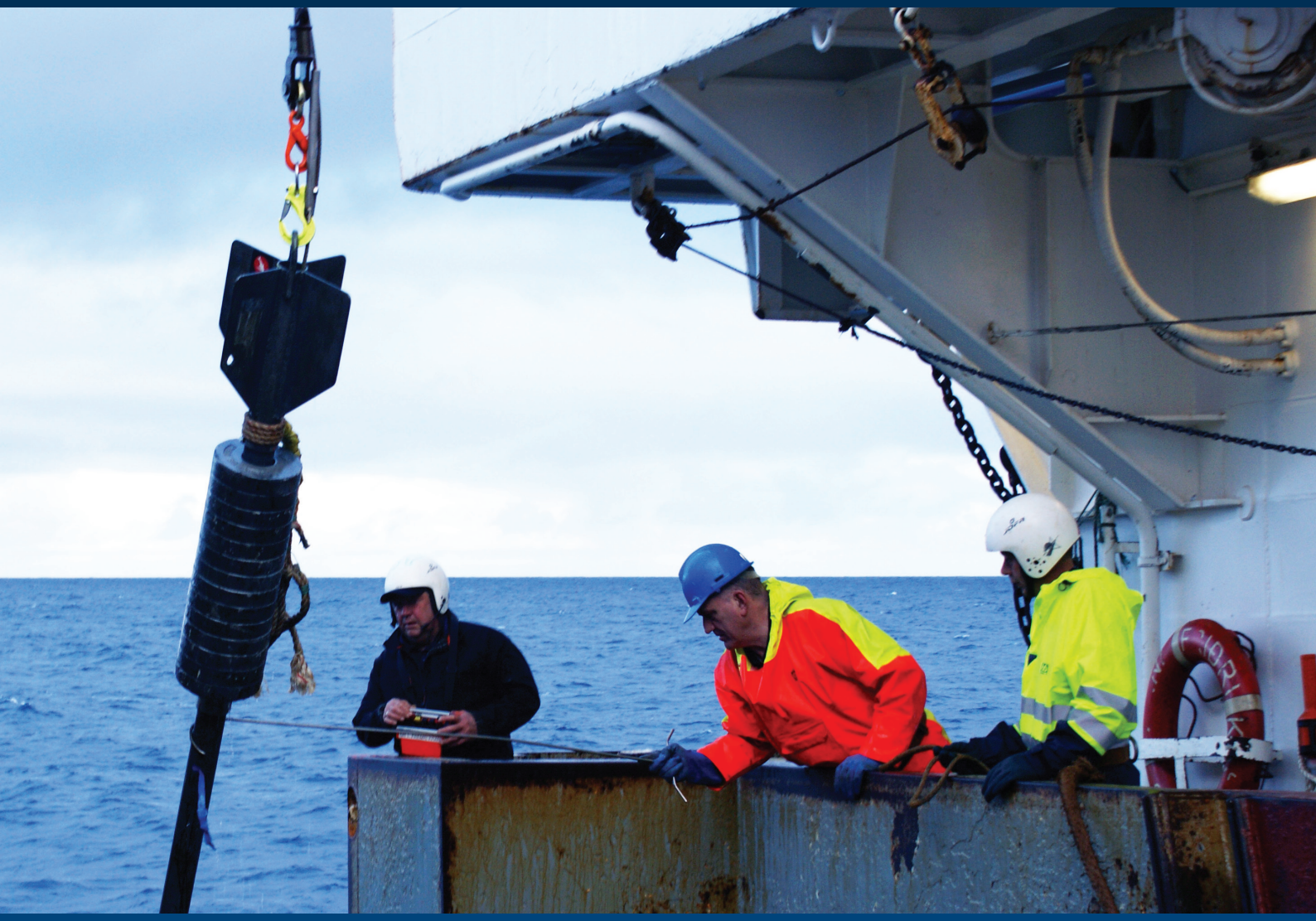
Dreki Area Sediment Cores

Preliminary Results on Litho- and Biostratigraphy



Höfundur:
Sædís Ólafsdóttir

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Preliminary Results on Litho- and Biostratigrapy

Sædís Ólafsdóttir

Prepared for Orkustofnun

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Key page

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Abstract:

In August 2010 several marine sediment cores were obtained from the Dreki and Jan Mayen Ridge area. The bottom part of the cores was sampled for extraction and analyses of petroleum liquids, leaving the remaining top part (< 6 m) available for other research. In this study we focus on the sedimentological properties of the cores by using the Geotek equipment located at the University of Iceland. Altogether, thirteen cores were scanned to measure the magnetic susceptibility and density of the sediments. Of those, six cores were chosen - based on location and morphological settings - for detailed analyses. Here we present preliminary results on lithology, micropaleontology, ice rafted detritus, high-productivity intervals, potential tephra layers and core correlations. Wealth of information lies in these cores concerning the paloenvironment and paleoceanograpy. Momentarily, the limitations lie in the age control preventing us from reconstructing these factors.

Keywords:

Marine sediment cores, sediment stratigraphy, Geotek measurements, foraminifera, tephra

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Project manager's signature

Þórarinn Sv. Arnarson

Reviewed by:

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DREKI – MARINE SEDIMENT CORES

INTRODUCTION

In August 2010 the National Authority of Iceland (Orkustofnun) in cooperation with the Norwegian Petroleum Directorate (NPD) and the Icelandic Marine Research Institute (MRI) conducted a marine research cruise covering the Dreki area and the Jan Mayen Ridge. The research vessel, Árni Friðriksson RE 200, carried out the sampling campaign obtaining thirty nine sediment cores with a piston gravity coring device (Fig. 1). The coring equipment consisted of Benthos Model 2175 piston corer, which has a 6.7 cm inner core liner diameter, with capacity to obtain samples up to 6 m long.

The main objective of the campaign was to map the presence and distribution of suggested oil and gas seepage to identify areas with potential for petroleum reservoirs. Consequently, several marine sediment cores were collected (< 6 m long) to analyze the bottom 30 cm of the obtained core material. Leaving the remaining top part of the sediment cores to be analyzed in respect to paleoenvironment, paleoceanography and sediment stratigraphy of the Dreki area. This report contains preliminary results of these factors and potential core correlations shedding light on the sediment stratigraphy of the Dreki area. Wealth of oceanographic information lies in these cores which awaits further analyses and would be more accessible with confirmed chronological constrains, such as tephra analyses or radiocarbon dating.

