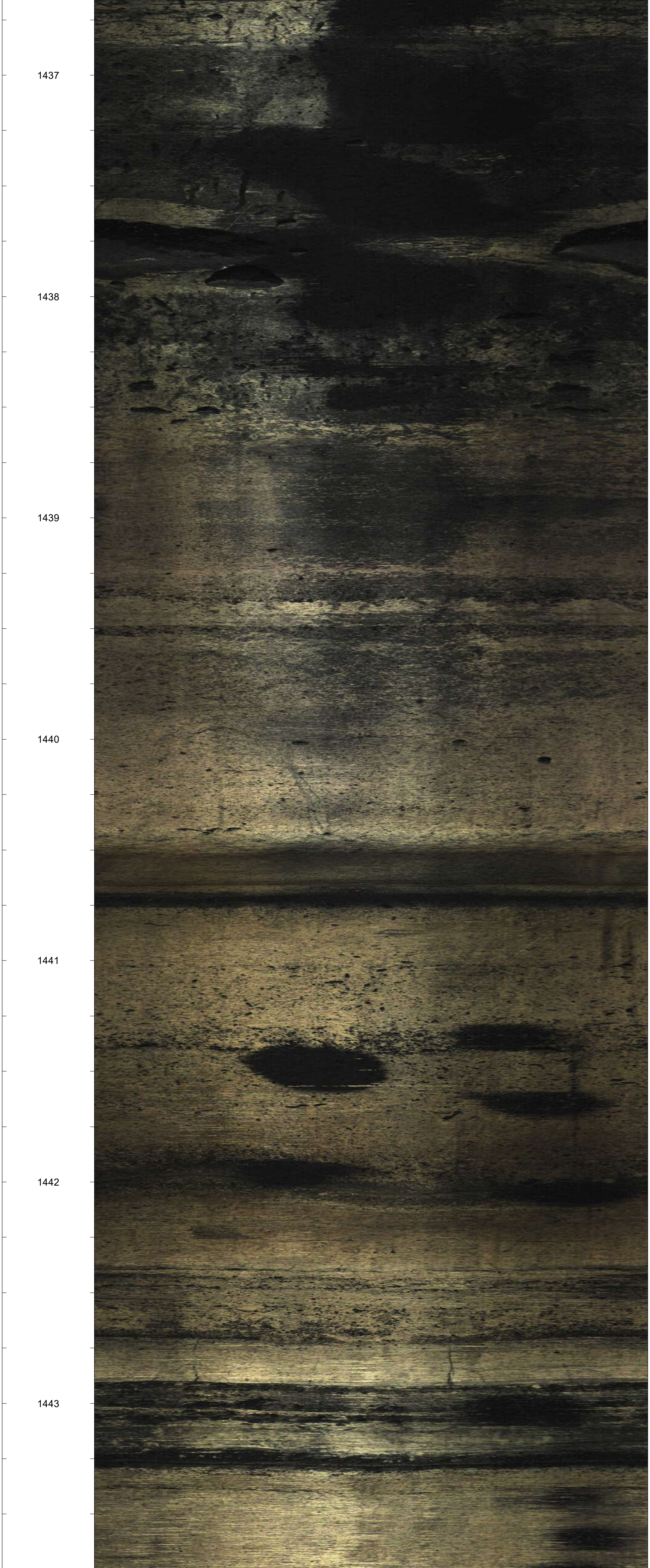
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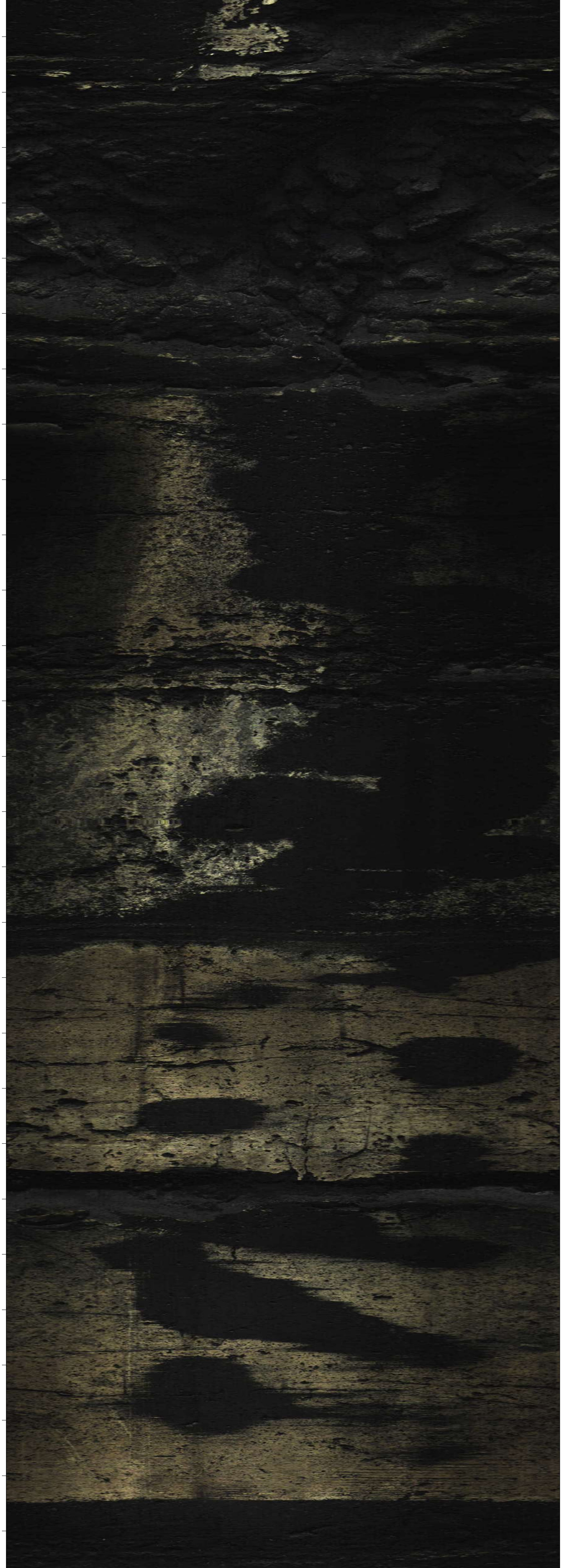

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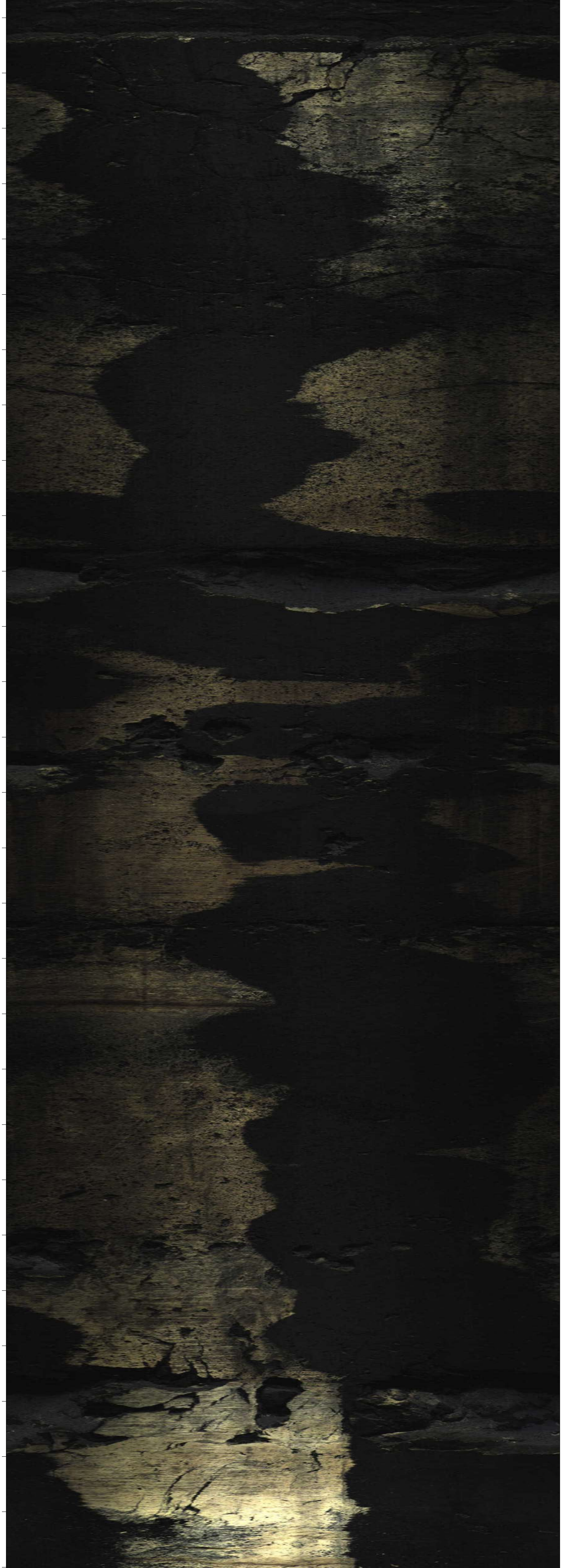

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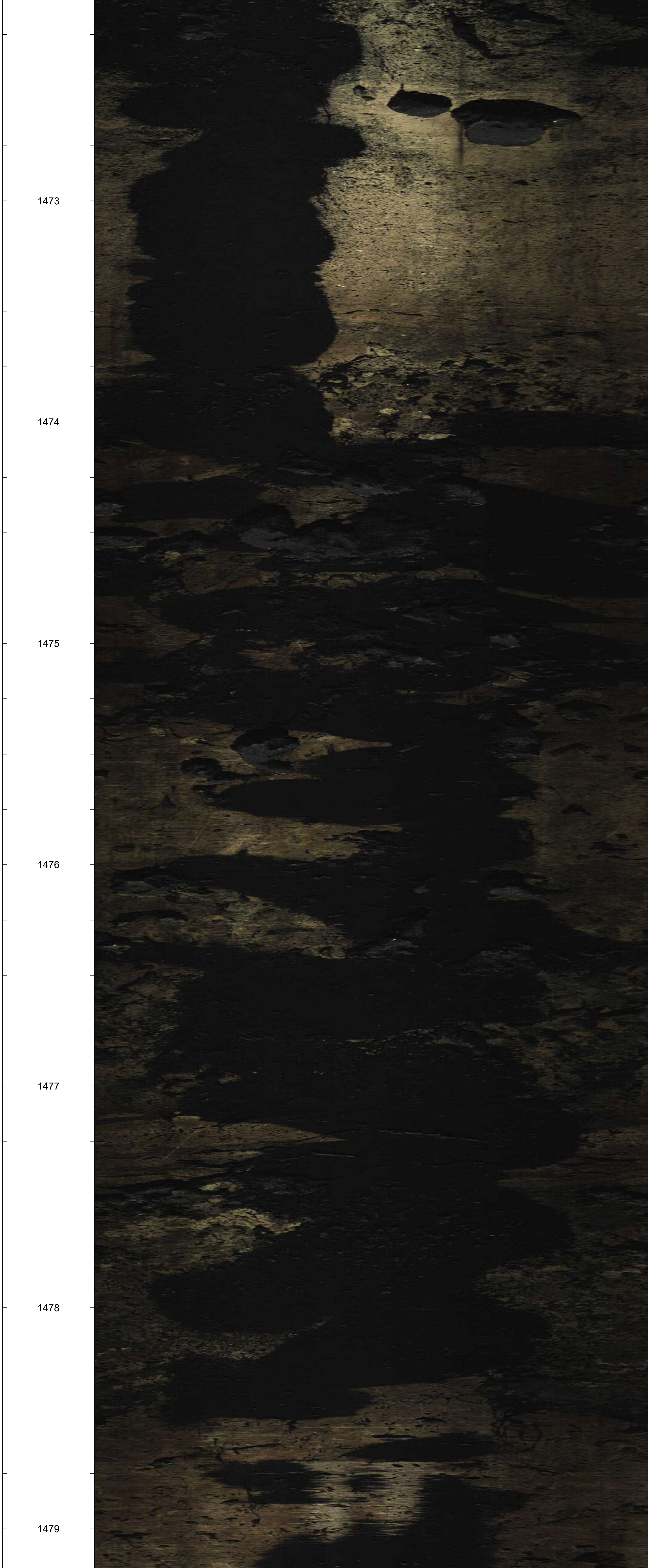
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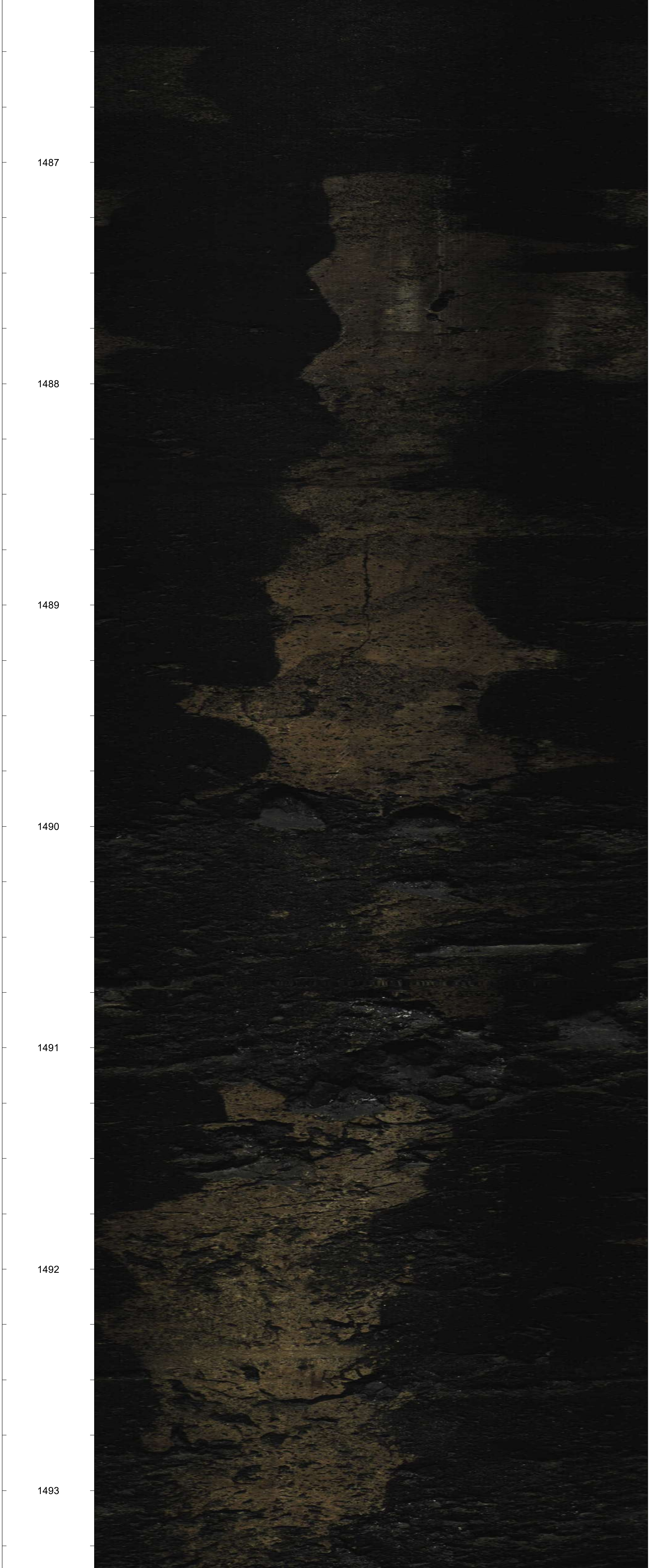
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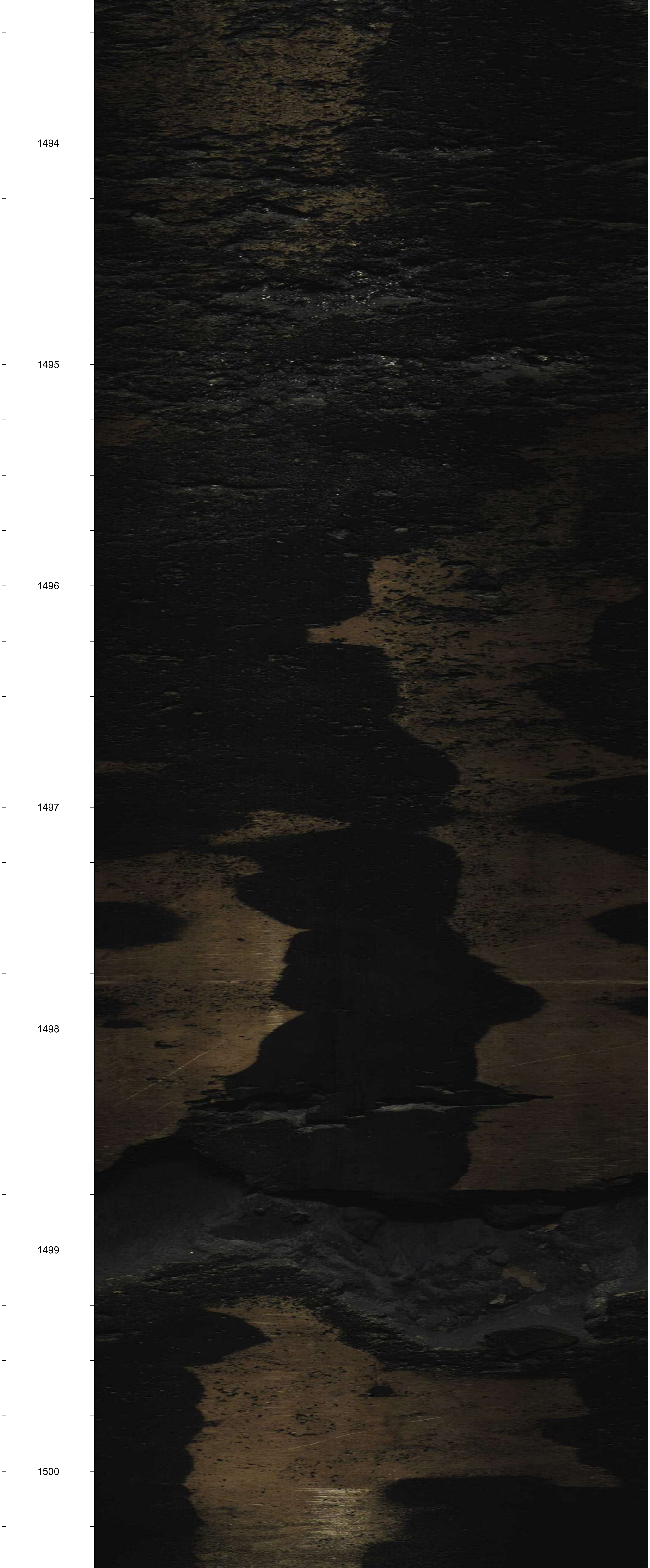
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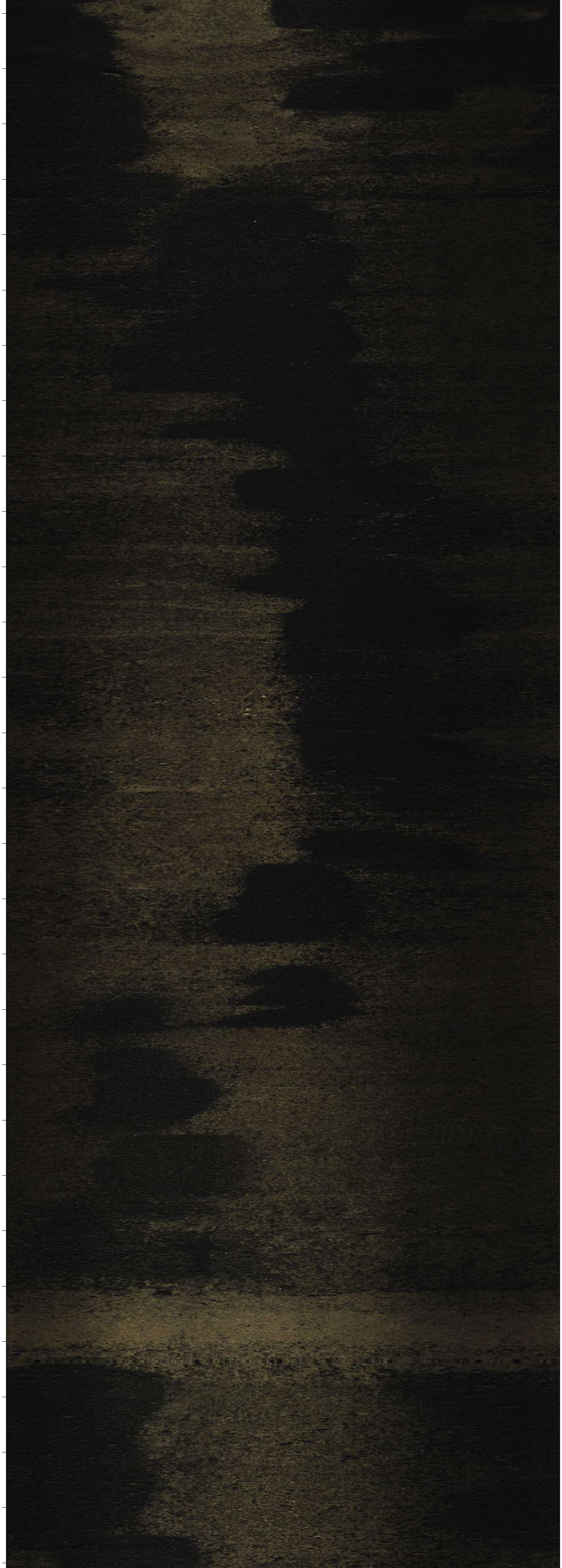

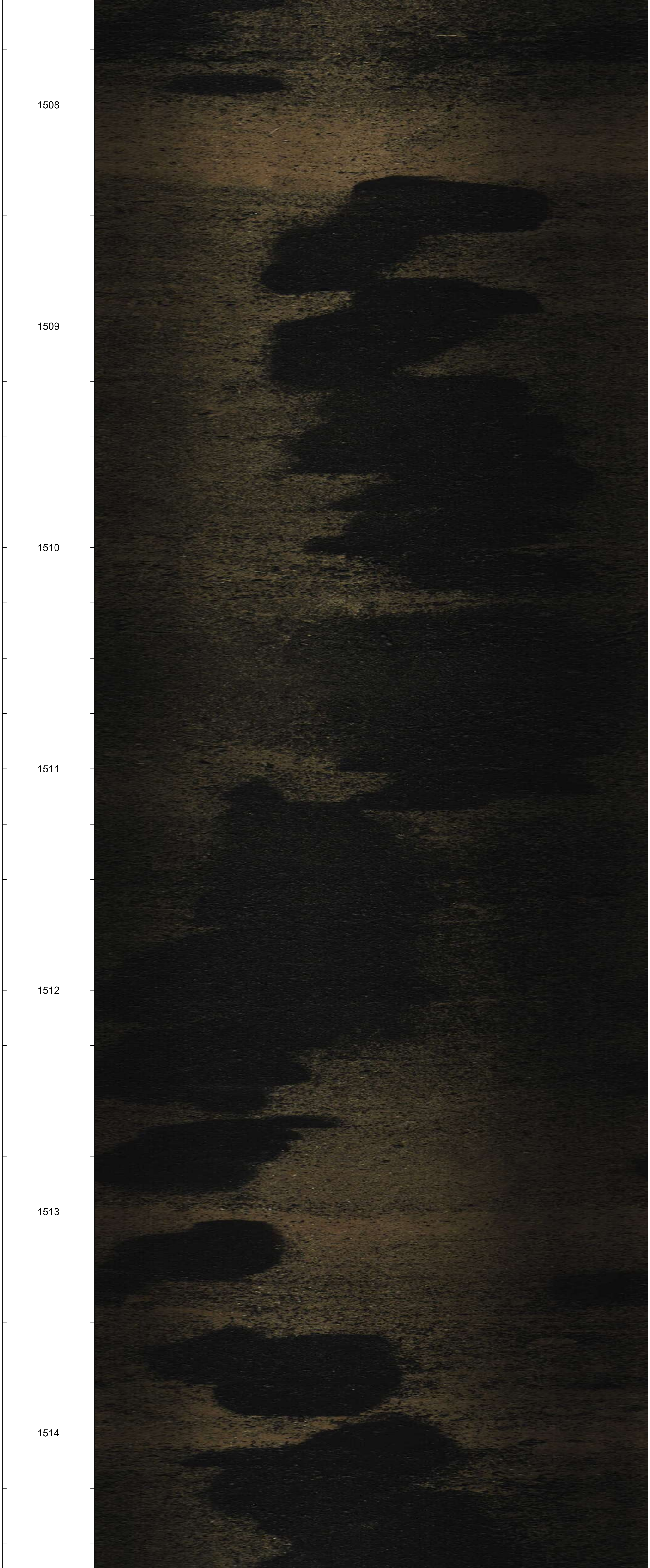
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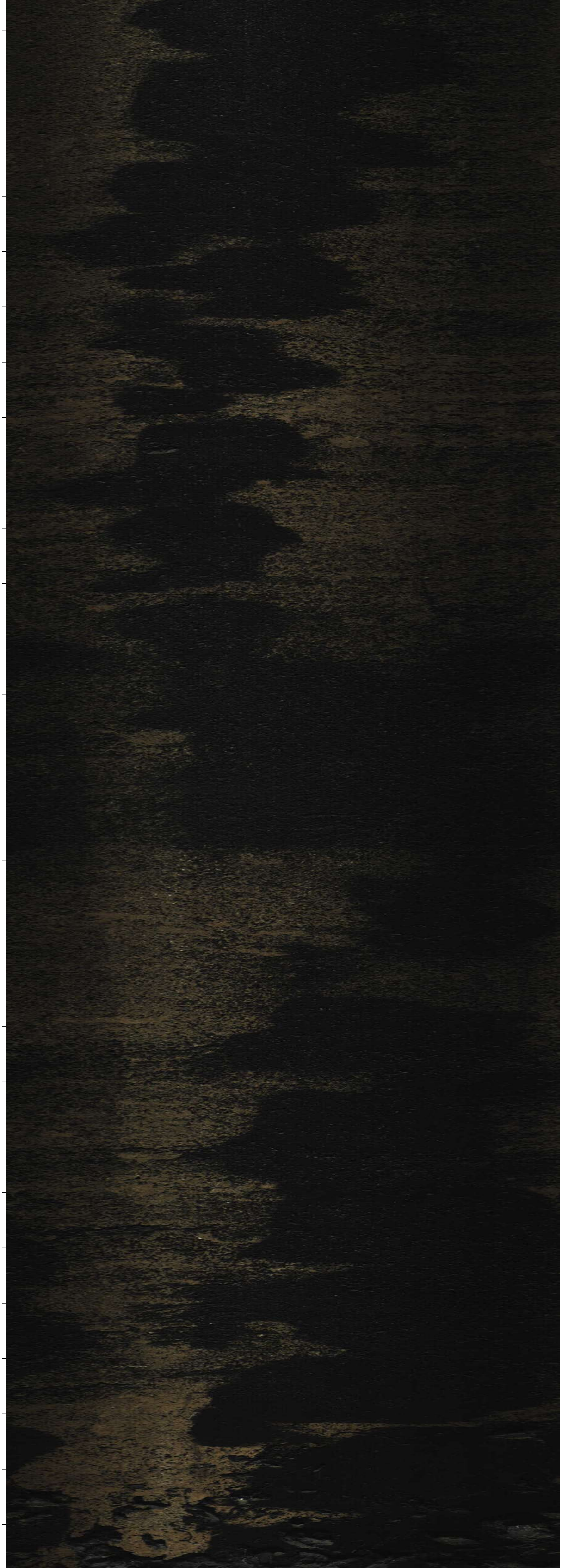

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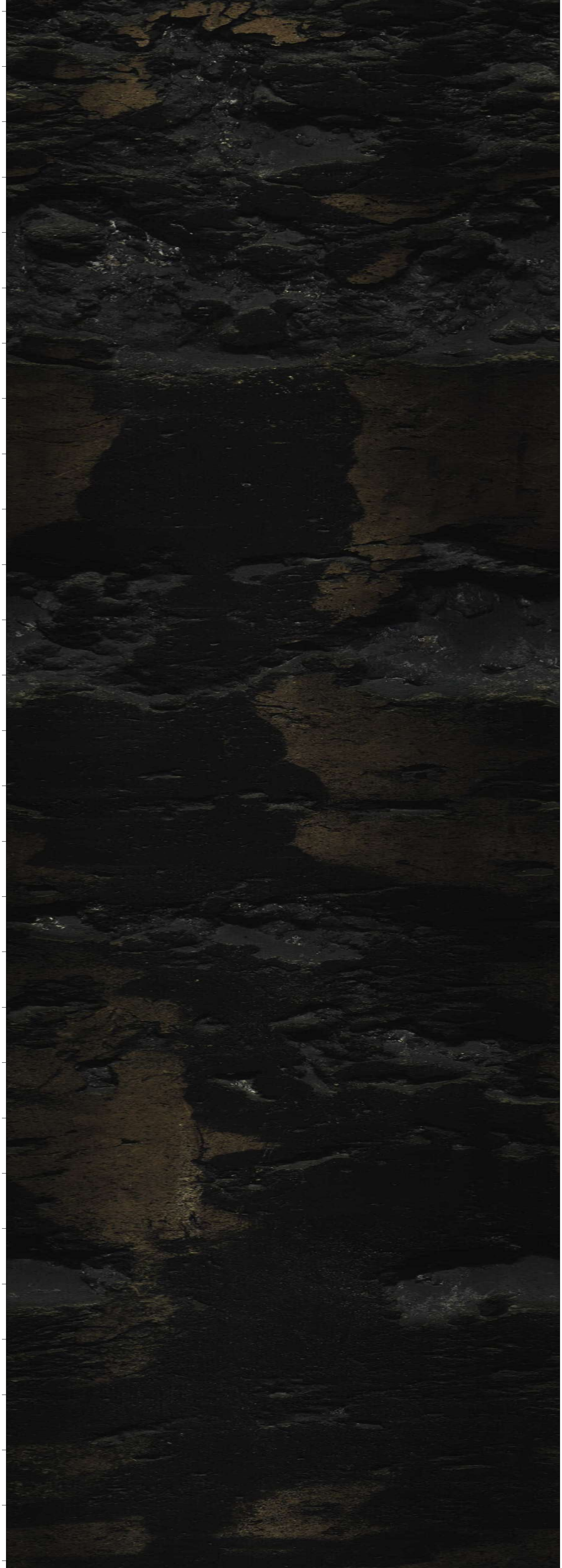

