Arbeitsbericht NAB 21-20

TBO Marthalen-1-1: Data Report

Dossier II
Core Photography

September 2021

National Cooperative
for the Disposal of
Radioactive Waste

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Dossier II Core Photography

September 2021

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[1] Maya & Daniele
[2] Nagra

Keywords:
MAR1-1, Zürich Nordost, TBO, deep drilling campaign, drill cores, cuttings, photos, composites, CoreScan[3]

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Nagra Arbeitsberichte NAB ("Working Reports") present the results of work in progress that have not necessarily been subject to a comprehensive review. They are intended to provide rapid dissemination of current information.

This NAB aims at reporting drilling results at an early stage. Additional borehole-specific data will be published elsewhere.

In the event of inconsistencies between dossiers of this NAB, the dossier addressing the specific topic takes priority. In the event of discrepancies between Nagra reports, the chronologically later report is generally considered to be correct. Data sets and interpretations laid out in this NAB may be revised in subsequent reports. The reasoning leading to these revisions will be detailed there.

This Dossier was prepared by:
D. Kaehr (photography post-processing and core photograph composite design and compilation)
M. Gysi (project management, conceptualisation, QC and writing)

Editorial work: Geomecon and M. Unger

The Dossier has greatly benefitted from technical discussions with, and reviews by, external and internal experts. Their input and work are very much appreciated!

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Note: The appendix is only included it the digital version of this report and can be found under the paper clip symbol.

1 Introduction

1.1 Context

To provide input for site selection and the safety case for deep geological repositories for radioactive waste, Nagra has drilled a series of deep boreholes ("Tiefbohrungen", TBO) in Northern Switzerland. The aim of the drilling campaign is to characterise the deep underground of the three remaining siting regions located at the edge of the Northern Alpine Molasse Basin (Fig. 1-1).

In this report, we present the results from the Marthalen-1-1 borehole.

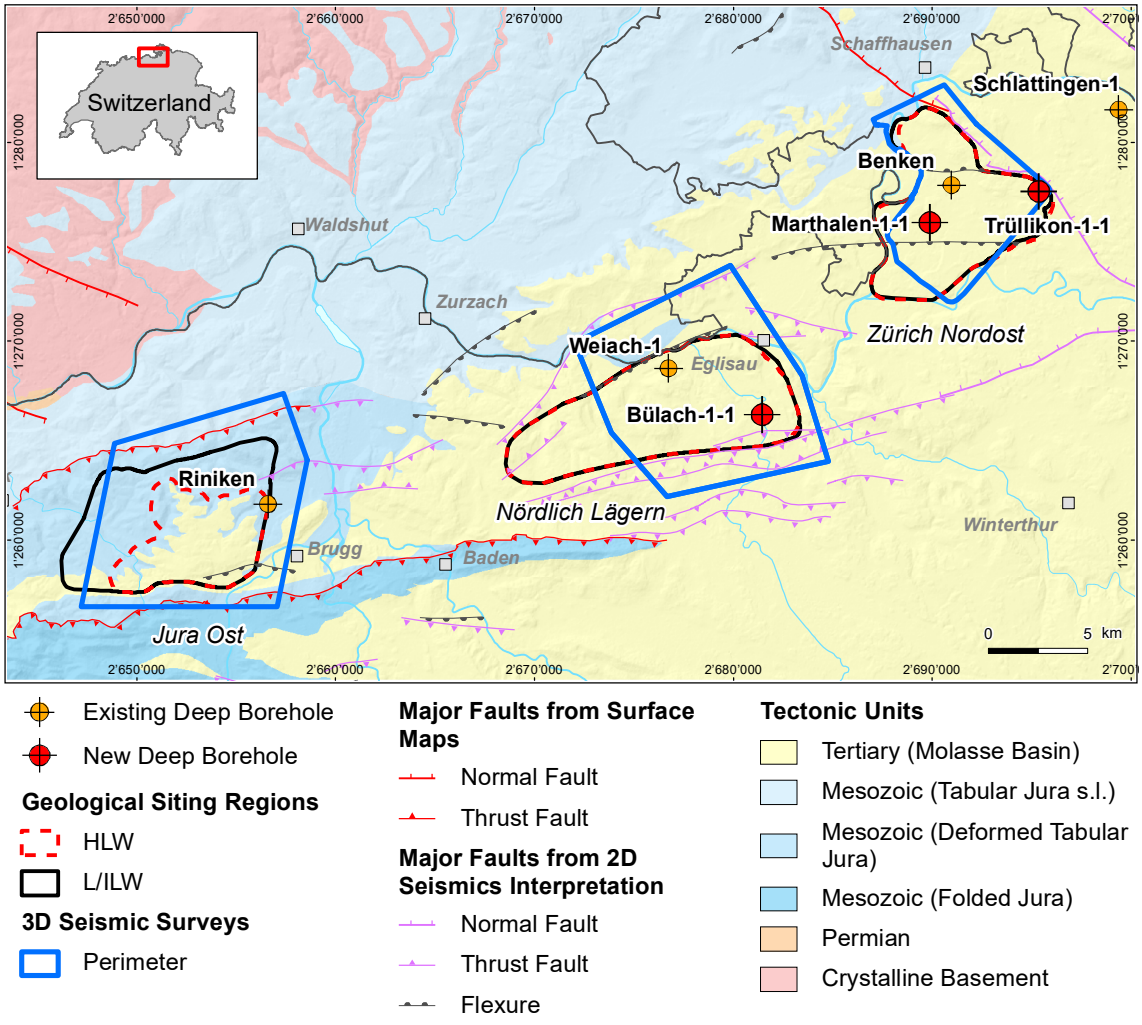


Fig. 1-1: Tectonic overview map with the three siting regions under investigation

1.2 Location and specifications of the borehole

The Marthalen-1-1 (MAR1-1) exploratory borehole is the third borehole drilled within the framework of the TBO project. The drill site is located in the western part of the Zürich Nordost siting region (Fig. 1-2). The vertical borehole reached a final depth of 1'099.25 m (MD)[1]. The borehole specifications are provided in Tab. 1-1.

Tab. 1-1: General information about the MAR1-1 borehole

Siting region	Zürich Nordost
Municipality	Marthalen (Canton Zürich / ZH), Switzerland
Drill site	Marthalen-1 (MAR-1)
Borehole	Marthalen-1-1 (MAR1-1)
Coordinates	LV95: 2'689'889.946 / 1'275'956.932
Elevation	Ground level = top of rig cellar: 399.48 m above sea level (asl)
Borehole depth	1'099.25 m measured depth (MD) below ground level (bgl)
Drilling period	9. February 2020 - 14. July 2020 (spud date to end of rig release)
Drilling company	Daldrup & Söhne AG
Drilling rig	Wirth B 152 t
Drilling fluid	Water-based mud with various amounts of different components such as:[2] 55 – 460 m: Bentonite & polymers 460 – 881 m: Potassium silicate & polymerss 881 – 961 m: Sodium silicate & polymer 961 – 1'099.25 m: Sodium chloride & polymers

The lithostratigraphic profile and the casing scheme are shown in Fig. 1-3. The comparison of the core versus log depth[3] of the main lithostratigraphic boundaries in the MAR1-1 borehole is shown in Tab. 1-2.

[1] Measured depth (MD) refers to the position along the borehole trajectory, starting at ground level, which for this borehole is the top of the rig cellar. For a perfectly vertical borehole, MD below ground level (bgl) and true vertical depth (TVD) are the same. In all Dossiers depth refers to MD unless stated otherwise.

[2] For detailed information see Dossier I.

[3] Core depth refers to the depth marked on the drill cores. Log depth results from the depth observed during geophysical wireline logging. Note that the petrophysical logs have not been shifted to core depth, hence log depth differs from core depth.

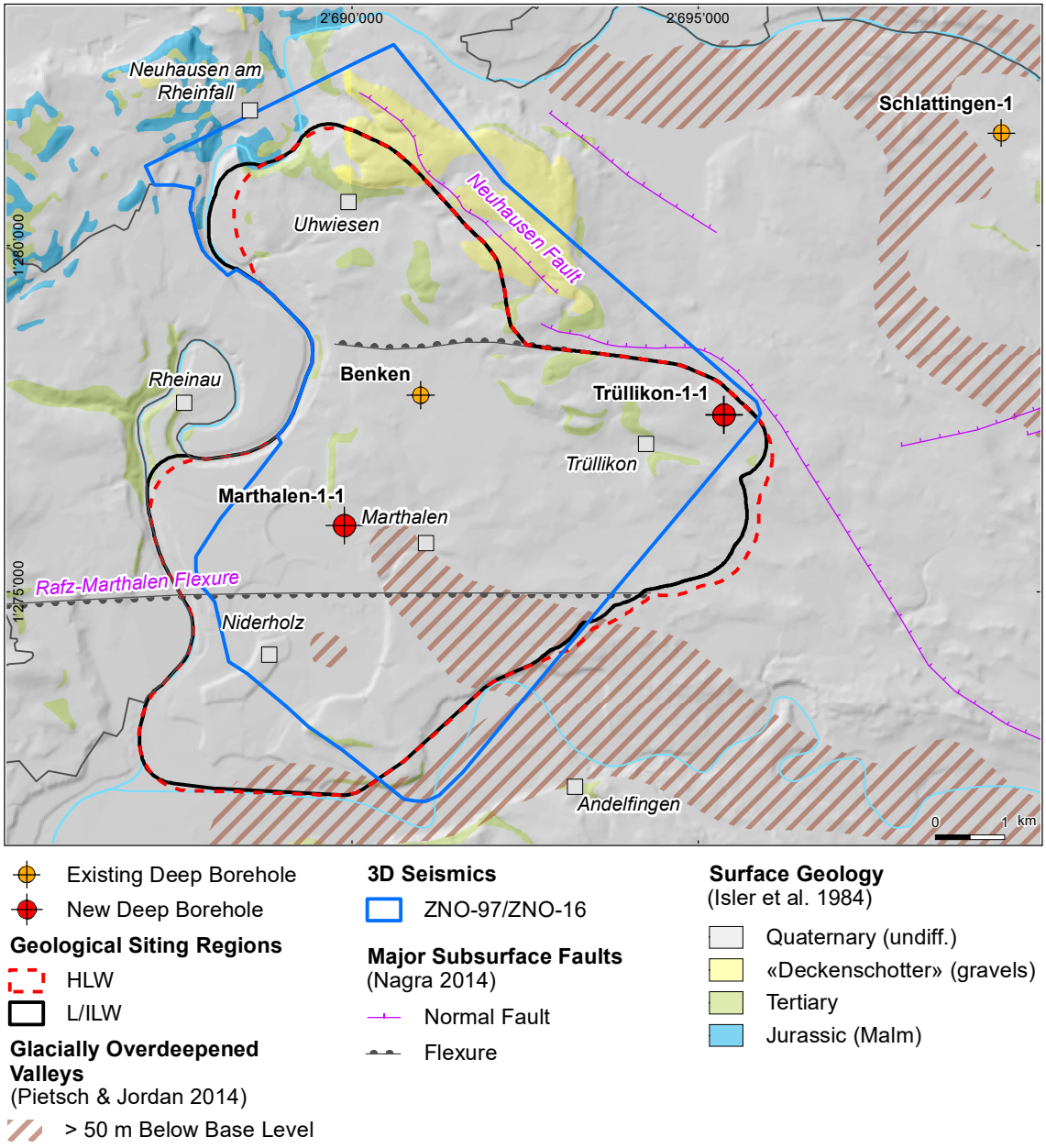


Fig. 1-2: Overview map of the investigation area in the Zürich Nordost siting region with the location of the MAR1-1 borehole in relation to the boreholes Benken, Schlattingen-1 and TRU1-1

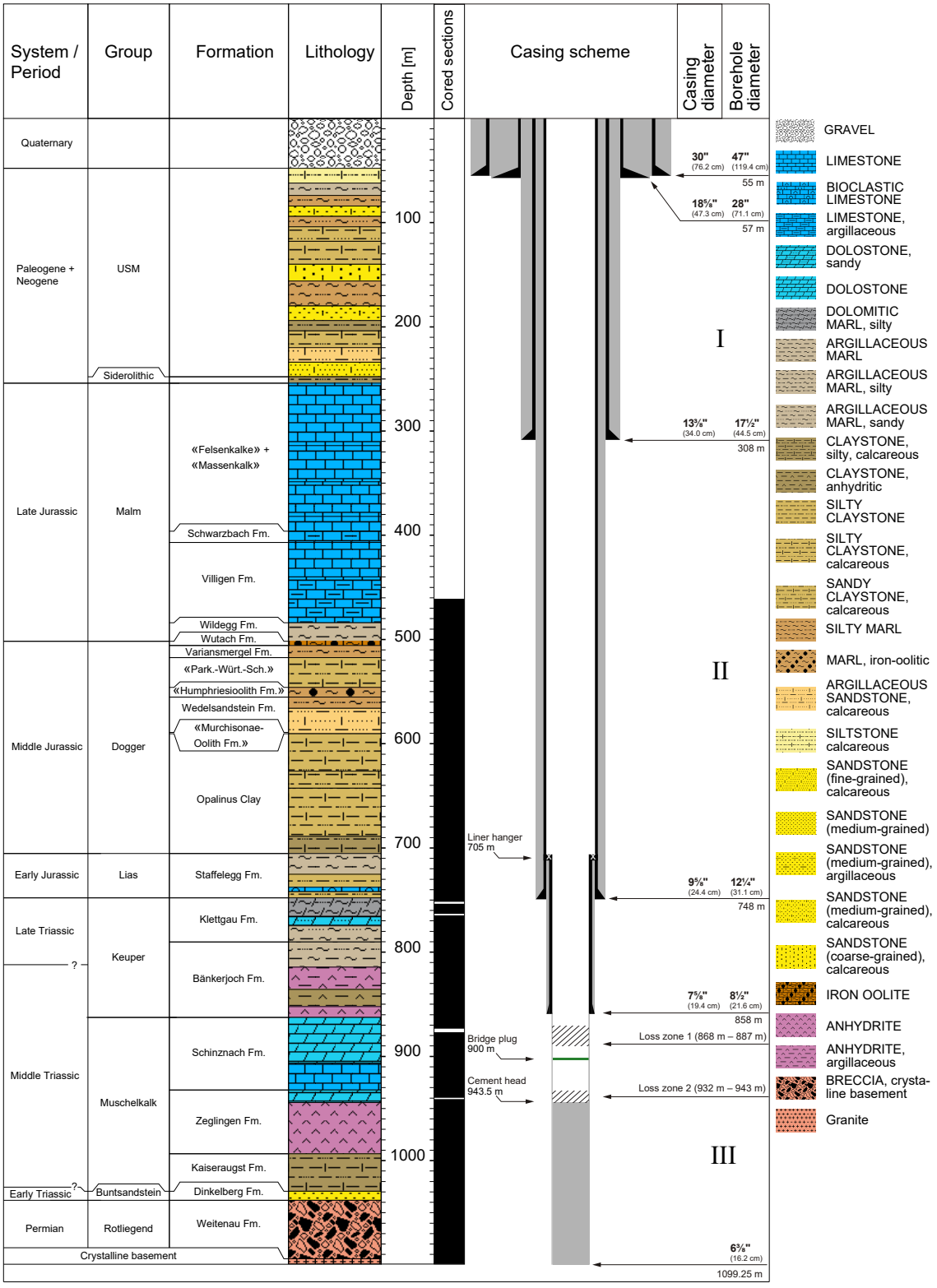


Fig. 1-3: Lithostratigraphic profile and casing scheme for the MAR1-1 borehole[4]

[4] For detailed information see Dossier I and III.

Tab. 1-2: Core and log depth for the main lithostratigraphic boundaries in the MAR1-1 borehole[5]

System / Period	Group	Formation	Core depth in m (MD)	Log depth in m (MD)	
Quaternary			**48**		—
Paleogene + Neogene	USM		248		—
	Siderolithic		**254**		—
Jurassic	Malm	«Felsenkalke» + «Massenkalk»	396.1		—
		Schwarzbach Formation	406.9		—
		Villigen Formation	484.02	484.22	—
		Wildegg Formation	501.80	501.92	—
	Dogger	Wutach Formation	505.75	506.03	—
		Variansmergel Formation	517.43	517.57	—
		«Parkinsoni-Württembergica-Schichten»	545.93	546.12	—
		«Humphriesioolith Formation»	555.23	555.47	—
		Wedelsandstein Formation	589.17	589.19	—
		«Murchisonae-Oolith Formation»	590.35	590.37	—
		Opalinus Clay	705.40	705.52	—
	Lias	Staffelegg Formation	**747.83**	**747.89**	—
Triassic	Keuper	Klettgau Formation	790.12	790.34	—
		Bänkerjoch Formation	862.52	862.77	—
	Muschelkalk	Schinznach Formation	932.24	932.47	—
		Zeglingen Formation	993.50	993.97	—
		Kaiseraugst Formation	1029.45	1029.95	—
	Buntsandstein	Dinkelberg Formation	**1037.98**	**1038.23**	—
Permian	Rotliegend	Weitenau Formation	**1094.08**	**1094.08**	—
		Crystalline Basement	1099.25 final depth		

[5] For details regarding lithostratigraphic boundaries see Dossier III and IV; for details about depth shifts (core goniometry) see Dossier V.

1.3 Documentation structure for the MAR-1 borehole

NAB 21-20 documents the majority of the investigations carried out in the MAR1-1 borehole, including laboratory investigations on core material. The NAB comprises a series of stand-alone dossiers addressing individual topics and a final dossier with a summary composite plot (Tab. 1-3).

This documentation aims at early publication of the data collected in the MAR1-1 borehole. It includes most of the data available approximately one year after completion of the borehole. Some analyses are still ongoing (e.g. diffusion experiments, analysis of veins, hydrochemical interpretation of water samples) and results will be published in separate reports.

The current borehole report will provide an important basis for the integration of datasets from different boreholes. The integration and interpretation of the results in the wider geological context will be documented later in separate geoscientific reports.

Tab. 1-3: List of dossiers included in NAB 21-20

Black marks the dossier at hand.

Dossier	Title	Authors
I	TBO Marthalen-1-1: Drilling	P. Hinterholzer-Reisegger & B. Garitte
II	**TBO Marthalen-1-1: Core Photography**	**D. Kaehr & M. Gysi**
III	TBO Marthalen-1-1: Lithostratigraphy	P. Jordan, P. Schürch, H. Naef, M. Schwarz, R. Felber, T. Ibele & M. Gysi
IV	TBO Marthalen-1-1: Microfacies, Bio- and Chemostratigraphic Analysis	S. Wohlwend, H.R. Bläsi, S. Feist-Burkhardt, B. Hostettler, U. Menkveld-Gfeller, V. Dietze & G. Deplazes
V	TBO Marthalen-1-1: Structural Geology	A. Ebert, L. Gregorczyk, E. Hägerstedt, S. Cioldi & M. Gysi
VI	TBO Marthalen-1-1: Wireline Logging and Micro-hydraulic Fracturing	J. Gonus, E. Bailey, J. Desroches & R. Garrard
VII	TBO Marthalen-1-1: Hydraulic Packer Testing	R. Schwarz, S.M.L. Hardie, H.R. Müller, S. Köhler & A. Pechstein
VIII	TBO Marthalen 1-1: Rock Properties, Porewater Characterisation and Natural Tracer Profiles	U. Mäder, L. Aschwanden, L. Camesi, T. Gimmi, A. Jenni, M. Kiczka, M. Mazurek, D. Rufer, H.N. Waber, P. Wersin, C. Zwahlen & D. Traber
IX	TBO Marthalen-1-1: Rock-mechanical and Geomechanical Laboratory Testing	E. Crisci, L. Laloui & S. Giger
X	TBO Marthalen-1-1: Petrophysical Log Analysis	S. Marnat & J.K. Becker
	TBO Marthalen-1-1: Summary Plot	Nagra

1.4 Scope and objectives of this dossier

The dossier at hand (Dossier II) documents core photography. The objectives are the following:

- summary of core handling and core photography of this drilling campaign
- visual documentation of the cuttings samples and cores of MAR1-1 from 4 m to 1'099.25 m MD core depth

2 Executed working procedures

2.1 On-site core handling

The cores were drilled with a 6 m long inner core barrel containing an inner plastic tube. To avoid core jamming and to obtain a better core quality the length of a core run was 3 m, only. After cutting the core, the drilling crew pulled the inner core barrel up with a winch (wireline coring) and placed it on the pipe rack (Fig. 2-1). The core catcher was detached and the inner plastic tube was removed and laid down on trestles. The section containing the core was separated from the empty plastic tube by cutting the tube to a length of approximately 3.5 m. The core was then carried to the core processing area (Fig. 2-2) and pushed out of the tube using an appropriate rod. If the core was jammed inside the tube, the plastic liner was cut laterally using an electric cutting machine.



Fig. 2-1: The inner core barrel is placed on the pipe rack

Showcase picture of rig 16 (Marriott); workflow comparable at the Daldrup rig (picture credits: © Maya & Daniele)



Fig. 2-2: The 3 m core in the plastic liner is carried to the core processing area

Showcase picture of rig 16 (Marriott); workflow comparable at the Daldrup rig (picture credits: © Maya & Daniele)

Once laid out, the core was washed with water to remove the drilling fluid (Figs. 2-3 and 2-4). Afterwards, the top of the newly cut core was aligned with the bottom of the previous core section. If the two core pieces did not fit properly, they were marked with a red cross and a new set of orientation lines was started. If a fit was established, the orientation lines were correctly copied onto the newly cored section. These orientation lines consist of two parallel lines drawn along the core axis with additional arrows indicating the downhole direction. The line on the right-hand side when looking towards the core top is red (Figs. 2-5 and 2-6). The colour of the line on the left-hand side can be white, yellow or black depending on the colour of the cored rock. The core depth was marked on the core with a line perpendicular to the core axis and corresponding depth labels at 0.5 m intervals.

To facilitate proper core handling, transportation and further analyses, the core sections were cut into pieces approximately one metre long using a diamond-impregnated rock saw before being stored in one metre core boxes.



Fig. 2-3: A core covered in drilling fluid on the core processing table

Picture credits: © Maya & Daniele



Fig. 2-4: A core is washed with water on the core processing table to remove the drilling fluid

Picture credits: © Maya & Daniele



Fig. 2-5: A core is marked with orientation lines

Picture credits: © Maya & Daniele

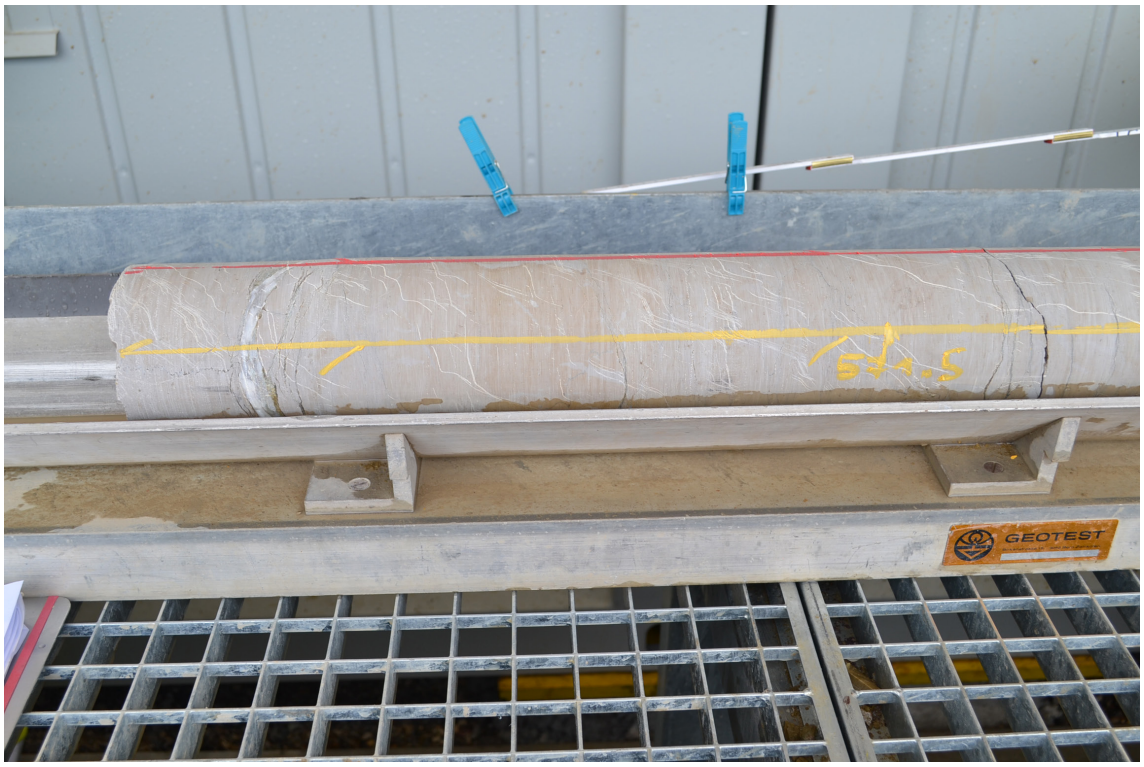


Fig. 2-6: Cleaned, measured and marked core

2.2 Core photography

All core pieces were photographed (planar pictures) using a modified version of the DMT CoreScan^3 system (Fig. 2-7) specifically designed to take high-resolution core photographs (10 px/mm). If the core geometry and condition allowed it, 360° photographs of the core surface were also taken (not documented in this dossier). For both planar and 360° photographs, the core was placed on two rubber rollers and a digital line scan camera recorded the picture via an inclined mirror in the top section of the CoreScan^3 system. During 360° photography, the core was rotated around its longitudinal axis and the picture was taken at the upper section of the core. In addition, all 360° photographs were digitally rotated to set the red orientation line to 0°. Both planar and 360° photographs were saved on the CoreScan^3 computer, which automatically synchronised the data with the Nagra network-attached storage (NAS) located at the core storage facility in Würenlingen.

2.2.1 Specifications

Camera:

- manufacturer: avaluar GmbH
- camera model: CCD-Colour camera CSc3b1.26
- resolution y: 6'400 (10 px/mm)
- resolution x: 10'680 (10 px/mm)
- spectral response: 400 nm to 700 nm
- sharpening: 0
- gamma: 1.4
- lens maker: Schneider Kreuznach
- lens model: APO COMPONON f4.0/60mm
- aperture: f/8
- focal length: 35 mm
- exposure time: program very dark (custom calibrated for Nagra's LED panels)

LED panels:

- 4x Aladdin BI-FLEX 4 (200 W Bi-Colour Panel): two at the back and two at the front of the CoreScan^3 system, protected in aluminium boxes with a diffusor plate as front cover
- 2x Aladdin BI-FLEX 2 (70 W Bi-Colour Panel): one on the left-hand side and one on the right-hand side of the CoreScan^3 system, protected in an aluminium box with a diffusor plate as front cover
- all six panels are calibrated to 5'000 K with a Sekonic C-800 SpectroMaster

Reference cards:

- X-Rite ColorChecker White Balance: used for camera calibration (shading)
- X-Rite ColorChecker Classic Mini colour chart: colour reference on every core photo
- BST14 greyscale chart: greyscale reference on every core photo
- Datacolor SpyderCHECKR 48 colour chart: colour reference chart for reference photographs

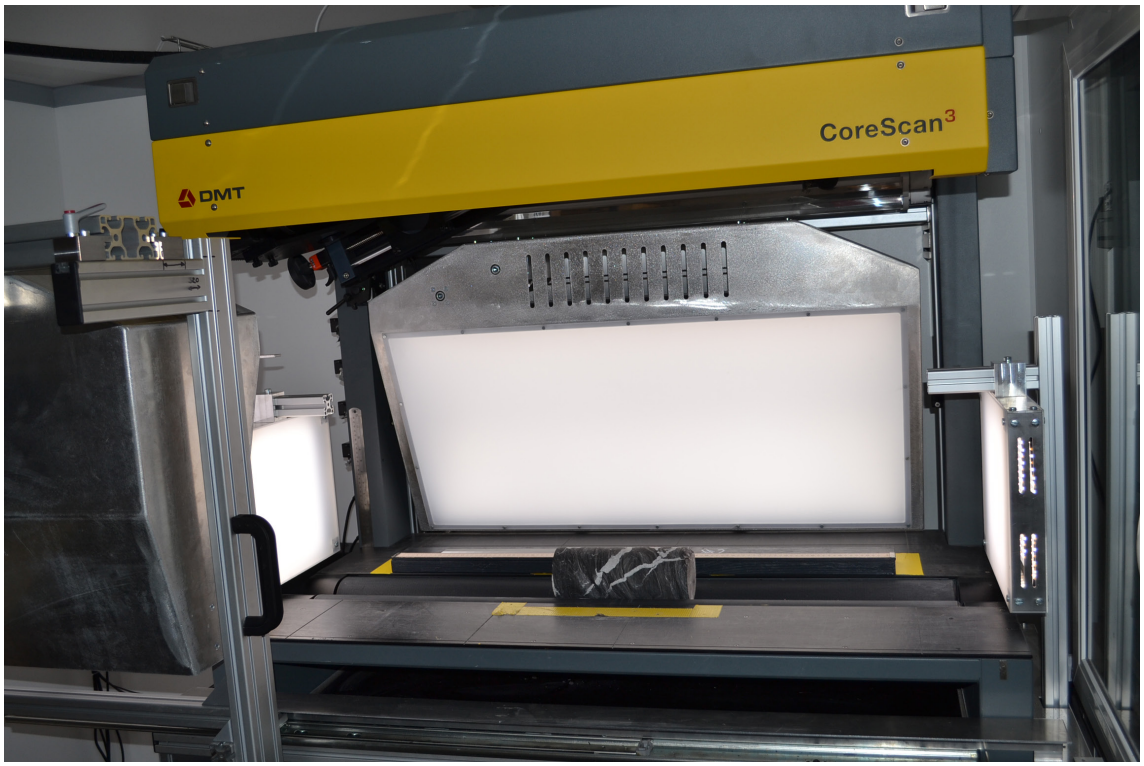


Fig. 2-7: Modified DMT CoreScan^3 system at the drill site

2.2.2 Colour drift monitoring

During coring operations, a reference photograph of the Datacolor SpyderCHECKR 48 colour chart was taken with the CoreScan^3 system at least twice per 24 h (Fig. 2-8). These reference photographs enabled to monitor the proper functioning of the CoreScan^3 system during operations. Issues regarding colour correctness and contrast could be detected early and necessary adjustments to the CoreScan^3 system or environment conditions (especially room temperature) could be made. The reference photographs could further be used to create an ICC profile (International Color Consortium): a data set characterising the colour input / output for the most accurate colour matching.

Each core photograph taken included a metre scale, a BST14 greyscale chart and an X-Rite ColorChecker Classic Mini colour chart (Fig. 2-9). The metre scale is essential to have a depth indicator on the core photograph, whereas the colour and greyscale charts allow manual colour management during post-processing of the core photograph if required.



Fig. 2-8: Reference photograph setup of the CoreScan³ system with a Datacolor Spyder-CHECKR 48 colour chart, a metre scale, a BST14 greyscale chart and an X-Rite ColorChecker Classic Mini colour chart

Picture credits: © Maya & Daniele



Fig. 2-9: CoreScan³ system setup during core photography with a metre scale, a BST14 grey-scale chart and an X-Rite ColorChecker Classic Mini colour chart

Picture credits: © Maya & Daniele

2.3 Post-processing of core photographs

All core photographs taken on the drill site were post-processed by a professional photographer. The colour management of the post-processing workflow provided colour-matched, high-resolution core photograph reproductions with enhanced quality and fidelity. The following post-processing steps were applied to a batch of core photographs with comparable camera settings and environmental conditions:

1. noise reduction of the reference photographs of the Datacolor SpyderCHECKR 48 colour chart, shot with the CoreScan³ system
2. ICC profiling of the noise-reduced reference photographs, shot with the CoreScan³ system
3. evaluation of the ICC profiles and selection of the best ICC profile for the post-processing of the core photographs
4. ICC profile application to the core photographs in batch mode
5. correction of contrast and brightness of the core photographs in batch mode
6. conversion of the photographs to eciRGB_v2 standard colour space in batch mode
7. noise reduction and pre-sharpening of every single core photograph
8. correction of colour, exposure and contrast of the core photographs in batch mode

9. comparison between the best ICC profile of the Datacolor SpyderCHECKR 48 colour chart reference photograph, shot with the CoreScan^3 system and the ICC profile of the Datacolor SpyderCHECKR 48 colour chart reference photograph, shot with a Canon 5DmkIV camera
10. visual adjustment of the best ICC profile of the Datacolor SpyderCHECKR 48 colour chart reference photograph, shot with the CoreScan^3 system to the ICC profile of the Datacolor SpyderCHECKR 48 colour reference photograph, shot with a Canon 5DmkIV camera
11. application of the colour adjustement defined in the previous step to the core photographs in batch mode
12. if required, manual colour neutralisation of every single core photograph based on the BST14 greyscale chart and the X-Rite ColorChecker Classic Mini colour chart
13. cropping of the core photographs to the core outlines
14. export of the core photographs as .jpg and .tiff in pre-defined resolutions and corresponding sharpening parameters

2.4 Signatures

The following signature was used in the composite displays of the complete cores:

- white hachures: missing core due to formation integrity test (FIT) pilot hole or drilling-related technical issues (Fig. 2-10)

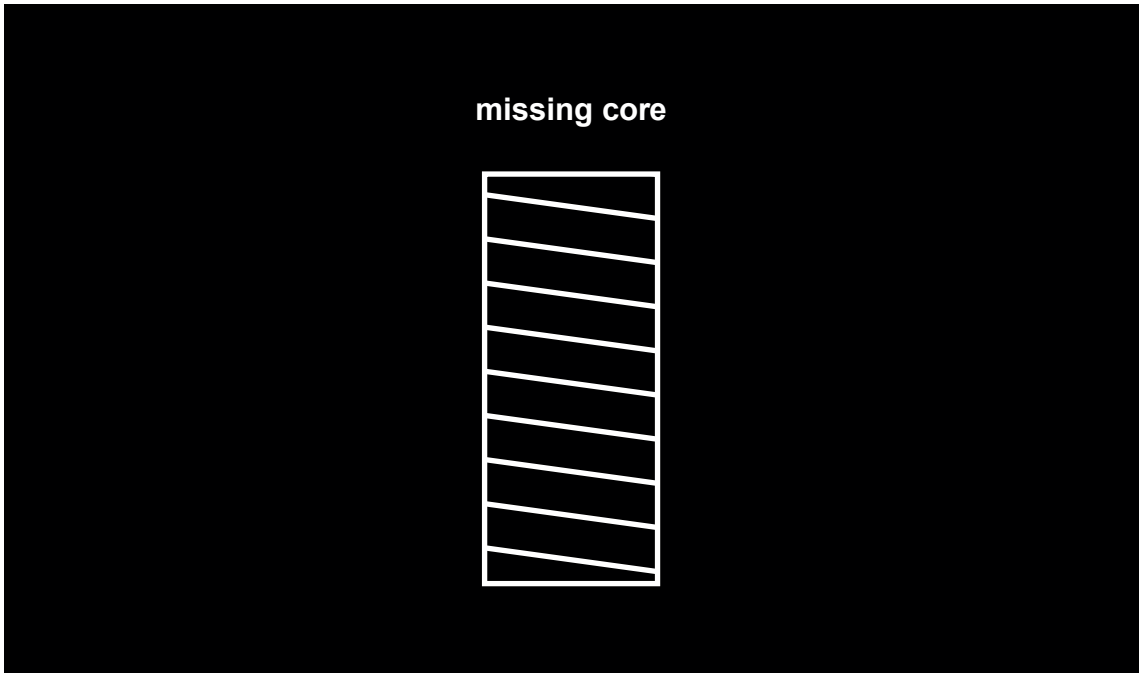


Fig. 2-10: White hachures signature used for missing core due to FIT pilot hole or drilling related technical issues in the composite displays

3 Marthalen-1-1 core- and cuttings composites

4.00m 22.00m 40.00m



20.00m 38.00m 54.50m

58.00m 98.00m 138.00m



96.00m 136.00m 176.00m

178.00m 218.00m 258.00m



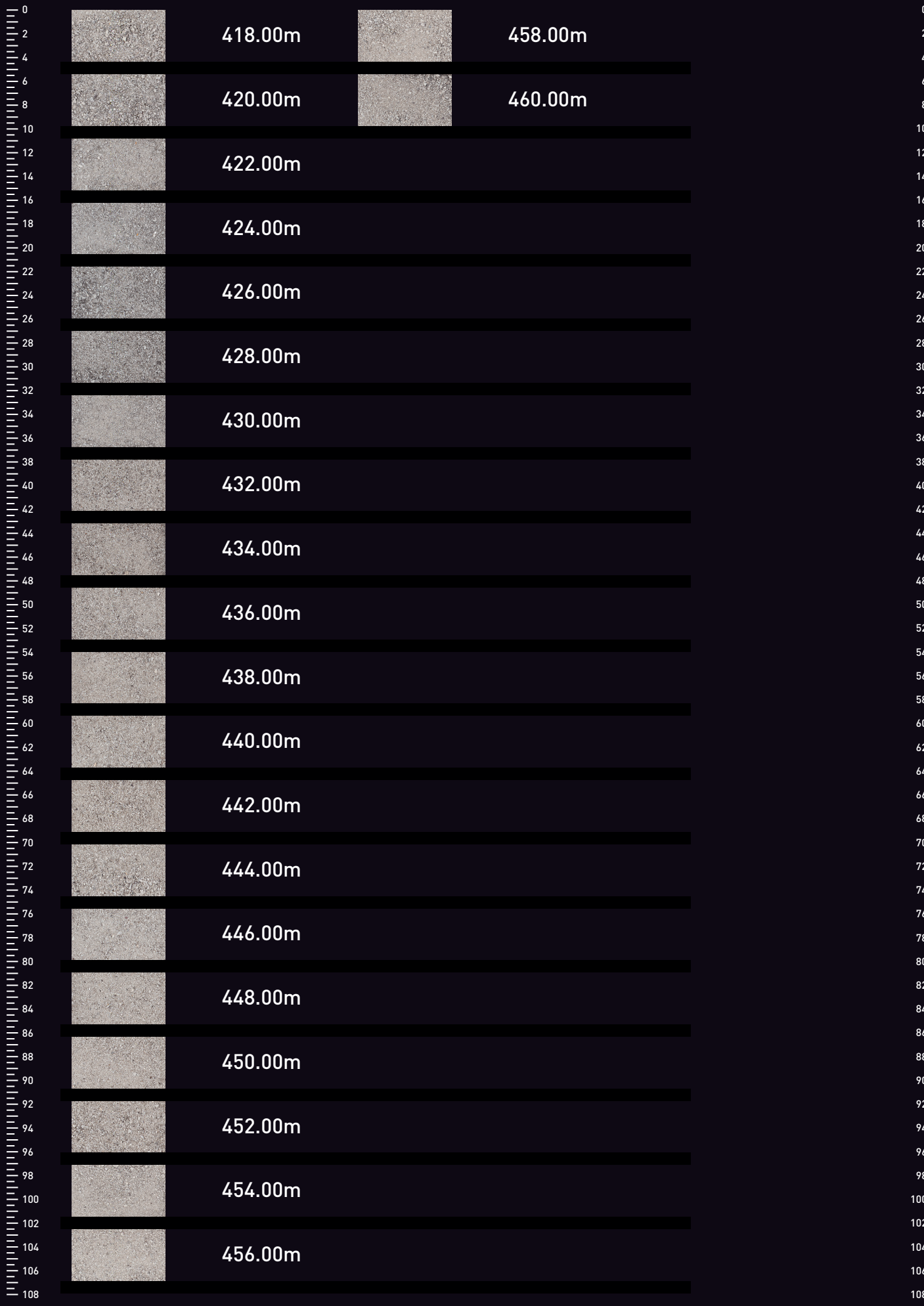
216.00m 256.00m 296.00m

298.00m 338.00m 378.00m



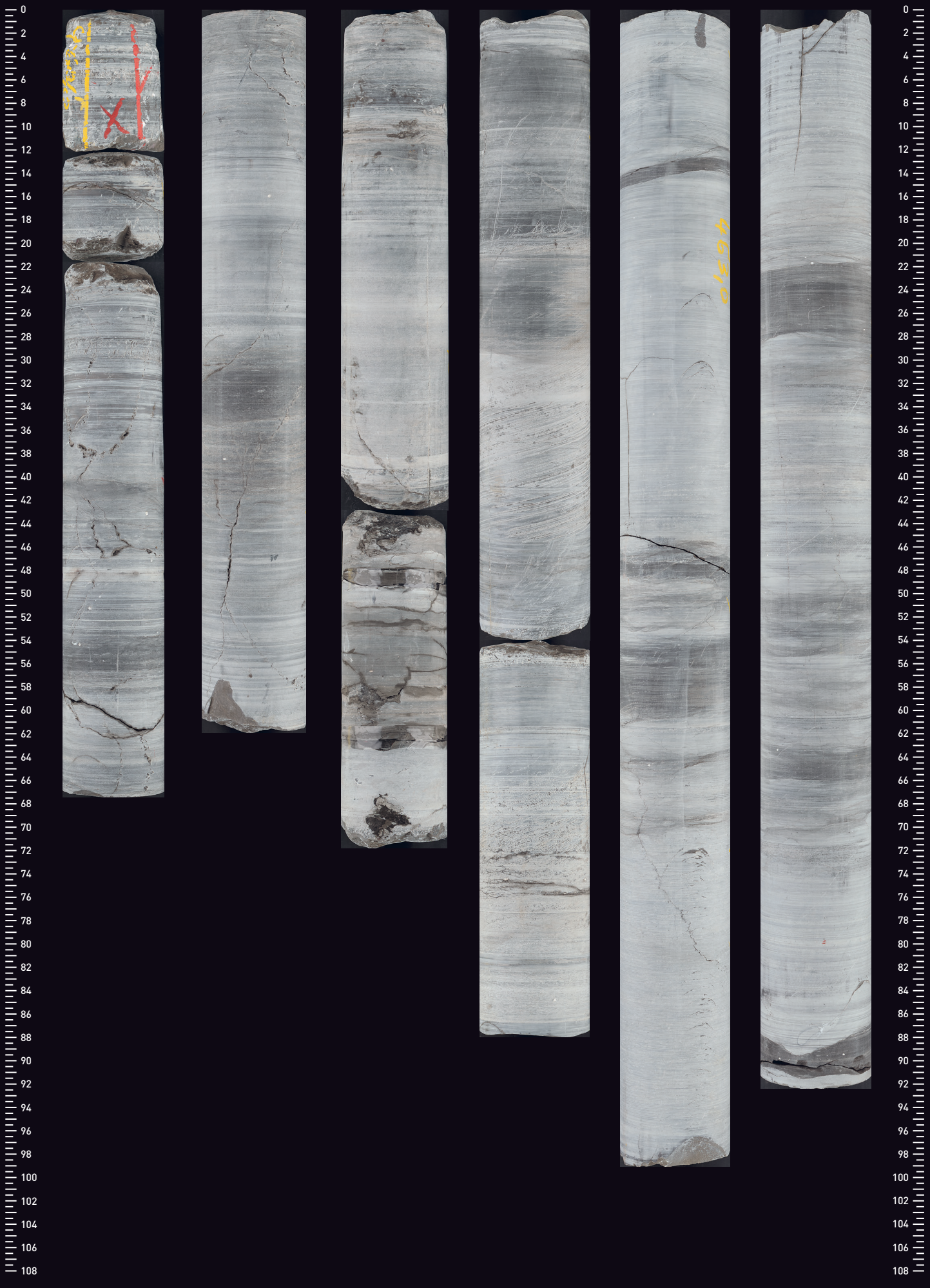
336.00m 376.00m 416.00m

418.00m 458.00m



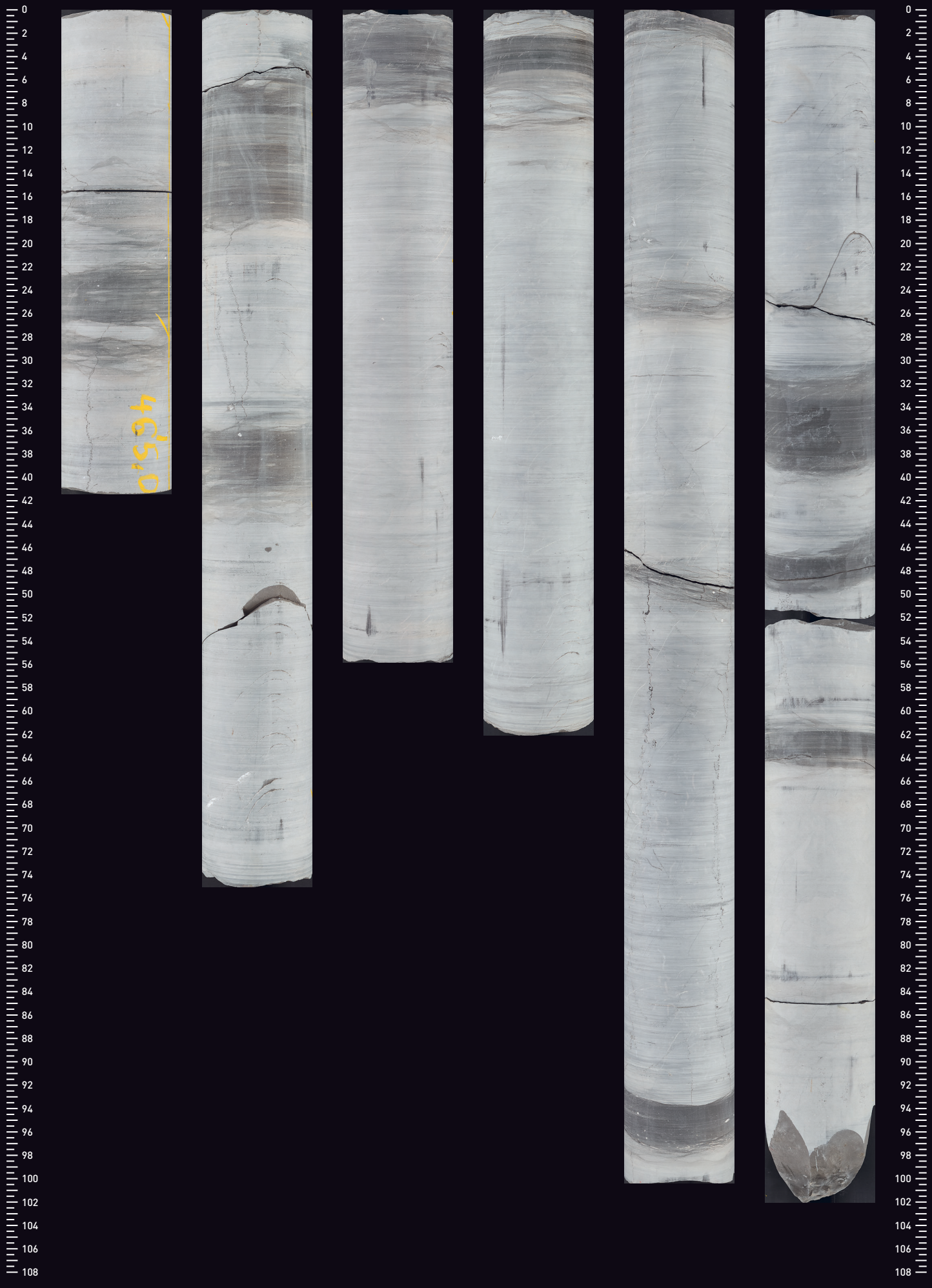
456.00m 460.00m

460.00m 460.65m 461.68m 461.97m 462.81m 463.75m



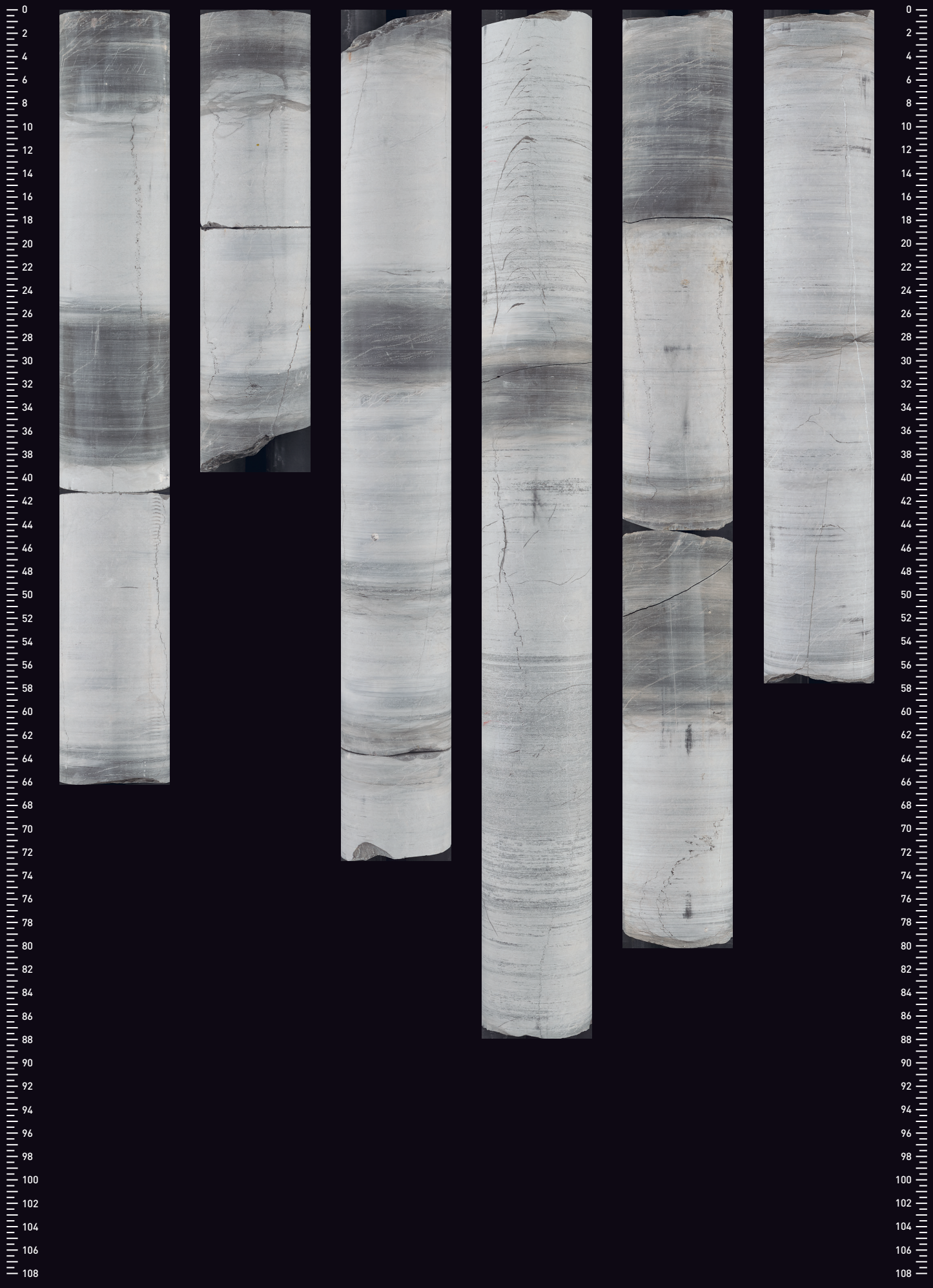
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464.64m 465.04m 465.78m 466.32m 466.90m 467.88m