The sampling stations were located in the area of the northern Dreki: roughly 150 km wide (W-E) and 250 km long (N-S). The sediment cores were sampled at a large range of water depth (930 m to 1895 m) and in different geological provinces, such as structural highs and lows, volcanic regions and suggested pre-Tertiary sedimentary regions. The marine sediment cores in this report vary in length from

105 to 280 cm. Off the 39 cores collected 13 have been analyzed with the Multi-Sensor Core Logger (MSCL) equipment located at the University of Iceland (Table 3; Fig. 11-16). More detailed measurements were then carried out on 5 cores (Fig. 1-2), measured as split cores and will be described in details in this report (Fig. 5-9).

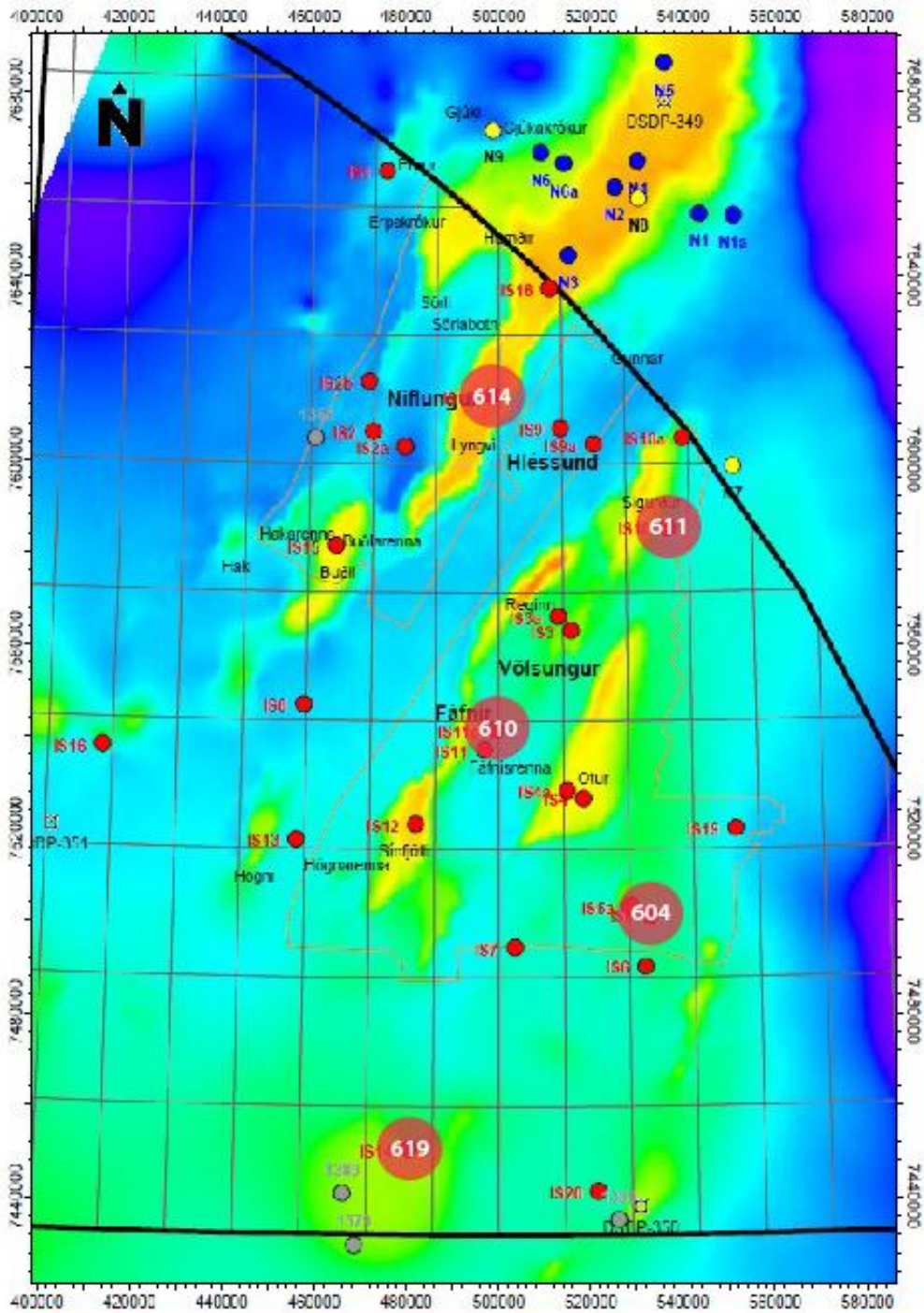

Figure 1. Sampling sites, red dots mark the Icelandic sites, blue dots the Norwegian sites. Large red circles show the location and split core number.

METHODS

GEOTEK

The MSCL was used to log the cores; it is equipped with two sensors operating at the same time, measuring gamma density and magnetic susceptibility (MS). The measurements were first carried out on whole cores and analyzed. Based on the result the most promising cores were split in two halves to carry on more detailed analyses. Hence, the cores were run through the MSCL system again and measured with the same procedure; gamma density and MS measurements. Noteworthy, the MS measurements were spot measurements with higher resolution and thus more time consuming compared to the whole core loop measurements.

Gamma Ray Density

With the gamma ray sensor the porosity or the density (ρ) of the marine core sediments can be evaluated (Table 1). The density of the material is a measure of how tightly the matter within it is packed together and is given by the ratio of its mass (m) to its volume (V) in SI units (kg/m^3). The instrument was calibrated at the start of each day using a plastic core liner filled with distilled water and aluminum standards of varying thickness. A choice of two operating positions (collimator: 5 or 2.5 mm in diameter, controls the size of the gamma beam) allows for resolution of 0.5 cm or higher. We used 5 mm beam radius with 10 sec operational time and measured on every 0.5 cm which gives us a high resolution data.