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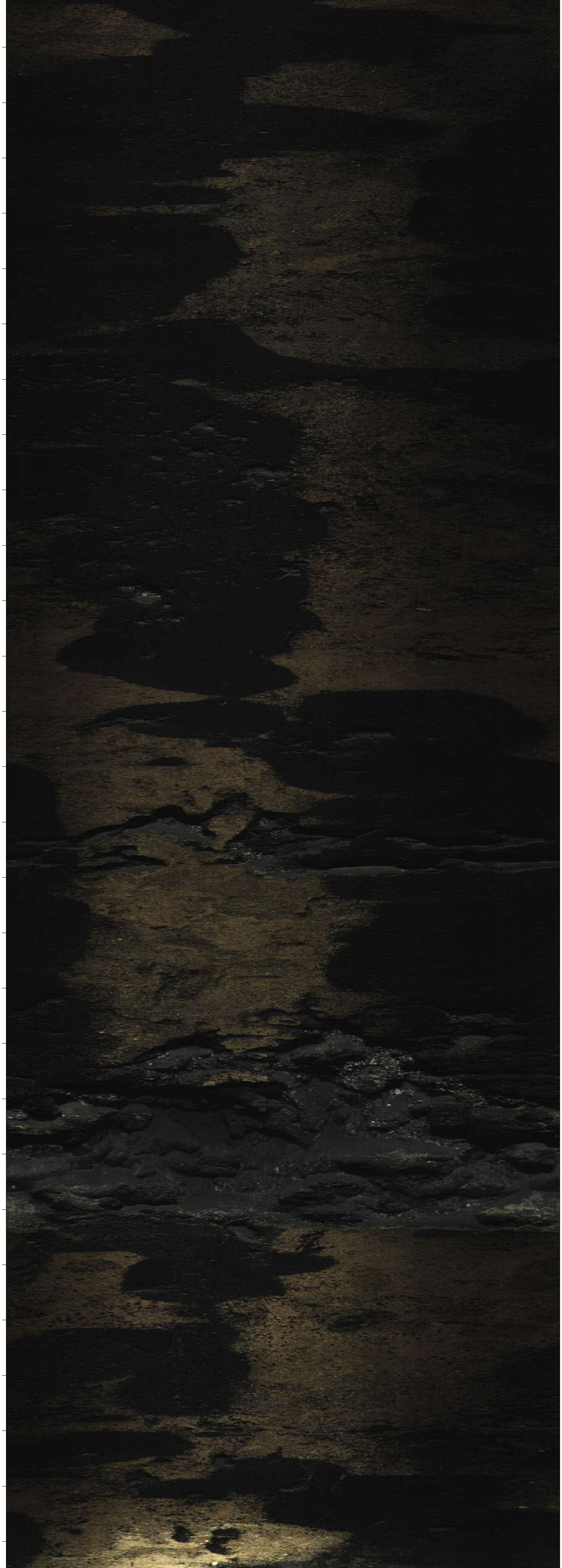

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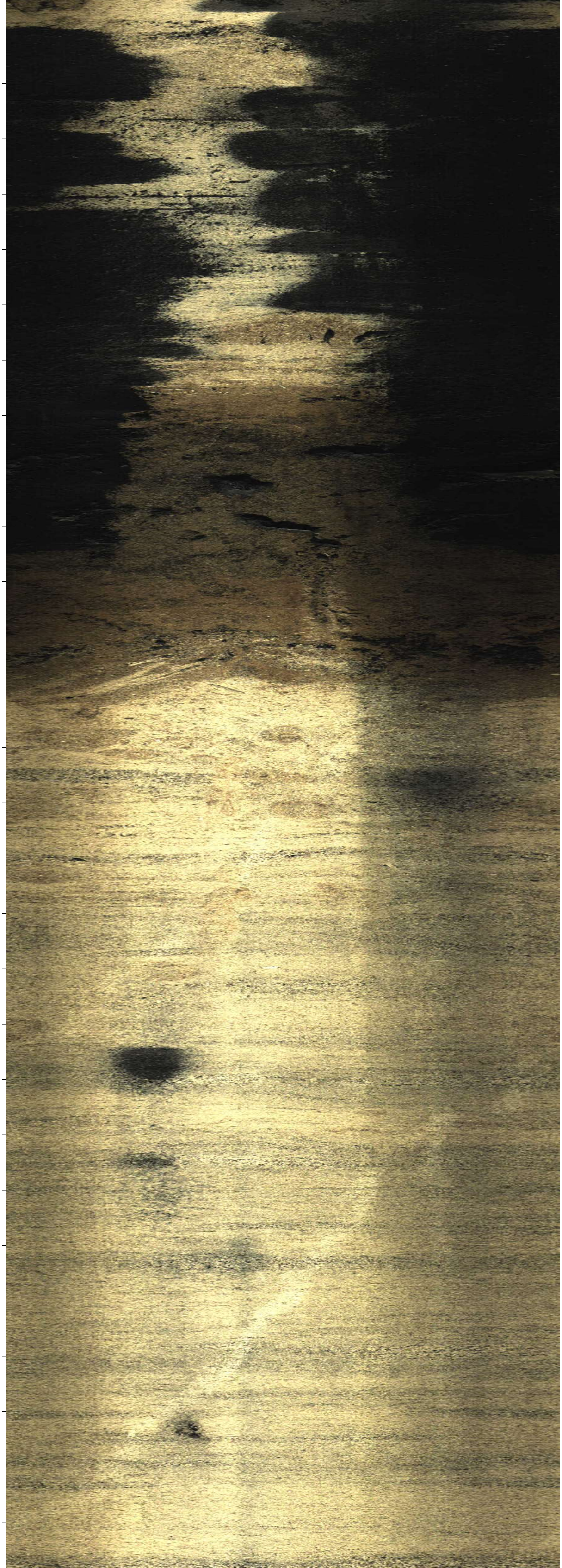

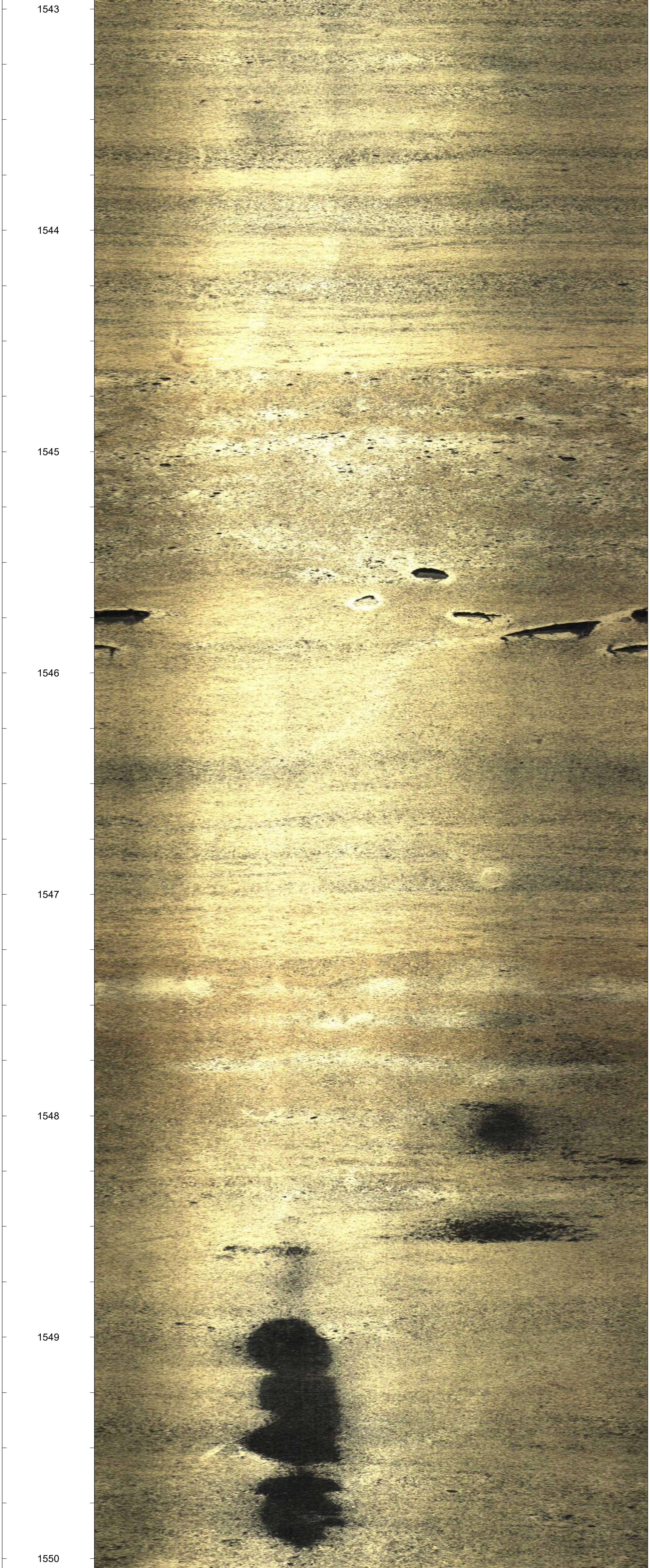
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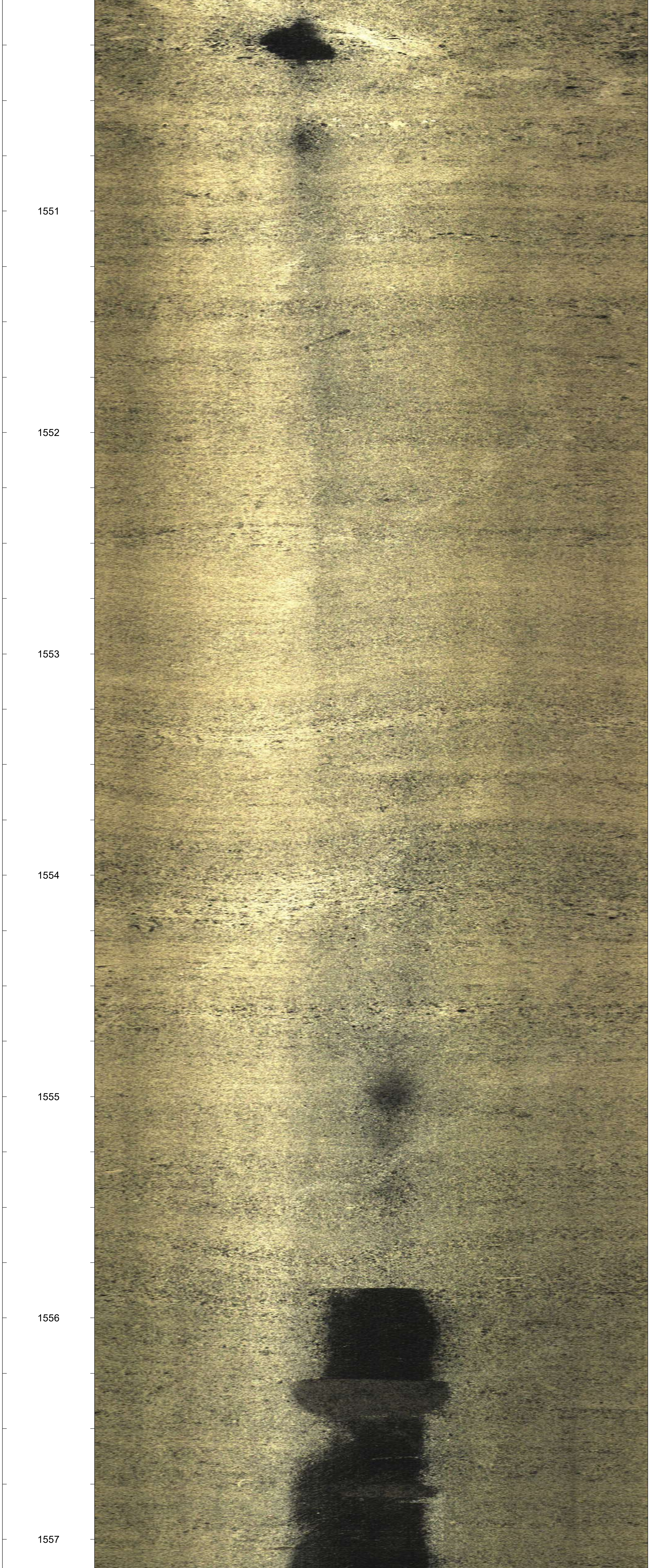
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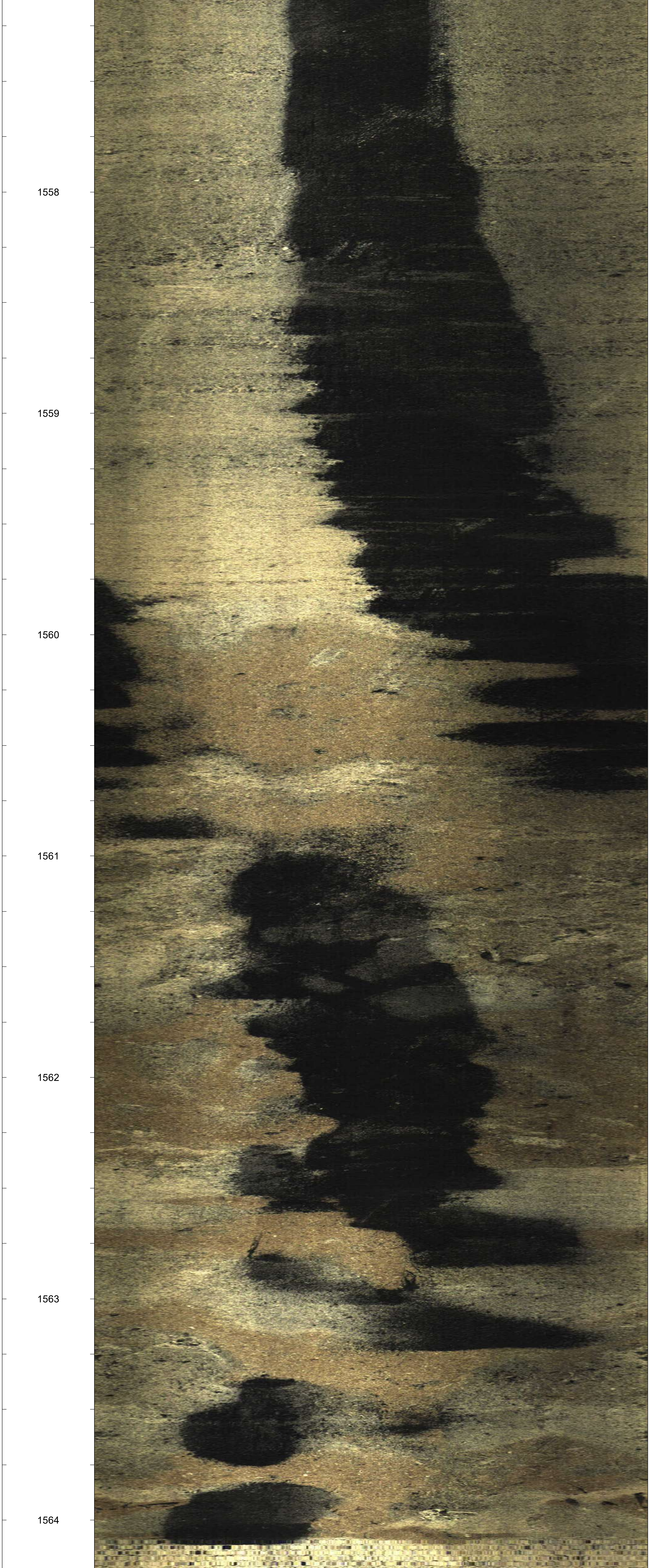
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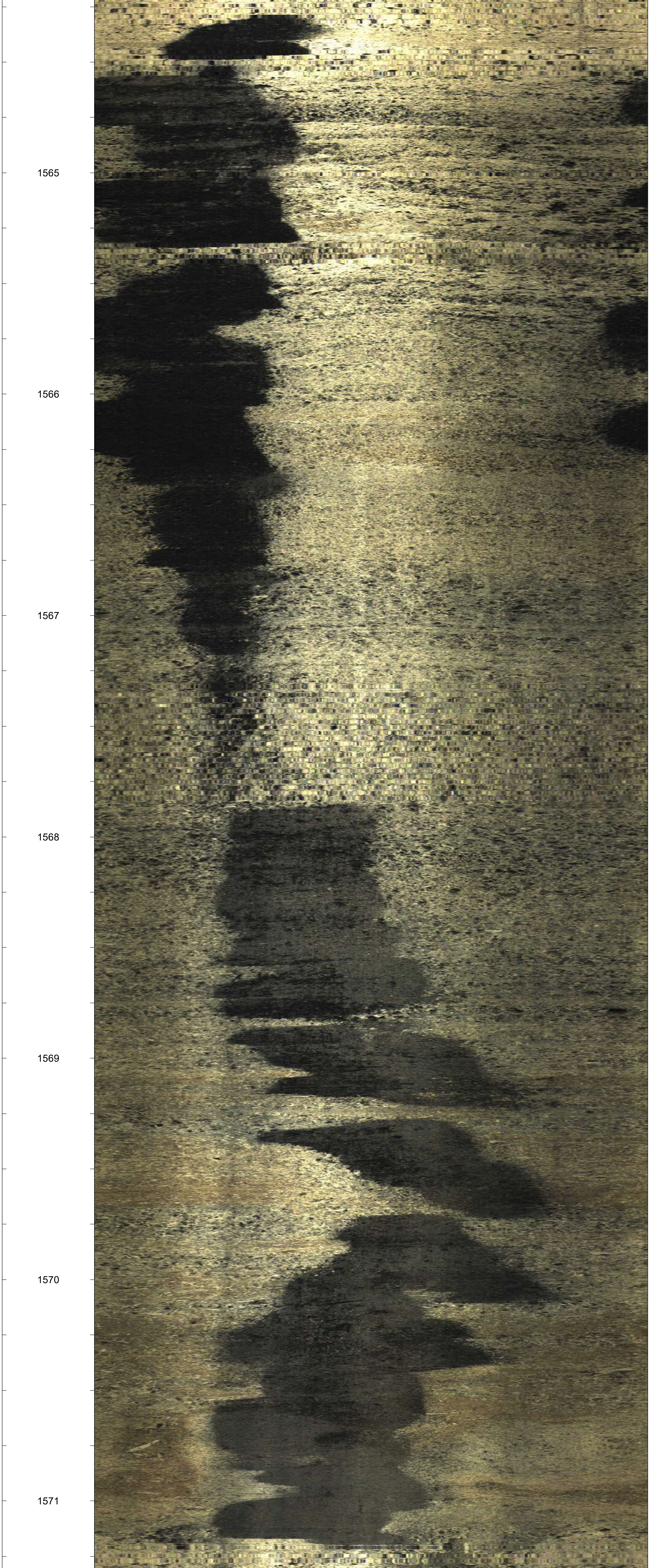
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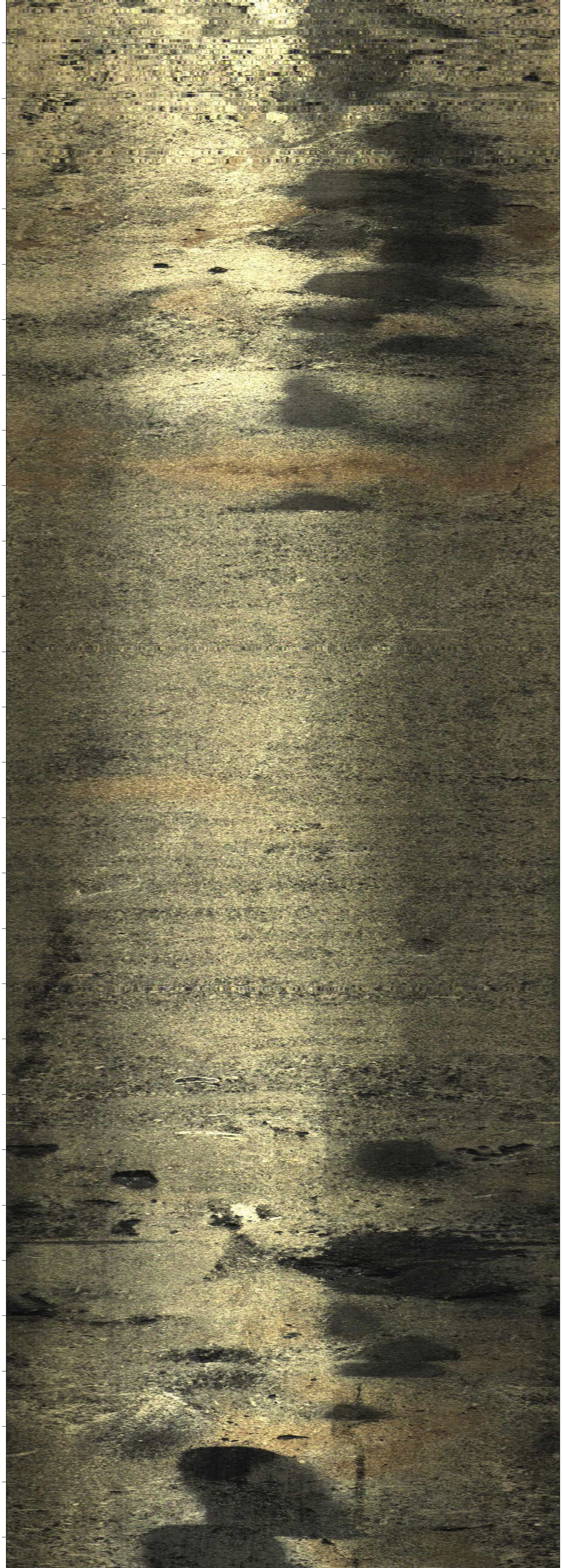

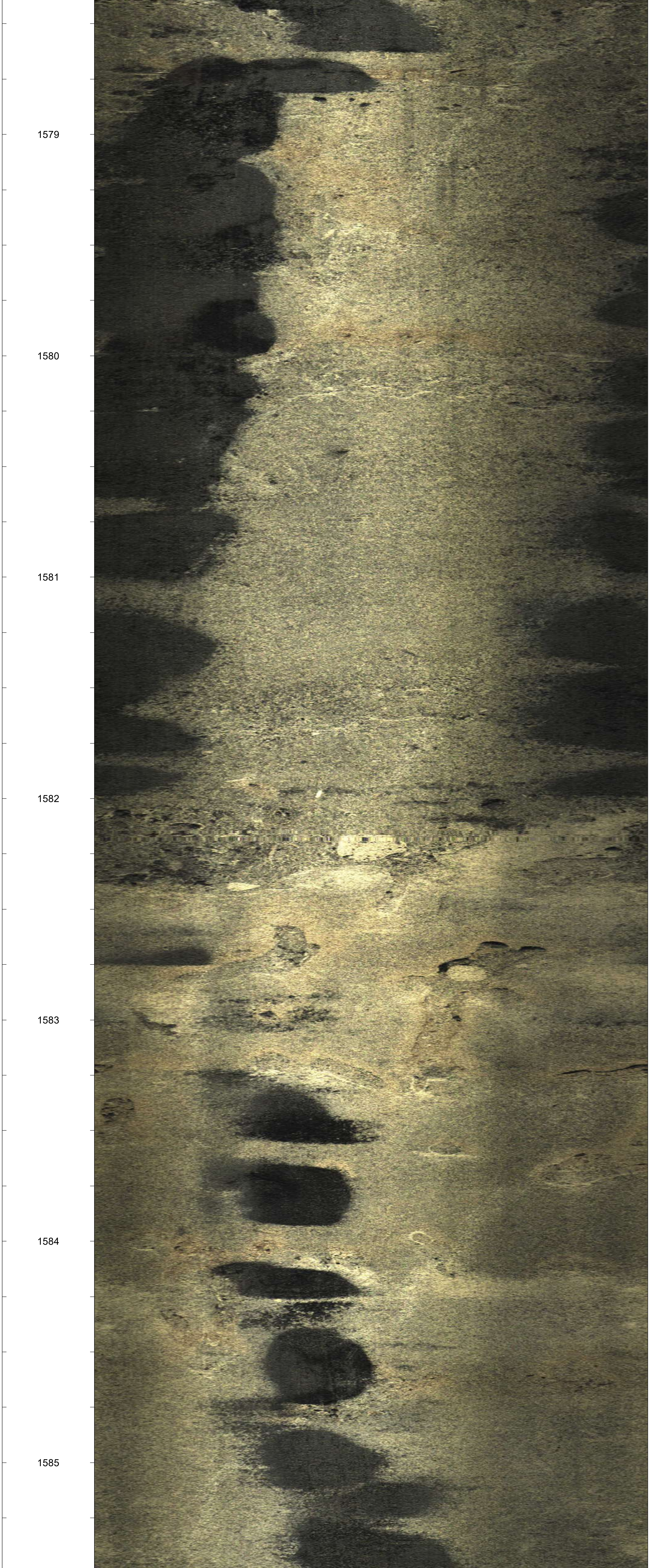
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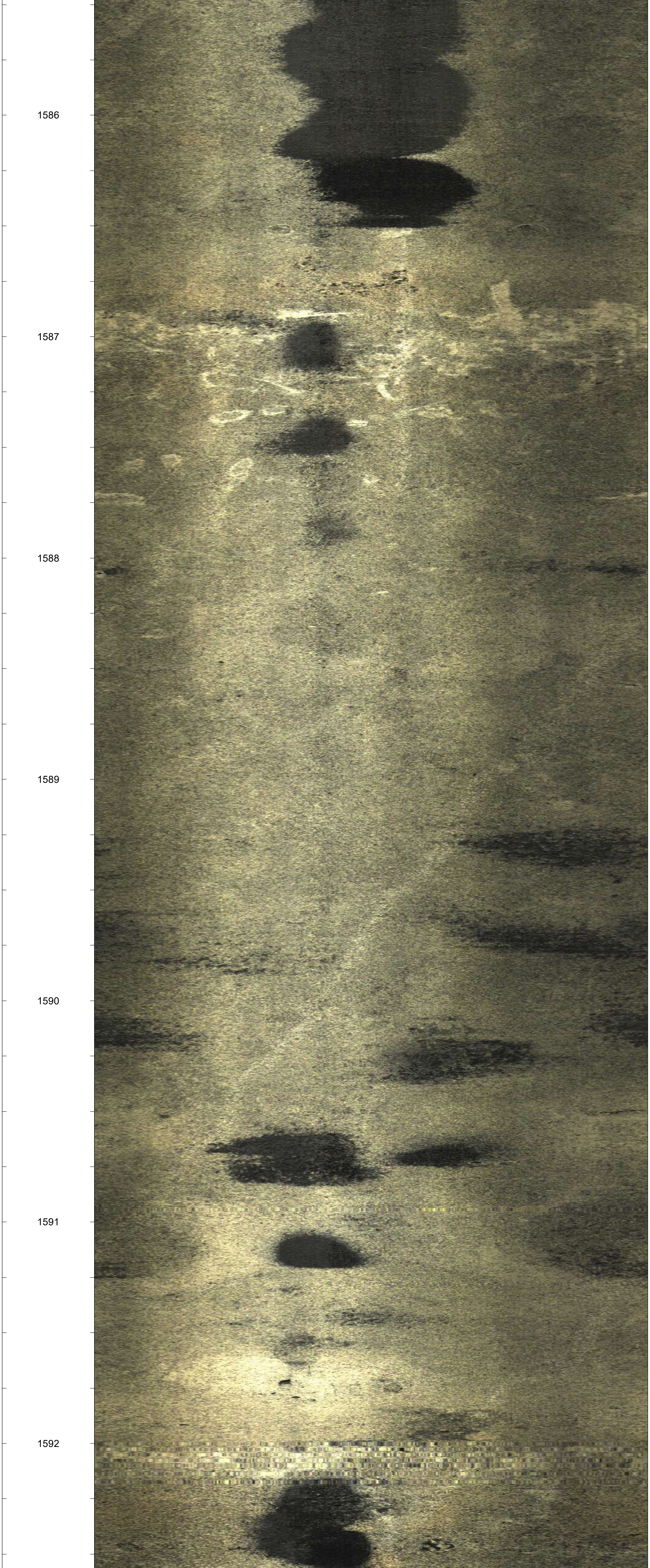
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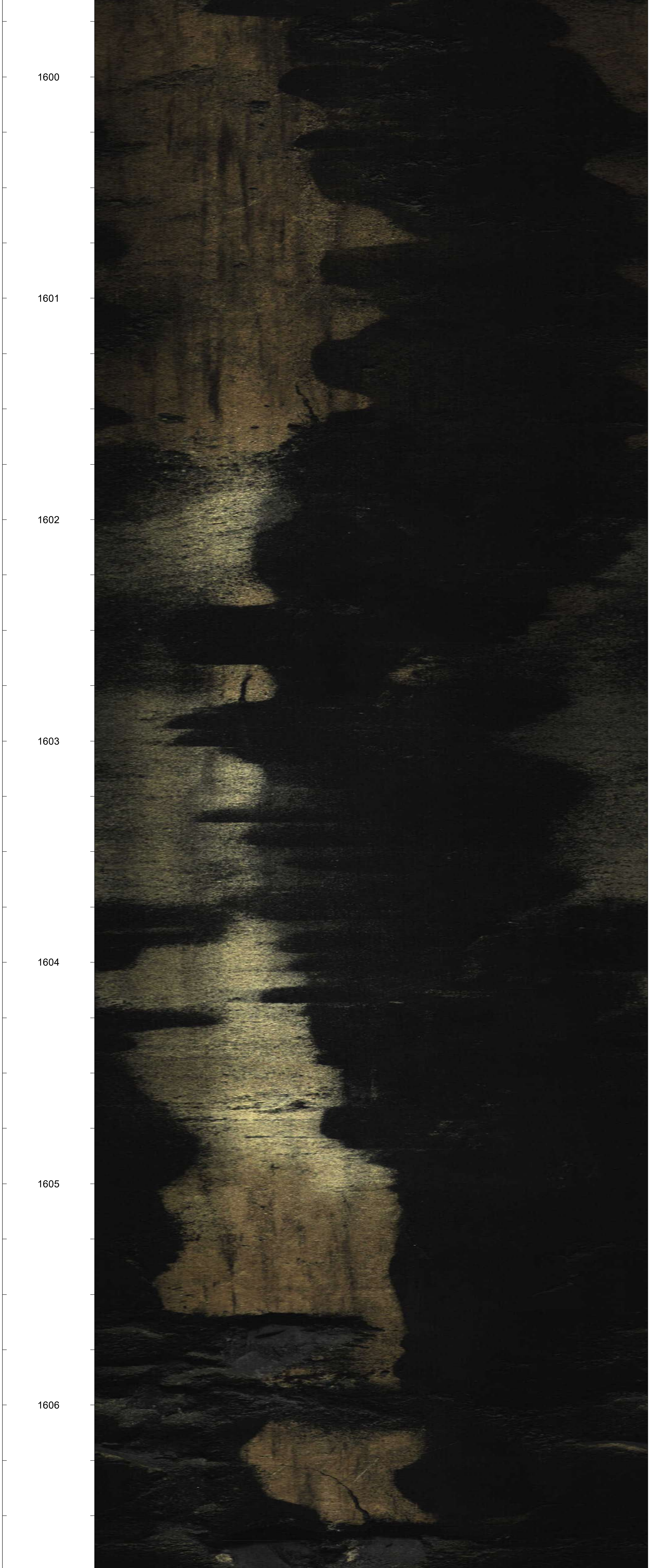
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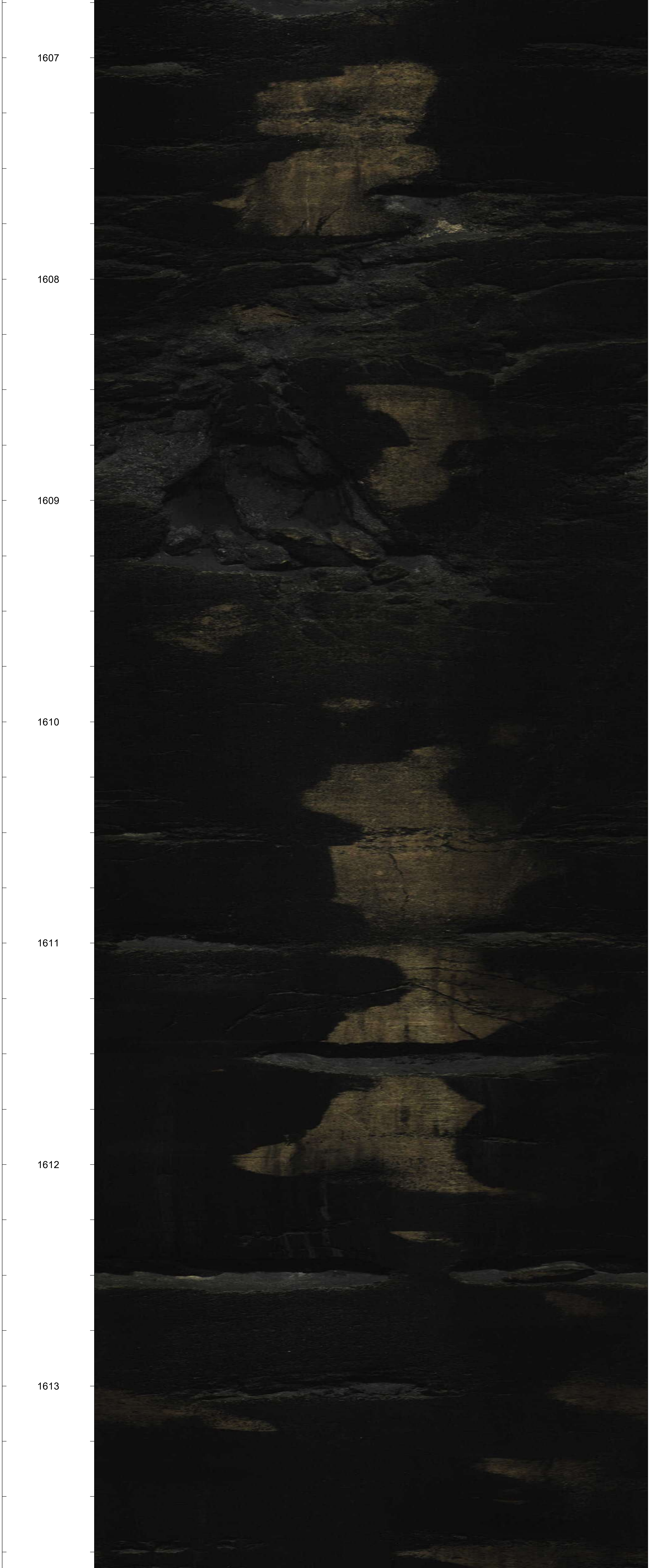
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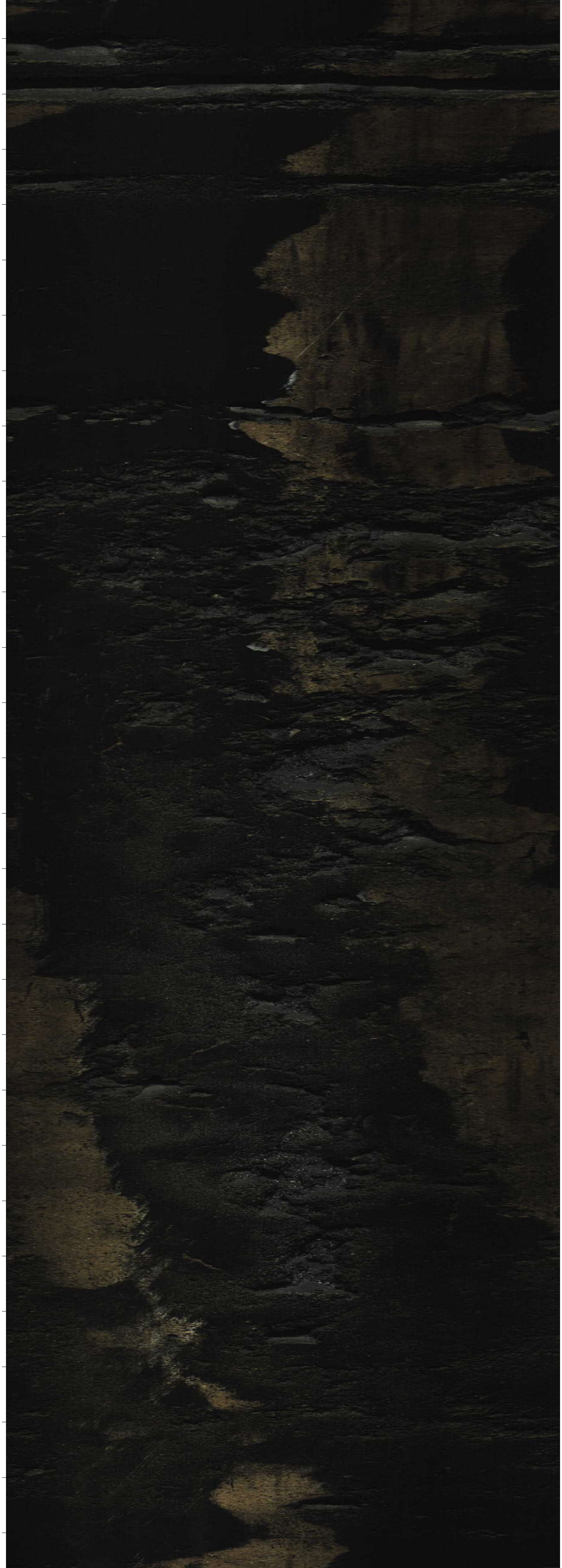