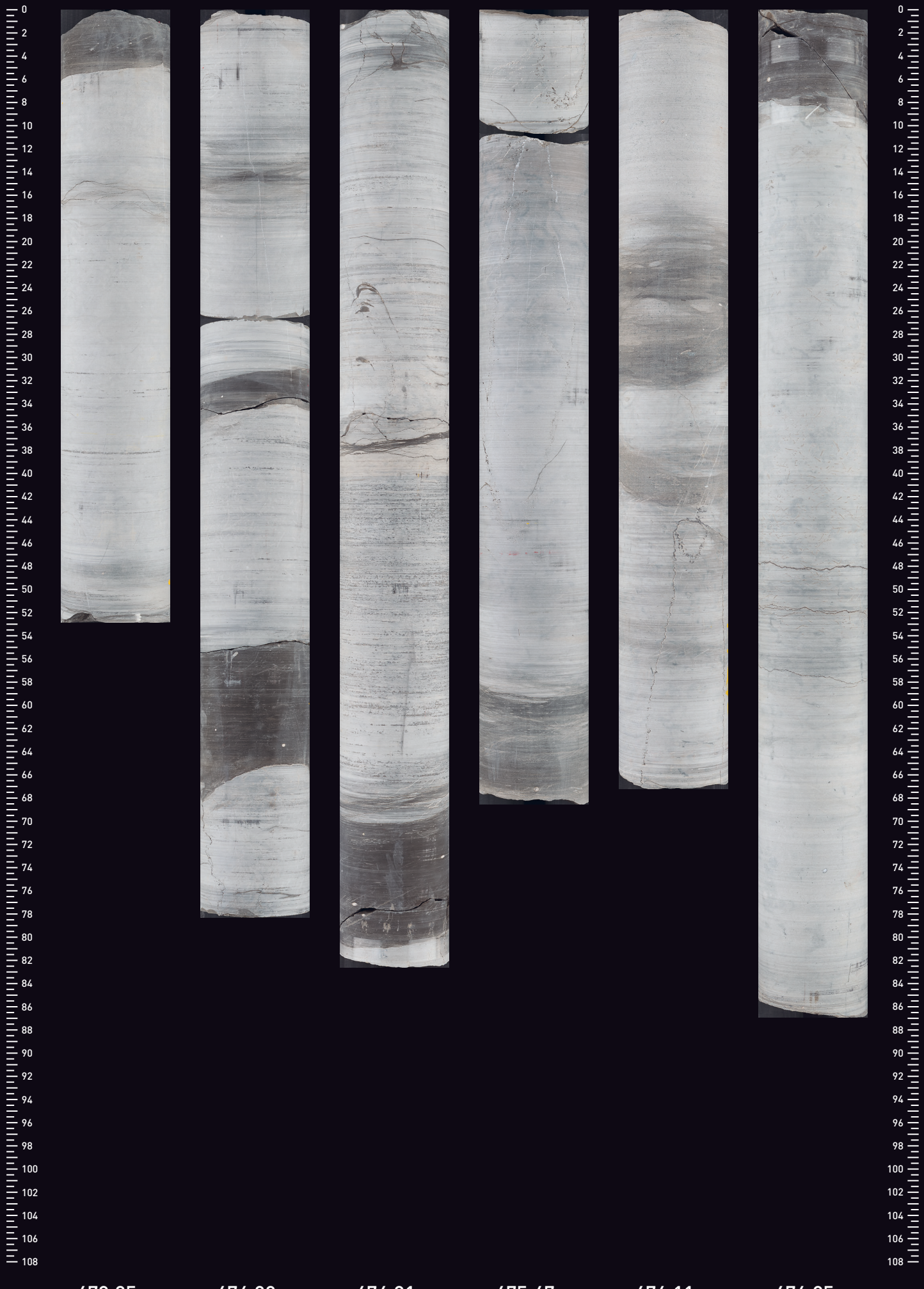


465.04m 465.78m 466.32m 466.90m 467.88m 468.87m

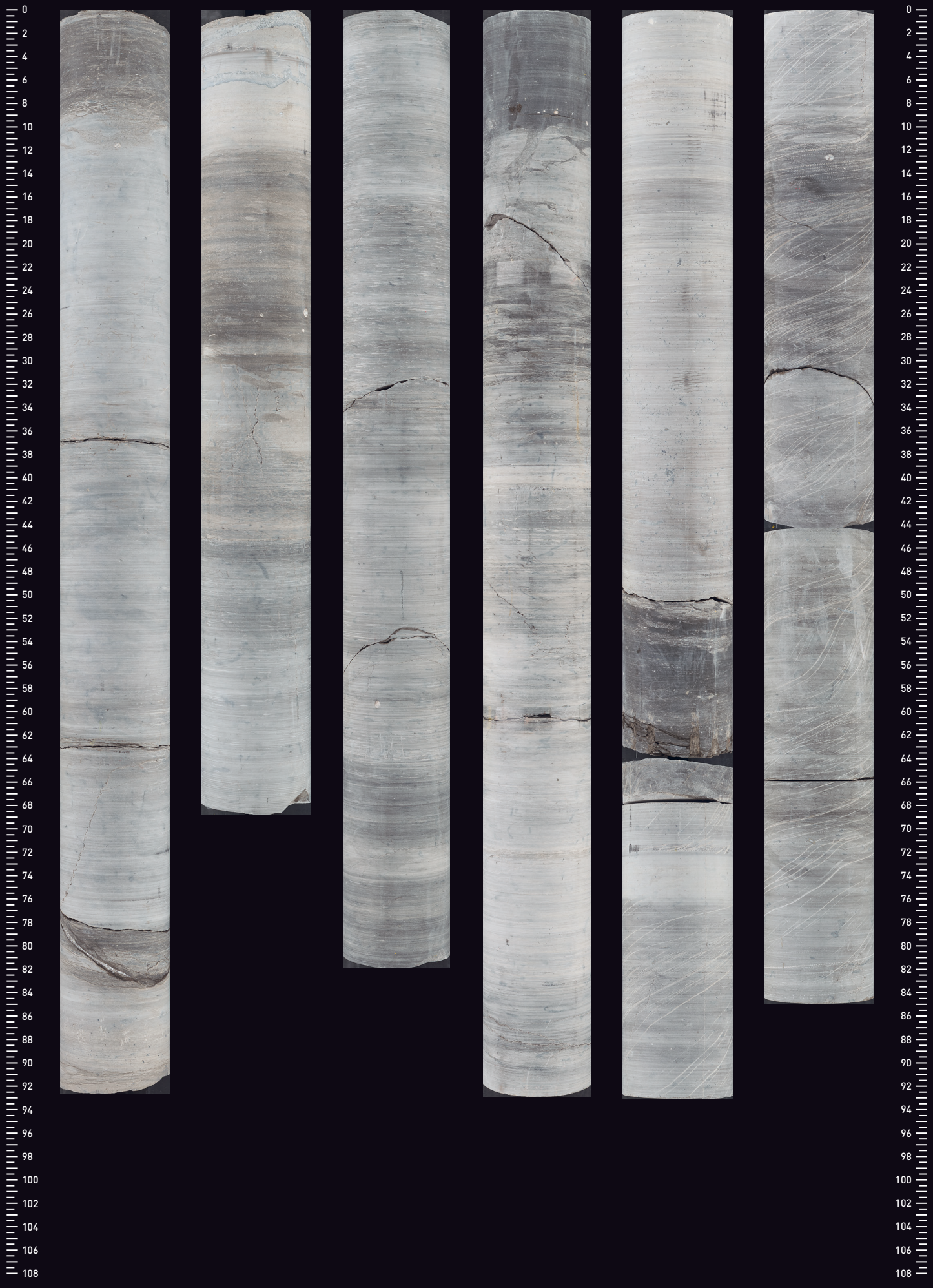
468.87m 469.52m 469.88m 470.59m 471.43m 472.18m



469.52m 469.88m 470.59m 471.43m 472.18m 472.74m

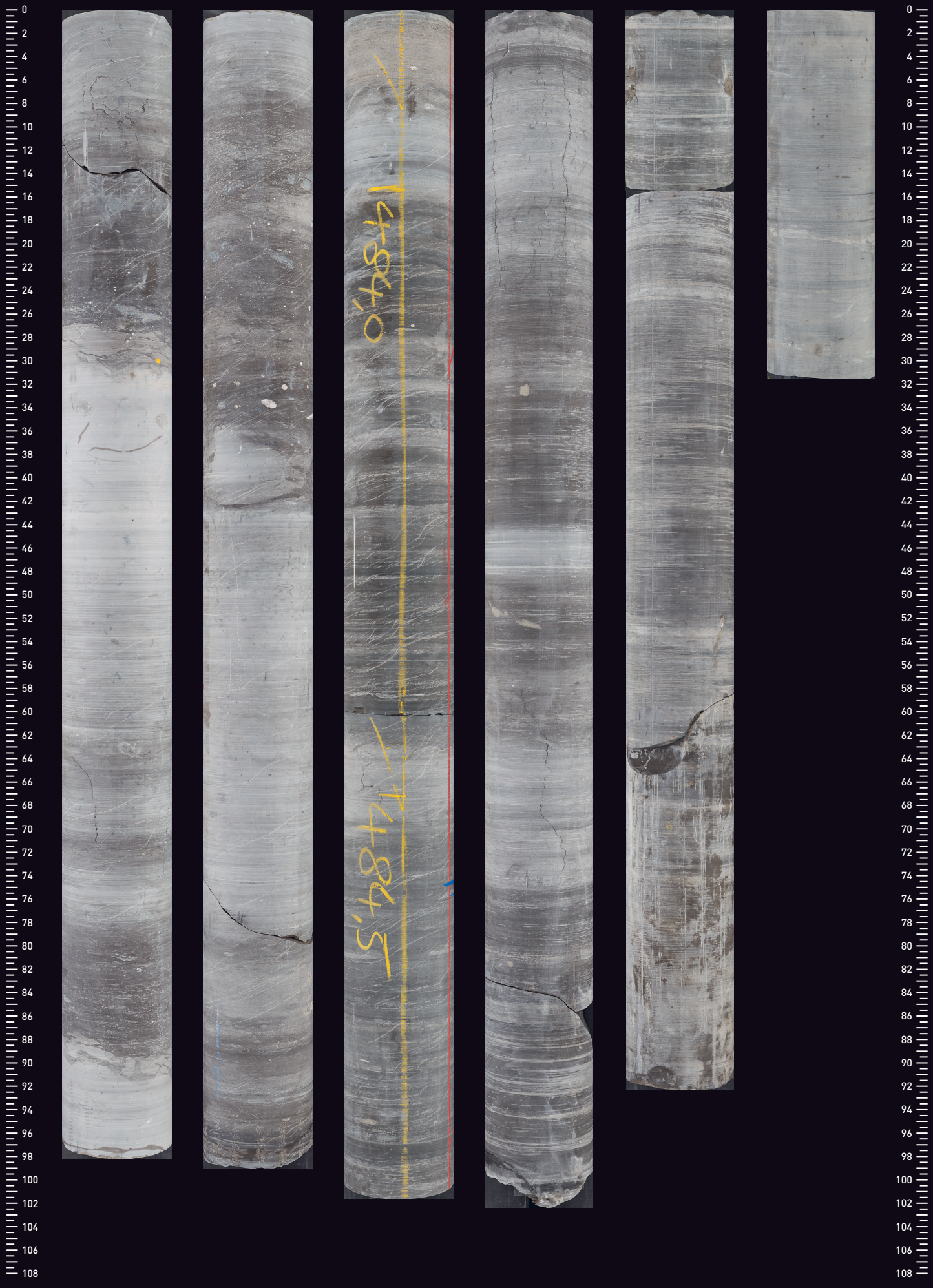

472.74m
473.25m
474.00m
474.81m
475.47m
476.11m
473.25m
474.00m
474.81m
475.47m
476.11m
476.95m

476.95m 477.85m 478.50m 479.30m 480.20m 481.12m



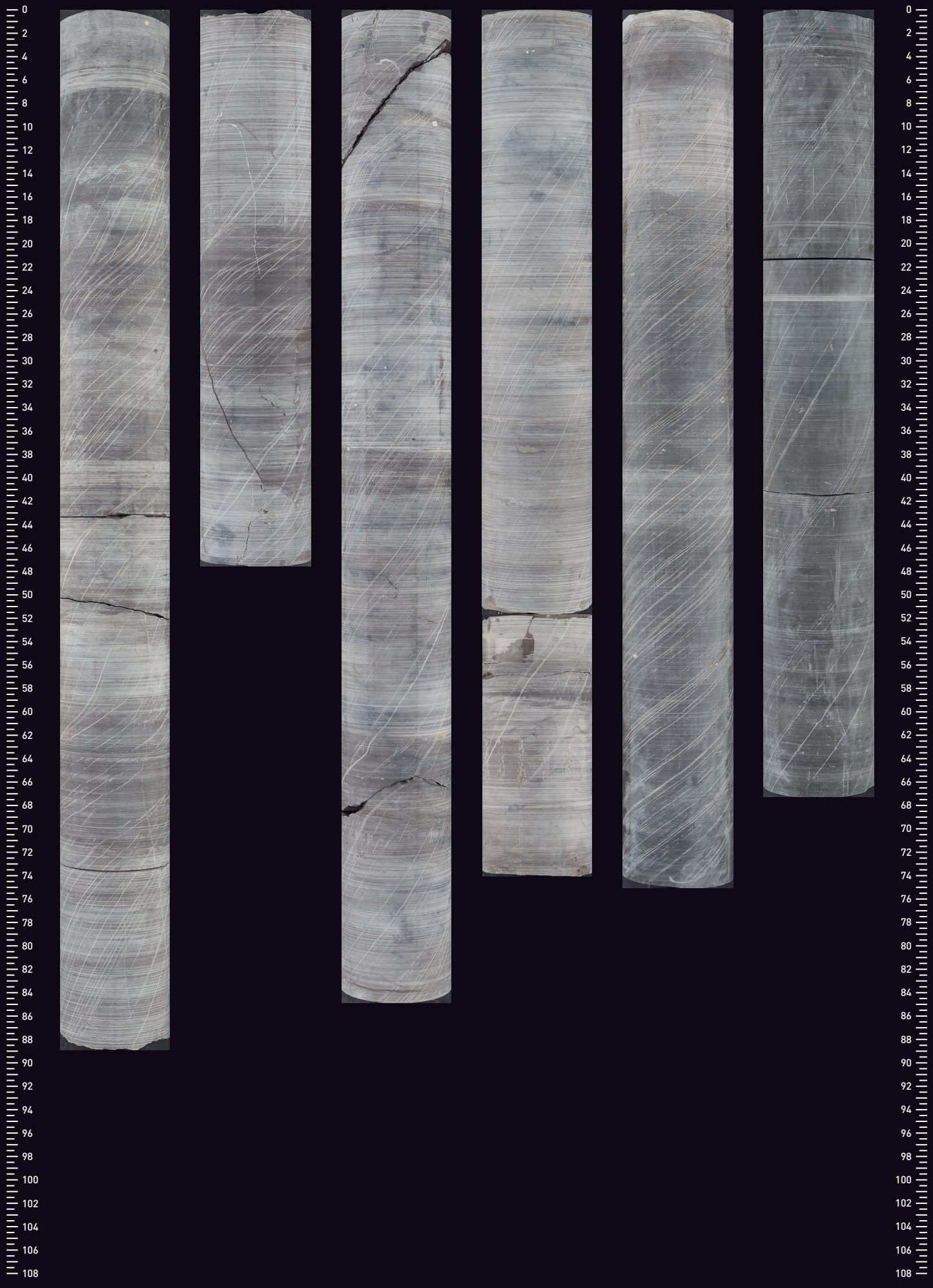
477.85m 478.50m 479.30m 480.20m 481.12m 481.95m

481.95m 482.90m 483.85m 484.83m 485.88m 486.77m



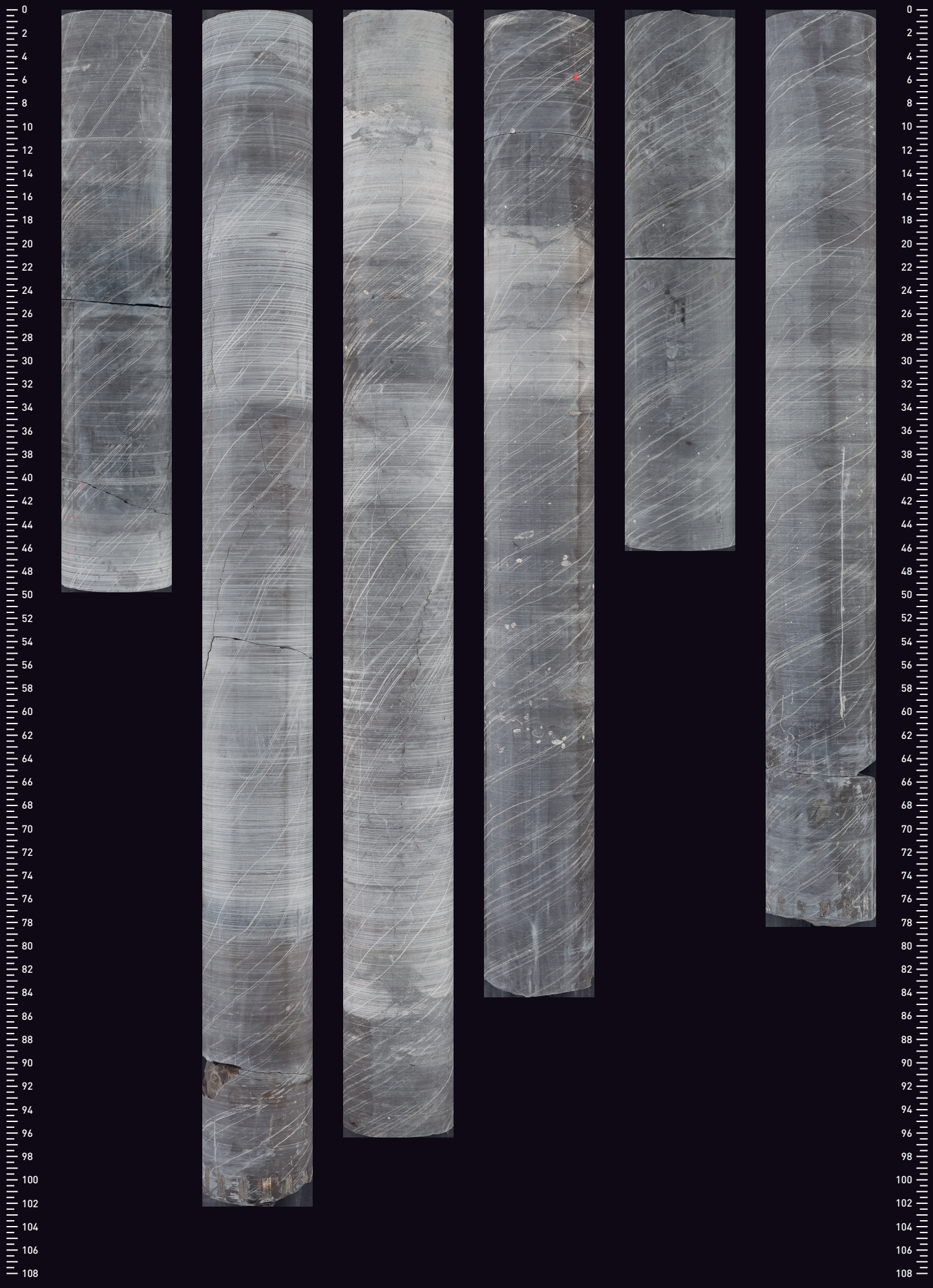
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487.09m 487.94m 488.40m 489.23m 489.93m 490.66m



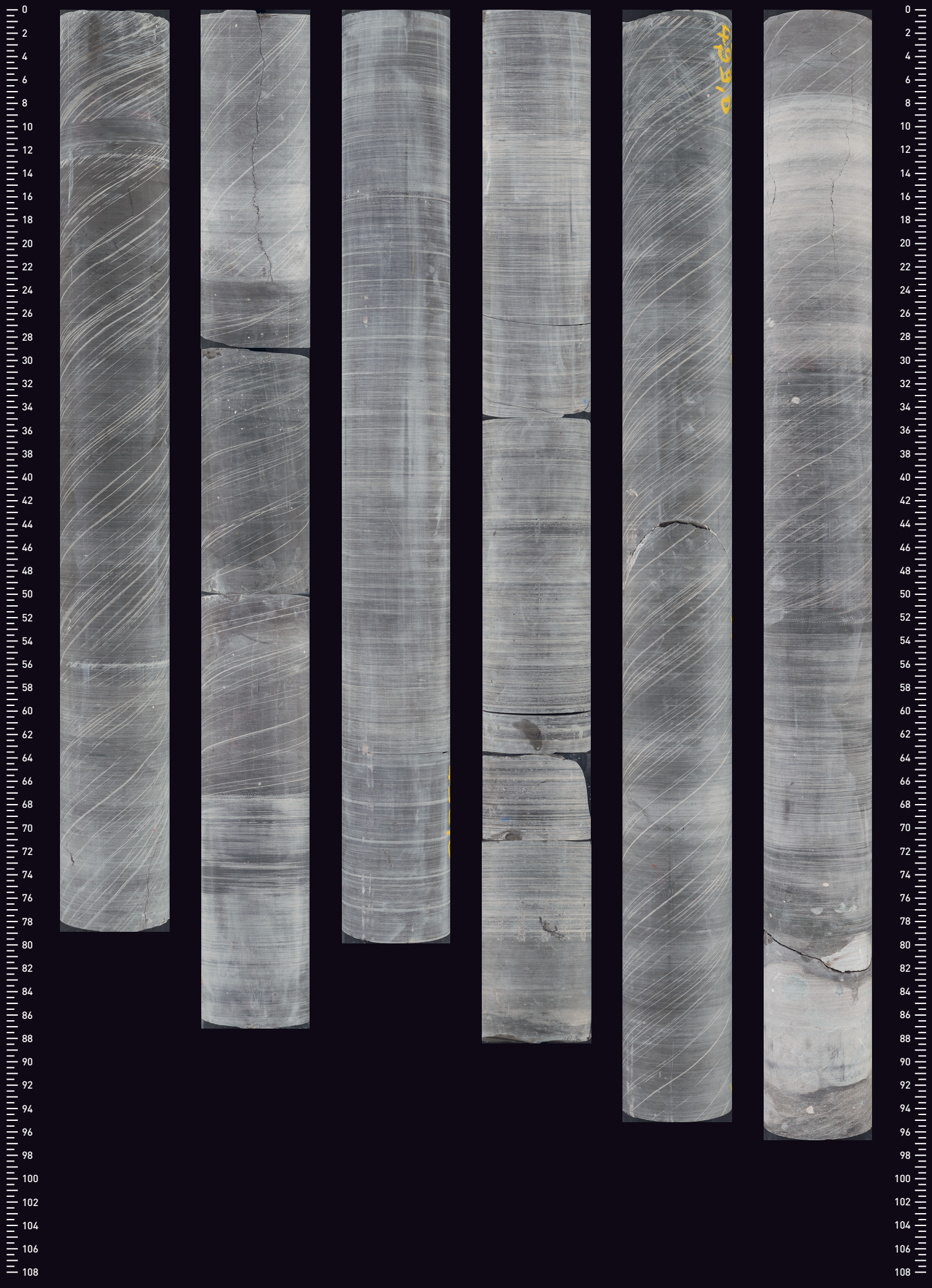
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491.80m 492.78m 493.72m 494.53m 494.98m 495.74m

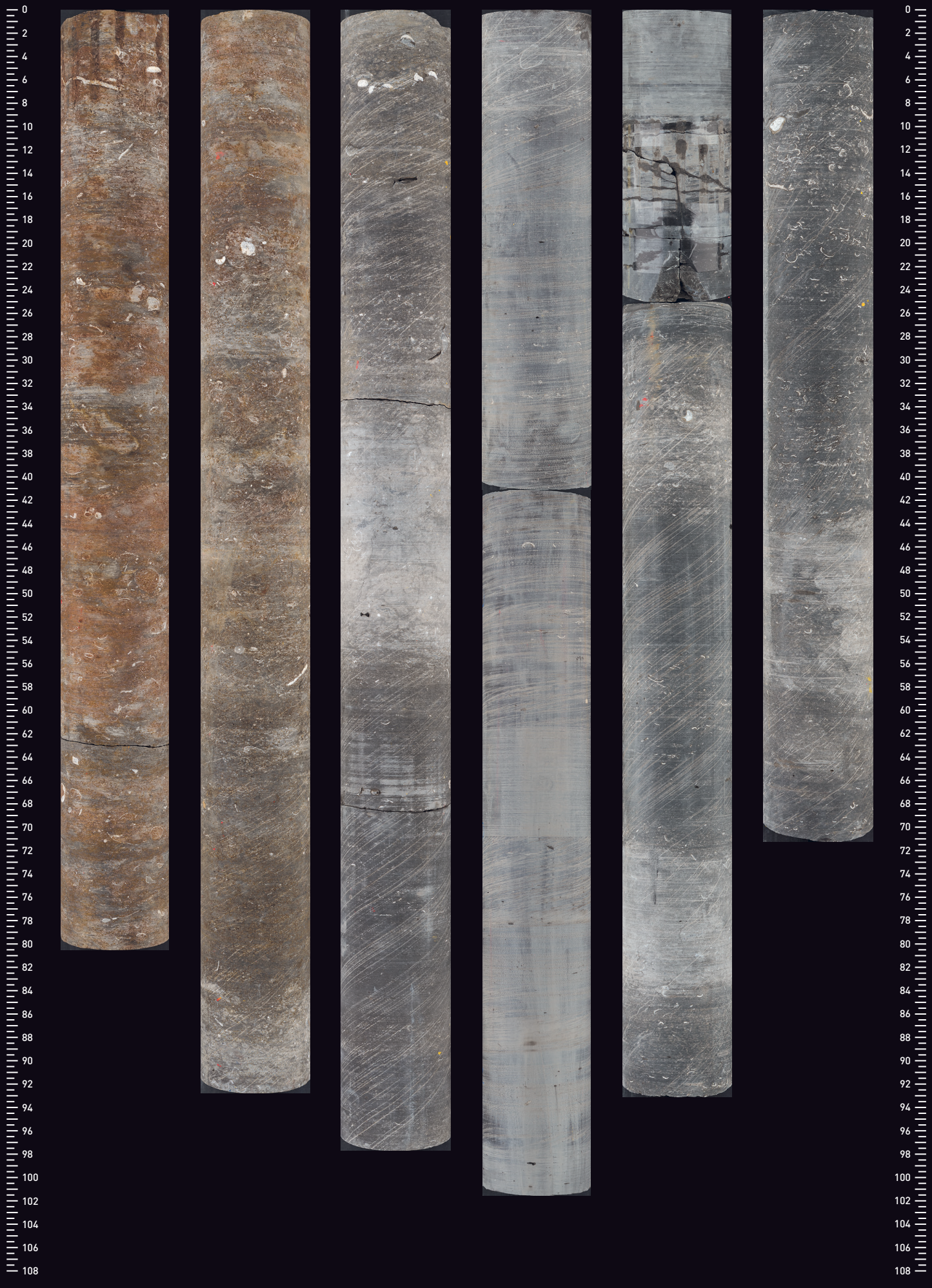
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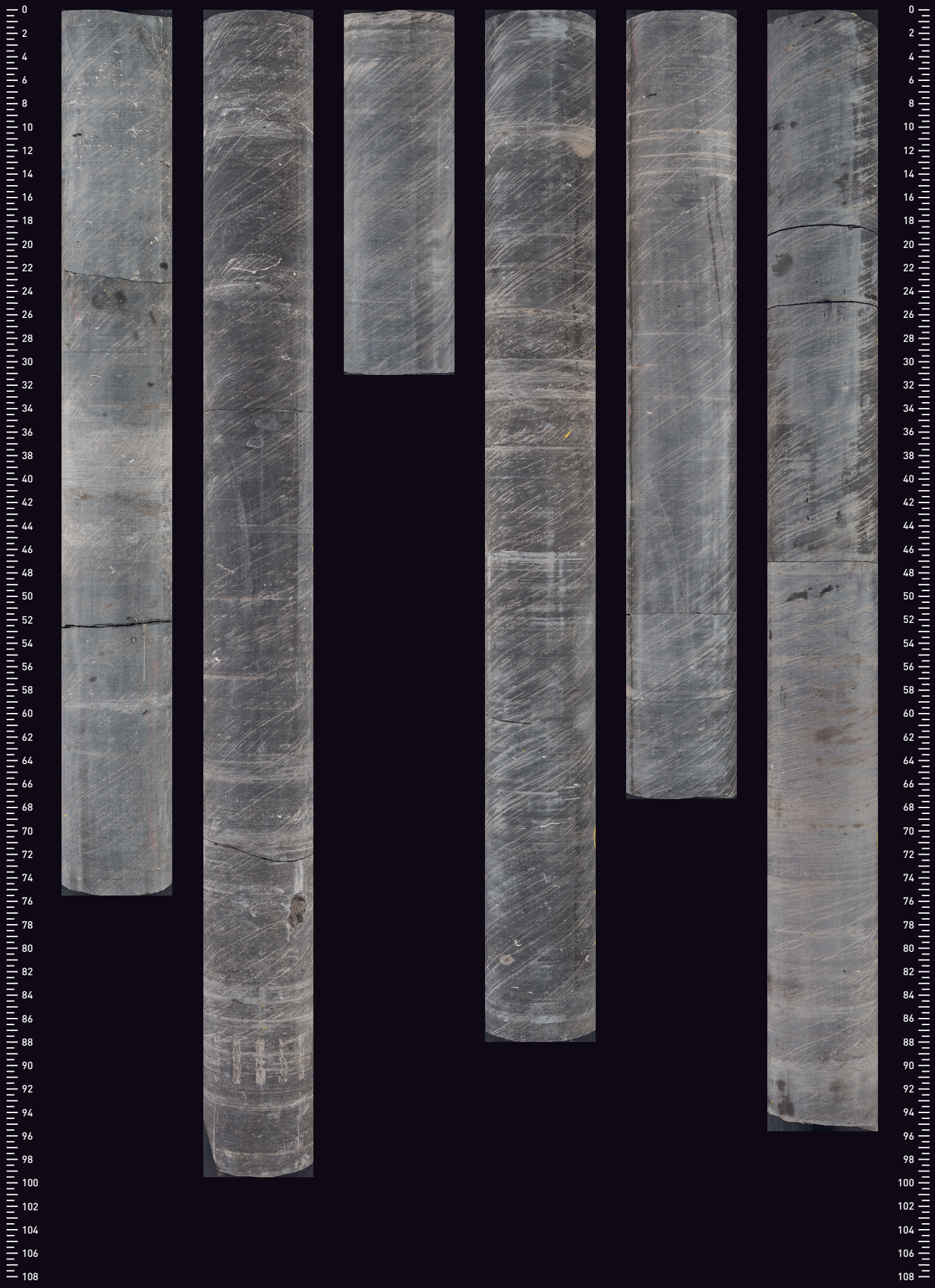

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503.89m
504.15m

504.15m 504.93m 505.83m 506.78m 507.77m 508.66m



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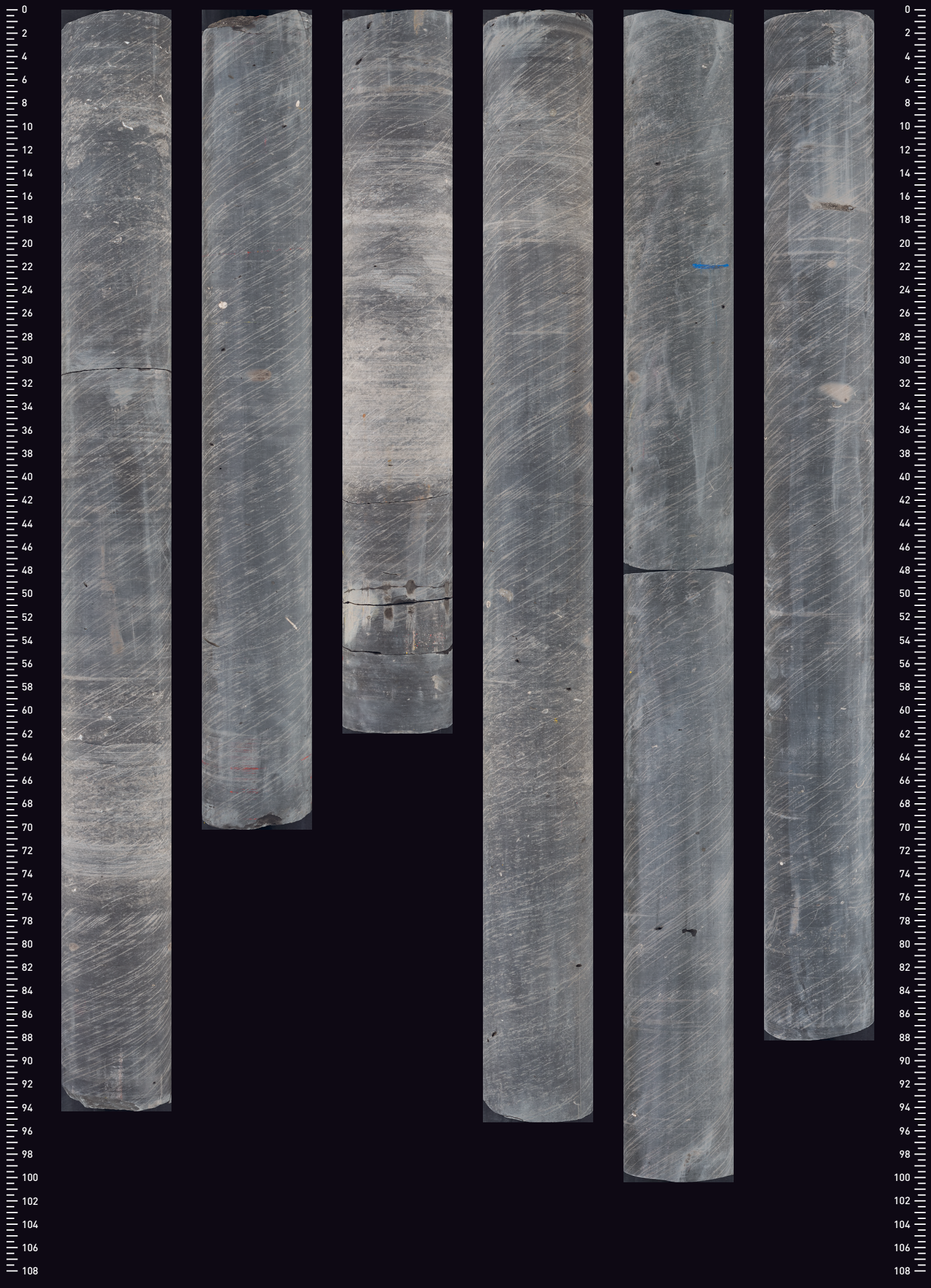


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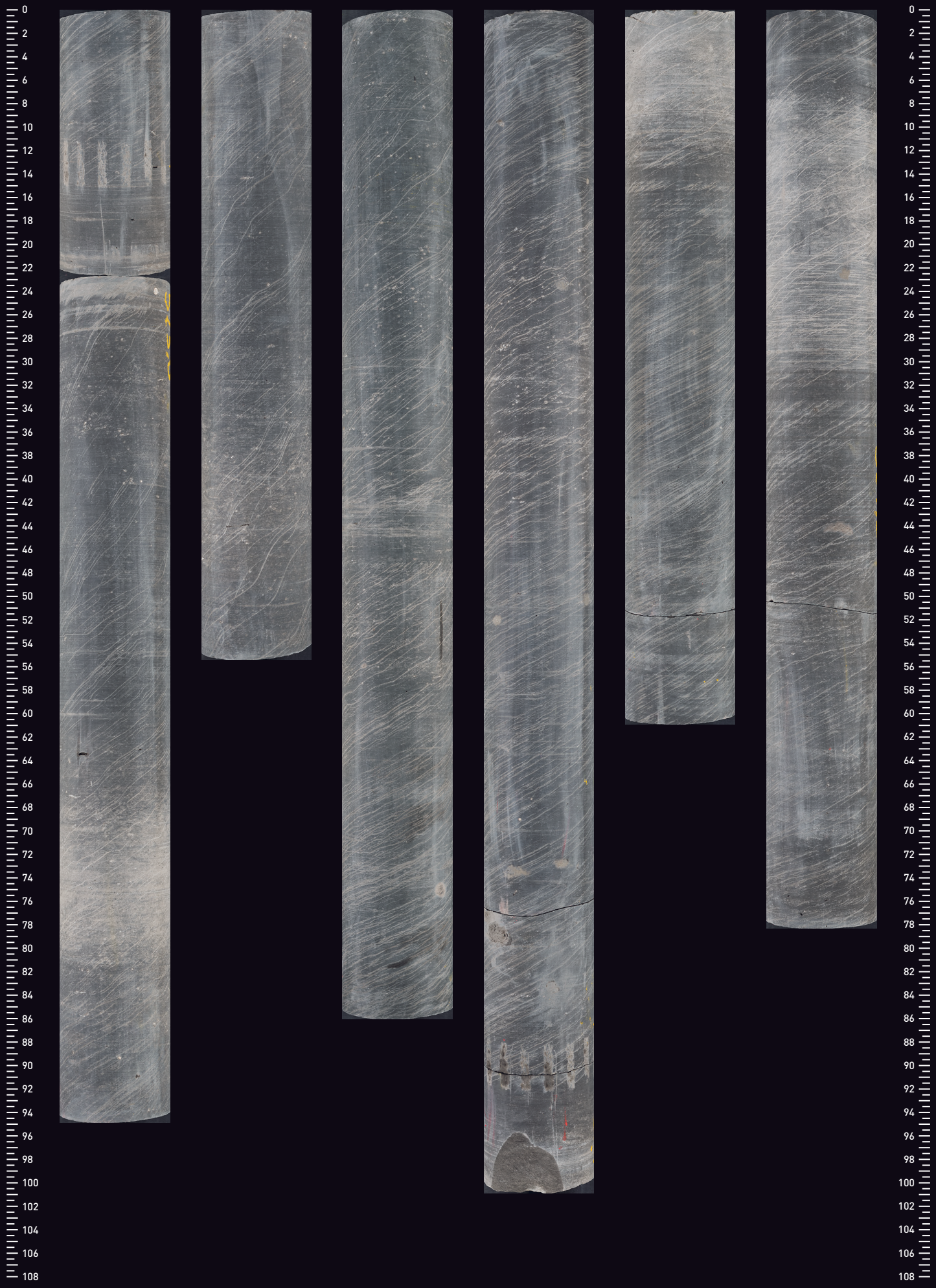
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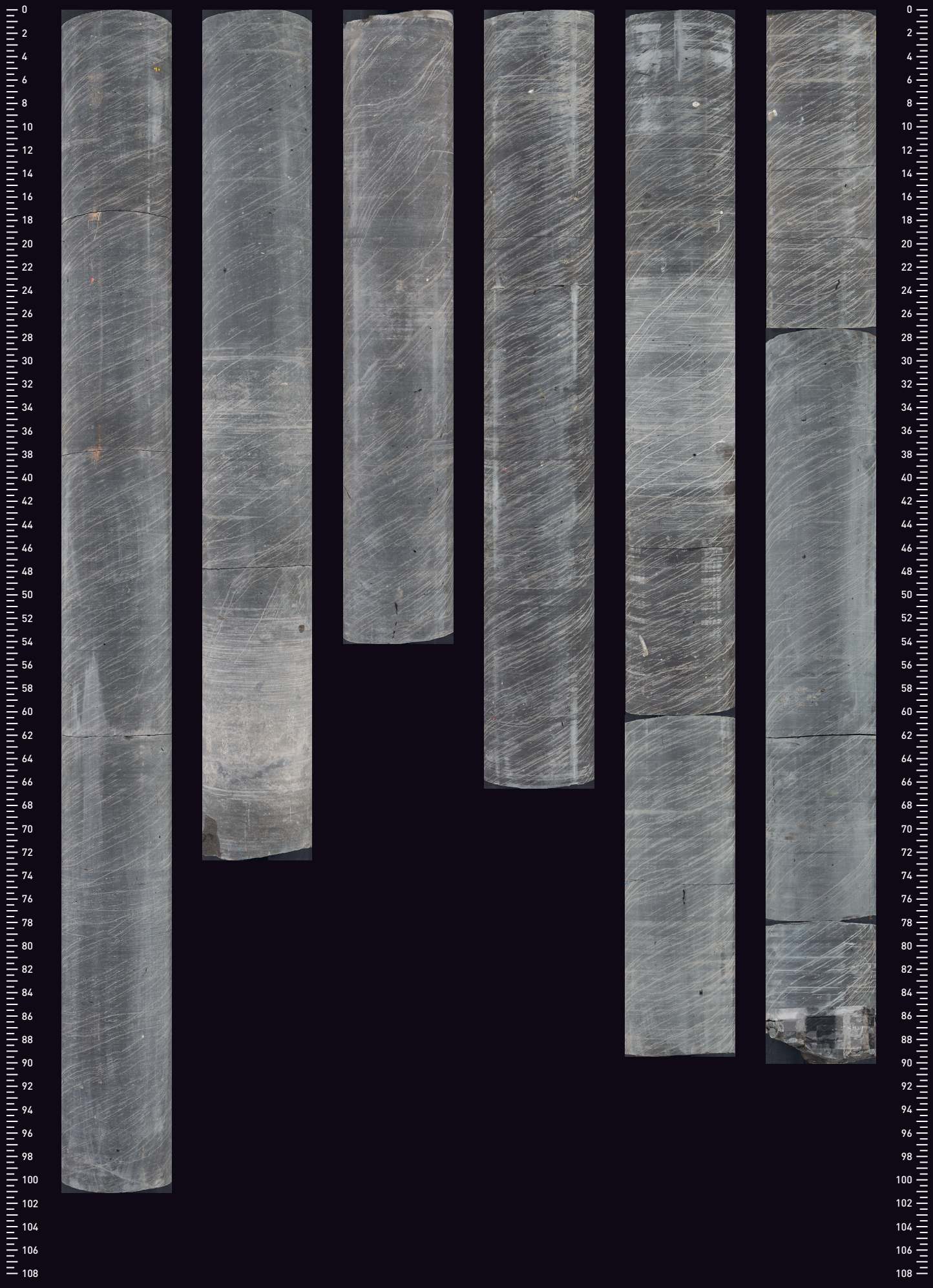

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522.77m 523.68m 524.21m 525.05m 526.02m 526.61m



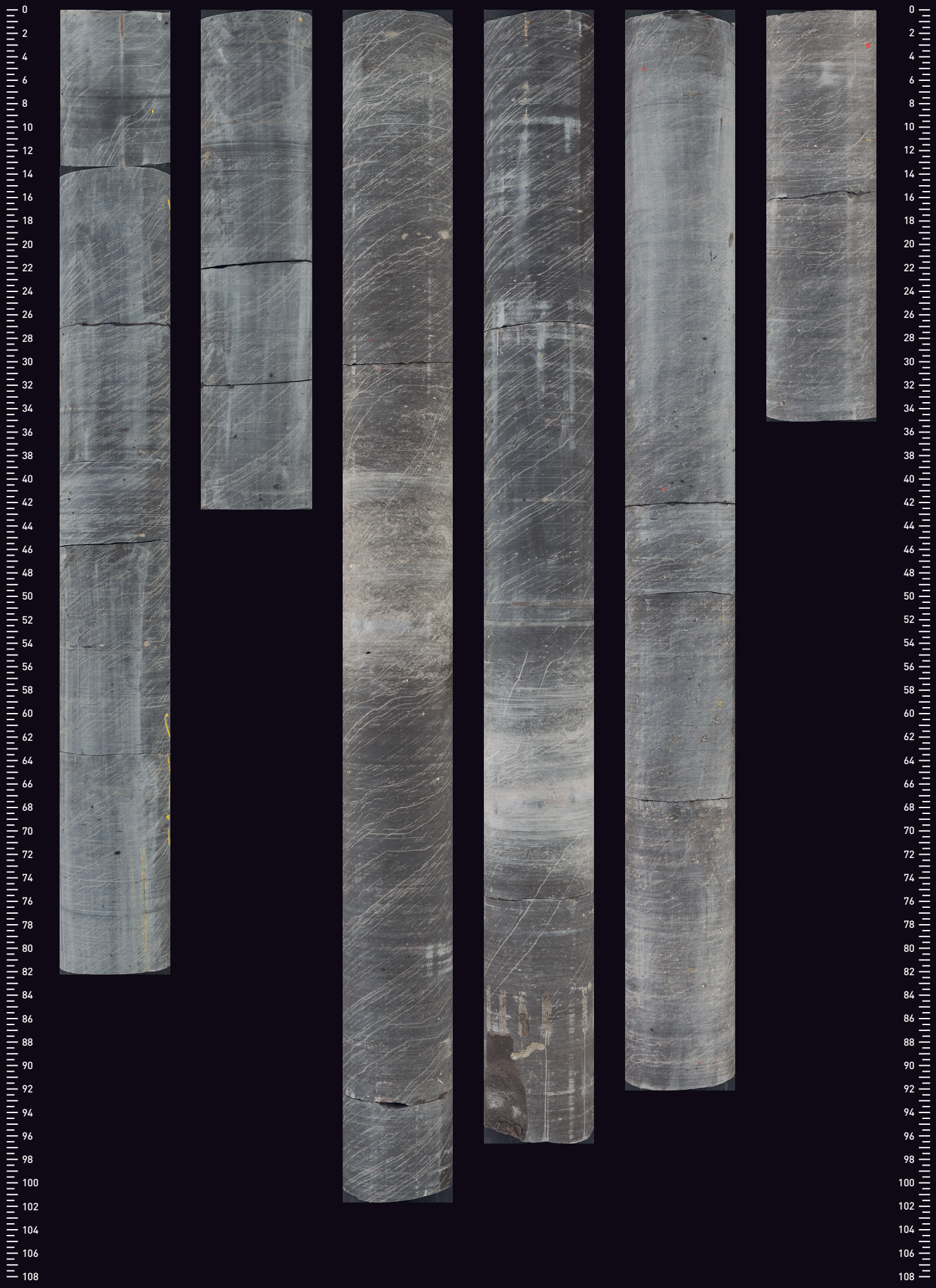
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531.93m 532.73m 533.14m 534.11m 535.04m 535.93m



532.73m 533.14m 534.11m 535.04m 535.93m 536.27m


536.27m
537.23m
538.07m
538.91m
539.41m
540.13m
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539.41m
540.13m
541.03m