Mineral	Density (g/cc)
Calcium carbonate, CaCO3 (calcite)	2.71
Calcium carbonate, CaCO3 (aragonite)	2.93
Quartz, SiO2	2.65
Biogenic silica, SiO2nH2O (opal)	2.15
Pyrite, FeS2	4.95 to 5.10
Galena, PbS	7.4 to 7.6
Haematite, Fe2O3	4.9 to 5.3

Table 1. Variable density of common mineral grains.

Magnetic susceptibility

Operating at the same time, as the gamma ray, was a loop sensor to measure the magnetic susceptibility, which is a degree of magnetization of a material in response to an applied magnetic field (Table 2). The material can either give positive or a negative value depending on if the loop magnetic field is strengthened or weakened in its presence. All the marine sediment cores from the Dreki area showed positive values. The susceptibility meter was zeroed before each section was analyzed. For the whole core magnetic susceptibility measurements an 15 cm Bartington loop sensor was used, but a point sensor for the split cores allowing the sensor to be placed on the core surface. The point sensor used on the split cores turned out to be more favorable due to much smaller response function than the 15 cm loop sensor explaining the smoothed (less accurate) whole core data (Fig. 11-16).

Mineral	Magnetic Susceptibility (x10-6) SI
Water	9
Calcite	-7.5 to -39
Quartz, Feldspar	-13 to -17
Kaolinite	-50
Halite, Gypsum	-10 to -60
Illite, Montmorillonite	330 to 410
Biotite	1,500 to 2,900
Pyrite	5 to 3,500
Haematite	500 to 40,000
Magnetite	1,000,000 to 5,700,000

Table 2. The magnetic susceptibility of some common minerals.

Visual description

The marine sediment cores were split longitudinally and described visually. The description includes color variations and identification of any sedimentary structures; laminations, ice rafted debris, tephra layers and material homogeneity. Smear slides were collected from each core to briefly examine the sediment composition, with special interest in the foraminiferal fauna and tephra grains.

Digital photographs were taken from each core. Based on this visual and smear slides observation core connections are suggested (Fig. 10), but further chemical analyses on tephra layers or radiocarbon dating is needed to conclude on accurate correlations and ages.

Figure 2. Core locations of the five marine sediment cores from the Dreki area which were split and analyzed in more details (Table 3; Fig. 5-9).

Core number (A2010-11)	Sampling Station	Latitude	Longitude	Water Depth (m)	Cumulative Depth (cm)	Split Core Measurements
600	IS-3a	68°12.30'N	08°41.80'V	1459		
601	IS4a	67°52.15'N	08°38.68'V	1092		
604	IS5	67°37.56'N	08°14.20'V	1590	203	x
605	IS6	67°31.26'N	08°13.69'V	1561		
606	IS7	67°33.91'N	08°55.50'V	1662		
608	IS12	67°48.17'N	09°25.64'V	930		
610	IS11a	67°59.03'N	09°01.25'V	1642	280	x
611	IS10	68°22.43'N	08°06.05'V	1629	240	x
614	IS17	68°38.06'N	09°02.31'V	895	206	x
616	IS15	68°20.31'N	09°51.49'V	1070		
618	IS13	67°46.30'N	10°02.02'V	1727		
619	IS14	67°09.45'N	09°27.98'V	1265	237	x

Table 3. Core information.

PRELIMINARY RESULTS

Gamma Ray Density

High resolution logging (every 0.5 cm) was carried out both on whole and split cores. The gamma ray density values range from approximately 1.7 – 2.3 g/cm^3 and presumably reflect changes in sediment lithology (Fig. 5-9). Higher values are associated with coarser grain size whereas clay-rich units have lower values.

Magnetic susceptibility

Variations in magnetic susceptibility can reflect changes in sediment lithology (Fig. 5-9). Magnetic susceptibility of the Dreki area sediments is generally high (<900 x 10^{-5} SI) ranging from approximately 10 to 900 SIx10^{-5}. Some tephra layers, if rich in magnetite, can be detected by the high magnetic susceptibility values they produce. Magnetic susceptibility is relatively greater in clay deposits and lower in sediments that are rich in gypsum or calcite, reflecting the different susceptibilities of these minerals. Hence, the IRD rich lithofacies (III B) have higher magnetic susceptibility values than the high productivity layers containing the microfossil ooze (lithofacies II).

Visual description – lithology

The lithostratigraphic units in the five split cores were defined on the basis of data obtained from four sources (1) visual description; (2) smear slide examination; (3) magnetic susceptibility and (4) natural gamma ray density. Three lithofacies and two subunits have been identified in the split cores (Fig. 5-9). The core material is classified as clay and silty clay, each core contains color changes in the sediments most likely due to grain size changes and variability in carbonate content. Calcareous microfossils, such as benthic and planktic foraminifera are present in all lithofacies based on smear slide samples, although varying highly in abundance. Few foraminiferal species were identified in the smear slide samples. The most abundant planktic species were *Neoglobigerina pachyderma* (s) and *Globigerina quinqueloba*

(Fig. 3). There was higher diversity in the benthic fauna, but significantly lower flux. Benthic species found were for example *Pyrgo depressa, Cibicides wullerstorfi, Epistominella exigua* and *Cassidulina neoteretis*, suggesting polar to subpolar paleoenvironmental conditions (Fig. 4).

