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Boremap mapping of core drilled borehole KFM24

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Keywords: Geology, Fractures, OPTV, Boremap, Drill core, AP SFK-16-008.

Summary

This report presents the results from the Boremap mapping of the cored borehole KFM24, which is located 50 metres west of drill site 8, within the designed industry area.

The aim for the borehole KFM24 was to gain additional information about the rock mass in the rock volume hosting a future skip shaft. A secondary aim, and equally important, was to validate the current geological model.

The borehole KFM24 was drilled with an initial bearing 311° and inclination of –83°. The core recovered from the borehole is 512.96 metres.

The fracture frequency in general for open fractures is 0.62 fracture/m and for sealed fractures 0.97 fracture/m.

The dominating rock type (~93 %) in KFM24 is a medium-grained and foliated metagranite to metagranodiorite (101057). Subordinated rock types are pegmatite (101061), aplitic metagranite (101058), amphibolite (102017), metagranitoid (101051) and granite (111058). Rock types less than one metre along the drill core are mapped as rock occurrences and constitute just over 8 % of the borehole. Rock occurrences are dominated by pegmatite to pegmatitic granite and subordinated occurrences are amphibolite, granite, metamorphic granitoid and aplitic metagranite.

The foliation in KFM24 is undulating and commonly of medium intensity.

Sammanfattning

Föreliggande rapport presenterar arbetet med kartering av KFM24. Borrhål KFM24 är beläget i ca 50 meter väster om borrplats 8.

Borrhål KFM24 borrades och undersöktes för att få information om bergvolymen där sänkschaktet kommer att finnas. Inte minst lika viktigt var att validera den aktuella geologiska modellen.

Ansättningsvinklarna för borrhålet är 311°/–83° och kärnan är 512.96 meter.

Frekvensen öppna sprickor är 0,62 per meter och 0,97 för läkta. Den dominerande bergarten, utgör ~93 % är en deformerad, medelkornig metagranit till metagranodiorit (101057). Underordnat förekommer pegmatit till pegmatitisk granit (101061), aplitisk metagranit (101058), amfibolit (102017), metagranitoid (101051) och slutligen den yngsta graniten (111058). Andelen underordnade bergarter utgör ca 8 % av kärnan.

Foliationen är undulerande och vanligtvis medelstark.

Contents

1 Introduction

The cored borehole KFM24 is situated 50 metres west of drill site 8 (DS8), within the designed industry area for the repository for spent nuclear fuel (Figure 1-1). The main aim for borehole KFM24 was to gain additional information about the rock mass in fracture domain FFM01 in the rock volume hosting a future skip shaft, one access to the repository for spent nuclear fuel. Secondary aim was to validate the current geological model. Table 1-1 displays general information about KFM24.

Table 1-1. General information for borehole KFM24

Plane coordinates (RT90 2.5 Gon W)	**y: 6700492, x: 1631153**
Elevation (RHb 70)	1.03 m.a.s.l.
Bearing	311°
Inclination	−83° (from the horizontal plane)
Length, percussion drilled part	35.7 m (from the surface.)
Length, core drilled part	37.2 m to 550.17 m (from the surface.)

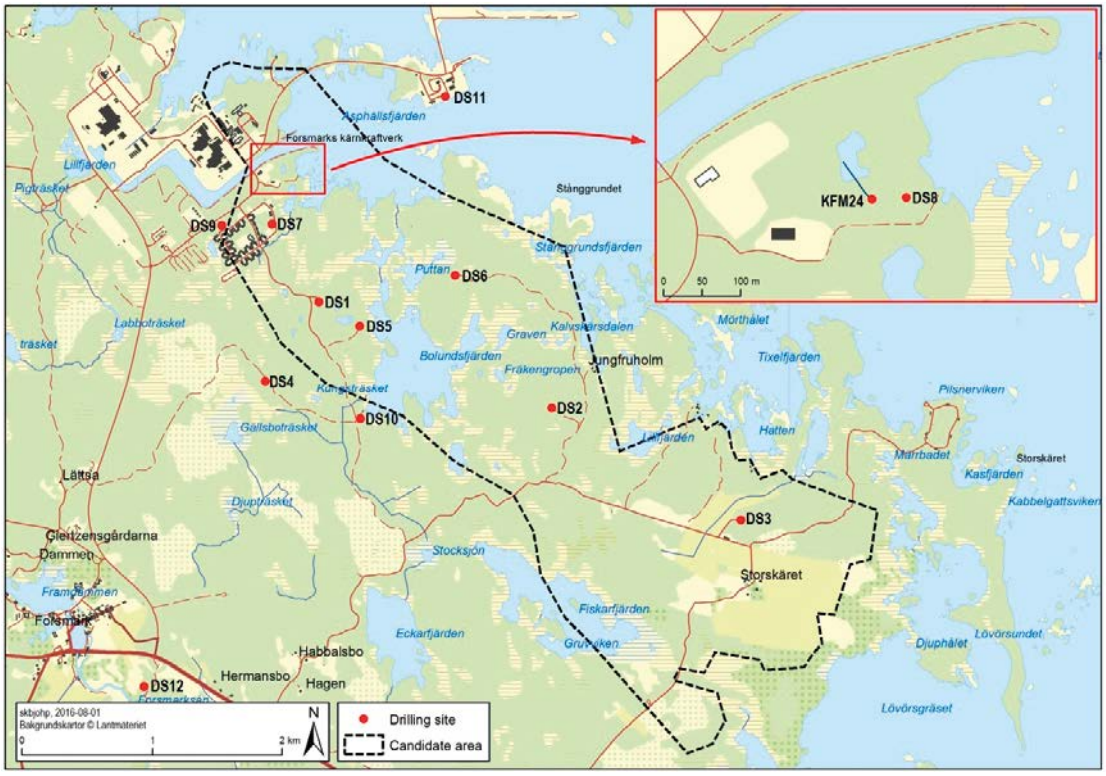


Figure 1-1. *Location of KFM24 and the drill sites 1 to 12.*

2 Objective and scope

This report describes the data obtained from the Boremap mapping of the cored borehole KFM24.

The Data from the reported activity are stored in SKB's database SICADA, but are also traceable by the Activity Plan number (Table 2-1). Only data in the SICADA database are accepted for further interpretation and modelling. The data may be revised, if needed, but such revisions will not necessarily result in a revision of the P-report. However, the normal procedure is that major data revisions entail a revision of the P-report. Minor data revisions are normally presented as supplements, available at www.skb.se.

Mapping of the drill core KFM24 was performed and documented in accordance with the activity plan AP SFK-16-008 (internal SKB document) and the method description for Boremap mapping (Internal SKB document, MD 143.006, Metodbeskrivning för Boremap-kartering). Controlling documents for the Boremap mapping are listed in Table 2-1. Both activity plan and method descriptions are SKB's internal controlling documents in Swedish.

Table 2-1. Controlling documents for the performance of the activity (internal SKB documents).

Document	Number	Version
Boremapkartering av kärnborrhål KFM24	AP SFK-16-008	1.0
Mätsystembeskrivning för Boremap	SKB MD 146.005	2.0
Metodbeskrivning för Boremapkartering	SKB MD 143.006	3.0
Nomenklatur vid Boremapkartering	SKB MD 143.008	1.0
Instruktion: Regler för bergarters benämningar vid platsundersökningen i Forsmark	SKB MD 132.005	1.0

3 Equipment

3.1 Description of equipment and interpretation tools

The core logging was performed with Boremap v. 6.0.1.0. The bedrock and mineral standard used for surface mapping at the Forsmark investigation site is used to enable correlation with the surface geology. Measurements of orientation of planar structures (foliations, fractures, lithological contacts etc.) are made on the linked OPTV-image of the borehole wall, and orientations of the structures are calculated by the Boremap system. Deviation measurements of the borehole and the borehole diameter are used as in-data for the calculations.

The following equipment was used to facilitate the core documentation: folding ruler, 10 % hydrochloric acid, hand lens, paint brush and tap water.

4 Execution

4.1 General

Overview mapping of rock types and fracture frequency in the drill core was executed by Kenneth Åkerström. All observations were made by ocular inspection of the drill core, since no OPTV-image was available.

The Boremap mapping was performed in SKB's facilities in Forsmark between the 5th and 18th of July by Peter Dahlin and Olga Maskenskaya.

4.2 Preparations

The length adjustment of the OPTV-image relative to the core is made with the help of clearly identifiable geological reference features, e.g. rock contacts or specific fractures, which are identified both in the OPTV-image and in the core (Table 4-1). Due to difficulties with the with length adjustments, the standard 30–50 m spacing between reference features was shorter for number 6–7, 8–9 and 10–11.

Table 4-1. Adjusted lengths of the KFM24.

No.	Recorded length (m)	Adjusted length (m)	Reference feature
1	43.30	43.21	Sec up, rock occurrence amphibolite
2	98.87	98.64	Sec low, alteration albitization
3	143.90	143.54	Sec up, rock occurrence amphibolite
4	197.88	197.37	Sealed fracture with calcite/adularia/hematite and oxidized walls. 2 mm wide.
5	243.58	242.87	Sealed fracture with calcite/adularia/hematite and oxidized walls. 9 mm wide.
6	294.20	293.31	Sec low, alteration albitization
7	307.38	306.41	Sealed fracture with high alfa angle
8	358.57	357.49	Sec up, rock type amphibolite
9	366.67	365.51	Sec up, rock occurrence pegmatite
10	408.86	407.56	Open fracture with chlorite
11	417.39	416.07	Sec up, rock occurrence amphibolite
12	453.22	451.71	Sec up, rock occurrence amphibolite
13	513.54	511.78	Sec low, rock occurrence amphibolite

4.3 Concepts used during mapping

The core logging with the Boremap system is based on the use of OPTV-image of the borehole wall and the simultaneous study of the drill core. Measurements such as orientations widths/aperture of a fracture are based on OPTV-image, whereas other data such as rock type, alteration, fracture mineralogy and surface are observed in the drill core.

4.3.1 Feature definitions

Definitions of different fracture types and their apertures, rock type and rock occurrence are found in SKB MD 143.008 (Nomenklatur vid Boremapkartering, internal SKB document).

4.4 Data handling

The mapping data was uploaded from the local database to the SICADA database twice a day; before lunch and at the end of the day.

When the mapping was completed, a summary report was extracted from the Boremap software to check the whole mapping for possible errors such as unlikely mineral fillings or unlikely lithological features.

4.5 Nonconformities

4.5.1 Overrepresented fracture mineral

The occurrence of calcite in fractures might be overrepresented relative to other minerals, since it is detected by reaction with diluted hydrochloric acid even though it is macroscopically invisible.

5 Results

The mapping results of KFM24 are stored in the SICADA database under the name KFM24_PD_OM_2.

Results from the mapping are briefly described in this chapter and the OPTV-image is given in Appendix 1 as a WellCad-diagram.

5.1 Lithology

The rock type distribution of KFM24, shown in Table 5-1, is supporting this lithological predication. The division into different generations of rocks are based on both absolute and relative dating.

Table 5-1. Rock types of the KFM24.

%	Description	Number	Generation
92.8	Metagranite to metagranodiorite, medium grained, foliated to lineated	101057	B
3.6	Pegmatitic granite	101061	D
2.1	Metagranite to metatonalite, fine to medium grained	101051	C
1.1	Amphibolite, fine to medium grained	102017	B
0.4	Granite, fine to medium grained	111058	D

The medium-grained metagranite (rock code 101057) is non-equigranular with elongated quartz domains, alternating with feldspar-dominated domains and undulating streaks of biotite. Deformation is manifested in foliation (and lineation) and is generally medium in intensity, with intervals of strong foliation, especially in the lithological contact zones.

Medium to coarse grained pegmatitic granite mainly occur as rock occurrences (see below) is massive and do not show any obvious signs of deformation. Dykes, veins and pegmatite and pegmatitic granite are the most frequent occurrences in KFM24 (cf. Table 5-2).

The fine- to medium-grained, metagranitoid (granite to tonalitic in composition) is characteristically less deformed than the metagranite.

Amphibolite occurrences range from fine to medium grained, and seems less deformed than the metagranite. However, this is probably due to the homogeneous content of ferromagnesian minerals in the amphibolites contrasting the mineralogically heterogeneous metagranite, which show foliation more readily.

Rock occurrences constitute 8.6% of the core and the distribution is shown in Table 5-2. Contacts of amphibolite occurrences are more or less parallel with the tectonic foliation and in places bounded by up to one decimetre wide rims of bleached wall rock, inferred to as albitization.

Table 5-2. Rock occurrences distribution of the KFM24.

%	Description	Number	Generation
68.2	Pegmatitic granite	101061	D
16.5	Amphibolite, fine to medium grained	102017	B
5.9	Granite, fine to medium grained	111058	D
4.7	Aplitic metagranite, deformed	101058	B
4.7	Metagranite to tonalite, fine to medium grained	101051	C

5.2 Fractures

The total amount of fractures mapped in KFM24 is 823; broken fractures are 354 and 469. Broken fractures with aperture are 318. The fractures per metre average for open are 0.6 and 1.0 for sealed. Occurrence of mineral fillings and alteration of open fractures are shown in Table 5-3 and for sealed fractures in Table 5-4.

Table 5-3. Proportion of mineral infilling and alteration in open fractures.

%	No	Mineral
74.2	236	Chlorite
48.4	154	Calcite
19.8	63	Oxidized walls
17	54	Pyrite
11.3	36	No detectable mineral
5.7	18	Quartz
5.0	16	Laumontite
0.9	3	Prehnite
0.9	3	Adularia
0.9	3	Hematite
0.6	2	Iron hydroxide
0.6	2	Clay Minerals
0.3	1	Epidote

Table 5-4. Proportion of mineral infilling and alteration in sealed fractures.

%	No	Mineral
74.4	369	Oxidized walls
31.0	154	Adularia
25.2	125	Calcite
23.0	114	Chlorite
19.8	98	Hematite
5.6	28	Epidote
3.8	19	Quartz
3.6	18	No detectable mineral
3.2	16	Laumontite
2.4	12	Prehnite
2.2	11	Pyrite
0.2	1	Unknown mineral

5.3 Brittle structures

Sections with extensive sealed network or crush have not been identified in borehole KFM24. However, at 278 m length, a clast to matrix-supported breccia occurs in the meta-granite to meta-granodiorite, along 18 cm the borehole (Figure 5-1). The orientation of the breccia is 033°/86°, with clasts ranging between 0.5 and 5 cm in a chlorite filled matrix.

Figure 5-1. *Clast to matrix-supported breccia at 278 m length.*

5.4 Ductile structures

The rock types in borehole KFM24 commonly show medium intensity foliation and lineation. Worth highlighting is the shift in strike that occurs at 320 m length (Figure 5-2A), whereas the dip do not show any obvious change at 320 m (Figure 5-2B). This shift is authentic and not an effect of a change in dip of the foliation in respect to the plunge of the borehole (cf. Figure 5-2B).

The foliation and the rock occurrences of amphibolite are shown in Figure 5-3, indicating their common deformation history.

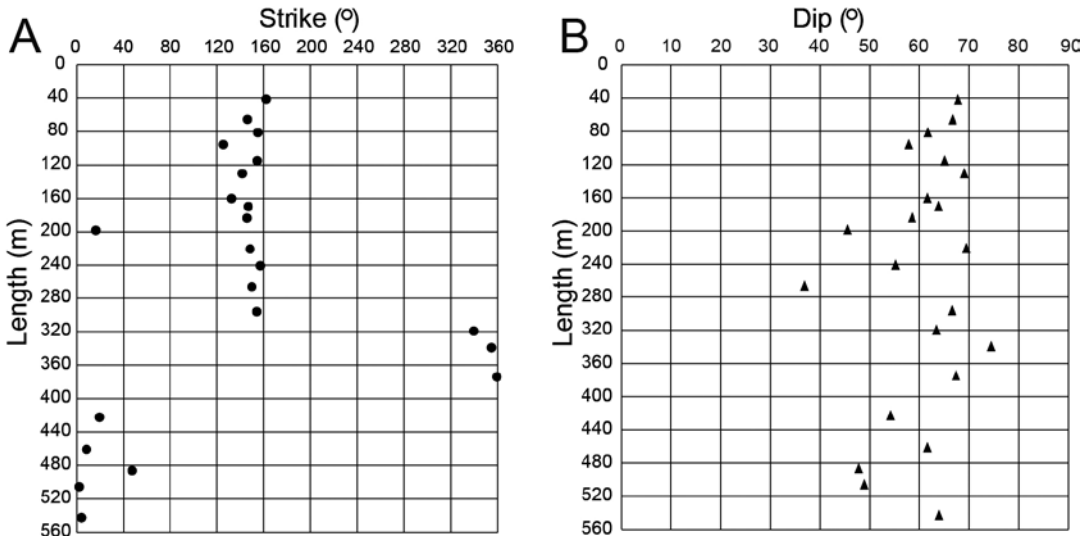


Figure 5-2. *A) Strike of foliation versus drillcore length. An abrupt change in strike occurs at ca 320 m length and with one outlier at ca 200 m length. B) Dip of foliation versus drillcore length. Now obvious change in dip is visible at 320 m length.*

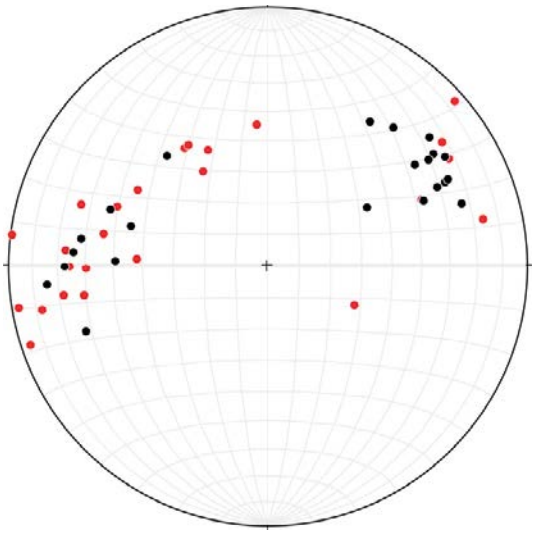


Figure 5-3. *Lower hemisphere, equal area stereonet displaying the orientation of foliation (black dots) and amphibolite occurrences (red dots).*

5.5 Alteration

Albitization is the most common alteration type and covers 3.5 % of the borehole. It is in general associated to amphibolite, whereas oxidation is related to fractures.

Appendix 1

Borehole Image Report

Borehole Name:

Mapping Name:

Mapping Range: 0.000 - 0.000 m

Diameter: 100.0 mm

Printed Range: 37.030 - 549.409

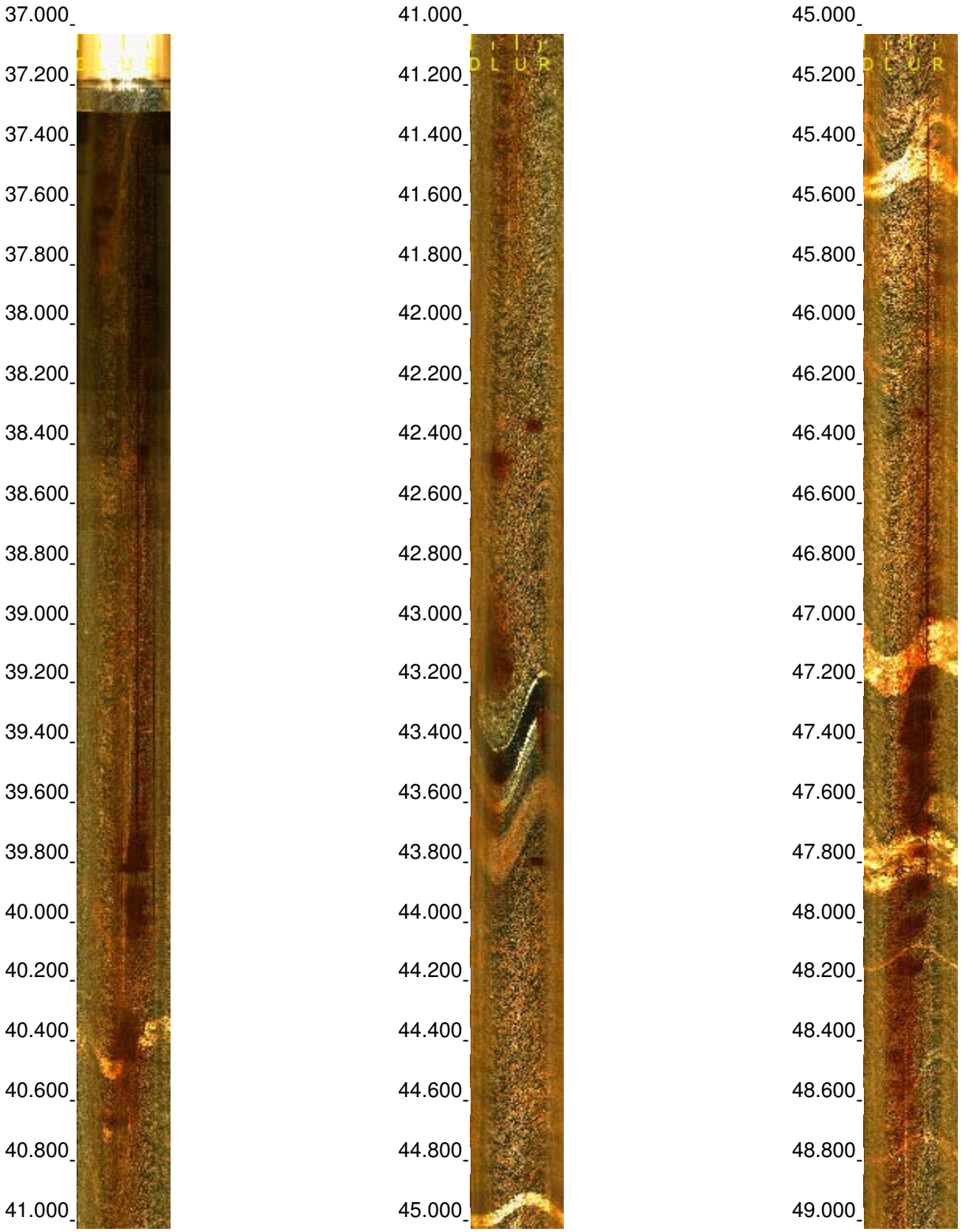
Pages: 44

Image File Information:

File:	G:\skb\boremap\forsmark\OPTV\KFM24ner160704\LGX\KFM24ner160704_H_LGX.HED
Date/Time:	2016-07-04
Start Depth:	37.030 m
End Depth:	549.409 m
Resolution:	1.00 mm/pixel (depth)
Orientation:	Gravimetric
Image height:	512380 pixels
Image width:	720 pixels
Intrinsic angle:	180 degrees
LGX Version:	101
Locality:	
Wellname:	
Scan Direction:	Down