541.03m 541.90m 542.68m 543.40m 544.06m 544.81m



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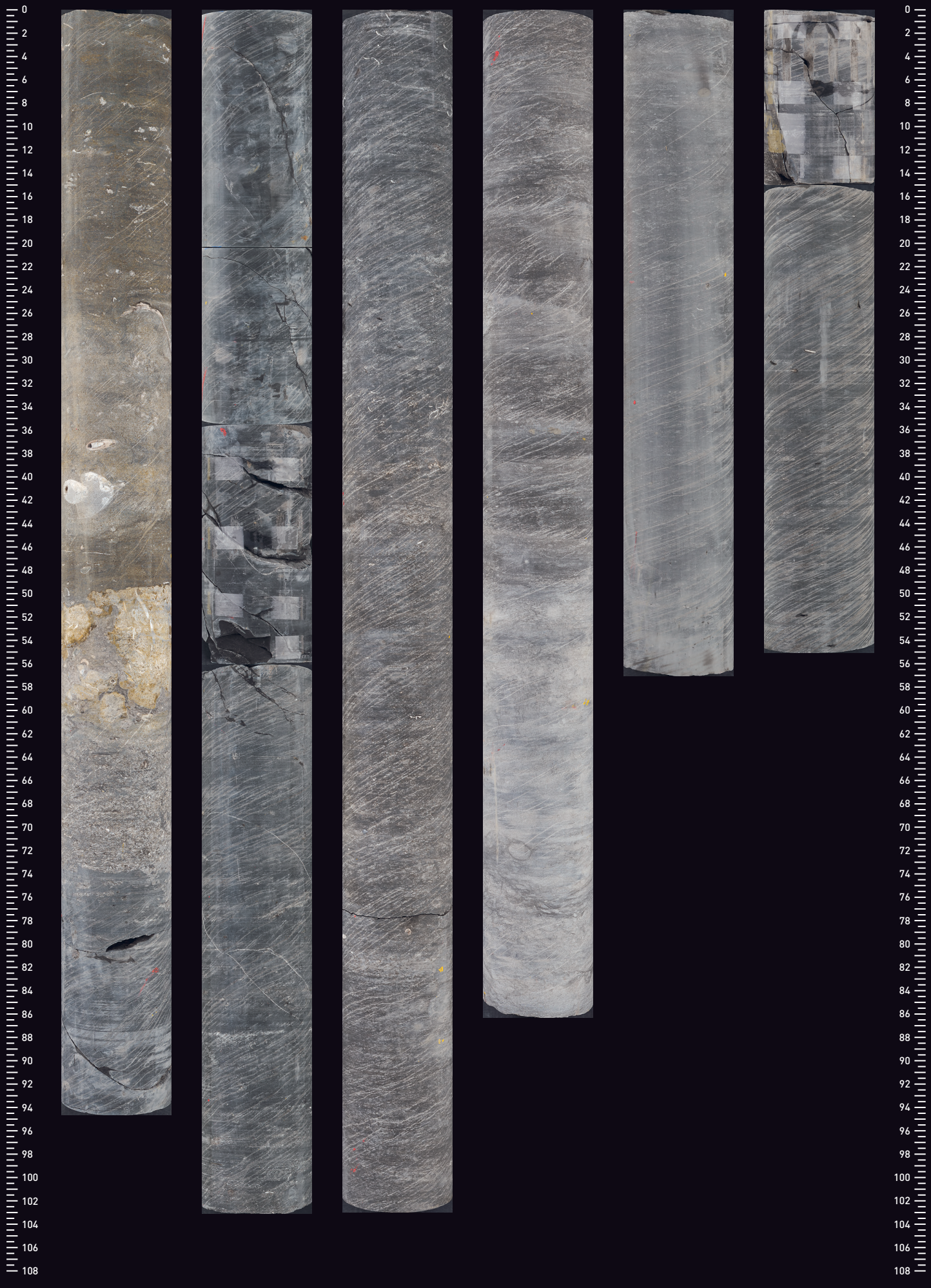
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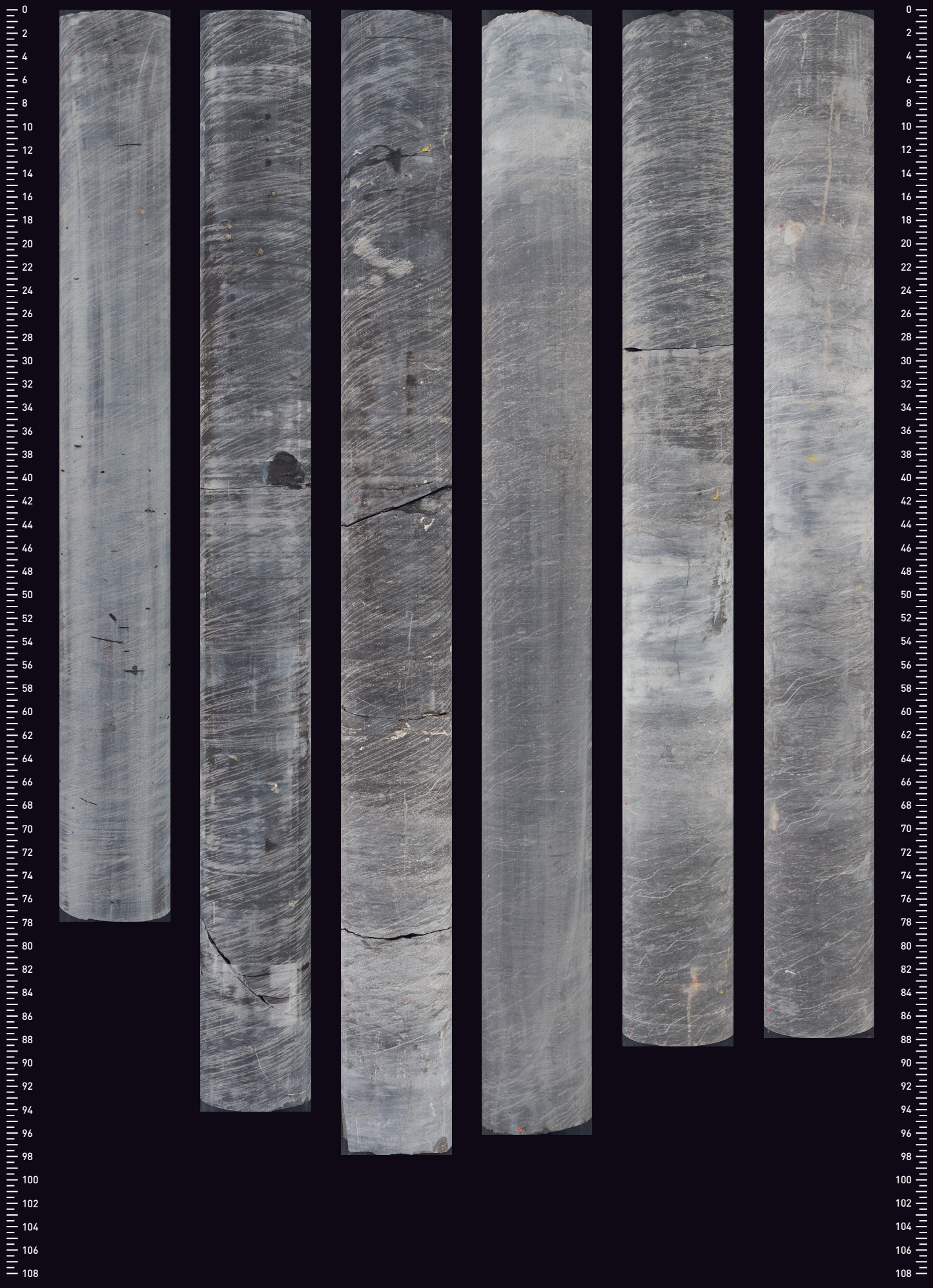
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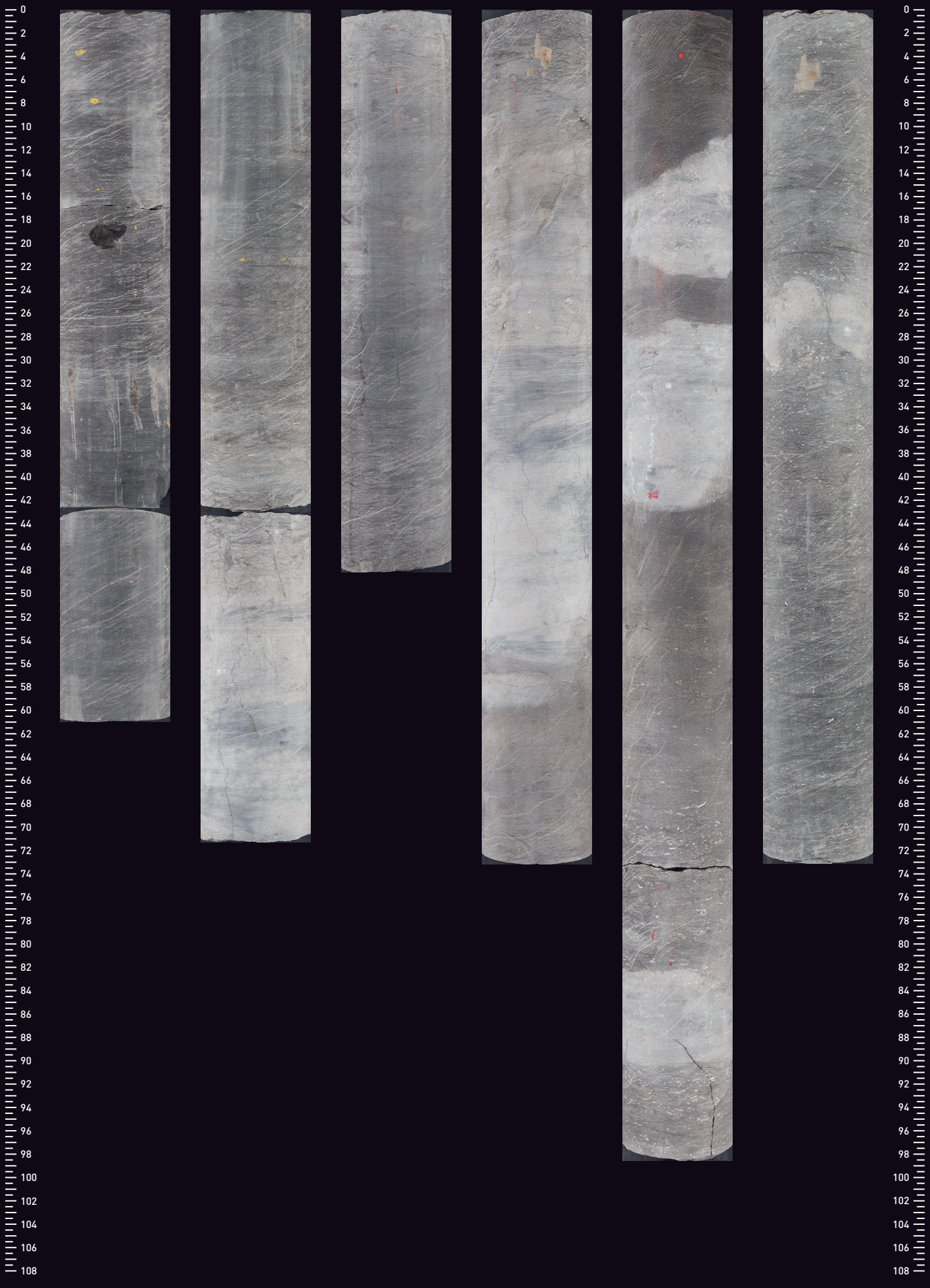
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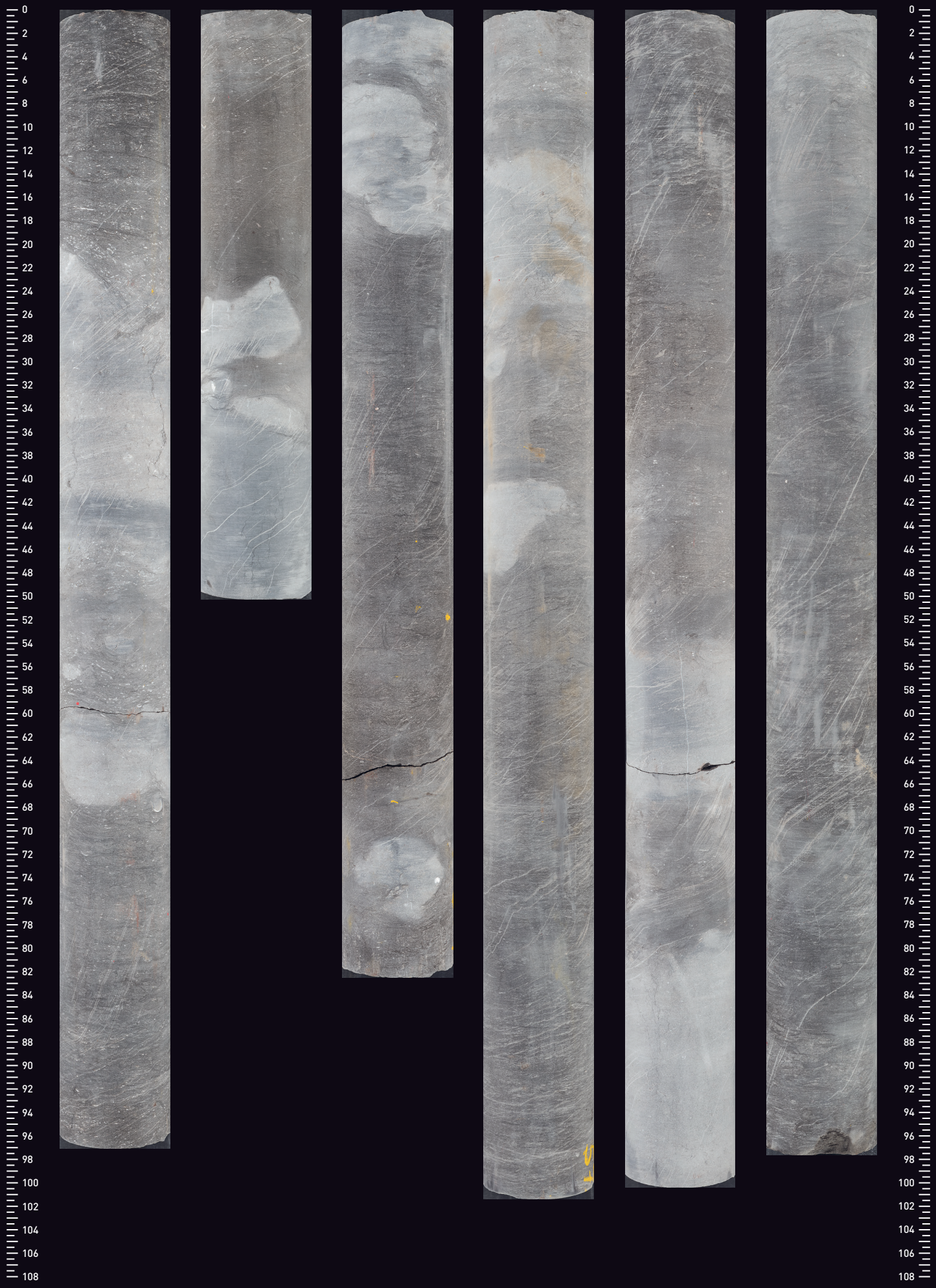
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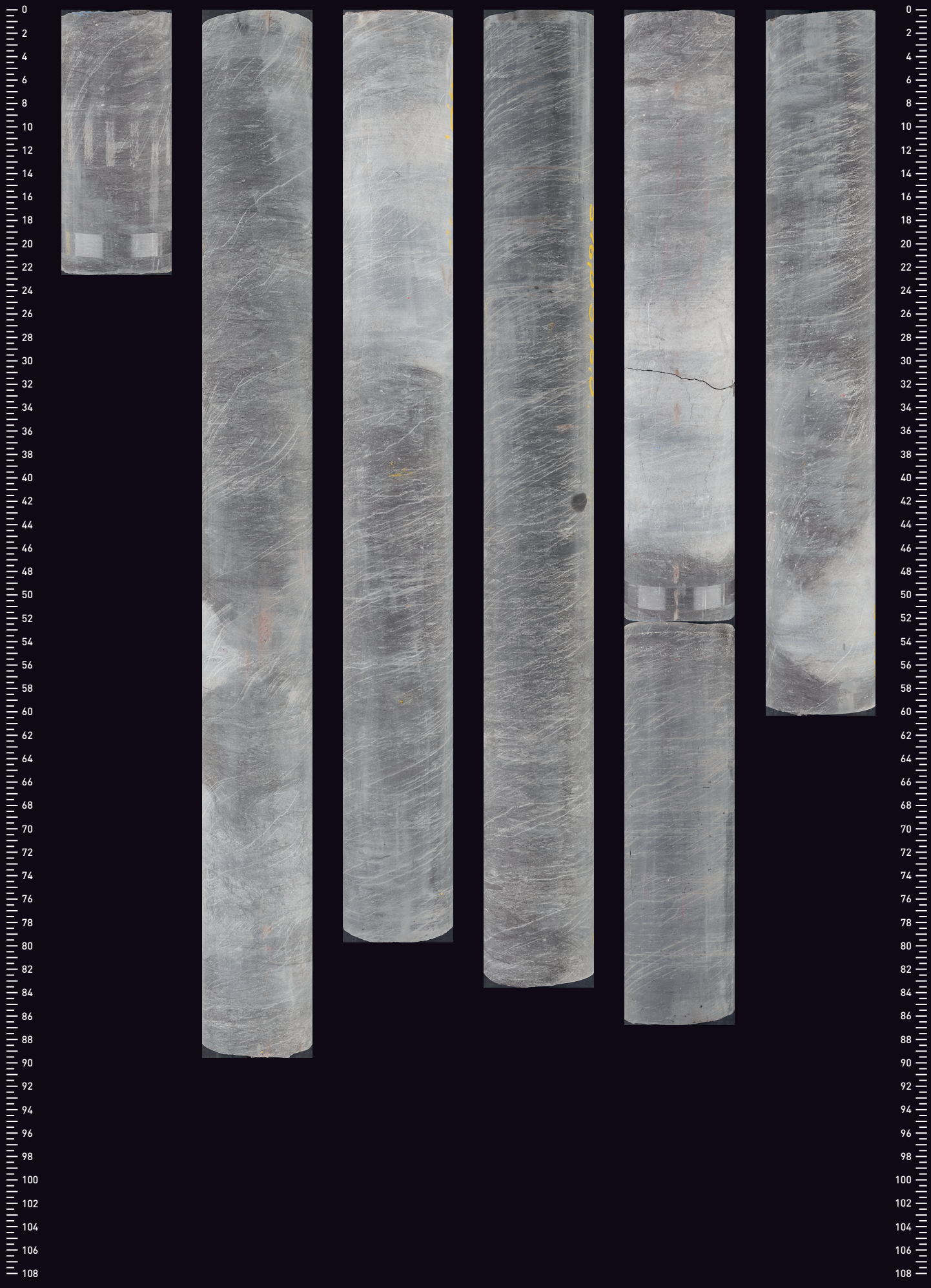
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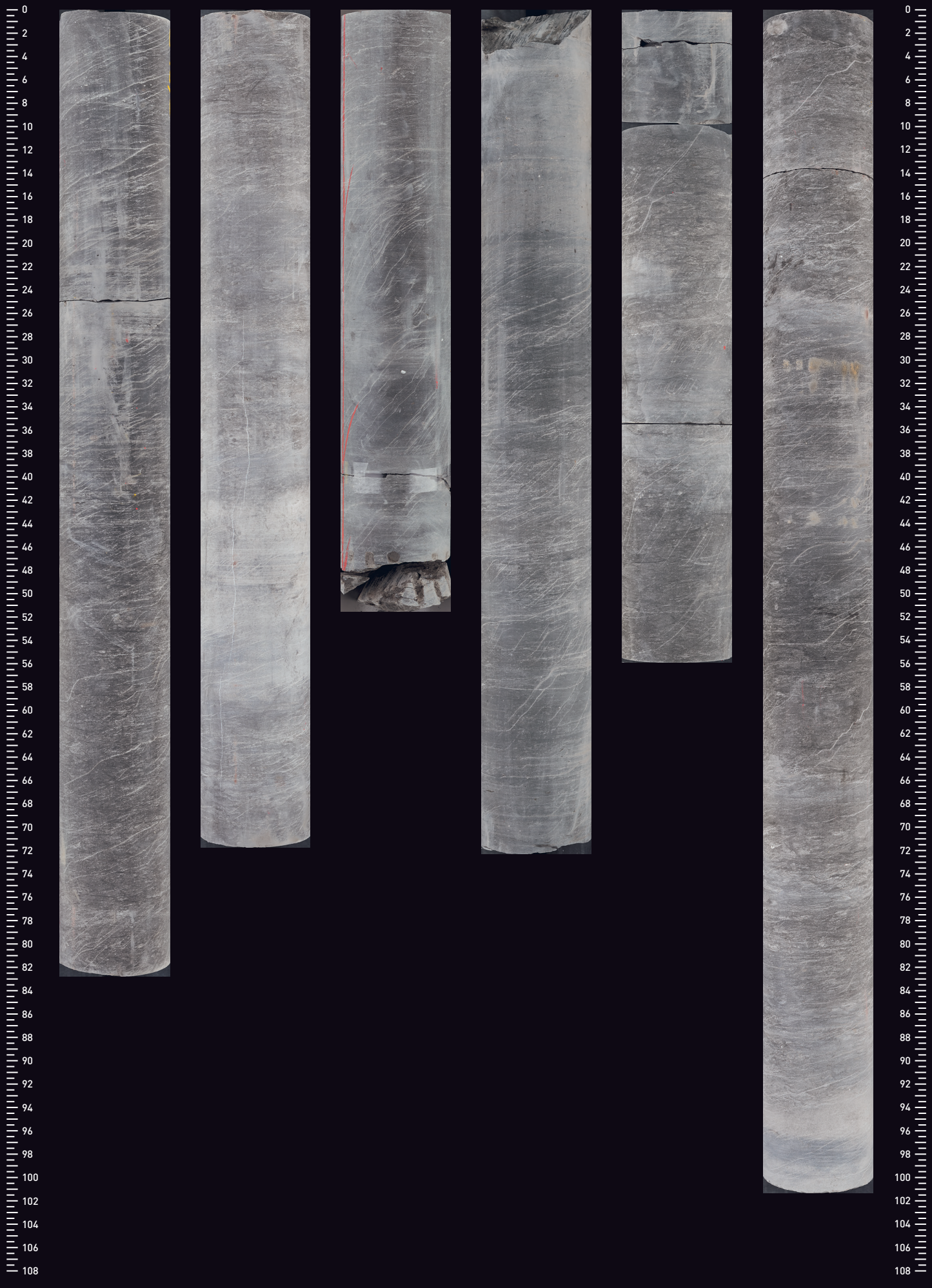
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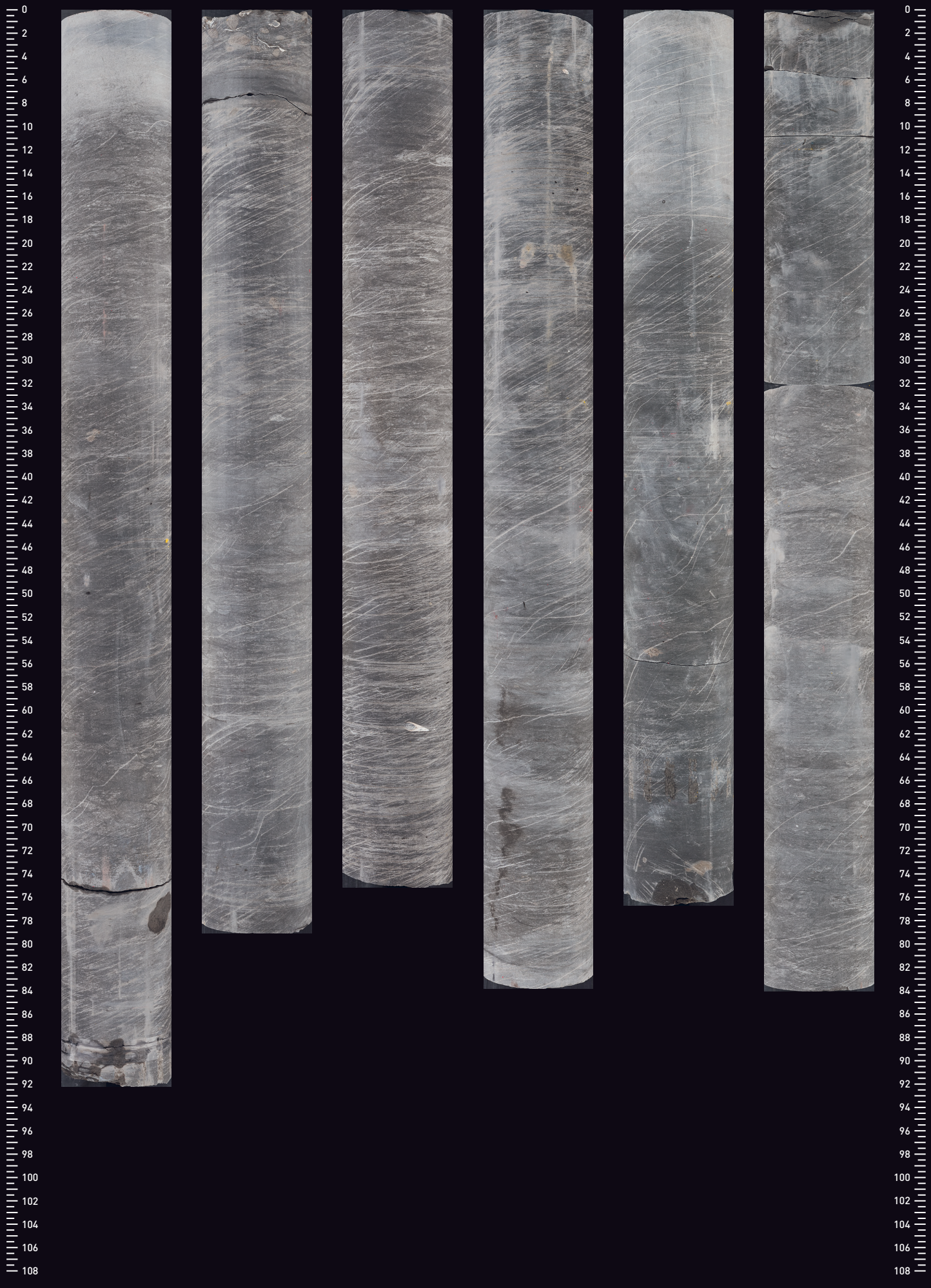
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578.80m 579.50m 579.99m 580.69m 581.21m 582.19m

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583.09m 583.86m 584.58m 585.39m 586.13m 586.95m

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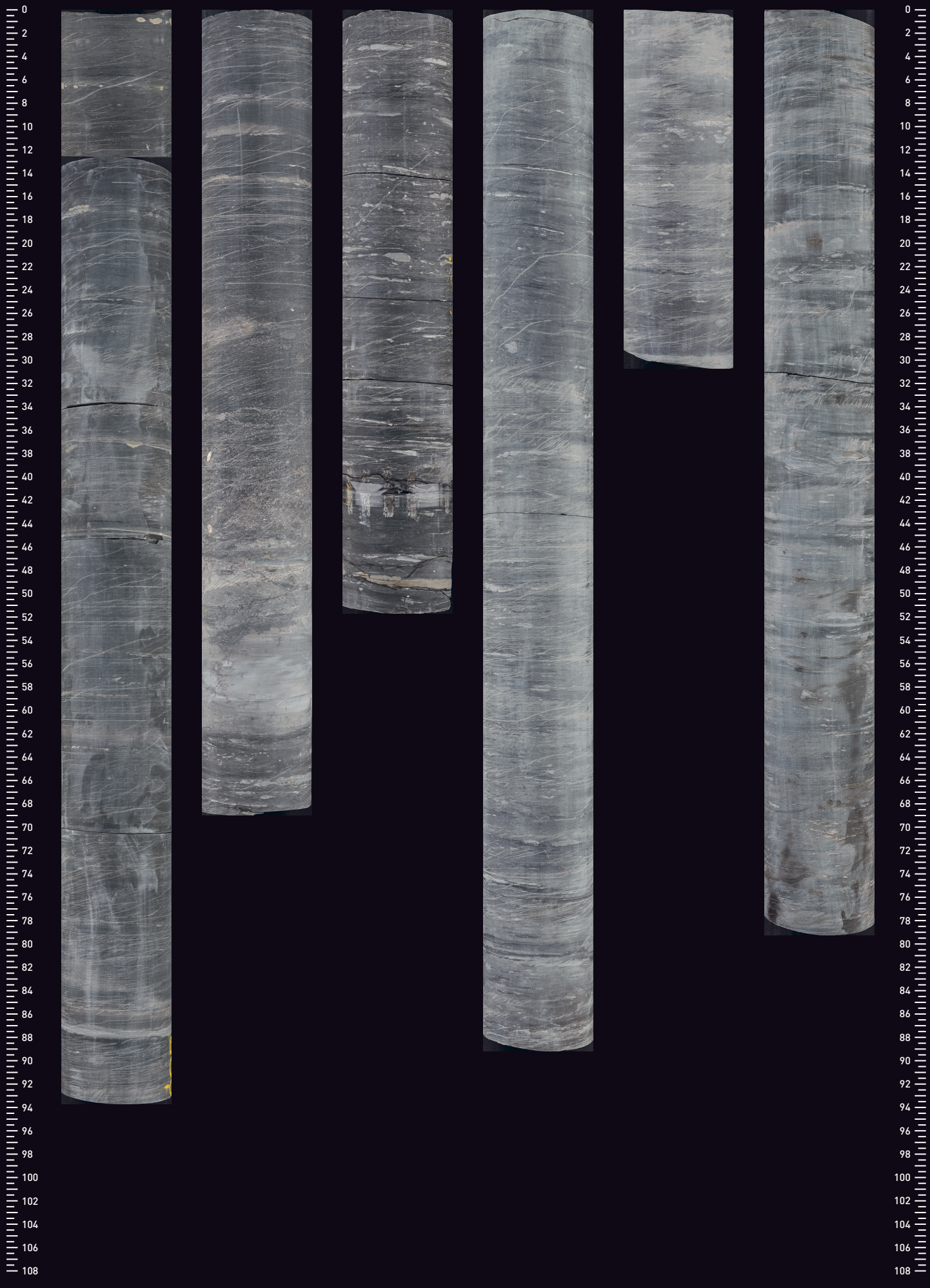


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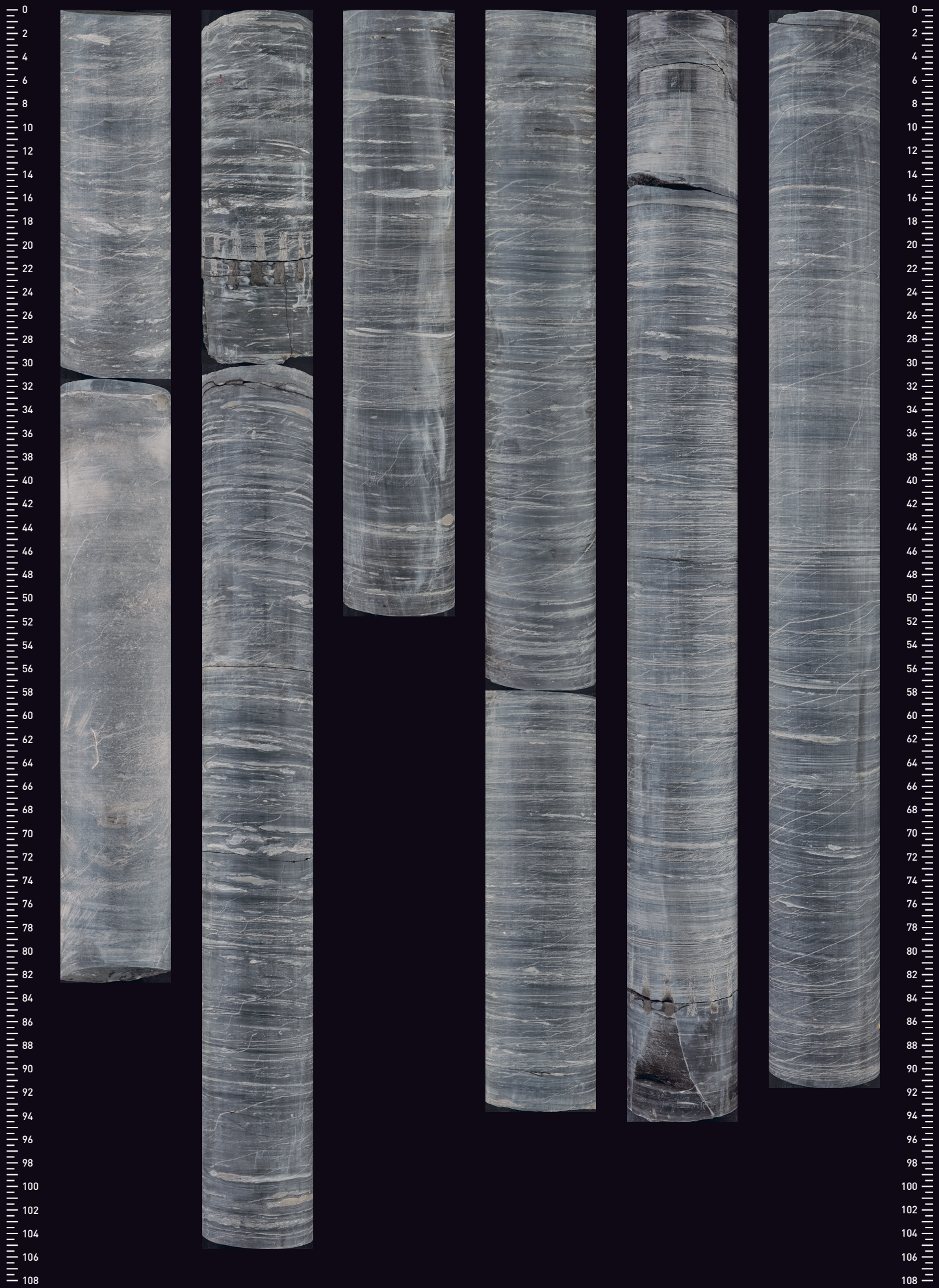
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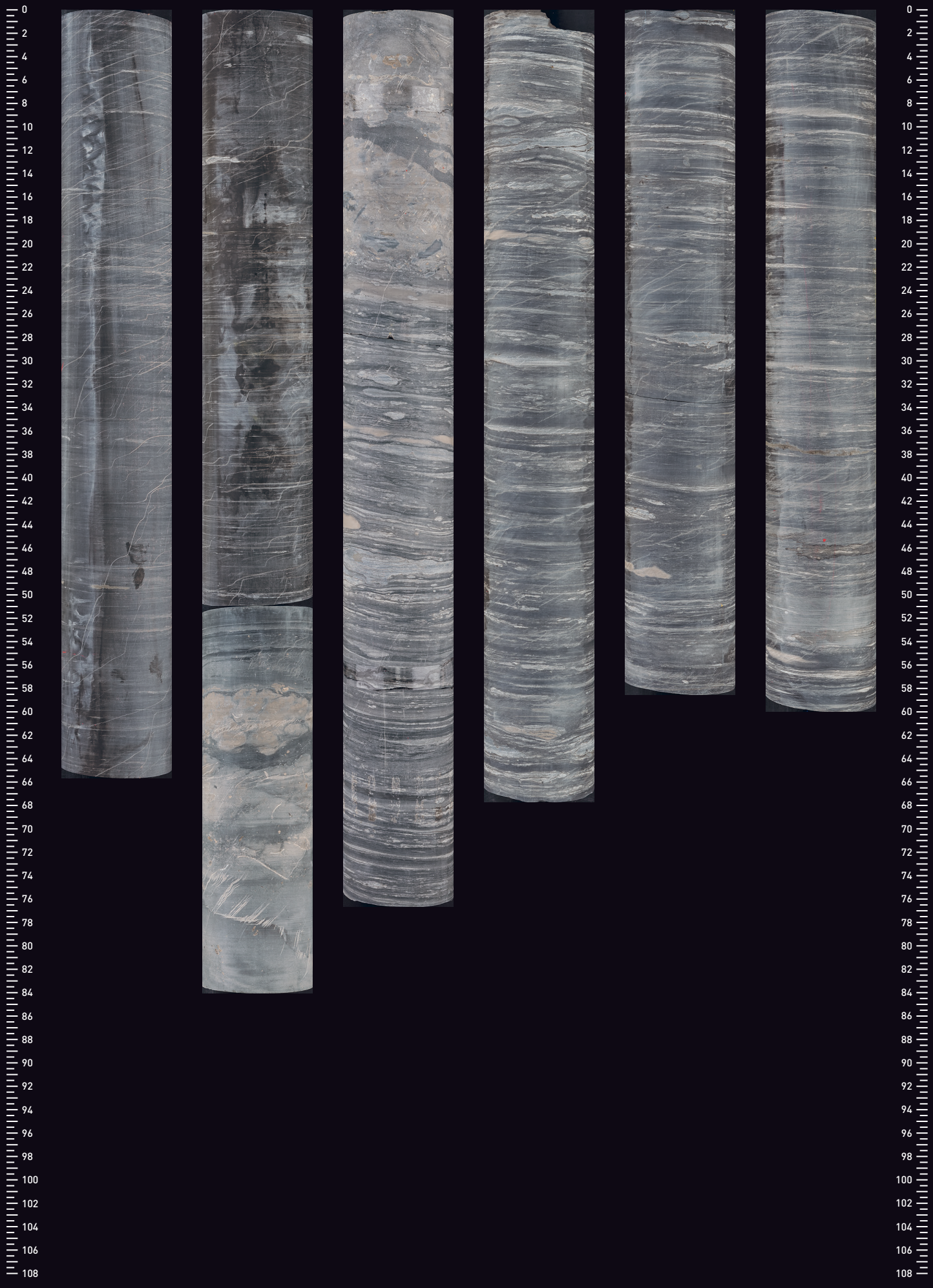

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602.33m
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603.08m 603.87m 604.87m 605.37m 606.27m 607.18m



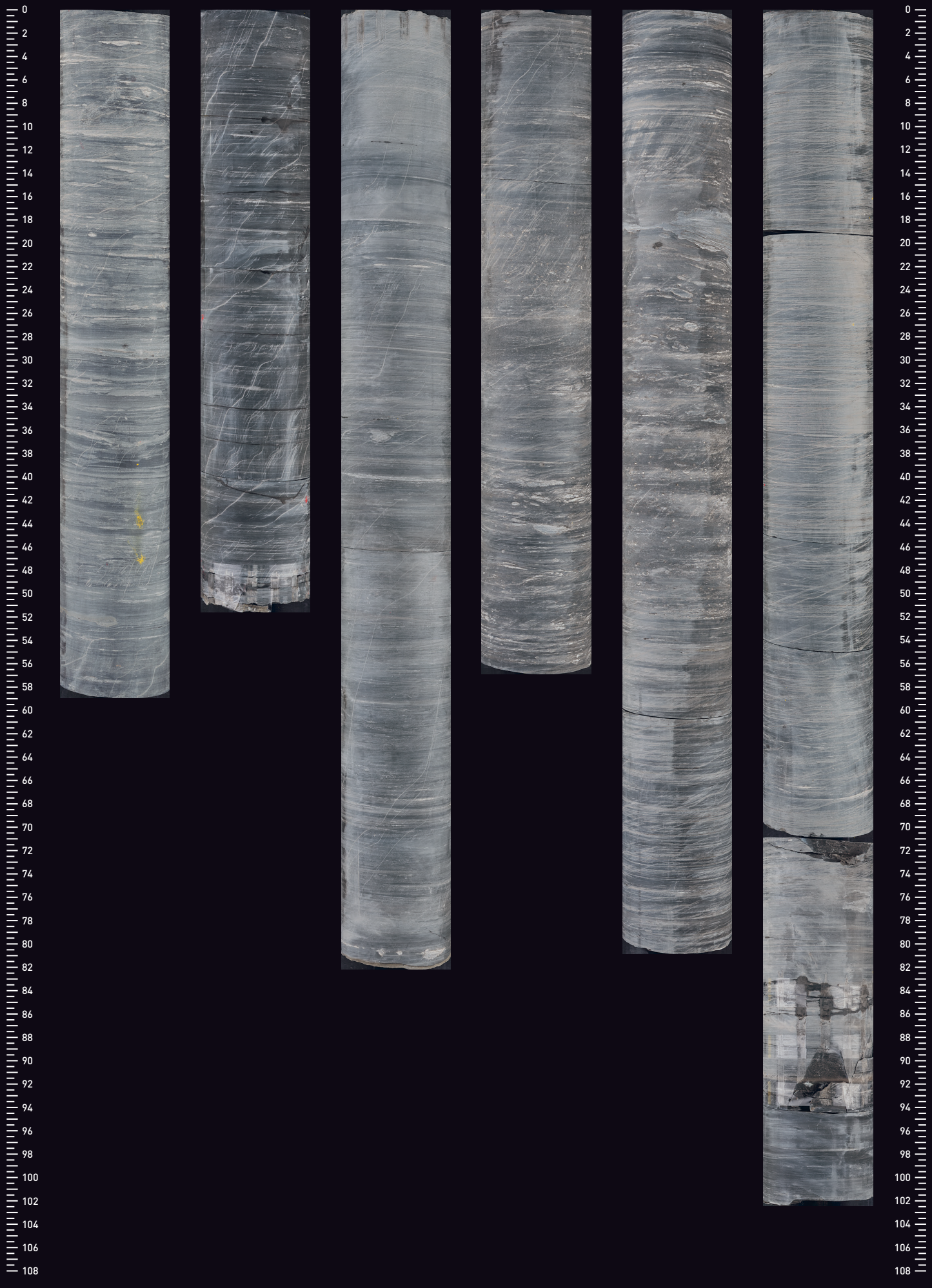
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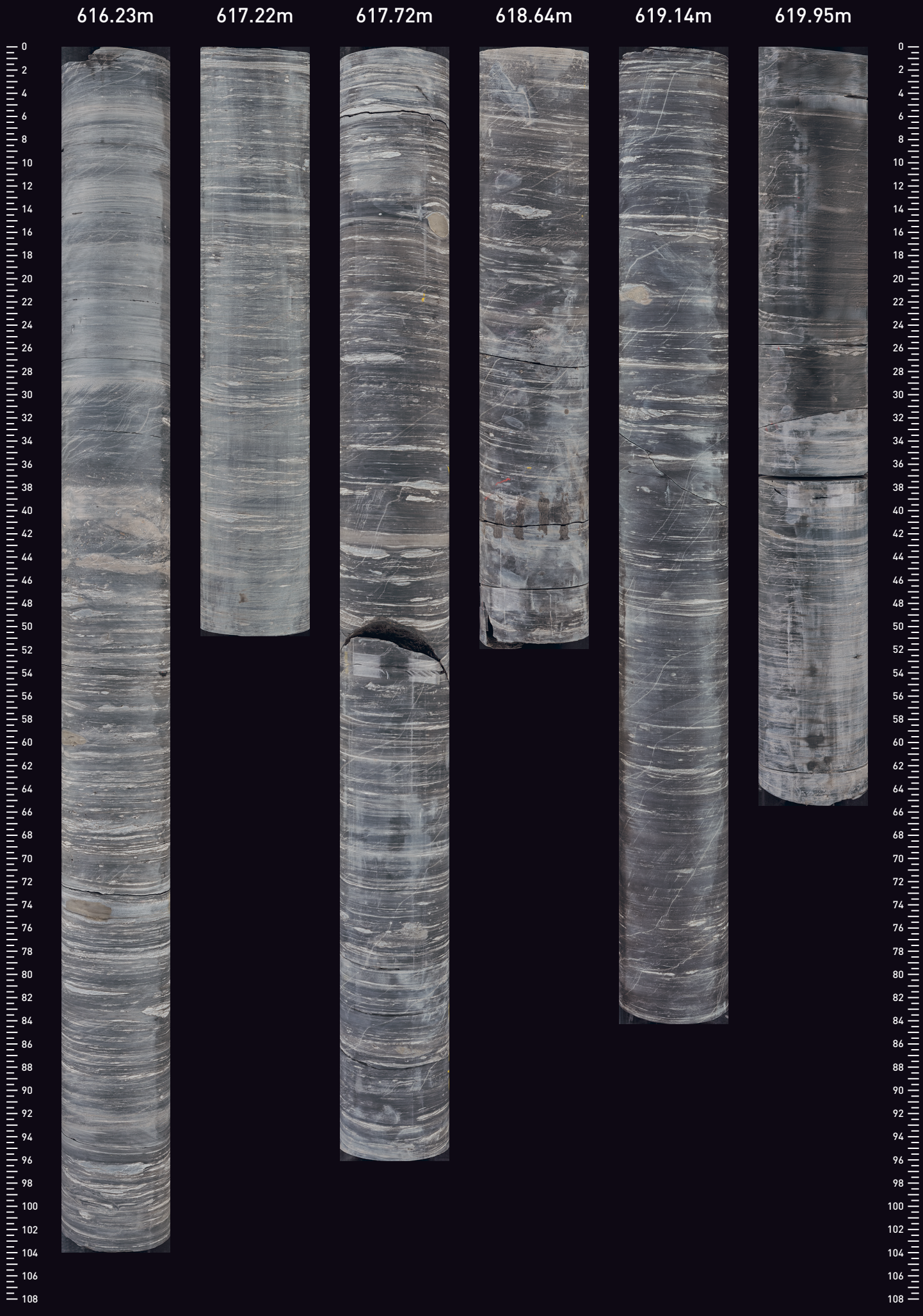