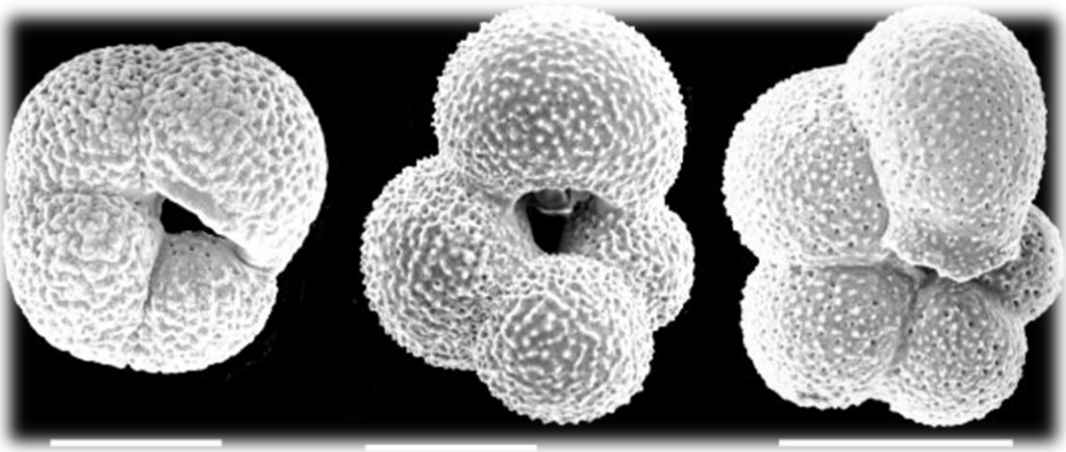

Figure 3. The planktic species *N. pachyderma* (s), *G. bulliodis* and *G. quinqueloba* (source: Norris and de Vargas, 2000)

Lithofacies I: Is characterized by predominantly brownish clayey matrix, sediments are moist and soft. Both planktic and benthic foraminifera are found in smear slide samples. Dropstones (IRD – Ice Rafted Debris) are absent.

Lithofacies II: Is characterized by light gray clayey nanofossil ooze, sediments are moist and soft. Smear slide sample contains high abundance of planktic foraminiferal species and some crystal grains. This could possibly be correlated to high productivity (HP) intervals found in marine sediment cores from the N-Atlantic. These events are found along with H-events representing periods of seasonally ice-free conditions and vary in duration from 2000 to 10,000 years. (Dokken and Hald, 1996; Hald et al., 1996).

Lithofacies III: Is characterized by brownish silty clay or clayey silt, sediments are firm and homogeneous. Dropstones (IRD – Ice Rafted Debris) are found, primarily angular to subrounded, and can vary from igneous to metamorphic rock fragments

of all sizes (<4cm). This lithofacies can be divided into two subfacies based on foraminiferal content.

Subfacies A: One particular benthic foraminiferal species is visually seen in the sediments. This benthic foraminifera is the species *Pyrgo depressa* (d'Orbigny, 1826; Fig. 4). This species has also been found in glaciomarine units of cores from the N-Atlantic from the last glacial maximum (LGM – 18-20.000 cal yr BP) (Rasmussen et al., 2002).

Subfacies B: No foraminifera can be seen visually, but smear slide samples contain small amounts of foraminifera.

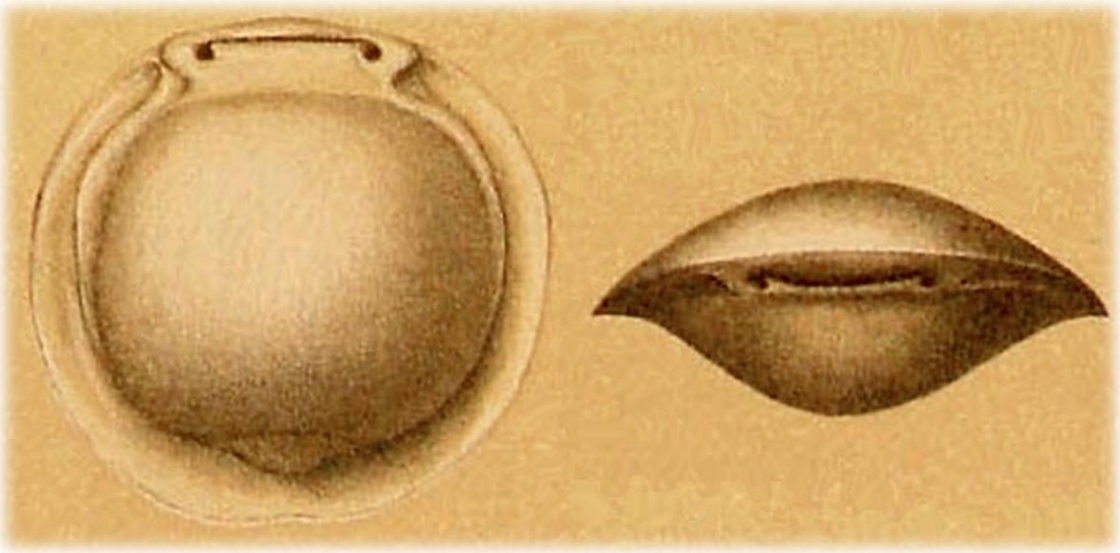

Figure 4. The benthic species *Pyrgo depressa* (source: Hesemann, 2013)