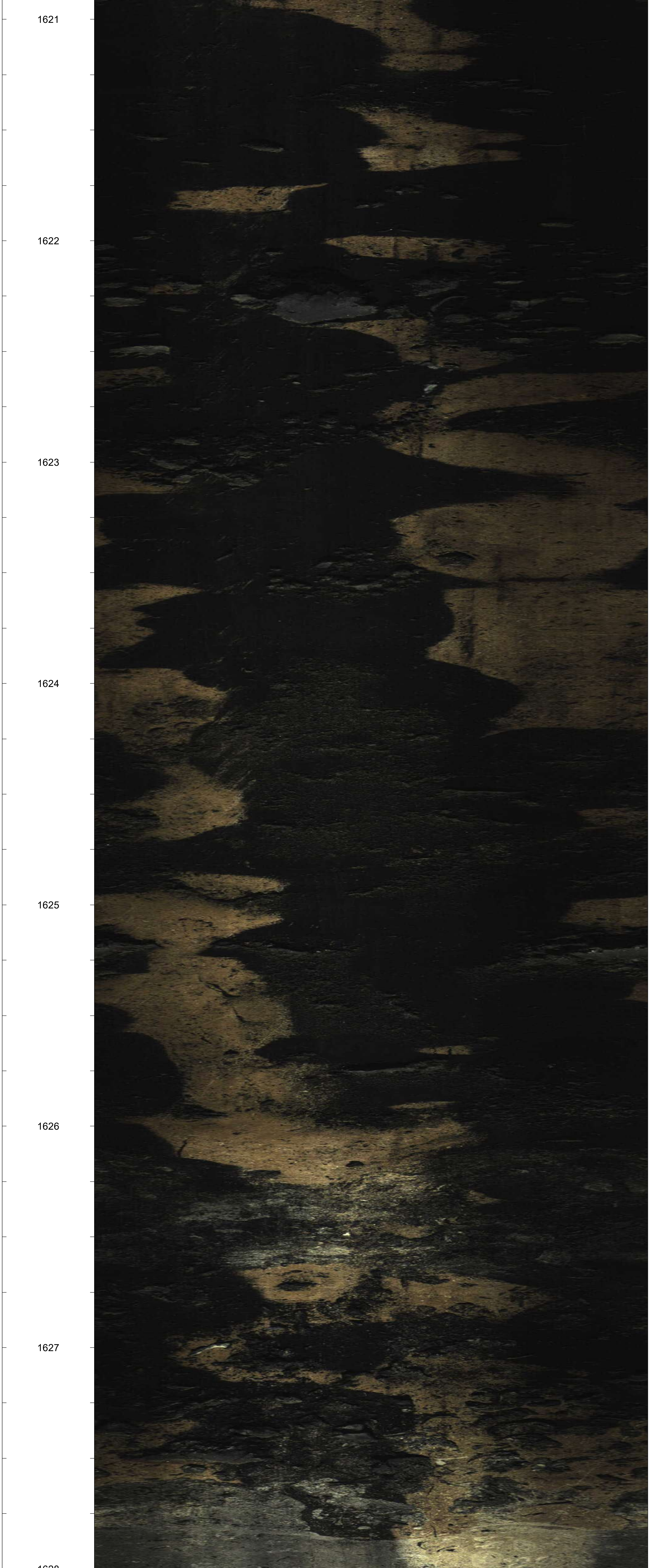
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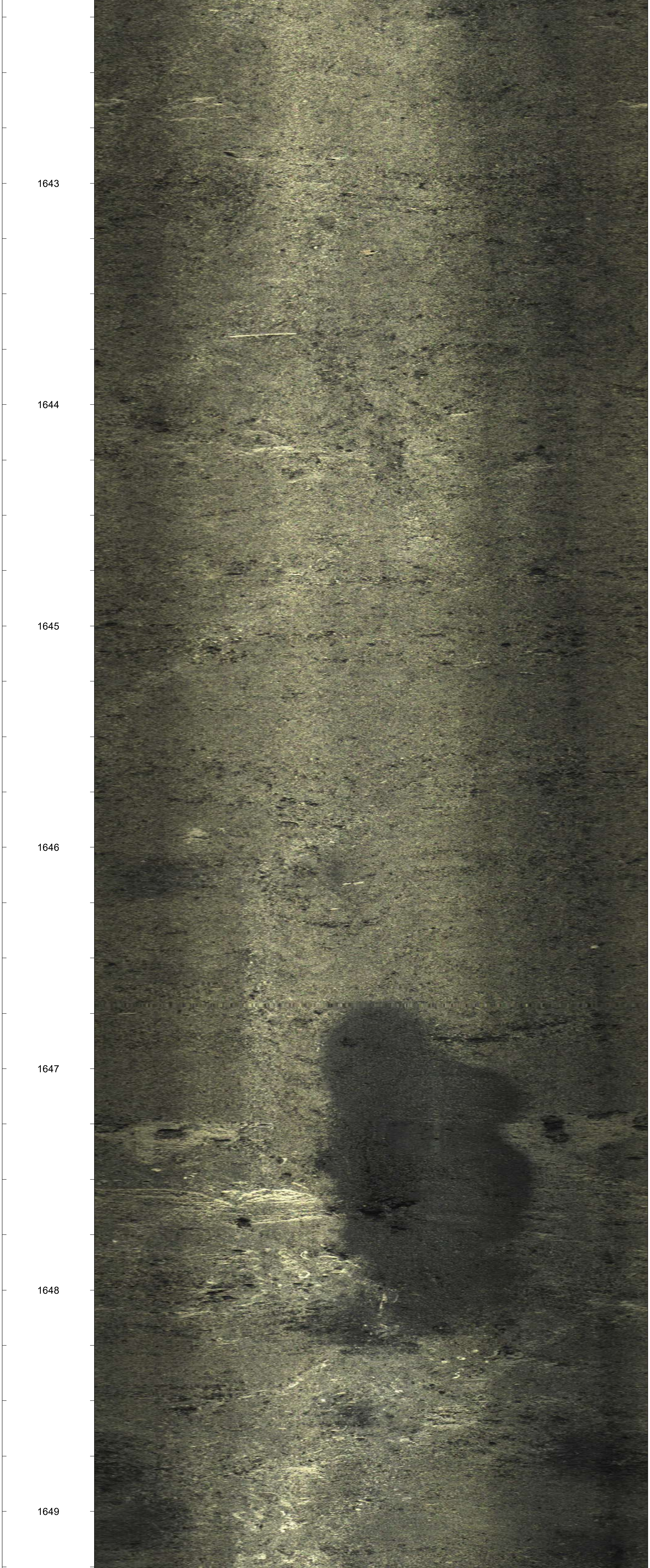
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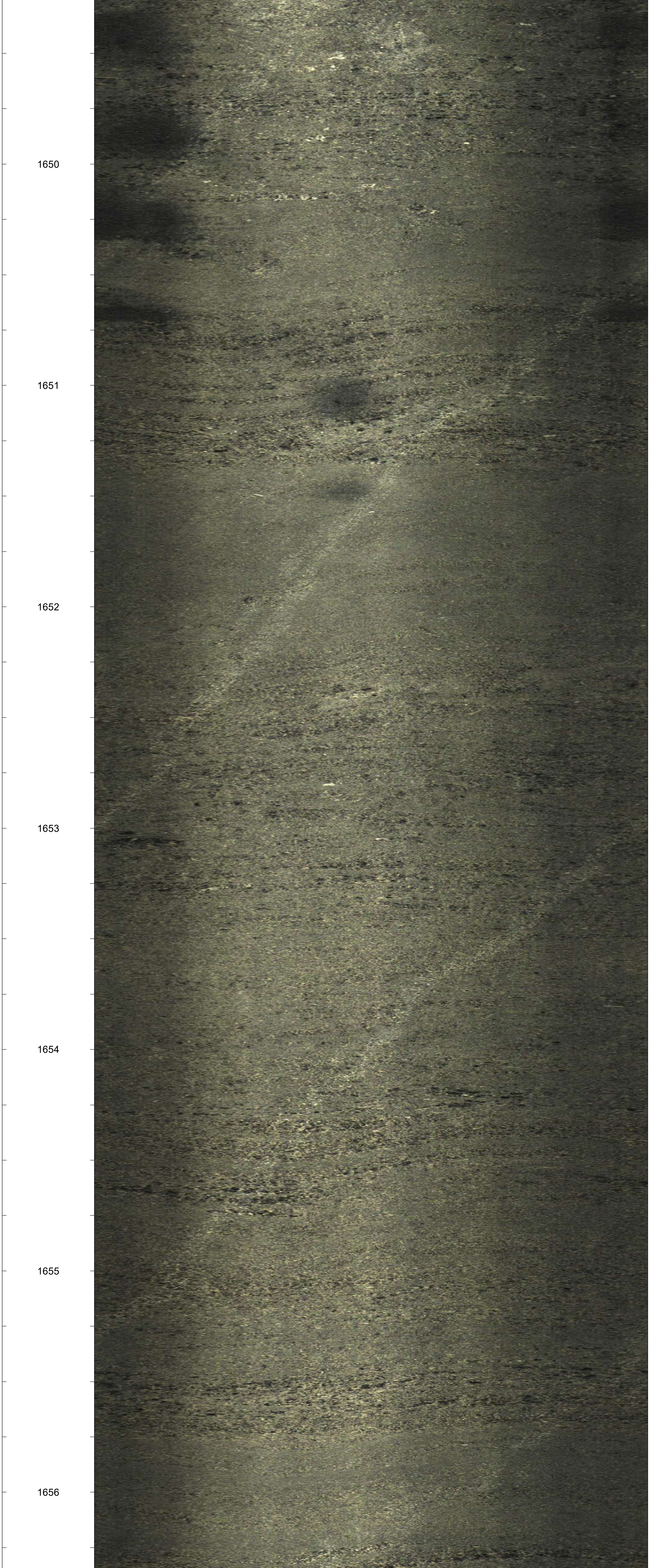
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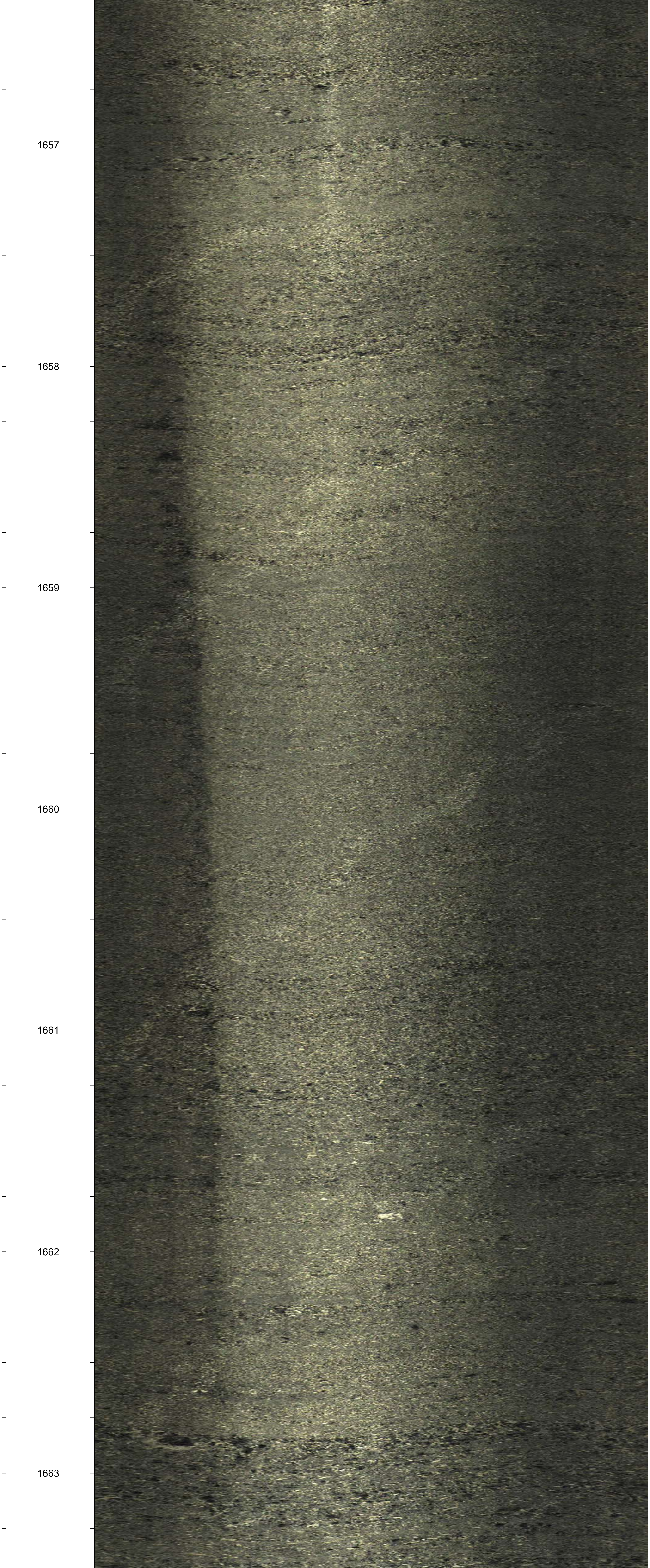
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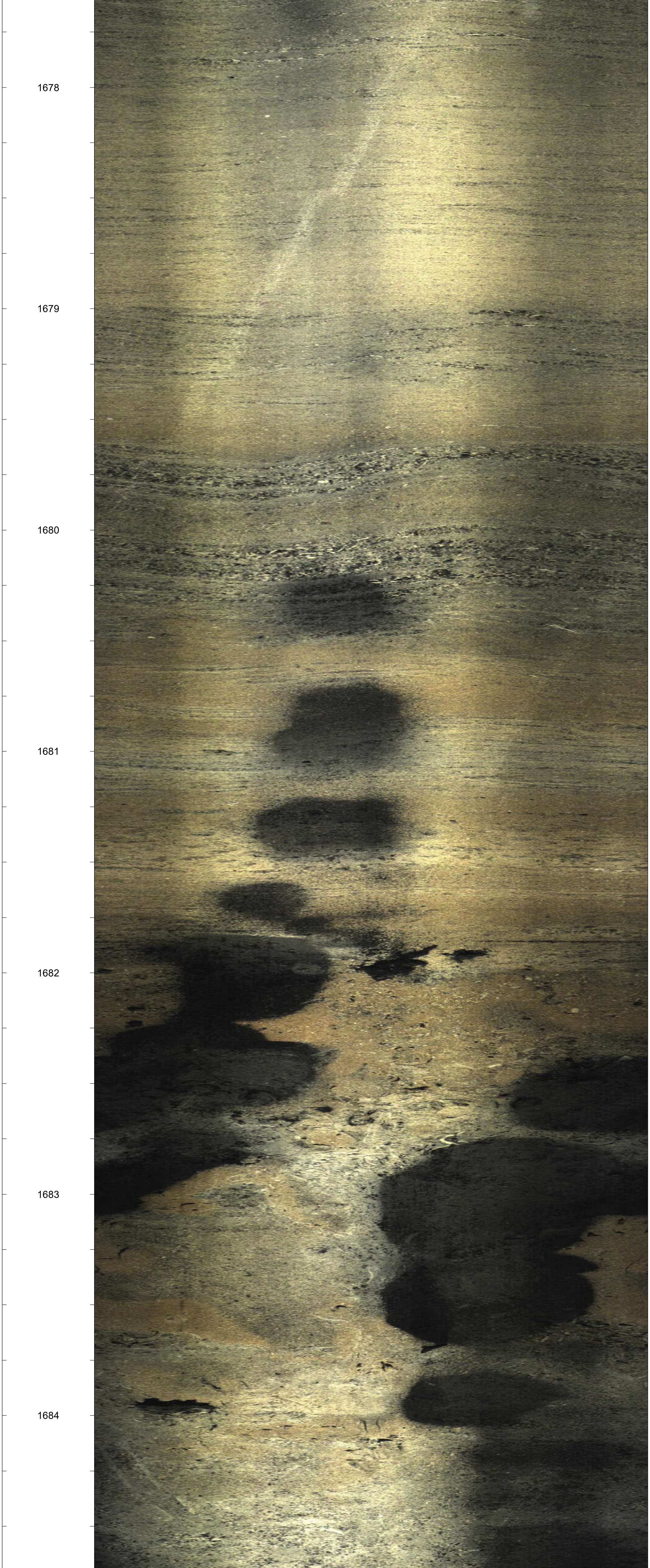
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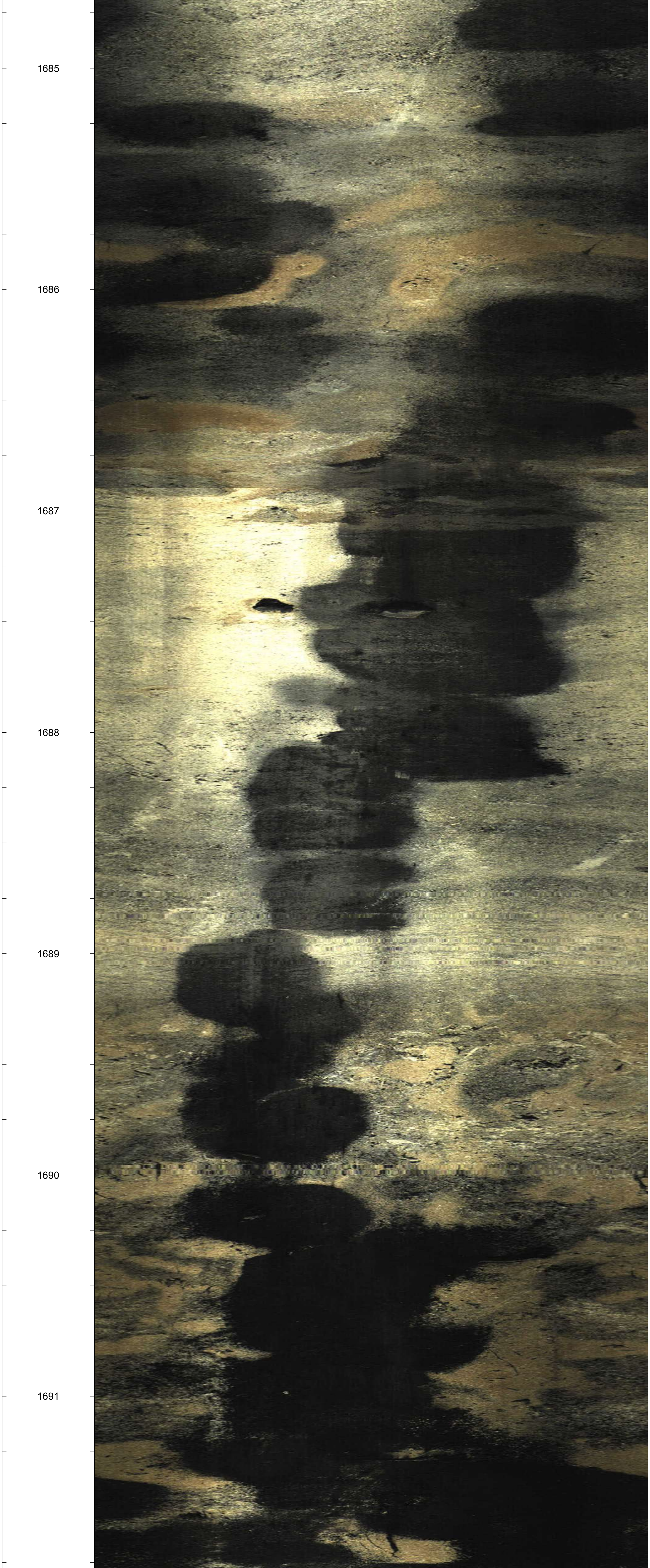
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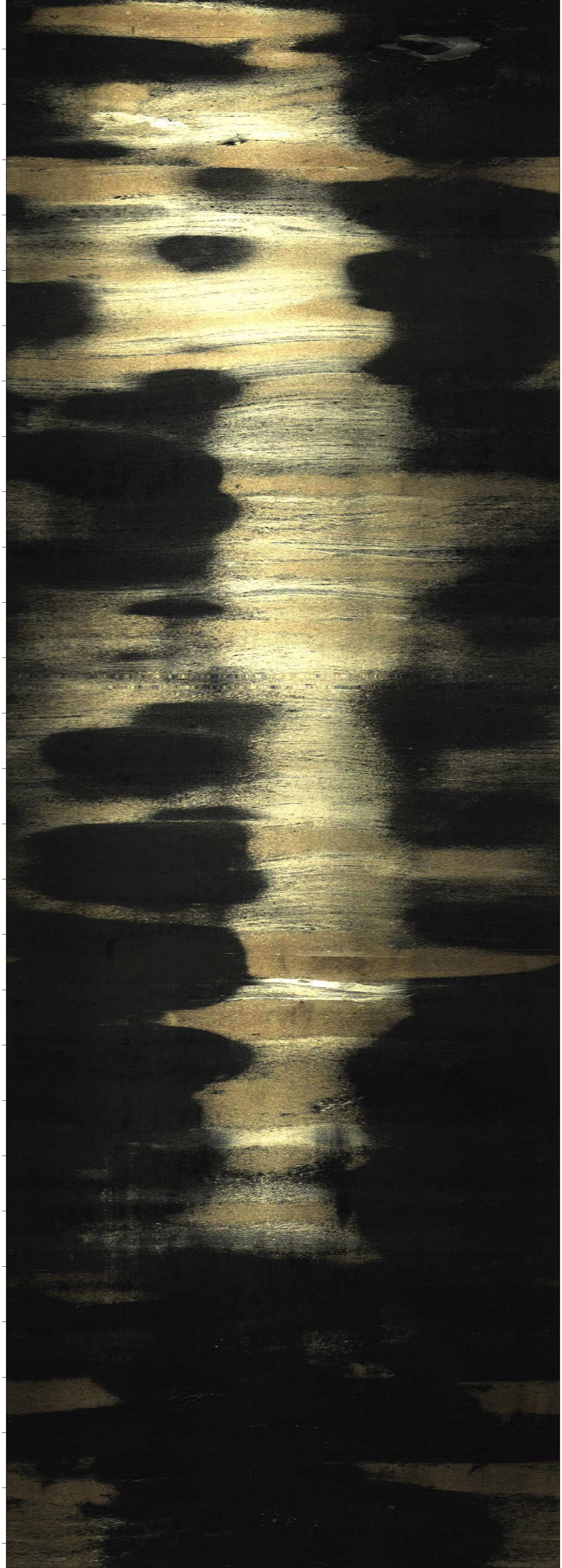