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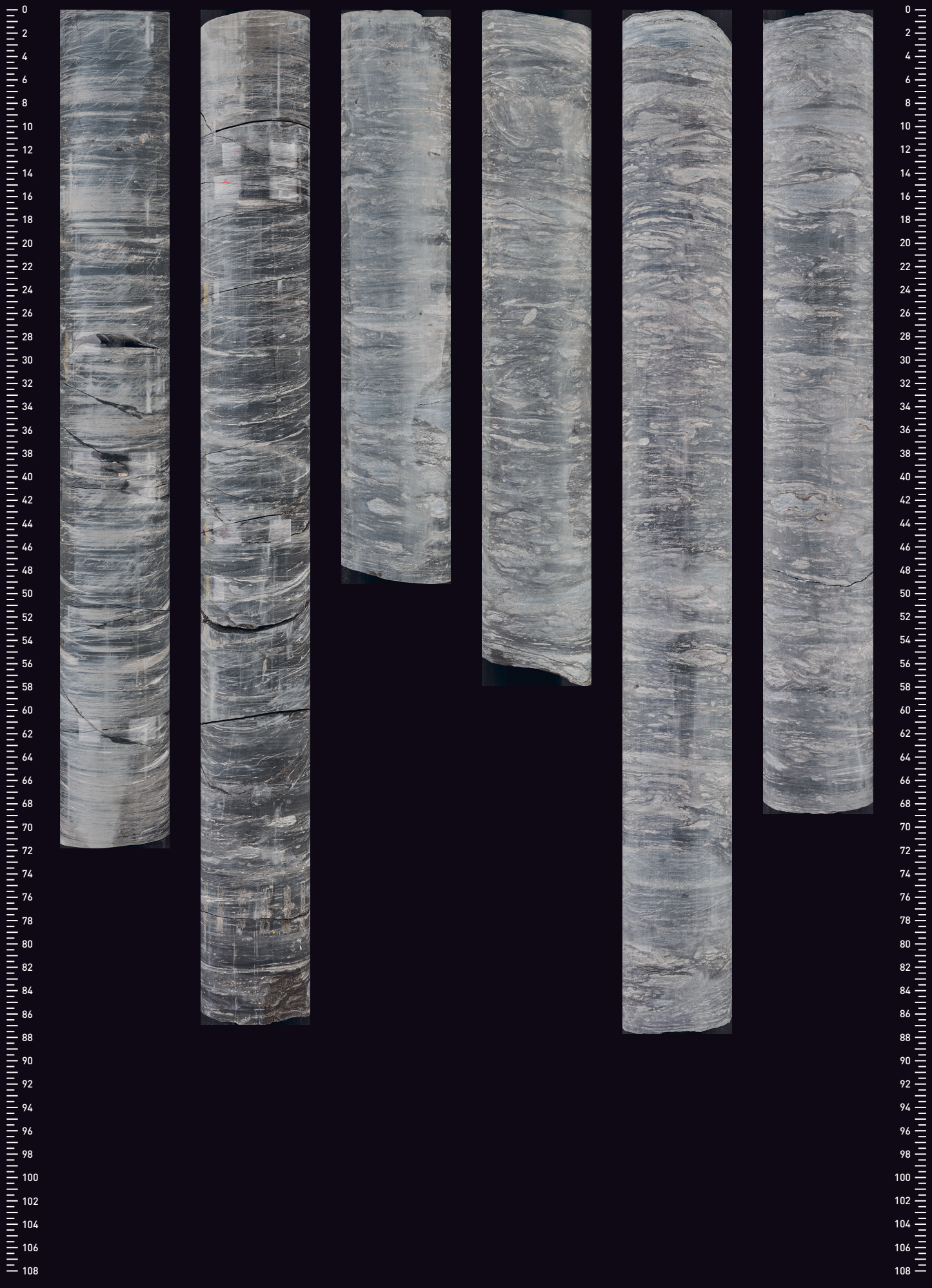
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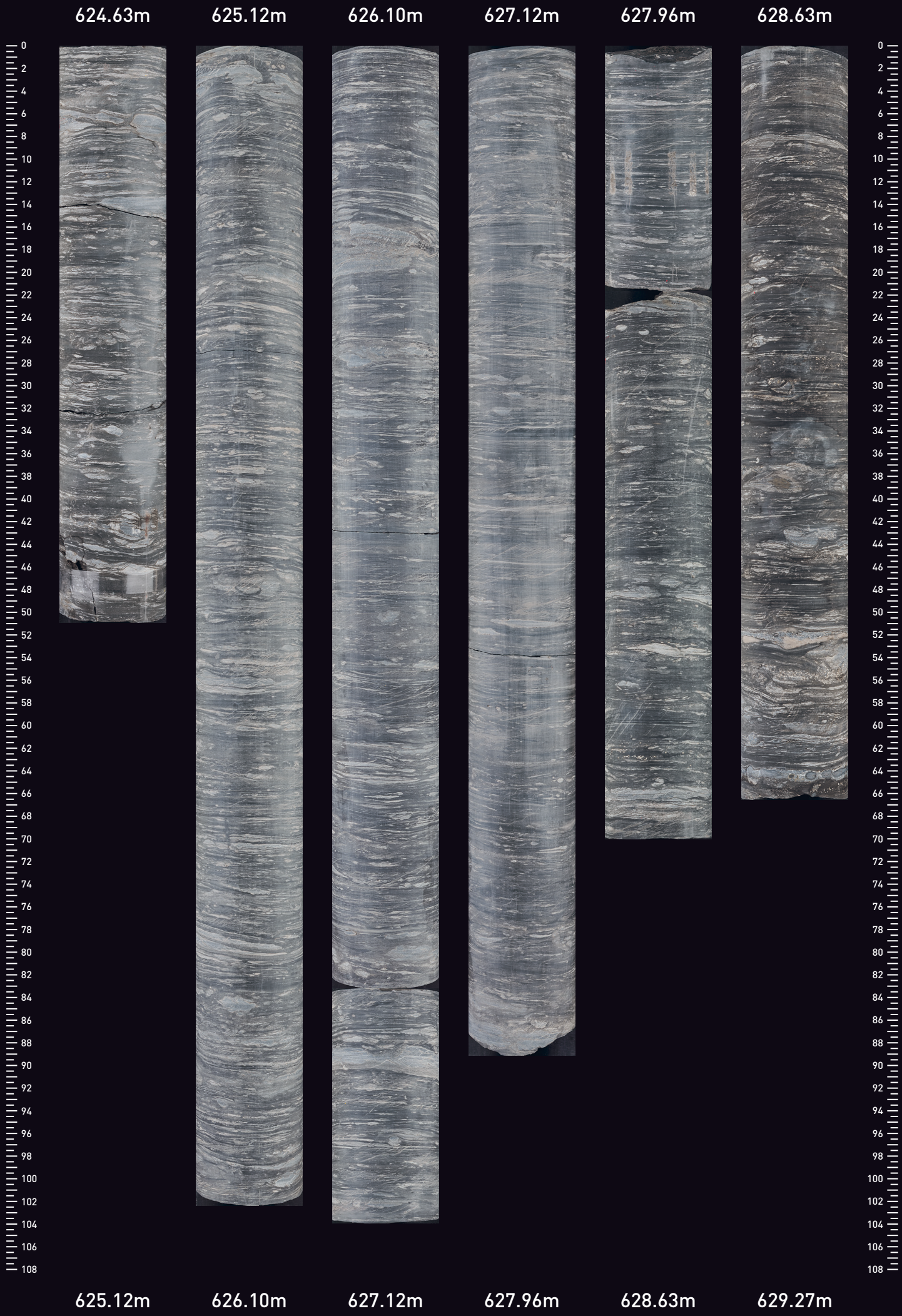
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616.23m
617.22m
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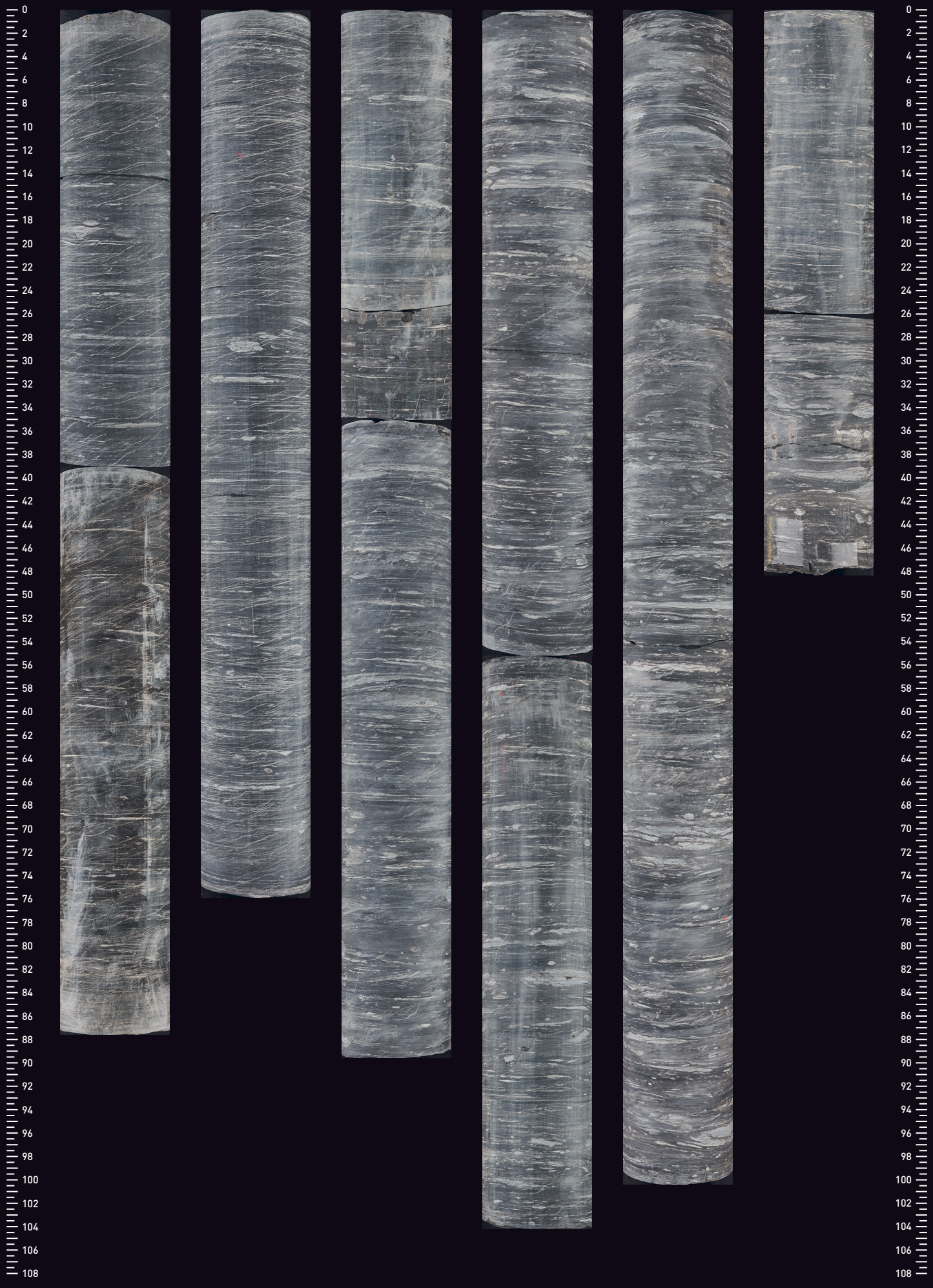
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621.28m 622.12m 622.60m 623.14m 623.96m 624.63m

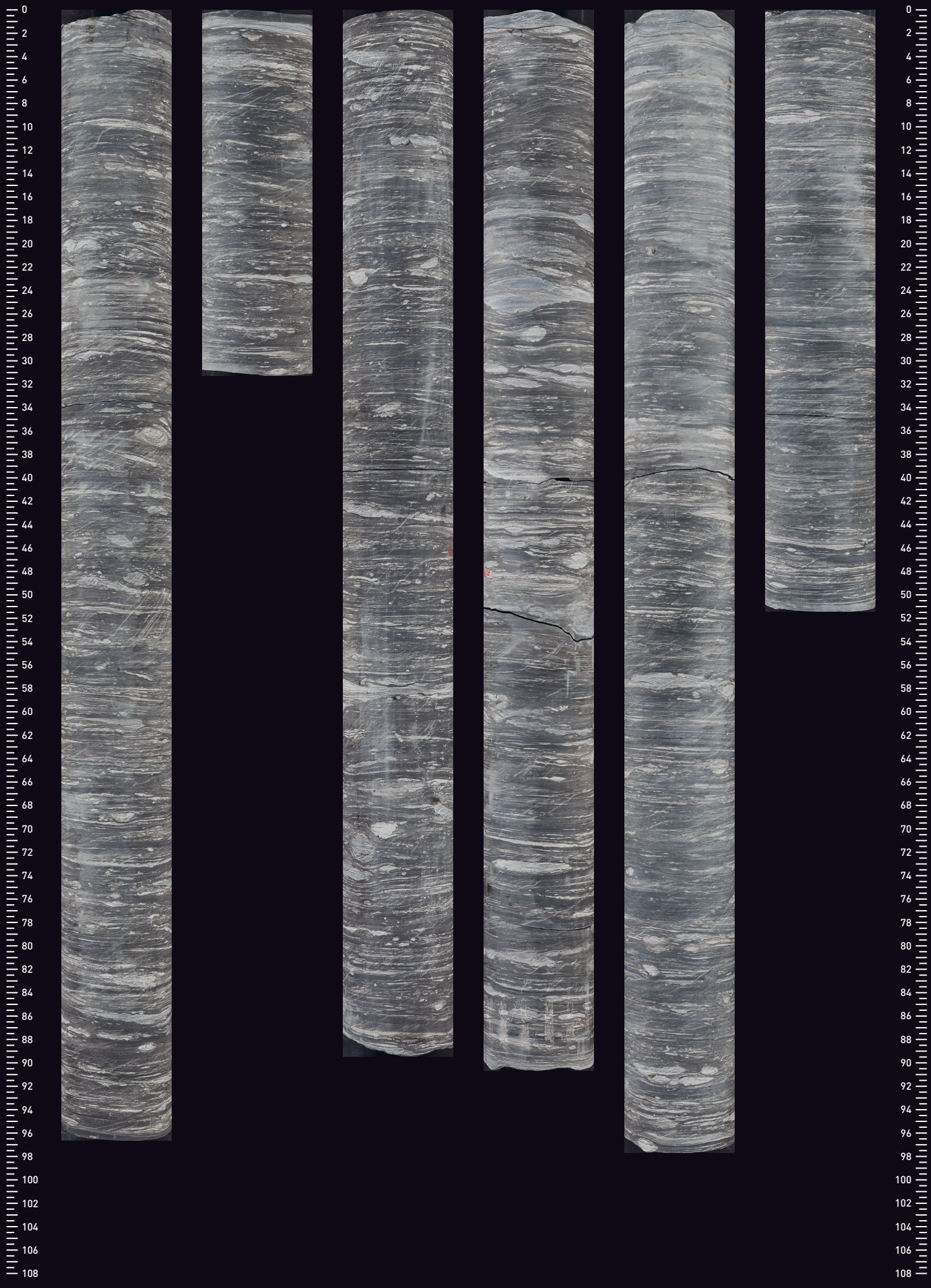

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629.27m 630.11m 630.84m 631.70m 632.70m 633.68m



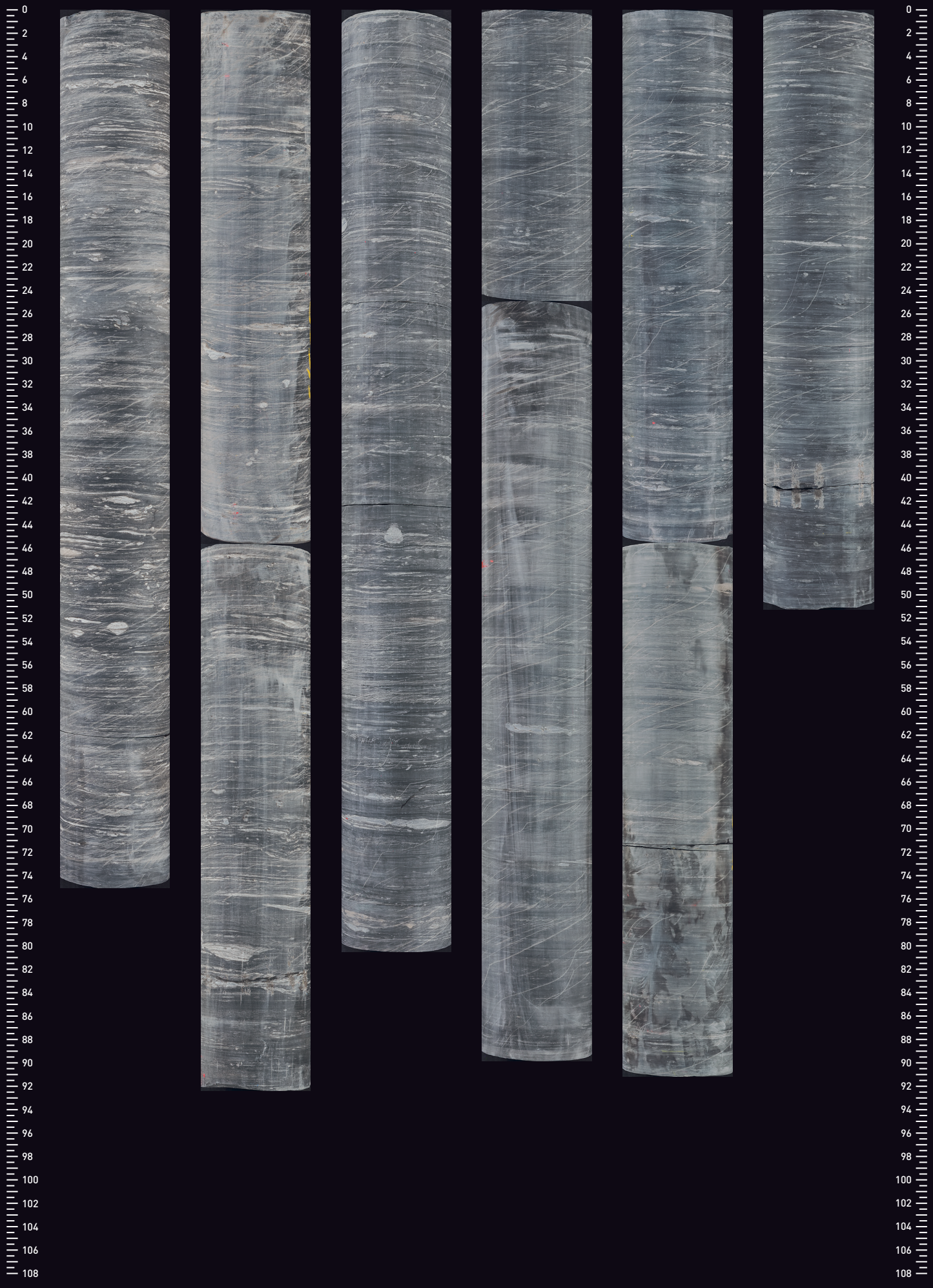
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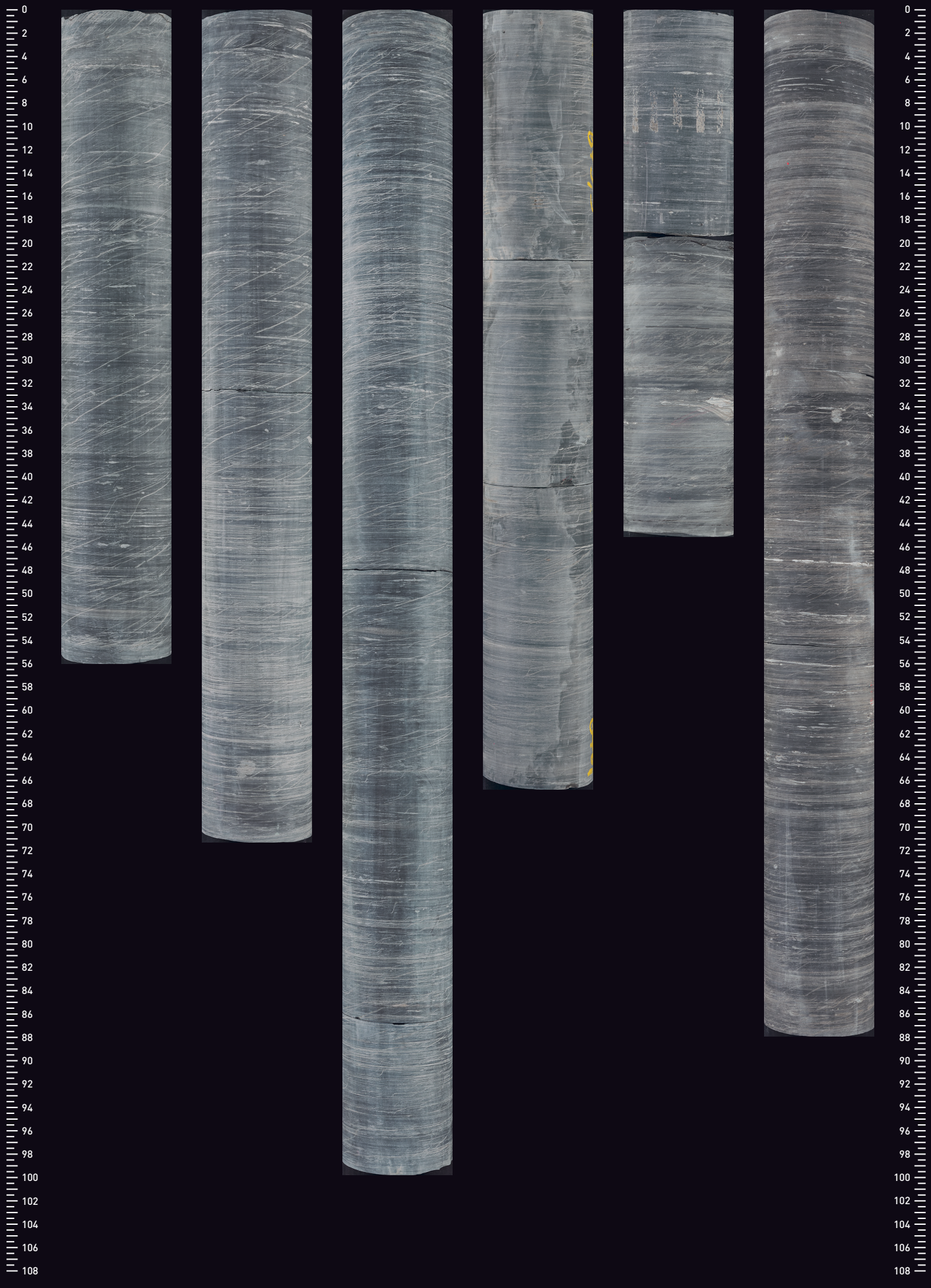
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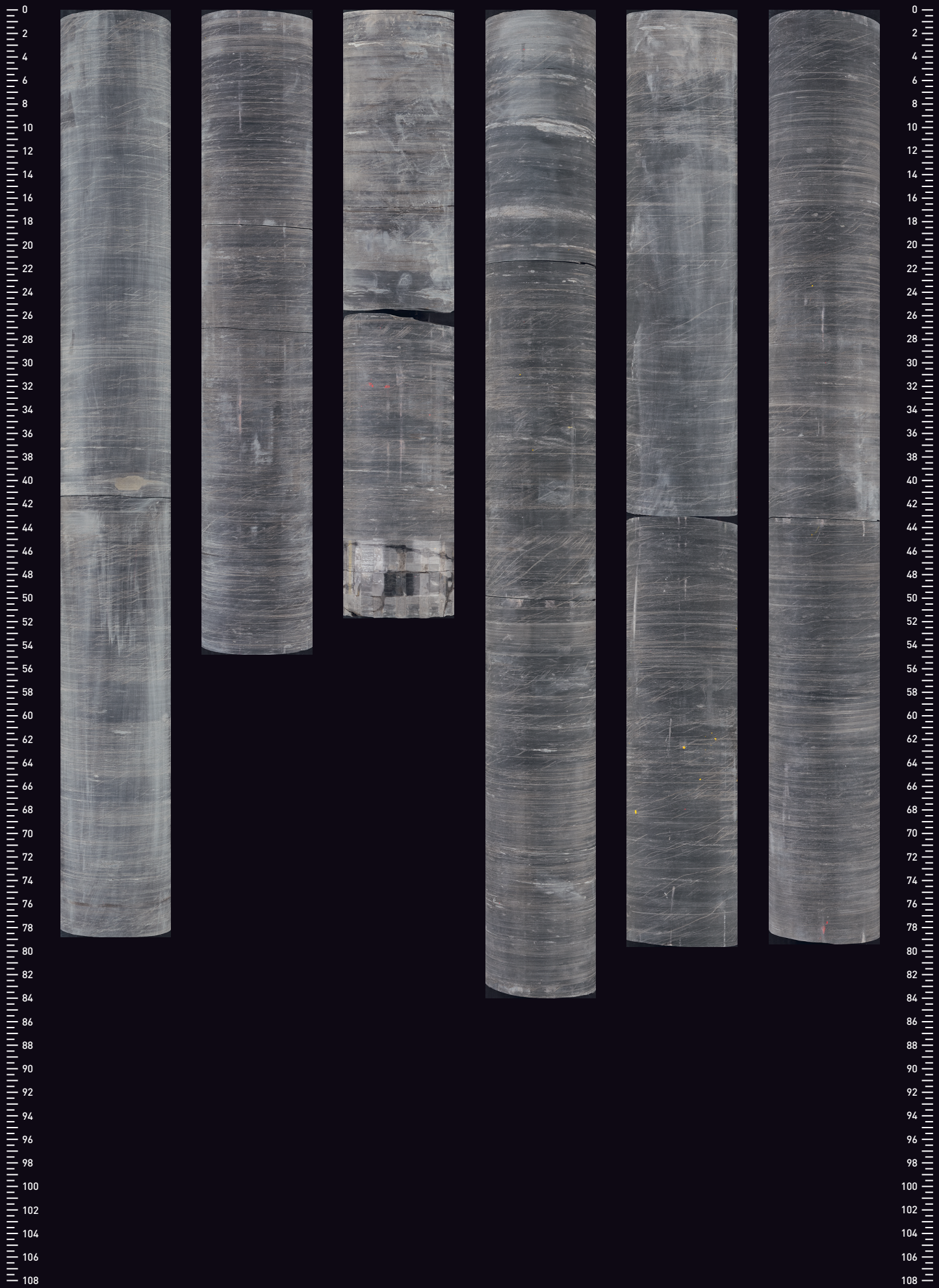
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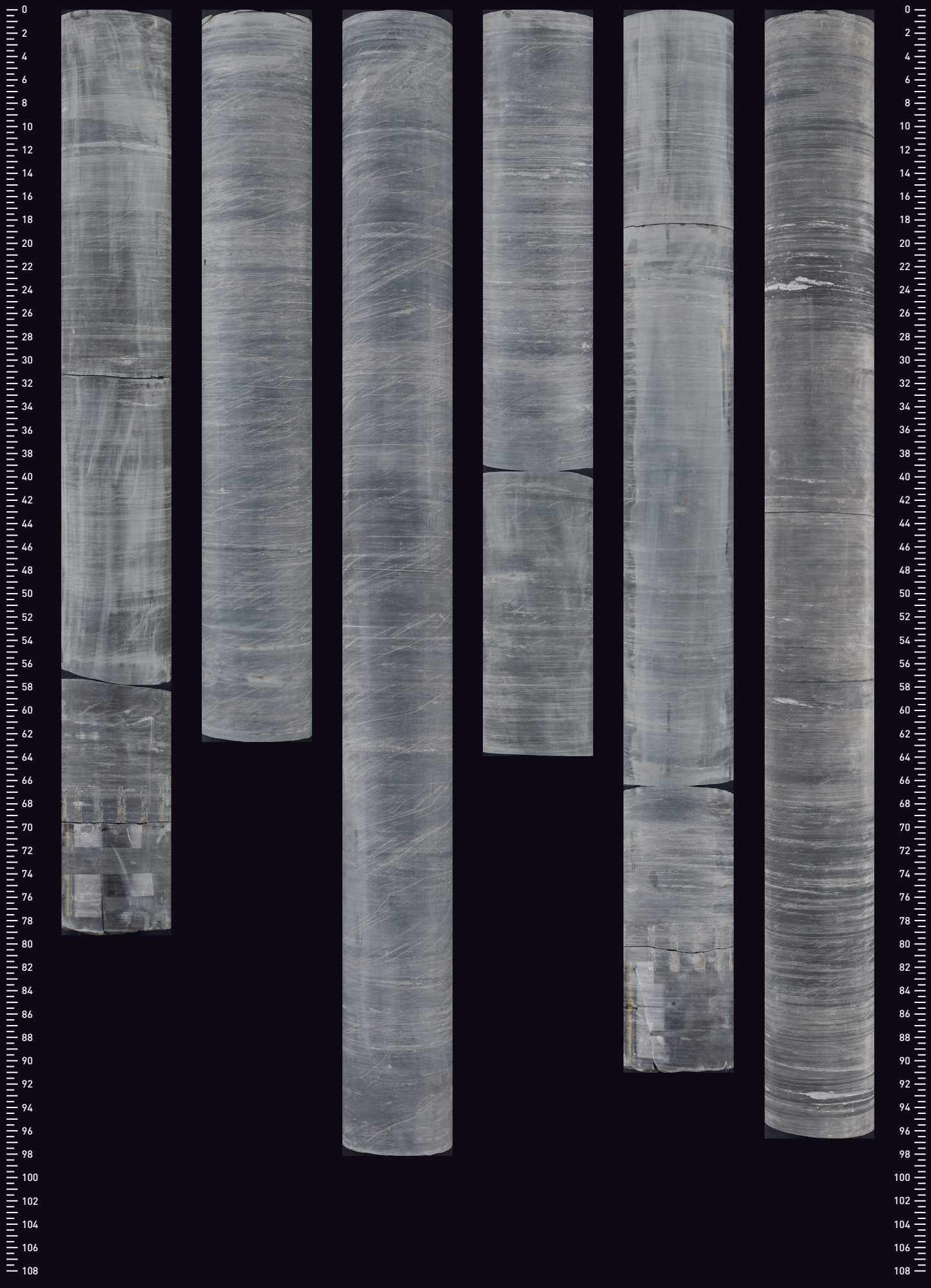
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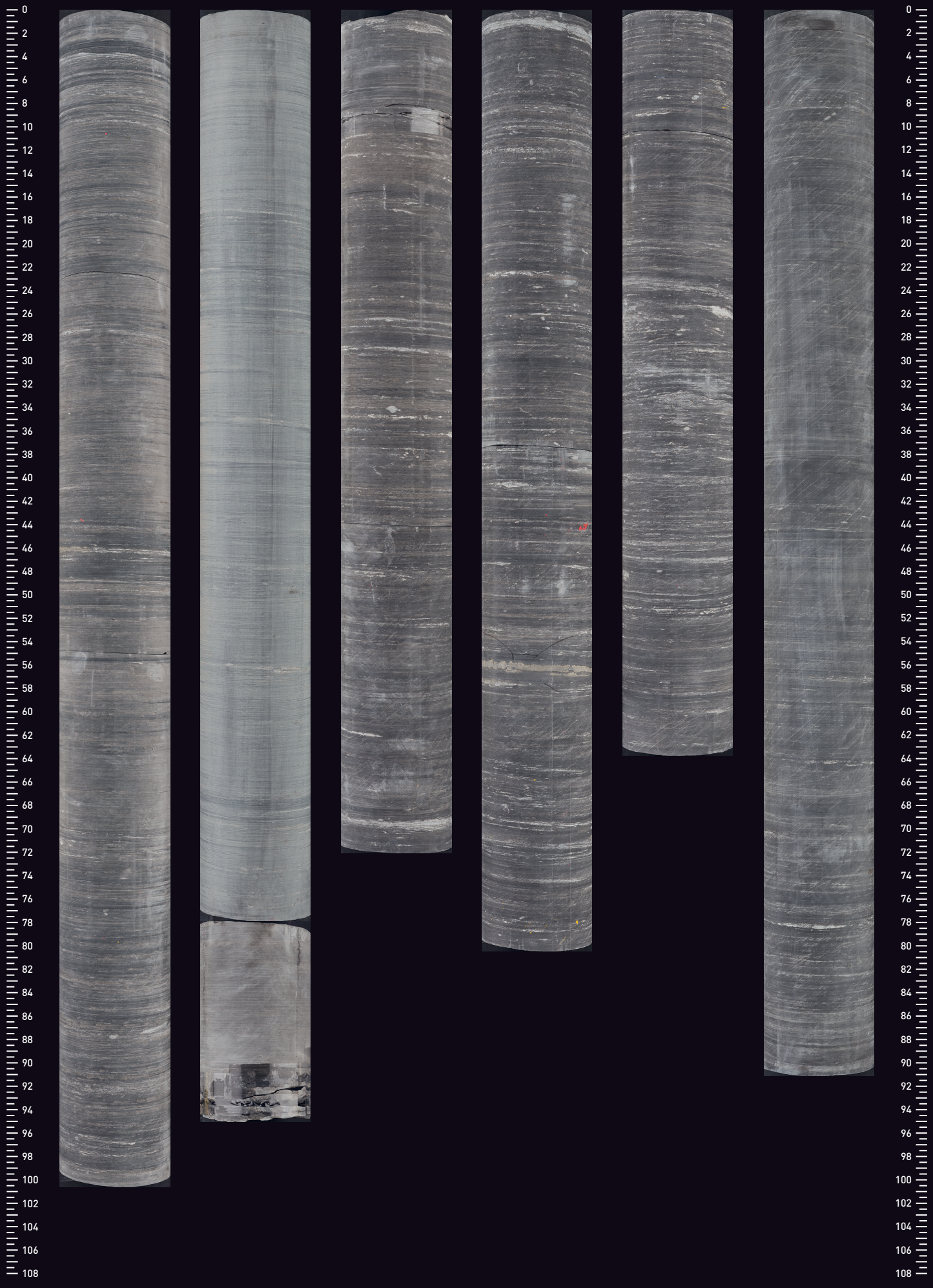
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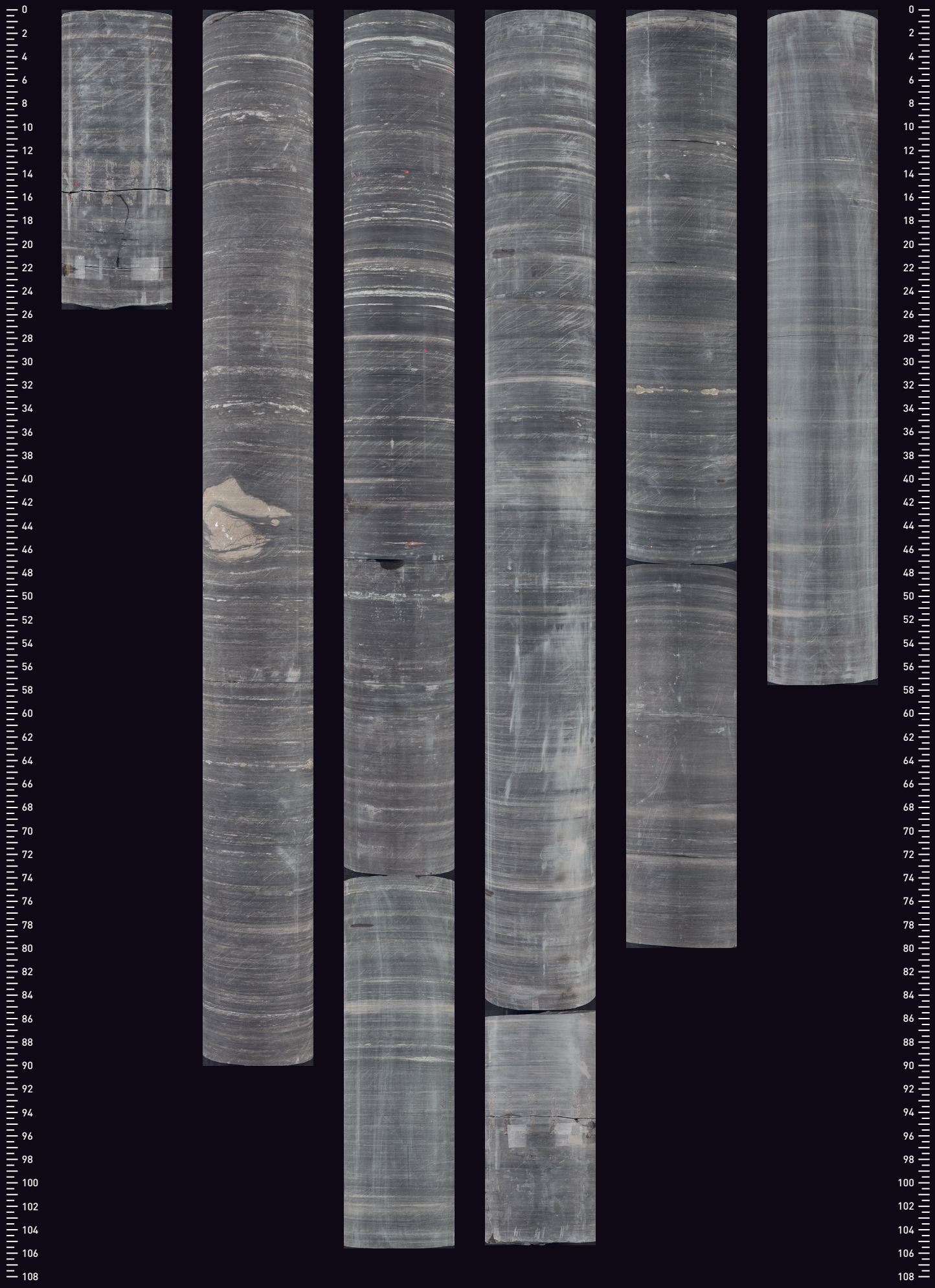
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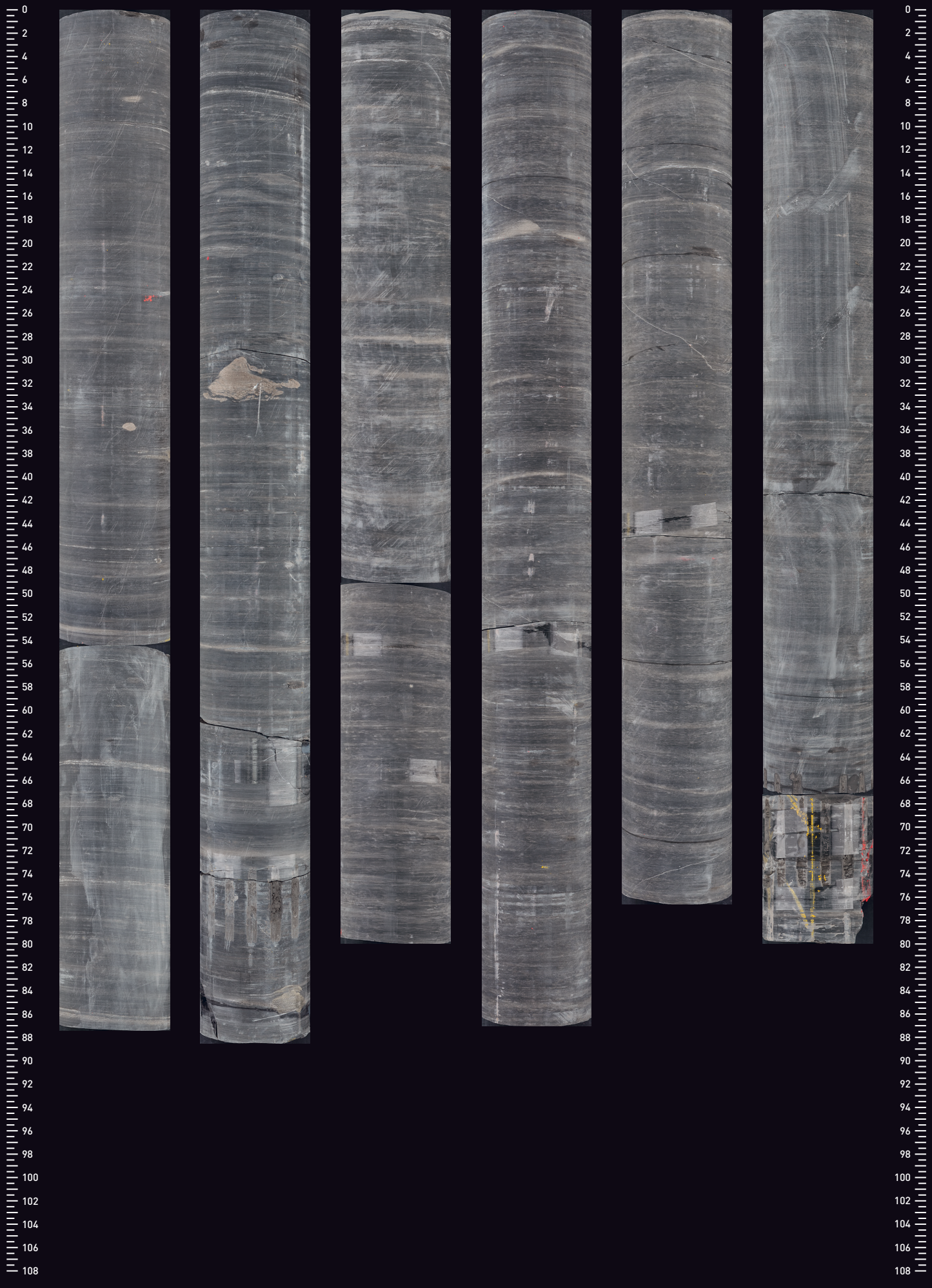
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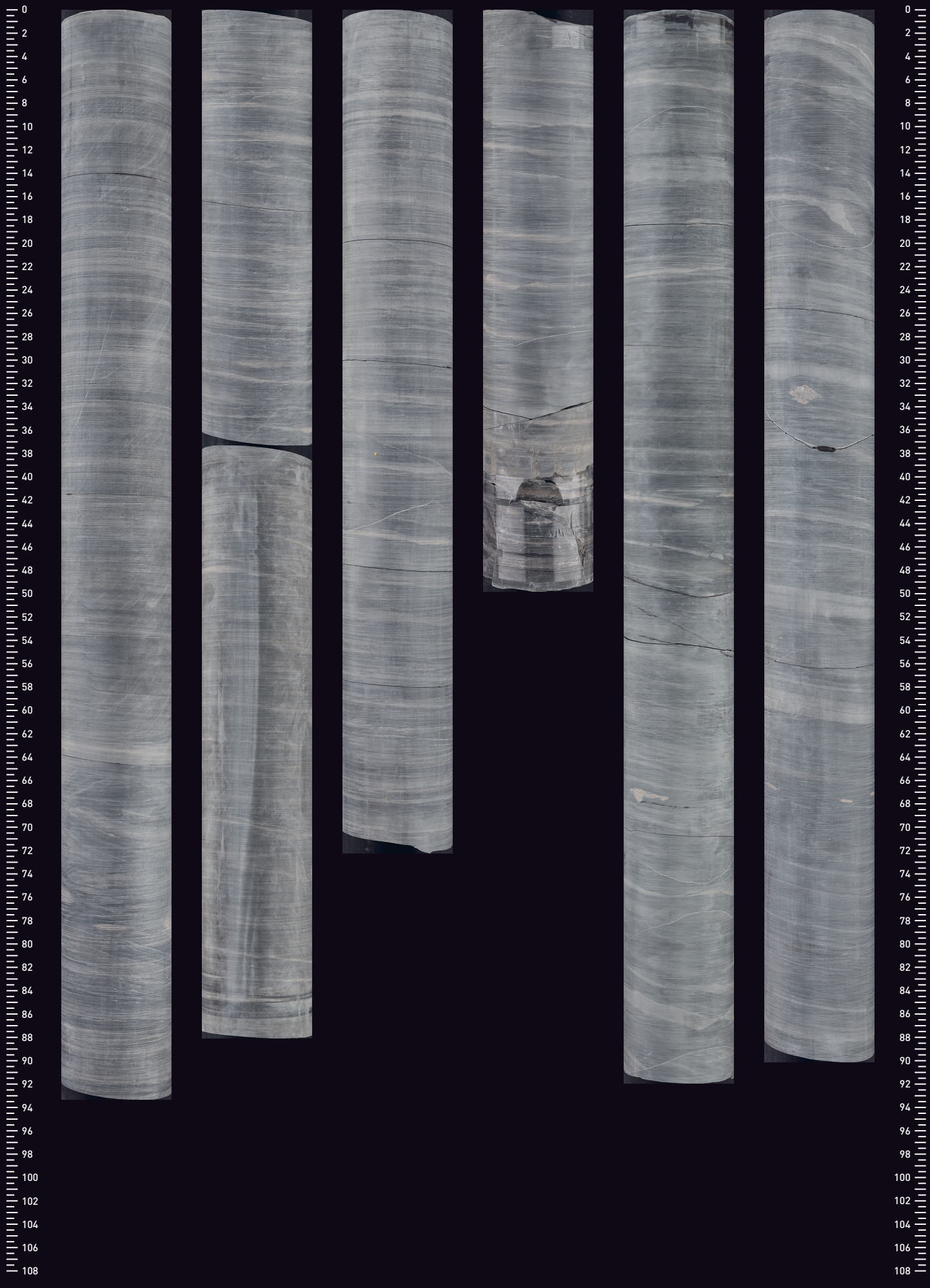


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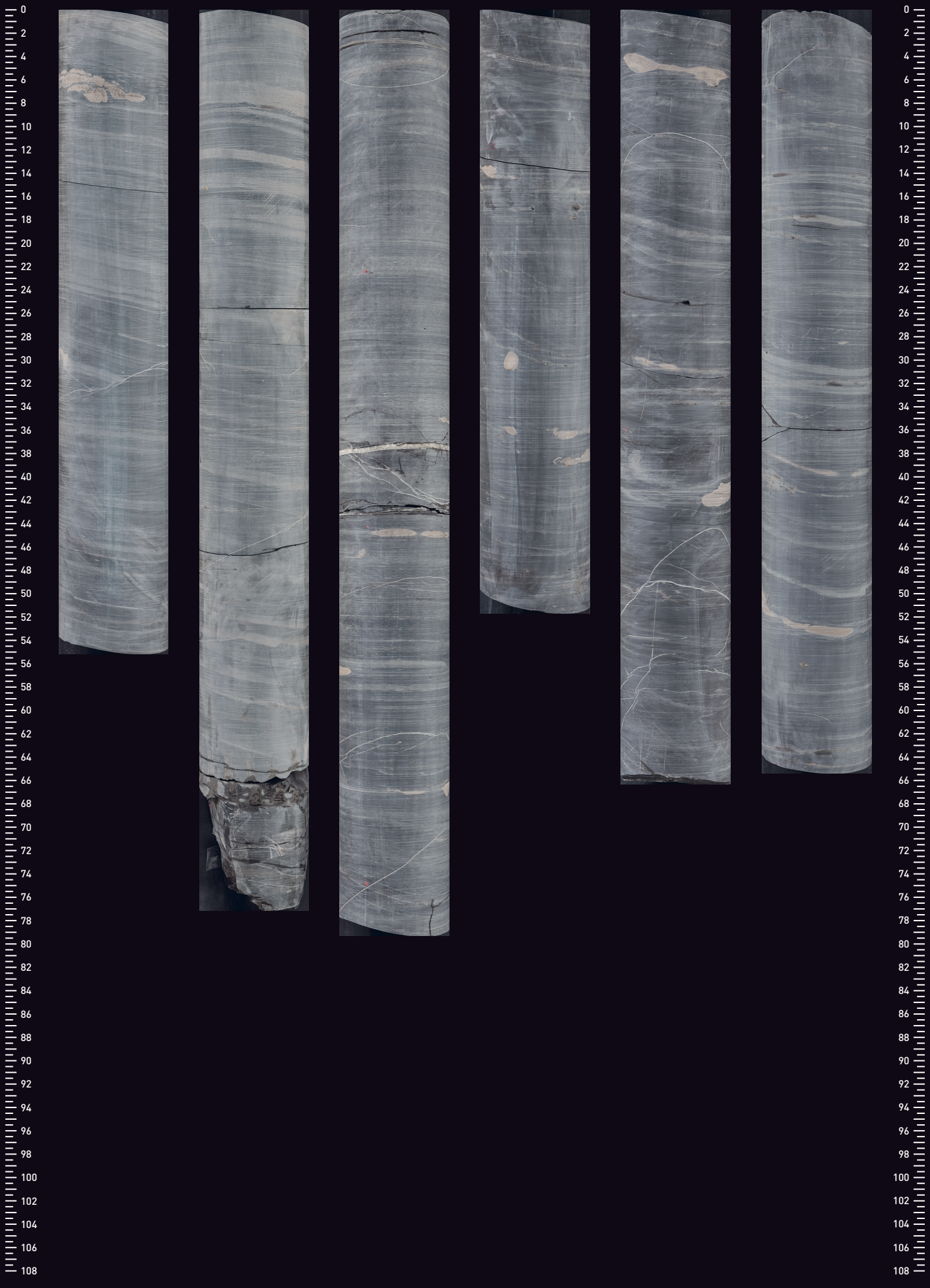
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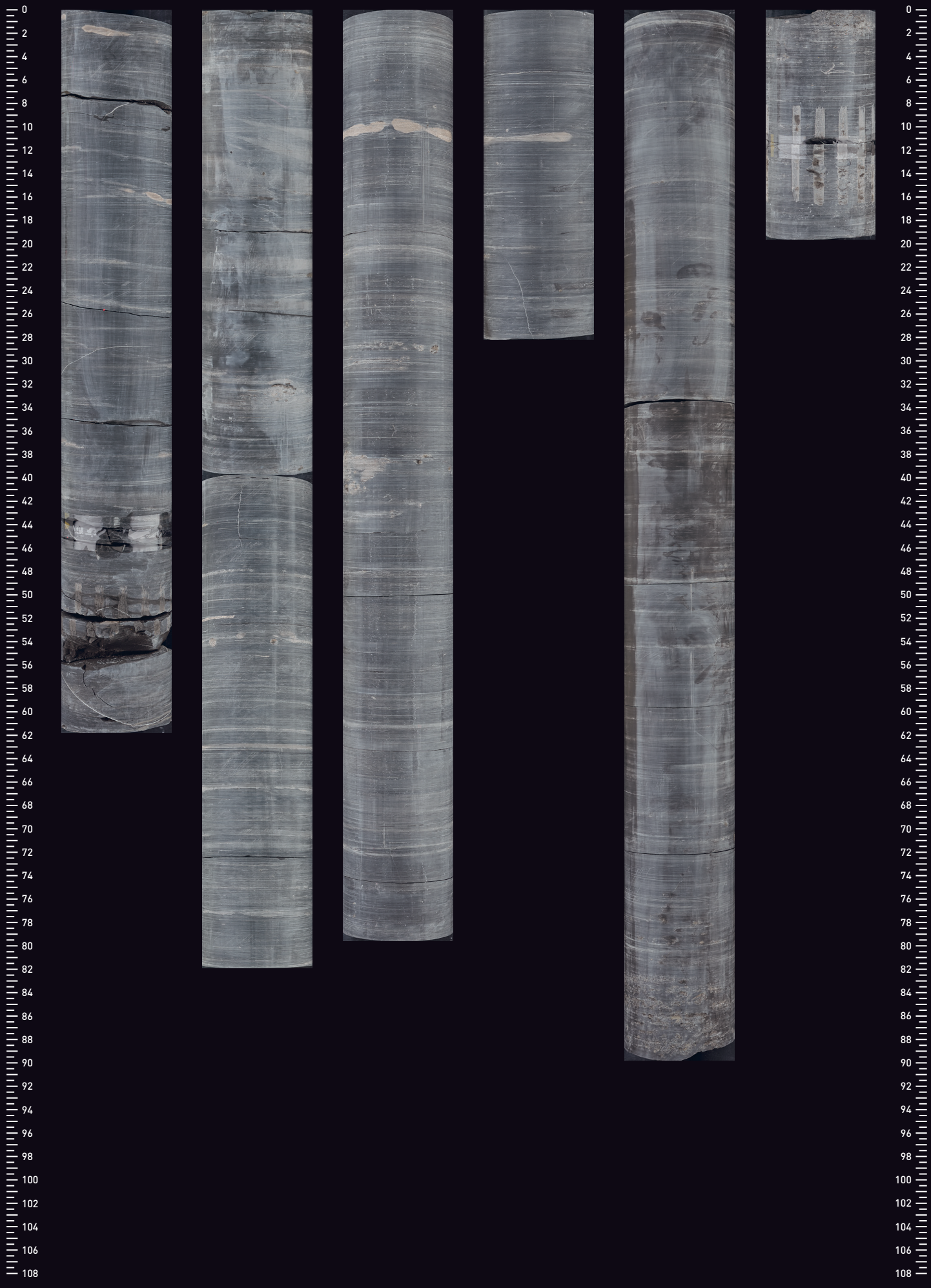

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674.07m
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674.93m 675.47m 676.20m 676.96m 677.45m 678.10m