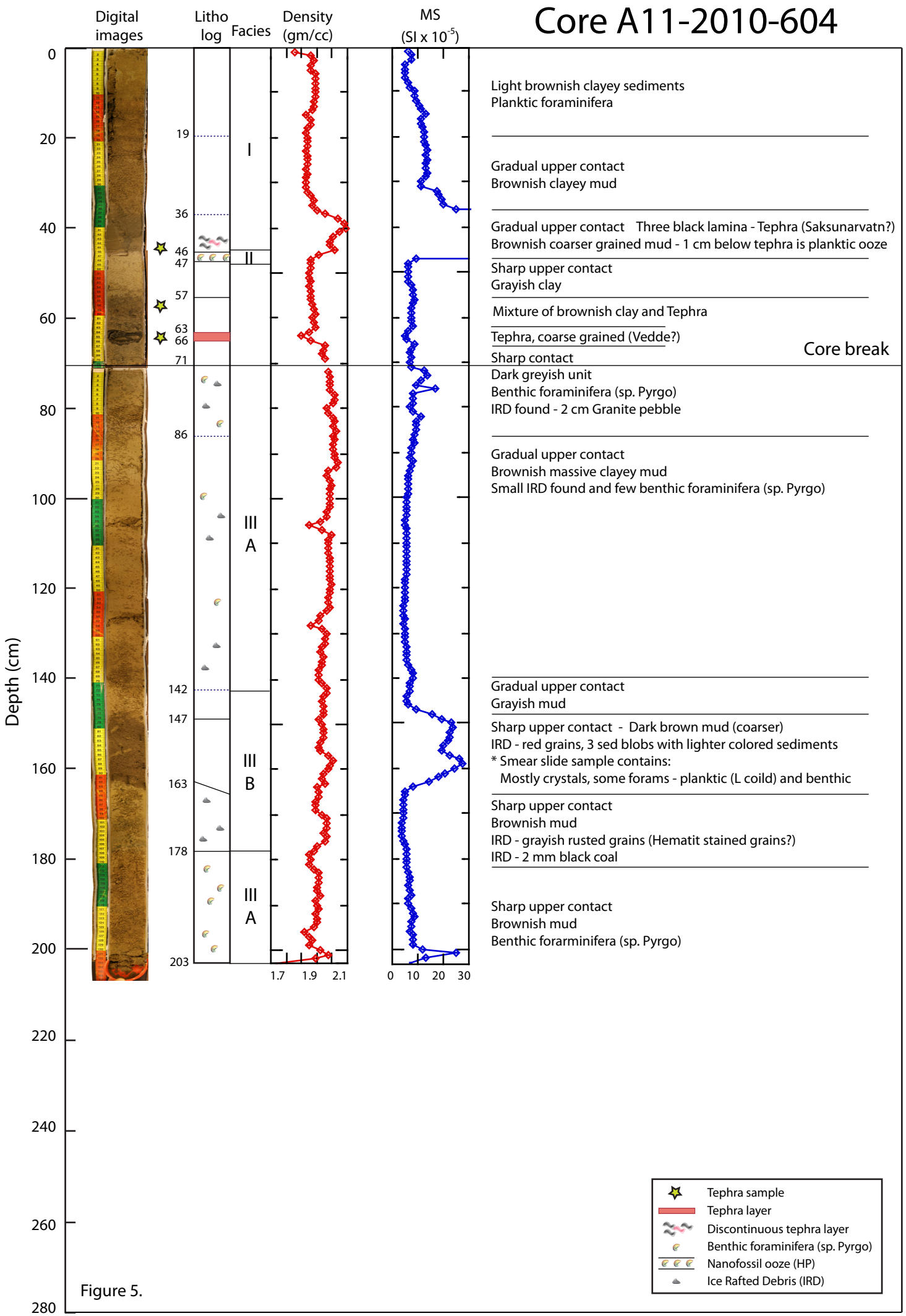
Core A11-2010-604
Digital images
Litho log
Facies
Density (gm/cc)
MS (SI x 10^-5)
Depth (cm)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
19
36
46
47
57
63
66
71
86
142
147
163
178
203
I
II
III A
III B
III A
1.7
1.9
2.1
0
10
20
30
Light brownish clayey sediments
Planktic foraminifera
Gradual upper contact
Brownish clayey mud
Gradual upper contact Three black lamina - Tephra (Saksunarvatn?)
Brownish coarser grained mud - 1 cm below tephra is planktic ooze
Sharp upper contact
Grayish clay
Mixture of brownish clay and Tephra
Tephra, coarse grained (Vedde?)
Sharp contact
Core break
Dark greyish unit
Benthic foraminifera (sp. Pyrgo)
IRD found - 2 cm Granite pebble
Gradual upper contact
Brownish massive clayey mud
Small IRD found and few benthic foraminifera (sp. Pyrgo)
Gradual upper contact
Grayish mud
Sharp upper contact - Dark brown mud (coarser)
IRD - red grains, 3 sed blobs with lighter colored sediments
* Smear slide sample contains:
Mostly crystals, some forams - planktic (L coild) and benthic
Sharp upper contact
Brownish mud
IRD - grayish rusted grains (Hematit stained grains?)
IRD - 2 mm black coal
Sharp upper contact
Brownish mud
Benthic forarminifera (sp. Pyrgo)
Tephra sample
Tephra layer
Discontinuous tephra layer
Benthic foraminifera (sp. Pyrgo)
Nanofossil ooze (HP)
Ice Rafted Debris (IRD)

Figure 5.