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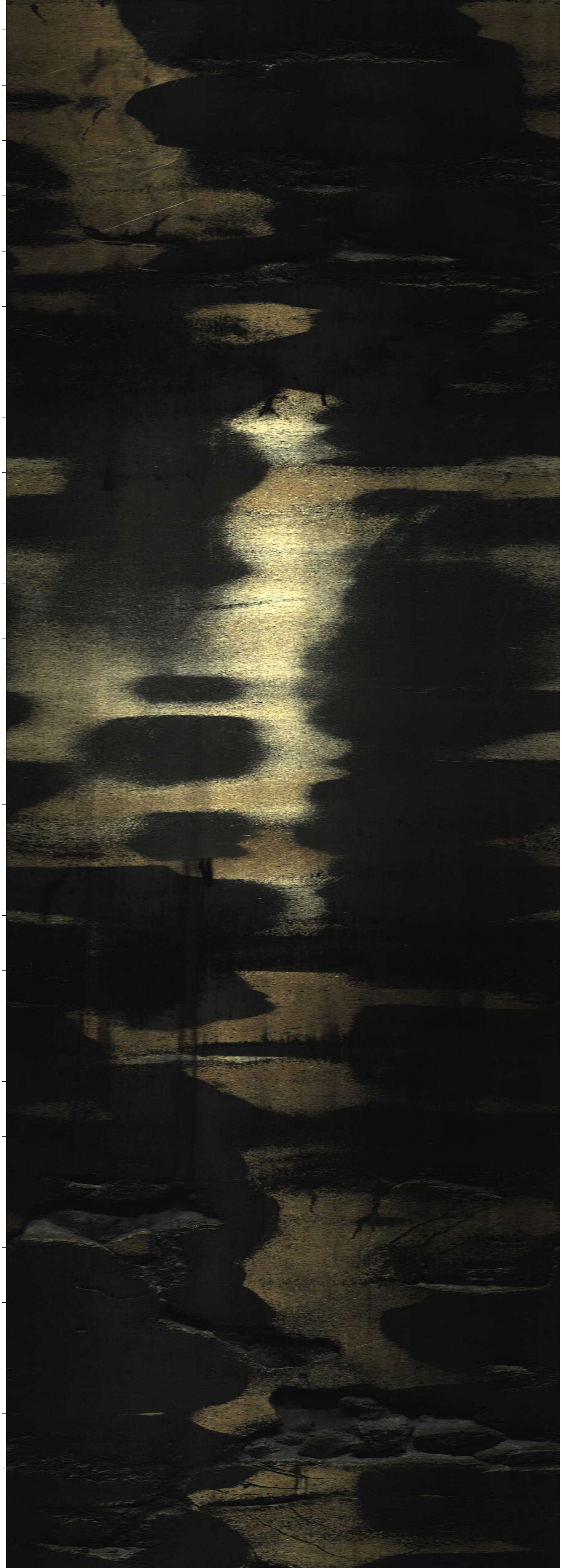

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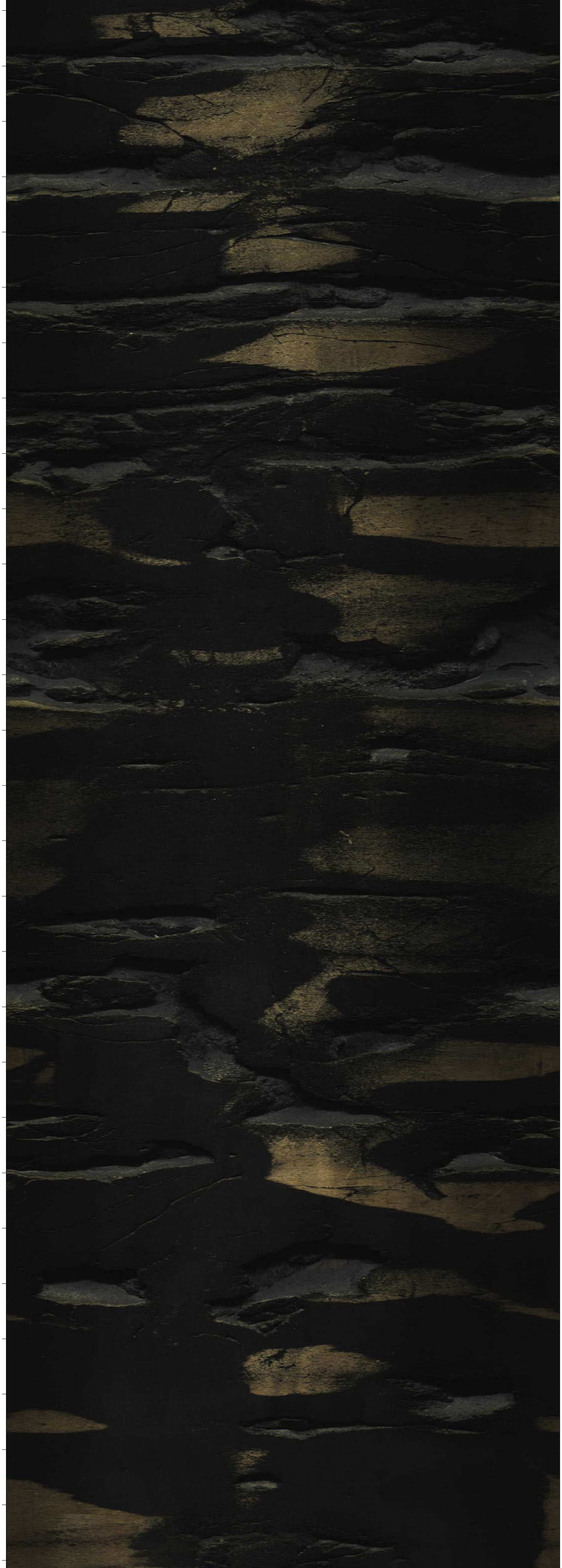

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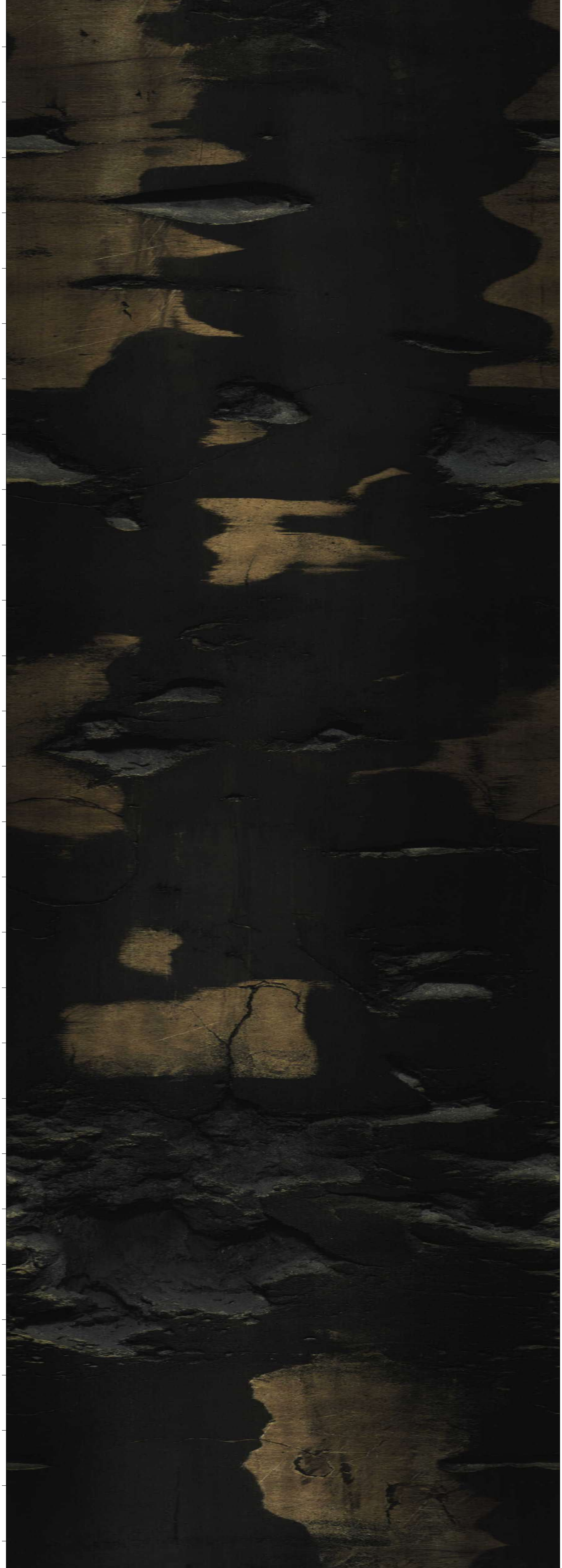

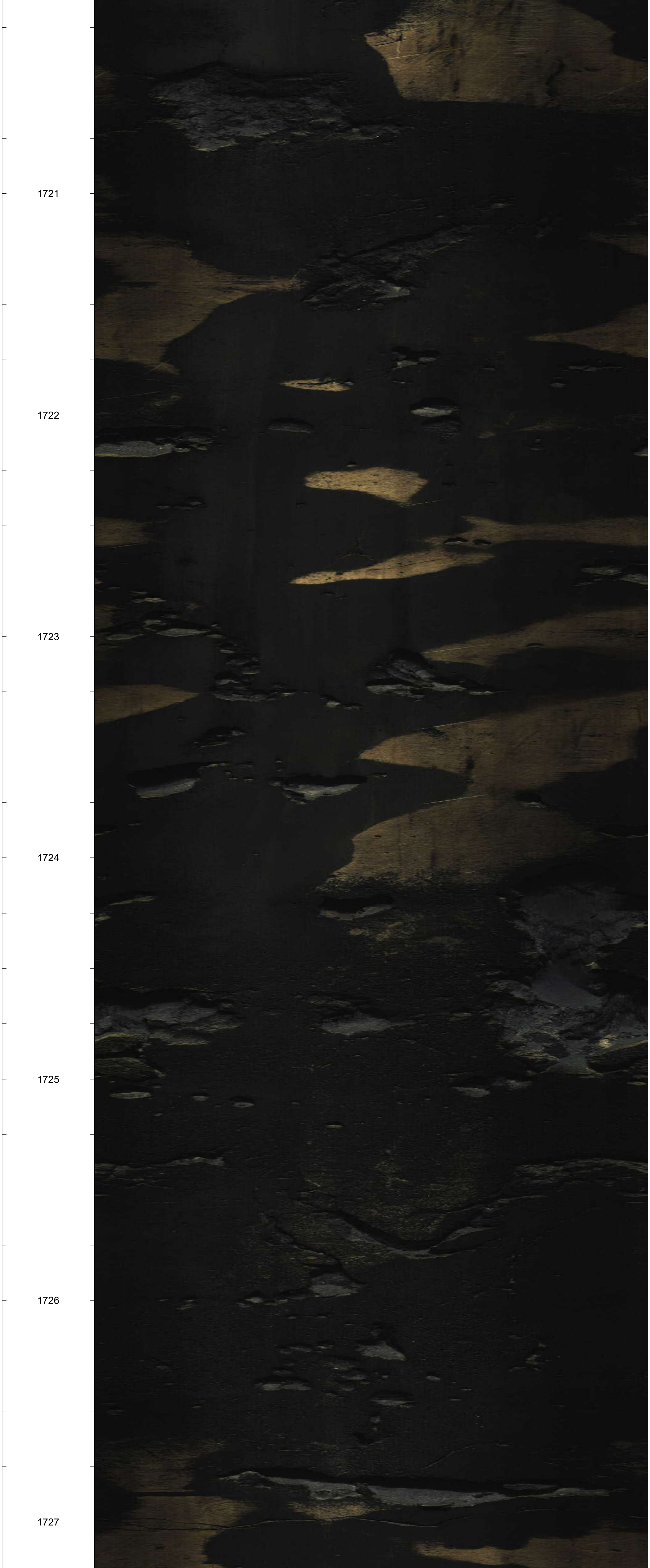
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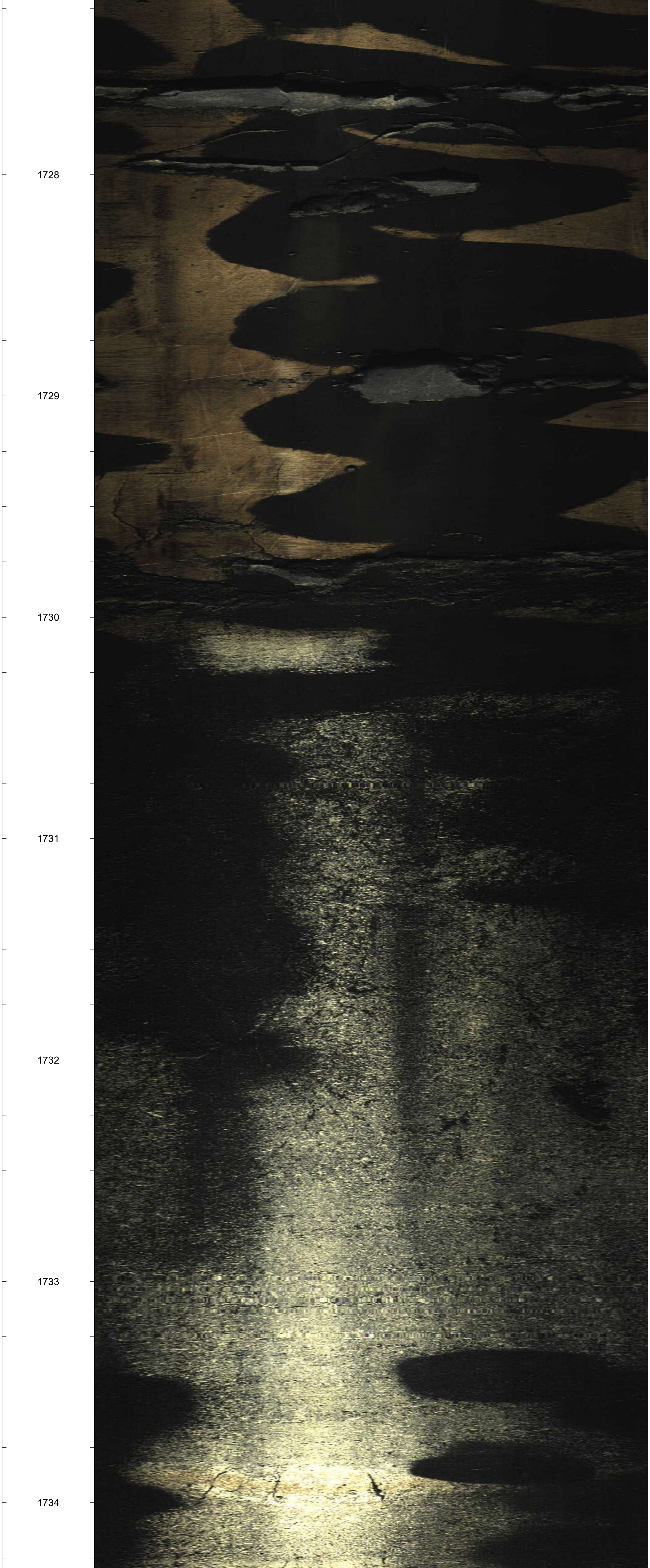
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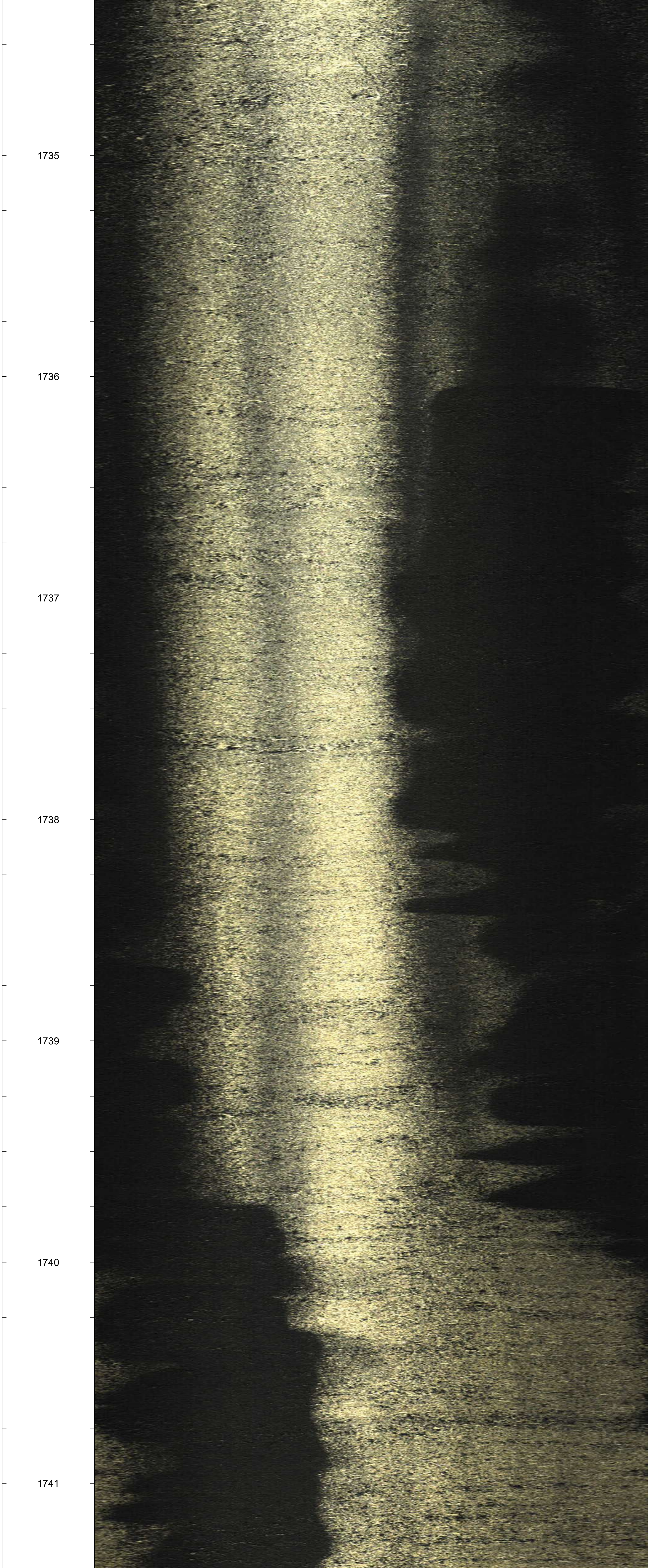
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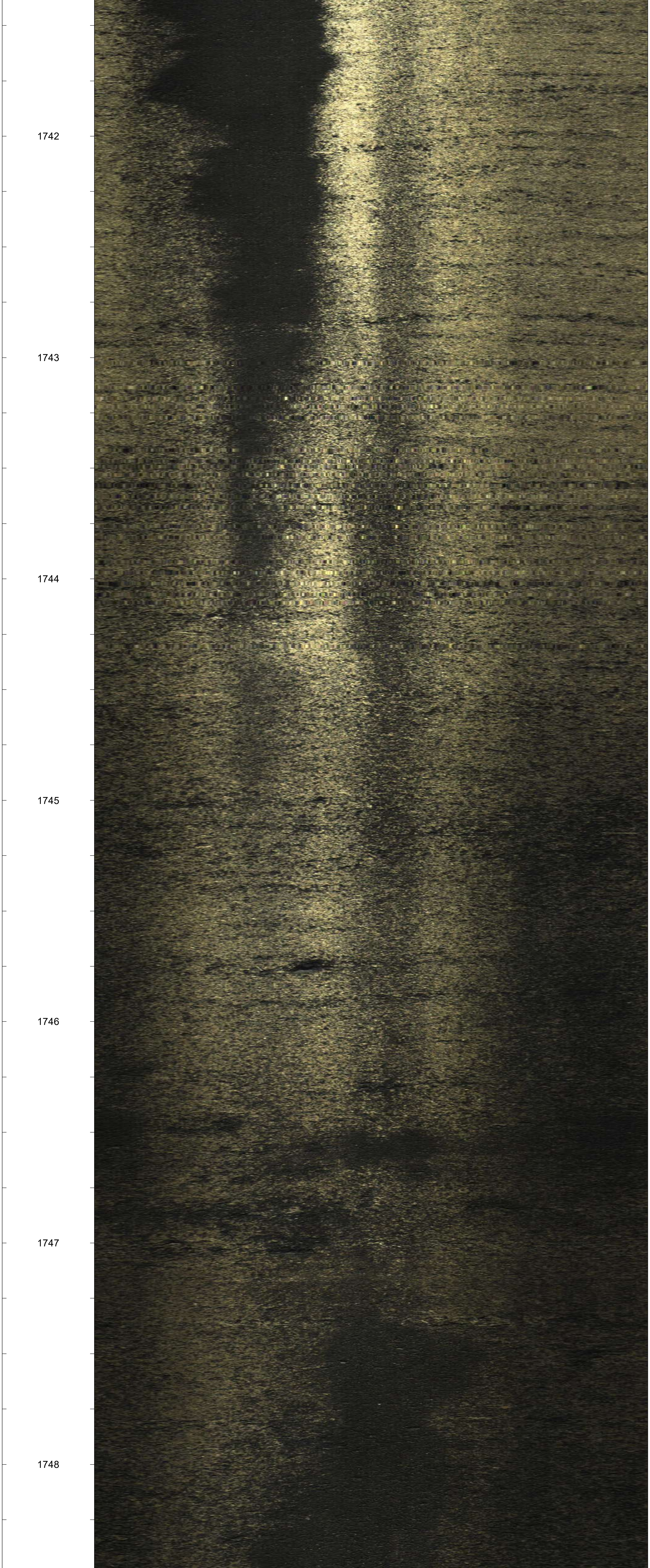
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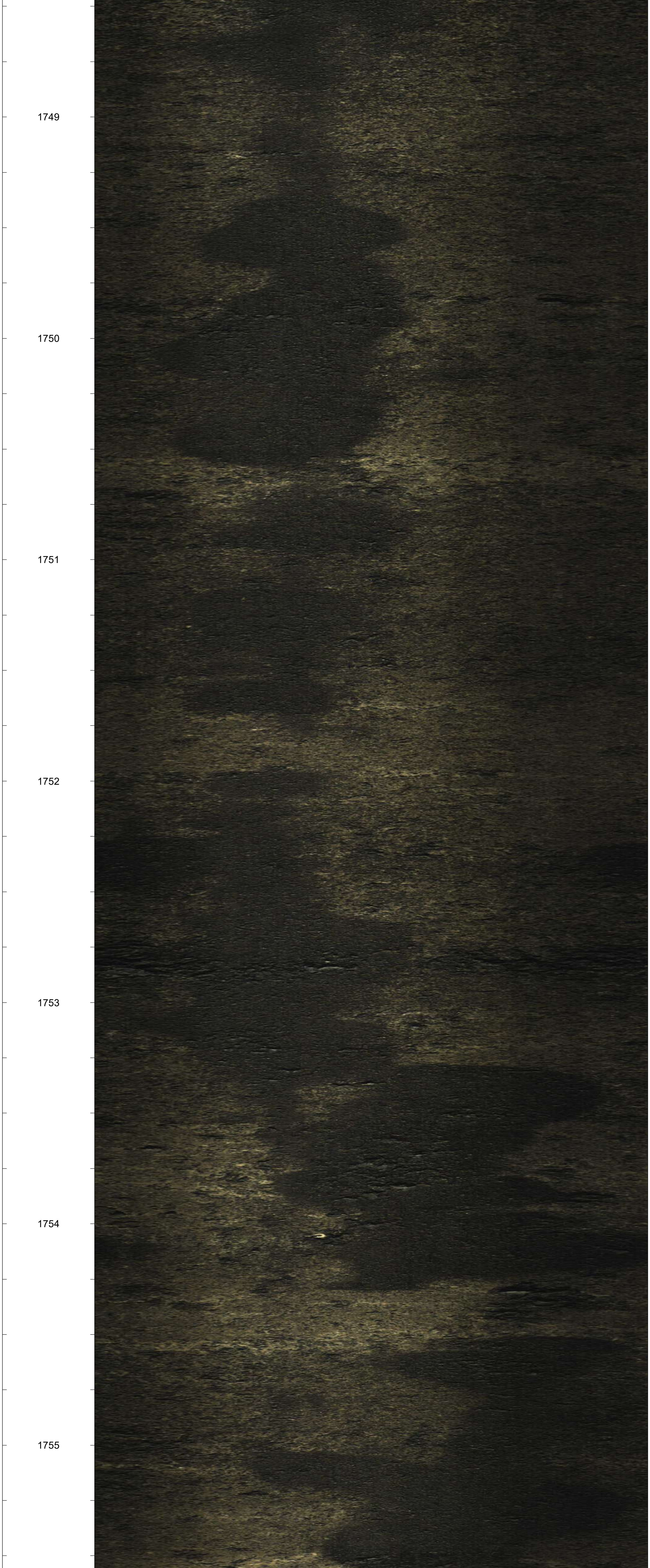
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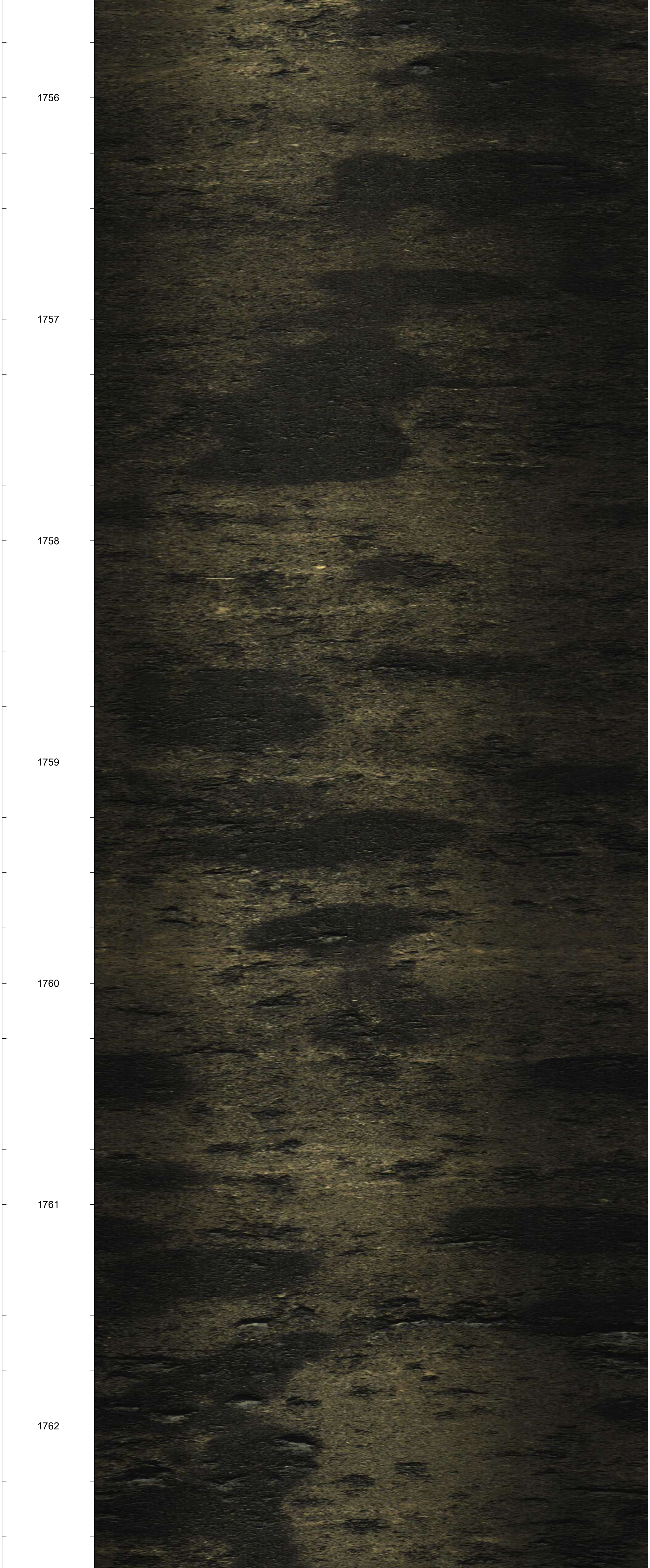
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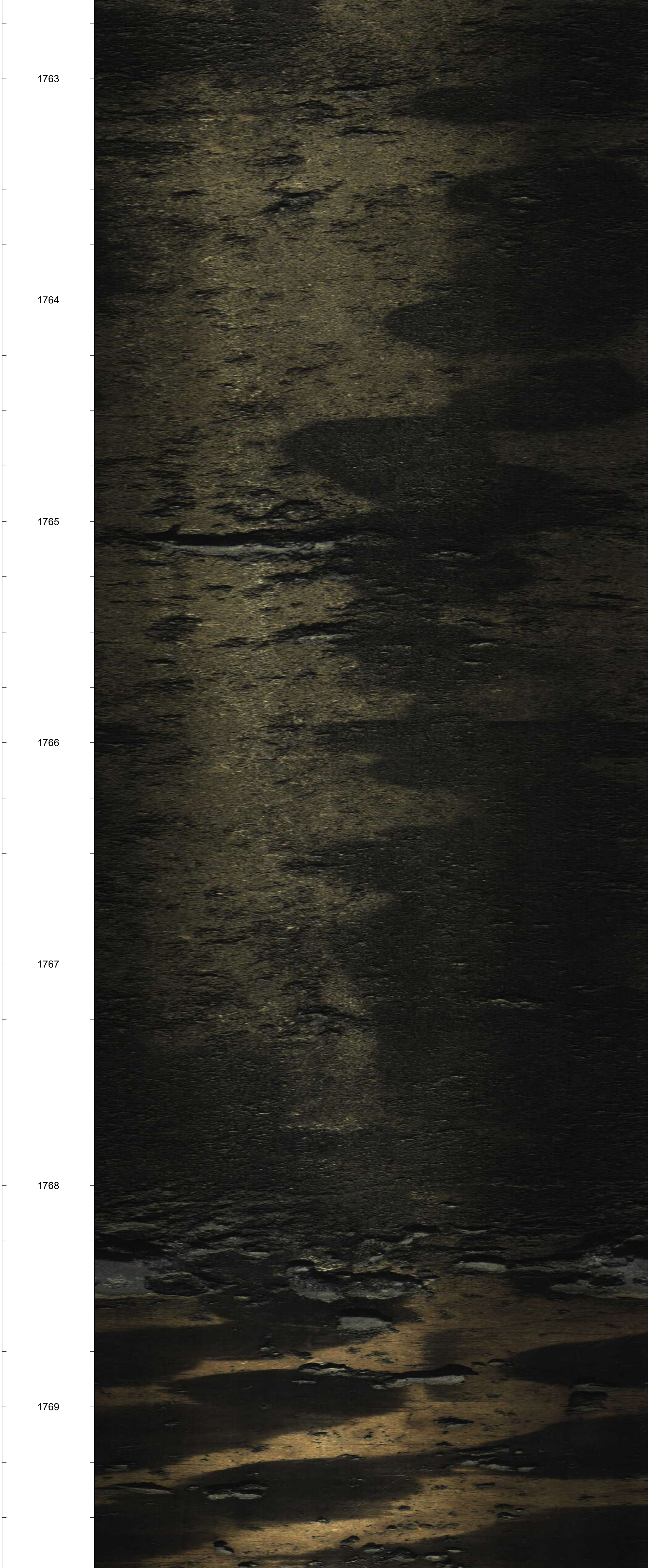
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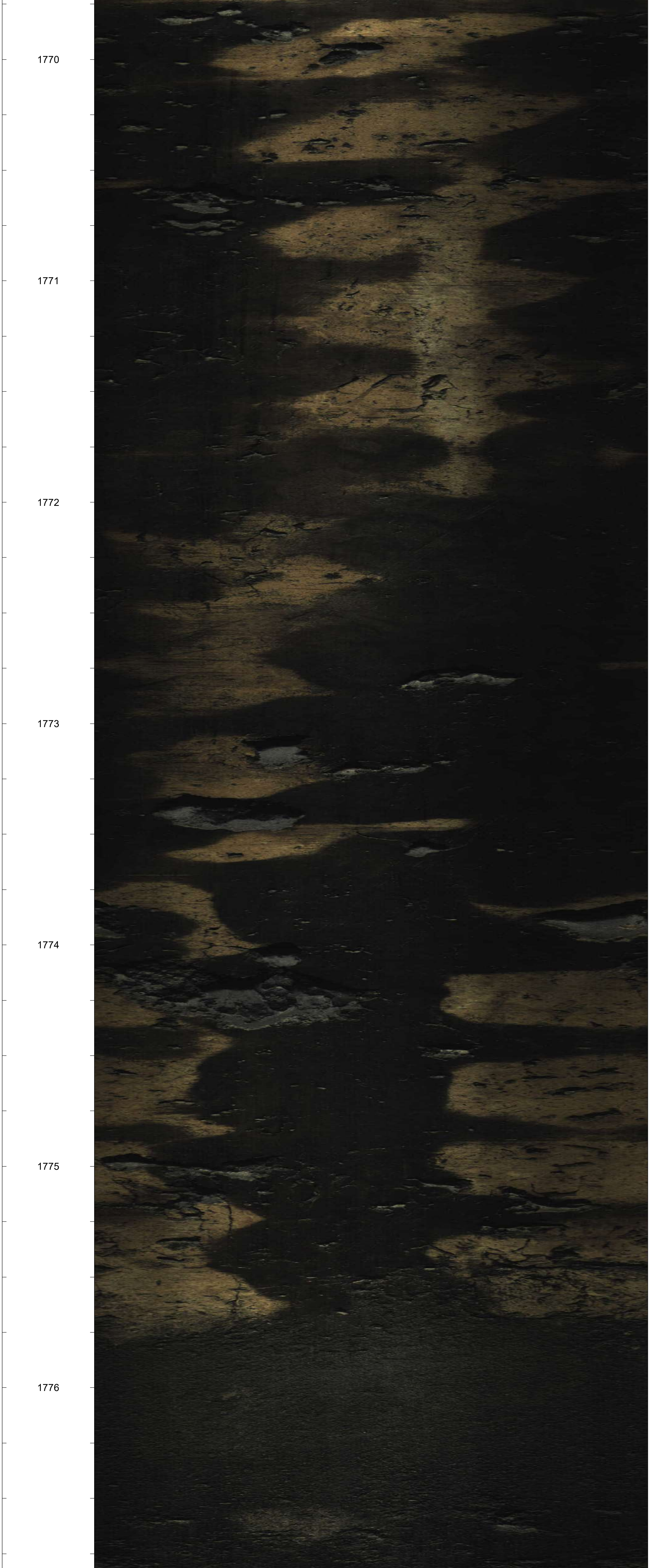
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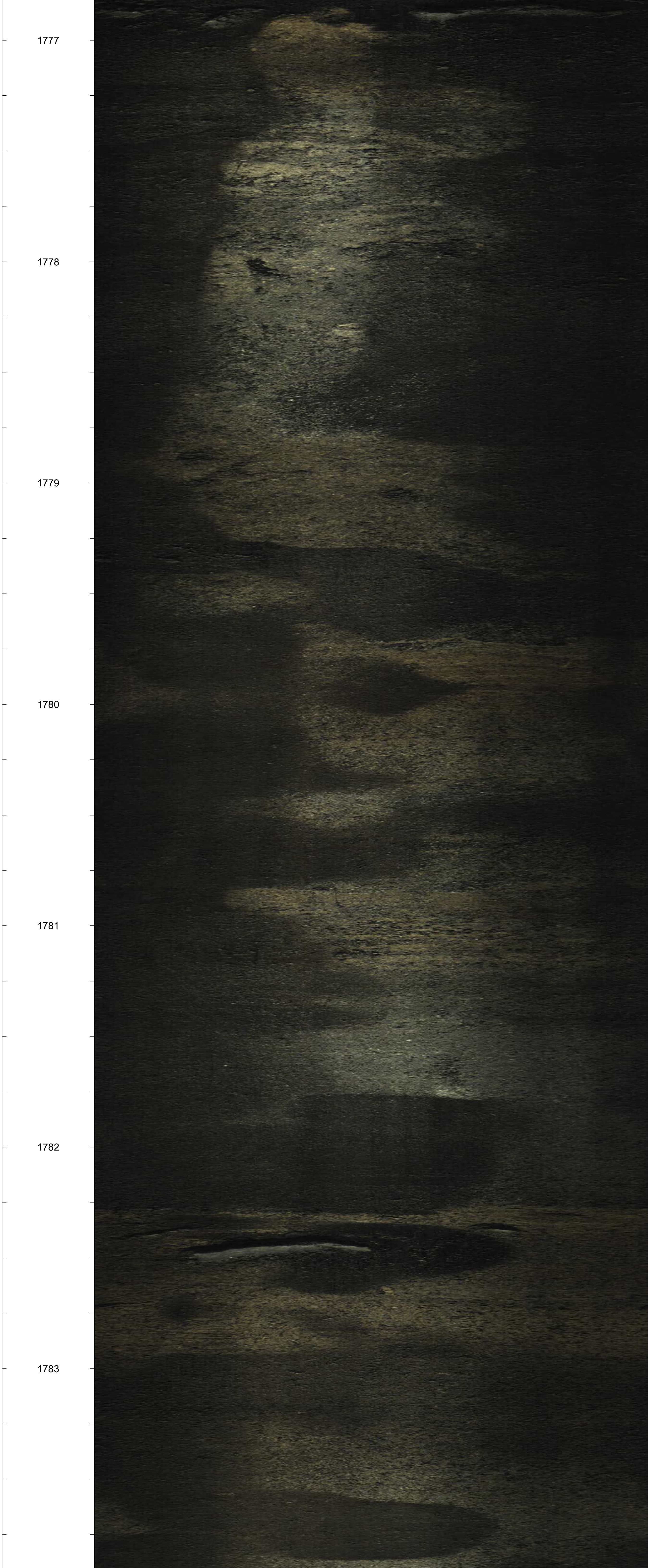
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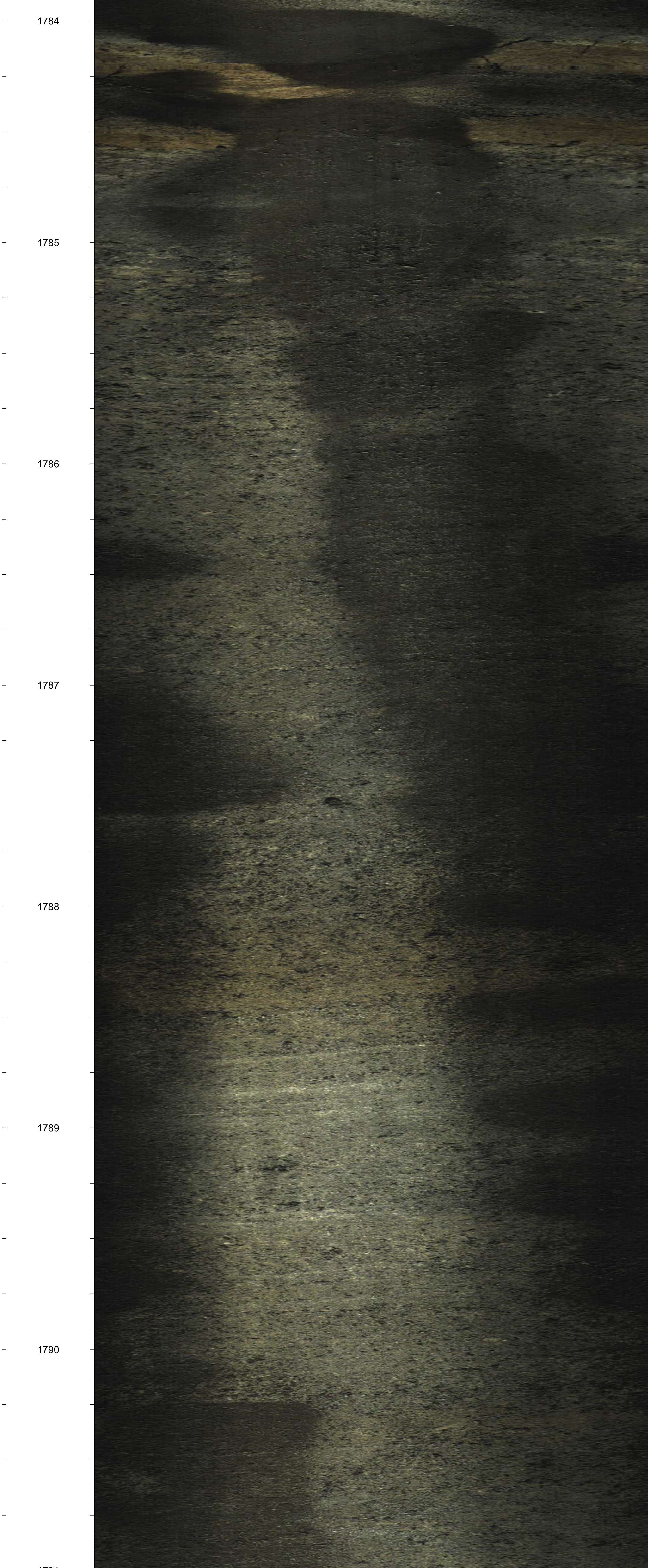
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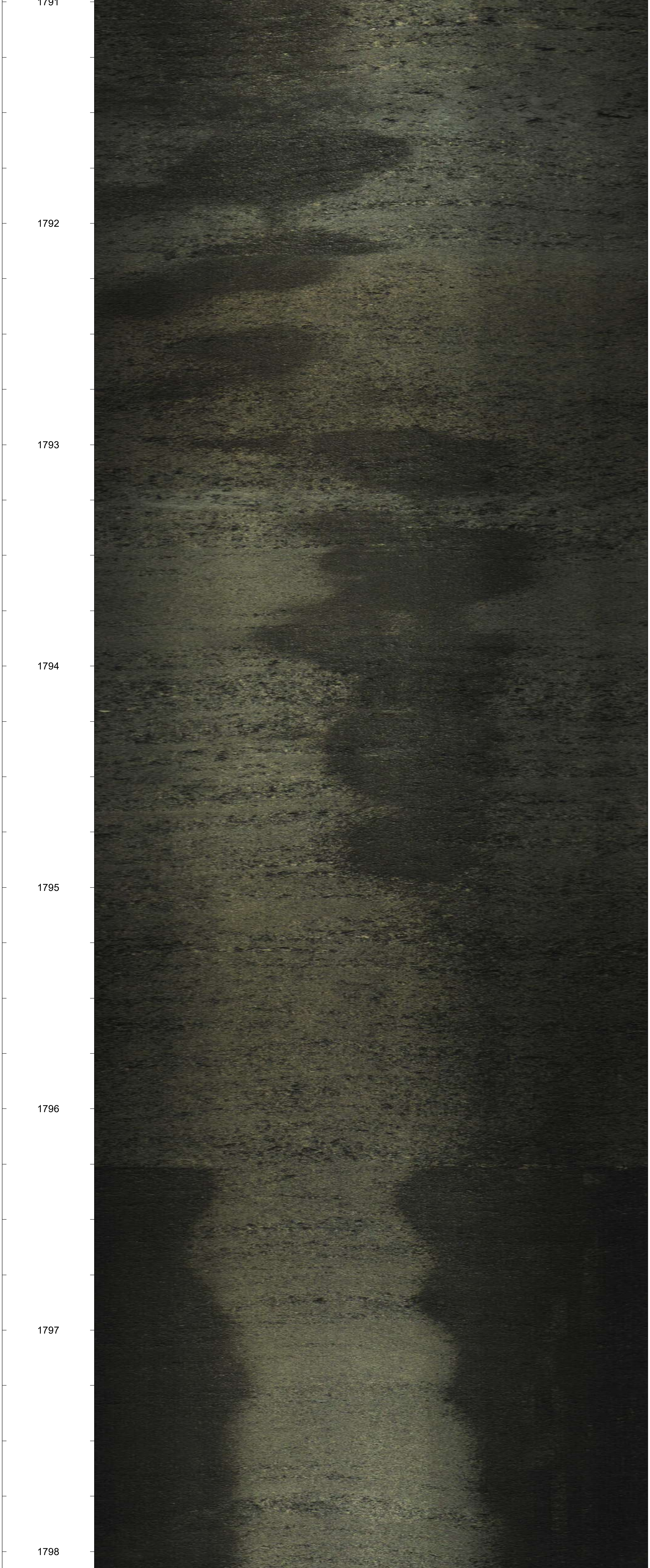
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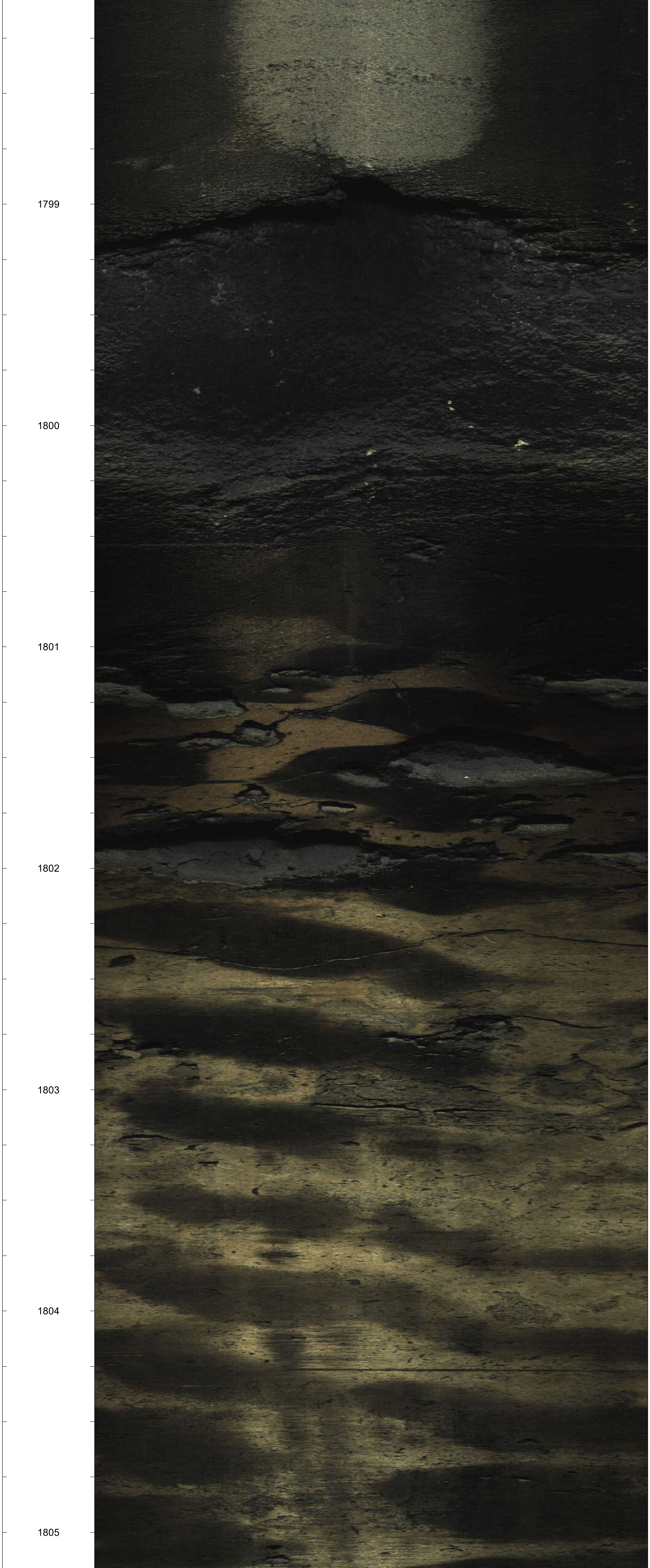
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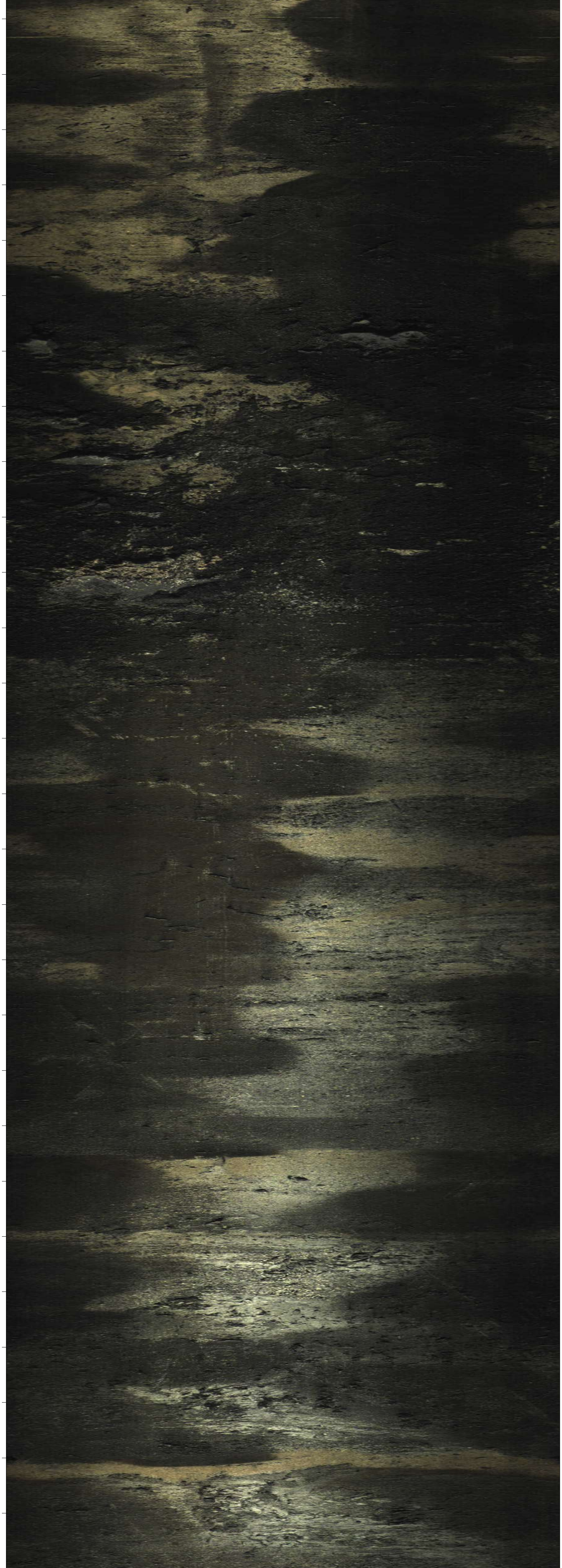