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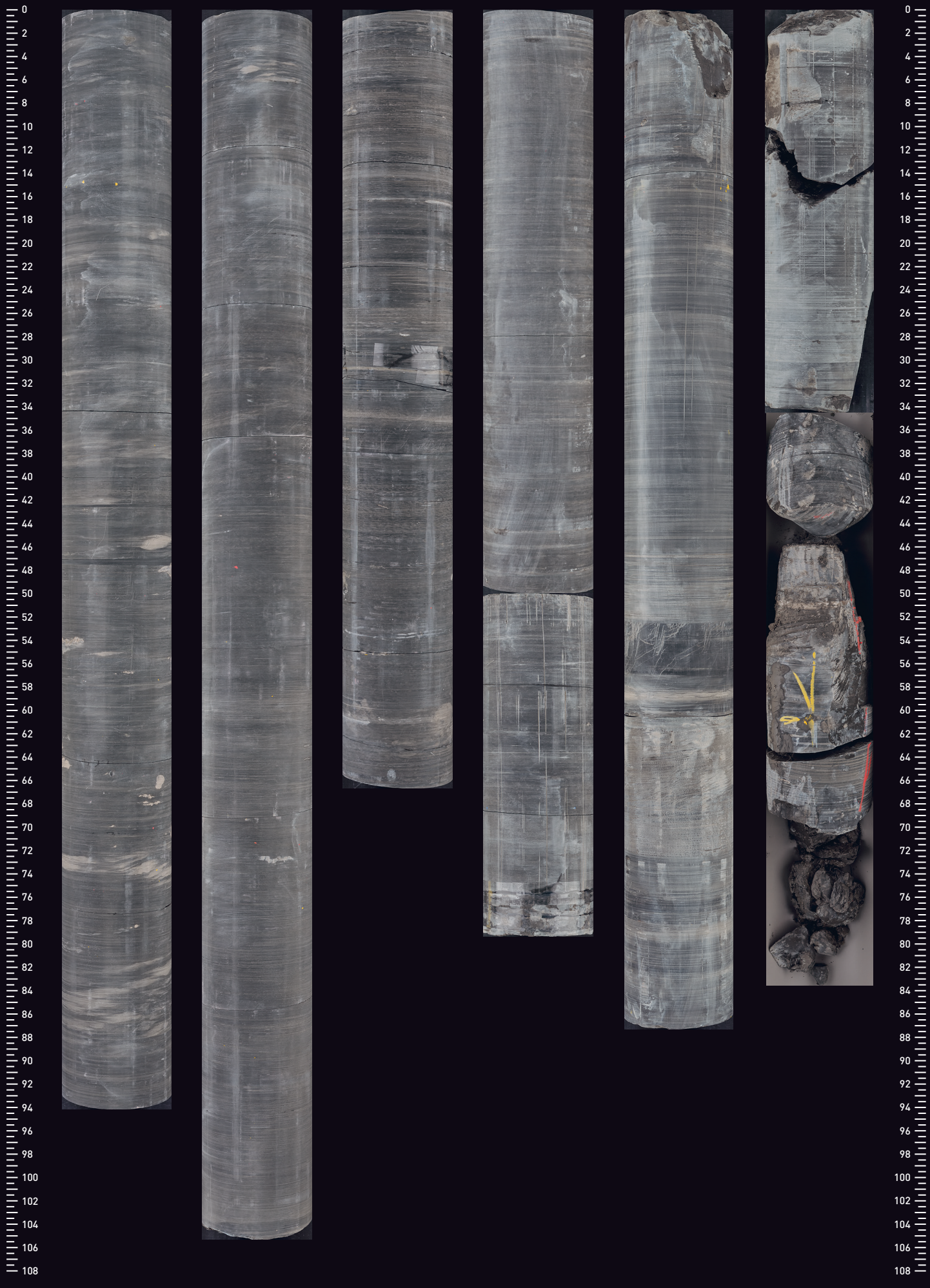
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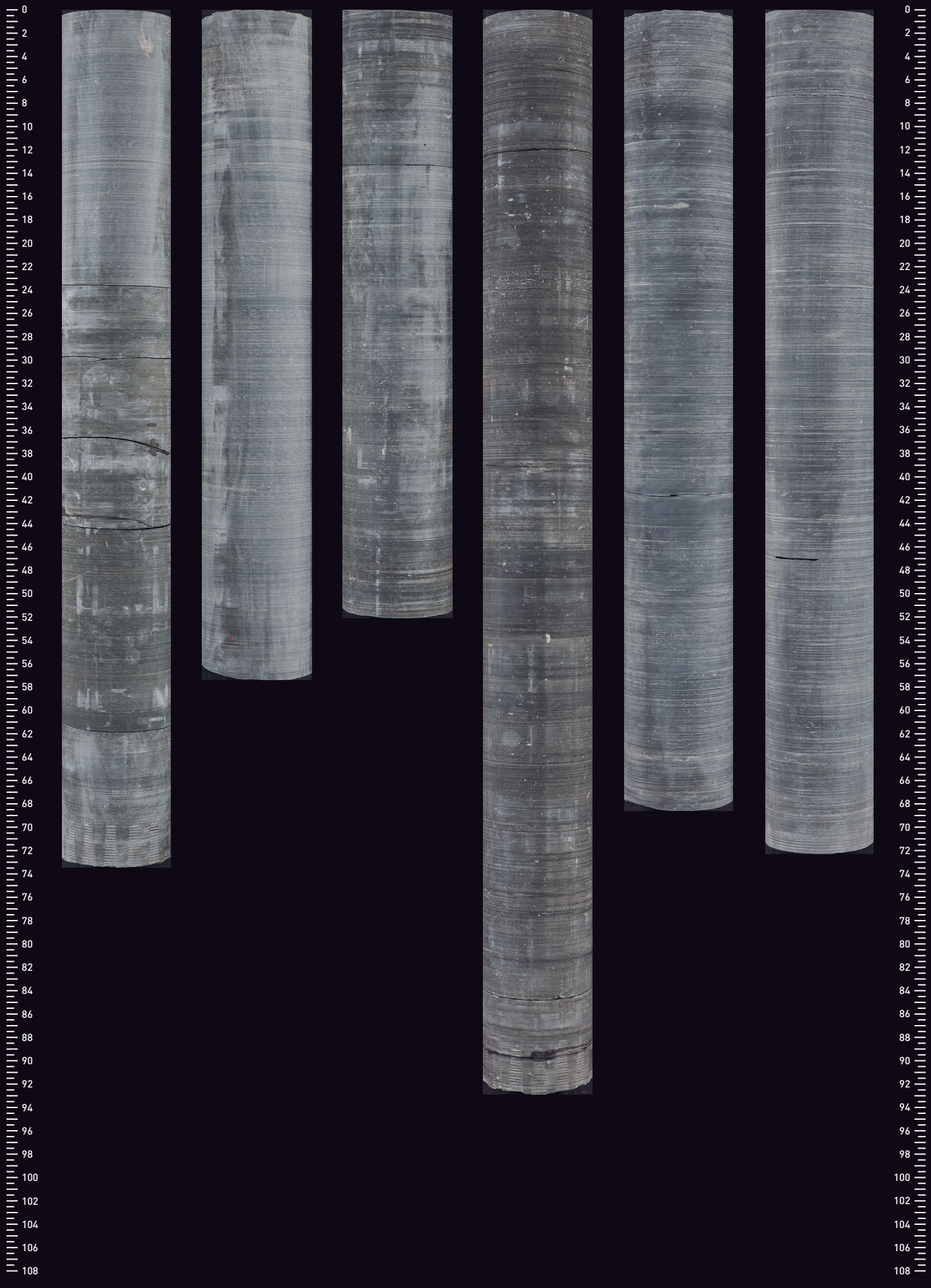
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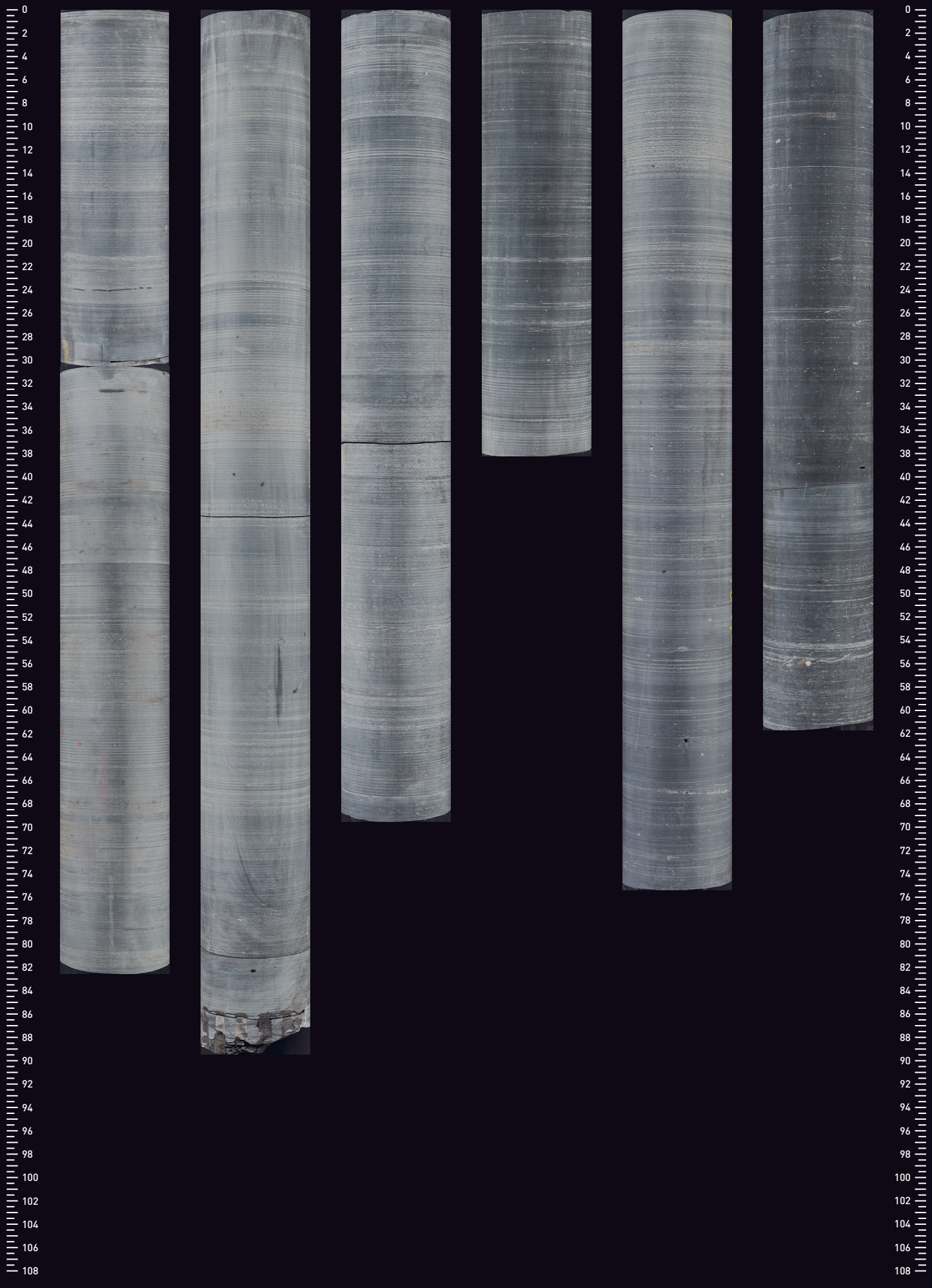
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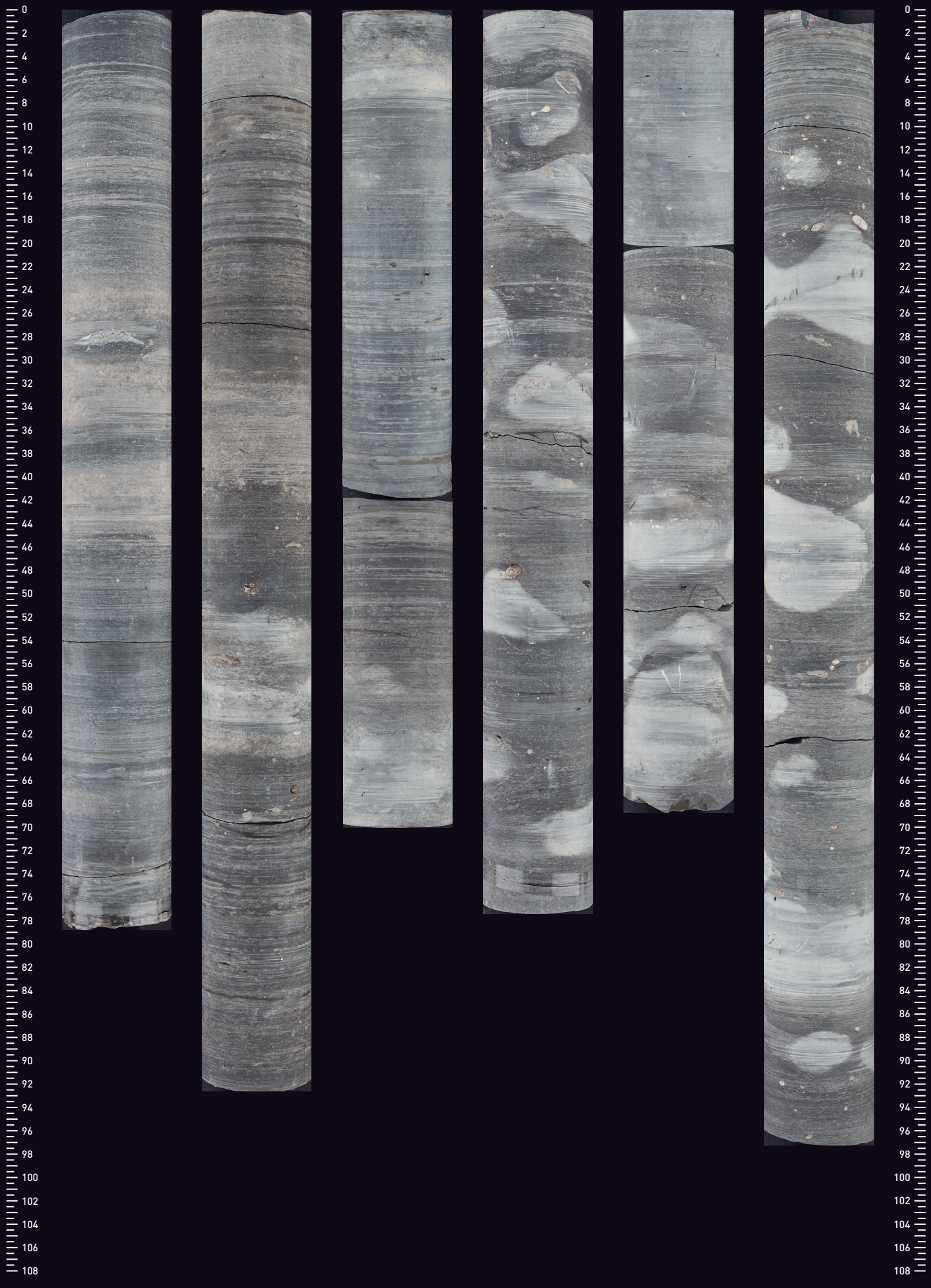
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701.33m 702.13m 702.98m 703.65m 704.01m 704.74m



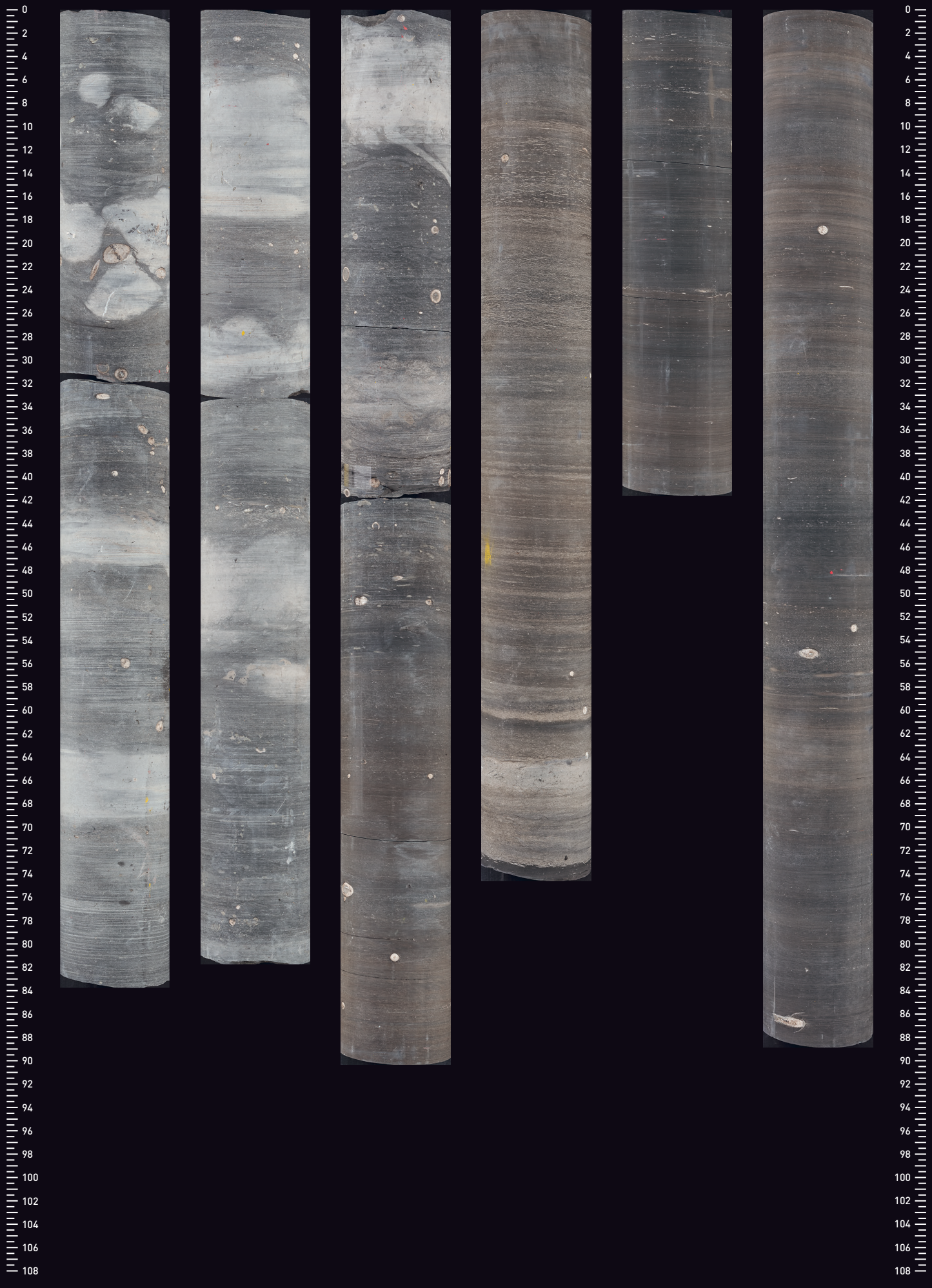
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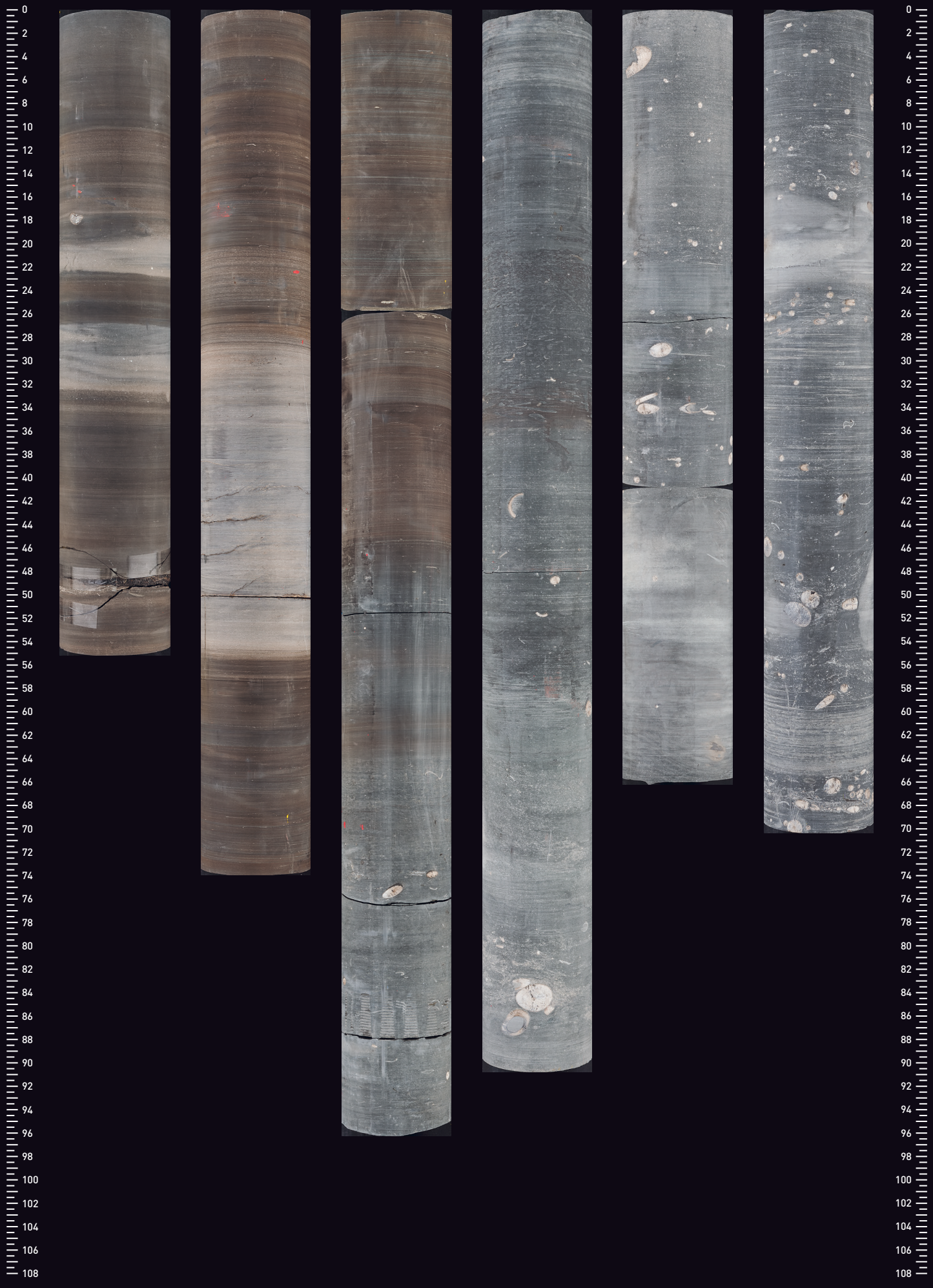
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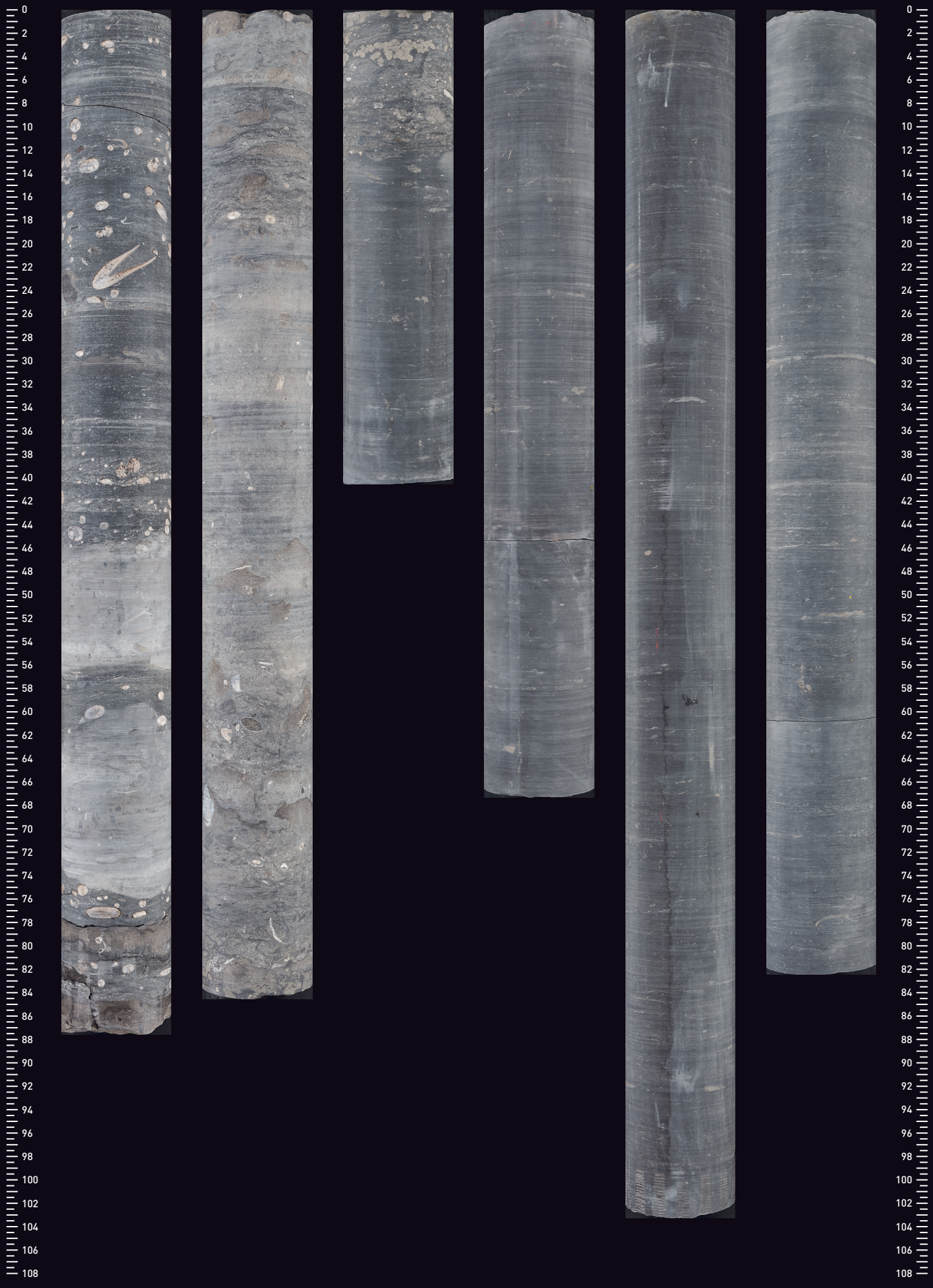
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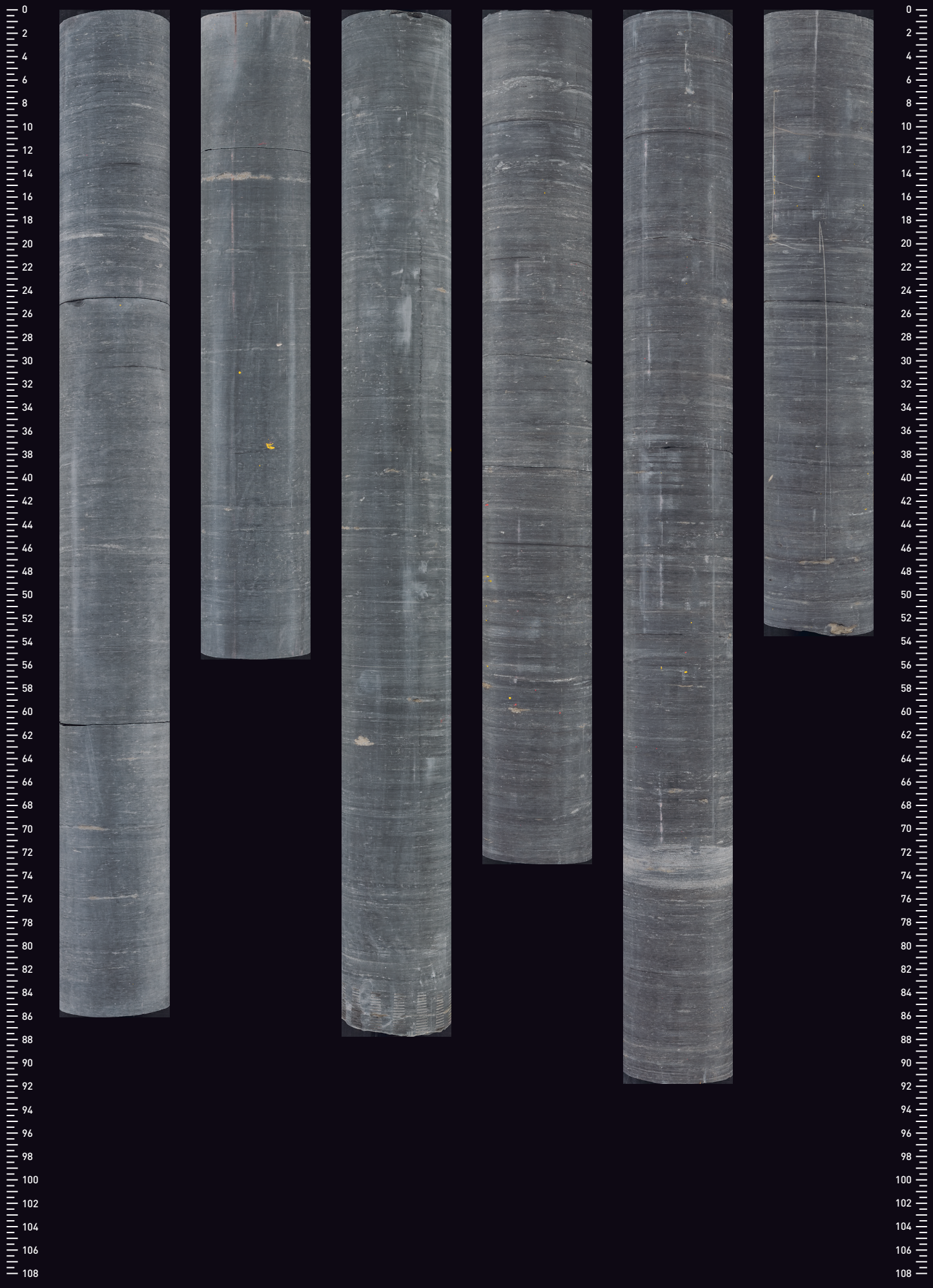
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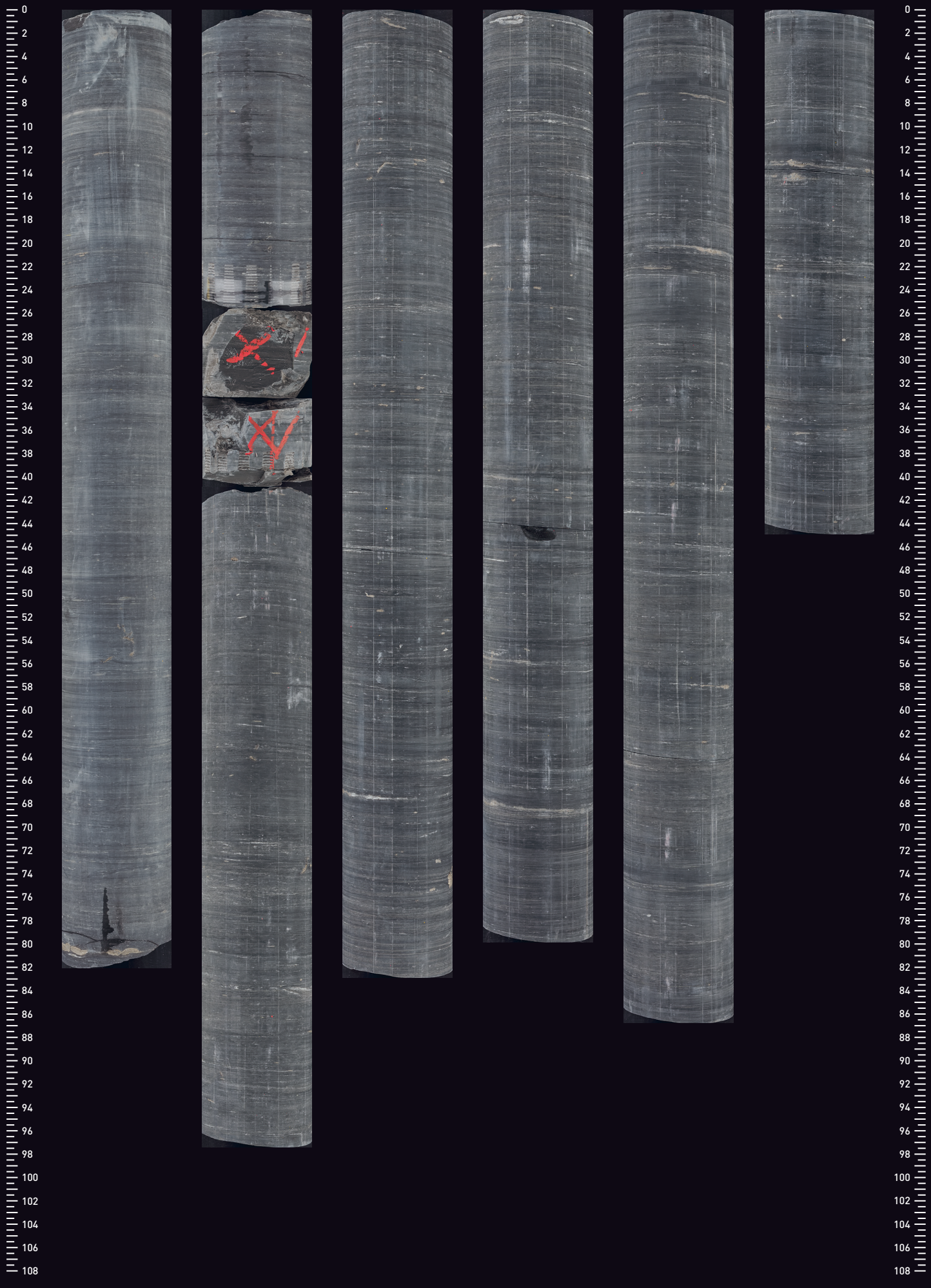
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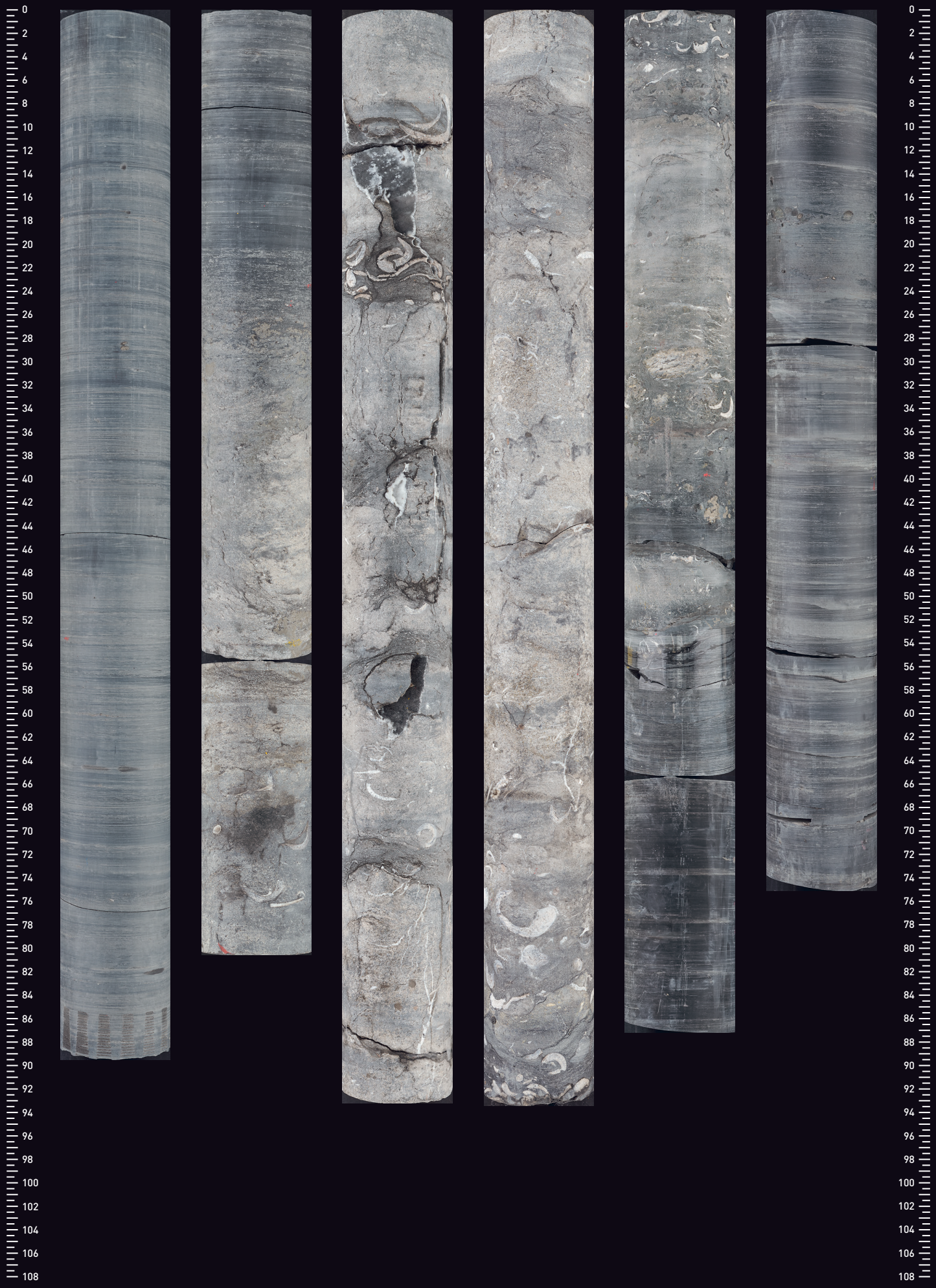
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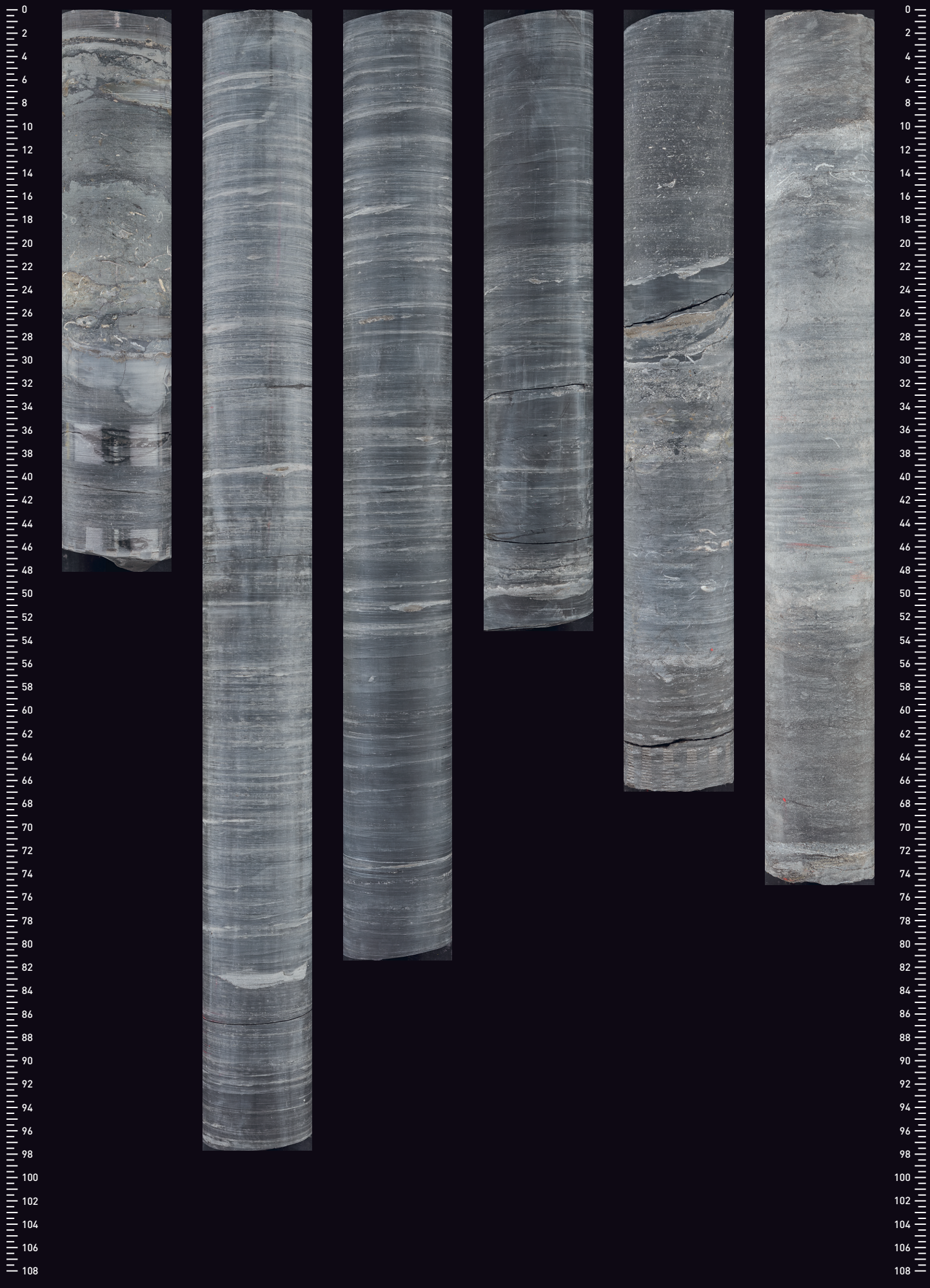
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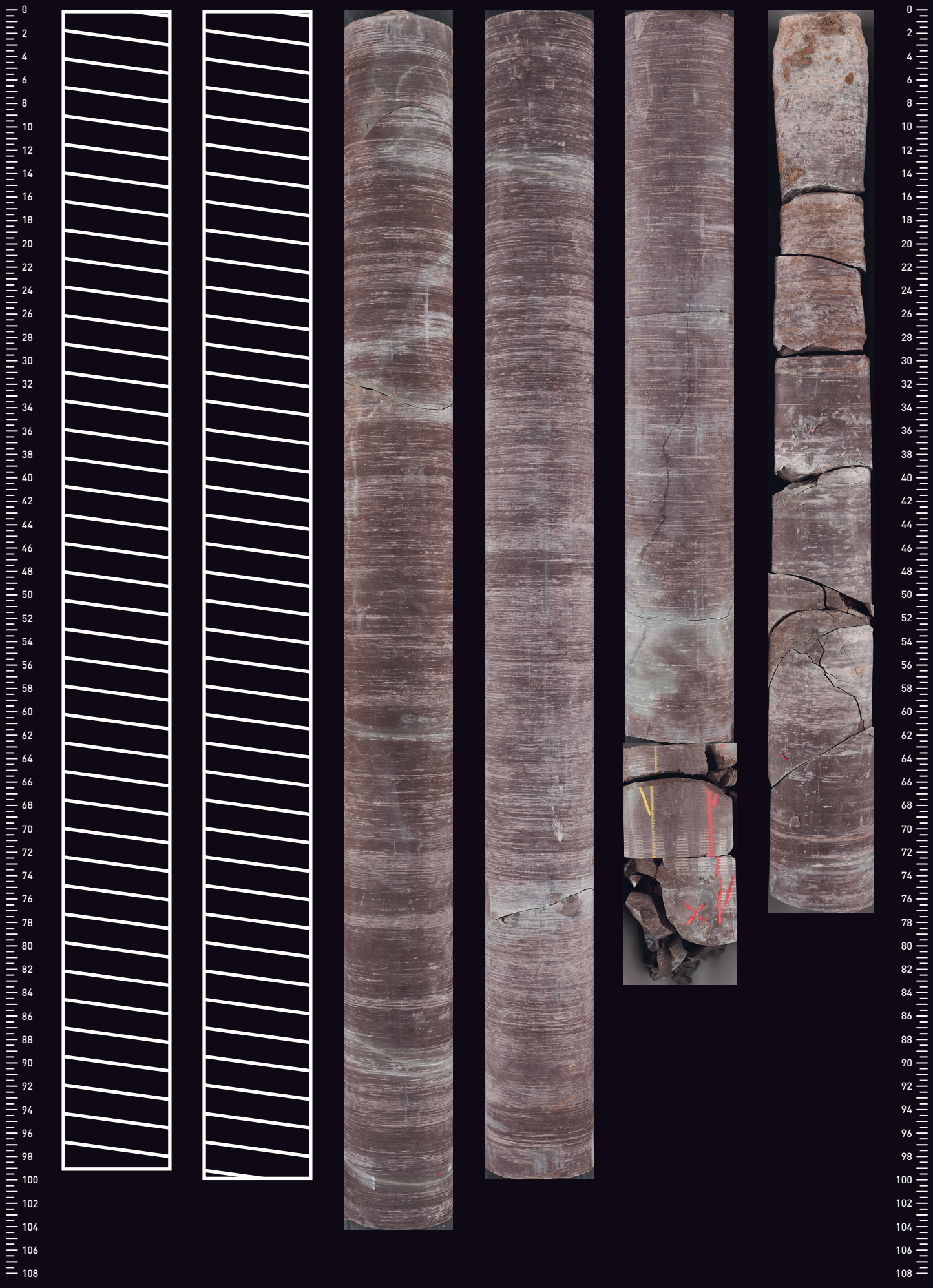
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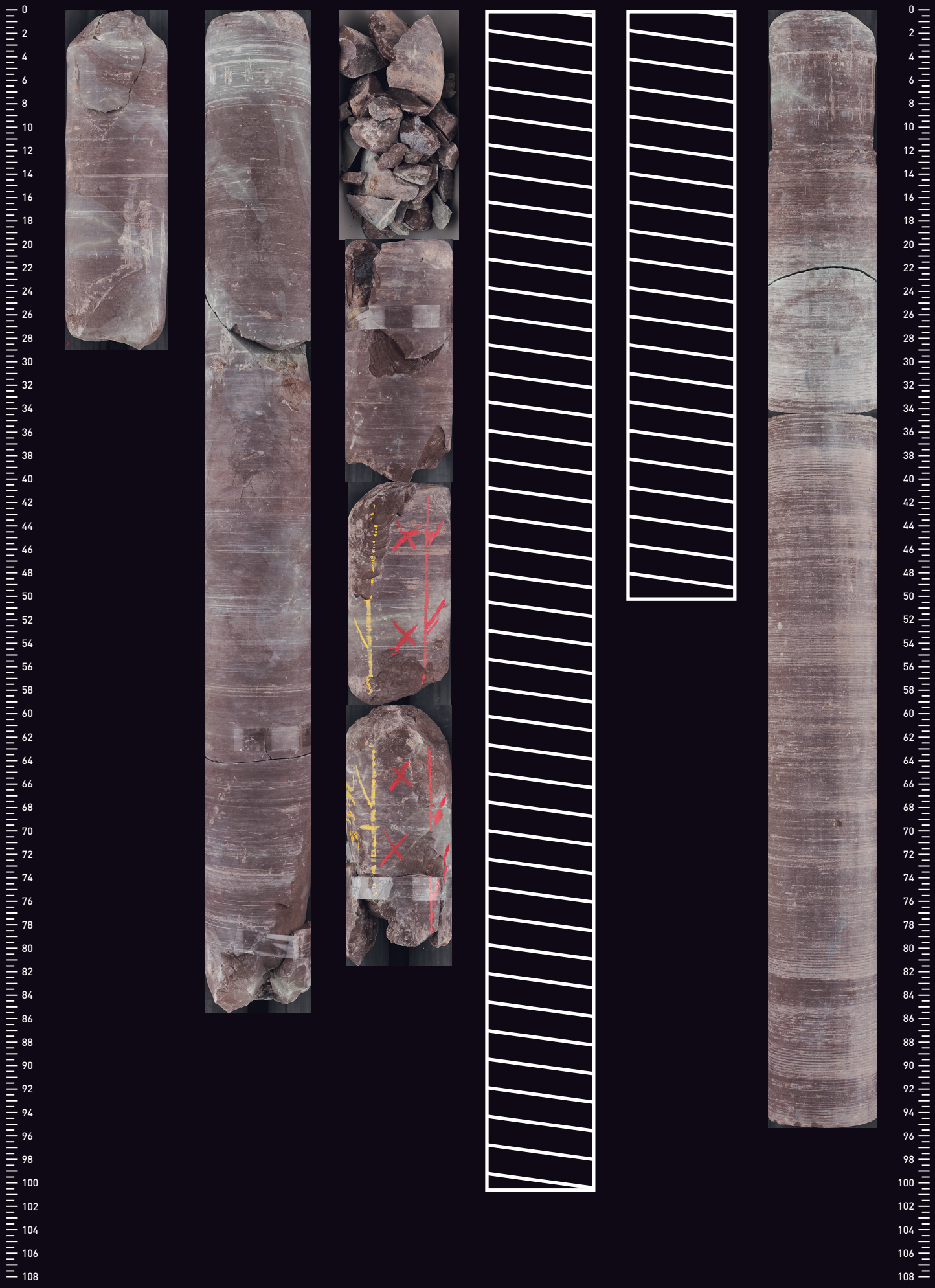
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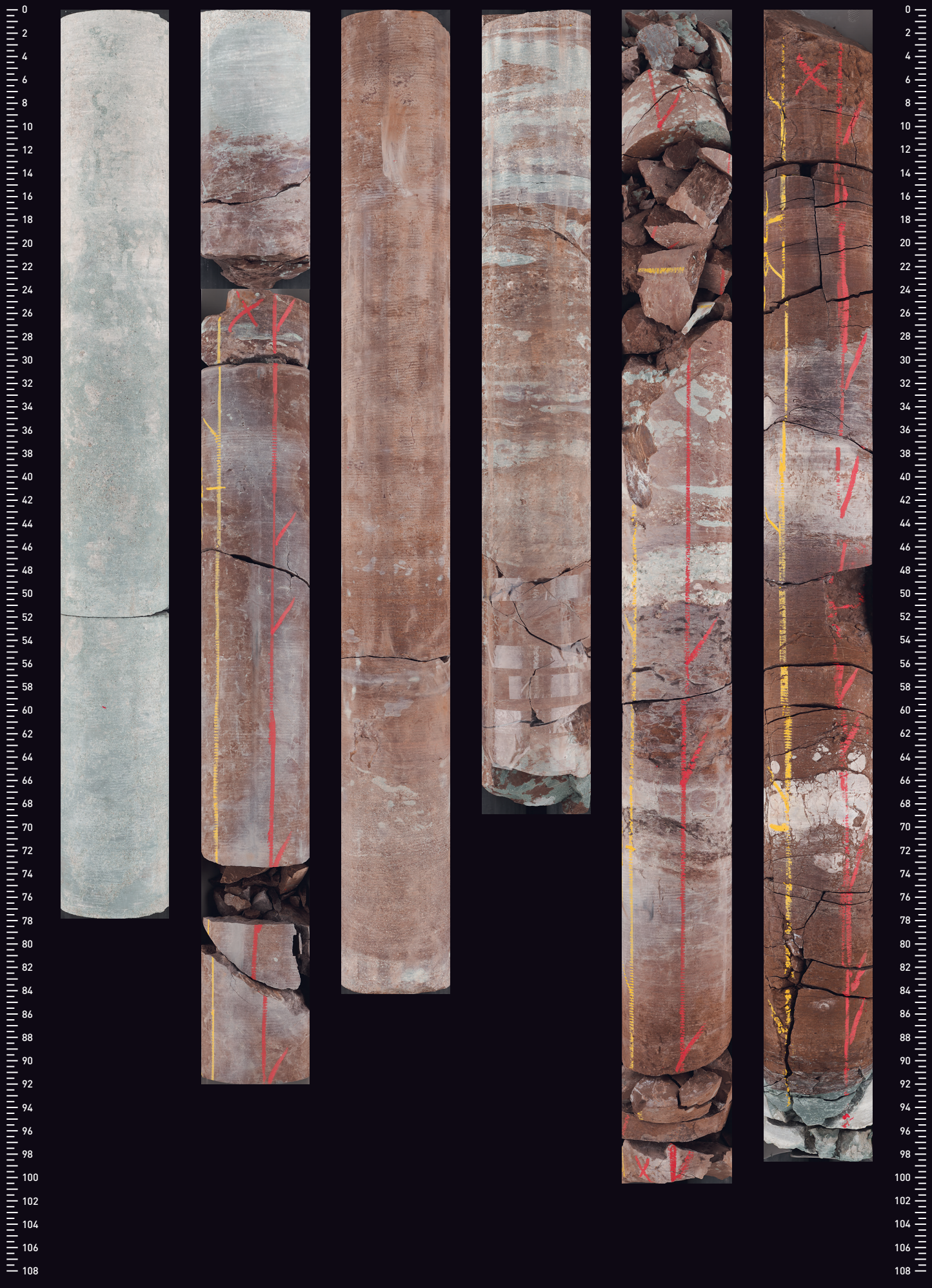
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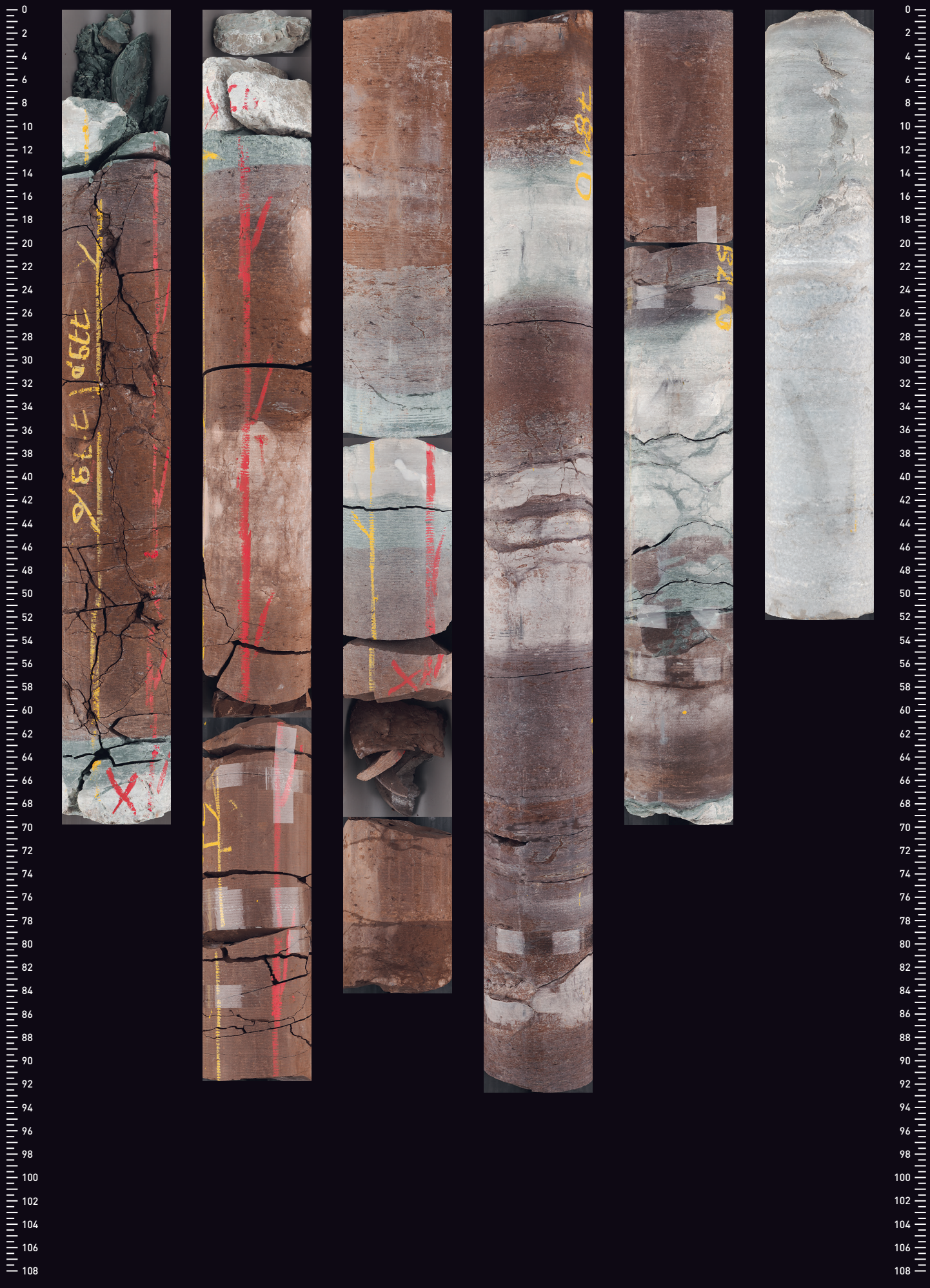
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779.37m 780.19m 780.91m 781.80m 782.48m 782.98m