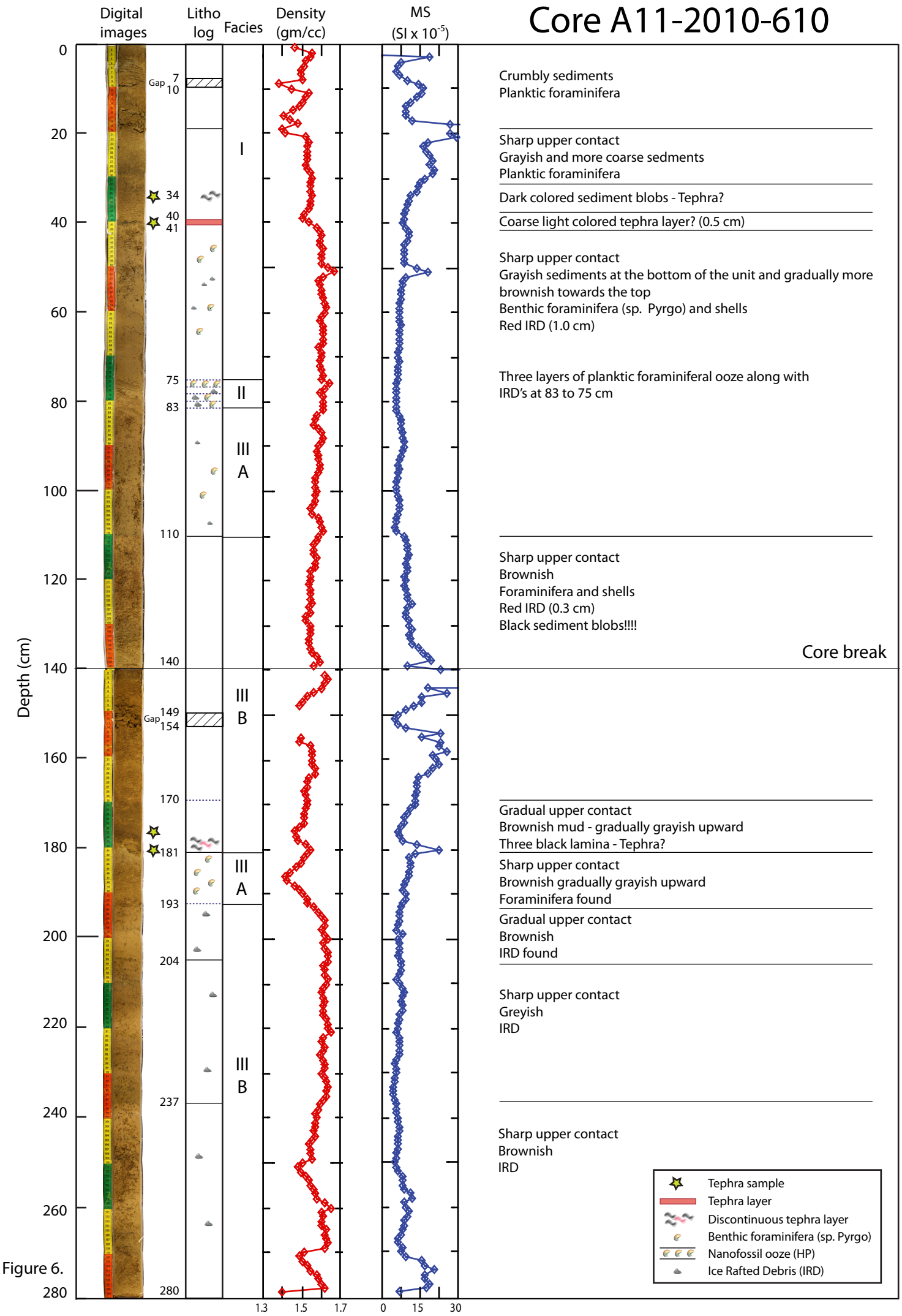
Core A11-2010-610
Digital images
Litho log
Facies
Density (gm/cc)
MS (SI x 10^{-5})
Depth (cm)
Gap
7
10
34
40
41
75
83
110
140
149
154
170
181
193
204
237
280
I
II
III A
III B
III A
III B
Crumbly sediments
Planktic foraminifera
Sharp upper contact
Grayish and more coarse sedments
Planktic foraminifera
Dark colored sediment blobs - Tephra?
Coarse light colored tephra layer? (0.5 cm)
Sharp upper contact
Grayish sediments at the bottom of the unit and gradually more brownish towards the top
Benthic foraminifera (sp. Pyrgo) and shells
Red IRD (1.0 cm)
Three layers of planktic foraminiferal ooze along with IRD's at 83 to 75 cm
Sharp upper contact
Brownish
Foraminifera and shells
Red IRD (0.3 cm)
Black sediment blobs!!!!
Core break
Gradual upper contact
Brownish mud - gradually grayish upward
Three black lamina - Tephra?
Sharp upper contact
Brownish gradually grayish upward
Foraminifera found
Gradual upper contact
Brownish
IRD found
Sharp upper contact
Greyish
IRD
Sharp upper contact
Brownish
IRD
Tephra sample
Tephra layer
Discontinuous tephra layer
Benthic foraminifera (sp. Pyrgo)
Nanofossil ooze (HP)
Ice Rafted Debris (IRD)
1.3
1.5
1.7
0
15
30

Figure 6.

Core A11-2010-611

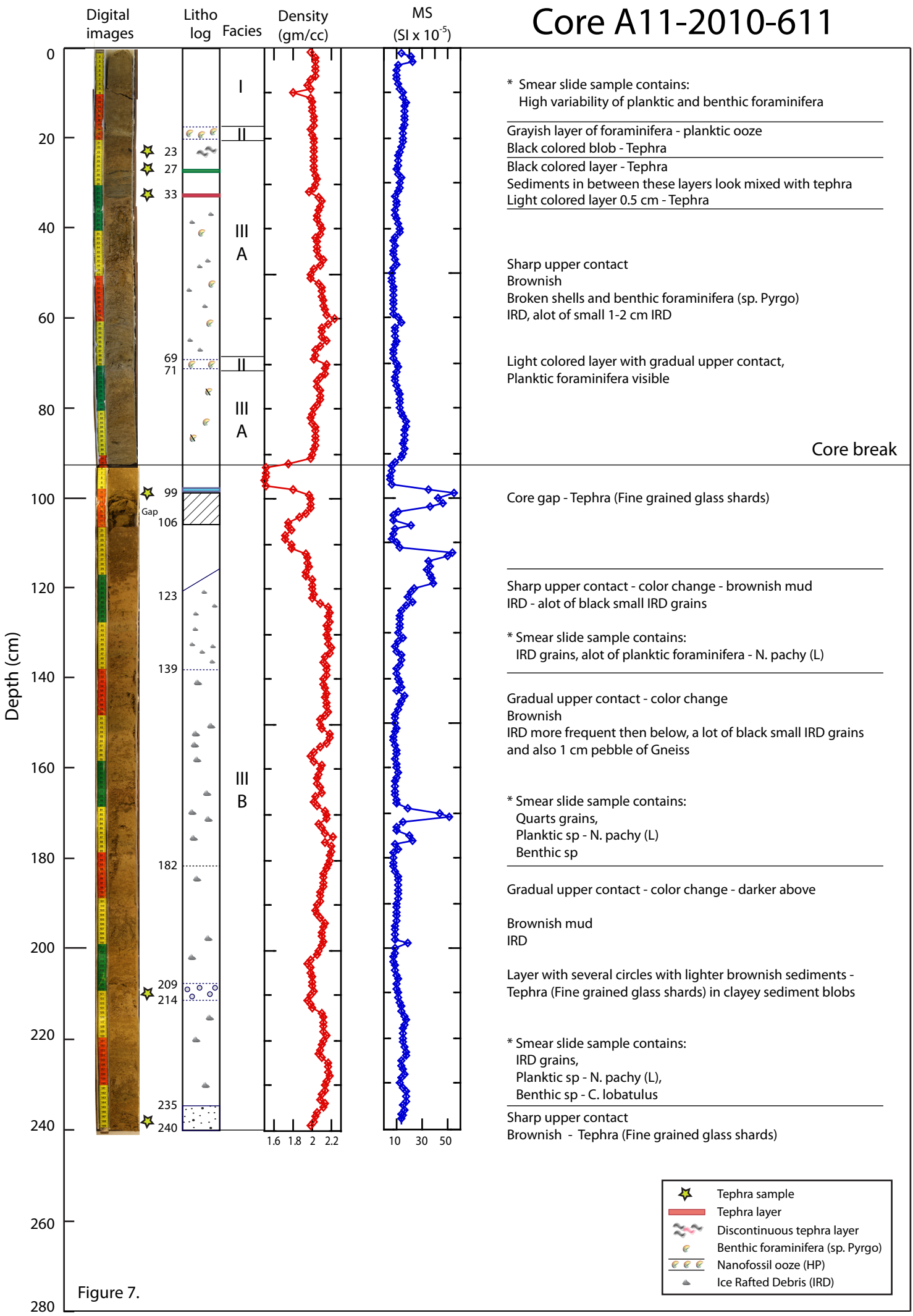

Figure 7.