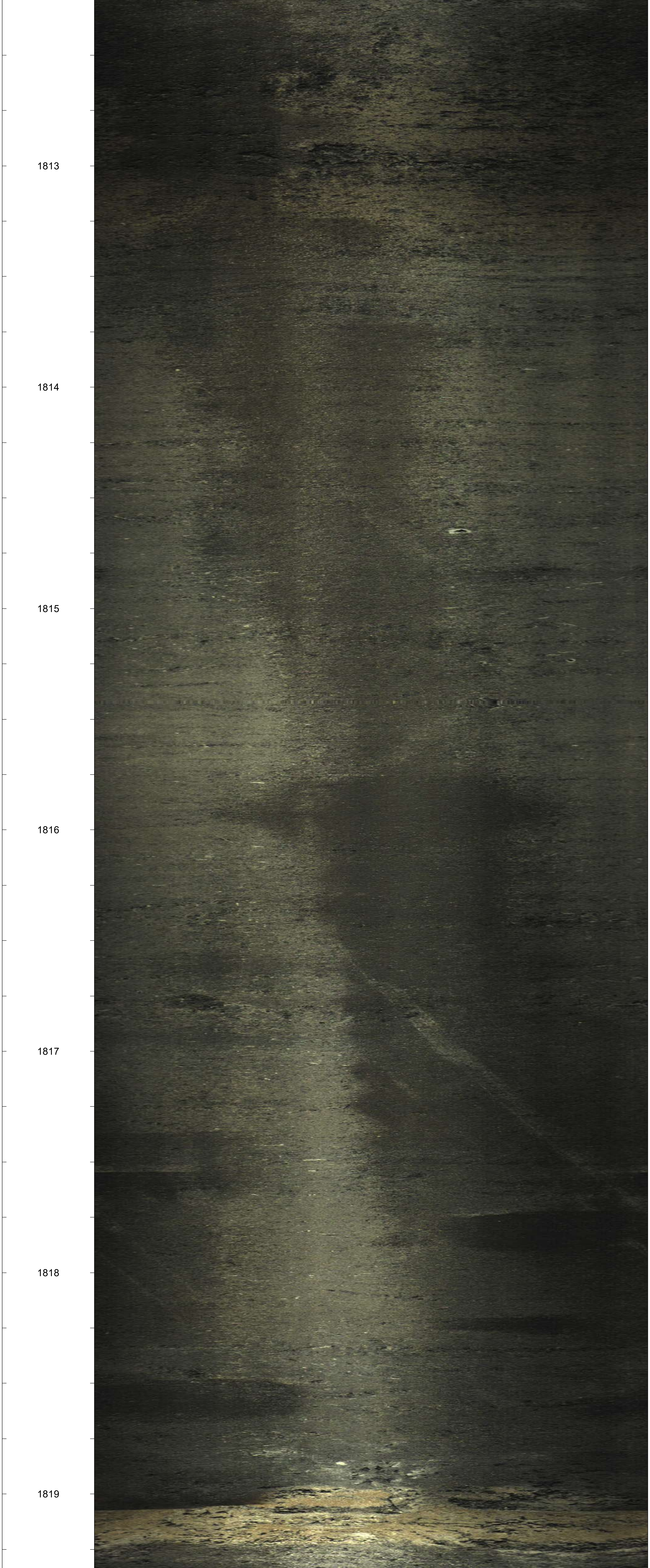
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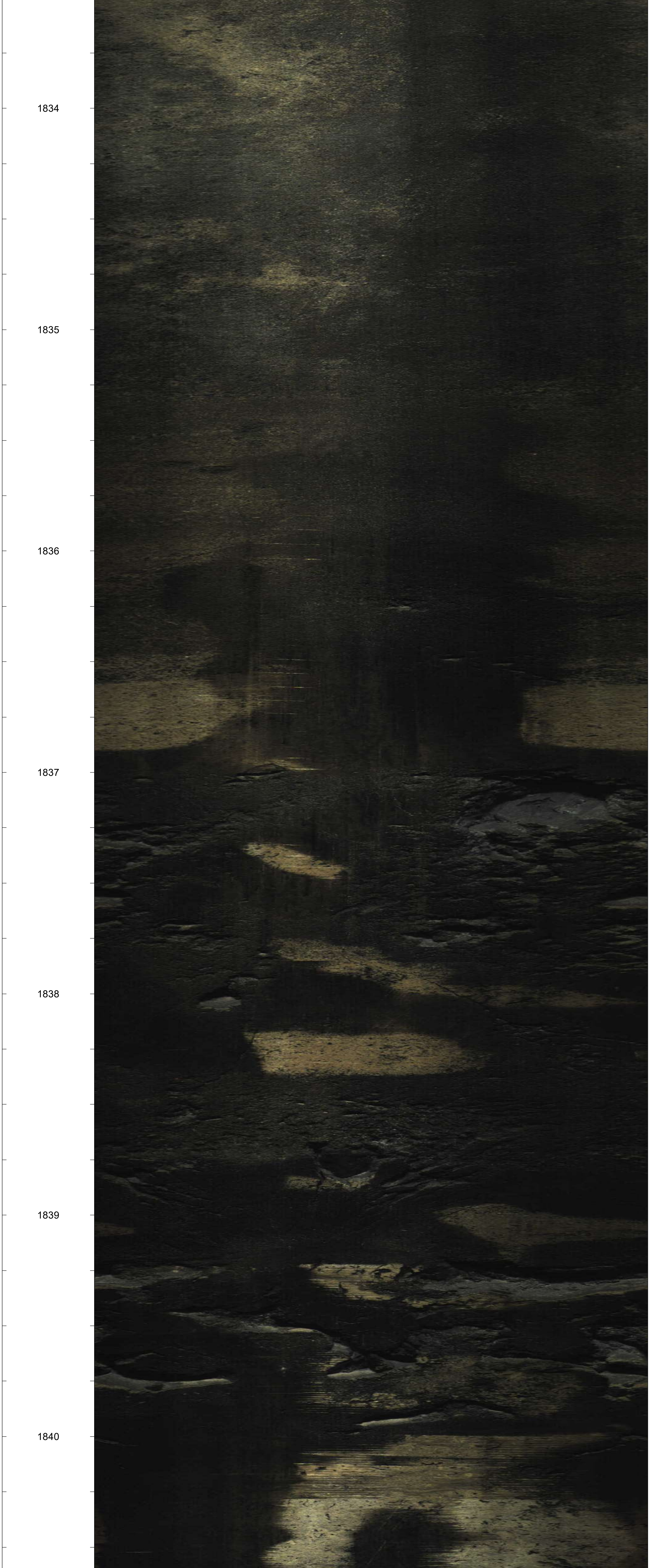
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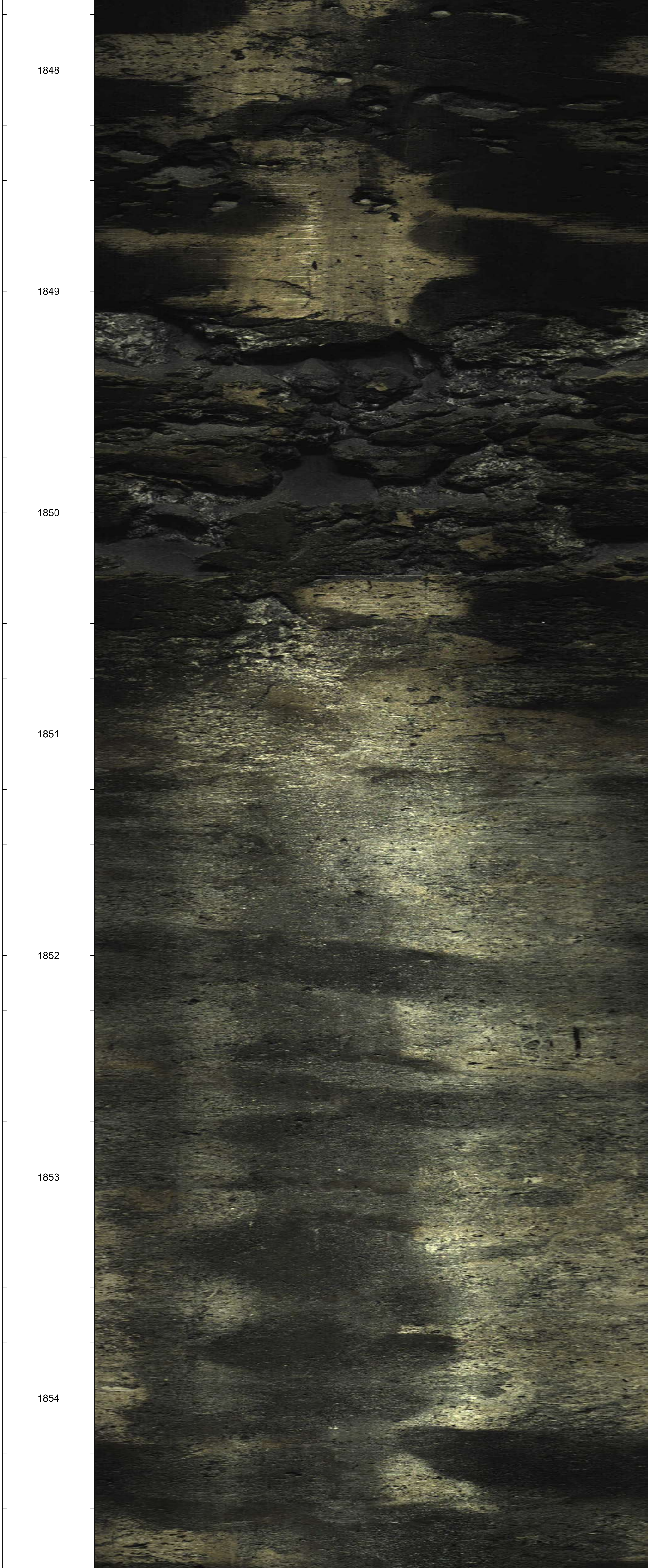
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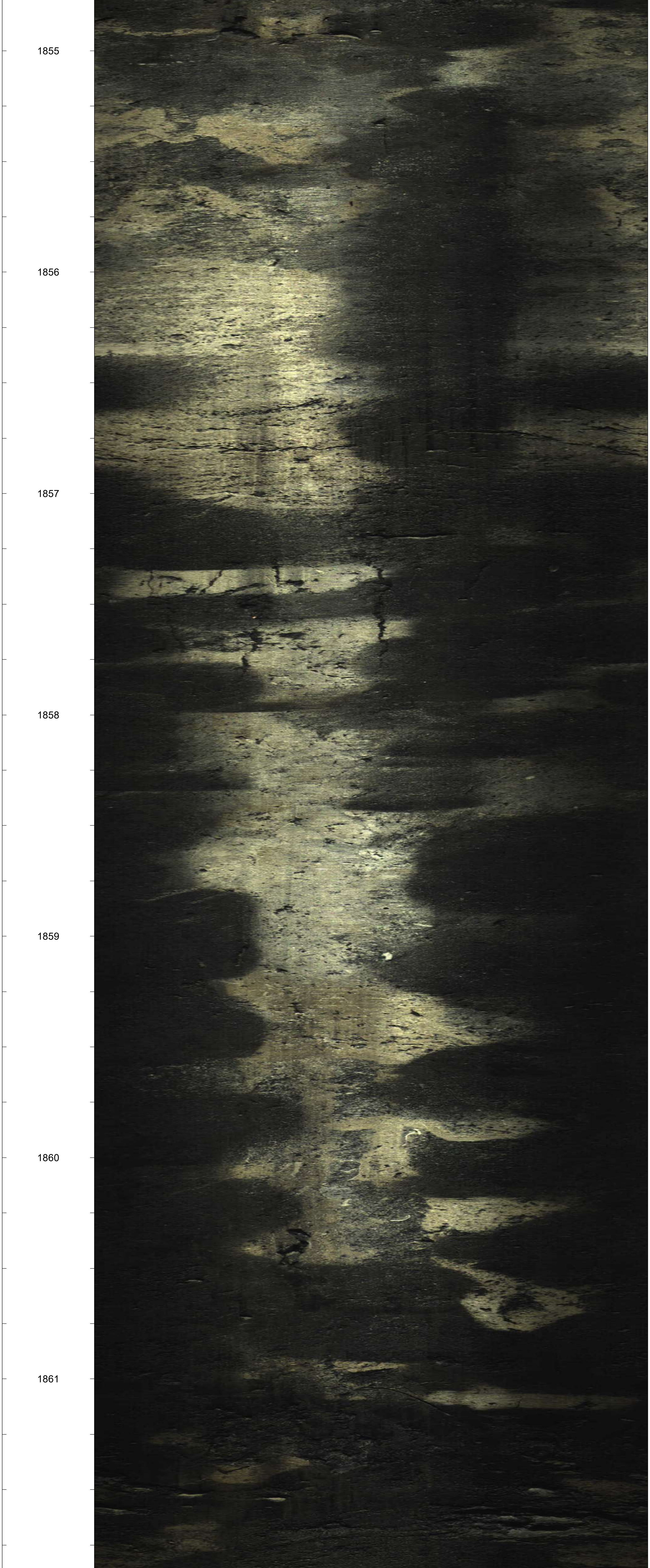
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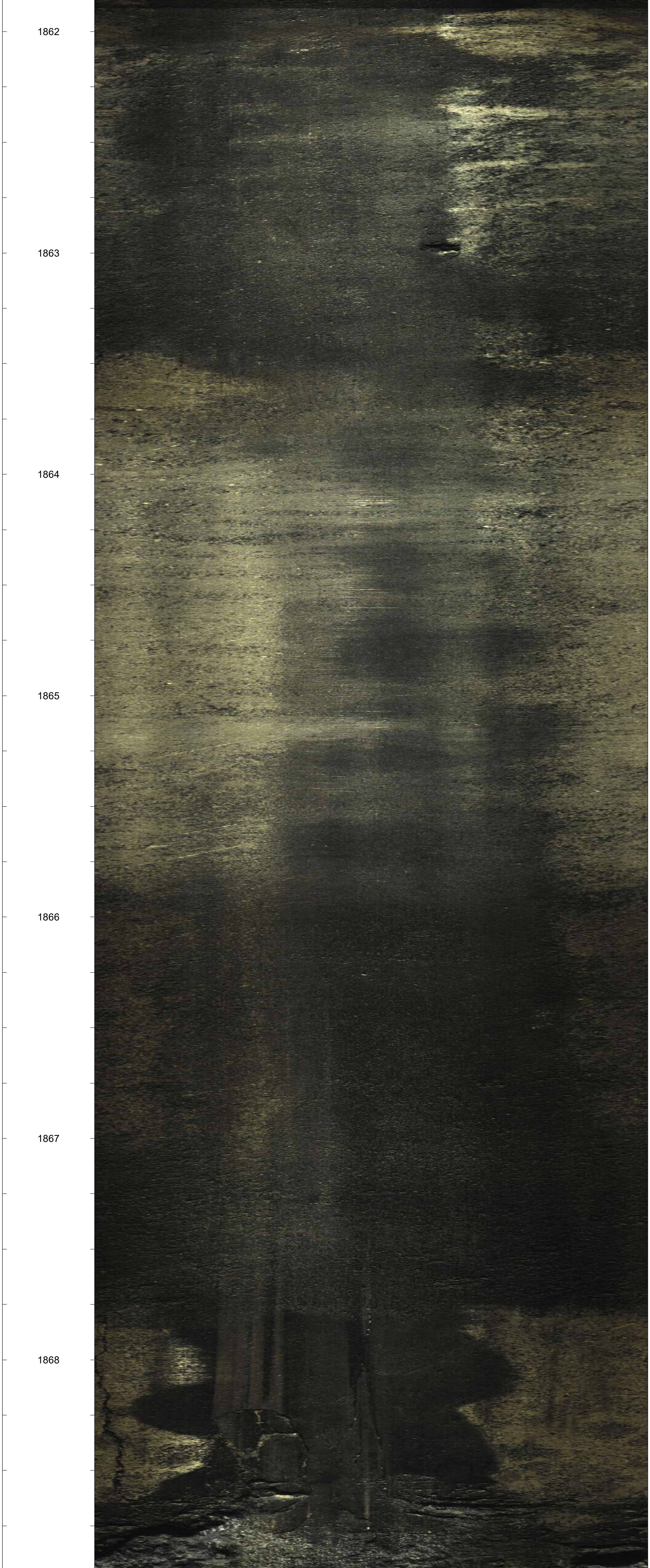
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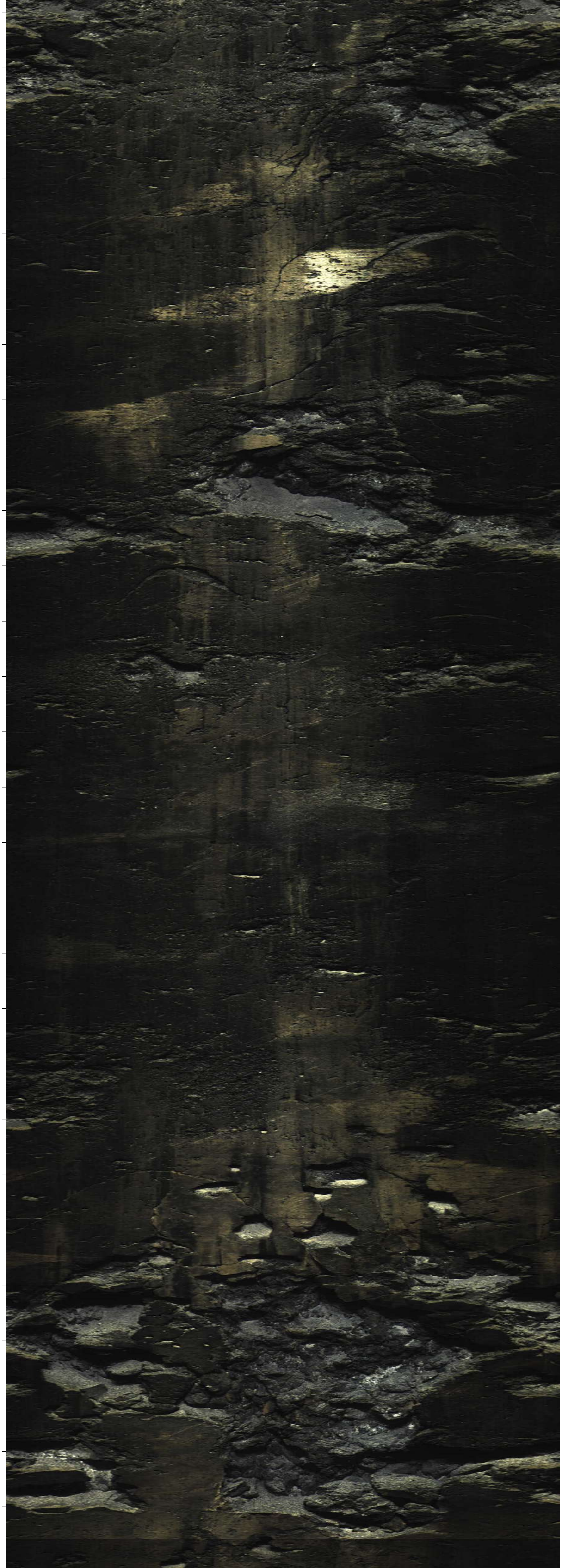