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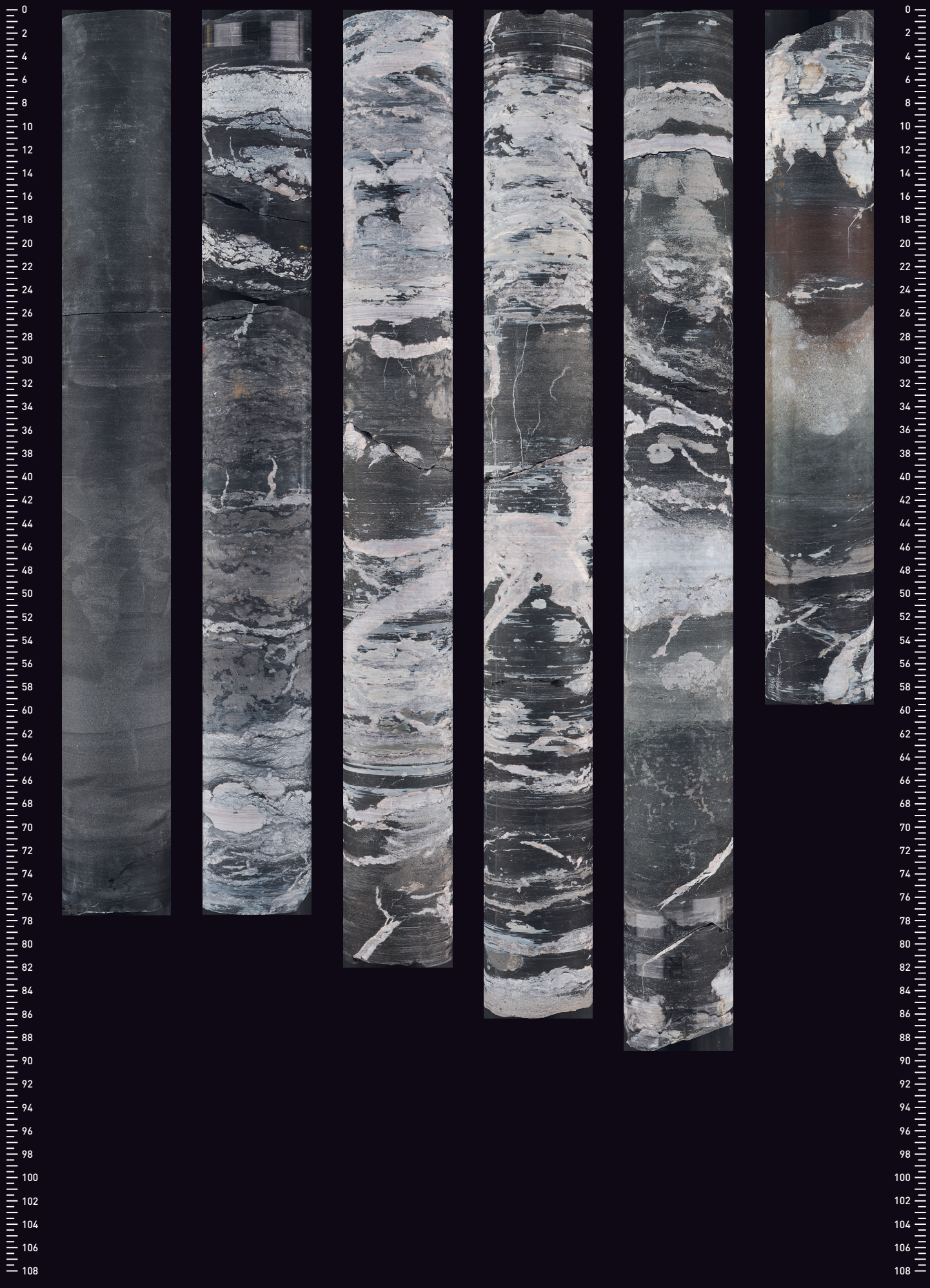

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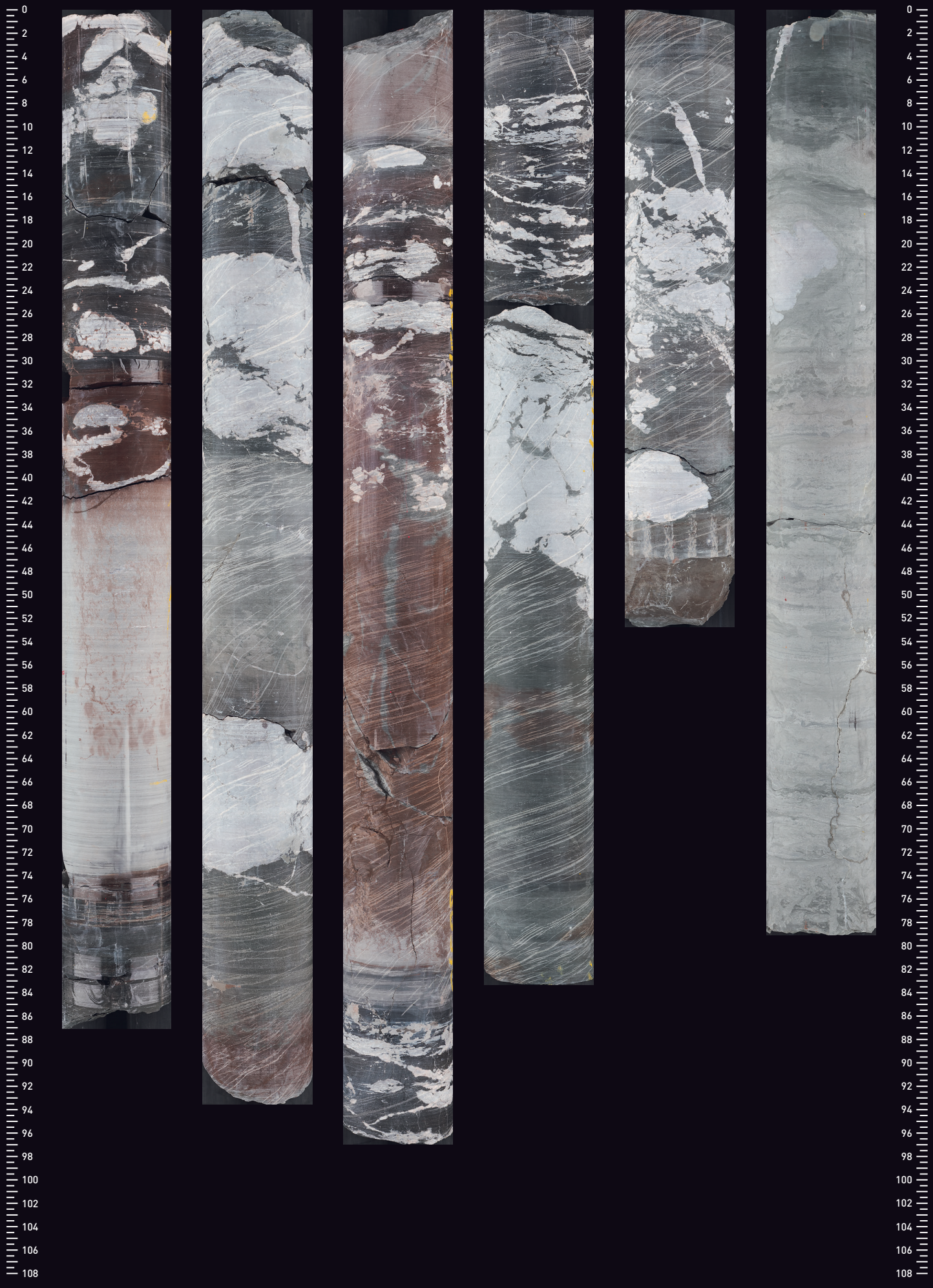
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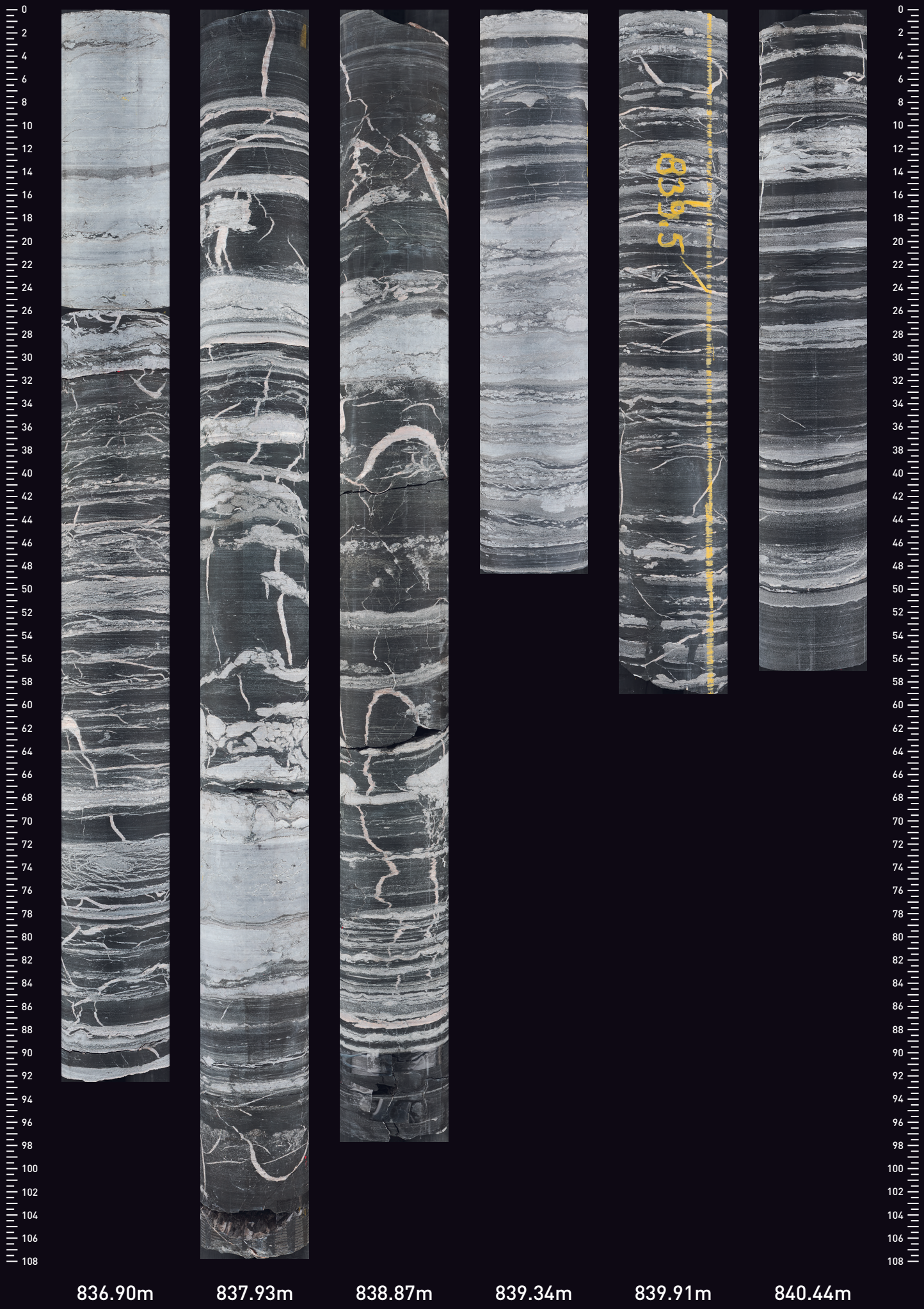


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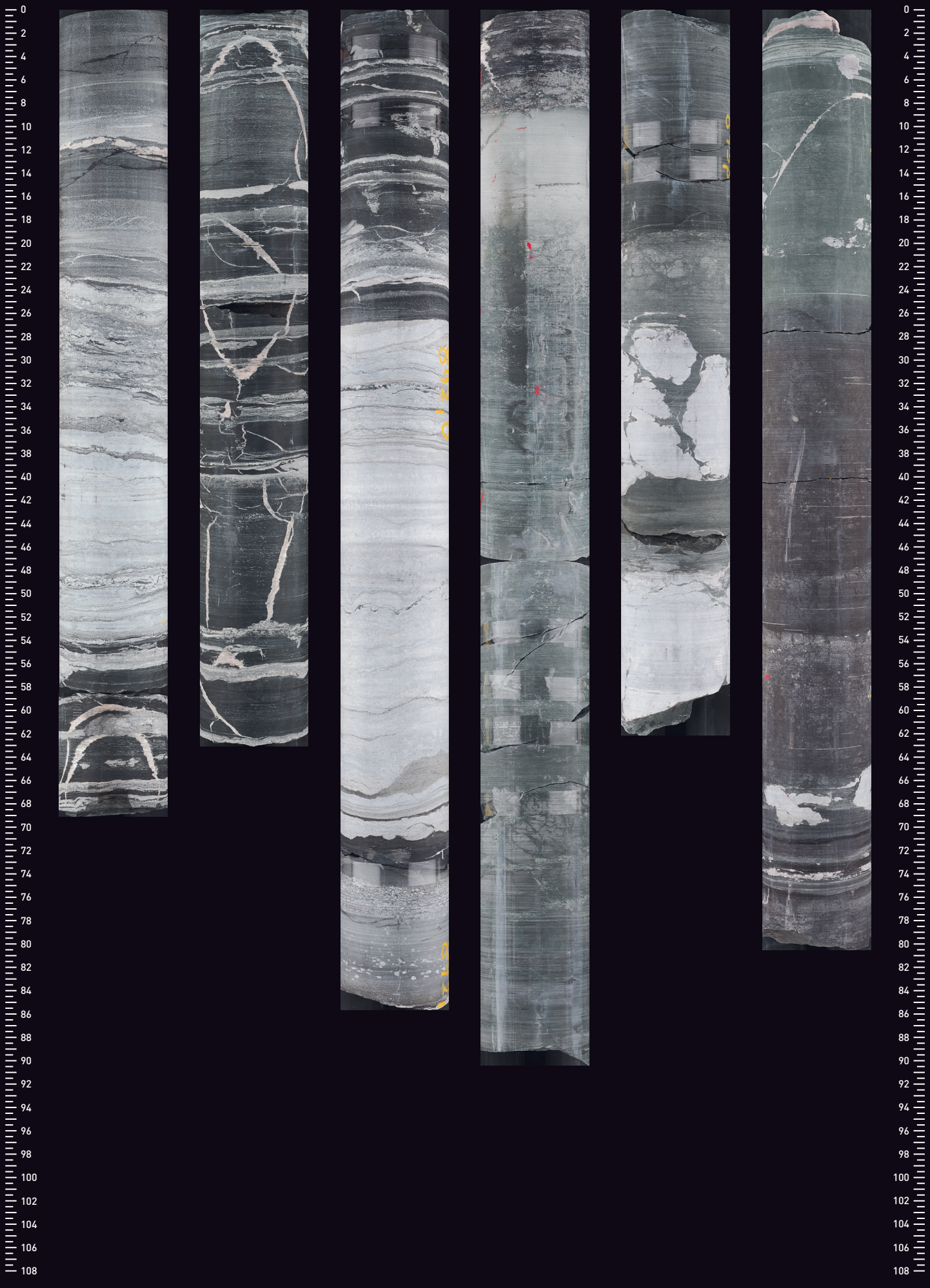
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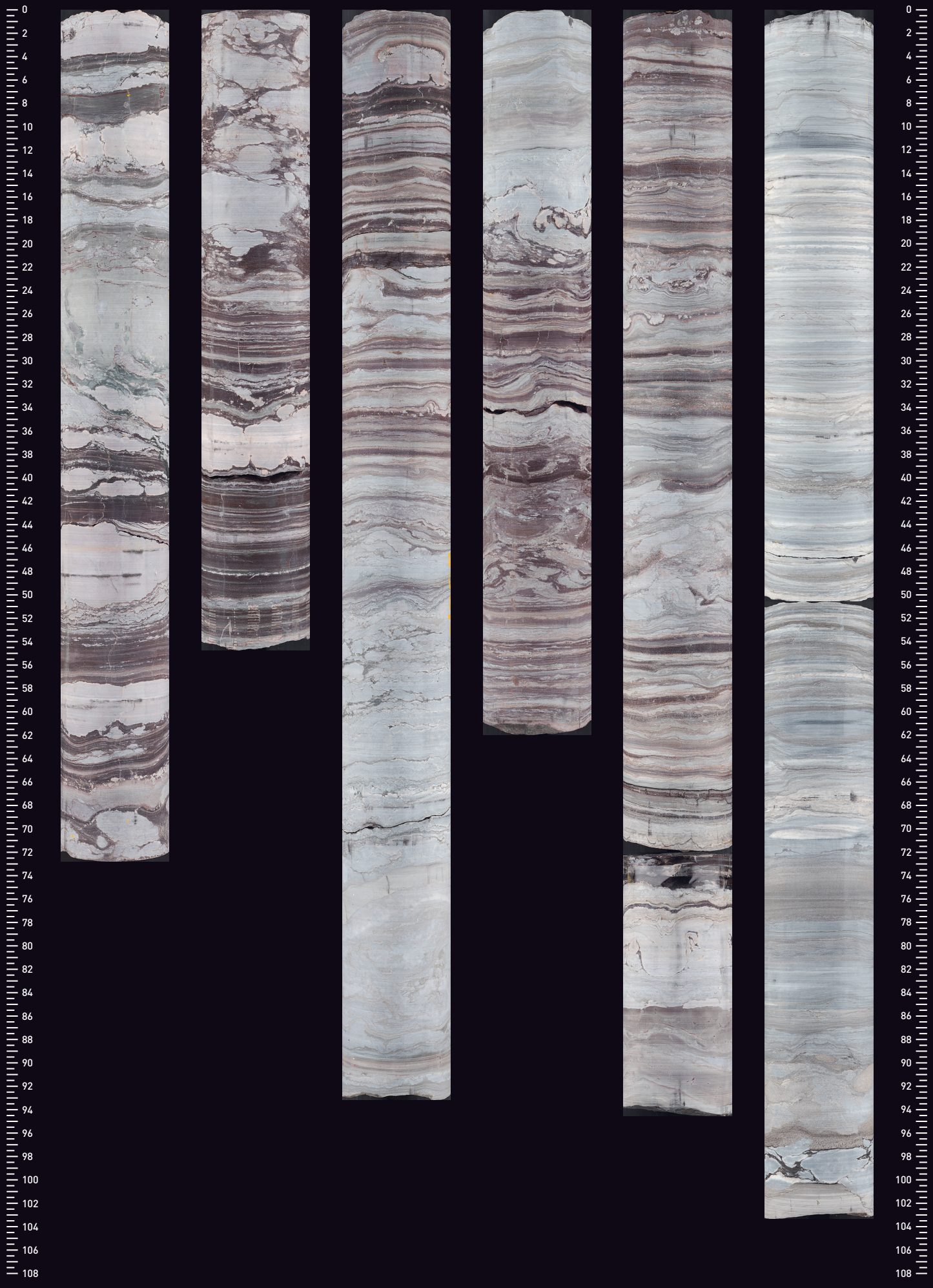
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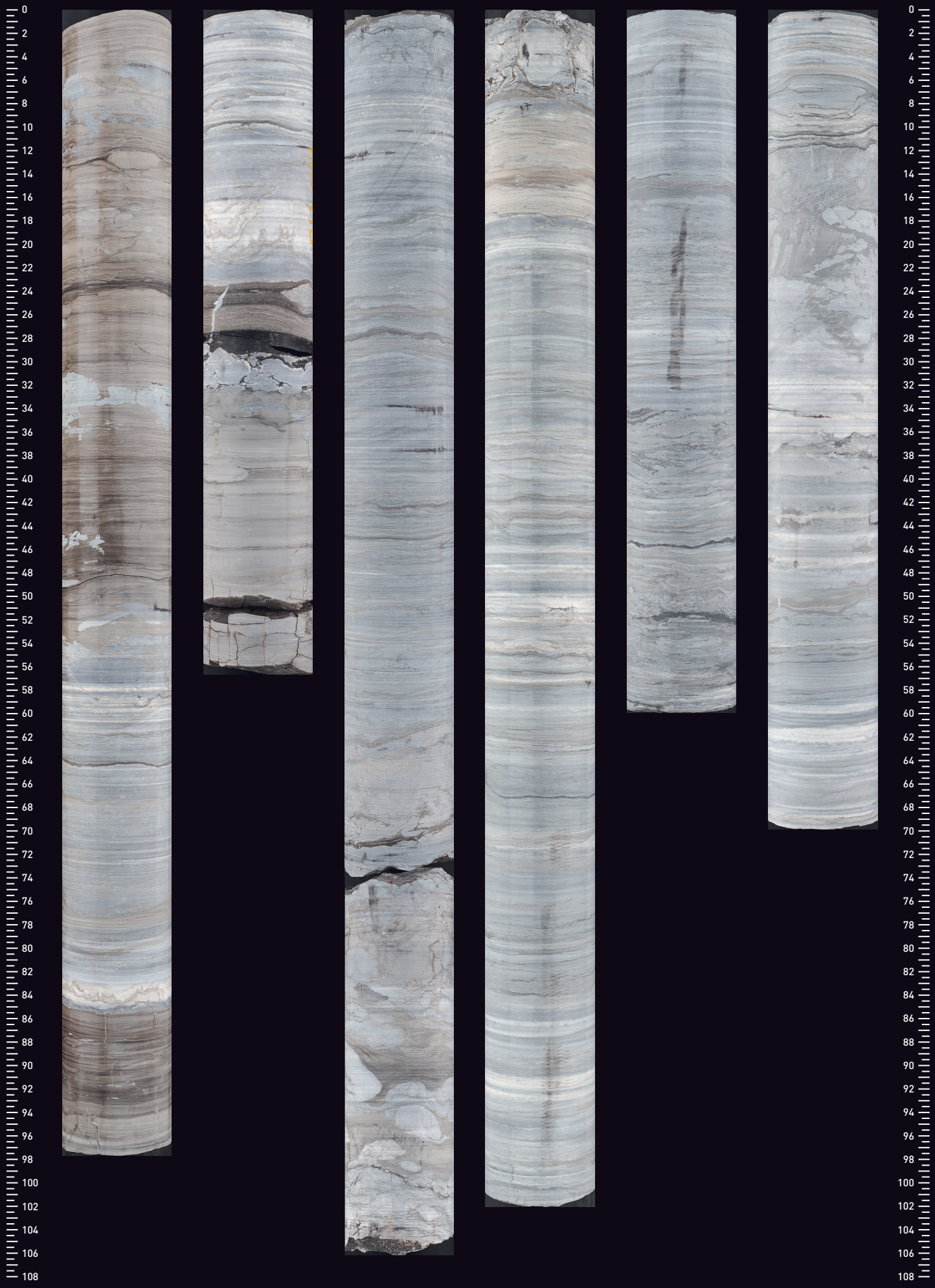
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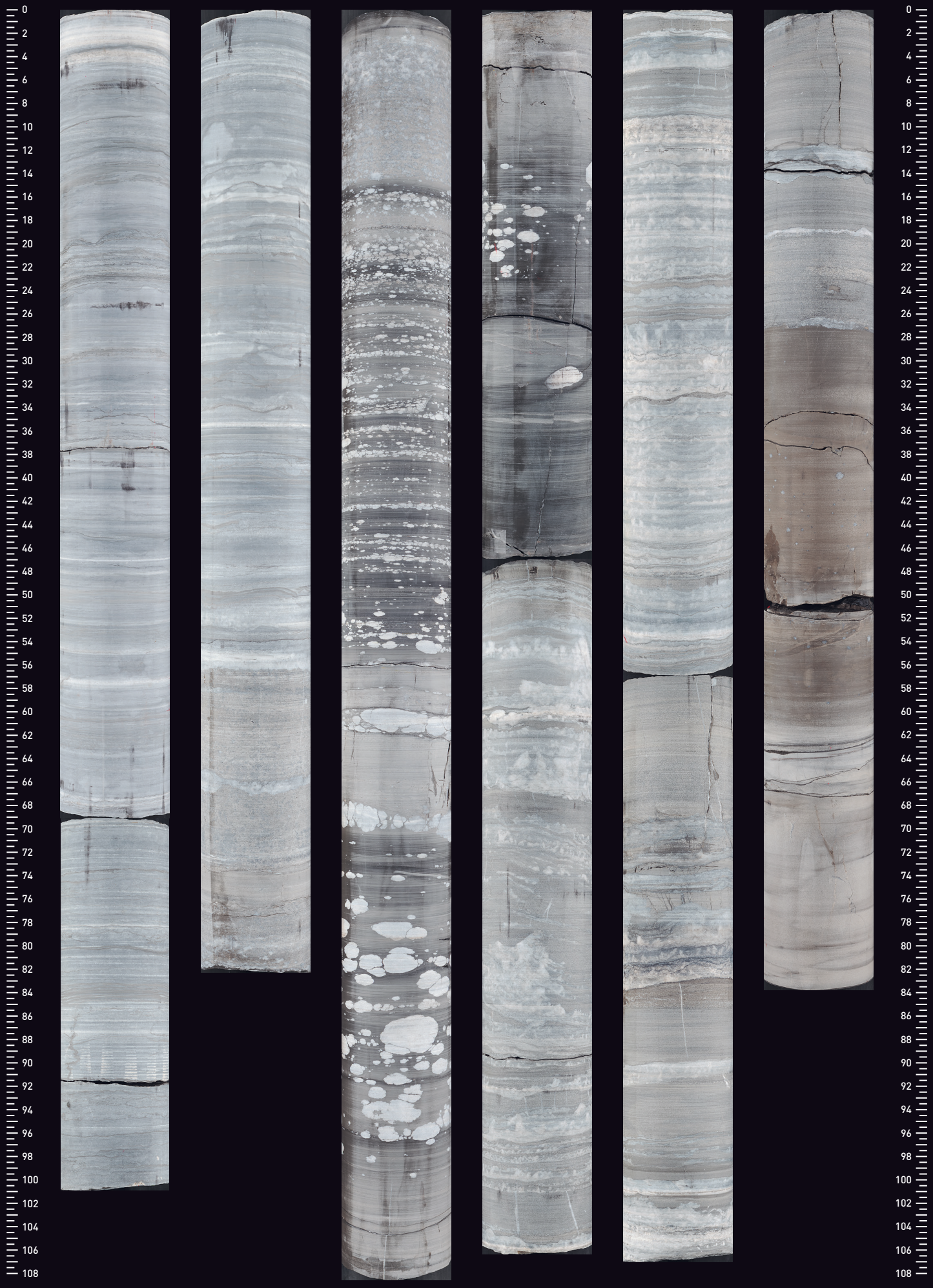
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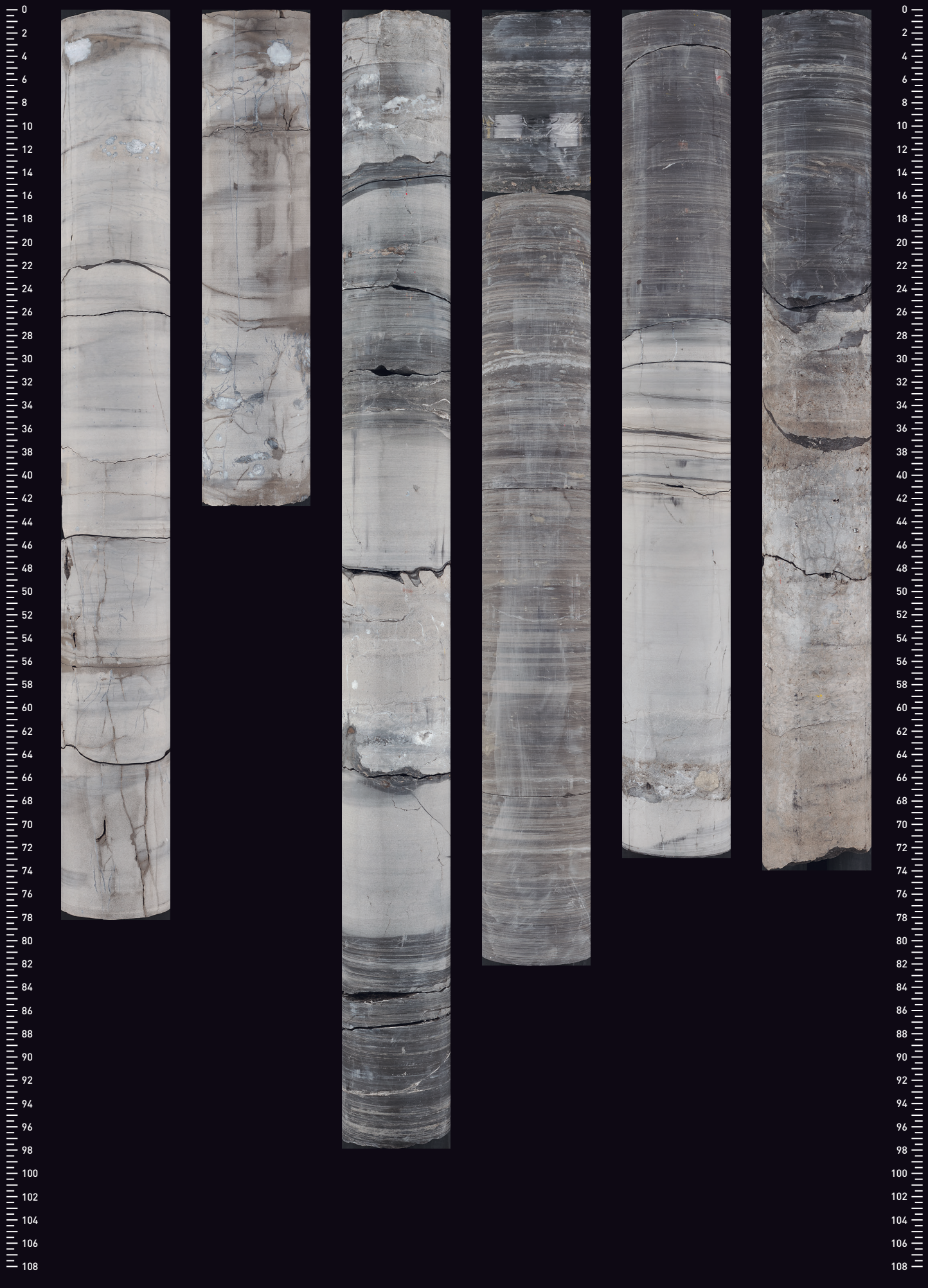


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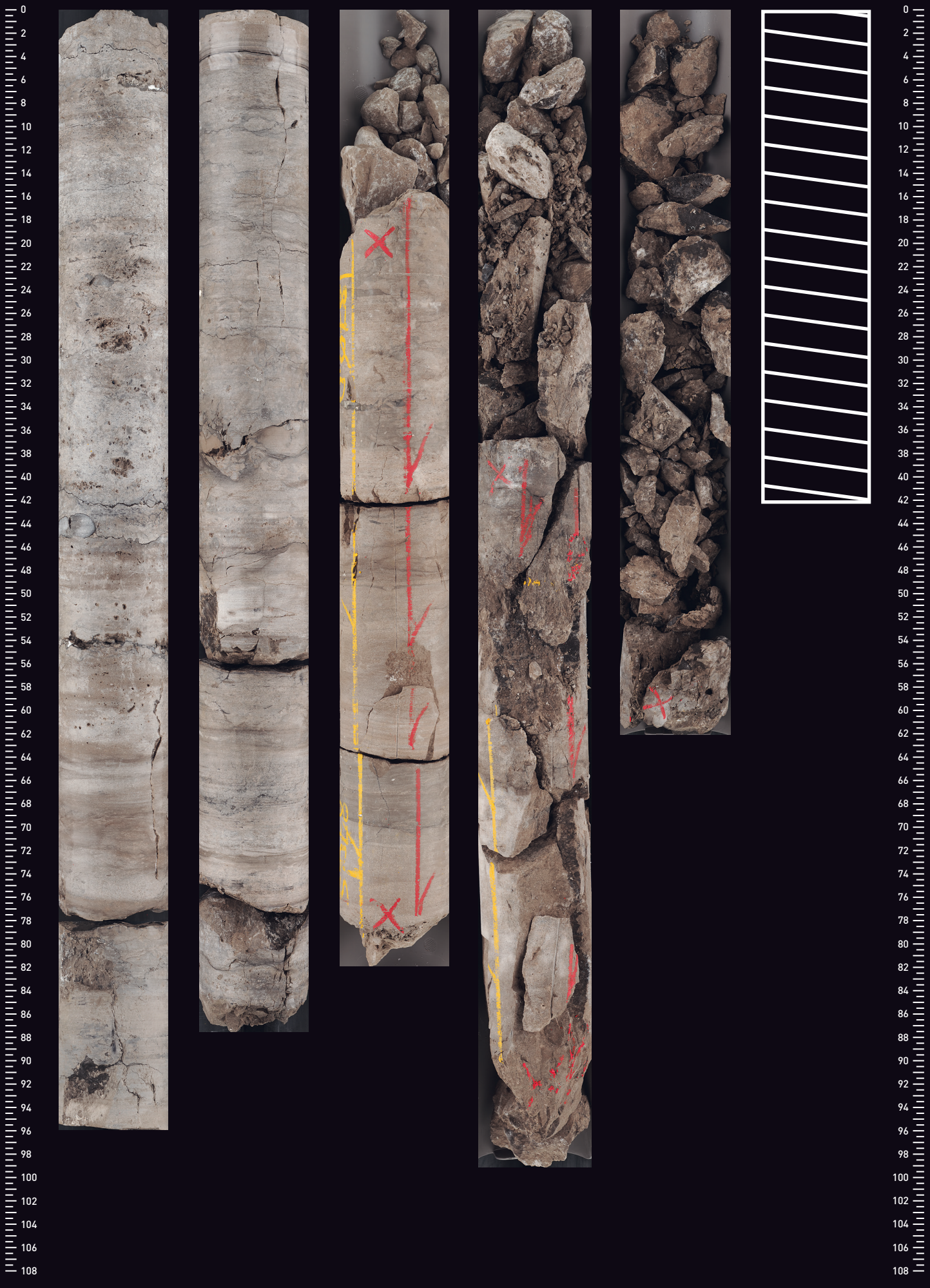
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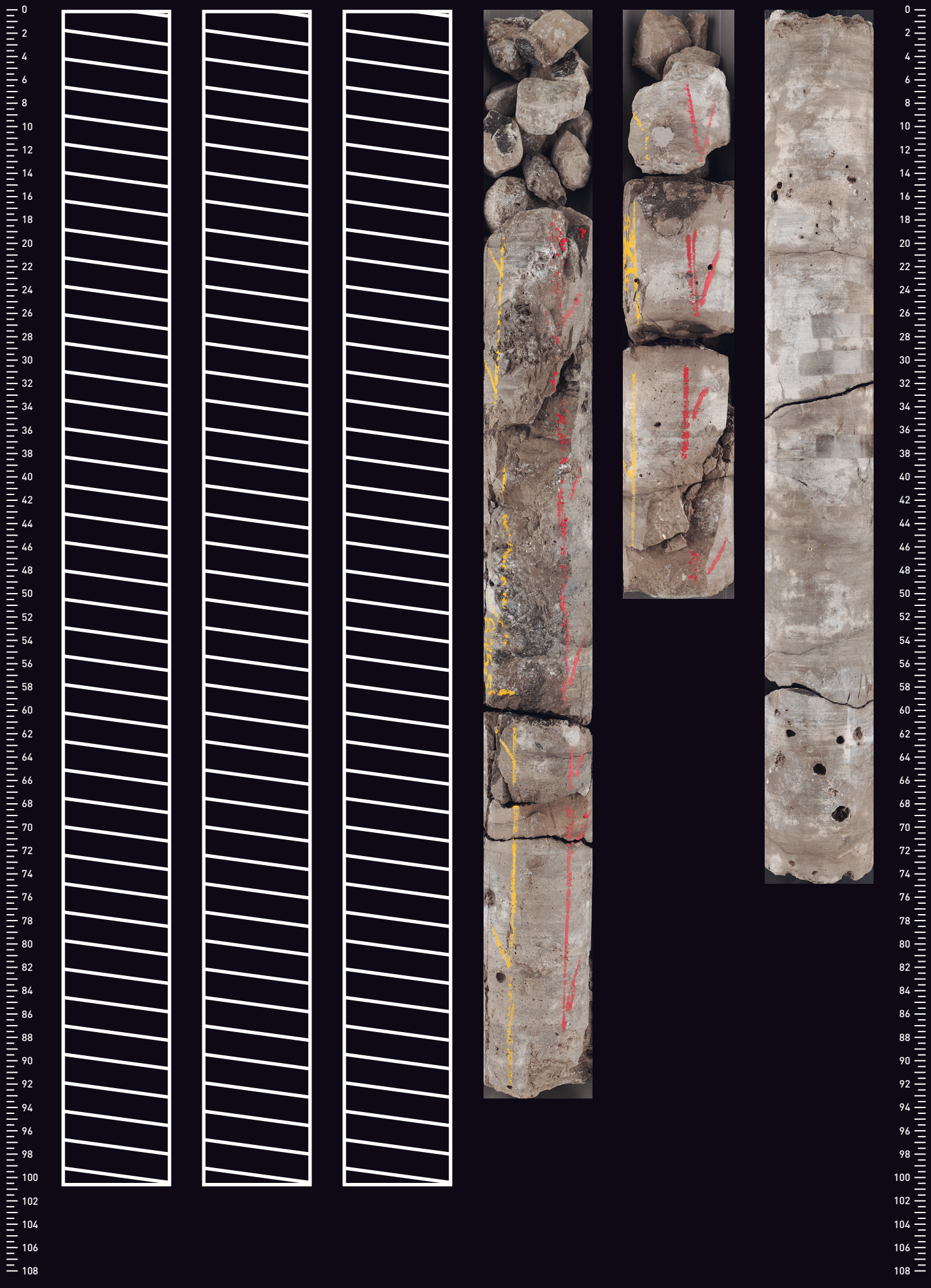

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864.57m
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873.00m 874.00m 875.00m 875.84m 875.84m 877.00m