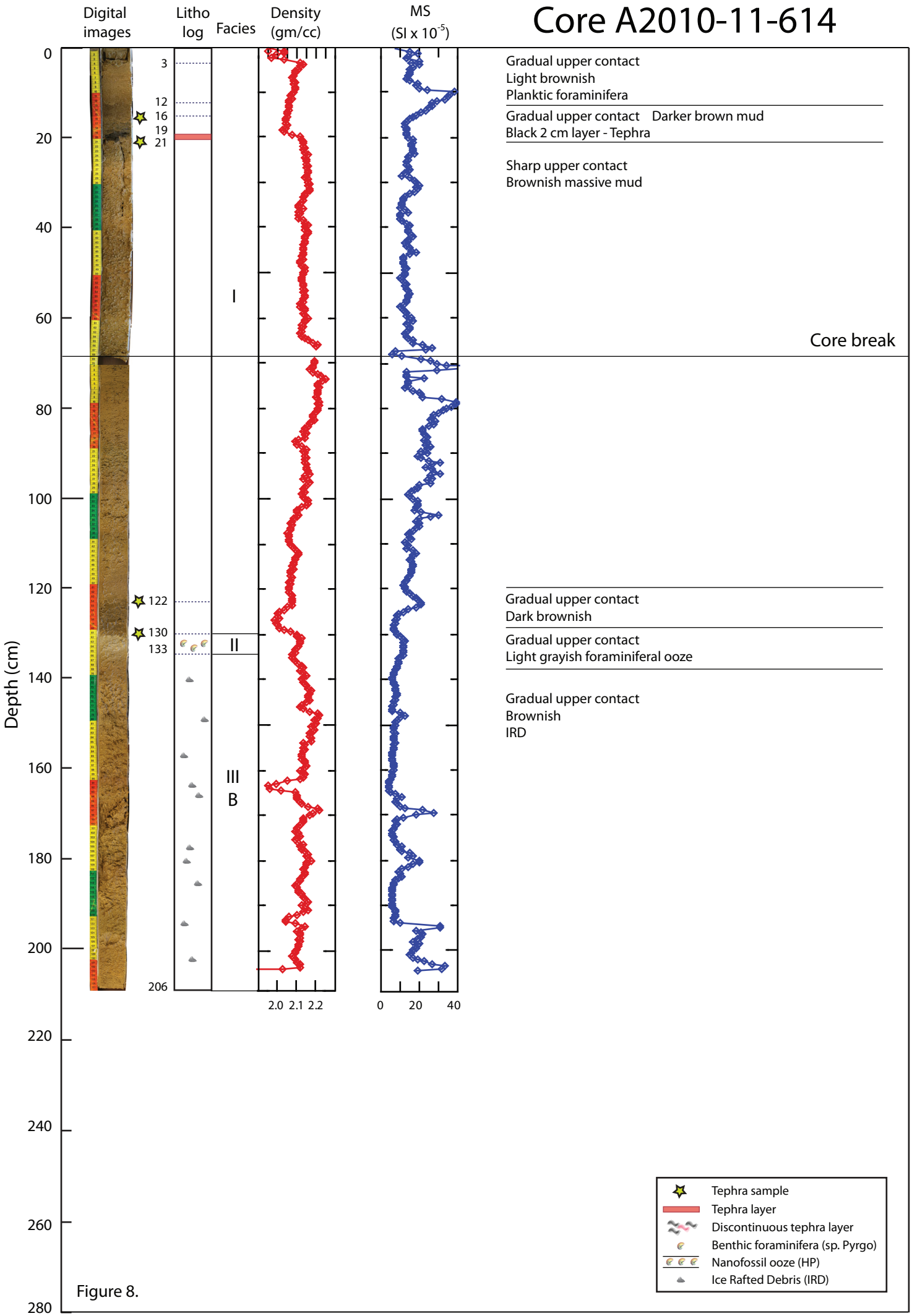
Core A2010-11-614
Digital images
Litho log
Facies
Density (gm/cc)
MS (SI x 10^{-5})
Depth (cm)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
3
12
16
19
21
122
130
133
206
I
II
III
B
2.0 2.1 2.2
0 20 40
Gradual upper contact
Light brownish
Planktic foraminifera
Gradual upper contact Darker brown mud
Black 2 cm layer - Tephra
Sharp upper contact
Brownish massive mud
Core break
Gradual upper contact
Dark brownish
Gradual upper contact
Light grayish foraminiferal ooze
Gradual upper contact
Brownish
IRD
Tephra sample
Tephra layer
Discontinuous tephra layer
Benthic foraminifera (sp. Pyrgo)
Nanofossil ooze (HP)
Ice Rafted Debris (IRD)

Figure 8.