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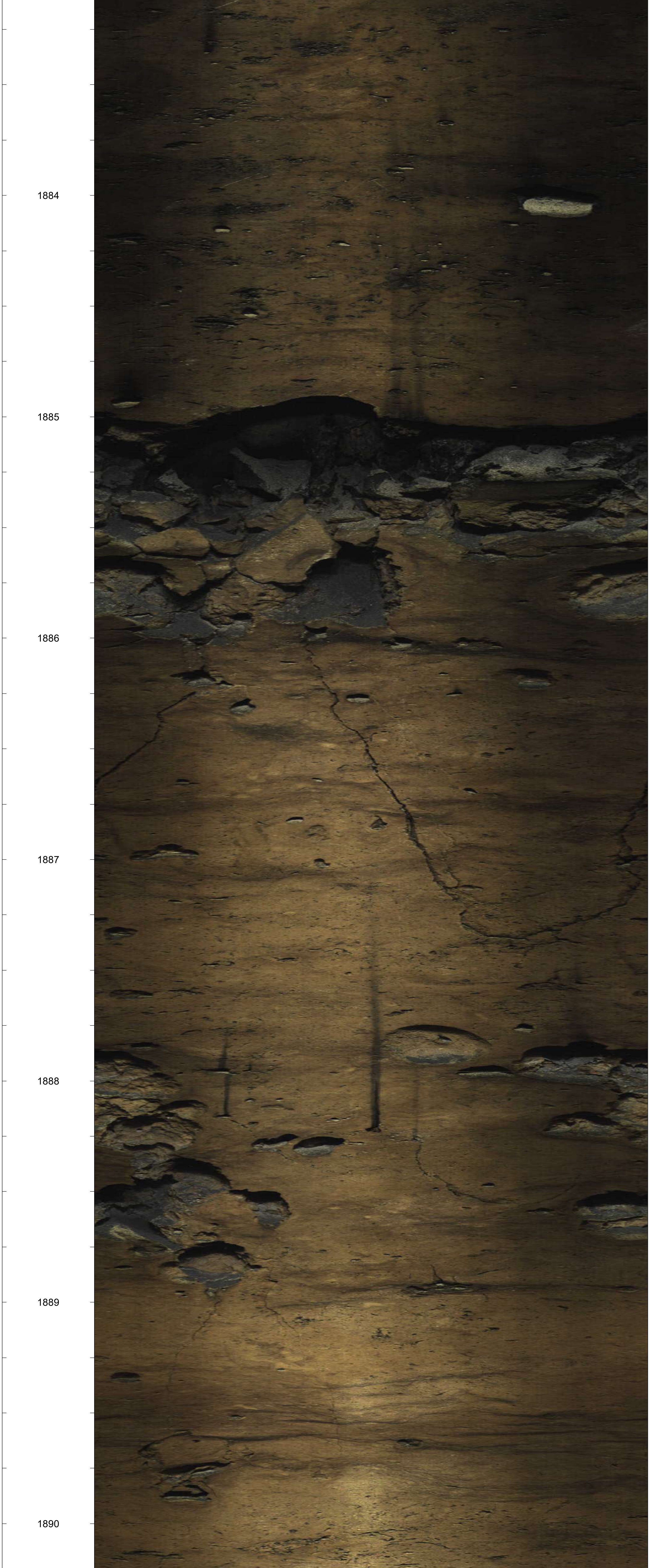
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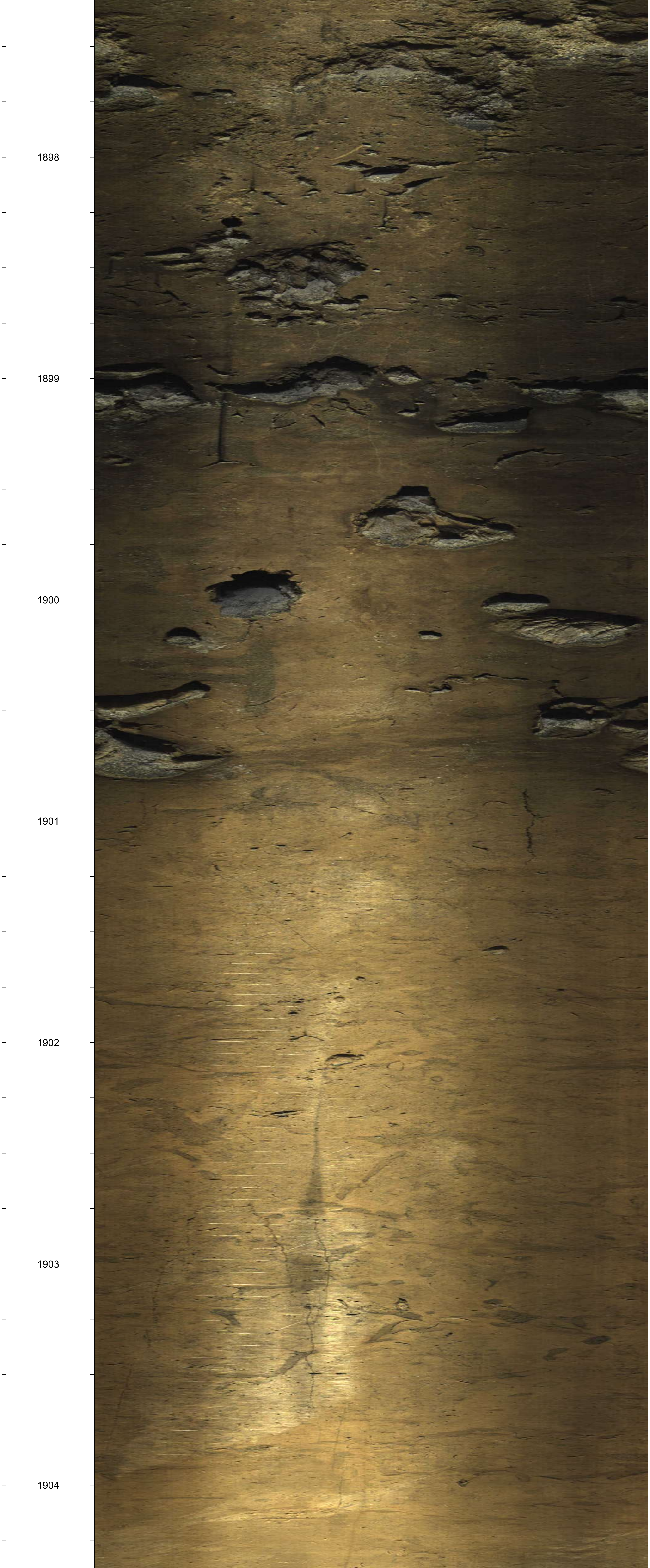
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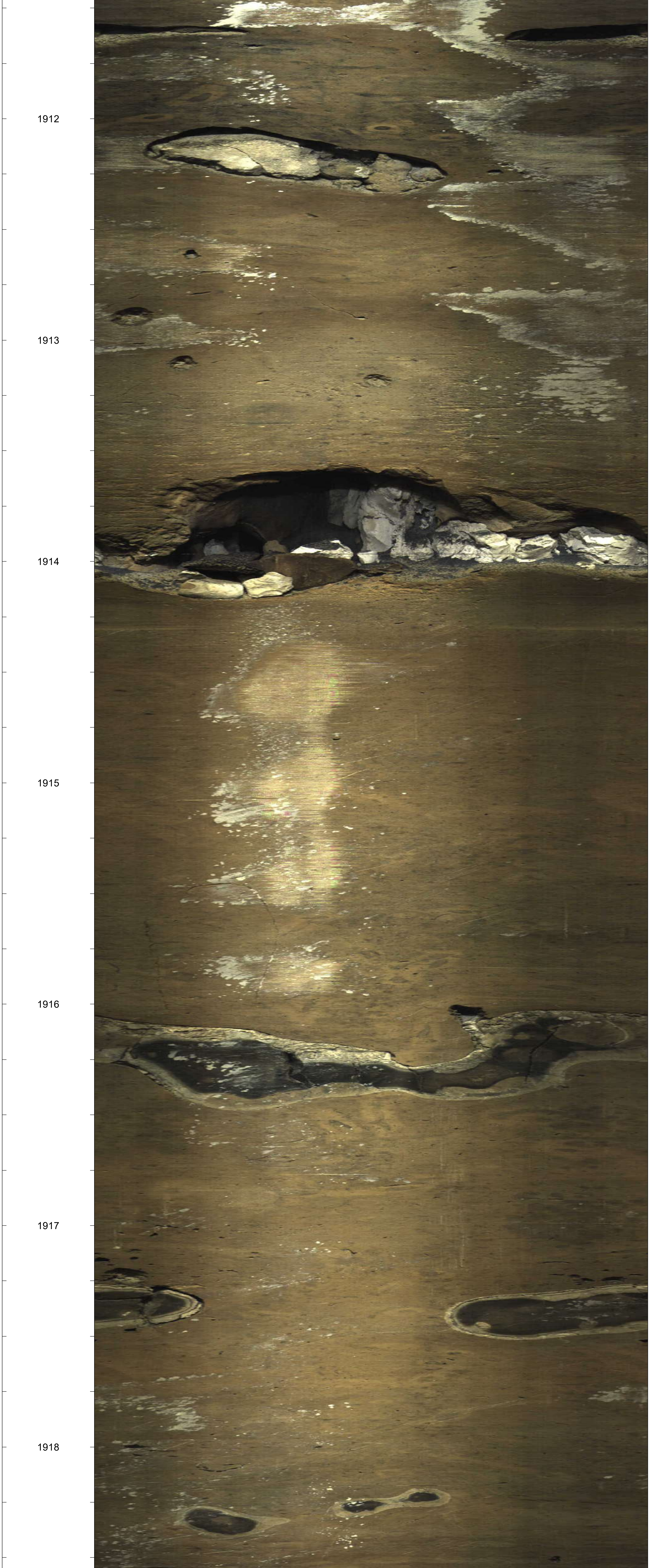
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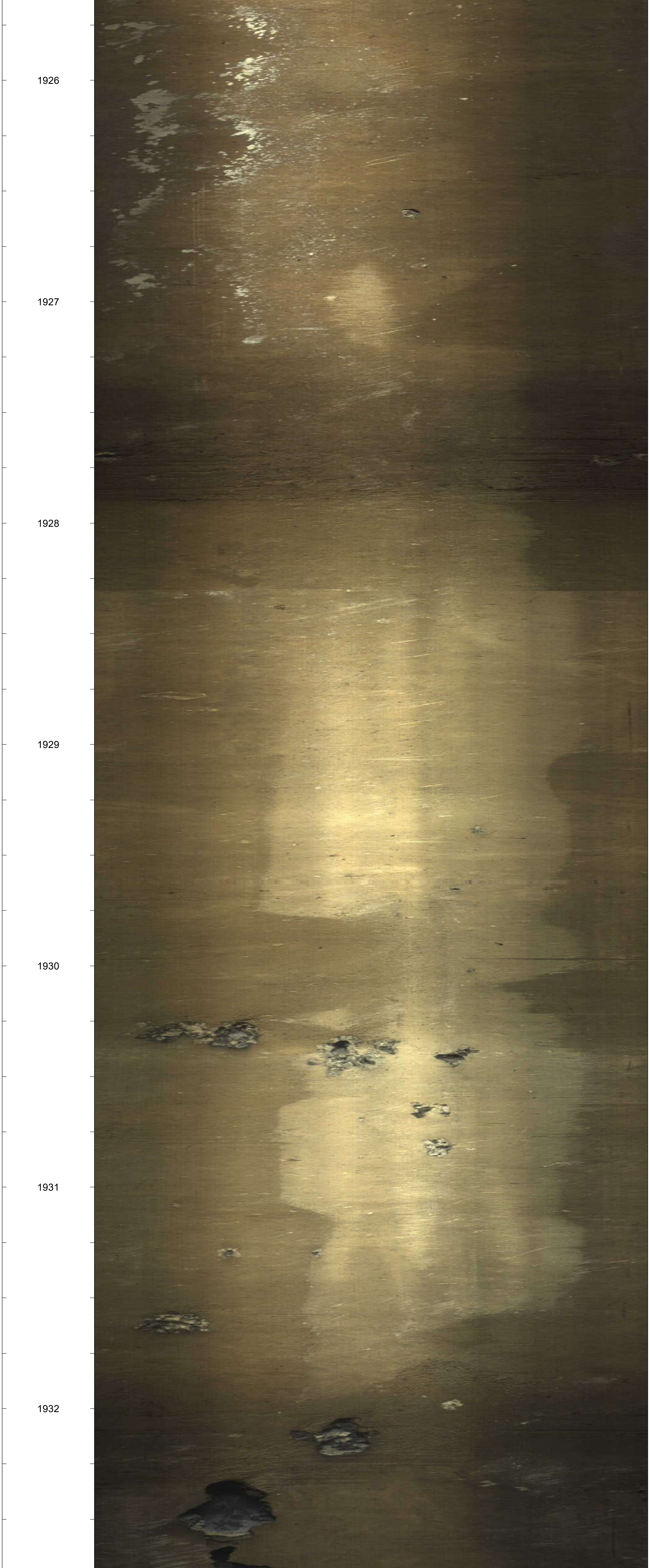
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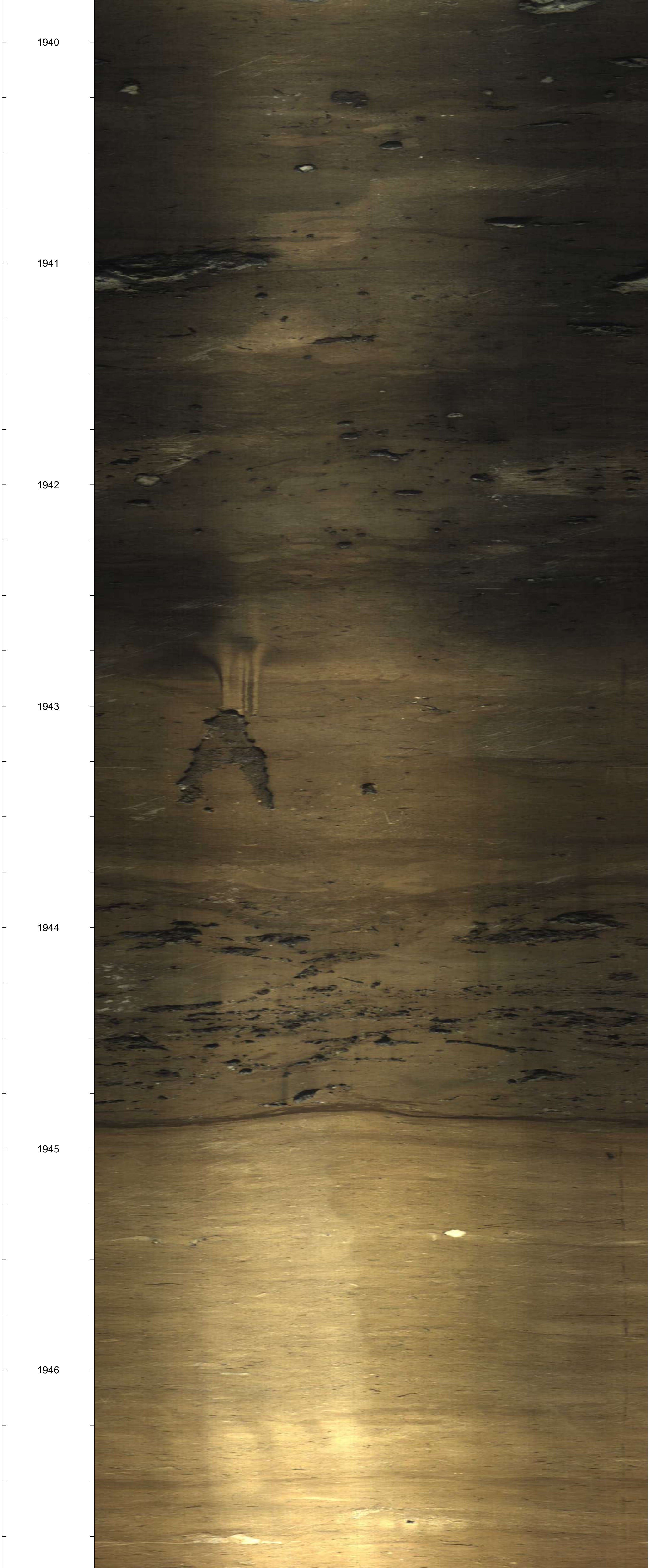
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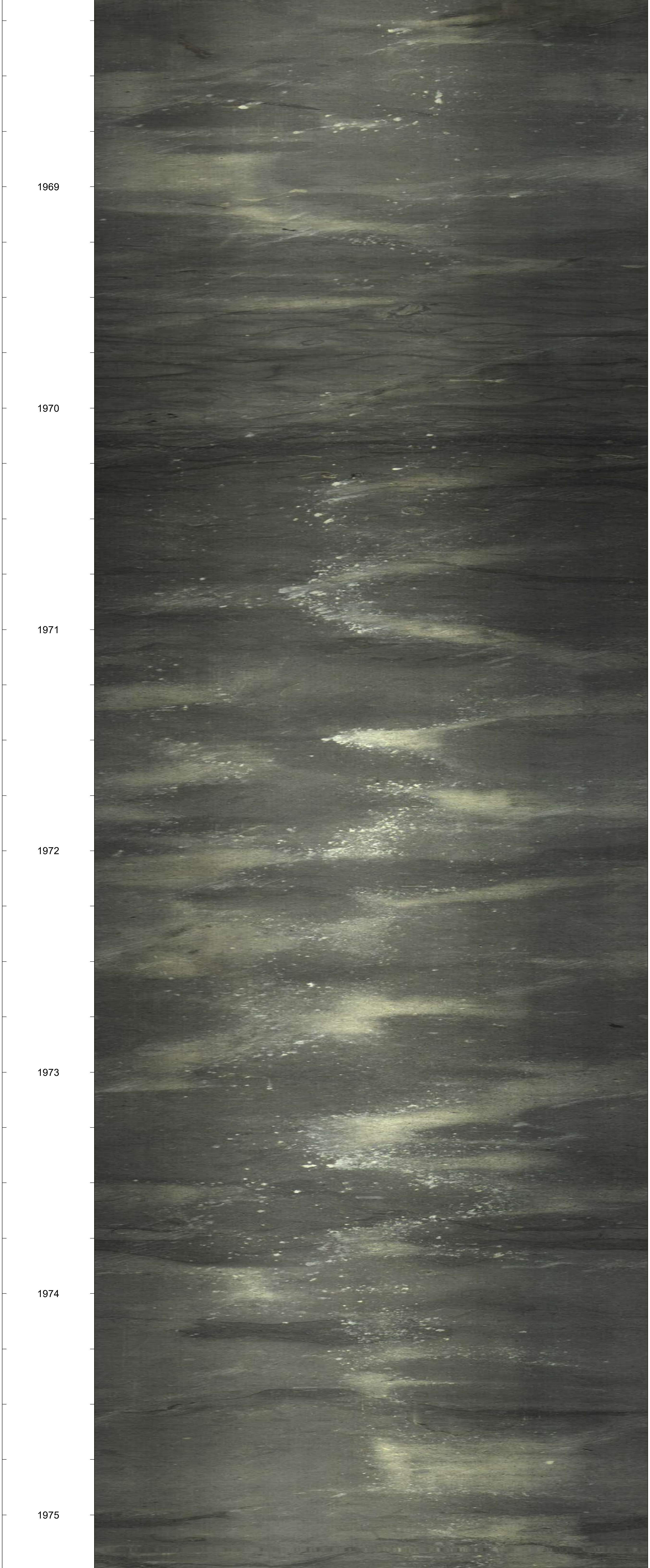
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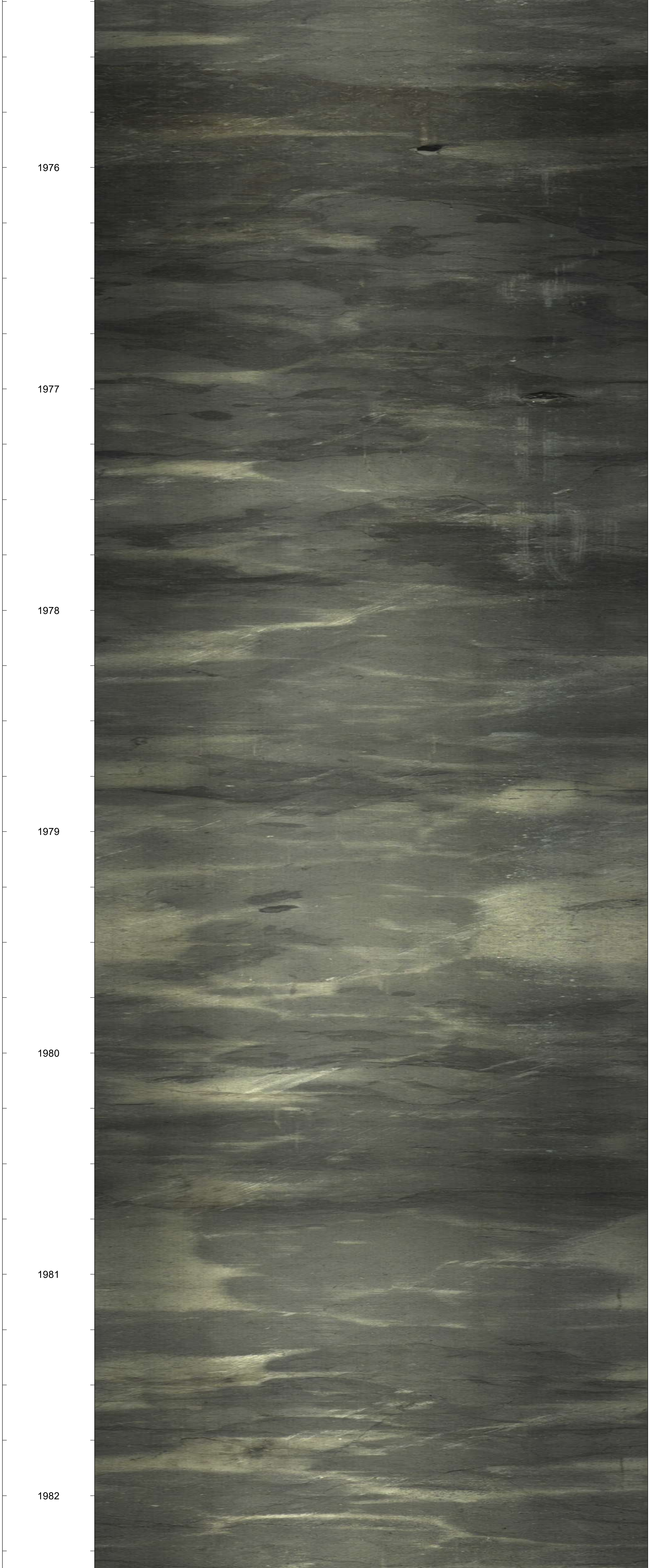