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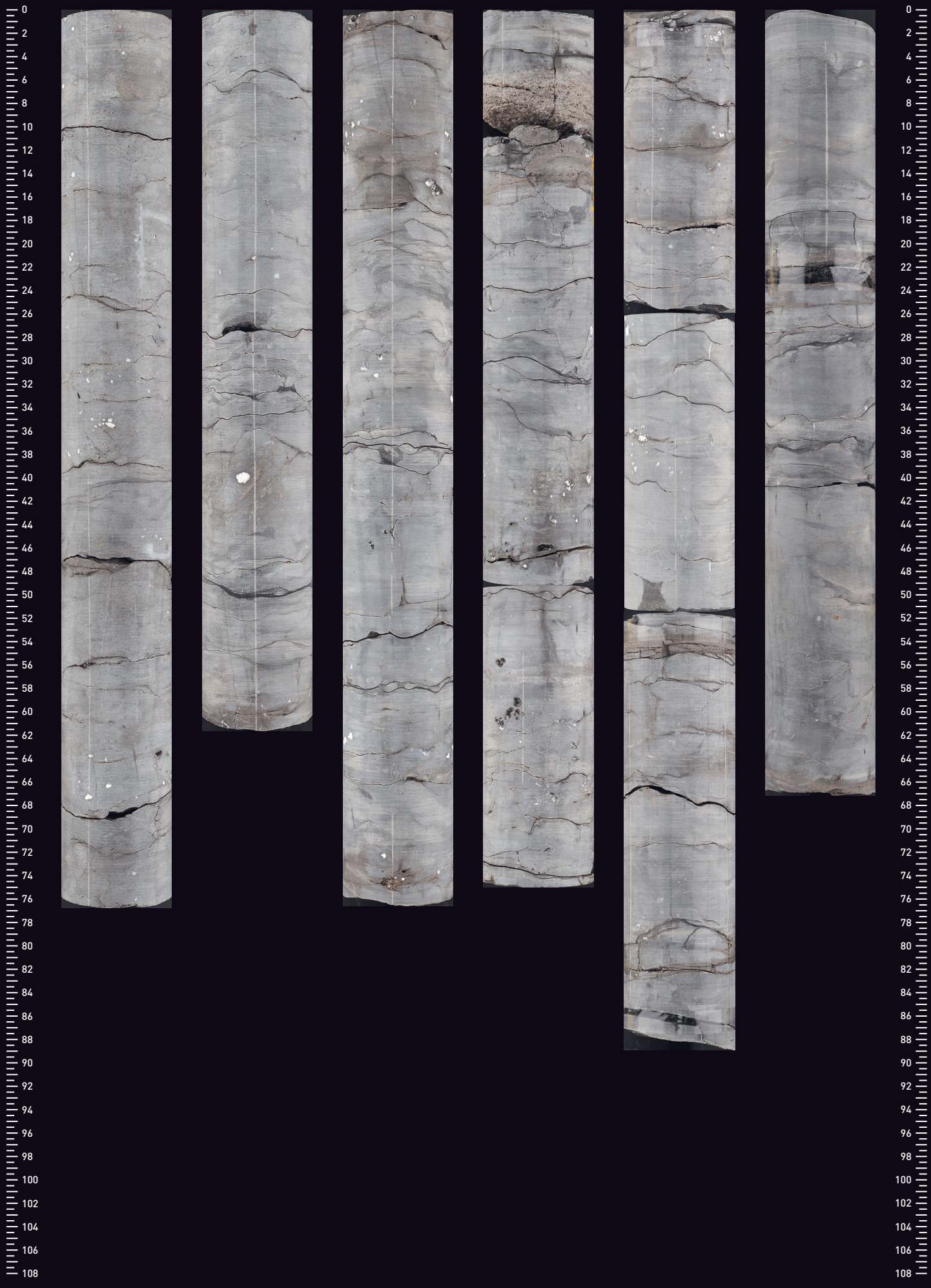
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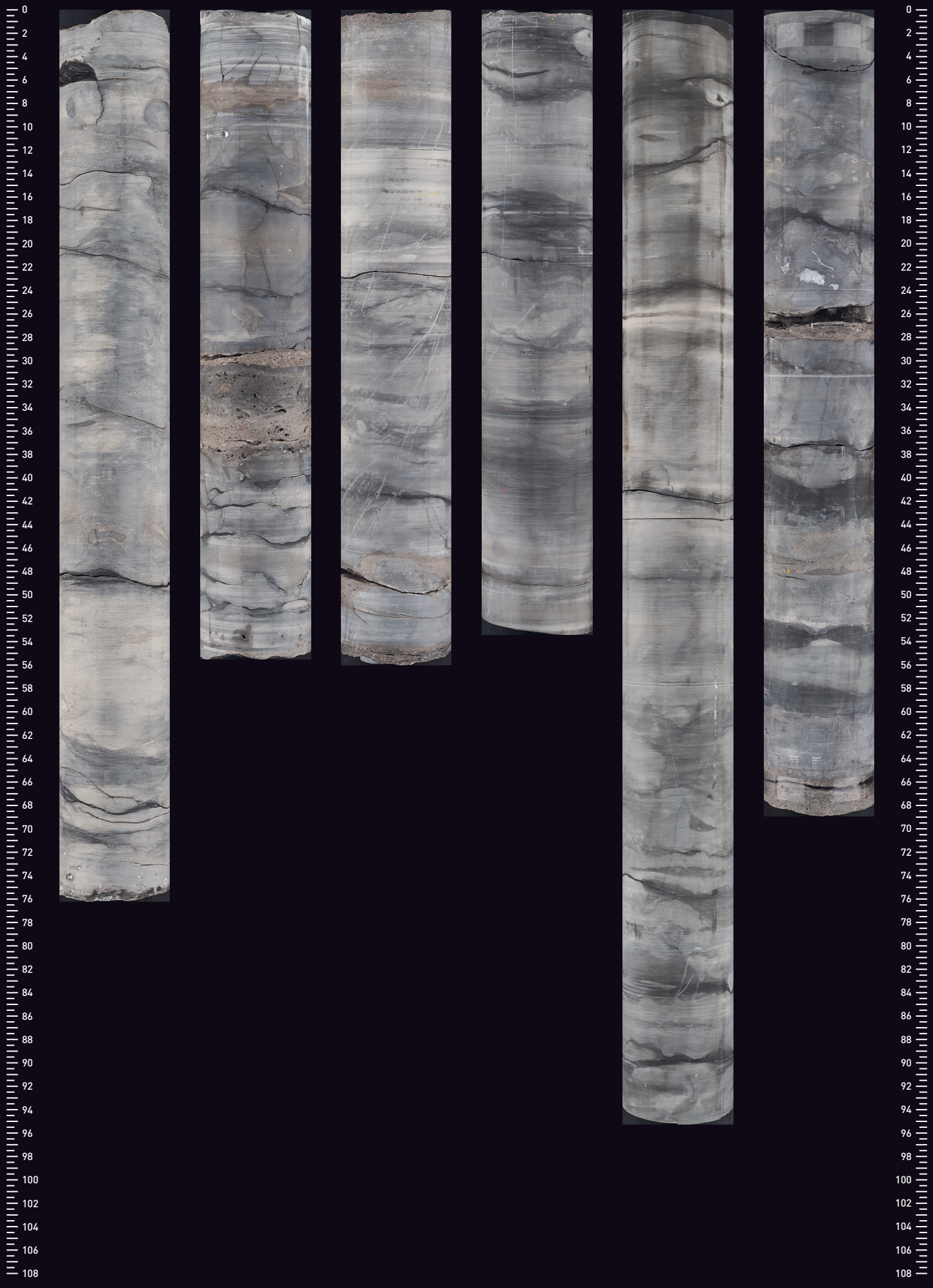
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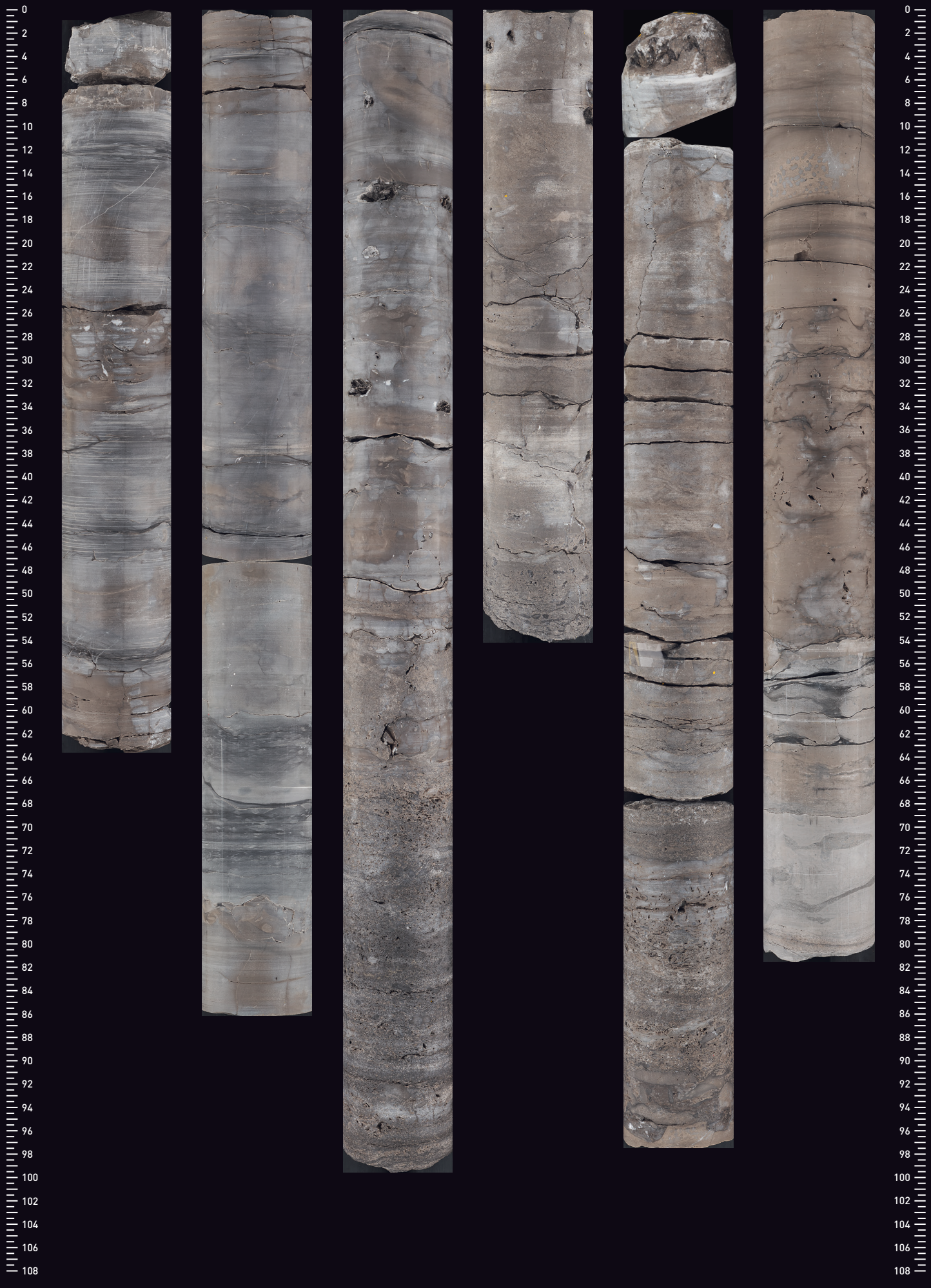


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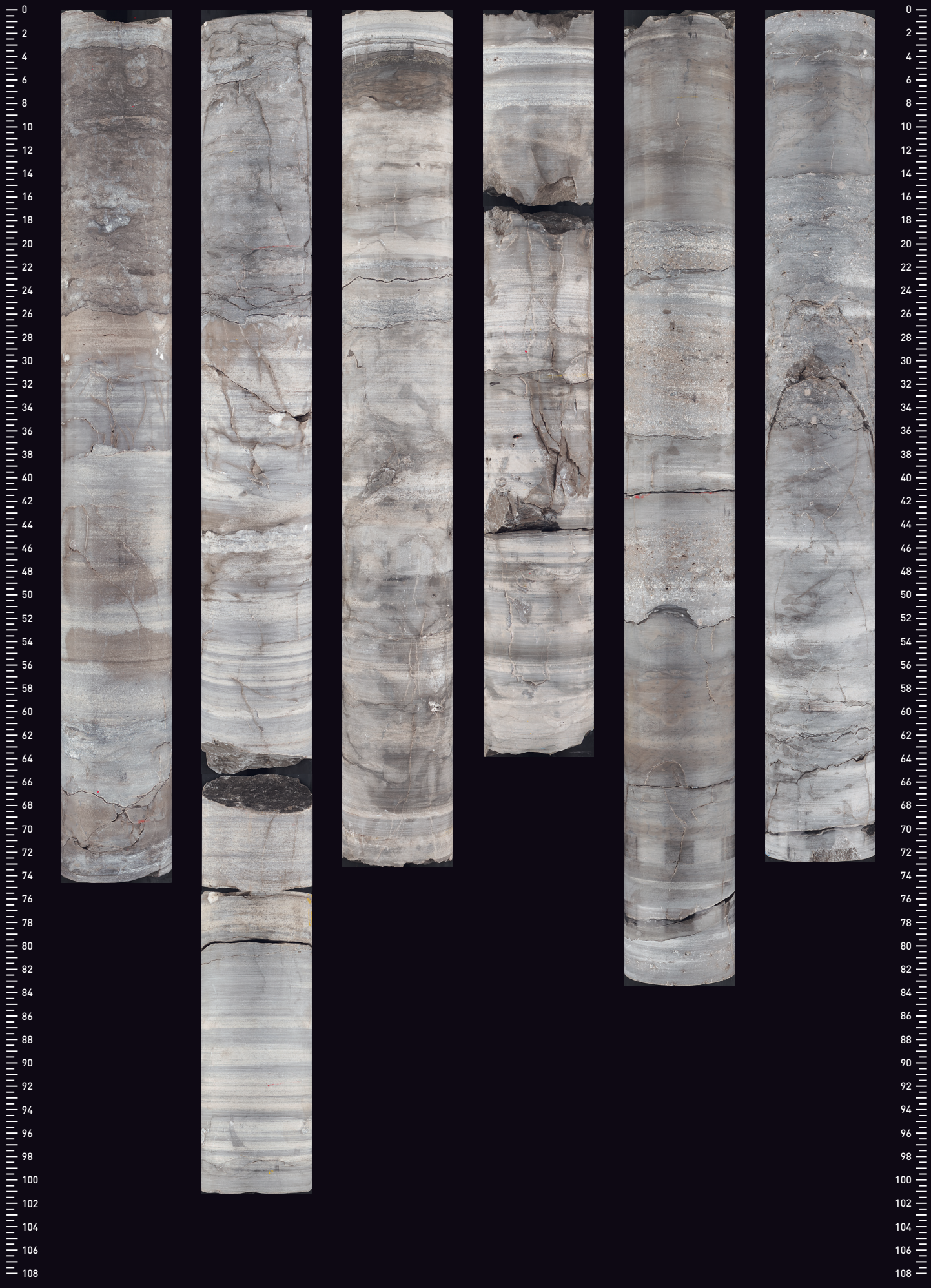

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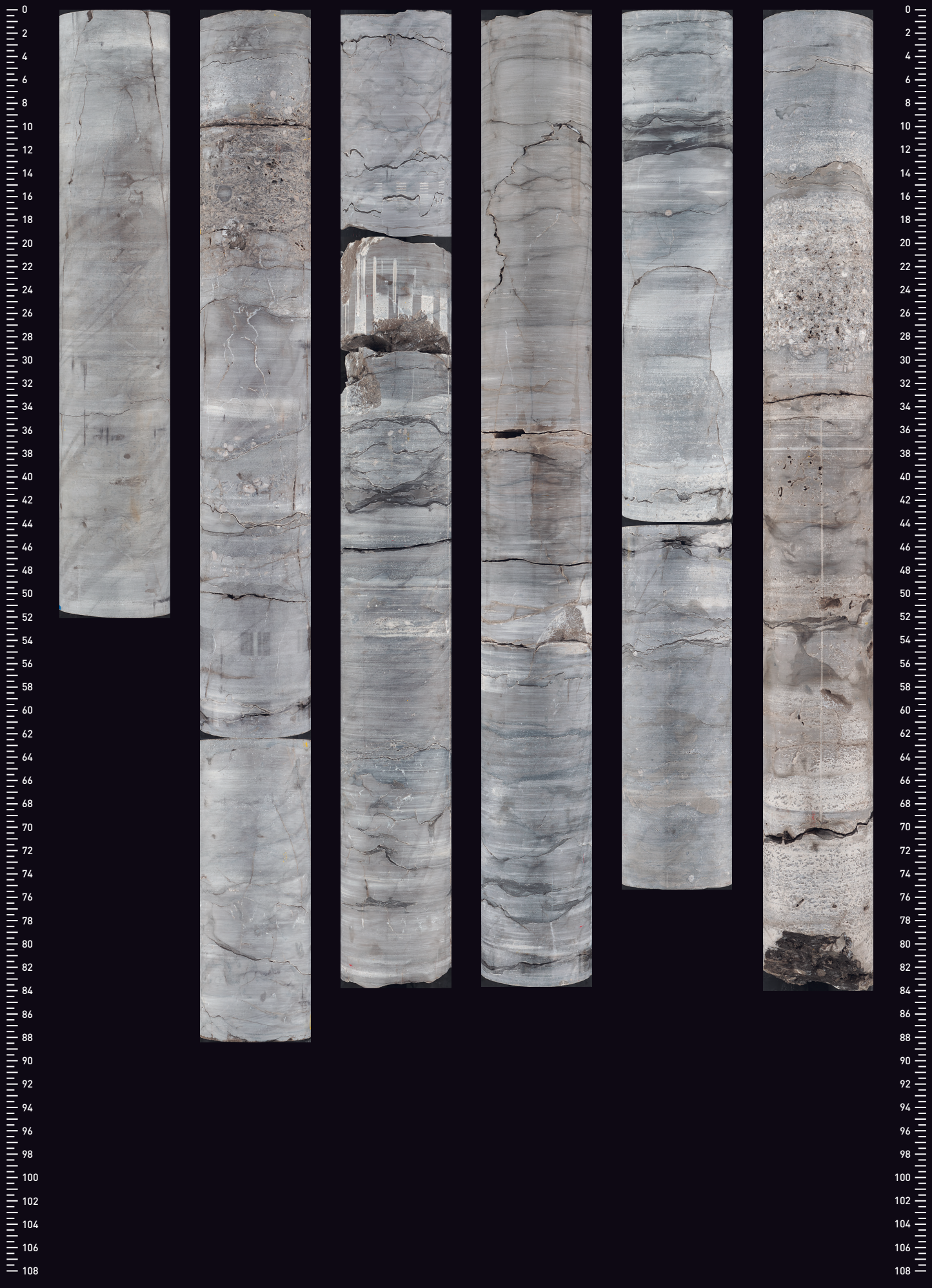
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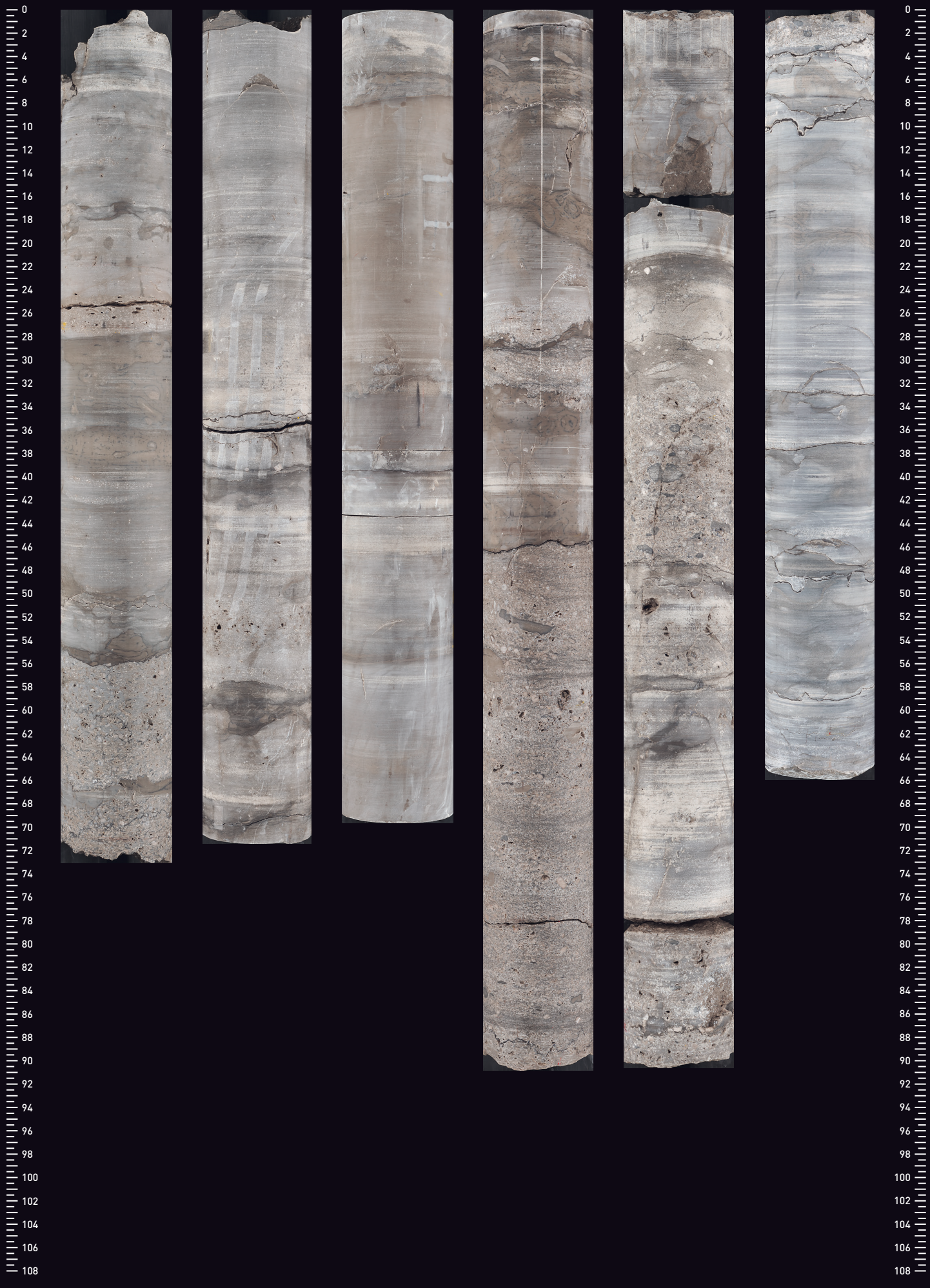


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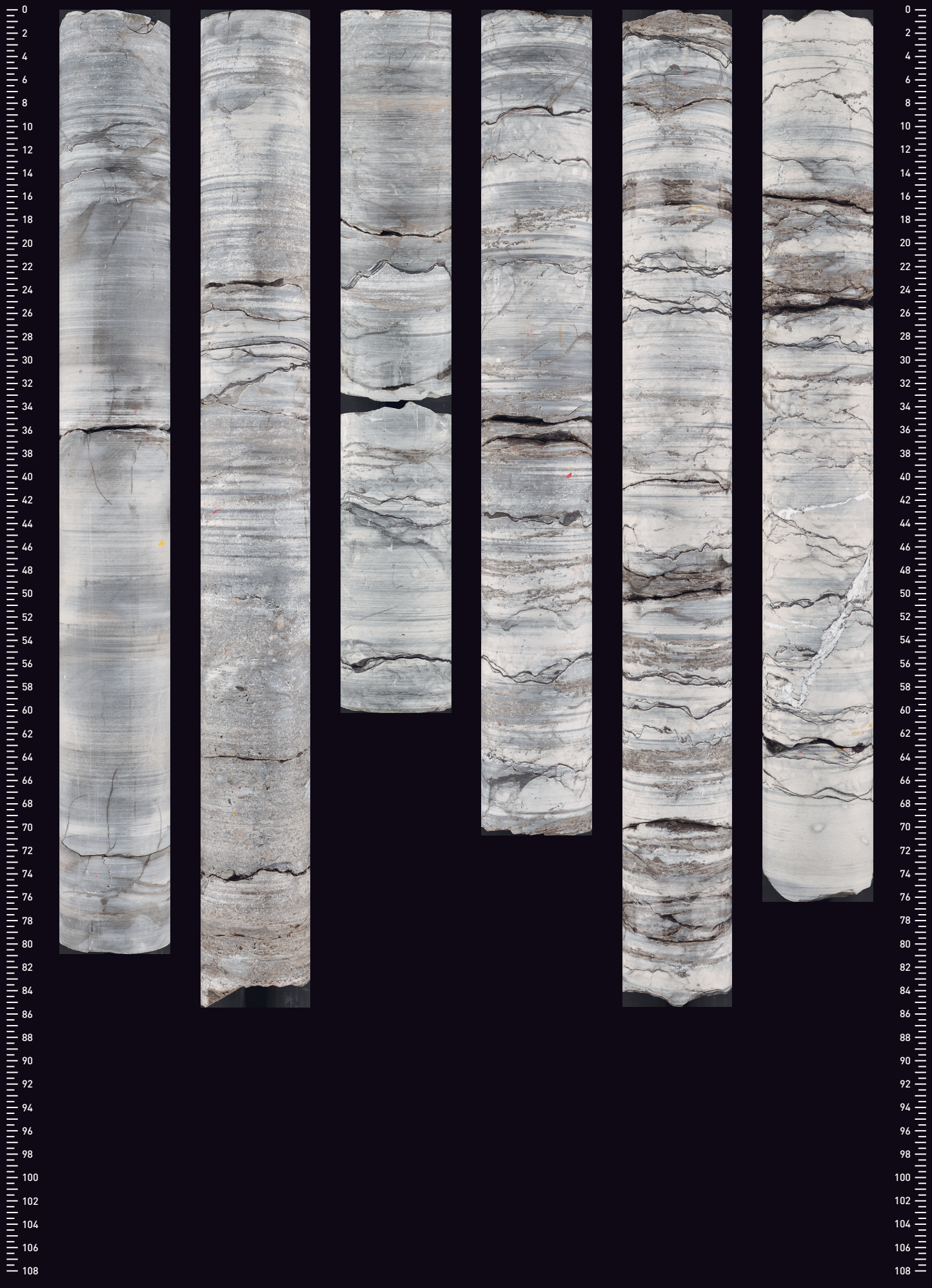
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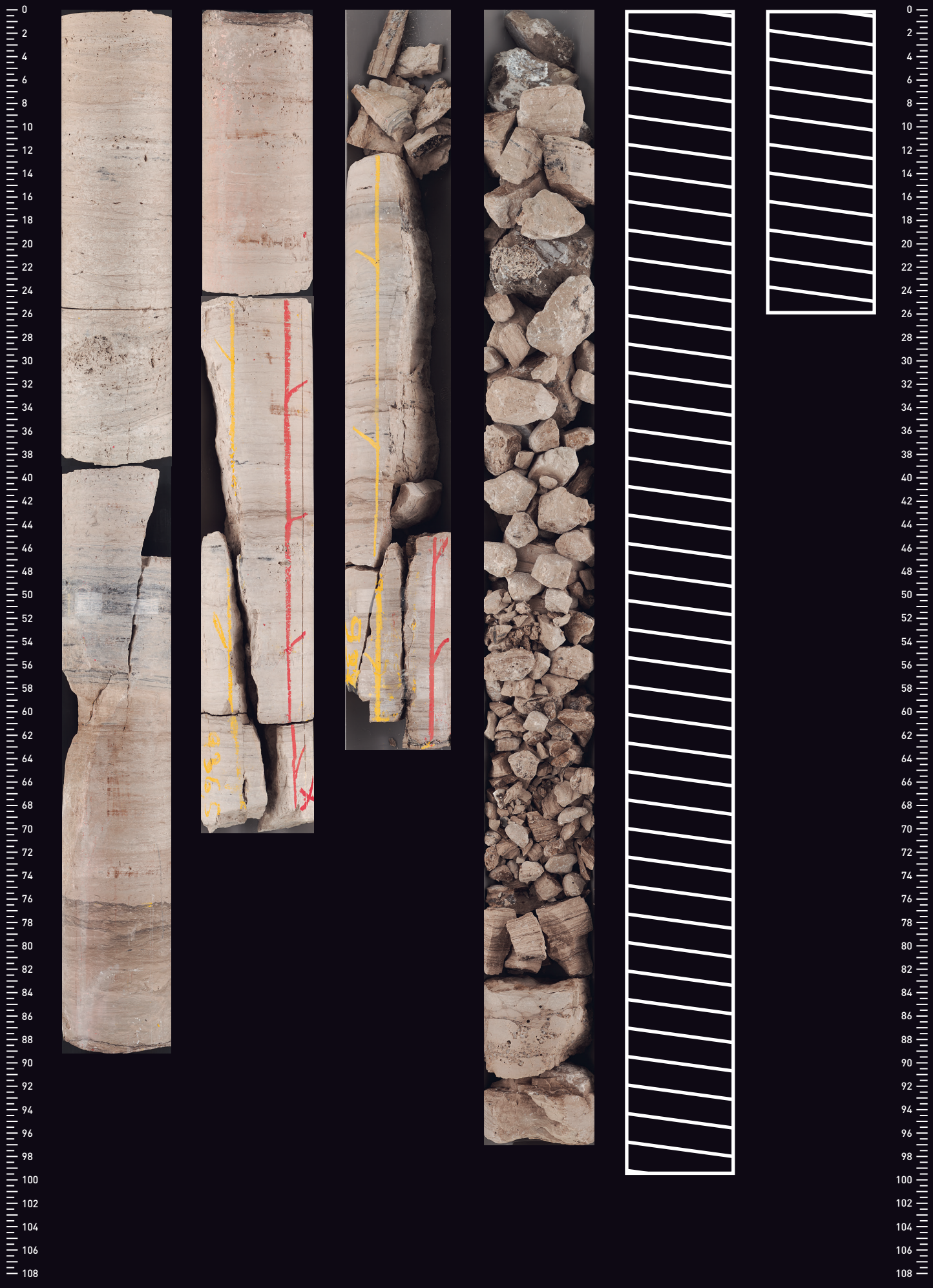
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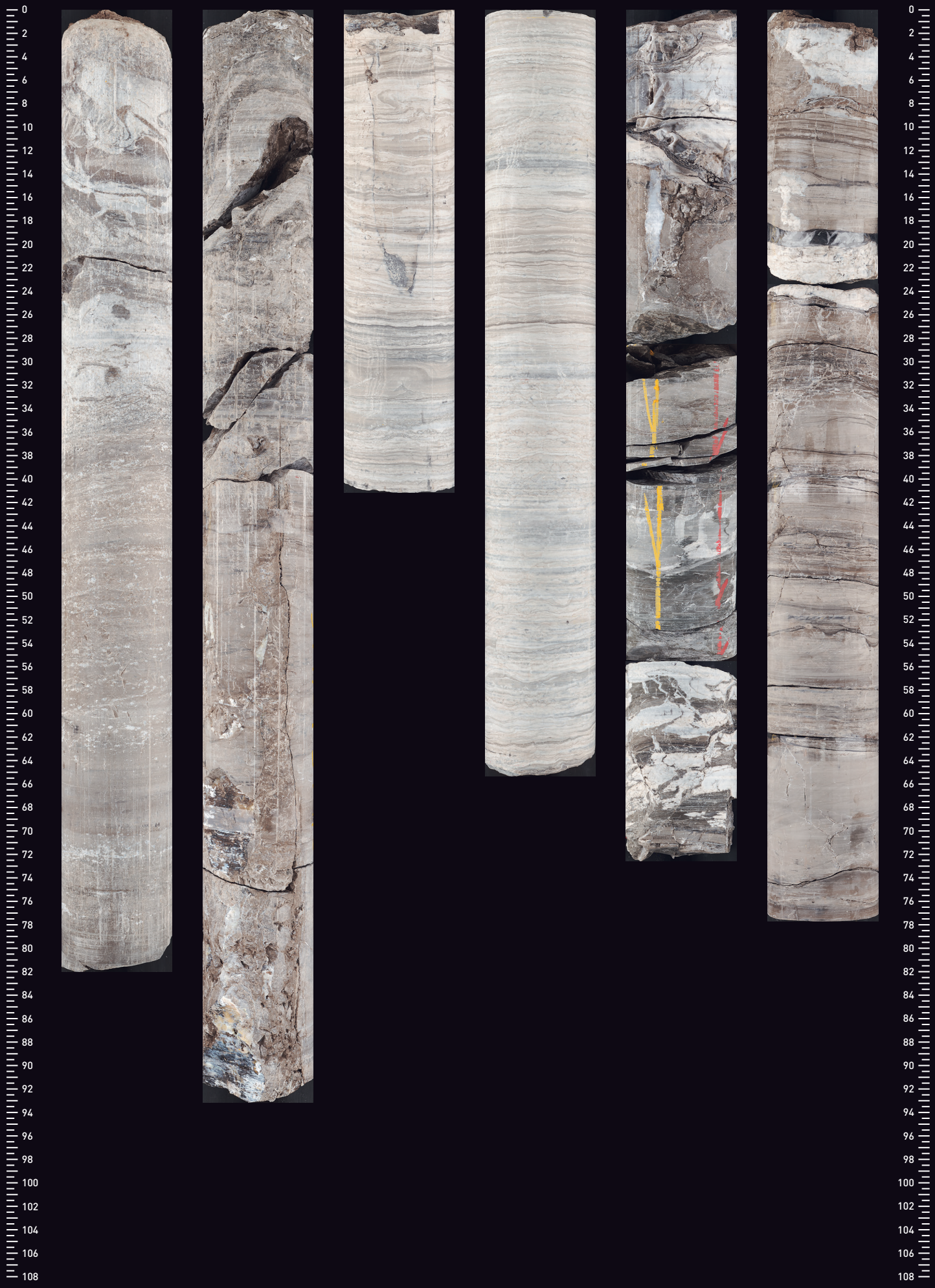
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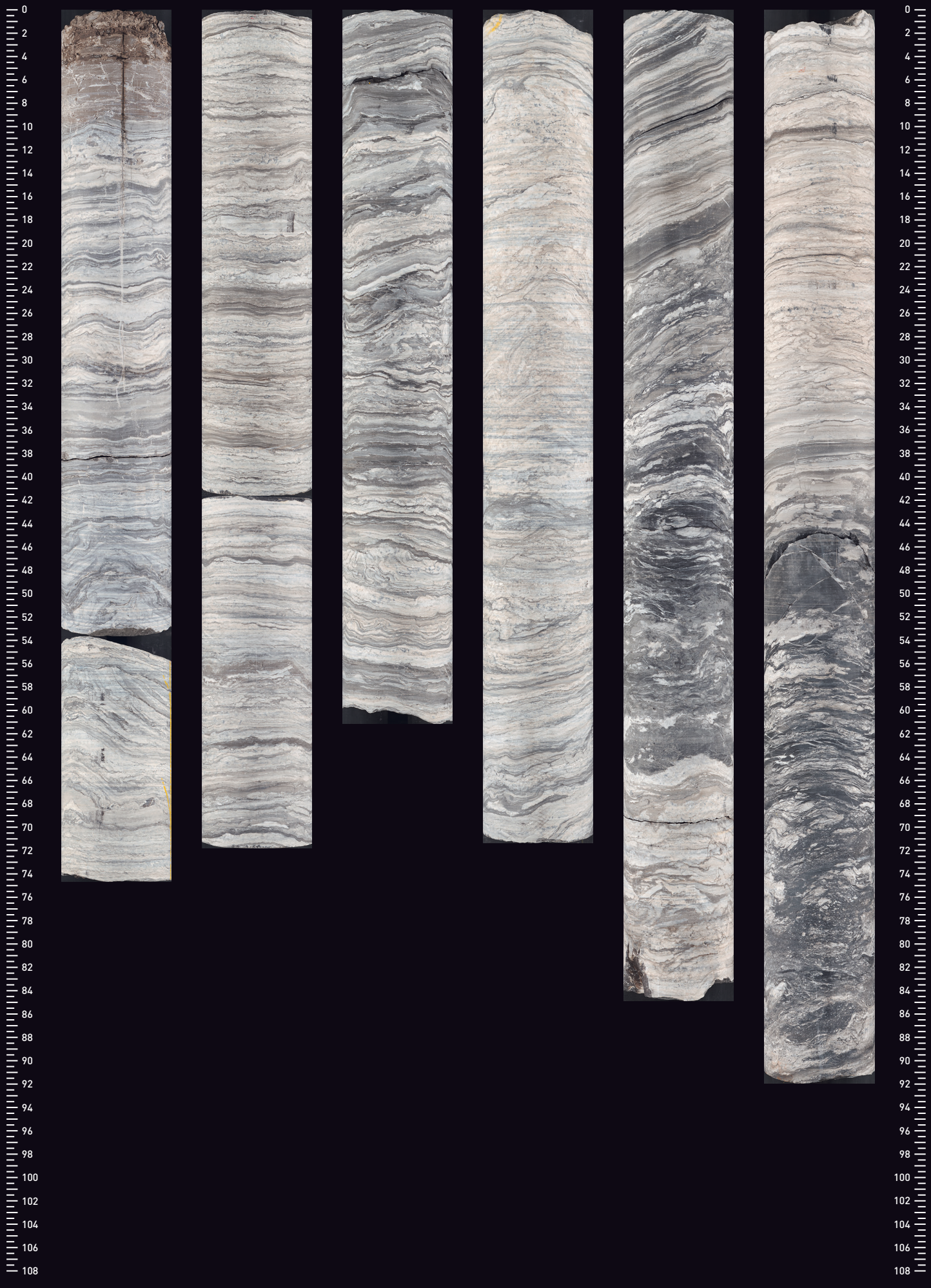
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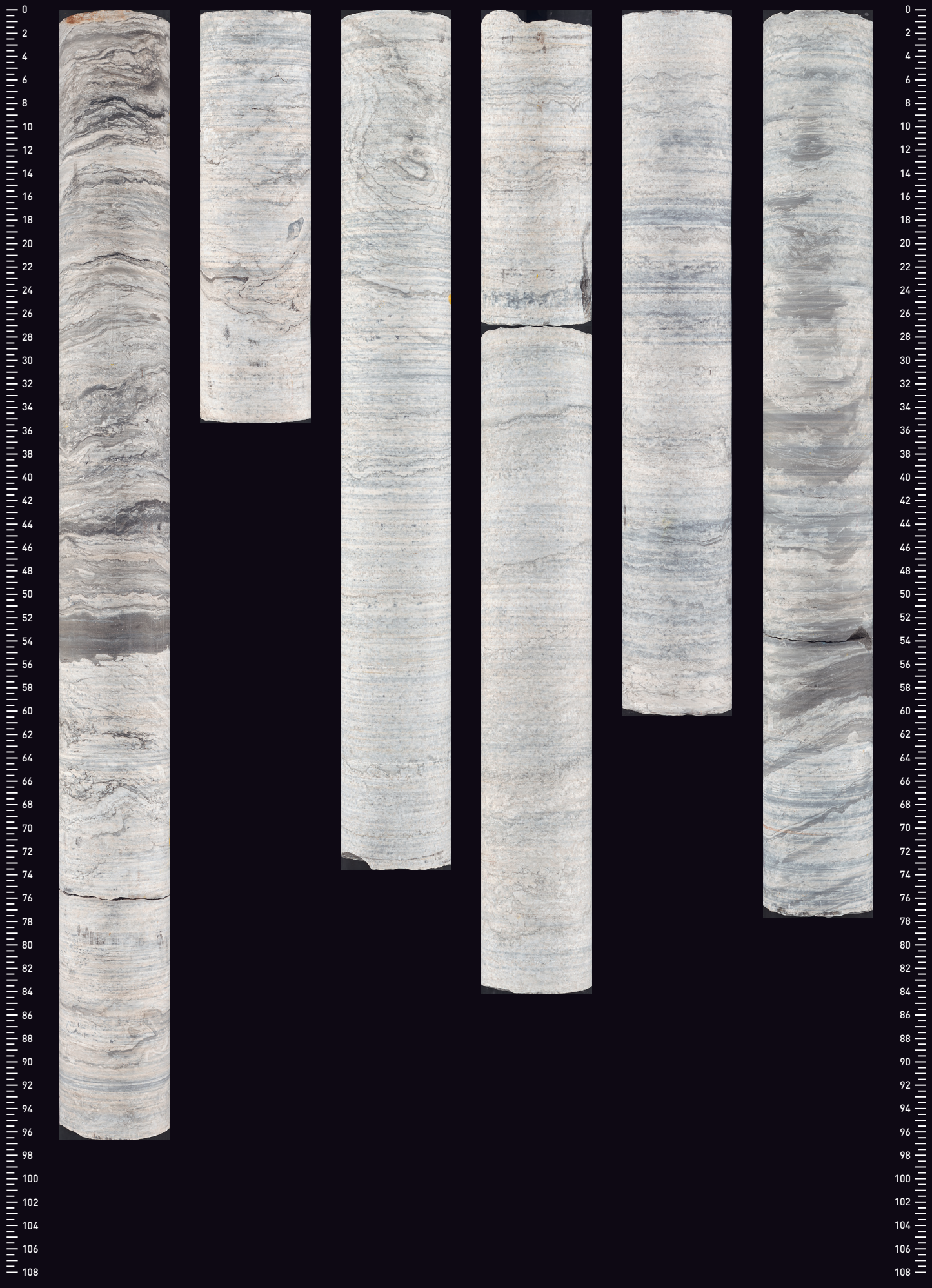
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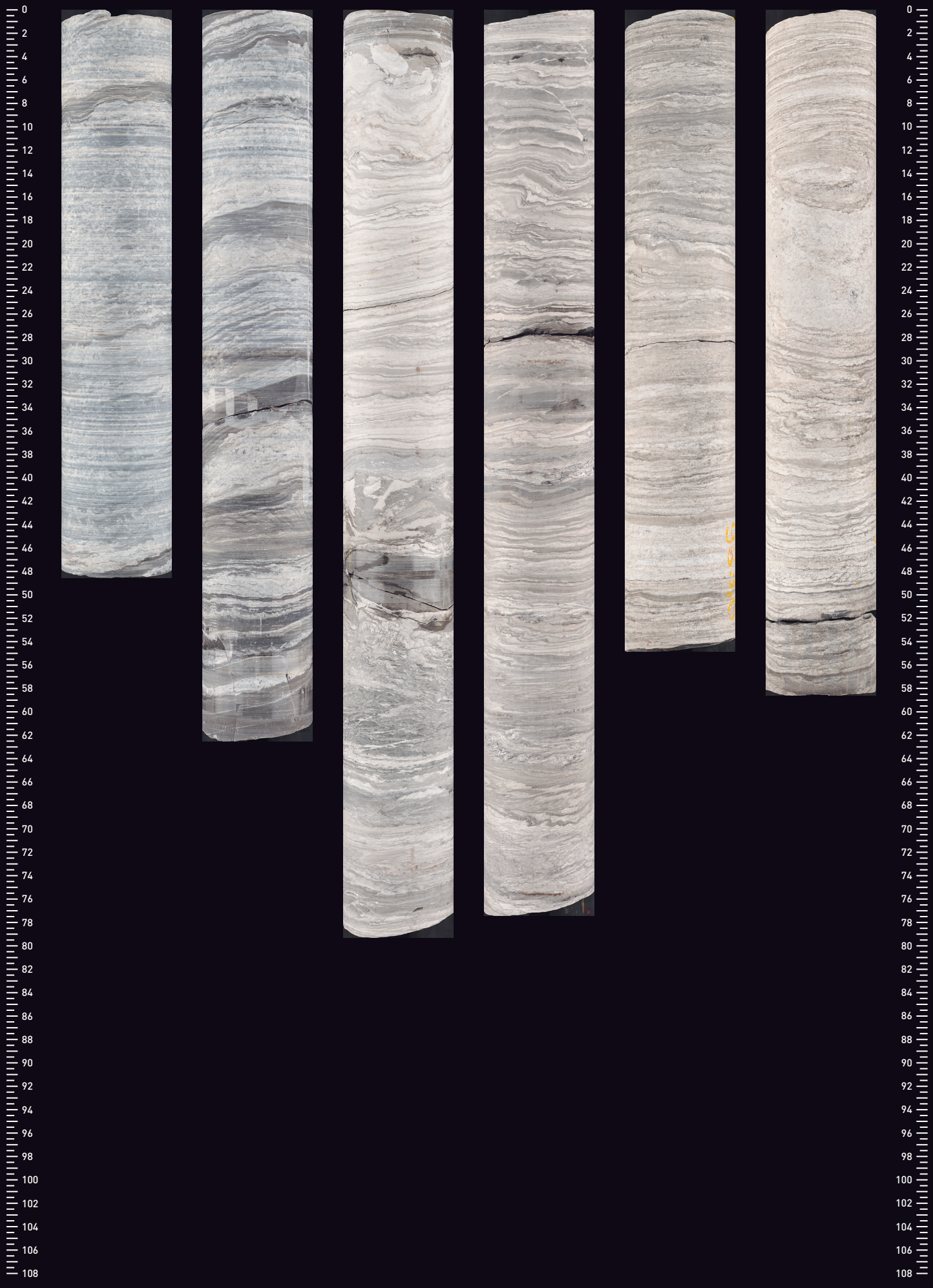
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956.78m 957.12m 957.84m 958.64m 959.23m 959.98m

959.98m 960.44m 961.04m 961.81m 962.55m 963.07m



960.44m 961.04m 961.81m 962.55m 963.07m 963.63m

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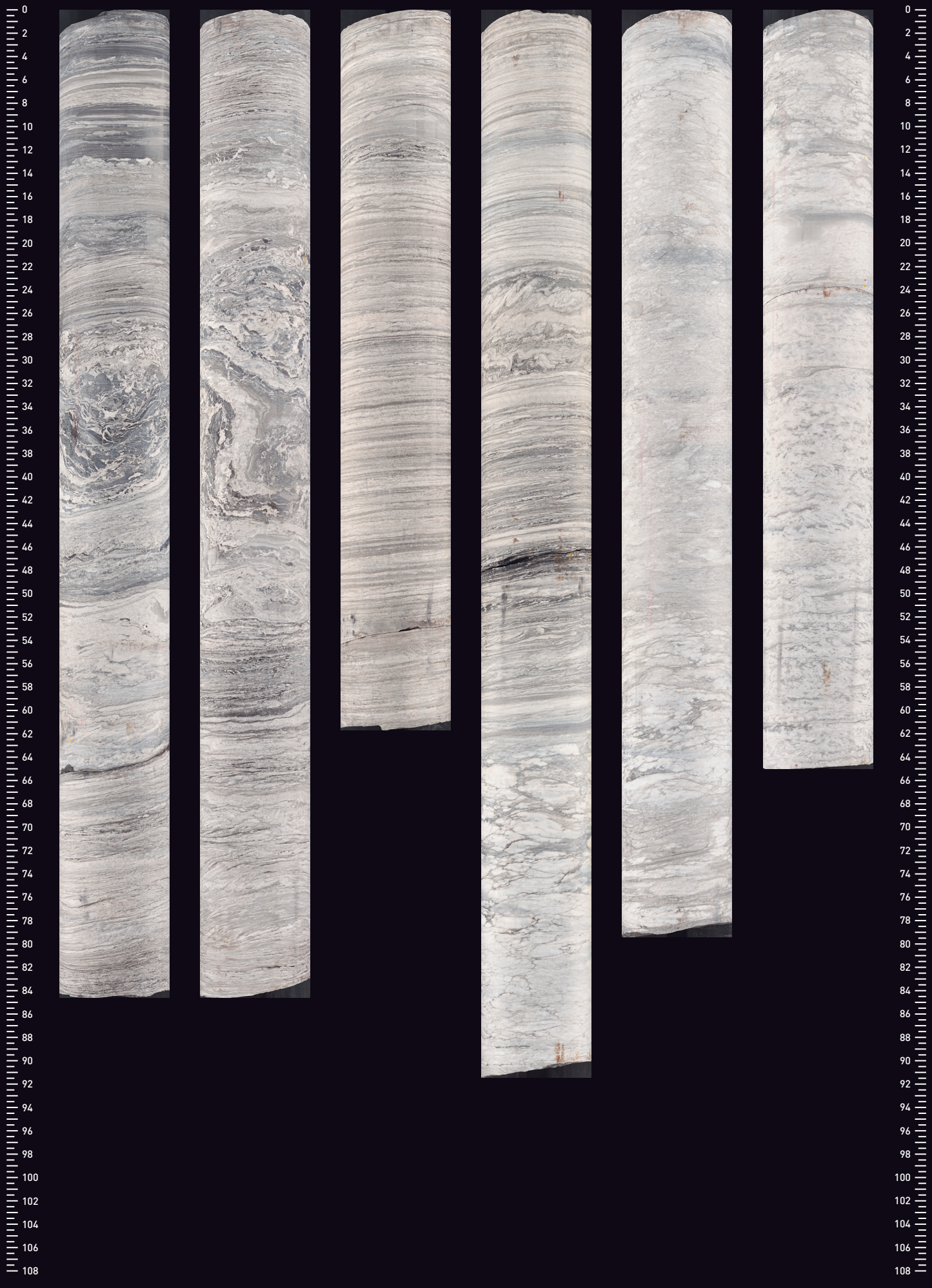
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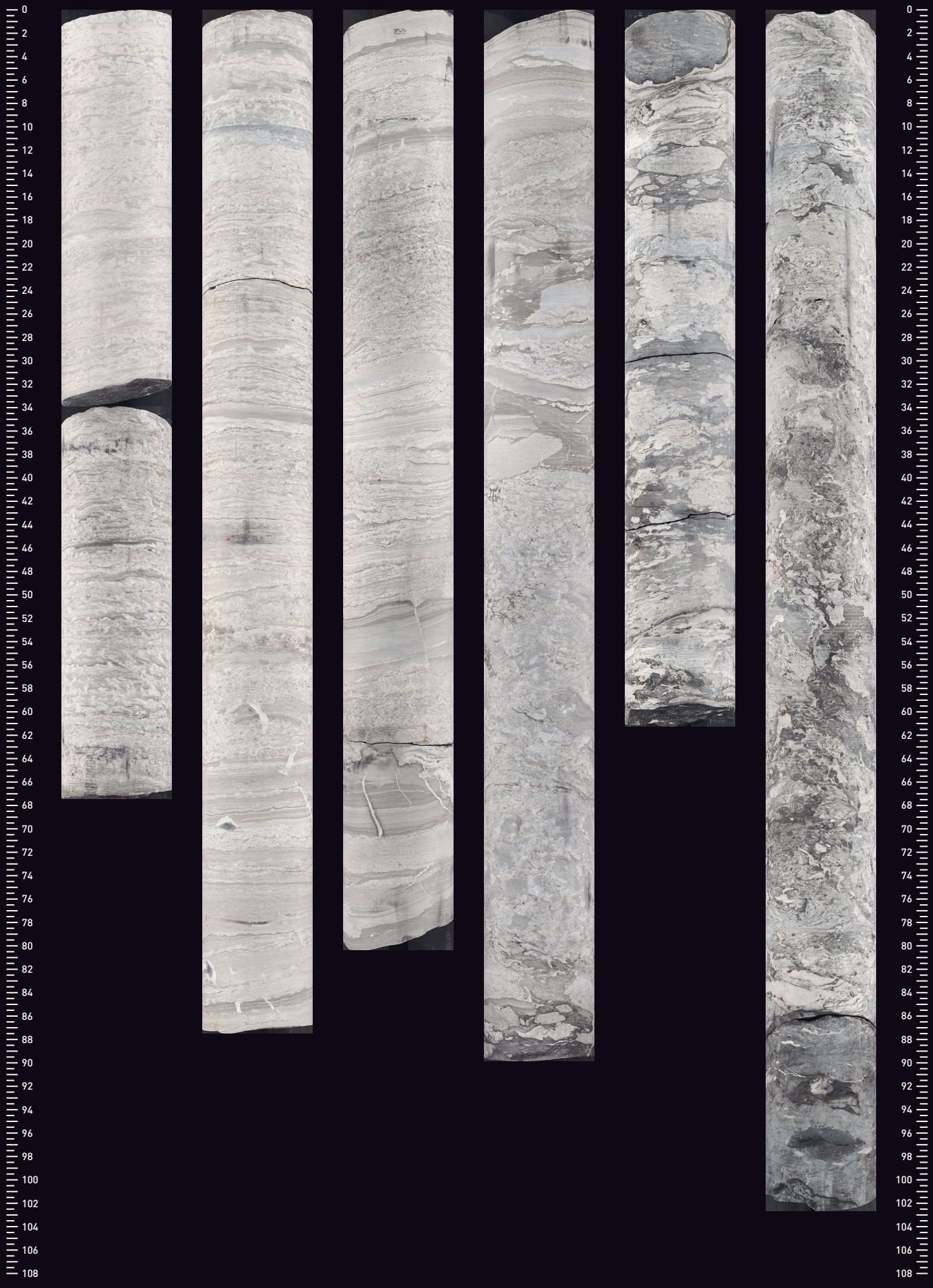
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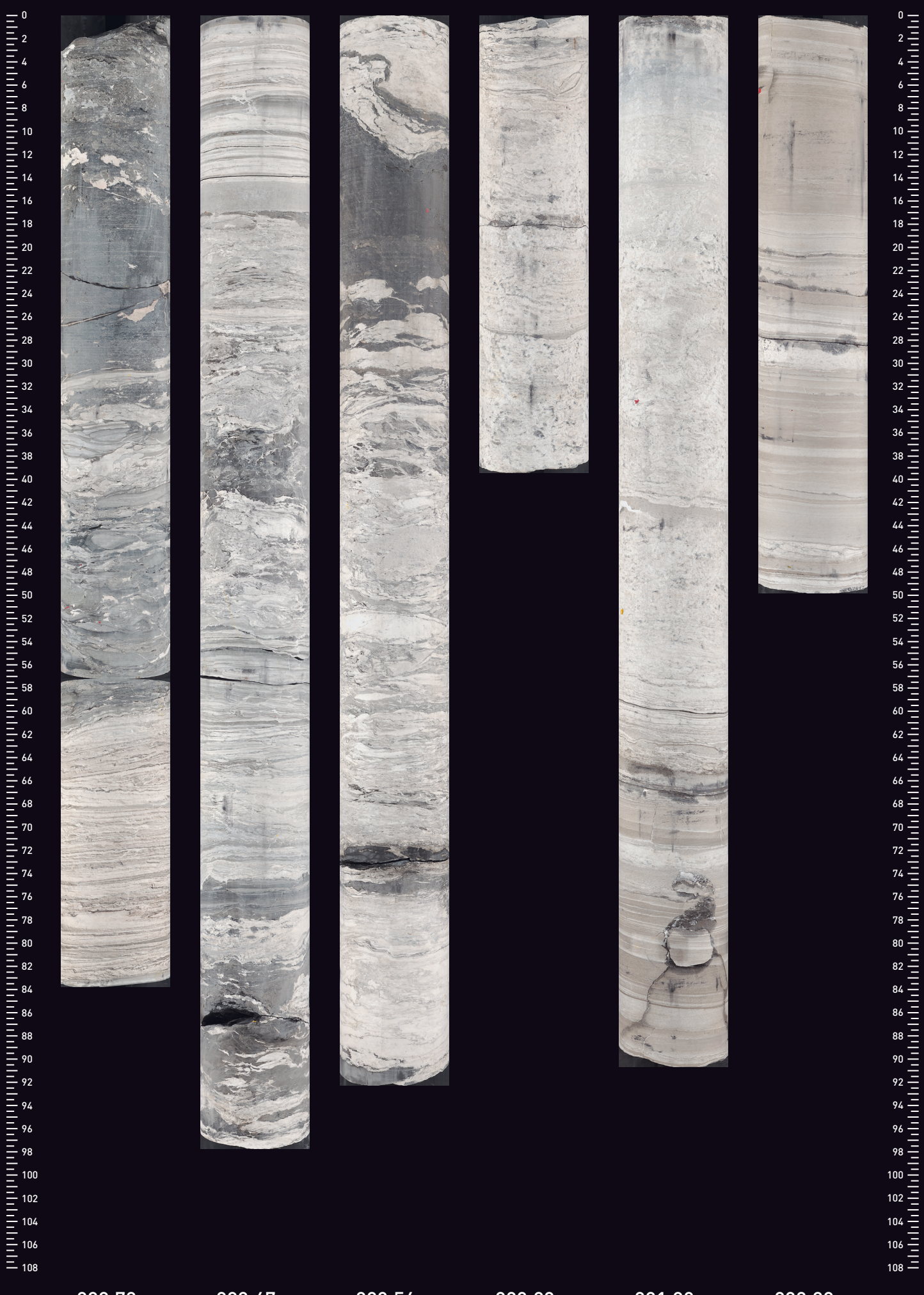