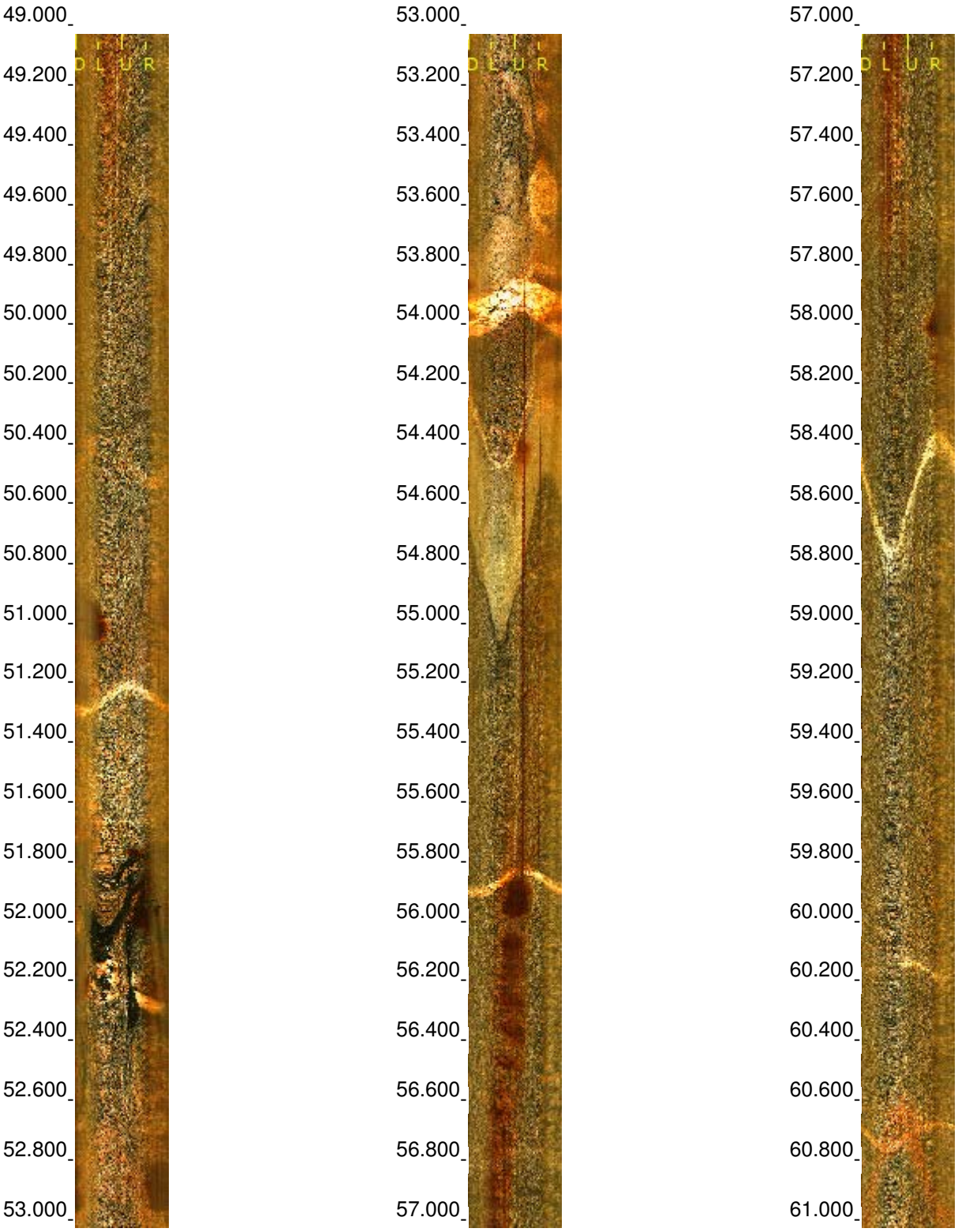
Borehole:
Mapping:

Depth range: 37.030 - 49.030 m
Azimuth: 0.0
Inclination: -90.0



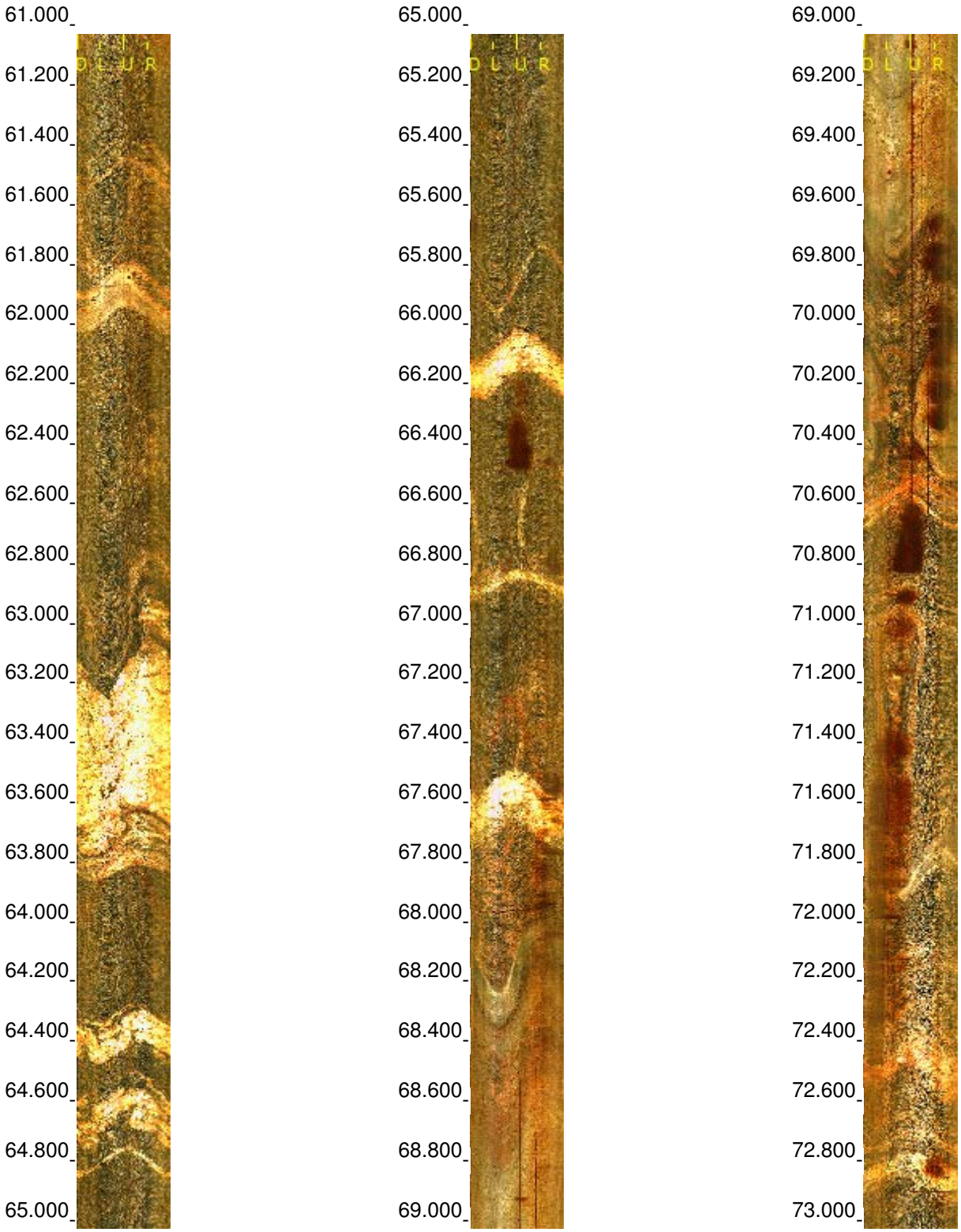
Borehole:
Mapping:

Depth range: 49.030 - 61.030 m
Azimuth: 0.0
Inclination: -90.0



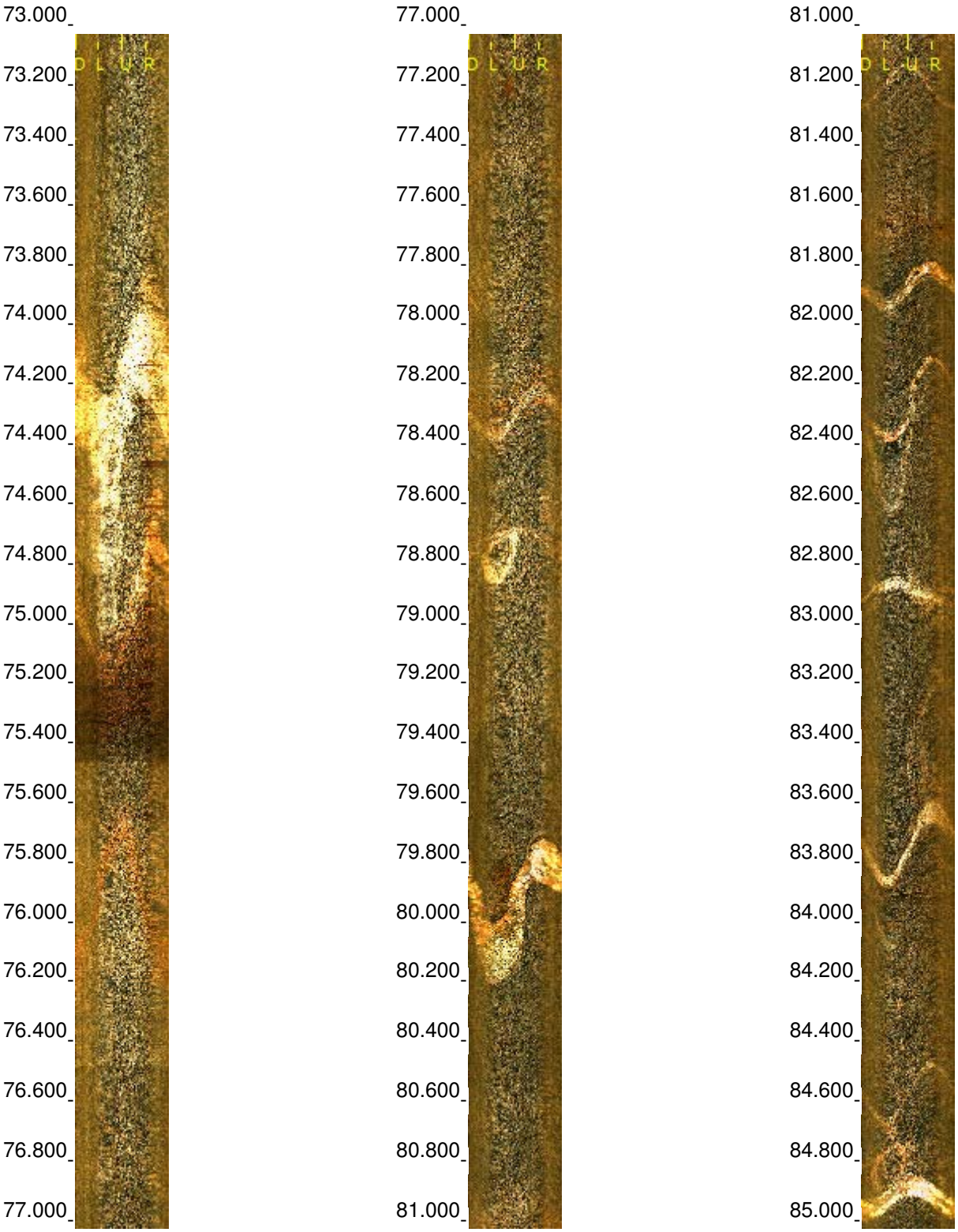
Borehole:
Mapping:

Depth range: 61.030 - 73.030 m
Azimuth: 0.0
Inclination: -90.0



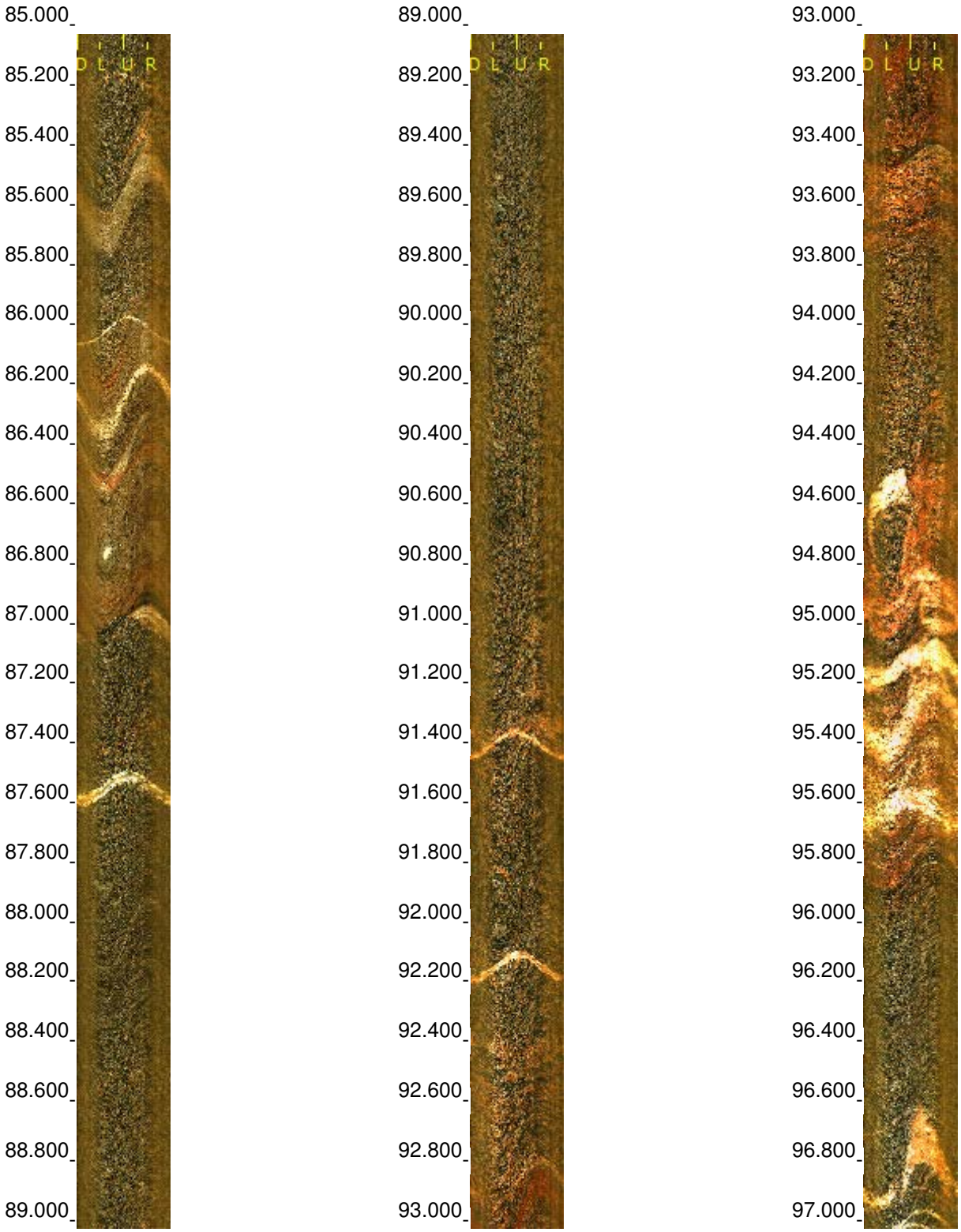
Borehole:
Mapping:

Depth range: 73.030 - 85.030 m
Azimuth: 0.0
Inclination: -90.0



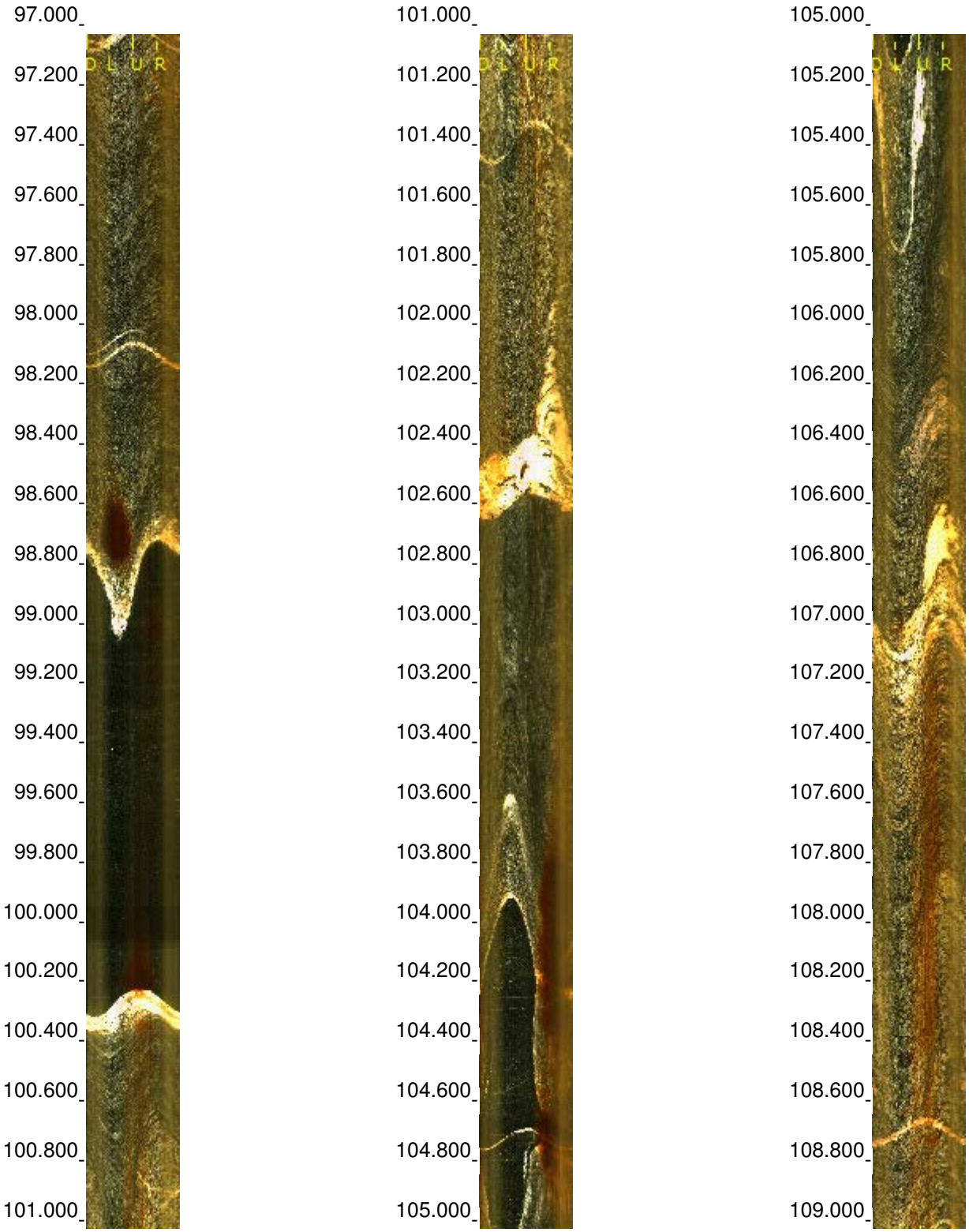
Borehole:
Mapping:

Depth range: 85.030 - 97.030 m
Azimuth: 0.0
Inclination: -90.0



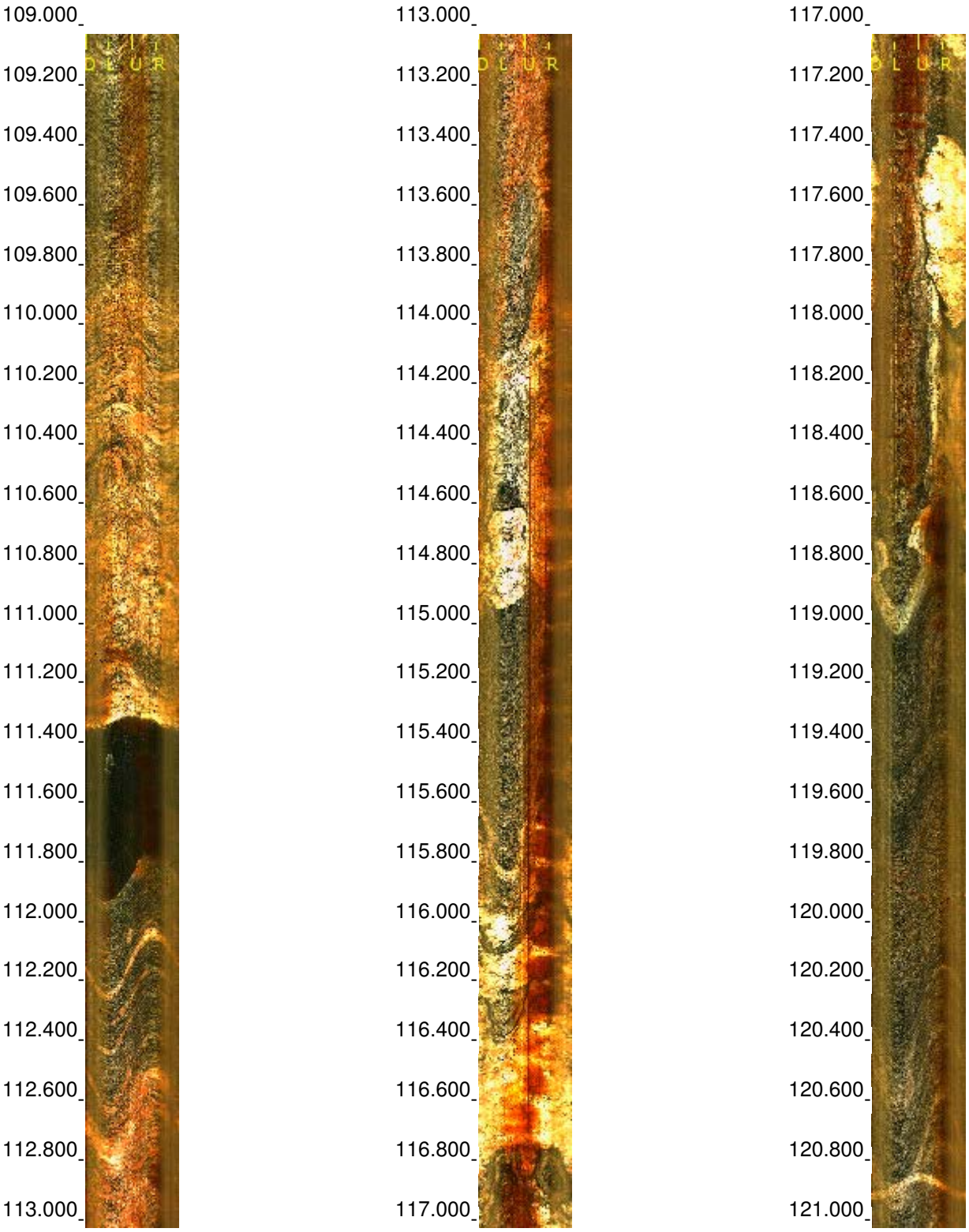
Borehole:
Mapping:

Depth range: 97.030 - 109.030 m
Azimuth: 0.0
Inclination: -90.0



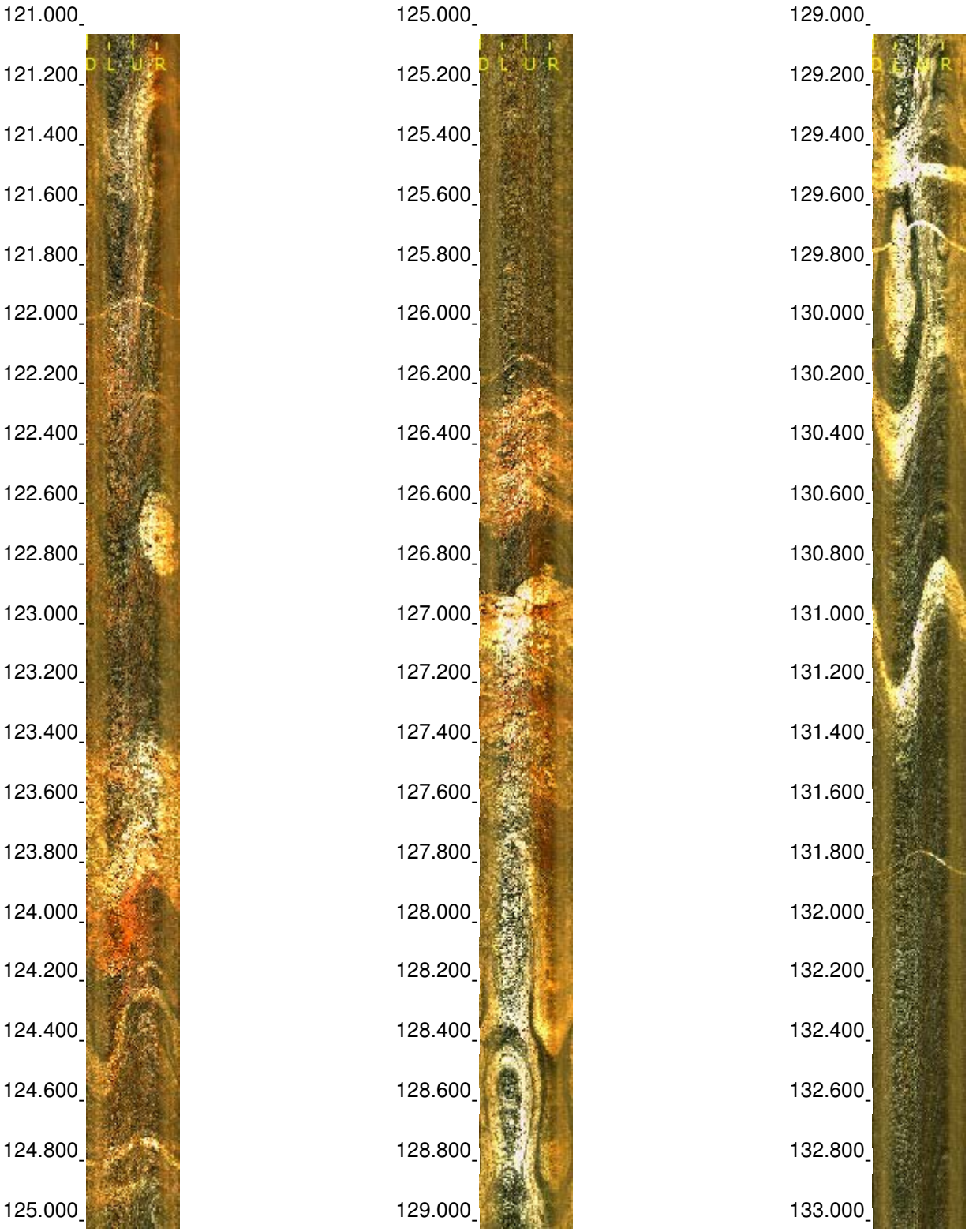
Borehole:
Mapping:

Depth range: 109.030 - 121.030 m
Azimuth: 0.0
Inclination: -90.0



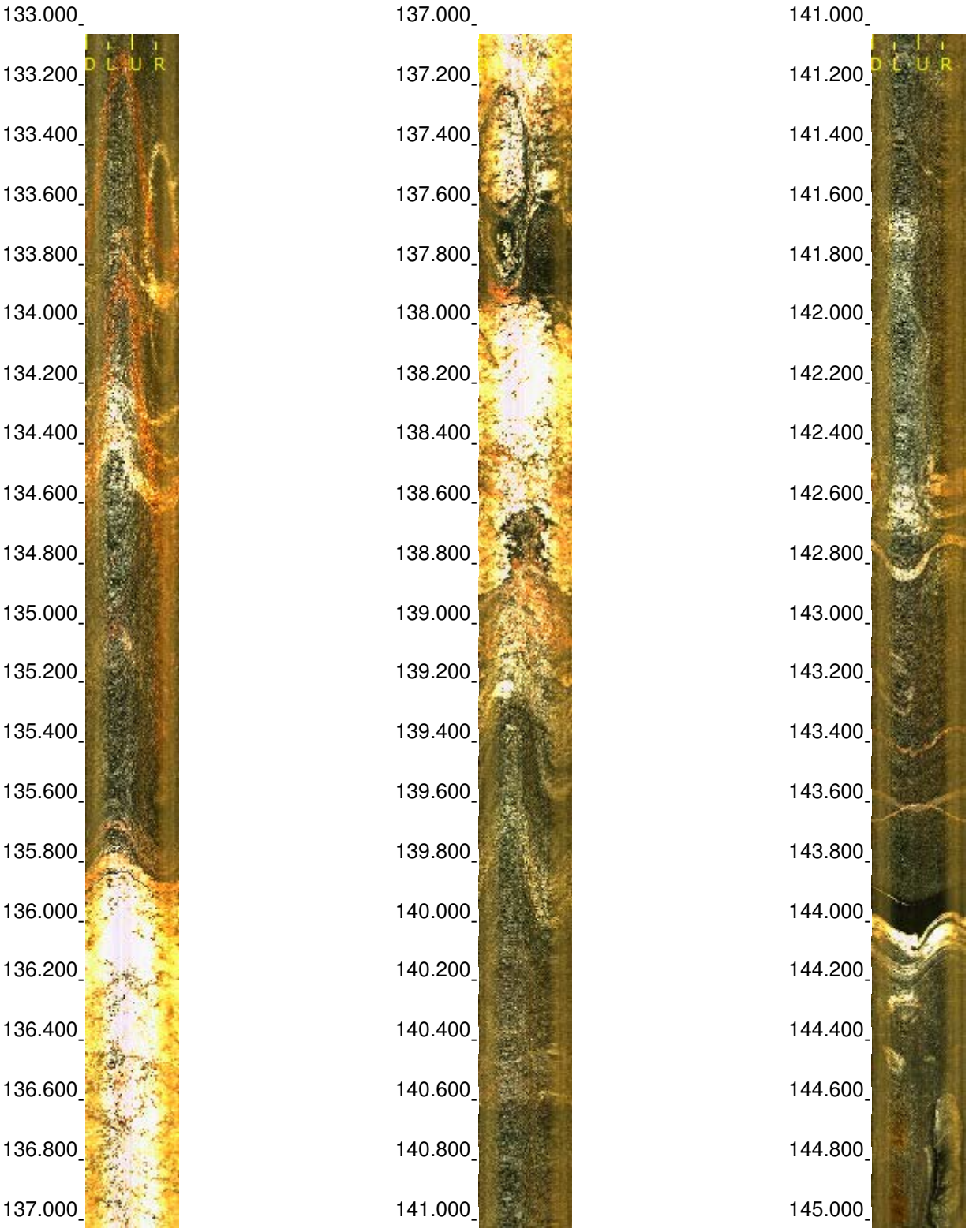
Borehole:
Mapping:

Depth range: 121.030 - 133.030 m
Azimuth: 0.0
Inclination: -90.0



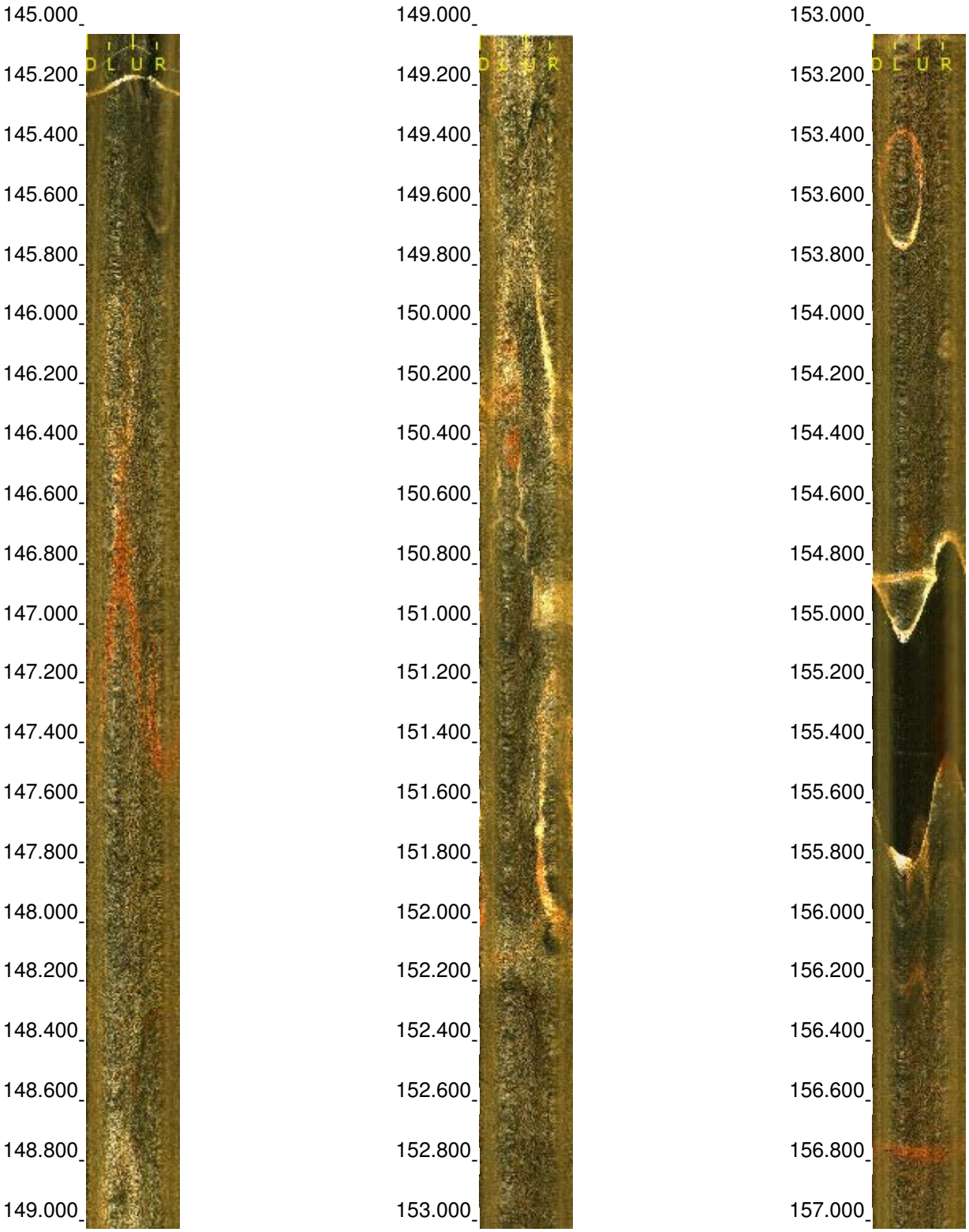
Borehole:
Mapping:

Depth range: 133.030 - 145.030 m
Azimuth: 0.0
Inclination: -90.0



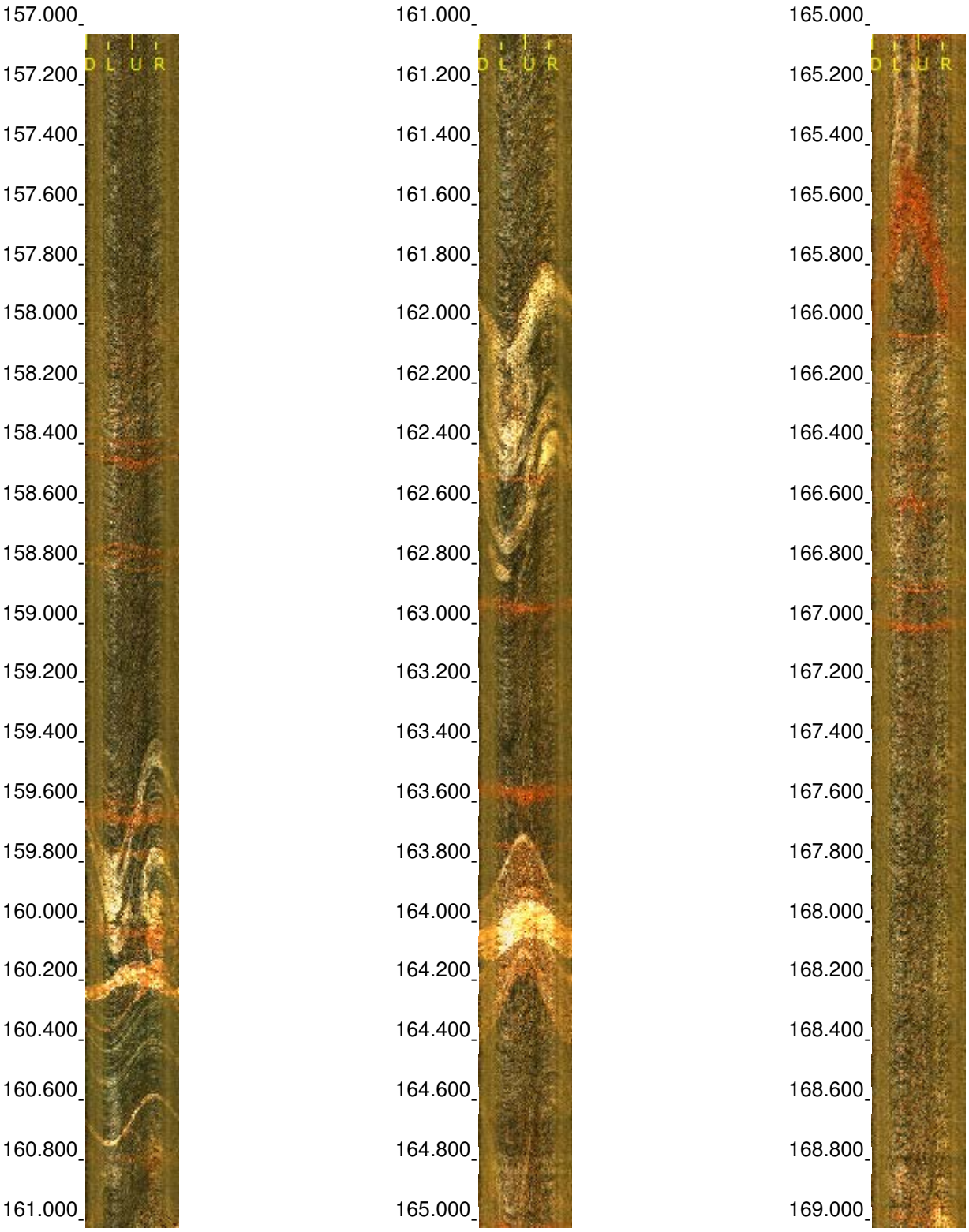
Borehole:
Mapping:

Depth range: 145.030 - 157.030 m
Azimuth: 0.0
Inclination: -90.0



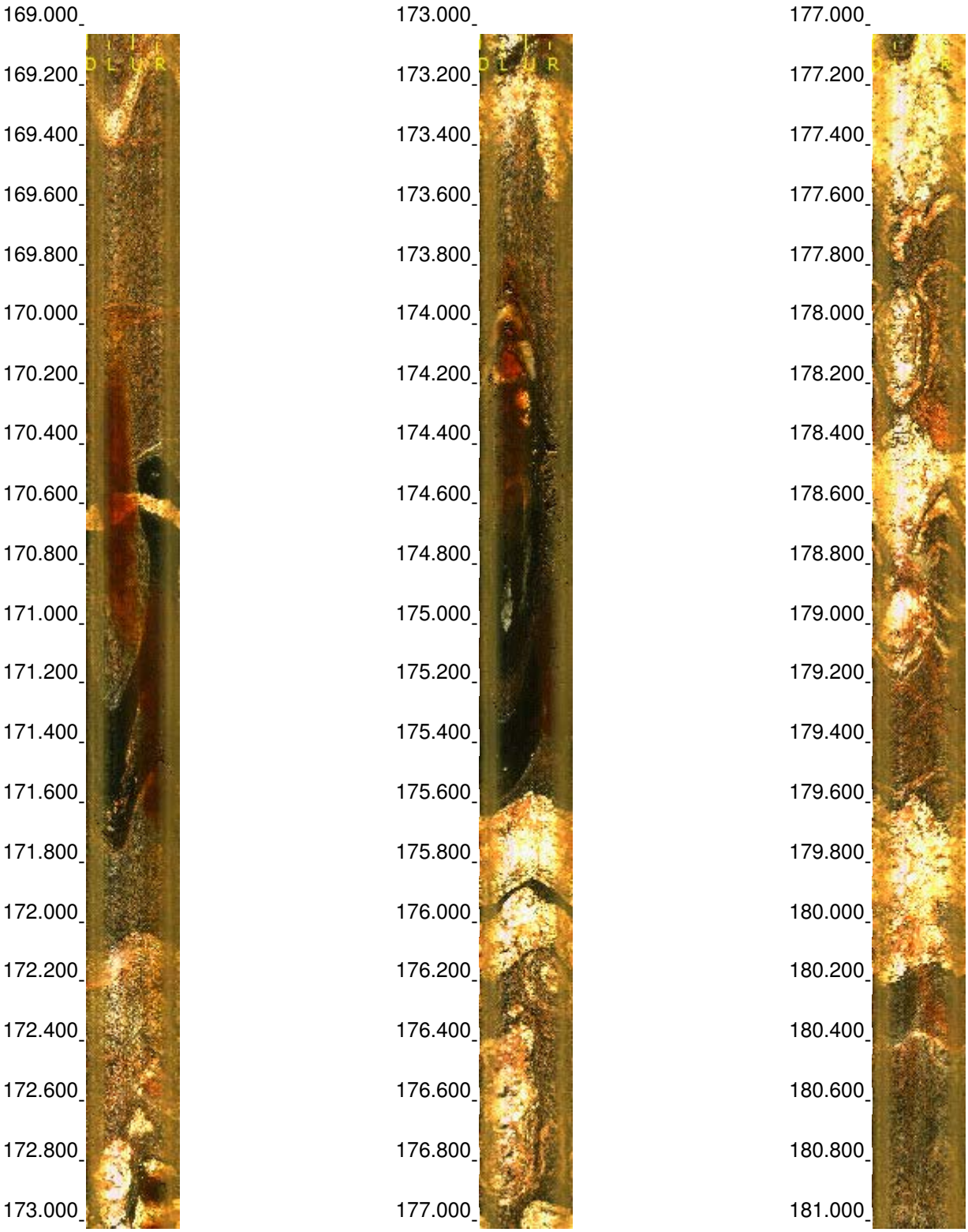
Borehole:
Mapping:

Depth range: 157.030 - 169.030 m
Azimuth: 0.0
Inclination: -90.0



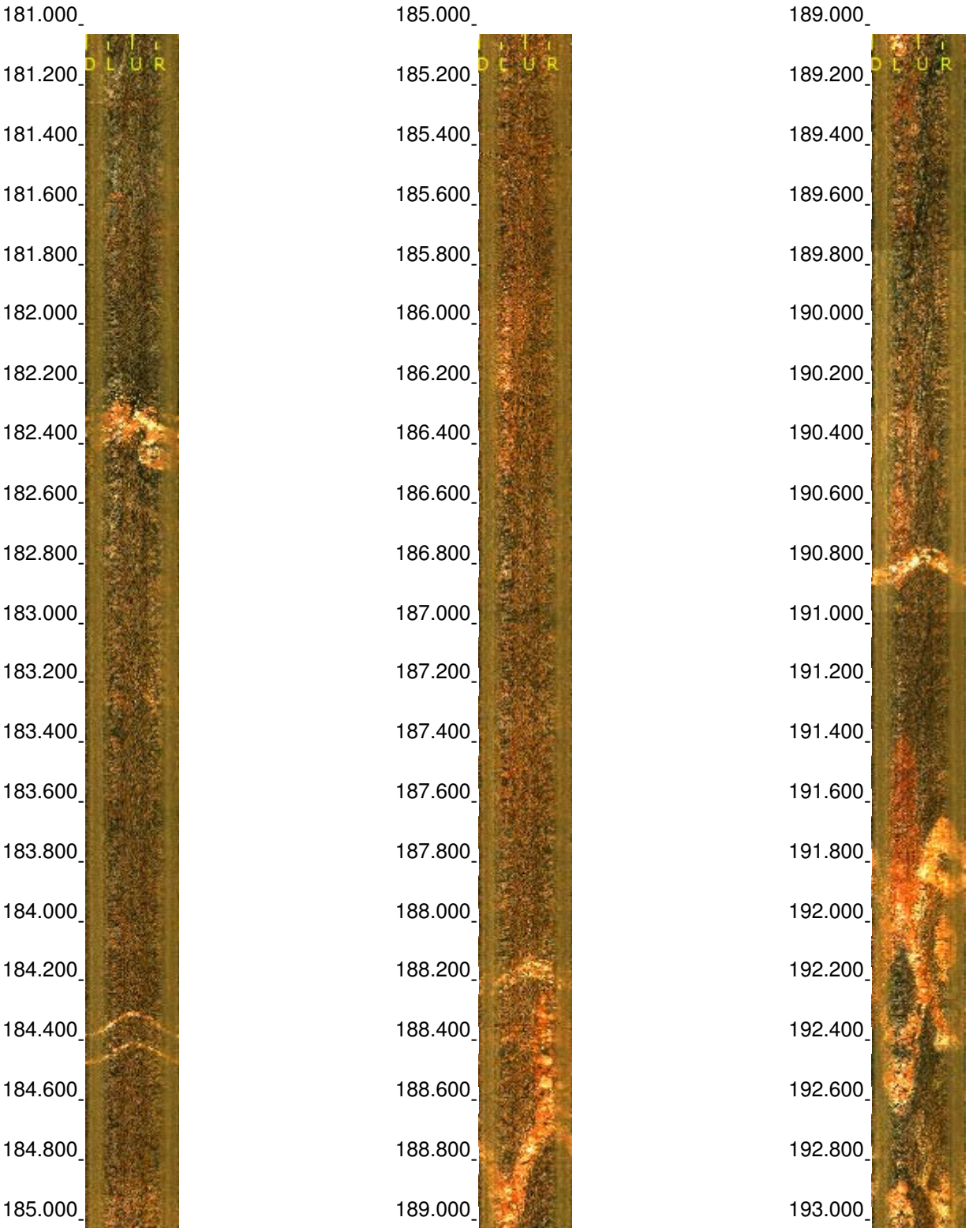
Borehole:
Mapping:

Depth range: 169.030 - 181.030 m
Azimuth: 0.0
Inclination: -90.0



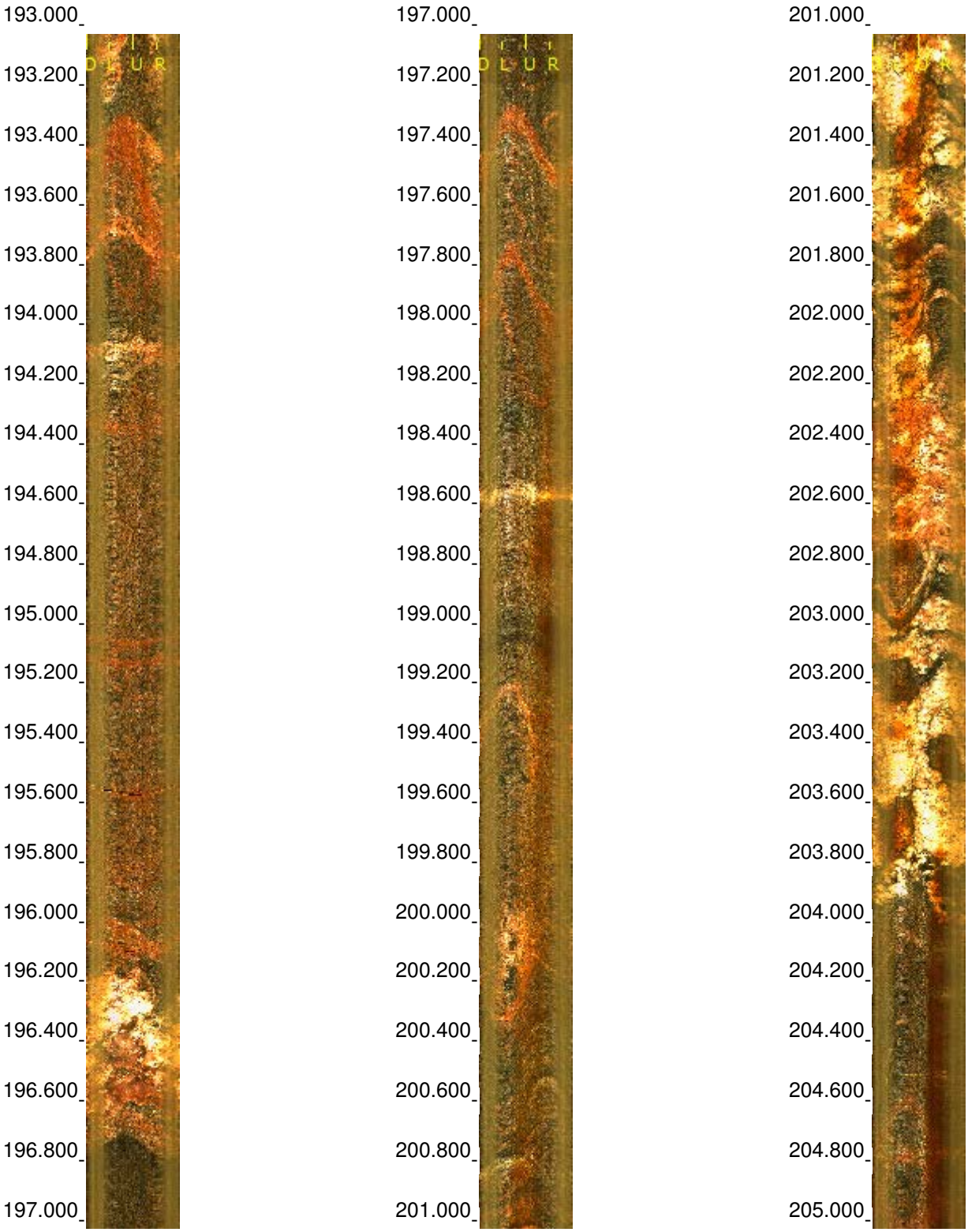
Borehole:
Mapping:

Depth range: 181.030 - 193.030 m
Azimuth: 0.0
Inclination: -90.0



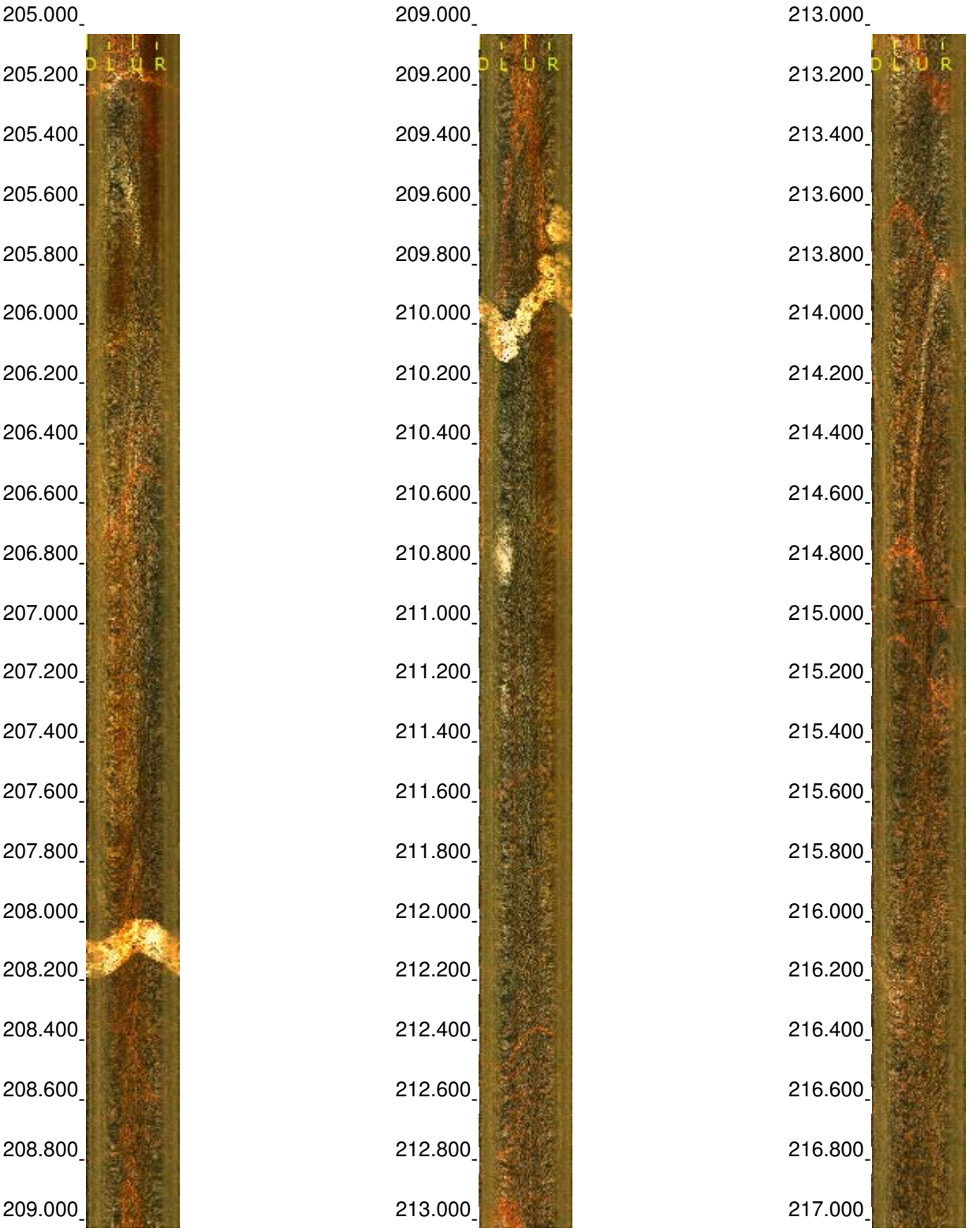
Borehole:
Mapping:

Depth range: 193.030 - 205.030 m
Azimuth: 0.0
Inclination: -90.0



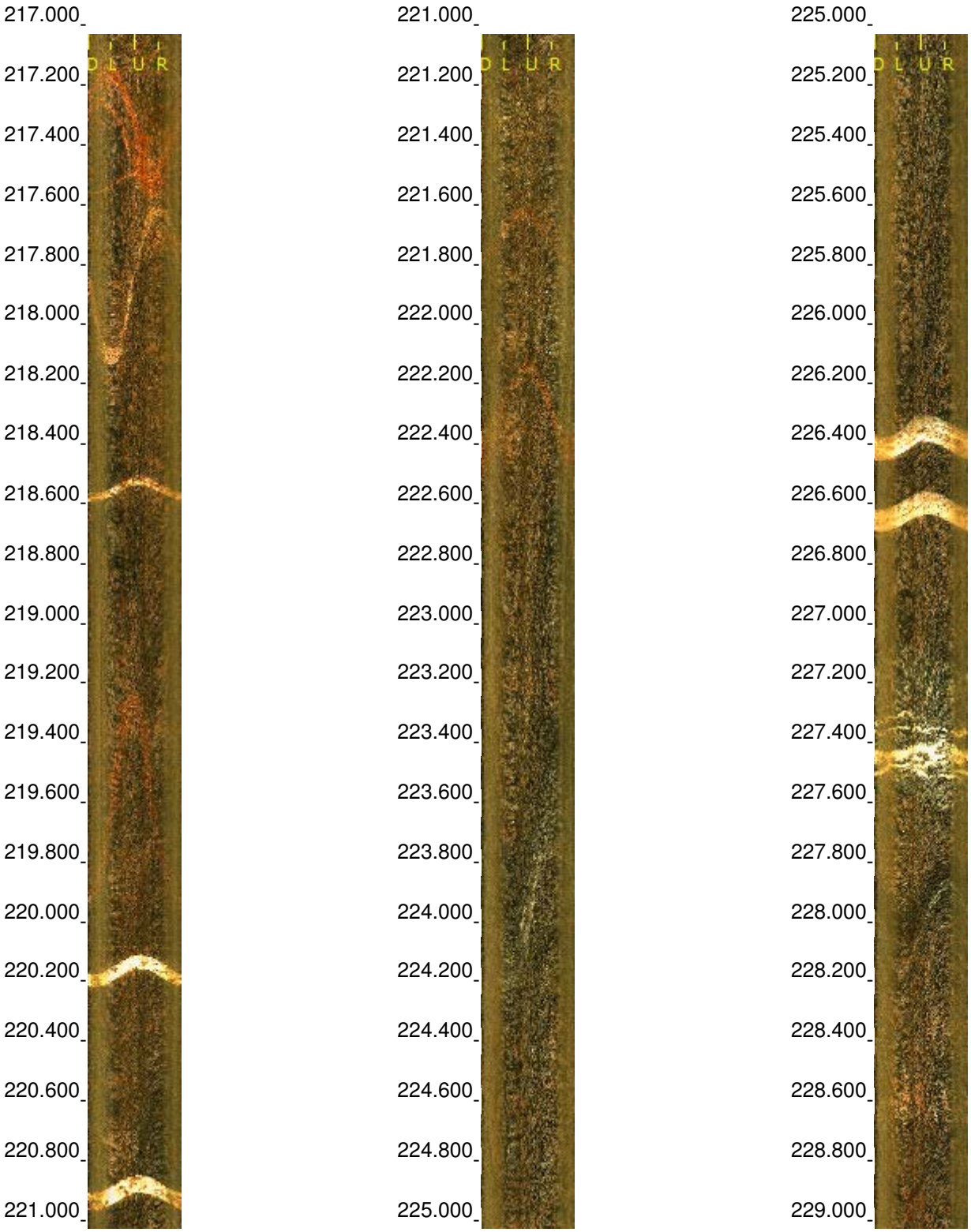
Borehole:
Mapping:

Depth range: 205.030 - 217.030 m
Azimuth: 0.0
Inclination: -90.0



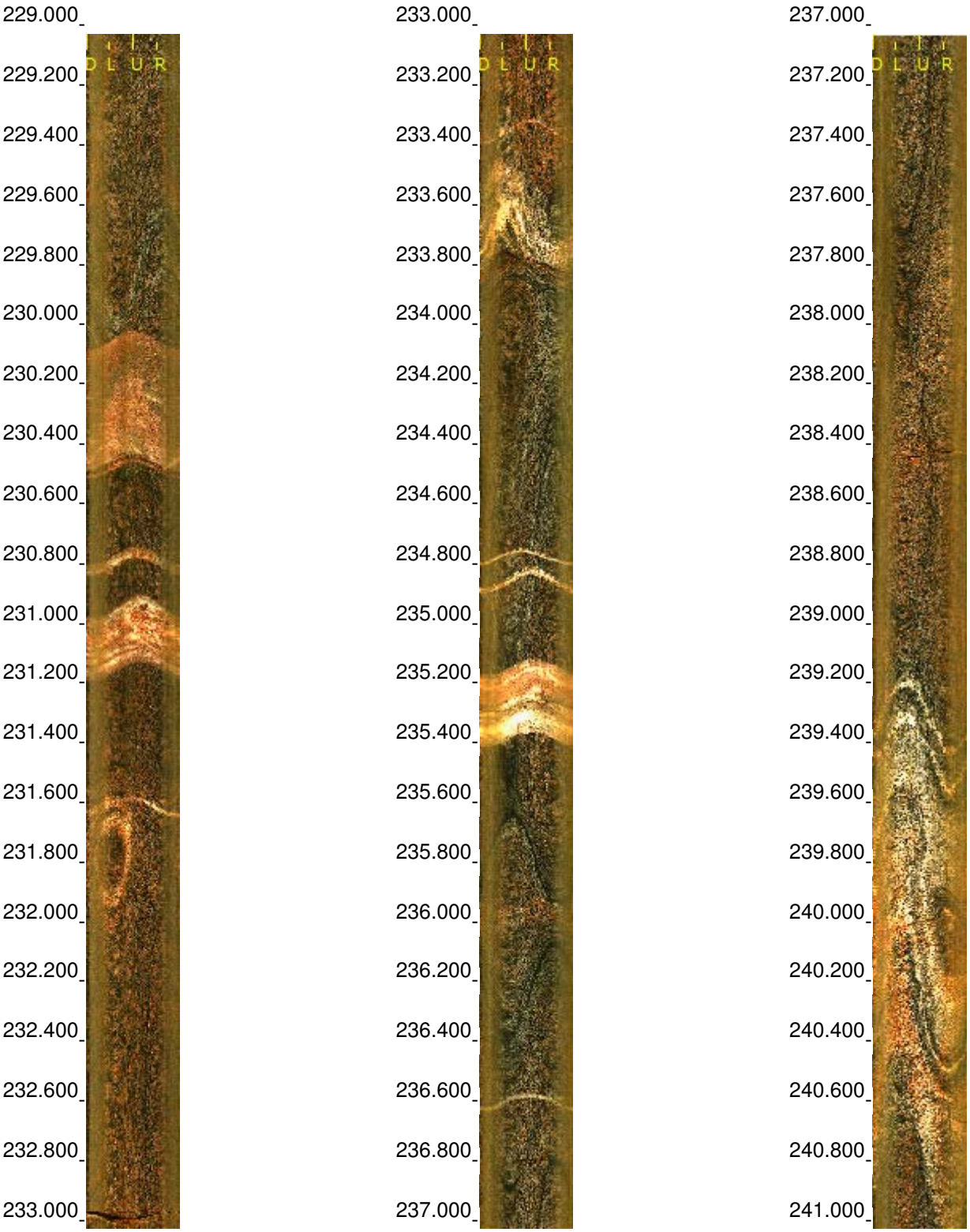
Borehole:
Mapping:

Depth range: 217.030 - 229.030 m
Azimuth: 0.0
Inclination: -90.0



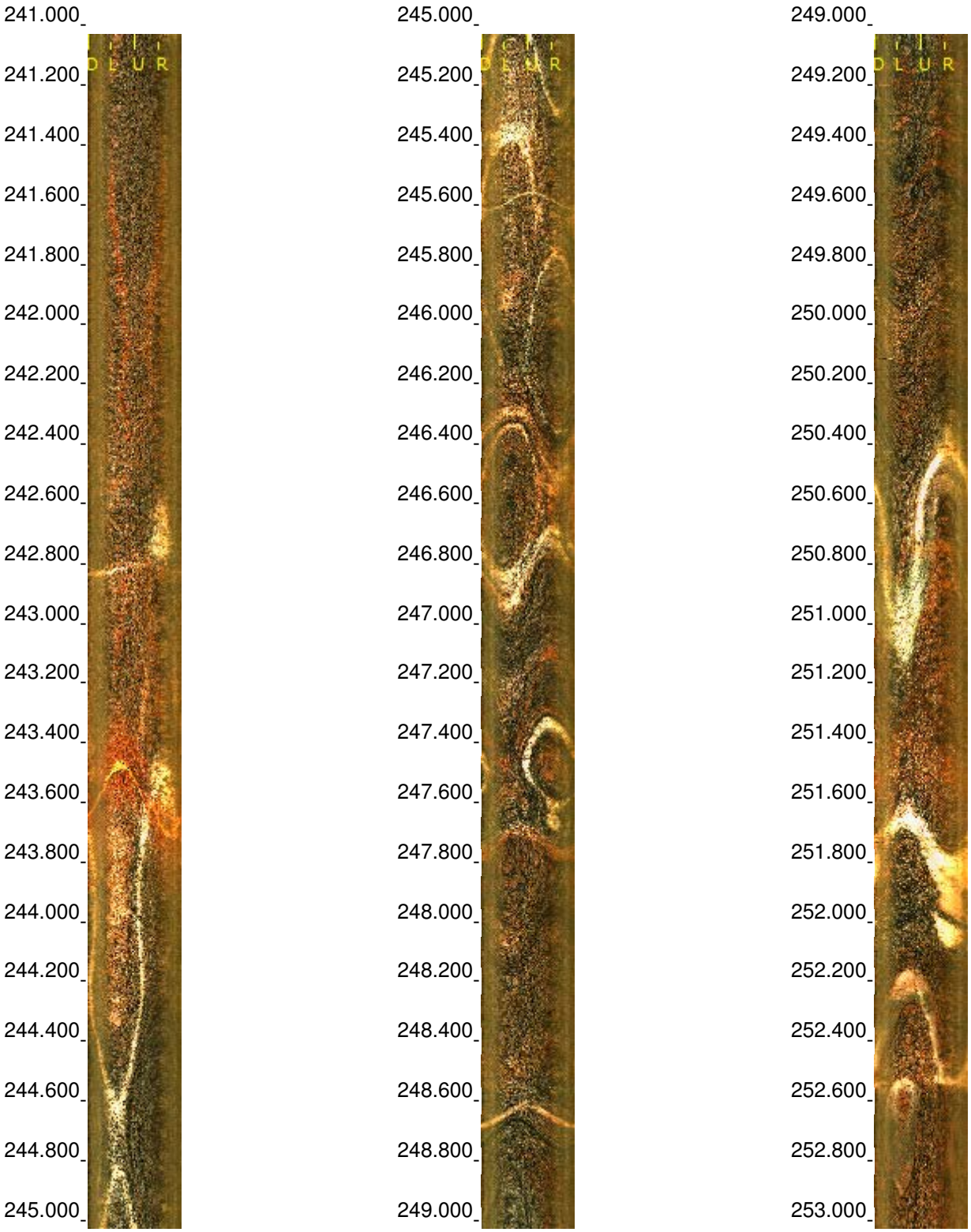
Borehole:
Mapping:

Depth range: 229.030 - 241.030 m
Azimuth: 0.0
Inclination: -90.0



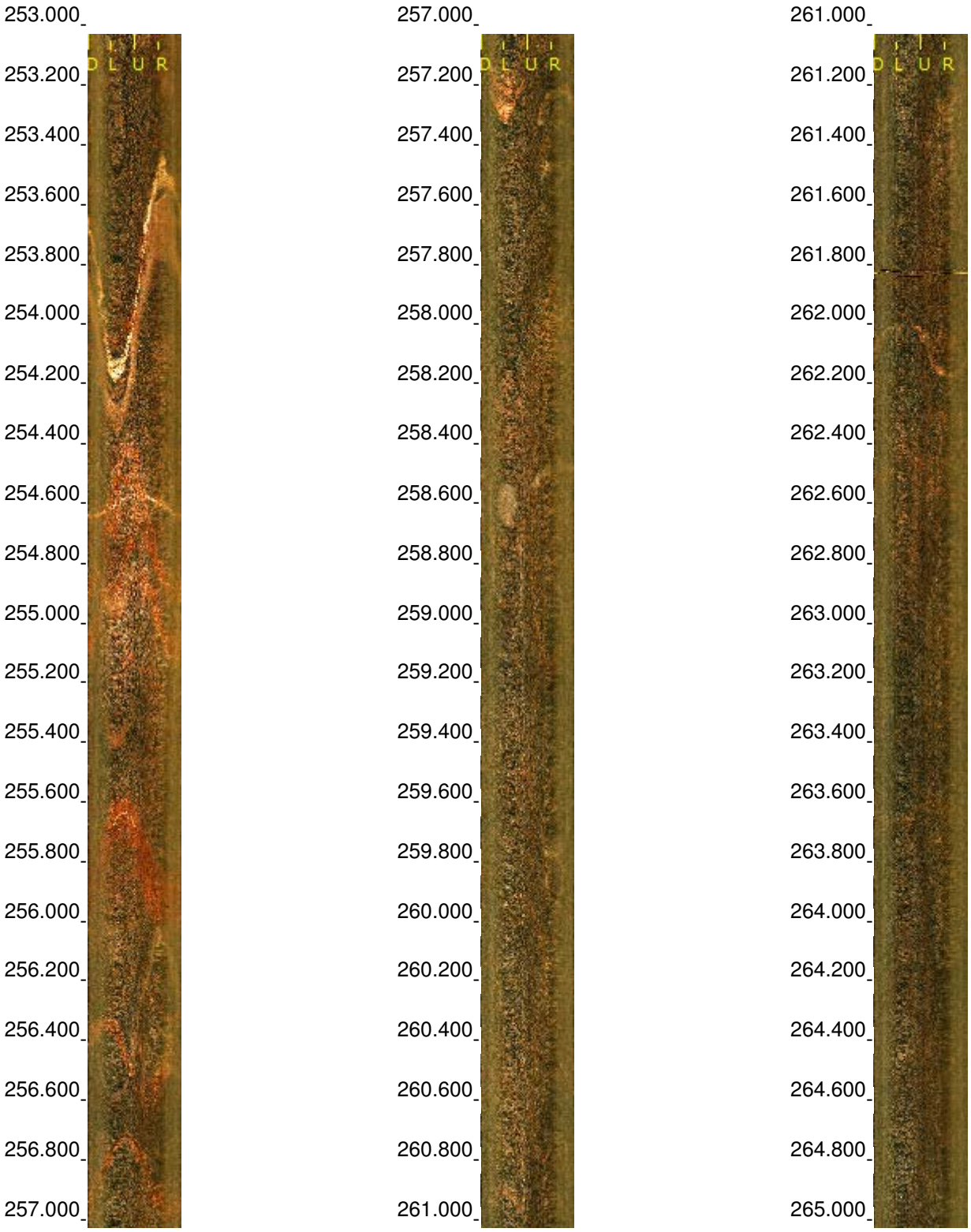
Borehole:
Mapping:

Depth range: 241.030 - 253.030 m
Azimuth: 0.0
Inclination: -90.0



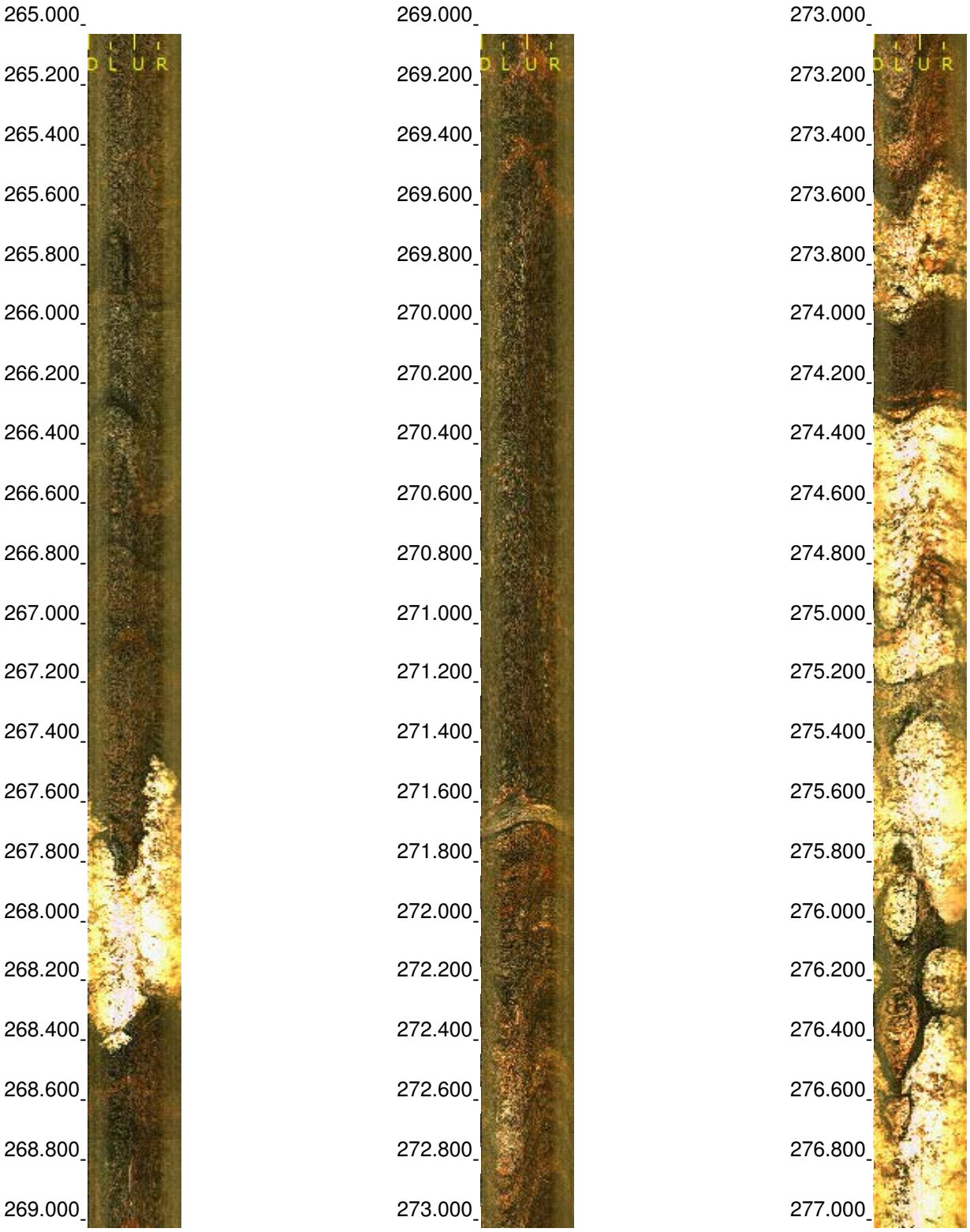
Borehole:
Mapping:

Depth range: 253.030 - 265.030 m
Azimuth: 0.0
Inclination: -90.0



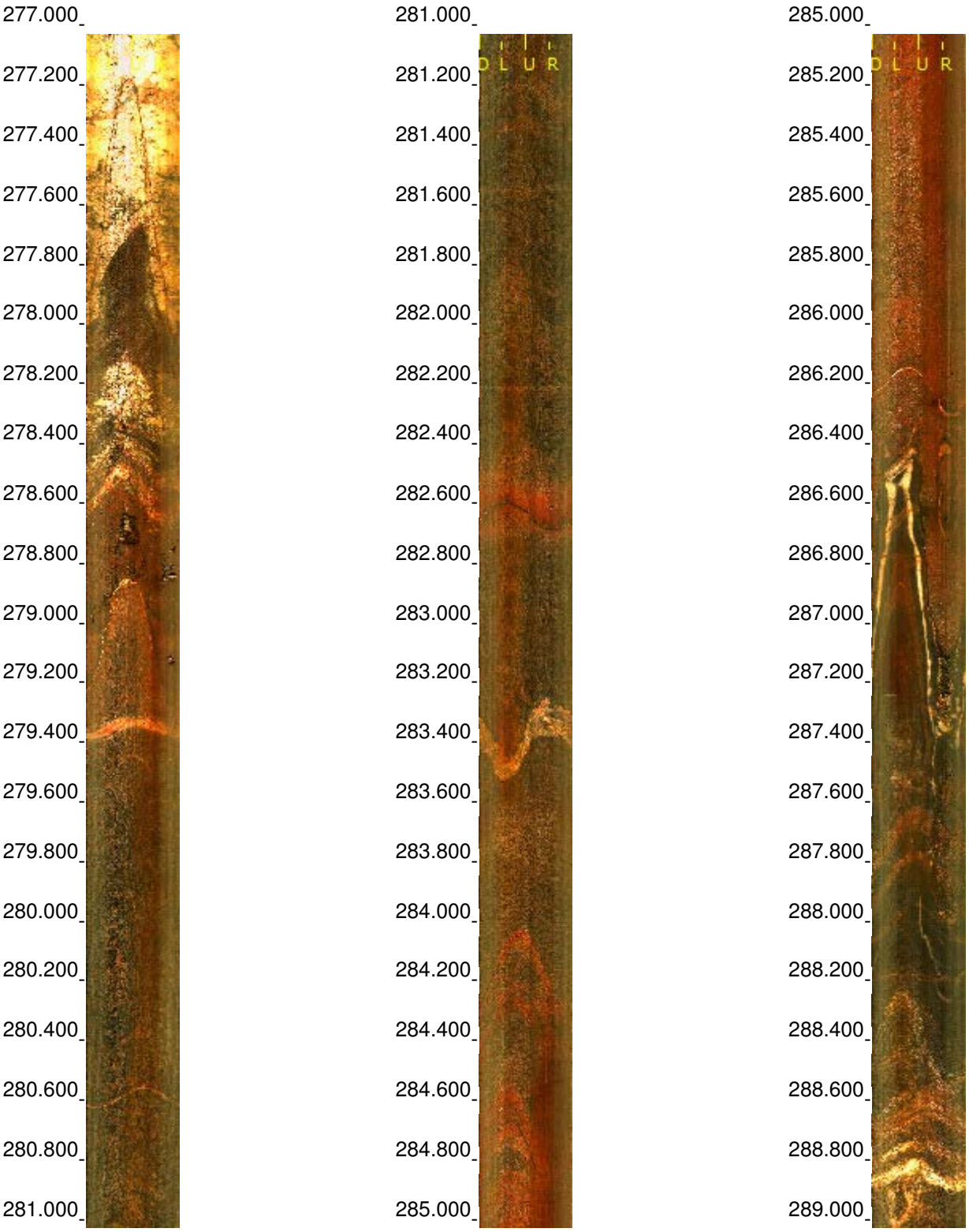
Borehole:
Mapping:

Depth range: 265.030 - 277.030 m
Azimuth: 0.0
Inclination: -90.0



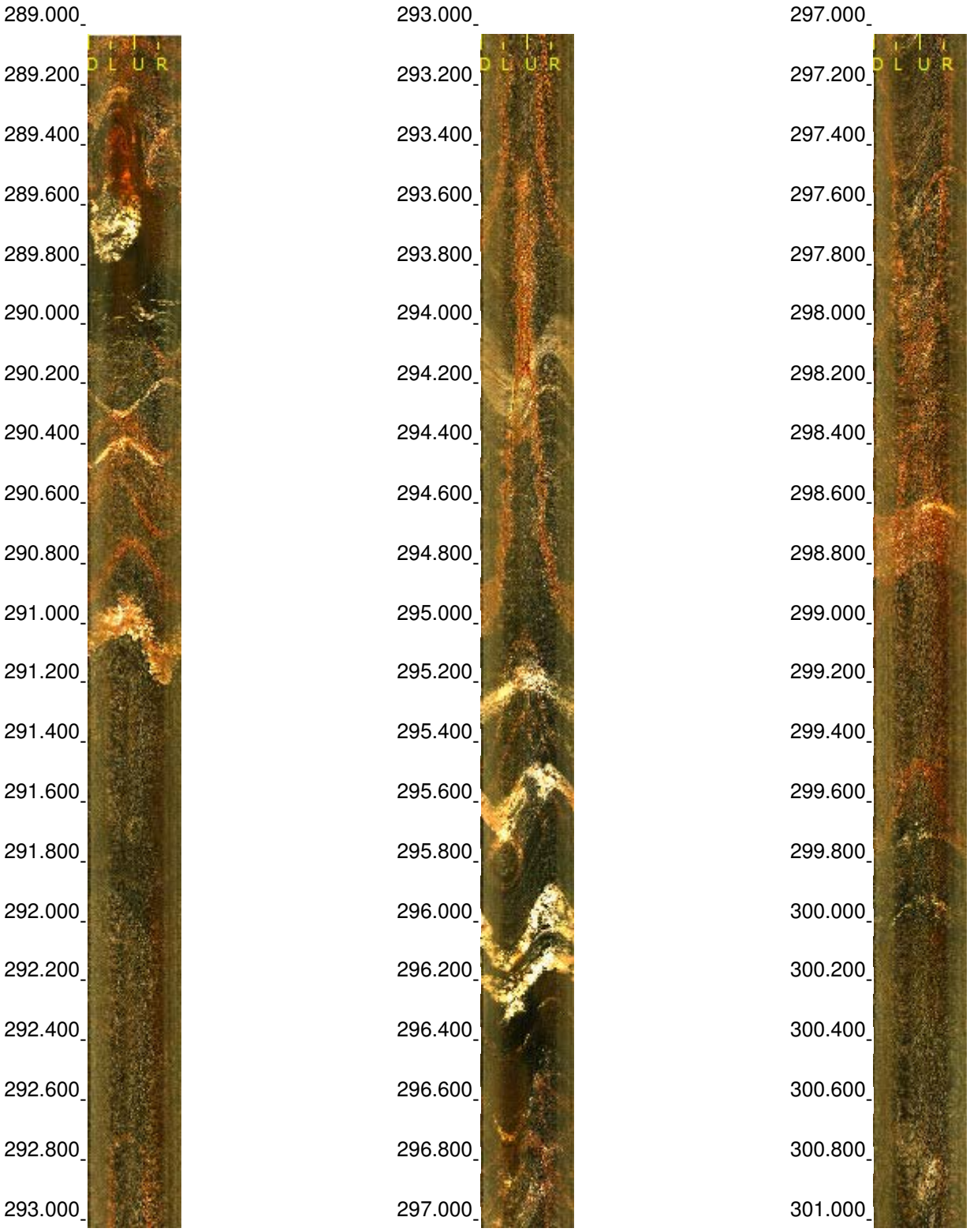
Borehole:
Mapping:

Depth range: 277.030 - 289.030 m
Azimuth: 0.0
Inclination: -90.0



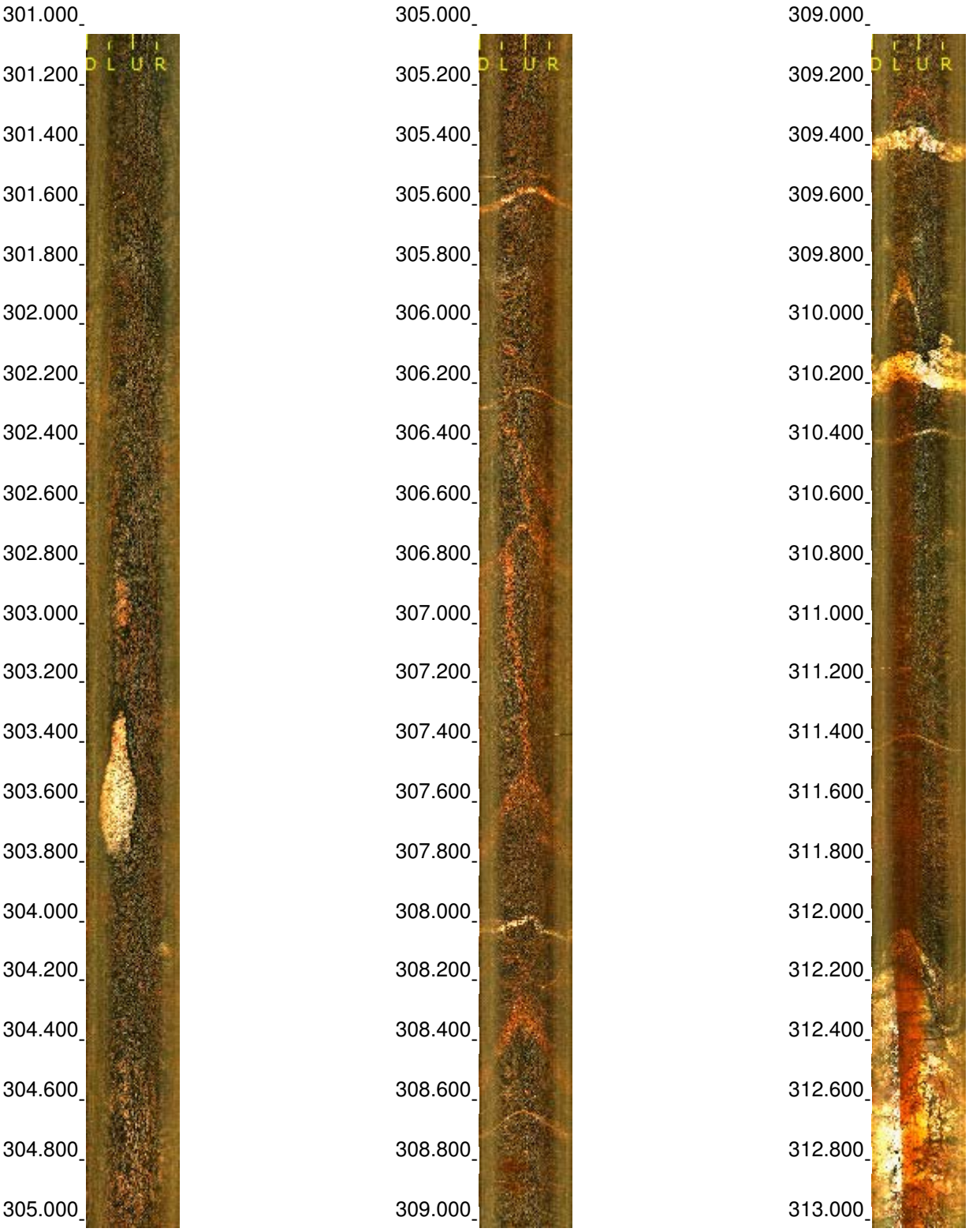
Borehole:
Mapping:

Depth range: 289.030 - 301.030 m
Azimuth: 0.0
Inclination: -90.0



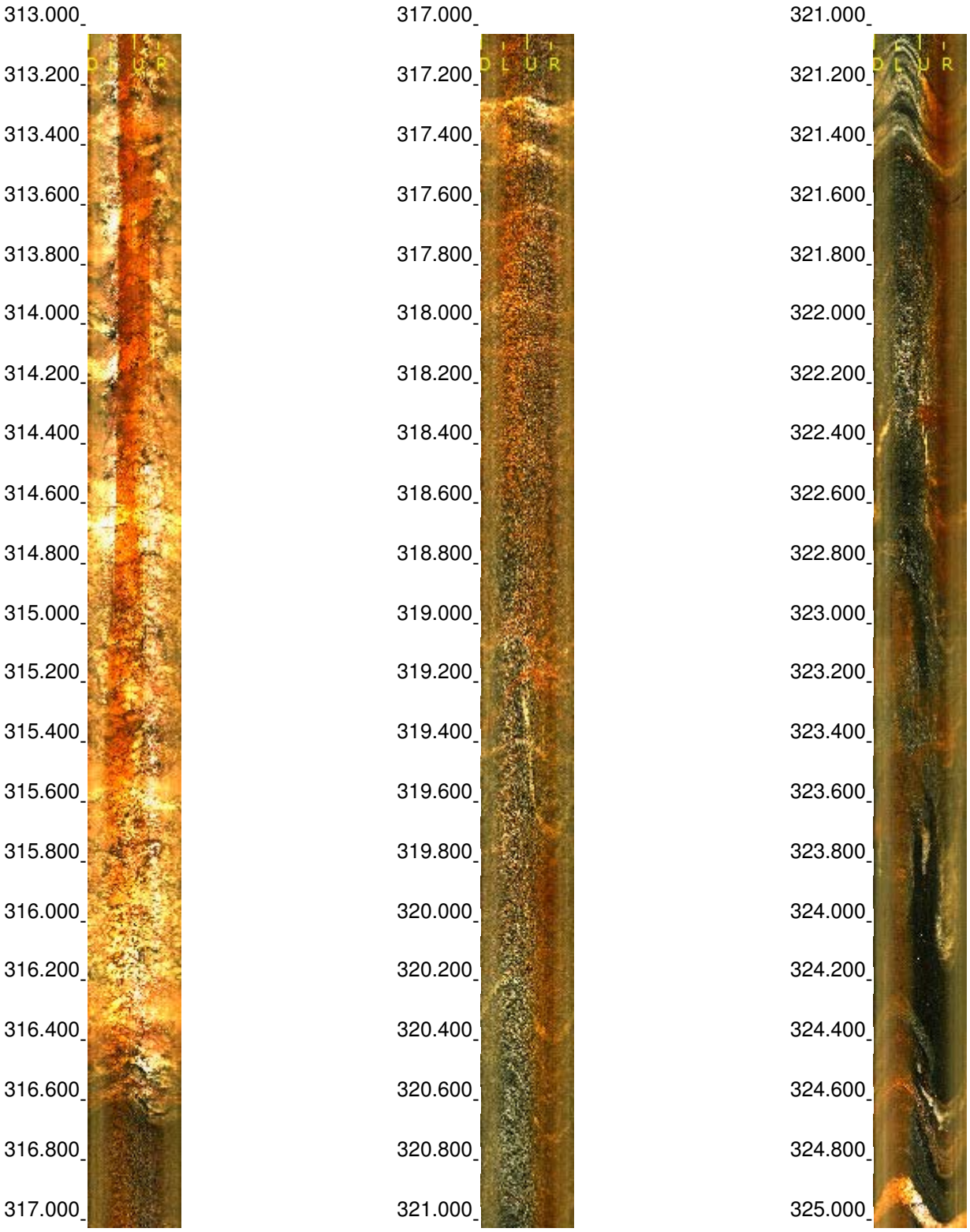
Borehole:
Mapping:

Depth range: 301.030 - 313.030 m
Azimuth: 0.0
Inclination: -90.0



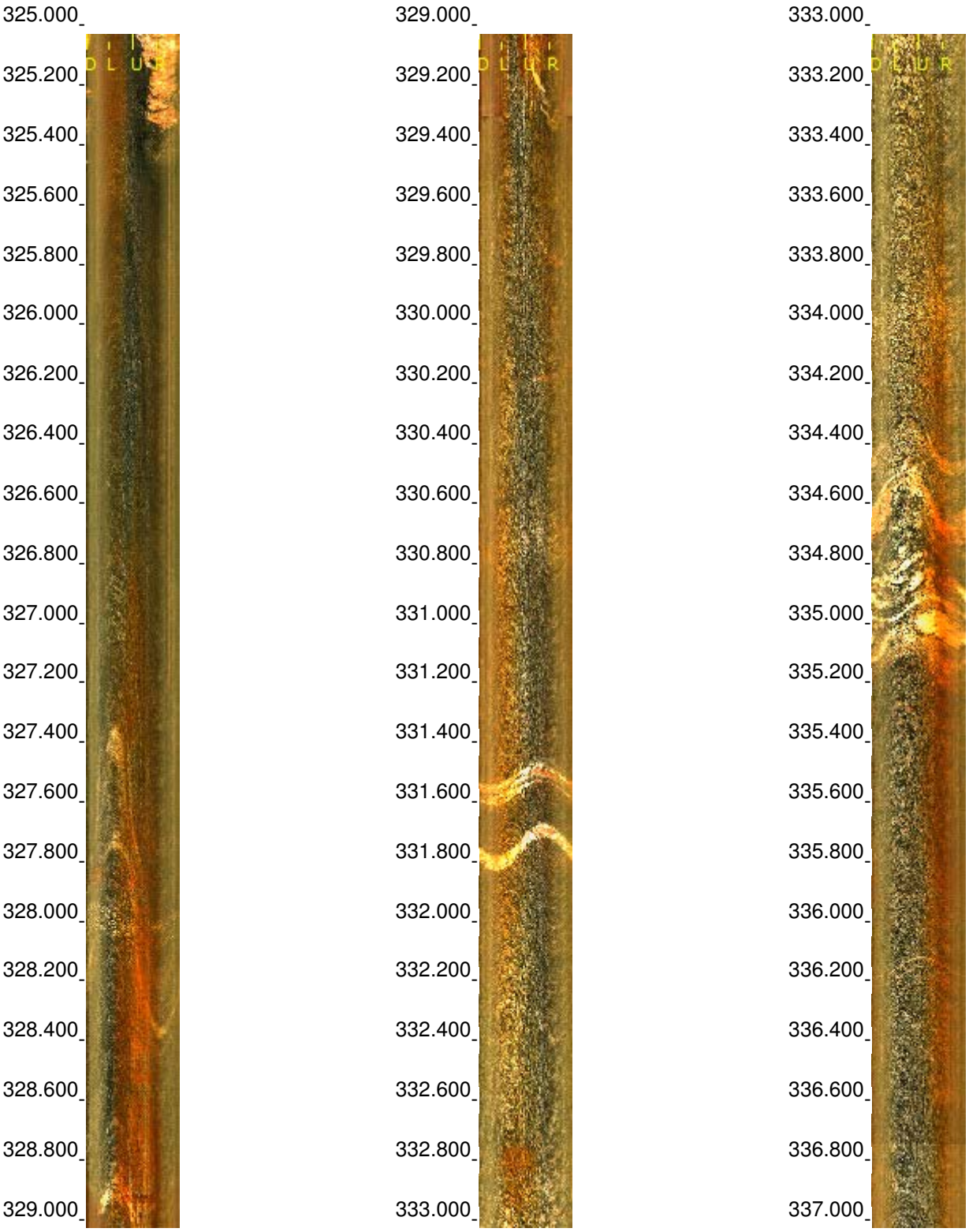
Borehole:
Mapping:

Depth range: 313.030 - 325.030 m
Azimuth: 0.0
Inclination: -90.0



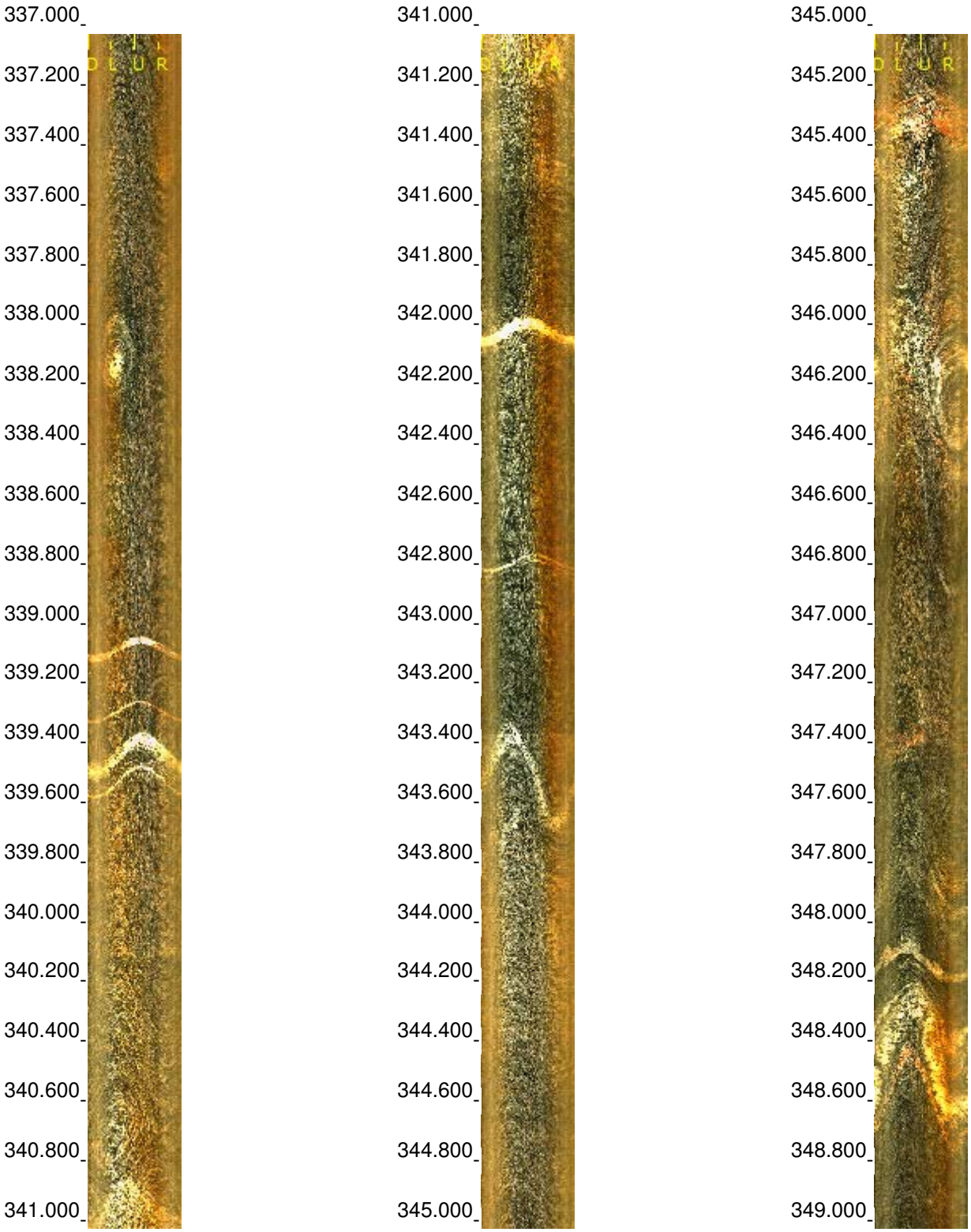
Borehole:
Mapping:

Depth range: 325.030 - 337.030 m
Azimuth: 0.0
Inclination: -90.0



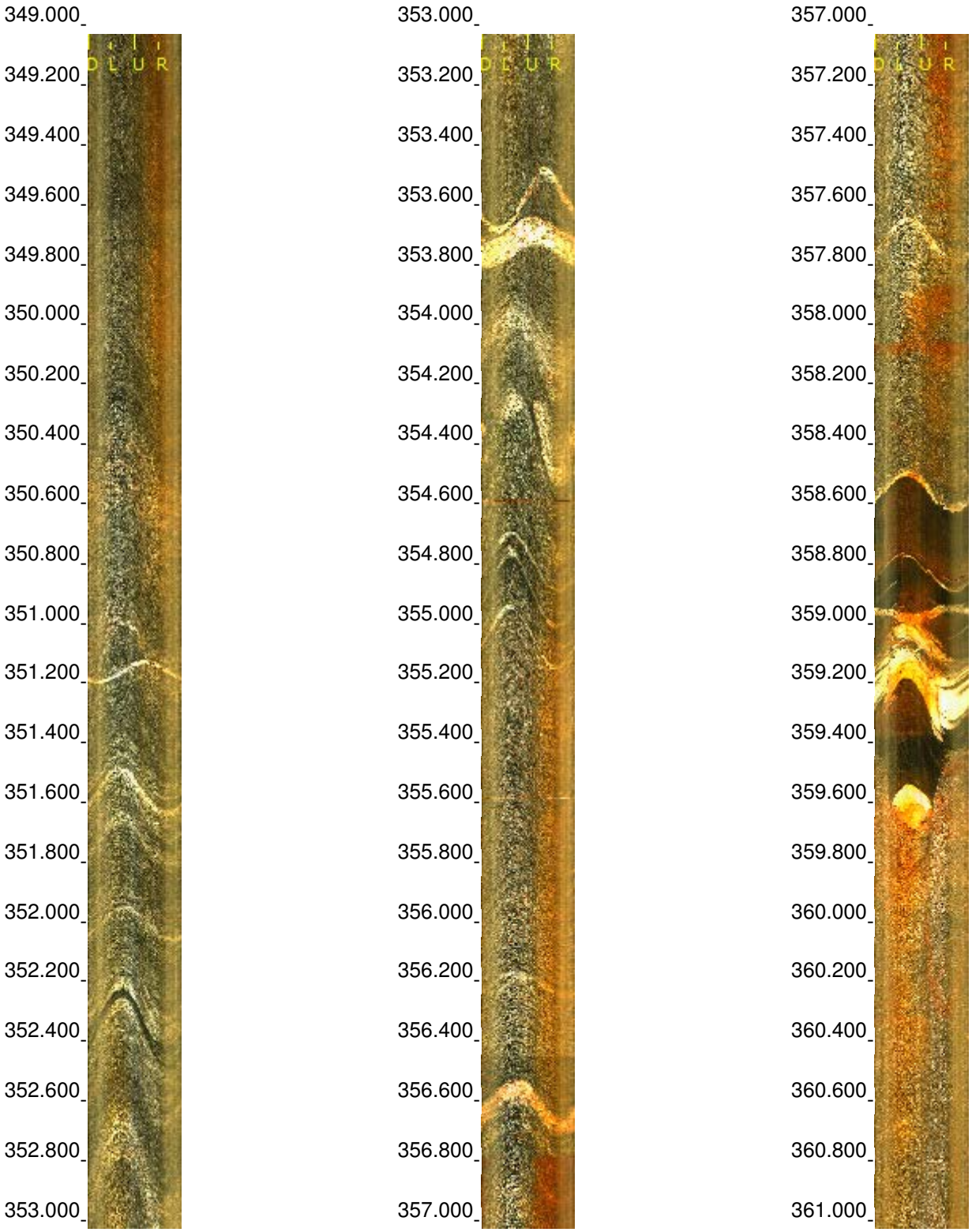
Borehole:
Mapping:

Depth range: 337.030 - 349.030 m
Azimuth: 0.0
Inclination: -90.0



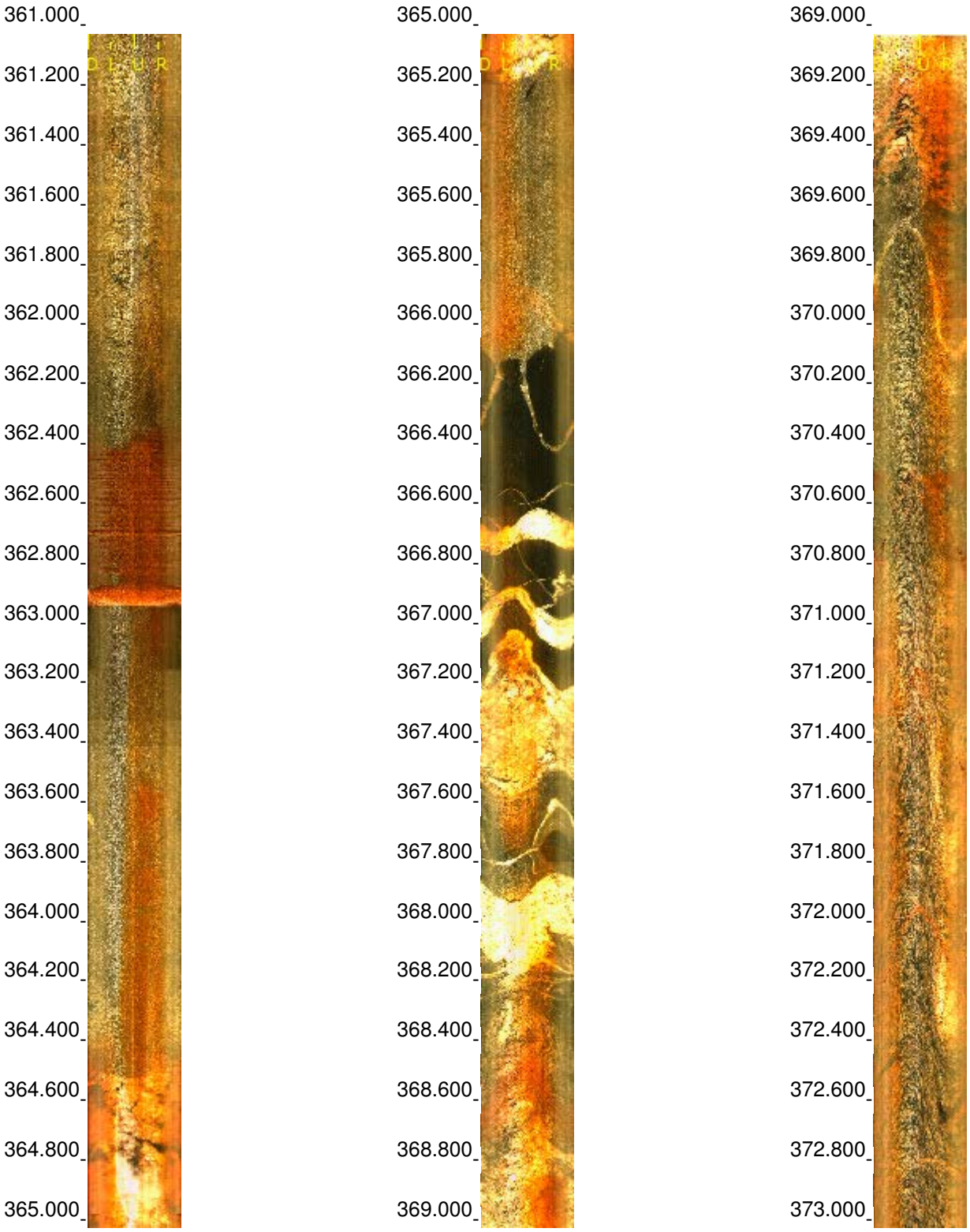
Borehole:
Mapping:

Depth range: 349.030 - 361.030 m
Azimuth: 0.0
Inclination: -90.0



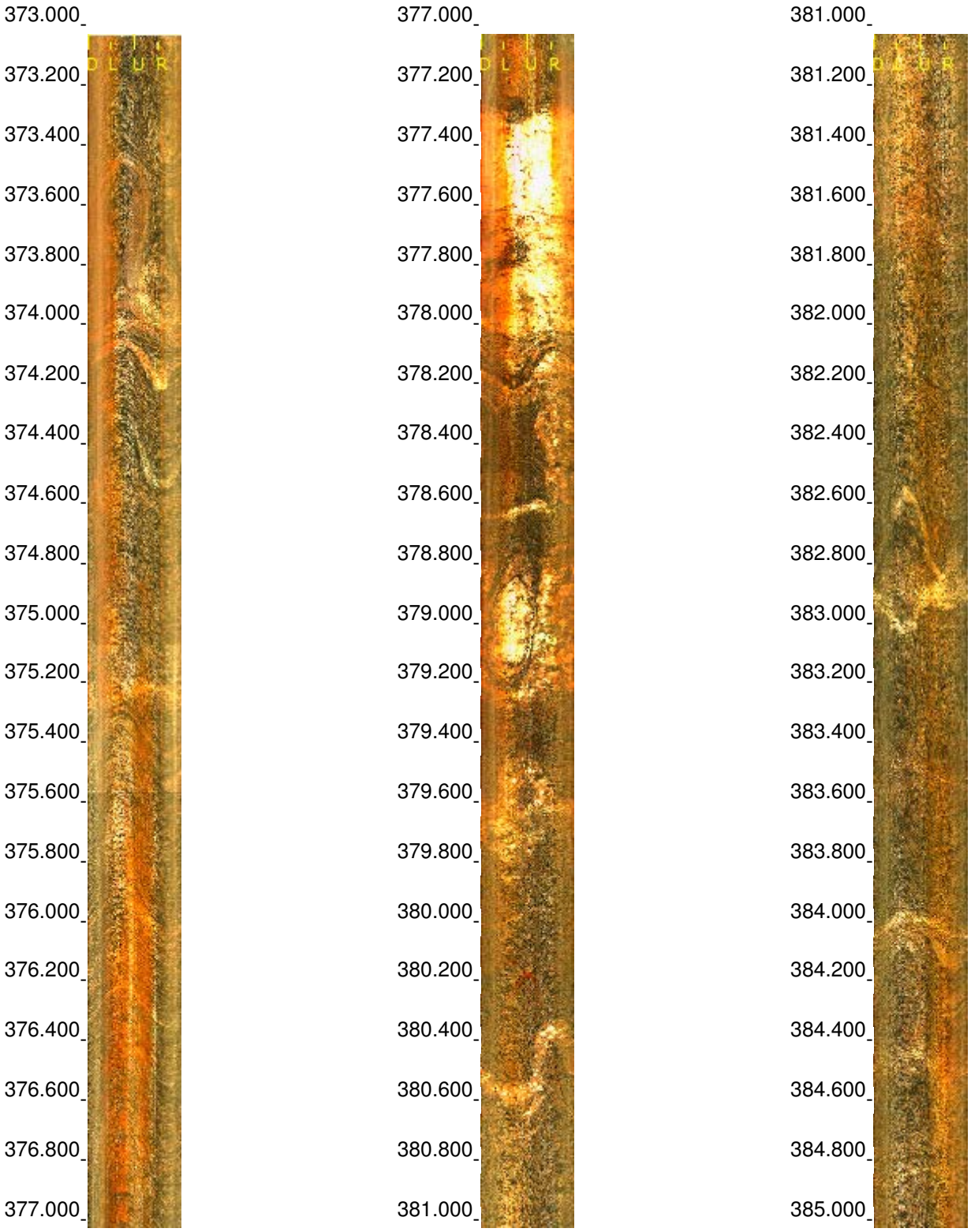
Borehole:
Mapping:

Depth range: 361.030 - 373.030 m
Azimuth: 0.0
Inclination: -90.0



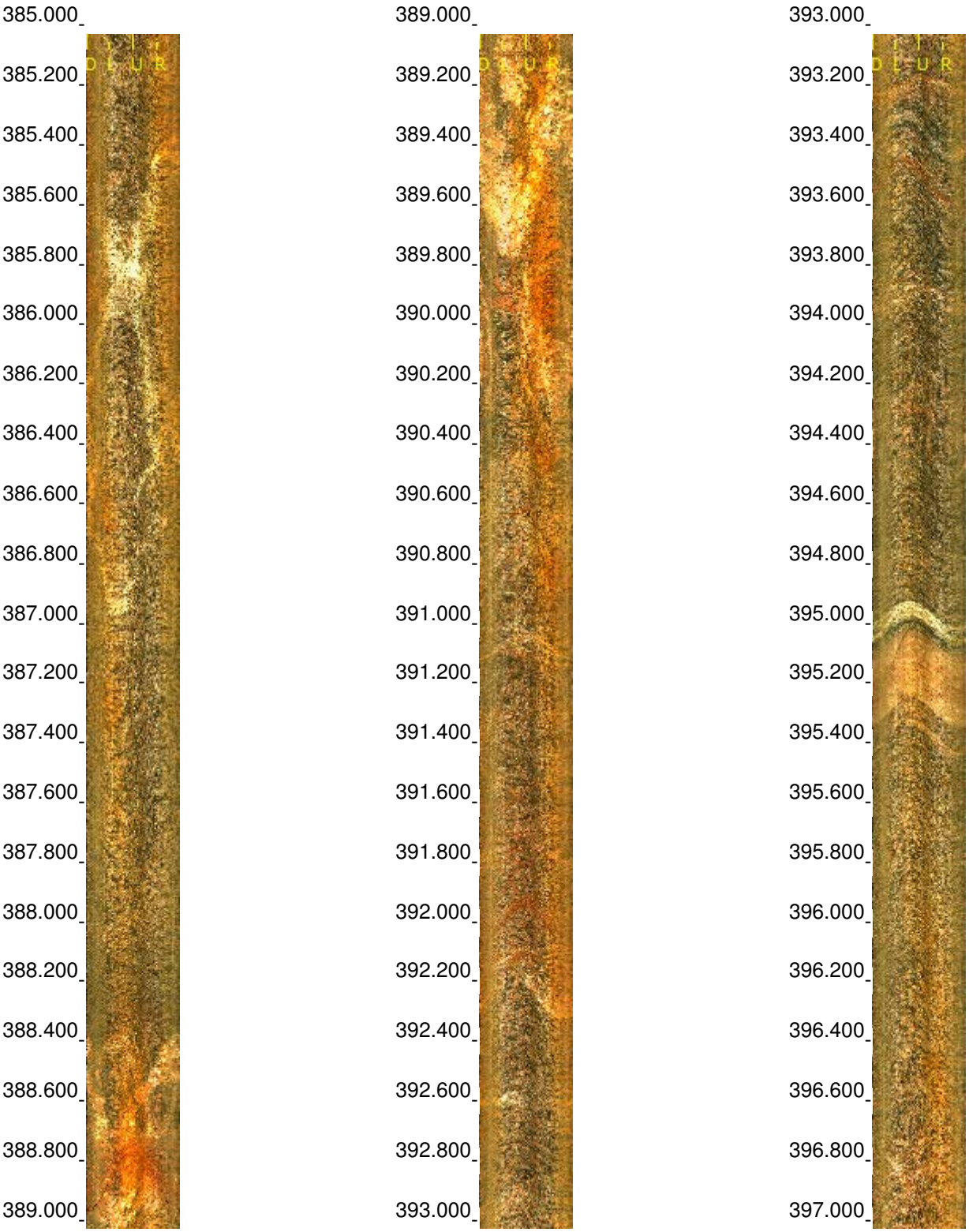
Borehole:
Mapping:

Depth range: 373.030 - 385.030 m
Azimuth: 0.0
Inclination: -90.0



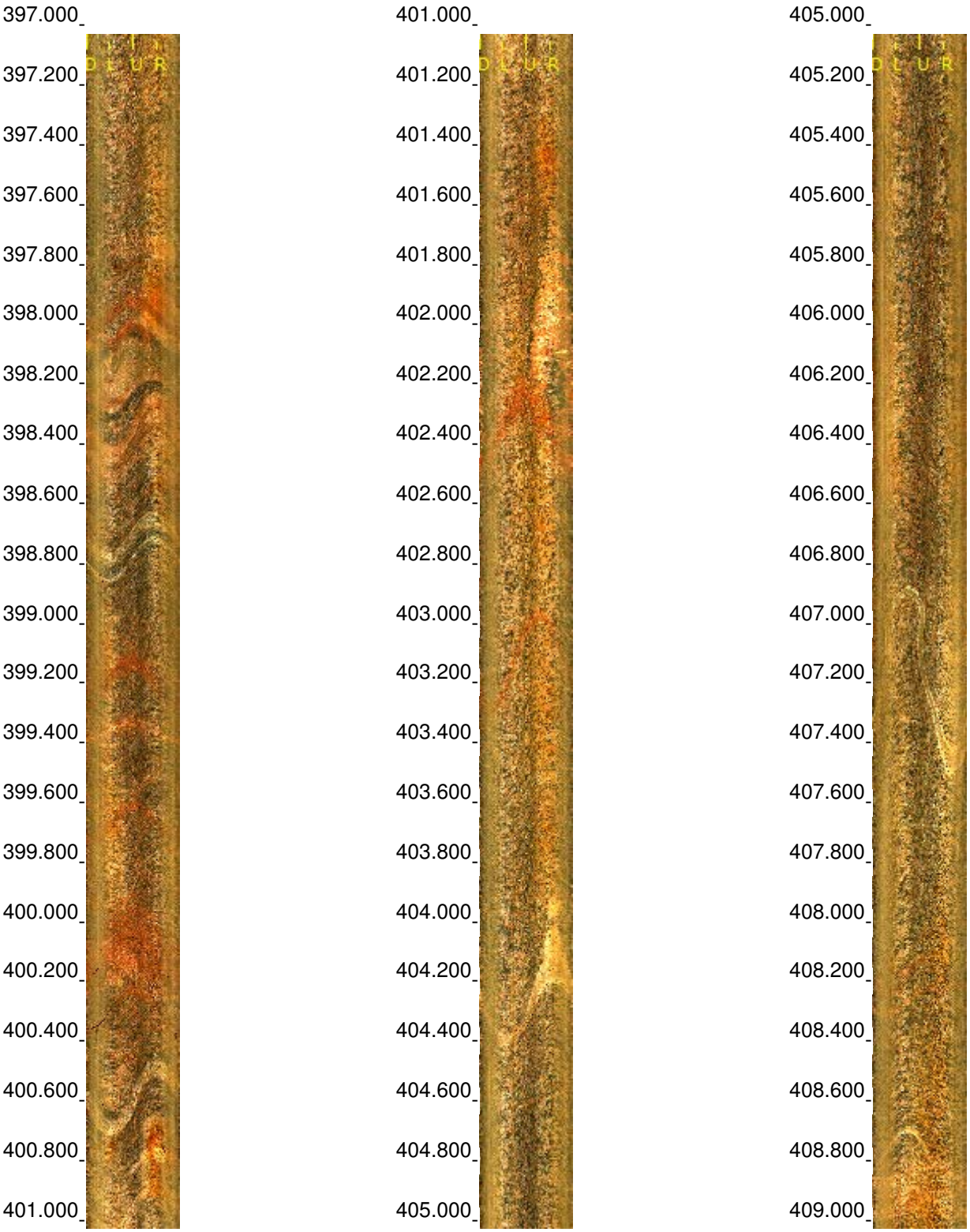
Borehole:
Mapping:

Depth range: 385.030 - 397.030 m
Azimuth: 0.0
Inclination: -90.0



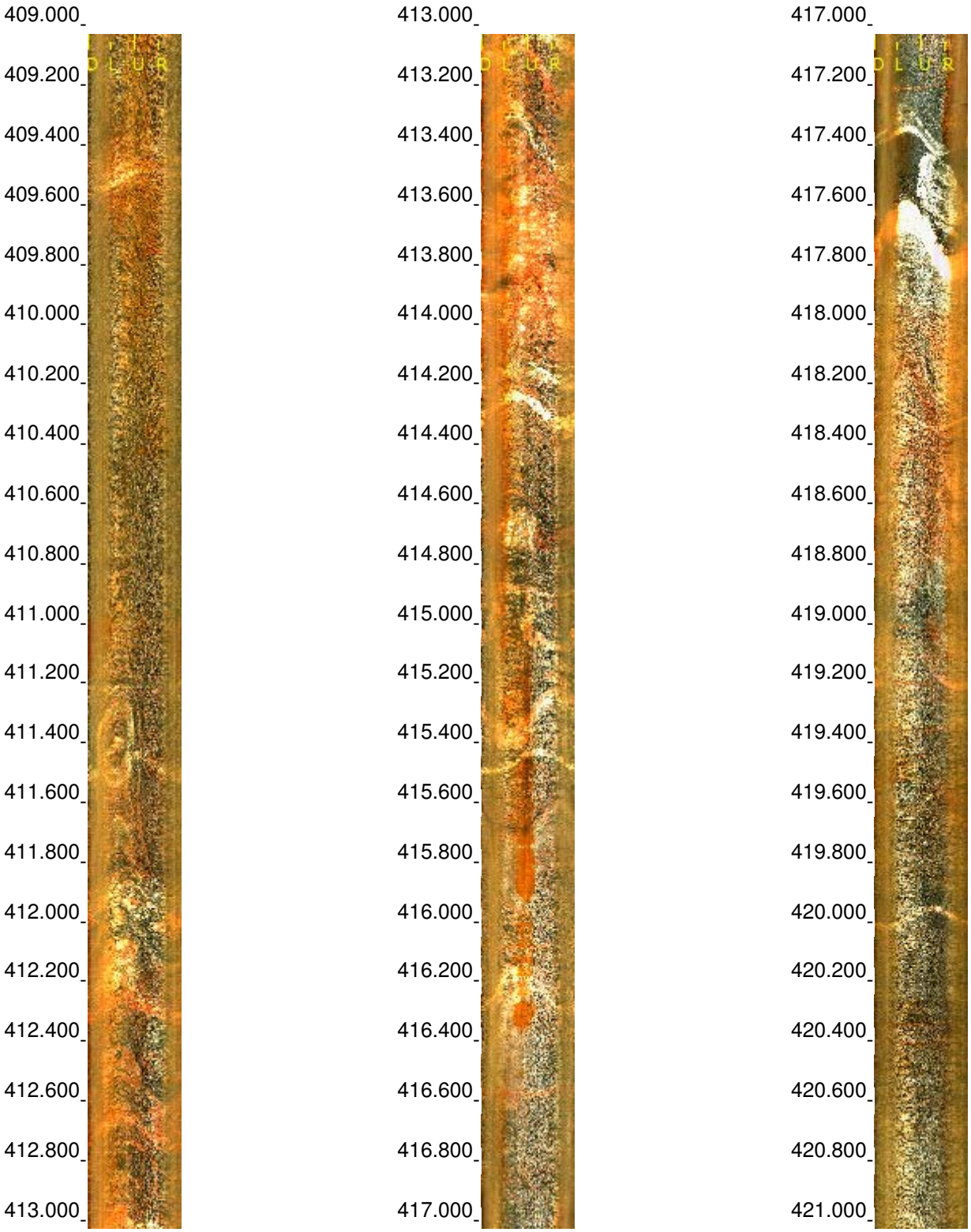
Borehole:
Mapping:

Depth range: 397.030 - 409.030 m
Azimuth: 0.0
Inclination: -90.0



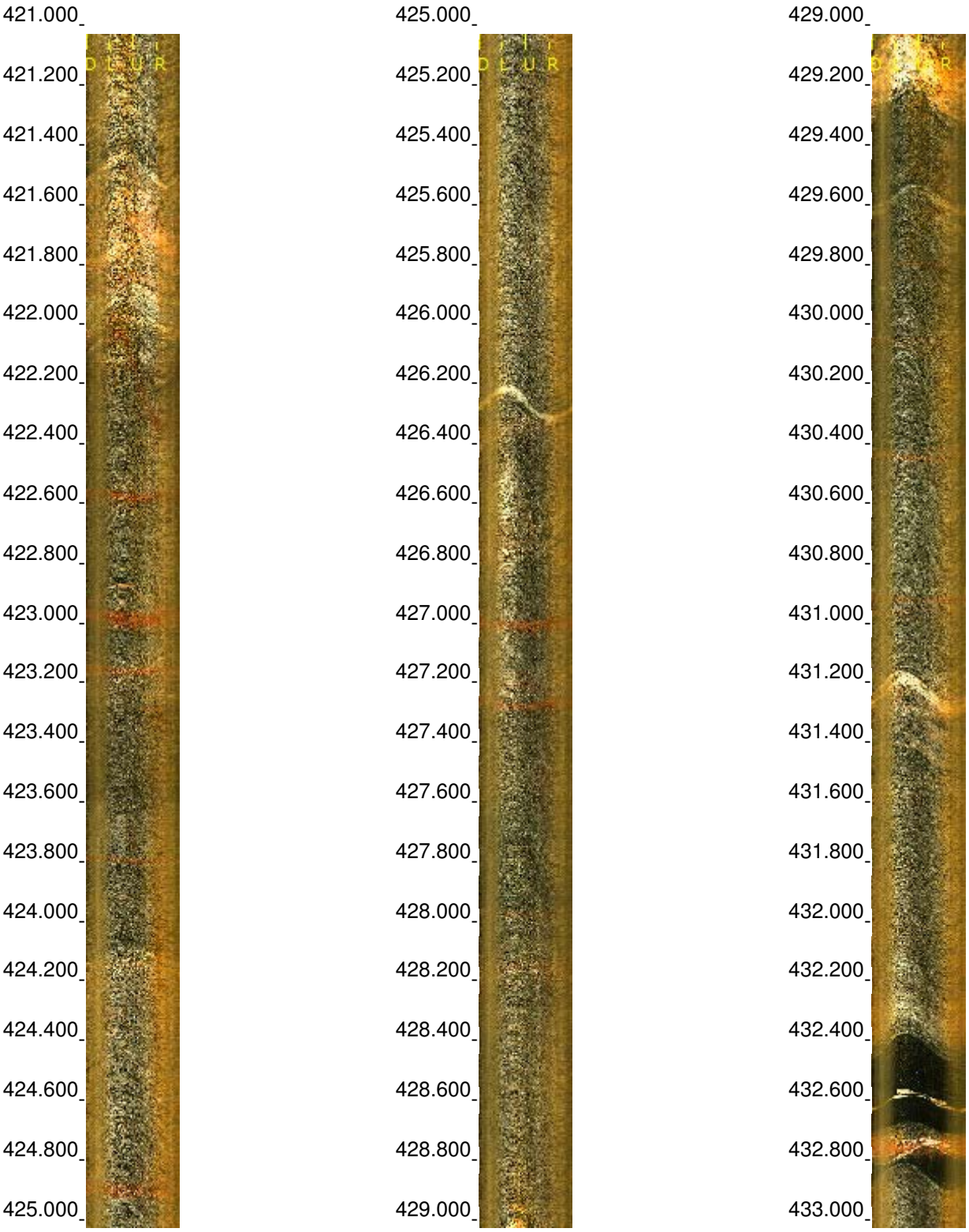
Borehole:
Mapping:

Depth range: 409.030 - 421.030 m
Azimuth: 0.0
Inclination: -90.0



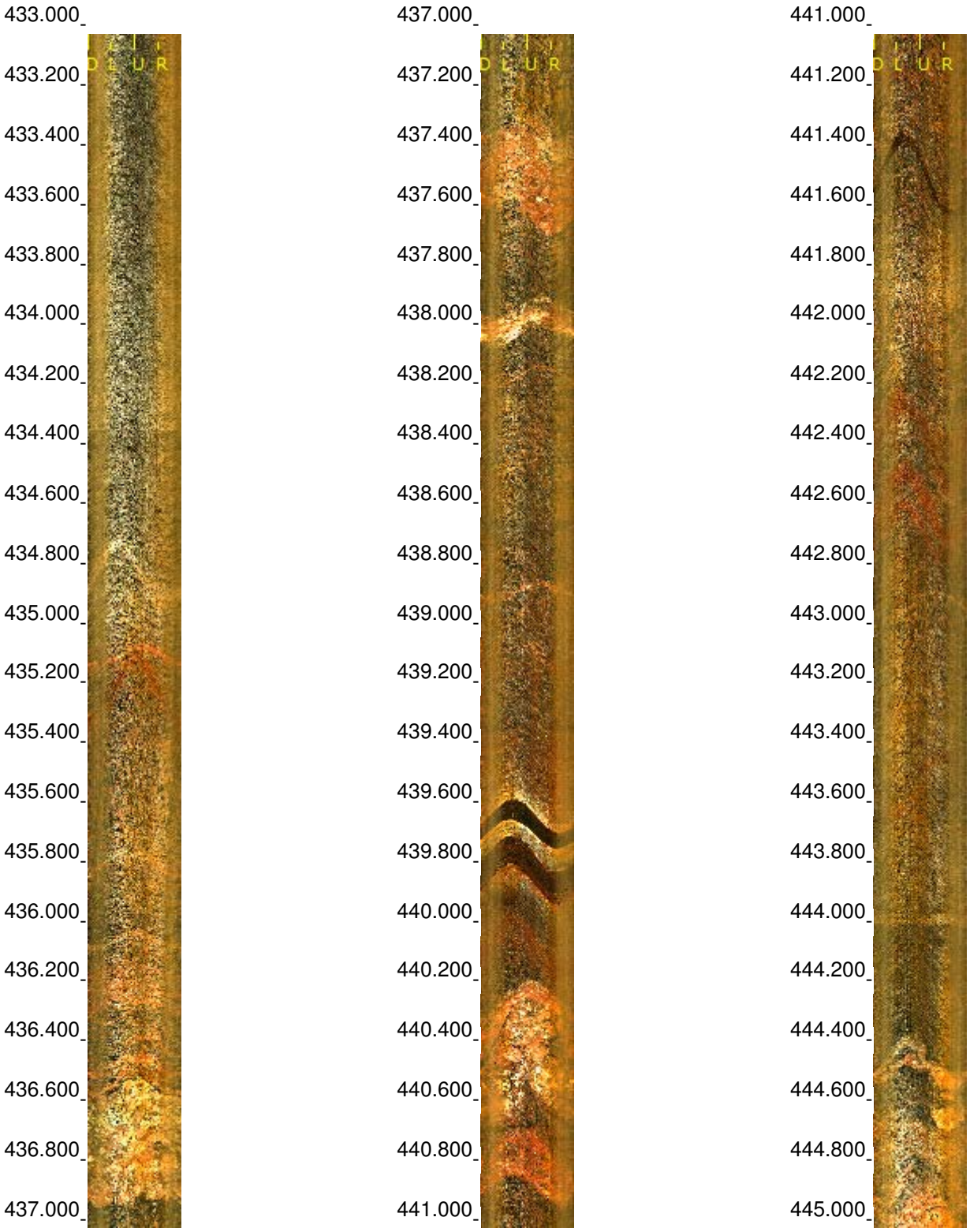
Borehole:
Mapping:

Depth range: 421.030 - 433.030 m
Azimuth: 0.0
Inclination: -90.0



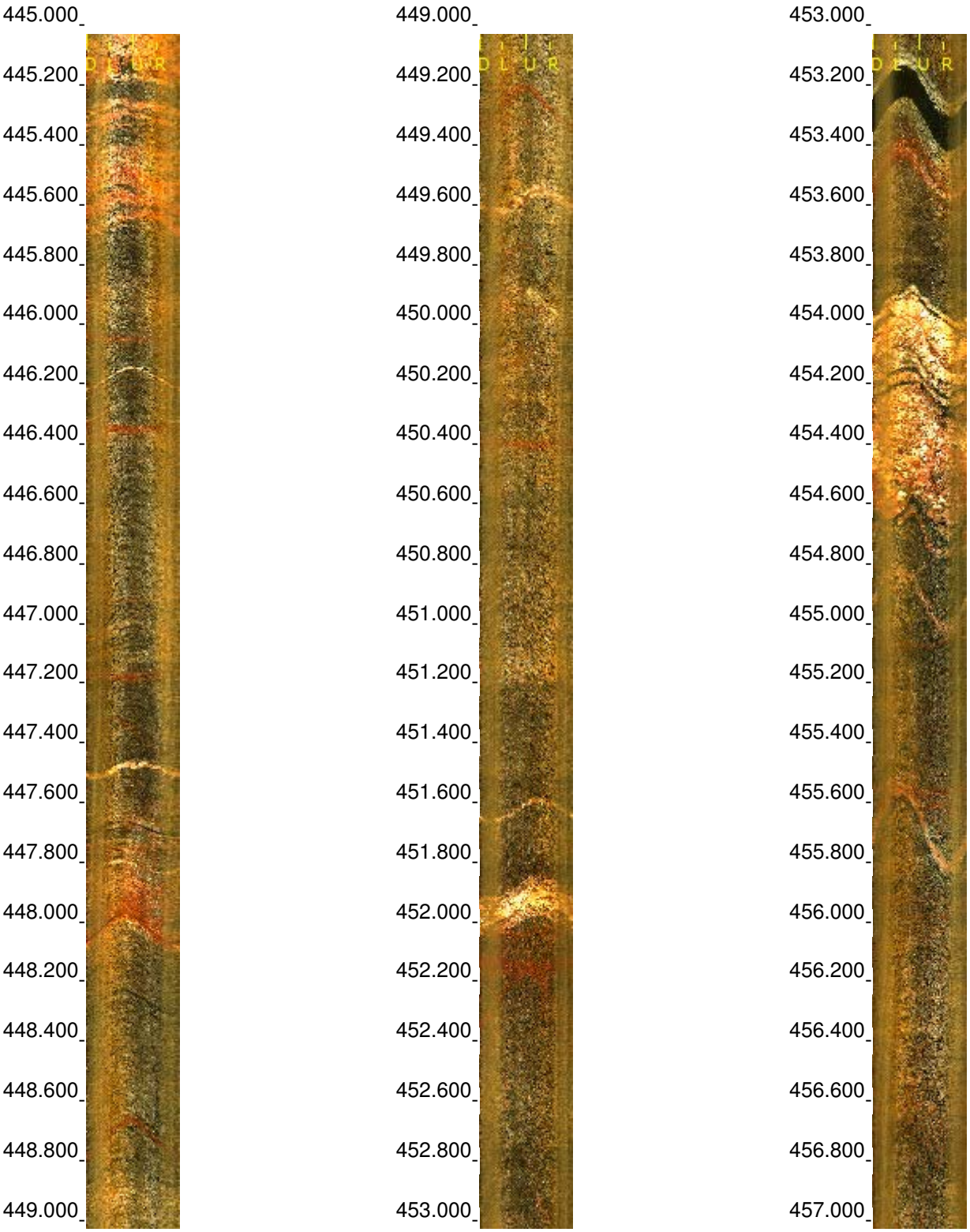
Borehole:
Mapping:

Depth range: 433.030 - 445.030 m
Azimuth: 0.0
Inclination: -90.0



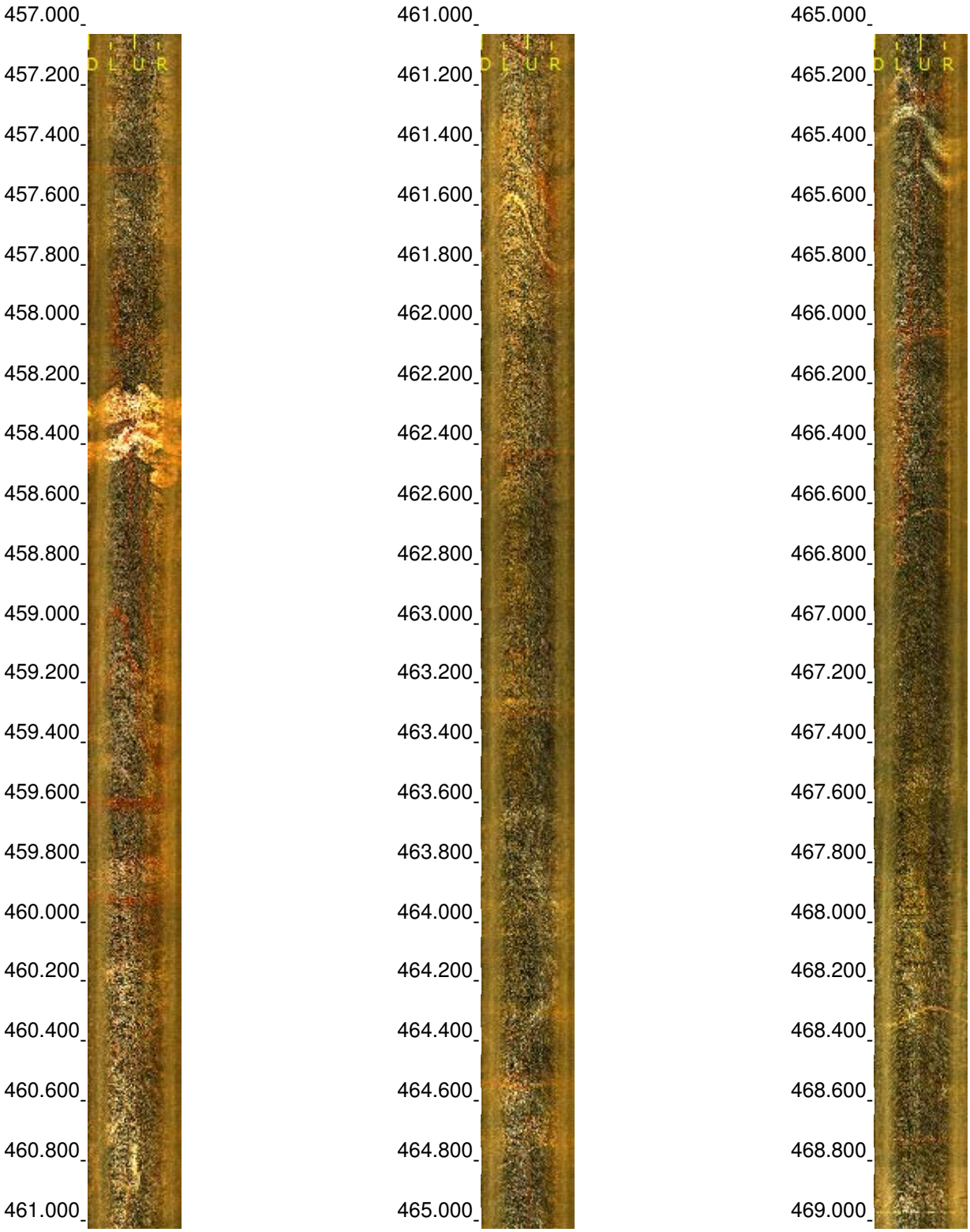
Borehole:
Mapping:

Depth range: 445.030 - 457.030 m
Azimuth: 0.0
Inclination: -90.0



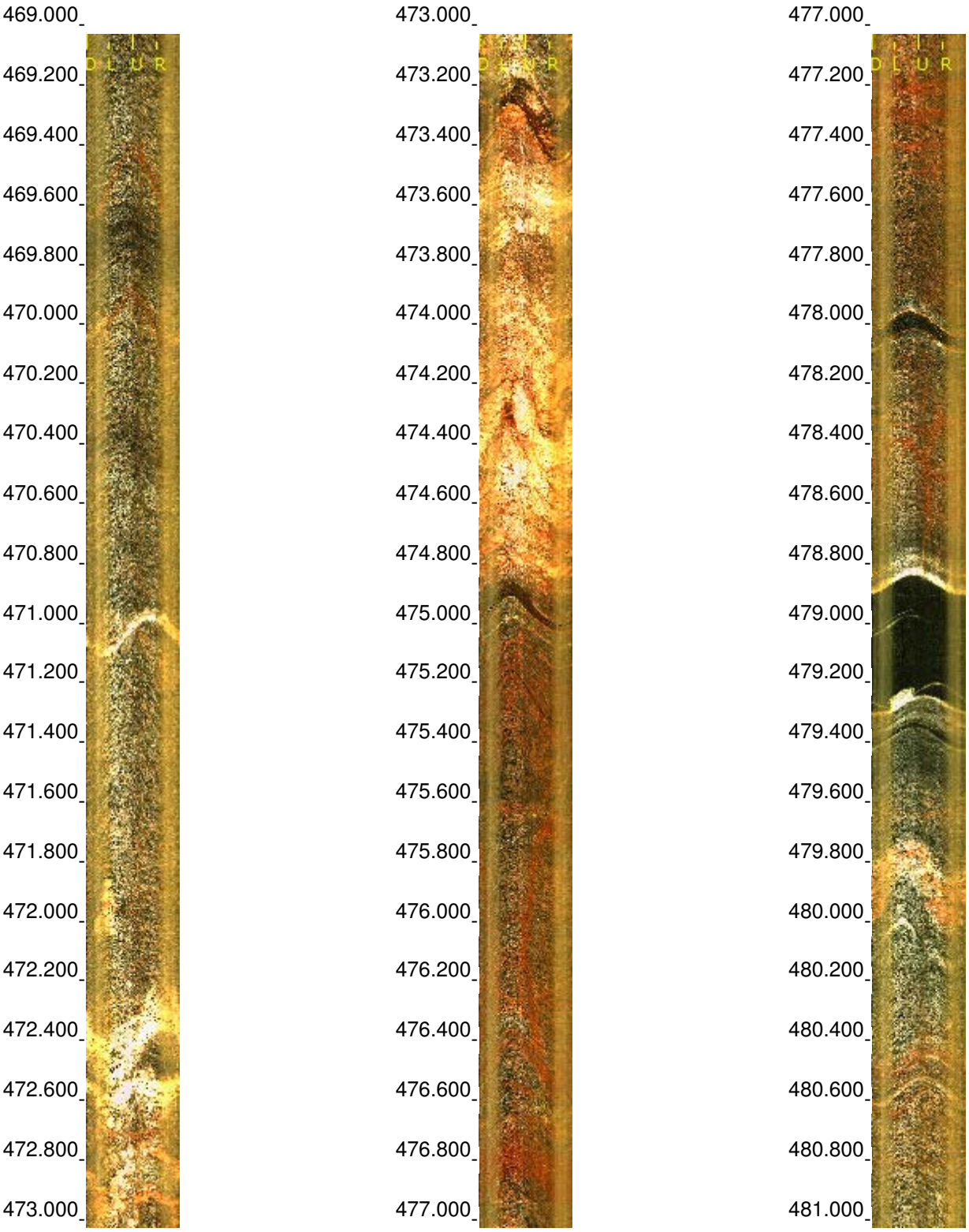
Borehole:
Mapping:

Depth range: 457.030 - 469.030 m
Azimuth: 0.0
Inclination: -90.0



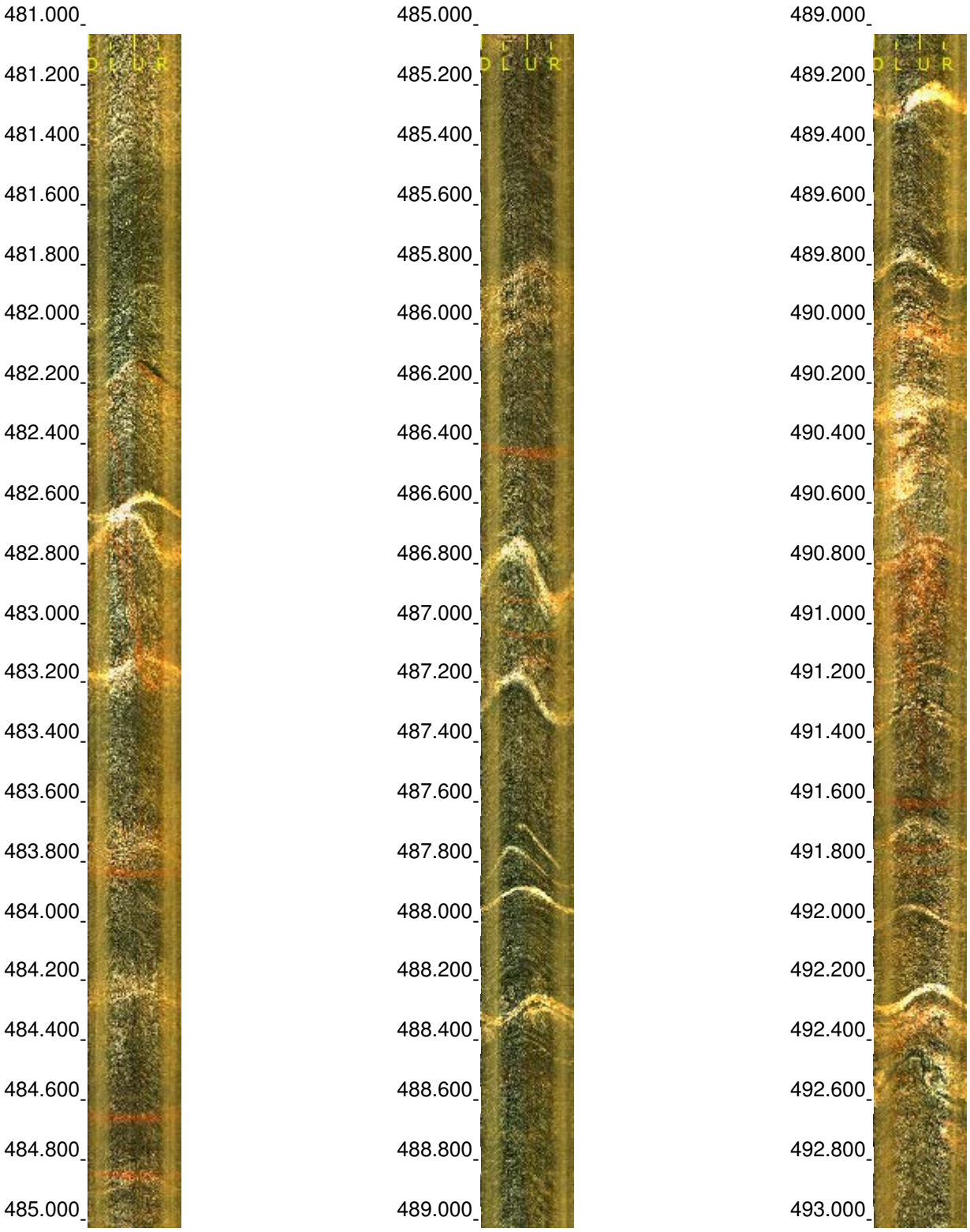
Borehole:
Mapping:

Depth range: 469.030 - 481.030 m
Azimuth: 0.0
Inclination: -90.0



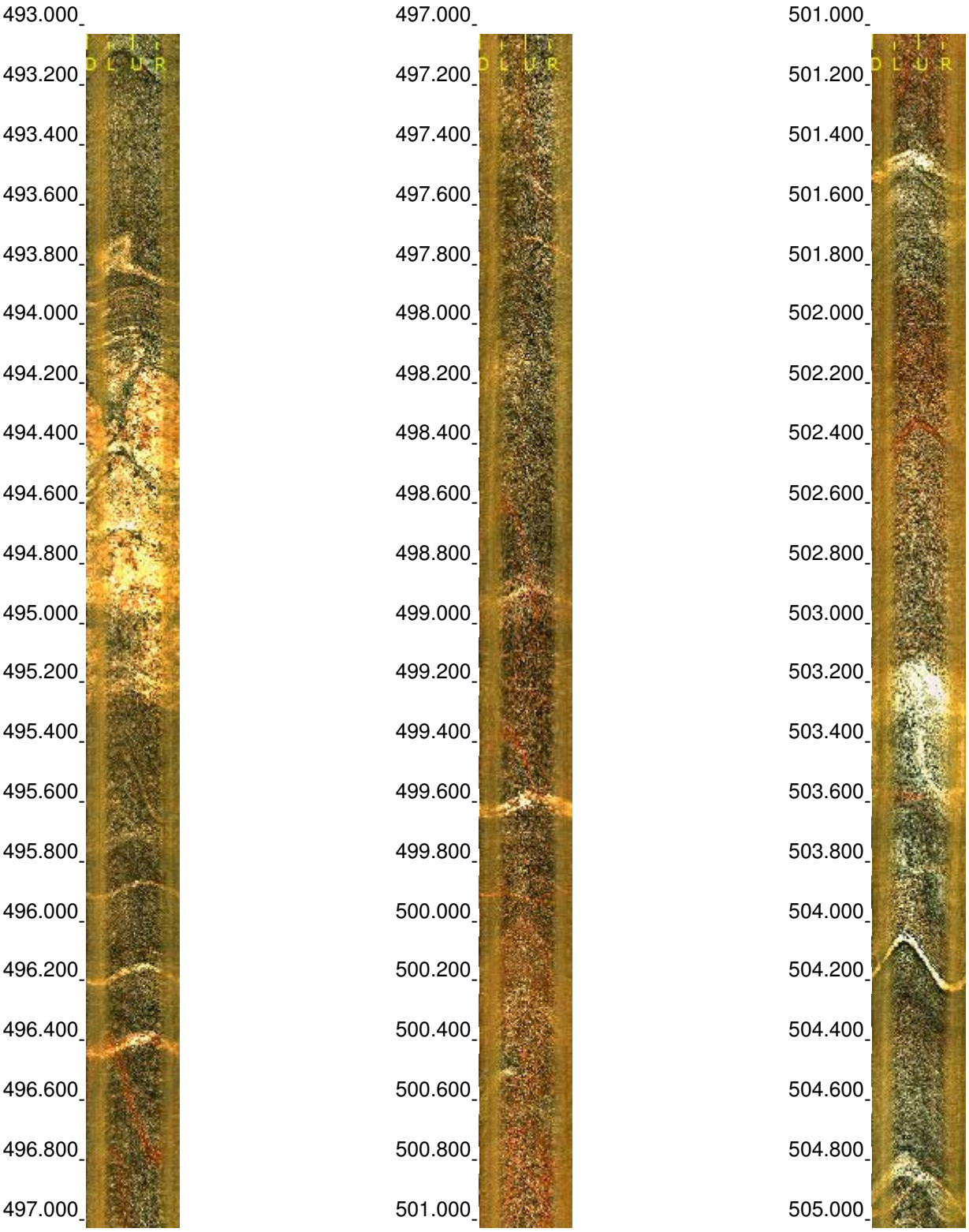
Borehole:
Mapping:

Depth range: 481.030 - 493.030 m
Azimuth: 0.0
Inclination: -90.0



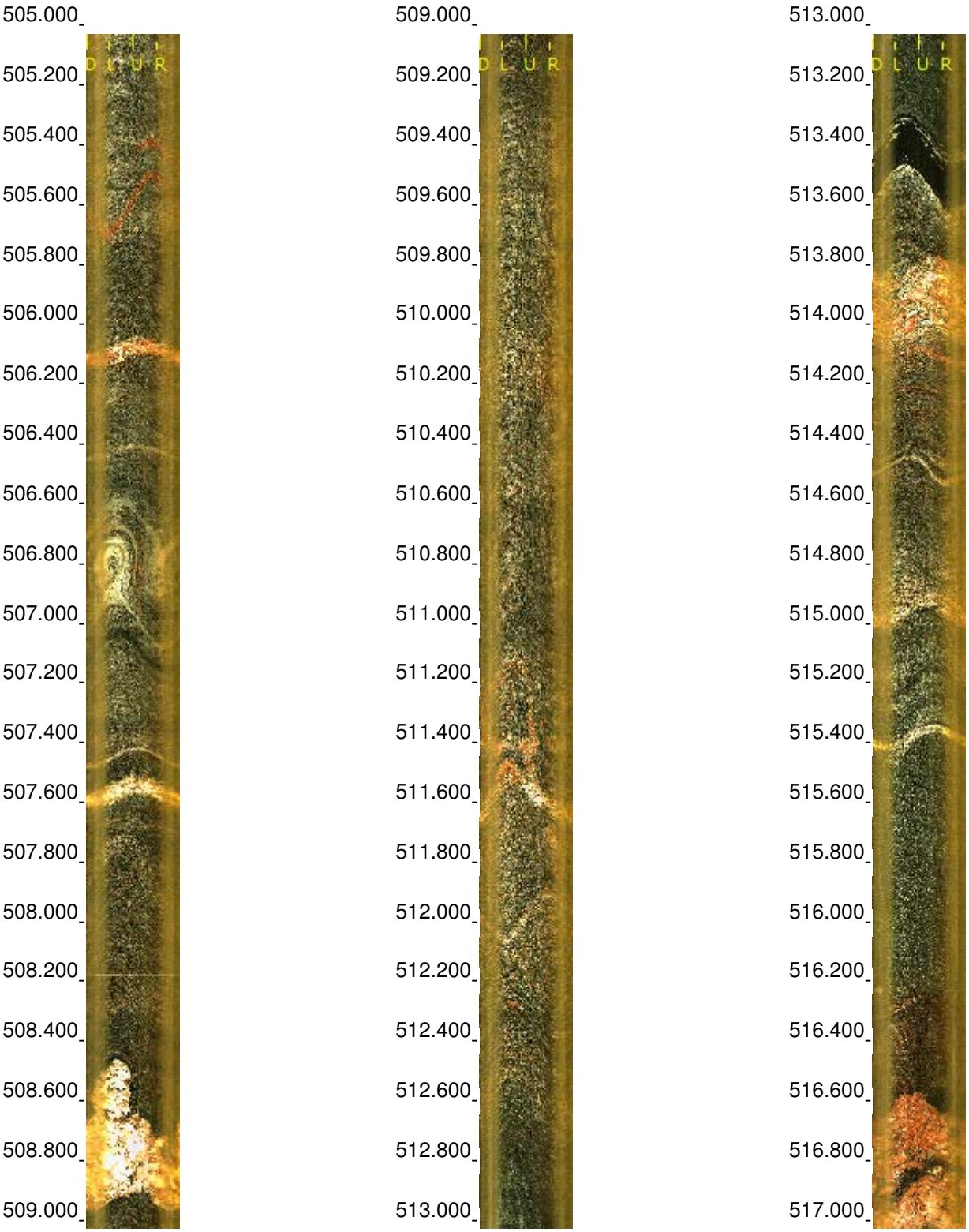
Borehole:
Mapping:

Depth range: 493.030 - 505.030 m
Azimuth: 0.0
Inclination: -90.0



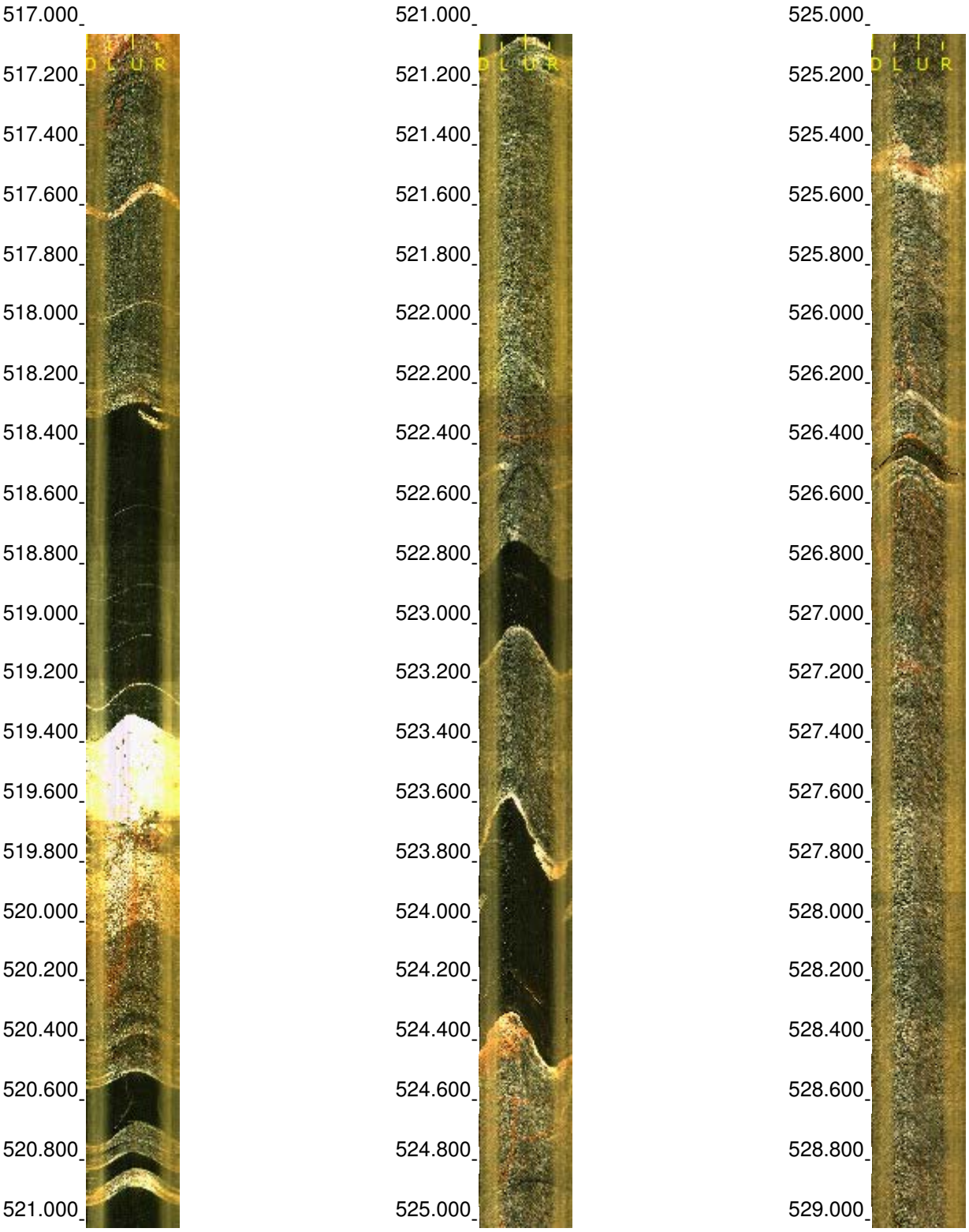
Borehole:
Mapping:

Depth range: 505.030 - 517.030 m
Azimuth: 0.0
Inclination: -90.0



Borehole:
Mapping:

Depth range: 517.030 - 529.030 m
Azimuth: 0.0
Inclination: -90.0

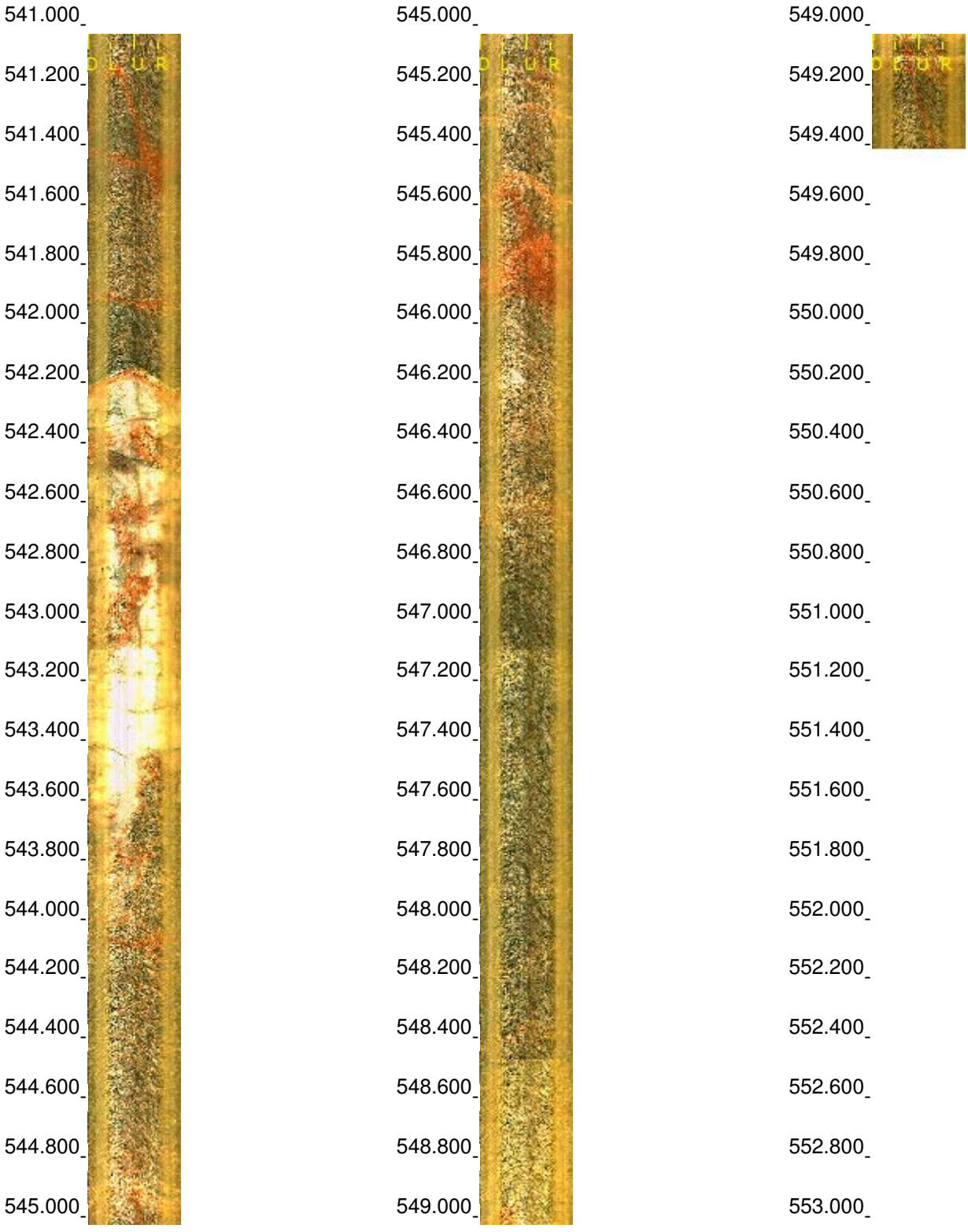


Borehole:
Mapping:

Depth range: 529.030 - 541.030 m
Azimuth: 0.0
Inclination: -90.0

Borehole:
Mapping:

Depth range: 541.030 - 549.409 m
Azimuth: 0.0
Inclination: -90.0



Arkitektkopia AB, Bromma, 2017

SKB is responsible for managing spent nuclear fuel and radioactive waste produced by the Swedish nuclear power plants such that man and the environment are protected in the near and distant future.

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