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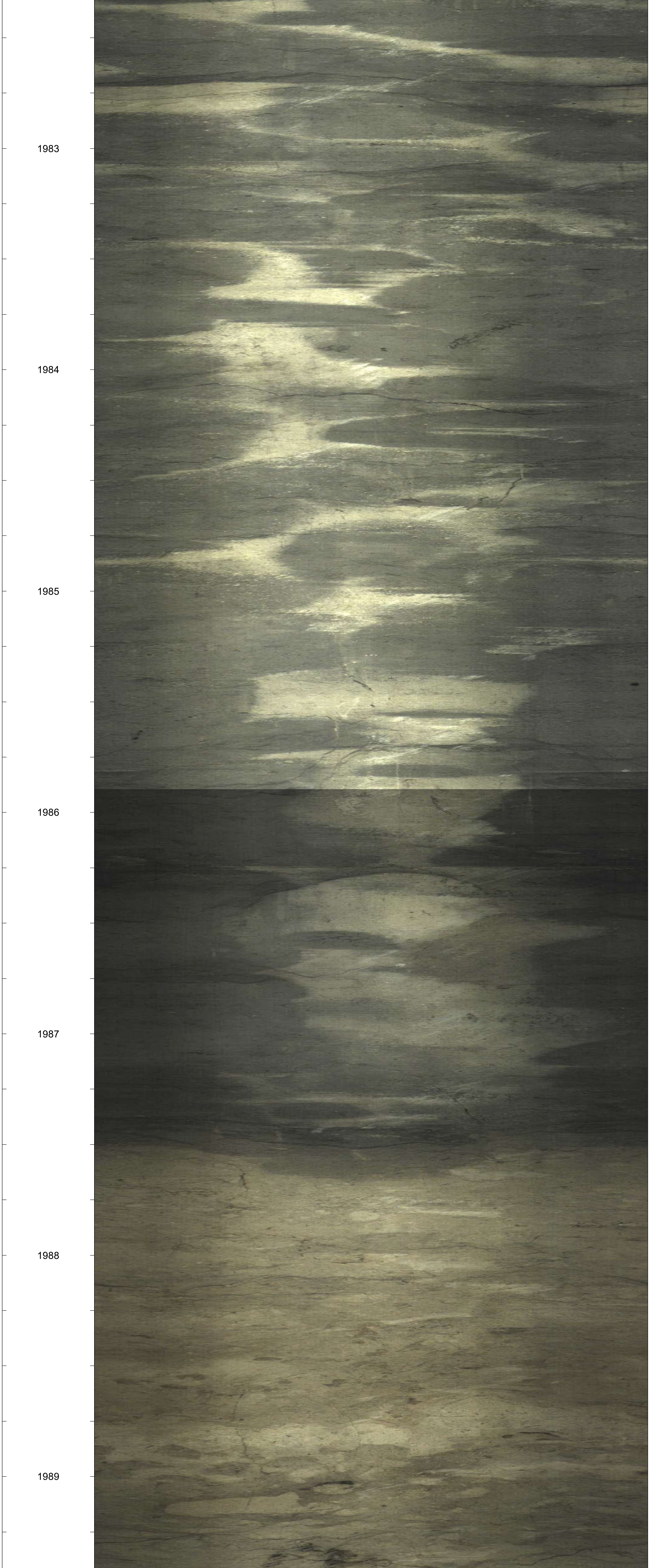

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APPENDIX F:
CORE LABORATORY REPORTS

CMS-300 CONVENTIONAL CORE ANALYSIS

SFWMD

OSF-113

Florida

CL File Number: 201903755

Date: January 15, 2020

SFWMD
OSF-113
Florida

CL File No: 201903755
Date: 15-Jan-2020

CMS-300 CONVENTIONAL CORE ANALYSIS

Sample Number	Depth (ft)	Net Confining Stress (psig)	Porosity (%)	Permeability Klinkenberg (md)	Permeability Kair (md)	b(air) psi	Beta ft(-1)	Alpha (microns)	Grain Density (g/cm3)	Footnote
1V	821.52 - 821.80	800	42.39	1845	1953	0.89	1.40E+06	8.32E+00	2.705	(6)
1H	821.86	800	44.50	3763	4658	3.55	4.75E+05	5.79E+00	2.706	(6)
2V	835.58 - 835.86	800	43.41	1411	1473	0.67	1.32E+06	6.04E+00	2.704	(6)
2H	835.50	800	43.26	1533	1589	0.56	1.52E+06	7.52E+00	2.708	(6)
3V	845.66 - 845.80	800	36.50	916	1261	5.84	5.16E+06	1.53E+01	2.699	(6)
3H	845.62	800	34.06	619	856	6.01	2.42E+07	4.84E+01	2.700	(3),(6)
4V	1030.80 - 1031.10	Ambient	7.55	NA	NA	NA	NA	NA	2.816	(2),(5)
4H	1030.85	800	36.20	915	994	1.34	4.47E+06	1.32E+01	3.478	(6)
5V	1032.72 - 1033	800	40.28	1964	2435	3.64	4.30E+06	2.73E+01	2.823	(6)
5H	1032.67	800	41.40	4032	4748	2.65	1.80E+06	2.34E+01	2.823	(6)
6V	1040.73 - 1040.90	800	30.12	13.1	23.3	14.53	4.41E+09	1.87E+02	2.817	(3),(6)
6H	1040.68	800	42.56	12877	12980	0.12	4.47E+05	1.86E+01	2.885	(6)
7V	1336.00 - 1336.40	800	31.92	26.6	32.2	3.80	2.86E+09	2.45E+02	2.841	(6)
7H	1336.17	800	27.90	26.9	30.3	2.33	1.29E+09	1.12E+02	2.838	(6)
8V	1366.33 - 1366.70	800	13.23	1.80	2.02	2.55	9.10E+10	5.25E+02	2.811	(3),(6)
8H	1366.28	800	13.70	43.0	53.6	4.34	9.18E+08	1.28E+02	2.792	(3),(6)
9V	1369.60 - 1369.80	800	30.81	2.80	4.40	11.70	3.01E+09	2.72E+01	2.833	(1),(3)
9H	1396.83	800	29.60	3.59	5.36	10.02	3.00E+09	3.47E+01	2.835	(1),(3)
10V	1422.35 - 1422.60	800	30.71	31.6	36.2	2.61	6.76E+08	6.90E+01	2.828	(6)
10H	1422.20	800	33.55	96.9	112	2.63	3.20E+07	1.00E+01	2.823	(6)
11V	1439.50 - 1440.00	800	29.29	6.01	9.02	9.85	1.39E+09	2.69E+01	2.841	(6)
11H	1439.80	800	30.17	4.84	7.20	9.70	2.13E+09	3.33E+01	2.841	(6)
12V	1782.72 - 1783.00	800	18.68	2.07	2.76	6.96	2.25E+10	1.50E+02	2.798	(6)
12H	1782.68	800	25.18	45.8	54.0	3.11	2.00E+08	2.96E+01	2.778	(6)

SFWMD
OSF-113
Florida

CL File No: 201903755
Date: 15-Jan-2020

CMS-300 CONVENTIONAL CORE ANALYSIS

Sample Number	Depth (ft)	Net Confining Stress (psig)	Porosity (%)	Permeability Klinkenberg (md)	Permeability Kair (md)	b(air) psi	Beta ft(-1)	Alpha (microns)	Grain Density (g/cm3)	Footnote
13V	1788.20 - 1788.50	800	28.16	168	227	5.80	1.35E+08	7.32E+01	2.754	(6)
13H	1788.10	800	27.60	221	315	6.88	5.71E+07	4.09E+01	2.747	(6)

Footnotes :

(1) : Denotes fractured or chipped sample. Permeability and/or porosity may be optimistic.

(2) : Sample permeability below the measurement range of CMS-300 equipment at indicated net confining stress (NCS). Data unavailable.

(3) : Denotes very short sample, porosity may be optimistic due to lack of conformation of boot material to plug surface.

(5) : Denotes sample unsuitable for measurement at stress. Porosity determined using Archimedes bulk volume at ambient conditions.

(6) : Sample contains vugs. Permeability and/or porosity may be optimistic.

Permeability greater than 0.1 mD measured using helium gas. Permeability less than 0.1 mD measured using nitrogen gas. All b values converted to b (air)

APPENDIX A: EXPLANATION OF CMS-300 TERMS "b", "Beta, and "Alpha"

K_∞	=	Equivalent non-reactive liquid permeability, corrected for gas slippage, mD
K_{air}	=	Permeability to Air, calculated using K_∞ and b, mD
b	=	Klinkenberg slip factor, psi
β (Beta)	=	Forcheimer inertial resistance factor, ft^{-1}
α (Alpha)	=	A factor equal to the product of Beta and K_∞. This factor is employed in determining the pore level heterogeneity index, H_i.
H_i	=	$\log_{10}(\alpha ø/RQI)$ α, microns = $3.238E^{-9}\ \beta K_\infty$
Ø	=	Porosity, fraction
RQI	=	Reservoir Quality Index, microns
RQI	=	$0.0314(K/ø)^{0.5}$

For further information please refer to:

Jones, S.C.: "Two-Point Determination of Permeability and PV vs. Net Confining Stress" SPE Formation Evaluation (March 1988) 235-241.

Jones S.C.: "A Rapid Accurate Unsteady-State Klinkenberg Permeameter," Soc. Pet. Eng. J. (Oct. 1972) 383-397.

Jones, S.C.: "Using the Inertial Coefficient, β, To Characterize Heterogeneity in Reservoir Rock: SPE 16949 (September 1987).

Amaefule, J.O.; Kersey, D.G.; Marschall, D.M.; Powell, J.D.; Valencia, L.E.; Keelan, D.K.: "Reservoir Description: A Practical Synergistic Engineering and Geological Approach Based on Analysis of Core Data,: SPE Technical Conference (Oct. 1988) SPE 18167.

CMS-300 CONVENTIONAL CORE ANALYSIS PROTOCOL

Sample Preparation

1.0" diameter plugs were drilled with water and trimmed into right cylinders with a diamond-blade trim saw.
All sample trims were archived.

Core Extraction

Plugs selected for routine core analysis were placed in Dean Stark equipment using toluene, followed by Soxhlet extraction cycling between a chloroform / methanol (87:13) azeotrope and methanol.

Sample Drying

Samples were oven dried at 240° F to weight equilibrium (+/- 0.01 g).

Porosity

Porosity was determined using Boyle's Law technique by measuring grain volume at ambient conditions & pore volume at indicated net confining stresses (NCS).

Grain Density

Grain density values were calculated by direct measurement of grain volume and weight on dried plug samples.
Grain volume was measured by Boyle's Law technique.

Permeability

Permeability to air was measured on each sample using unsteady-state method at indicated NCS.

SFWMD
OSF-113
Florida

CL File No: 201903755
Date: 15-Jan-2020
Analyst(s): SC

CMS-300 CONVENTIONAL CORE ANALYSIS

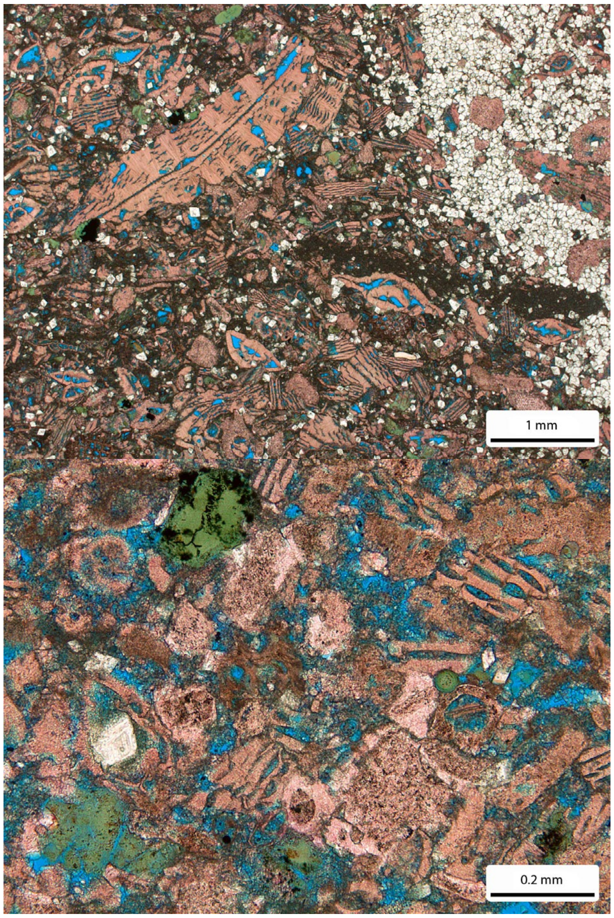
Sample Number	Depth (ft)	Net Confining Stress (psig)	Pore Volume (cm3)	Porosity (%)	Permeability Klinkenberg (md)	Permeability Kair (md)	Grain Volume (cm3)	Grain Density (g/cm3)	Dry Weight (g)	Length (cm)	Diameter (cm)	Fresh Weight (g)
1V	821.52 - 821.80	800	10.192	42.39	1845	1953	13.850	2.705	37.458	5.659	2.483	0.000
1H	821.86	800	7.820	44.50	3763	4658	9.753	2.706	26.393	3.799	2.522	0.000
2V	835.58 - 835.86	800	12.191	43.41	1411	1473	15.893	2.704	42.970	5.844	2.521	0.000
2H	835.50	800	7.861	43.26	1533	1589	10.310	2.708	27.923	3.771	2.525	0.000
3V	845.66 - 845.80	800	3.886	36.50	916	1261	6.762	2.699	18.252	2.463	2.516	0.000
3H	845.62	800	3.009	34.06	619	856	5.825	2.700	15.727	1.931	2.519	0.000
4V	1030.80 - 1031.10	Ambient	1.458	7.55	NA	NA	17.838	2.816	50.239	3.784	2.558	0.000
4H	1030.85	800	4.799	36.20	915	994	8.458	3.478	29.417	2.712	2.528	0.000
5V	1032.72 - 1033	800	10.683	40.28	1964	2435	15.839	2.823	44.714	5.435	2.551	0.000
5H	1032.67	800	8.692	41.40	4032	4748	12.303	2.823	34.727	4.271	2.548	0.000
6V	1040.73 - 1040.90	800	1.876	30.12	13.1	23.3	4.351	2.817	12.255	1.284	2.529	0.000
6H	1040.68	800	4.220	42.56	12877	12980	5.696	2.885	16.433	2.033	2.522	0.000
7V	1336.00 - 1336.40	800	5.613	31.92	26.6	32.2	11.969	2.841	34.003	3.504	2.557	0.000
7H	1336.17	800	6.167	27.90	26.9	30.3	15.935	2.838	45.231	4.365	2.549	0.000
8V	1366.33 - 1366.70	800	1.333	13.23	1.80	2.02	8.744	2.811	24.576	1.970	2.560	0.000
8H	1366.28	800	1.136	13.70	43.0	53.6	7.151	2.792	19.968	1.652	2.548	0.000
9V	1369.60 - 1369.80	800	2.183	30.81	2.80	4.40	4.903	2.833	13.892	1.544	2.545	0.000
9H	1396.83	800	2.125	29.60	3.59	5.36	5.055	2.835	14.333	1.428	2.536	0.000
10V	1422.35 - 1422.60	800	8.494	30.71	31.6	36.2	19.160	2.828	54.176	5.517	2.546	0.000
10H	1422.20	800	6.064	33.55	96.9	112	12.013	2.823	33.907	3.654	2.529	0.000
11V	1439.50 - 1440.00	800	7.105	29.29	6.01	9.02	17.154	2.841	48.741	4.755	2.553	0.000
11H	1439.80	800	5.881	30.17	4.84	7.20	13.613	2.841	38.677	3.907	2.539	0.000
12V	1782.72 - 1783.00	800	4.254	18.68	2.07	2.76	18.517	2.798	51.802	4.525	2.555	0.000
12H	1782.68	800	4.940	25.18	45.8	54.0	14.680	2.778	40.786	3.965	2.549	0.000

PETROLEUM SERVICES

Petrographic Analysis of OSF-113

For

SFWMD



January 2020

Core Laboratories, Inc.
Houston Advanced Technology Center
6316 Windfern Road
Houston, Texas 77040

Houston ATC Job File No.: 1903755GA

Core Laboratories
6316 Windfern Road
Houston, Texas 77040
Tel: 713-328-2673
Fax: 713-328-2170
www.corelab.com

January 24th, 2020

John Janzen
SFWMD
3301 Gun Club Road
West Palm Beach, FL 33406

RE: Petrographic Analysis of OSF-113
Houston Job #: 1903755GA

Dear Mr. Janzen,

This report presents the results of detailed thin section petrographic analysis performed on three (3) samples from the OSF-113 well. In Plates 1-3, the thin sections are described in detail and illustrated by representative photomicrographs. In addition, a total of 300 points were analyzed for each sample using the point-counting method. The objectives of this study are to determine the mineralogy, framework grains, authigenic minerals, pore types, textures, and fabrics of each sample in thin section.

The samples examined in this study include two foraminiferal packstones (sample 1964.15 ft. and 1977.45 ft.) and one well-sorted, fine-grained, mixed-fossil grainstone (sample 1990.80 ft.). Bioclasts consist mainly of relatively large benthic foraminifera (e.g. *Lepidocyclina* and *Nummulites)* (Plates 1A & 2A) and lesser amounts of echinoderm fragments, bryozoans, and planktonic foraminifera (Plates 1B & 2B). Red algae are rare to absent in the packstones and are minor in the grainstone. Phosphatic grains, fish bones, and organic matter are rare in the packstones. Intraclasts, peloids, and ostracods are rare in the grainstone. Some skeletal fragments cannot be identified due to diagenetic alteration (e.g. recrystallization, micritization, and dissolution). Glauconite is minor in the packstones and very minor in the grainstone, and occurs as grains, replacement, and grain coating (Plates 1B, 2B & 3B).

A moderate amount of matrix is present in the packstones and consists of micrite and microspar with trace amounts of clay. The matrix is rare to absent in the grainstone sample.

Authigenic minerals include calcite, dolomite, and trace amounts of pyrite and gypsum/anhydrite. Calcite is minor in the packstones (Plate 2B) and abundant in the grainstone (Plates 3A & 3B), and occurs mainly as finely to coarsely crystalline, pore-filling and pore-lining cement. Early syntaxial calcite cement around echinoderm fragments is relatively common in all three samples. Dolomite is moderate to locally abundant in the packstones (Plates 1A & 2A) and rare in the grainstone, and occurs as fine- to medium-crystalline, euhedral rhombs (Plate 1B).

The grainstone sample shows a higher porosity than the packstones. Pore types include interparticle, primary intraparticle, secondary intraparticle, intercrystal micropores, and moldic/ vuggy pores. Primary interparticle areas are mostly filled with micrite and microspar in the packstones (Plate 1A) and have been significantly reduced by calcite cementation in the grainstone (Plate 3B). Primary intraparticle pores are minor in the packstones (Plates 1B & 2B) and rare in the grainstone. Secondary intraparticle pores are minor in all three samples (Plate

1B). Intercrystal micropores are minor to moderate in the packstones (Plate 2B) and moderate in the grainstone (Plate 3B). Moldic/vuggy pores are rare in the packstones and minor in the grainstone.

Thank you for choosing Core Laboratories to perform this study. Please feel free to contact me if you have any questions or comments concerning this report.

Sincerely,

Dr. Jie Zhou
Geologist, Petroleum Services
Core Laboratories
713-328-2665
jie.zhou@corelab.com

ANALYTICAL PROCEDURES

Thin Sections

Thin sections were prepared by first impregnating the samples with epoxy to augment cohesion and prevent loss of material during grinding. Blue dye was added to the epoxy to highlight the pore spaces. Each thinly sliced sample was mounted on a frosted glass slide and then cut and ground in oil to an approximate thickness of 30 microns and wedged. Selected thin sections were partially stained with alizarin red-S to differentiate calcite (stains red) from clear dolomite (does not stain) and potassium ferricyanide to identify ferroan dolomite (stains medium blue) and ferroan calcite (stains purple). In an effort to avoid sample damage, samples containing large amounts of clay minerals were not stained. Thin sections were analyzed using standard petrographic techniques. Photomicrographs are calibrated for on-screen viewing, and the high magnification views are within the low magnification images, unless otherwise noted.

THIN SECTION PETROGRAPHY

Company: SFWMD
Well: OSF-113
Location: Florida
Job Number: 1903755GA

Depth (ft) 1964.15

Plate 1A

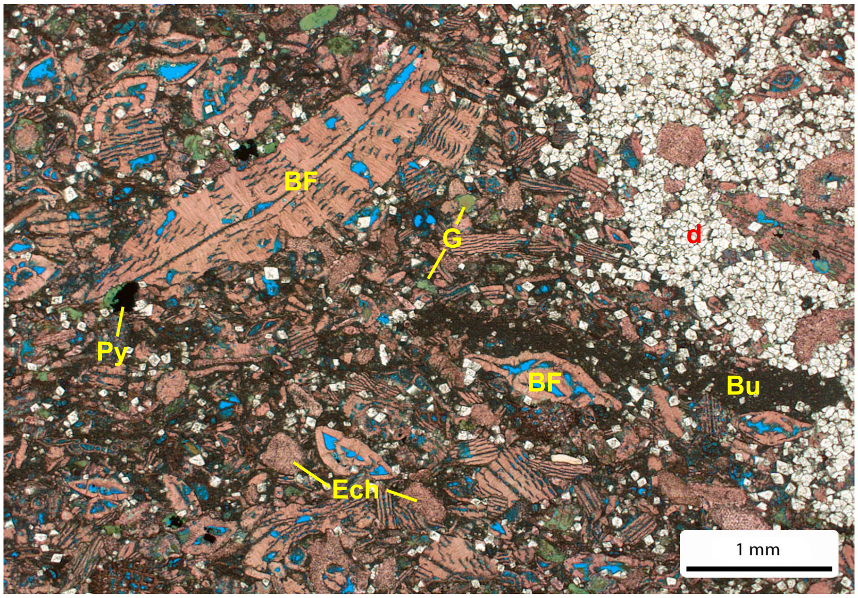
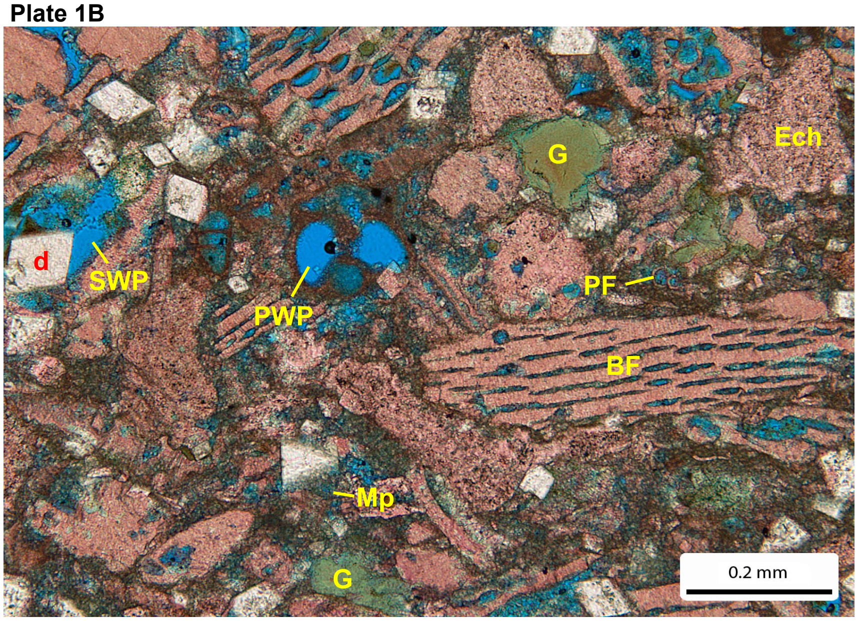


Plate 1B



Depositional texture	
Lithology	Dolomitic Limestone
Classification (Dunham)	Foraminiferal Packstone
Average grain size (mm)	
Average crystal size (mm)	
Framework grains	Abundance (%)
Red Algae	0.3
Benthic foraminifera	38.0
Bryozoans	2.3
Echinoderms	6.3
Glauconite	4.0
Intraclasts	
Mollusks	
Ooids / coated grains	
Ostracods	
Peloids	
Phosphatic fragments	0.3
Planktonic foraminifera	1.0
Undiff. skeletal fragments	3.0
Organic matter	
Authigenic minerals	
Calcite	4.0
Dolomite	22.0
Gypsum/Anhydrite	
Pyrite	
Silica	
Celestine	
Matrix	
Micrite/microspar	8.3
Dolomicrite	
Clay	
Pore types	
Primary Interparticle	1.0
Primary intraparticle	4.7
Secondary Intraparticle	2.7
Intercrystal micropores	2.0
Moldic	
Vugs	
Fractures	

Petrographic description

This sample is a foraminifer-rich, bioclastic packstone. Burrows (Bu) are noted locally. Relatively large benthic foraminifera (BF - e.g. *Lepidocyclina* and *Nummulites*) are abundant; echinoderms (Ech) are common; planktic foraminifera (PF), bryozoans, and undifferentiated skeletal fragments are minor. Glauconite (G) is minor and occurs as either grains or replacement. Trace phosphatic fragments and fish bones are present. Calcite cement is minor; dolomite (d) rhombs are minor to locally abundant; trace gypsum and pyrite (Py) are observed. Primary interparticle pore space is filled with moderate amounts of micrite/microspar (matrix); intercrystal micropores (Mp) are minor. Primary intraparticle (PWP) and secondary intraparticle pores (SWP) are minor; vuggy/moldic pores are rare.

Core Lab
RESERVOIR OPTIMIZATION

Trace/Rare (<1%)
Minor (1-5%)
Moderate (5-10%)
Common (10-20%)
Abundant (>20%)

THIN SECTION PETROGRAPHY

Company: SFWMD
Well: OSF-113
Location: Florida
Job Number: 1903755GA

Depth (ft) 1977.45

Plate 2A

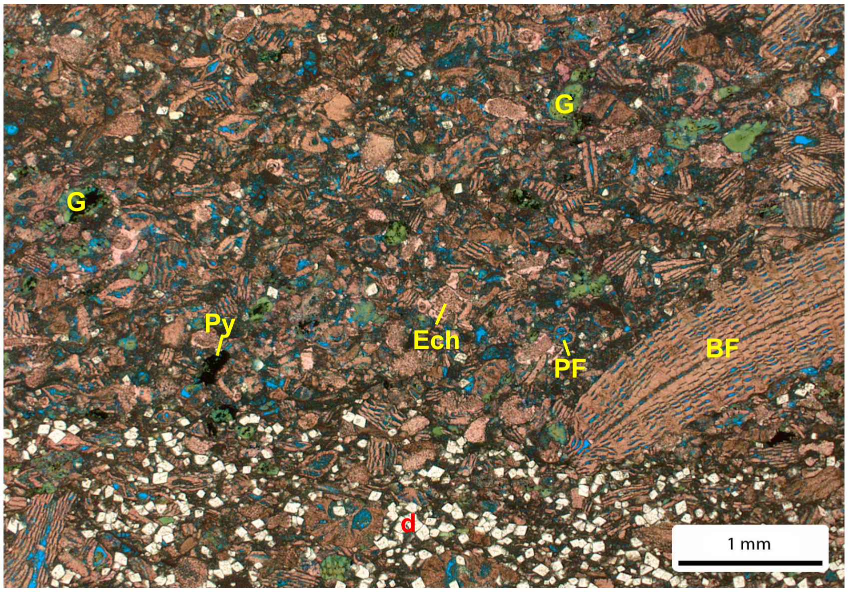
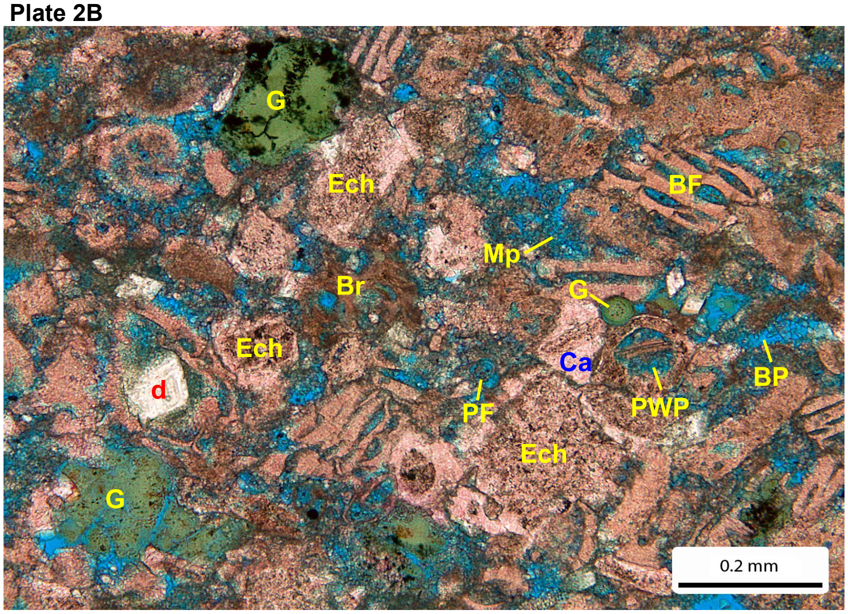


Plate 2B



Trace/Rare (<1%)
Minor (1-5%)
Moderate (5-10%)
Common (10-20%)
Abundant (>20%)

Depositional texture	
Lithology	Dolomitic Limestone
Classification (Dunham)	Foraminiferal Packstone
Average grain size (mm)	
Average crystal size (mm)	
Framework grains	Abundance (%)
Red Algae	
Benthic foraminifera	41.0
Bryozoans	0.7
Echinoderms	6.3
Glauconite	4.7
Intraclasts	
Mollusks	
Ooids / coated grains	
Ostracods	
Peloids	
Phosphatic fragments	
Planktonic foraminifera	2.7
Undiff. skeletal fragments	4.3
Organic matter	0.7
Authigenic minerals	
Calcite	4.3
Dolomite	9.0
Gypsum/Anhydrite	
Pyrite	1.0
Silica	
Celestine	
Matrix	
Micrite/microspar	8.7
Dolomicrite	
Clay	0.3
Pore types	
Primary Interparticle	2.3
Primary intraparticle	5.3
Secondary Intraparticle	3.0
Intercrystal micropores	5.7
Moldic	
Vugs	
Fractures	

Petrographic description

This is a foraminifer-rich, bioclastic packstone. Relatively large benthic foraminifera (BF - e.g. *Lepidocyclina* and *Nummulites*) are abundant; echinoderms (Ech) are moderate; planktic foraminifera (PF), bryozoans (Br), and undifferentiated skeletal fragments are minor. Glauconite (G) is minor and occurs as either grains or replacement. Trace mollusks, phosphatic fragments, fish bones, and organic matter are present. Calcite (Ca) cement is minor; dolomite (d) rhombs are minor to locally common. Trace gypsum and pyrite (Py) are observed. Interparticle pore (BP) space is mostly filled with moderate amounts of micrite/microspar (matrix), forming moderate intercrystal micropores (Mp). Primary intraparticle (PWP) and secondary intraparticle pores are moderate; vuggy/moldic pores are rare.