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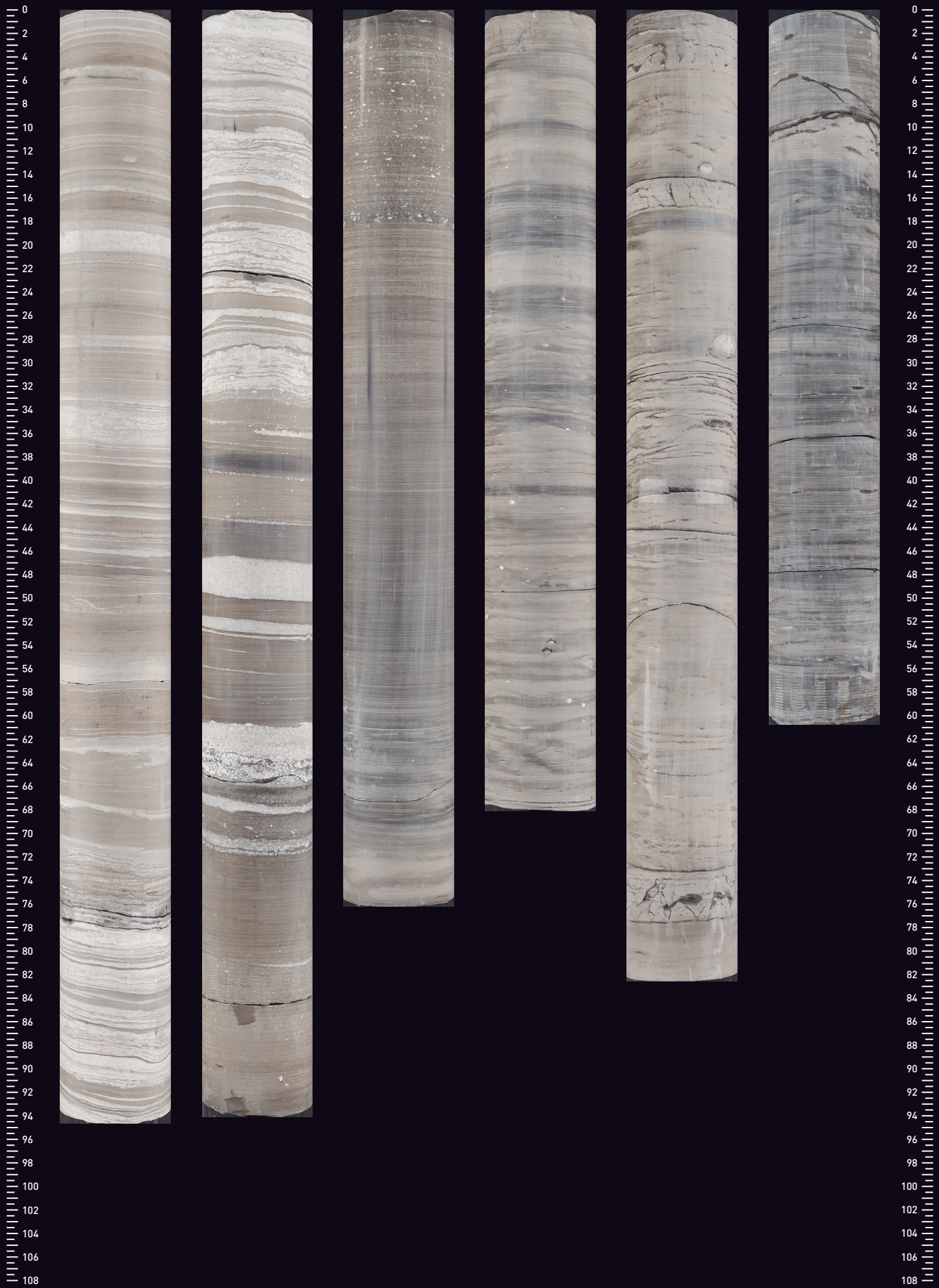
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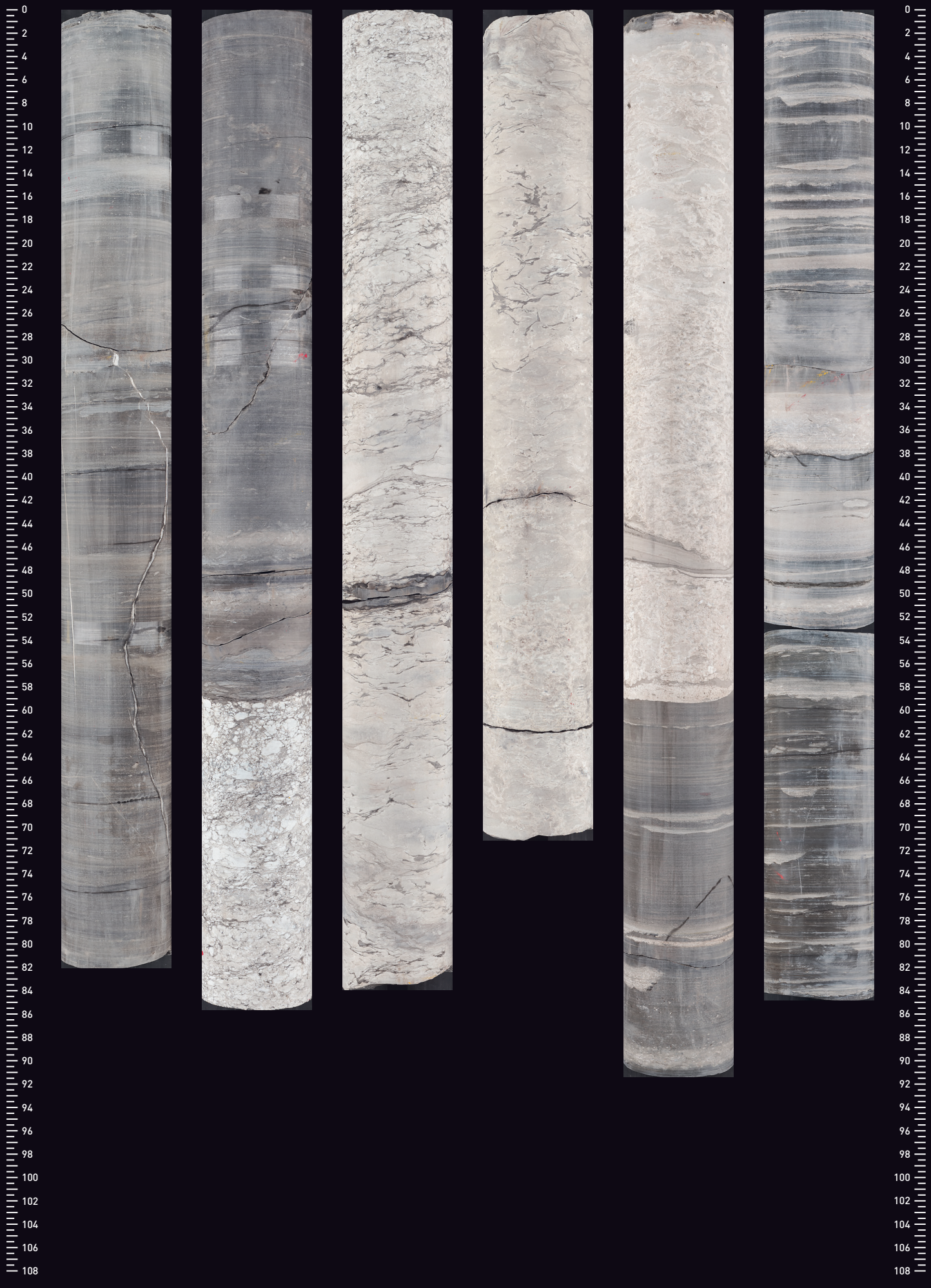

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992.28m 993.20m 994.11m 994.85m 995.50m 996.30m

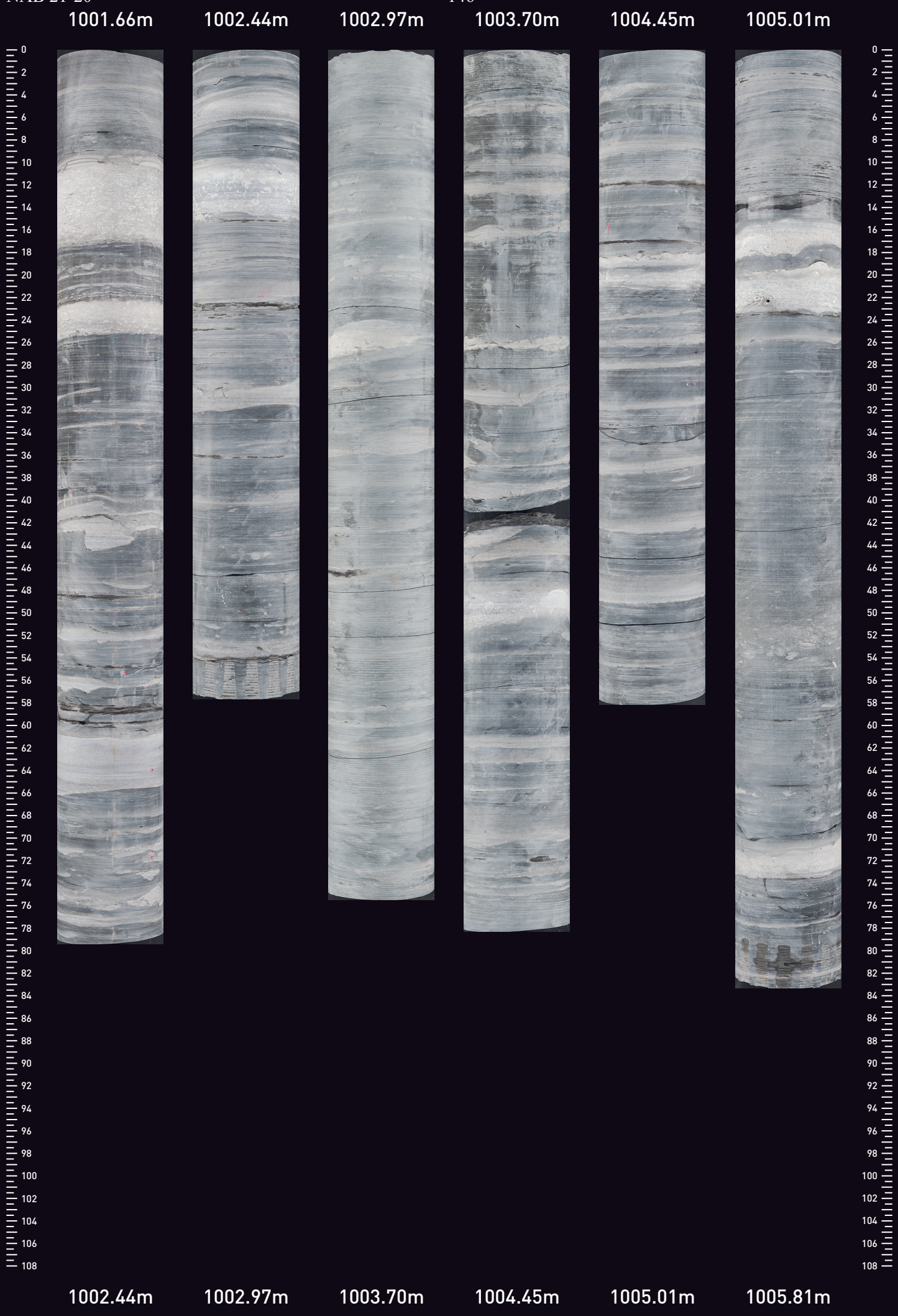


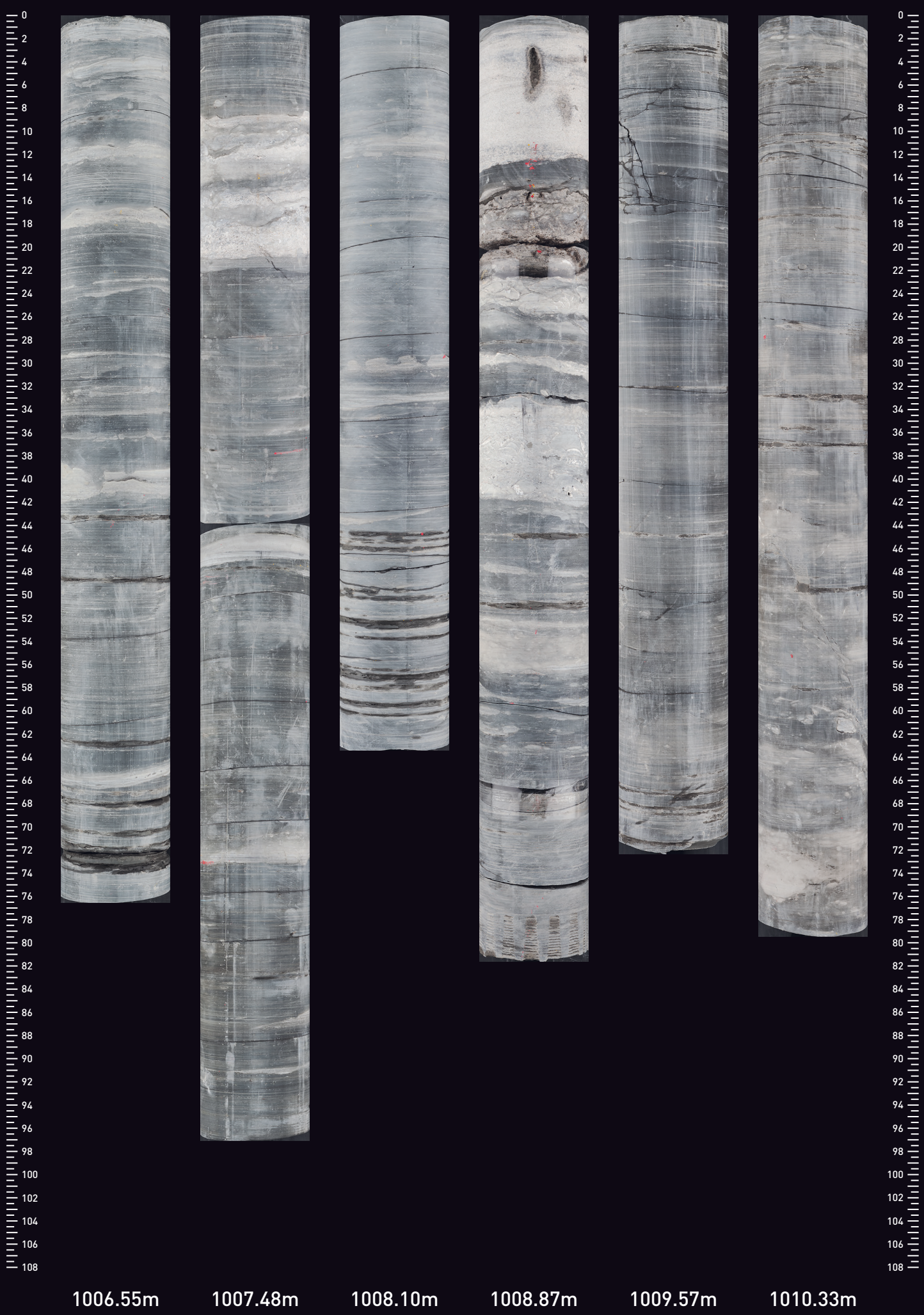
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1005.81m
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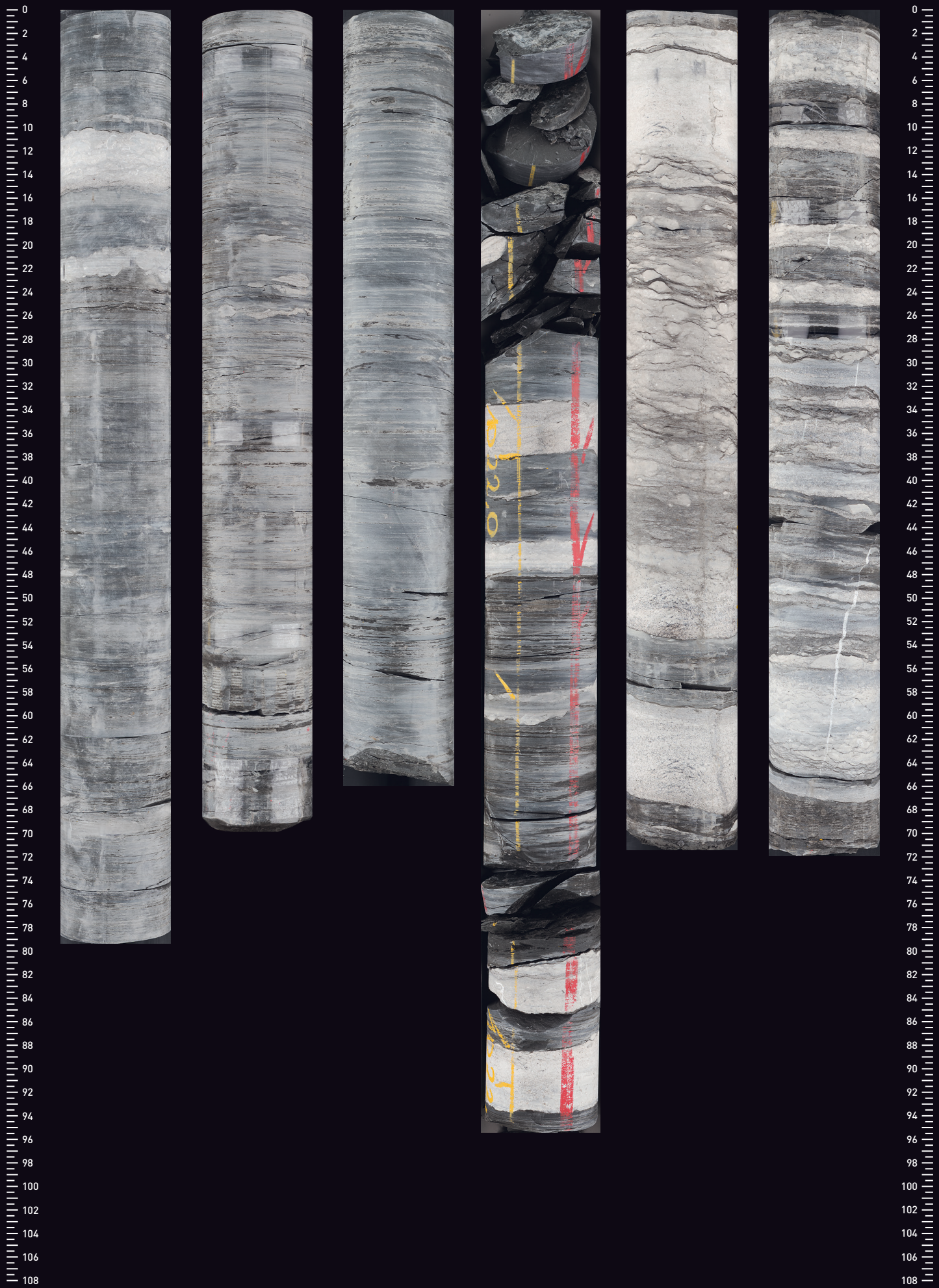
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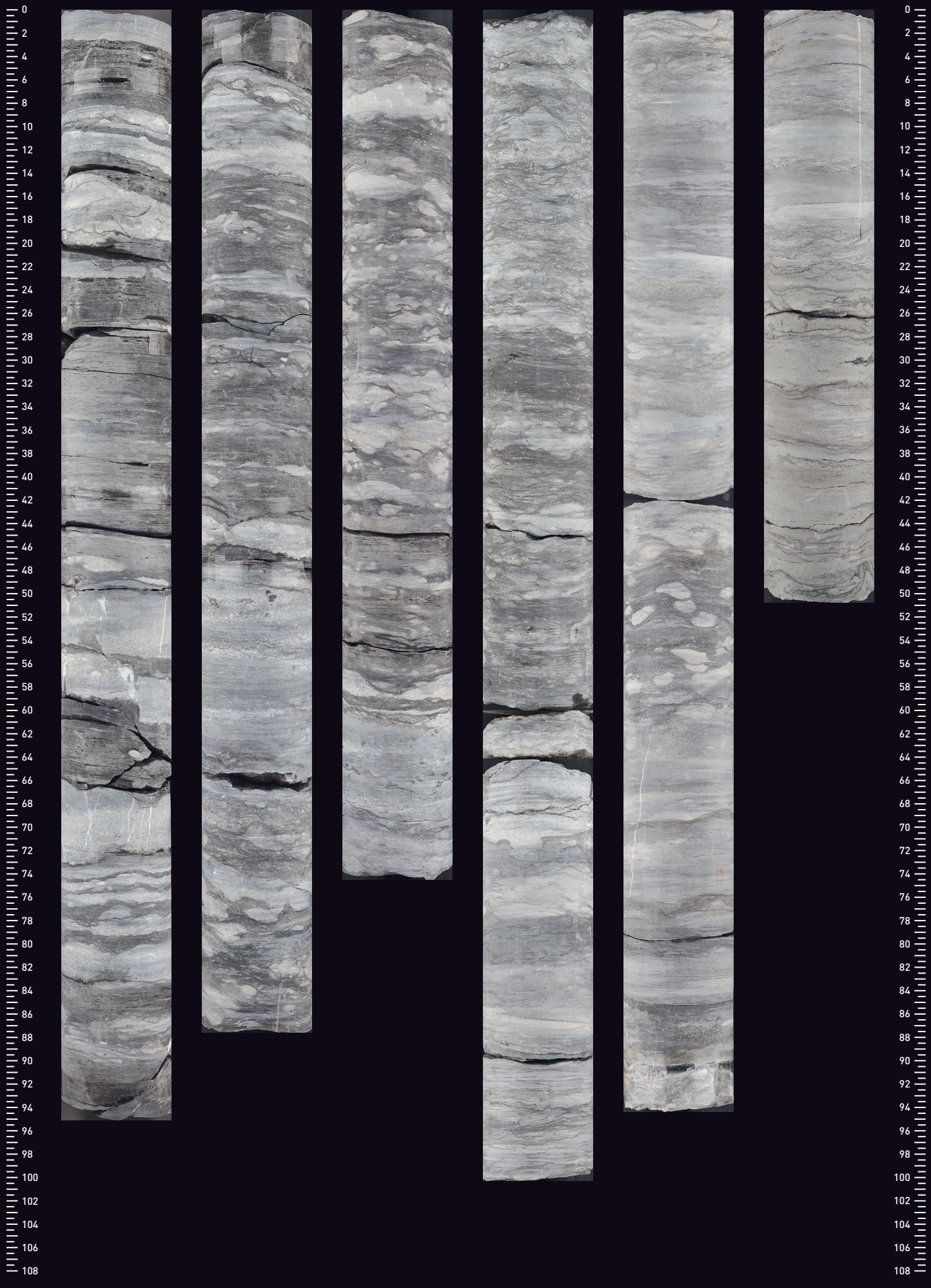
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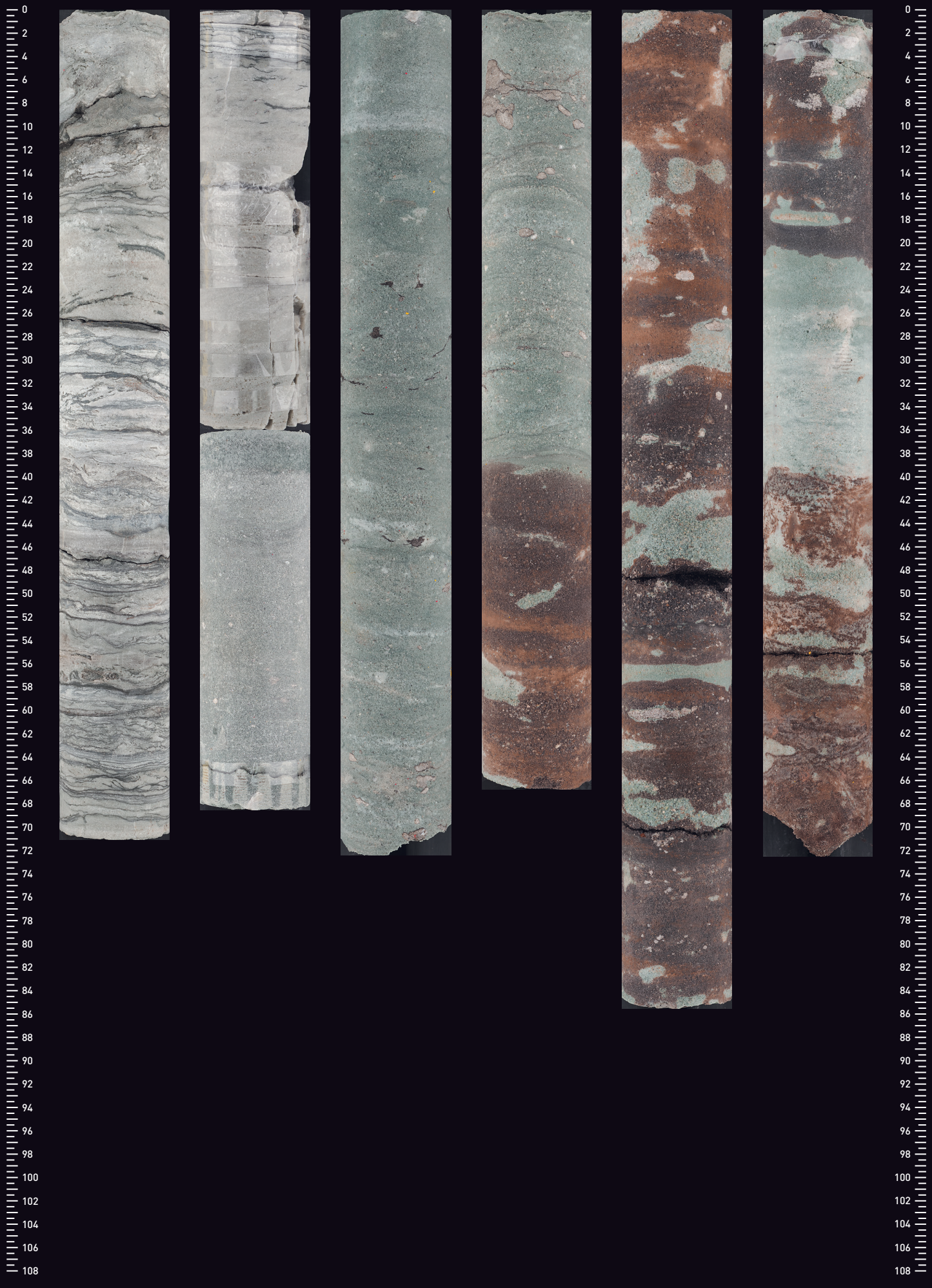
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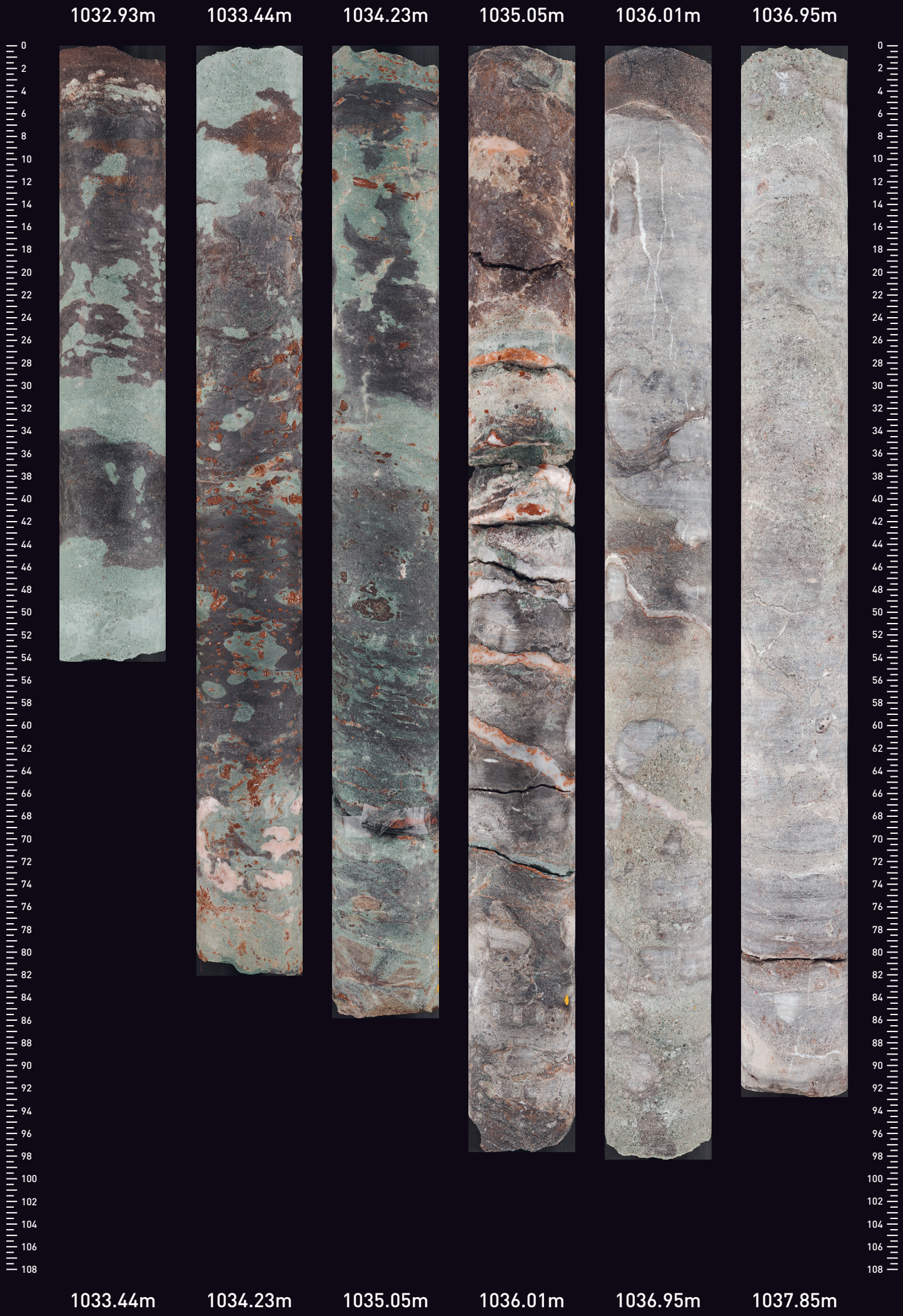
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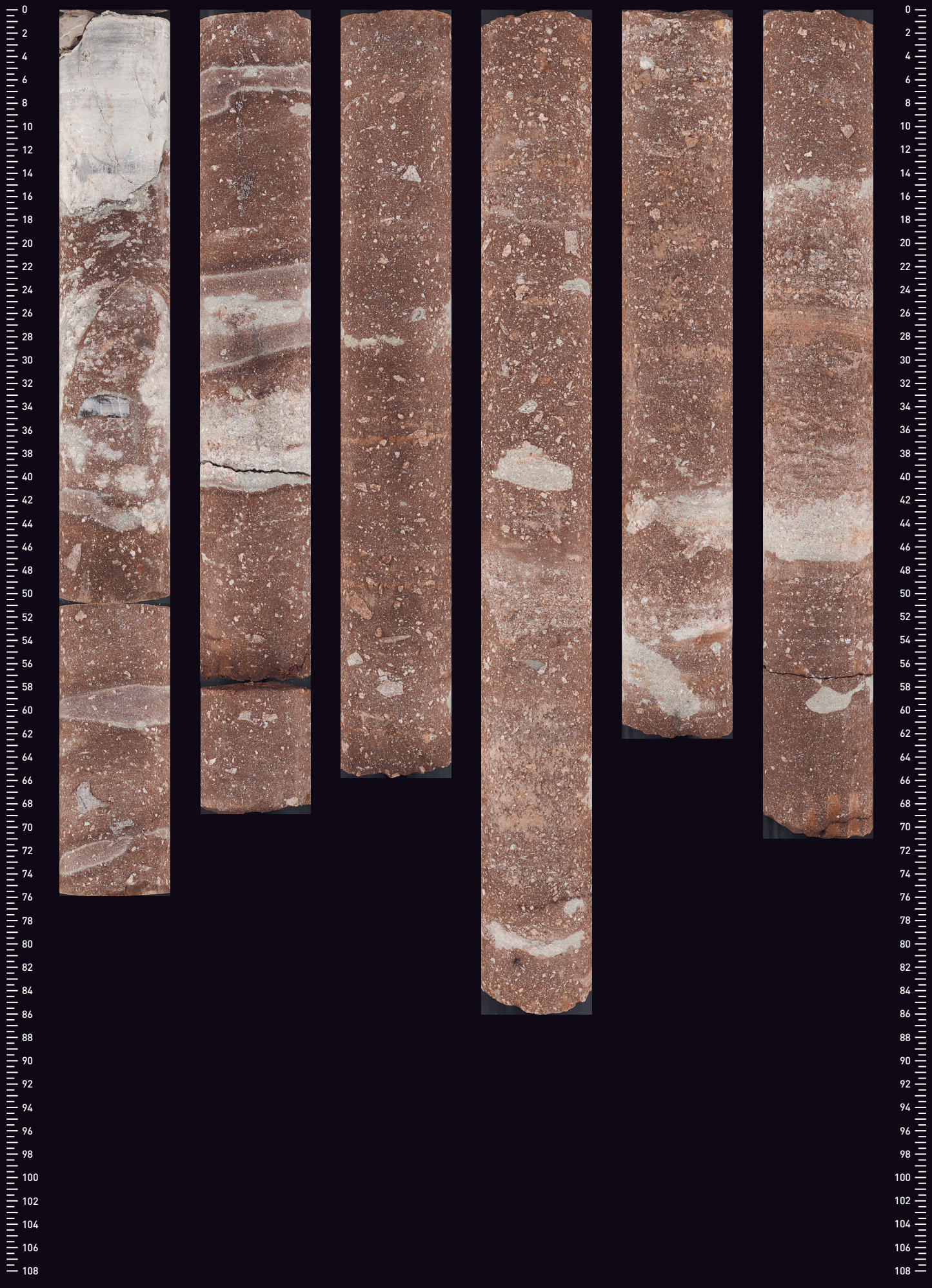
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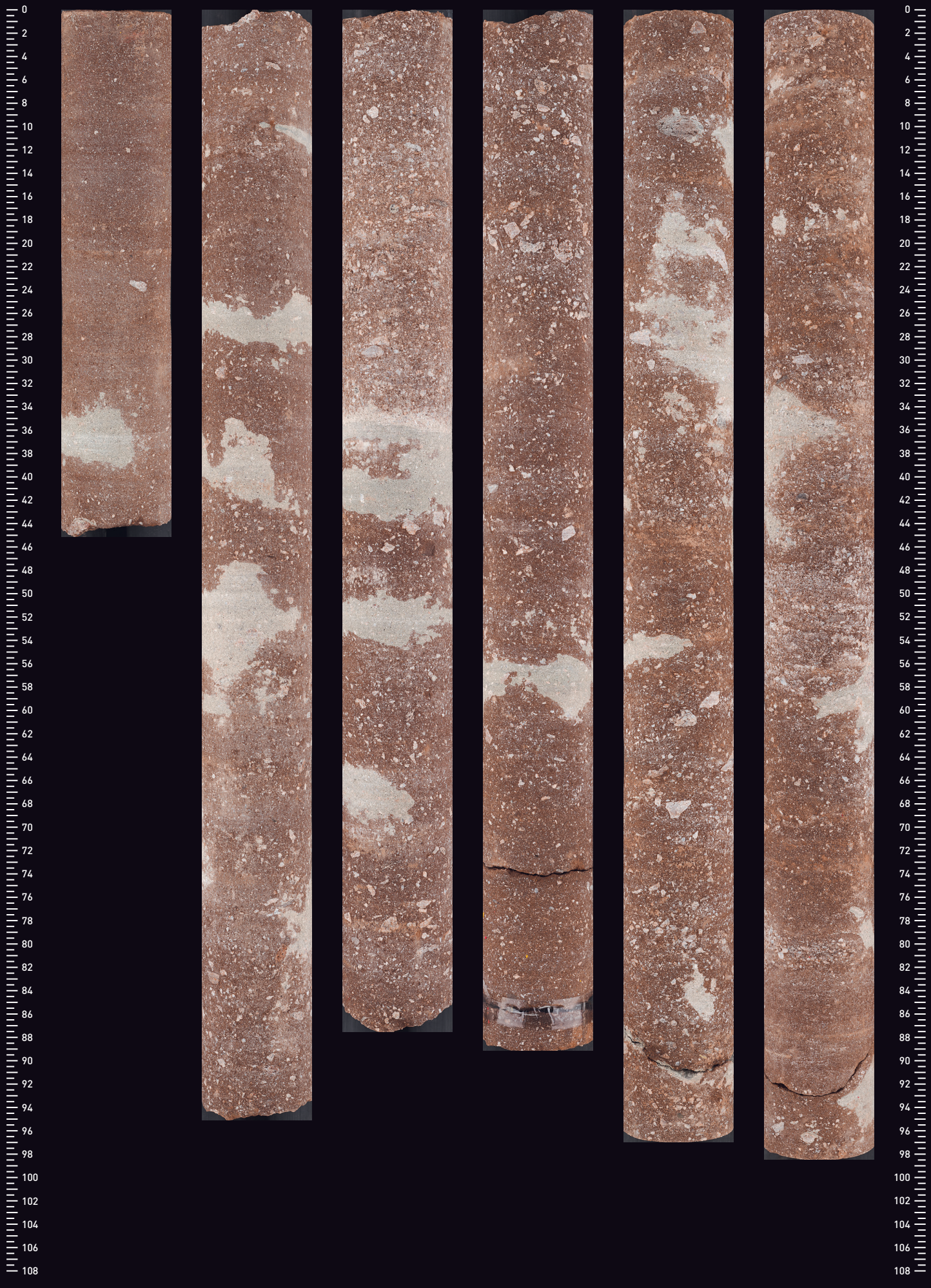
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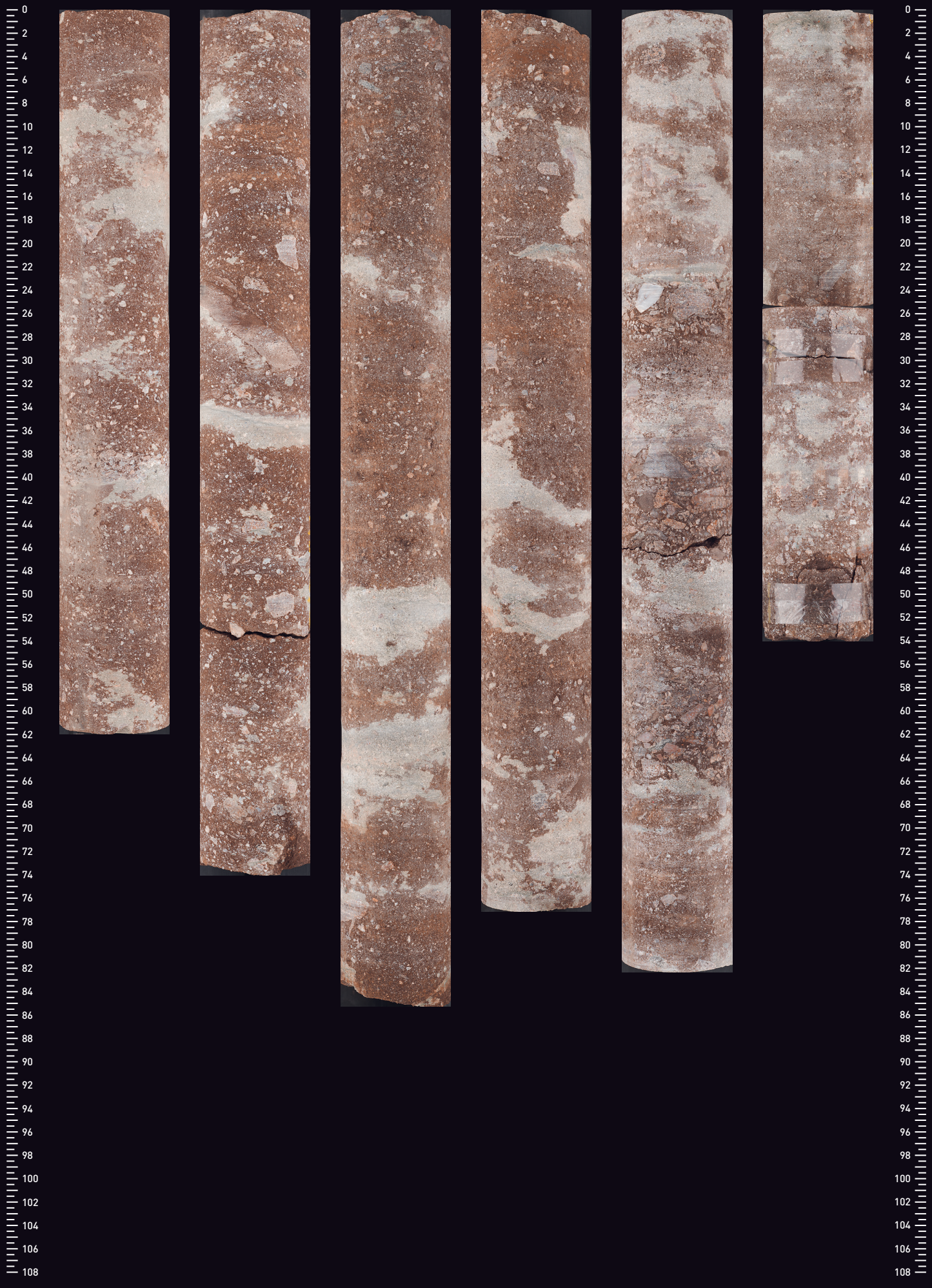
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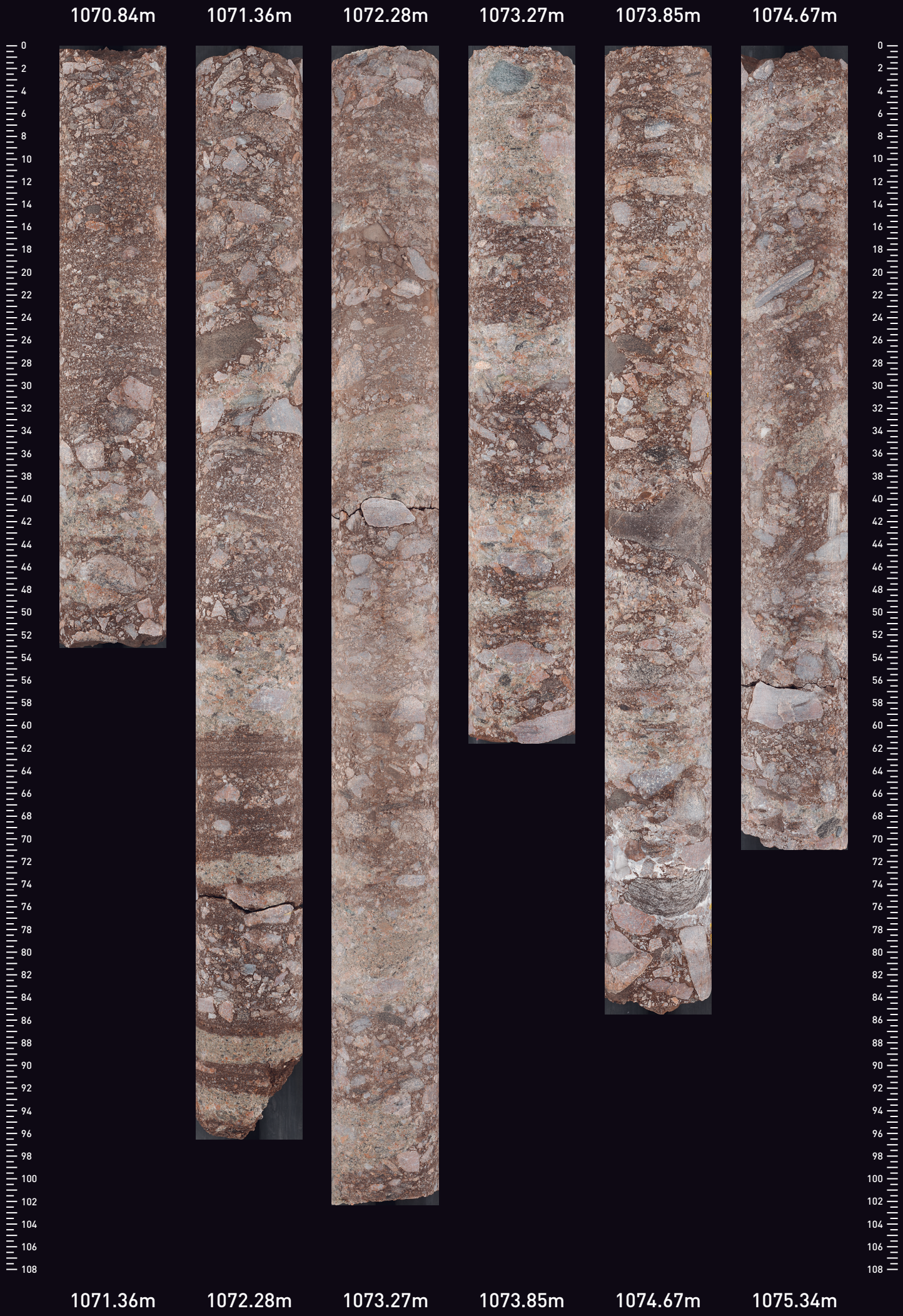
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