THIN SECTION PETROGRAPHY

Company: SFWMD
Well: OSF-113
Location: Florida
Job Number: 1903755GA

Depth (ft) 1990.80

Plate 3A

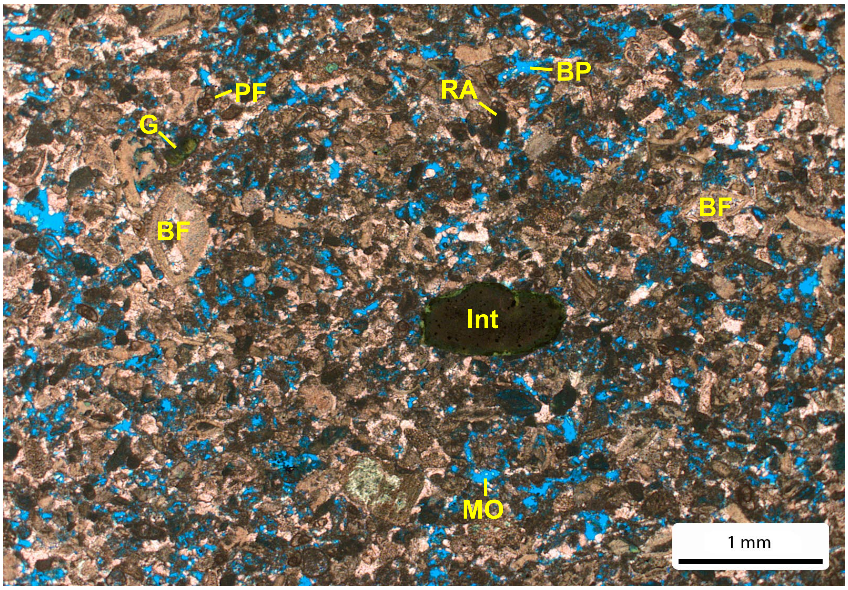
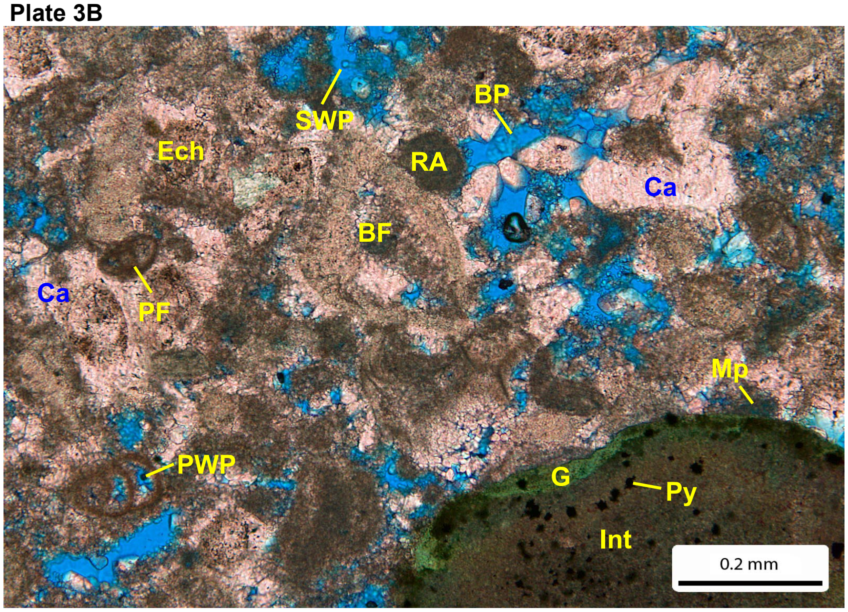


Plate 3B



Depositional texture	
Lithology	Limestone
Classification (Dunham)	Mixed-fossil Grainstone
Average grain size (mm)	
Average crystal size (mm)	
Framework grains	Abundance (%)
Algae	2.0
Benthic foraminifera	24.7
Bryozoans	1.7
Echinoderms	5.3
Glauconite	1.0
Intraclasts	0.7
Mollusks	
Ooids / coated grains	
Ostracods	0.3
Peloids	0.3
Phosphatic fragments	
Planktonic foraminifera	3.7
Undiff. skeletal fragments	8.3
Organic matter	
Authigenic minerals	
Calcite	28.3
Dolomite	
Gypsum/Anhydrite	
Pyrite	
Silica	
Celestine	
Matrix	
Micrite/microspar	
Dolomicrite	
Clay	
Pore types	
Primary Interparticle	10.0
Primary intraparticle	0.3
Secondary Intraparticle	4.3
Intercrystal micropores	7.0
Moldic	2.0
Vugs	
Fractures	

Petrographic description

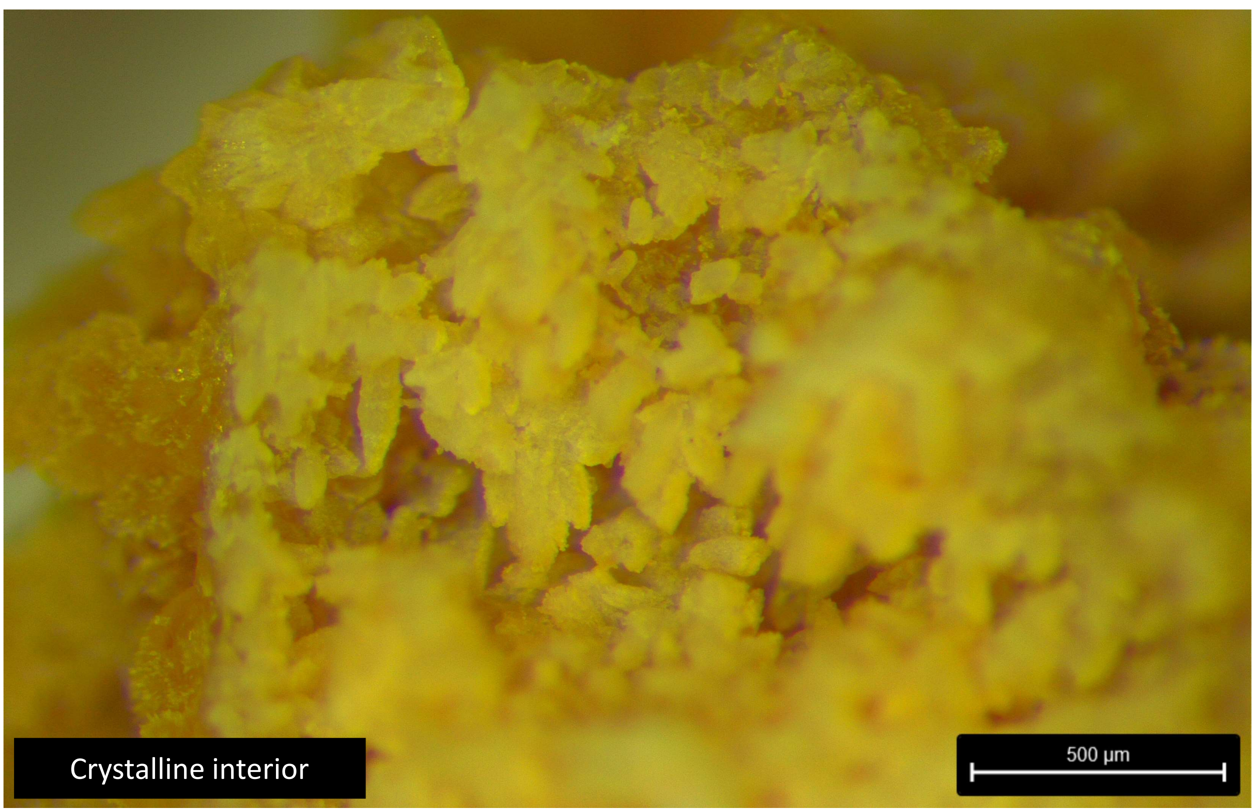
This is a well-sorted, fine-grained, bioclastic grainstone. Benthic foraminifera (BF - e.g. *Nummulites* and rotalids) are abundant; echinoderms (Ech) and undifferentiated skeletal fragments are moderate; planktic foraminifera (PF), red algae (RA), and bryozoans are minor. Intraclasts (Int), ostracods, and peloids are rare. Glauconite (G) is very minor and occurs as grains, replacement, or grain coatings. Pore-filling calcite (Ca) cement is abundant. Early syntaxial calcite cement around echinoderm fragments is relatively common. Authigenic dolomite, pyrite (Py), and gypsum are rare. Interparticle pores (BP) are common. Intercrystal micropores (Mp), primary and secondary intraparticle pores (PWP & SWP), and molds (MO) are minor.

Core Lab
RESERVOIR OPTIMIZATION

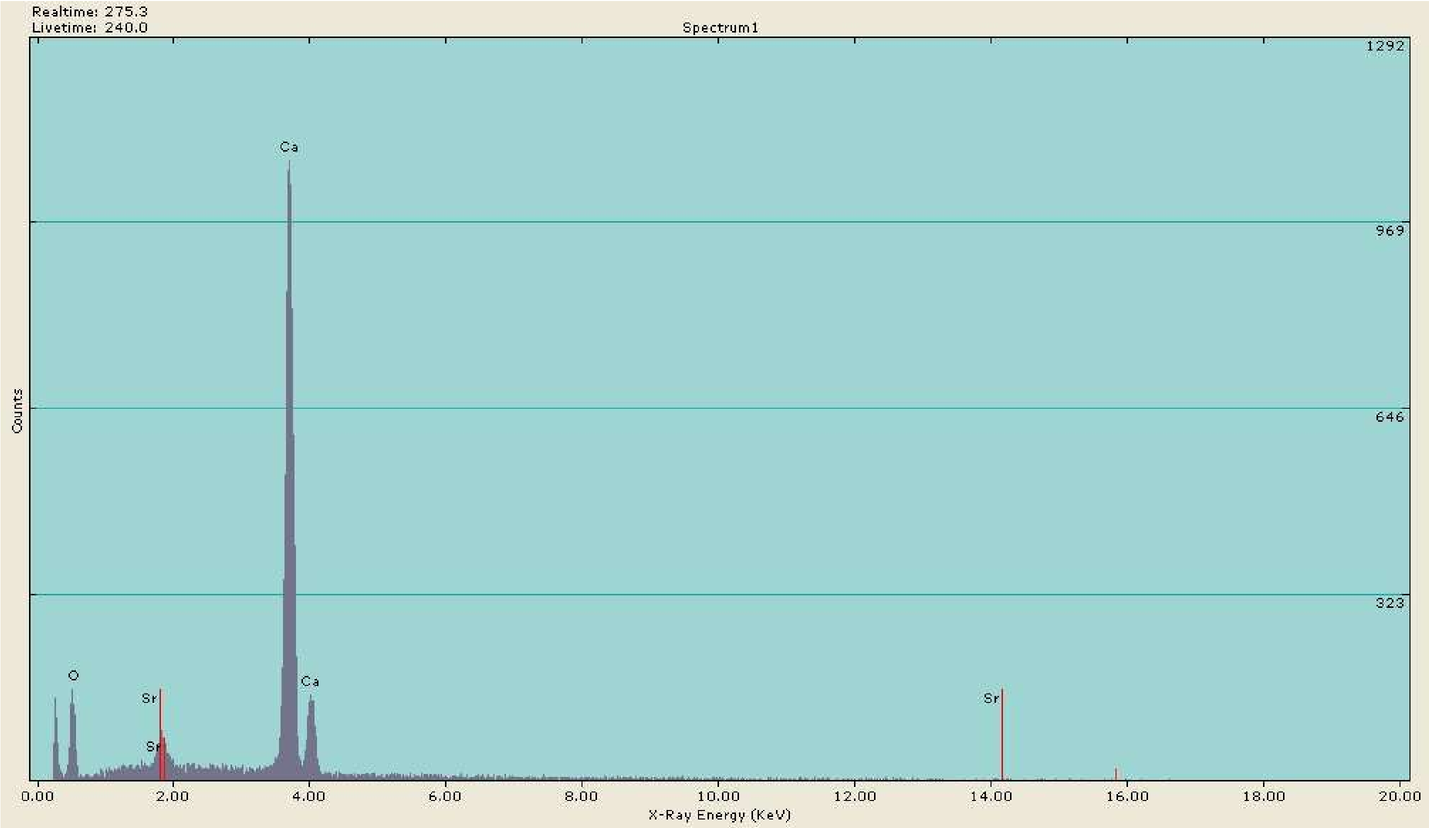
Trace/Rare (<1%)
Minor (1-5%)
Moderate (5-10%)
Common (10-20%)
Abundant (>20%)

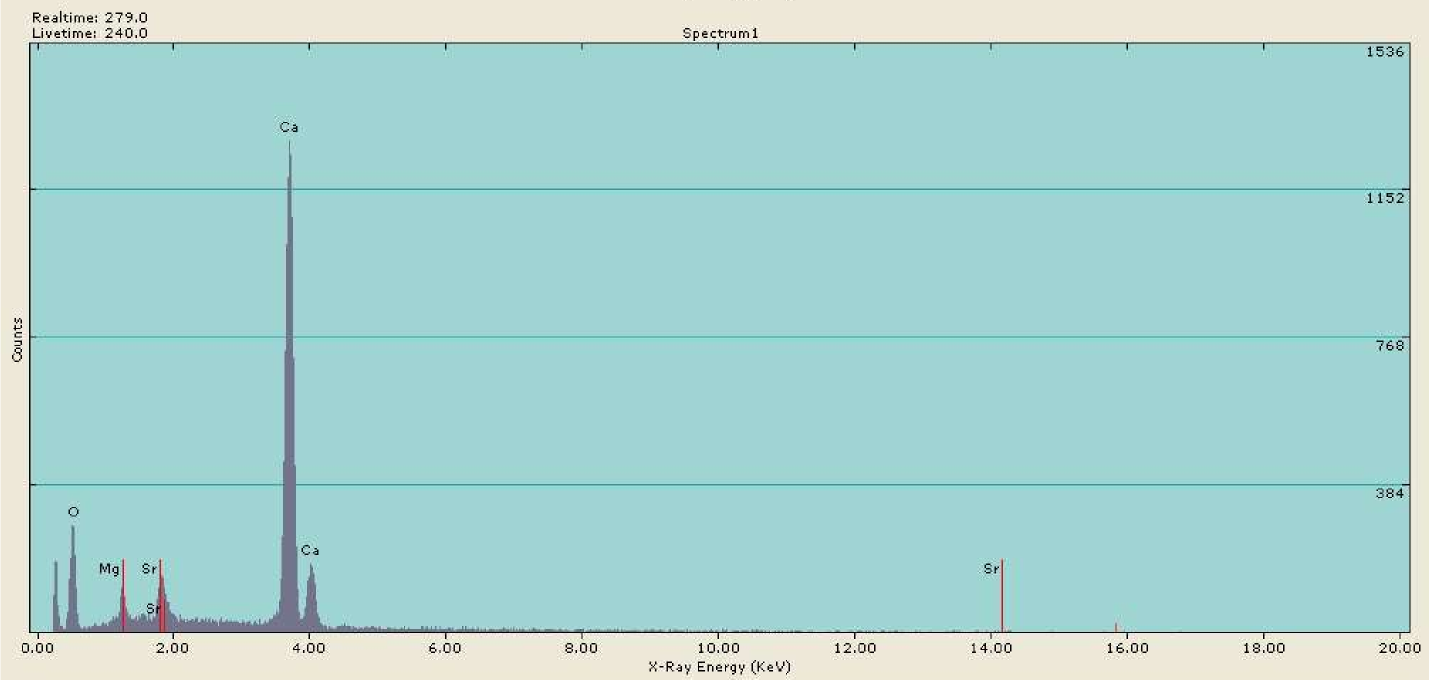
APPENDIX G:
OSF-52 MINERAL ANALYSIS

True color photographic images of OSF-52 borehole mineral



Representative EDS spectra from two points on the mineral specimen

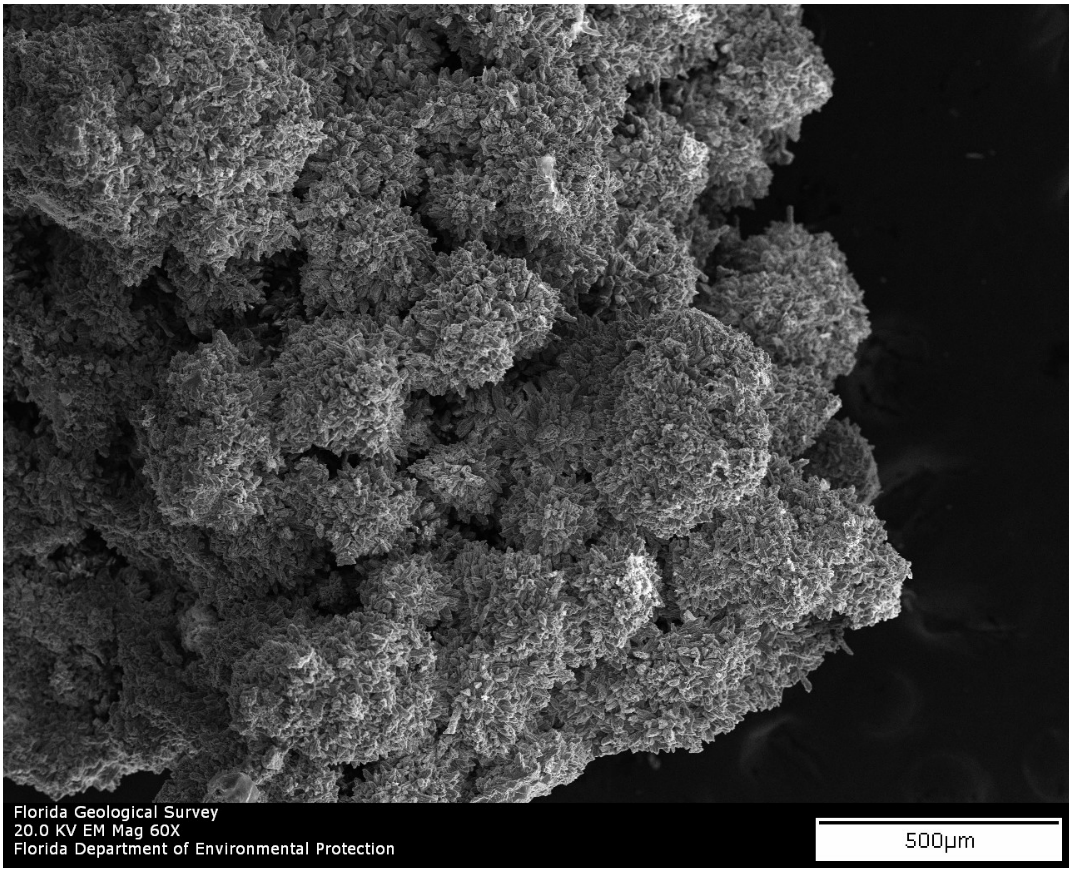


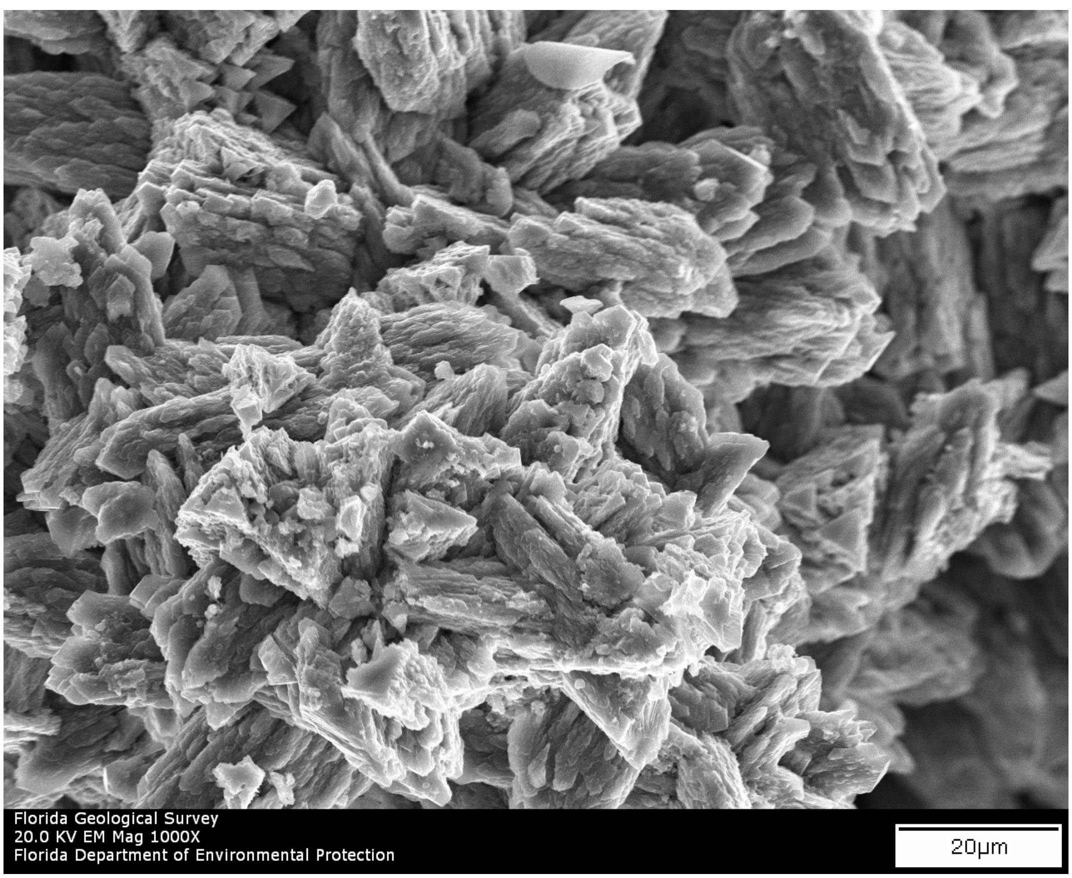


Quantitative Results for Spectrum1
Analysis: Bulk Method: Standardless
Acquired 08-Mar-2018, 20.0 KeV @10 eV/channel

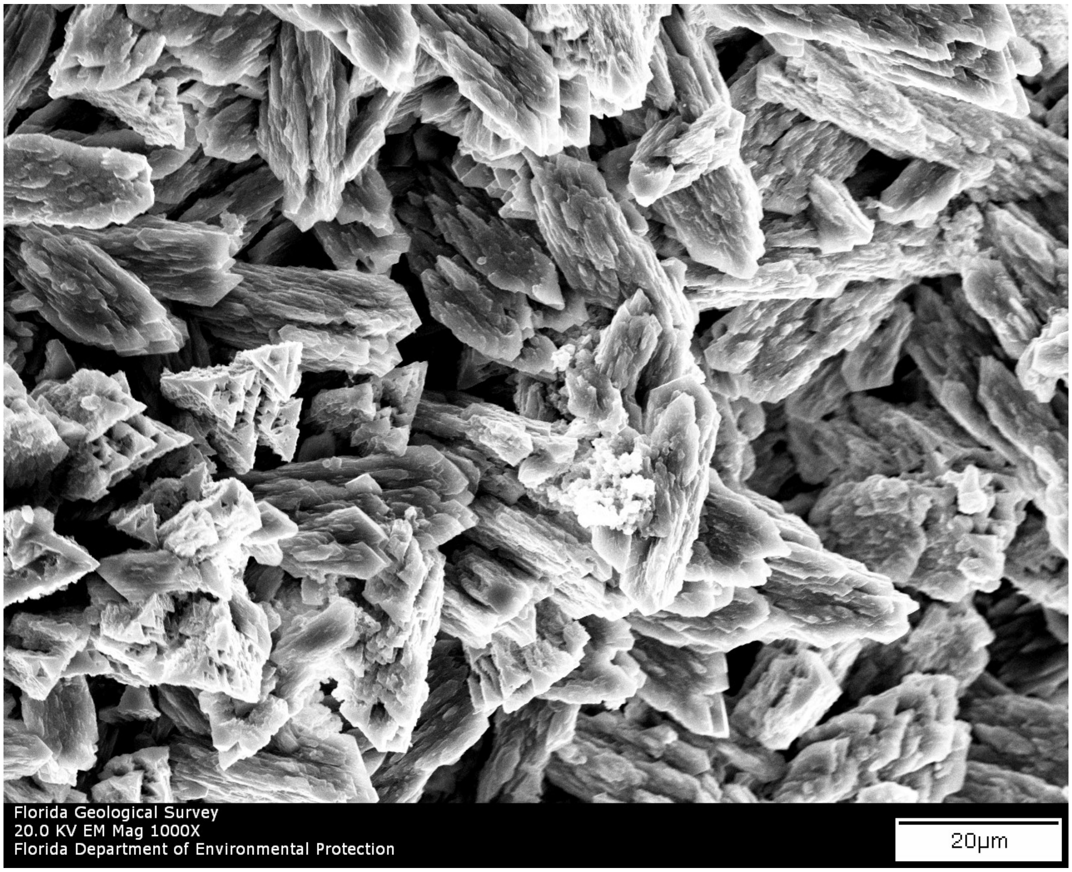
Element	Weight %	Std. Dev.	MDL	Atomic %	k-Ratio	Intensities	Probability
O	43.07	1.84	0.88	65.46	0.1500	1945.7	0.98
Ca	56.93	1.65	0.33	34.54	0.5533	12258.9	0.93
Total	100.00						

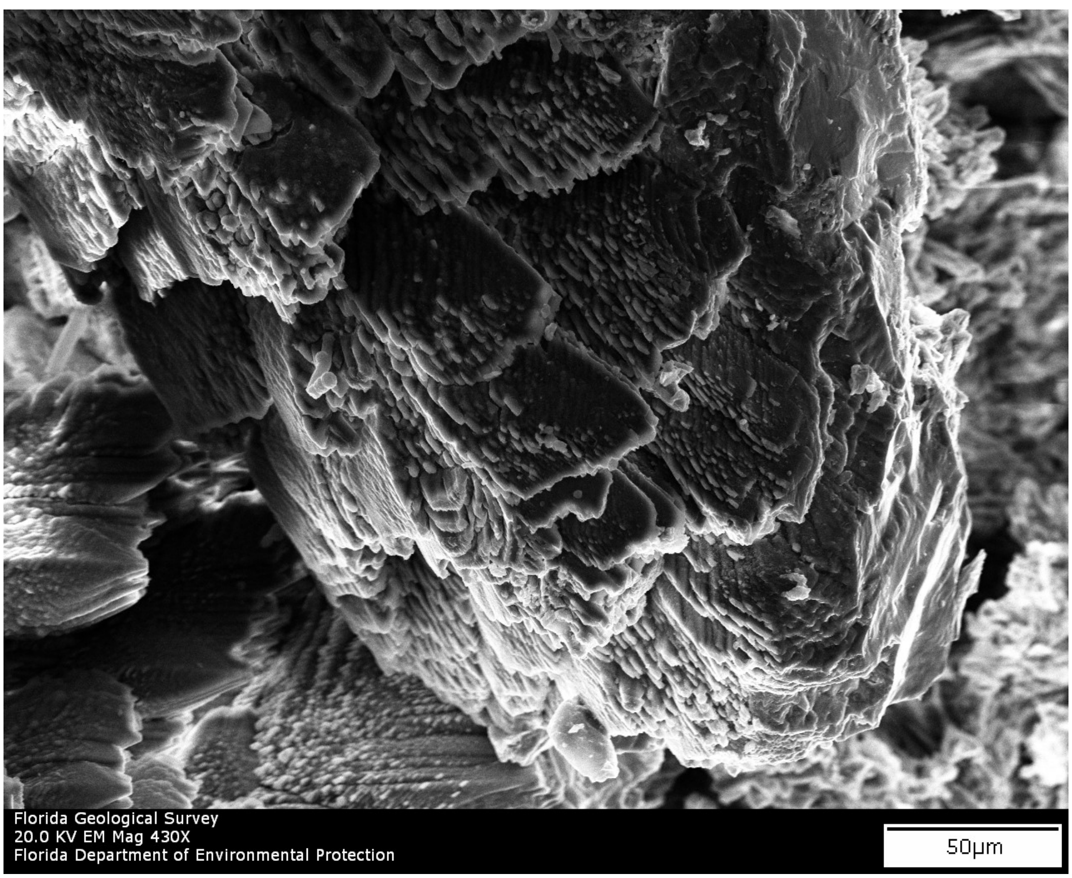
SEM Images from the OSF-52 borehole sample (p. 1 of 3)





SEM Images from the OSF-52 borehole sample (p. 2 of 3)





SEM Images from the OSF-52 borehole sample (p. 3 of 3)