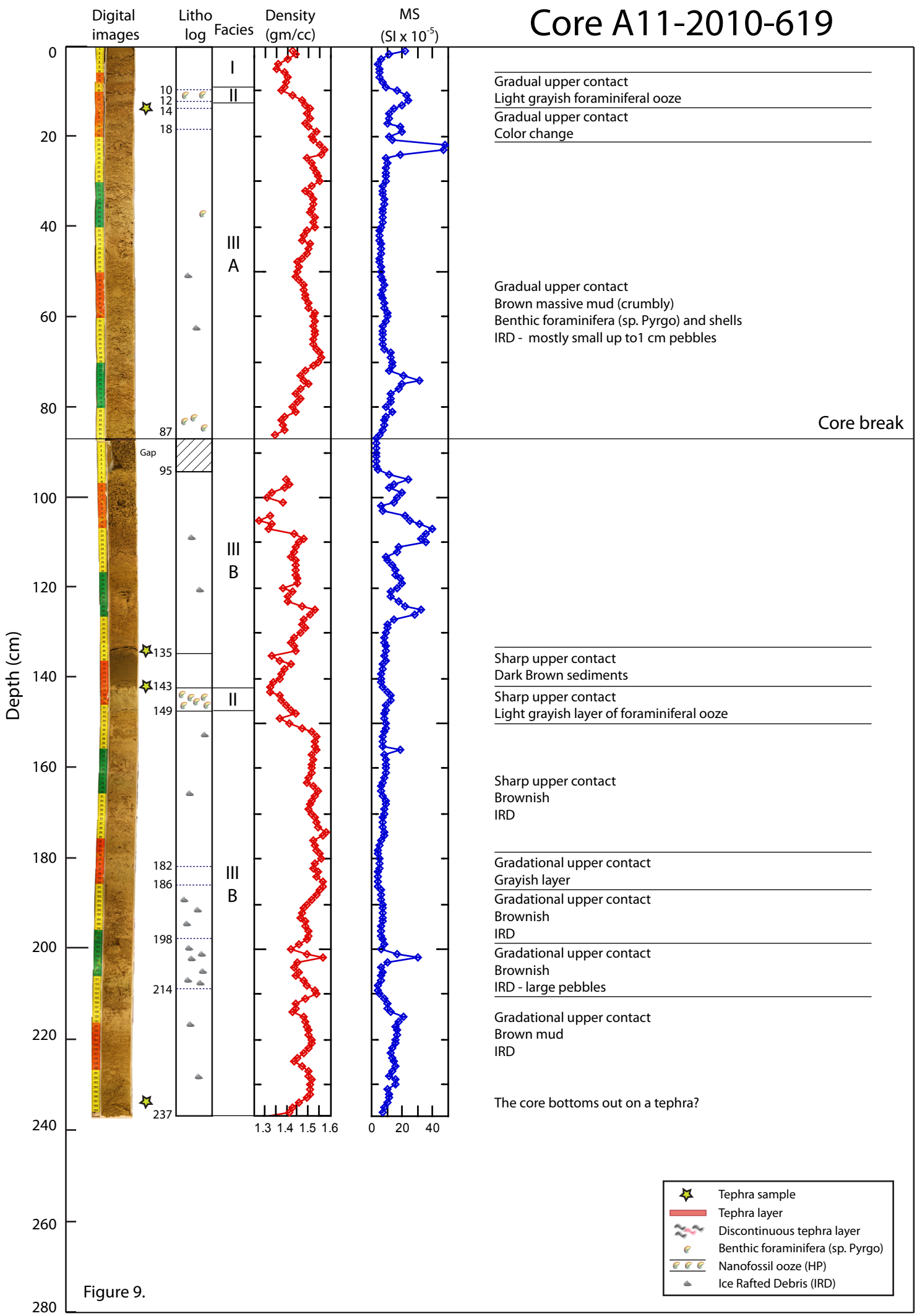
Core A11-2010-619
Digital images
Litho log
Facies
Density (gm/cc)
MS (SI x 10^-5)
Depth (cm)
I
II
III A
III B
II
III B
Gap
10
12
14
18
87
95
135
143
149
182
186
198
214
237
1.3 1.4 1.5 1.6
0 20 40
Gradual upper contact
Light grayish foraminiferal ooze
Gradual upper contact
Color change
Gradual upper contact
Brown massive mud (crumbly)
Benthic foraminifera (sp. Pyrgo) and shells
IRD - mostly small up to1 cm pebbles
Core break
Sharp upper contact
Dark Brown sediments
Sharp upper contact
Light grayish layer of foraminiferal ooze
Sharp upper contact
Brownish
IRD
Gradational upper contact
Grayish layer
Gradational upper contact
Brownish
IRD
Gradational upper contact
Brownish
IRD - large pebbles
Gradational upper contact
Brown mud
IRD
The core bottoms out on a tephra?
Tephra sample
Tephra layer
Discontinuous tephra layer
Benthic foraminifera (sp. Pyrgo)
Nanofossil ooze (HP)
Ice Rafted Debris (IRD)

Figure 9.

Volcanic Ash

Volcanic glass shards have been detected in all the split cores (604-610-611-614-619), either in form of layers or as a discontinuous layers and sediment blobs. The tephra layers found occur in range of color from light gray to black and in various grain sizes from fine to rather coarse. The dark coloration in a few of the layers appears to be due to the presence of secondary sulfides formation in association with the colorless volcanic ash. Smear slides were collected from core 611 to confirm suspected tephra layers; six tephra layers were identified varying significantly in morphology.

Tephra Layer 1 (Core 611 – Depth 22 cm): Black colored sediment blob. Smear slide sample consists of smaller grain size of black basaltic glass, sideromelane glass and translucent acid glass. ***(Potentially the Saksunarvatn tephra – 10.300 cal yrs BP)***

Tephra Layer 2 (Core 611 – Depth 26 cm): Very distinct black layer (0.2 cm). Smear slide sample consists mainly of black basaltic glass and less abundant of translucent acid glass. ***(Potentially the Askja-S tephra – 10.910-10.810 cal yrs BP)***

Tephra Layer 3 (Core 611 – Depth 32 cm): Very distinct (0.5 cm) light colored layer. Smear slide sample consists of coarse glass shards: translucent acid glass, black basaltic glass and few fiber looking glass shards. ***(Potentially the Vedde tephra – 12.120 cal yrs BP)***

Tephra Layer 4 (Core 611 – Depth ~100 cm): Not a distinct tephra layer, but glass shards are visible in clayey sediments (gap in core – less coherent due to glass

shards). Smear slide sample consists of fine grained, translucent acid glass shards. ***(Potentially the Borrobol tephra – 14.550 cal yrs BP)***

Tephra Layer 5 (Core 611 – Depth 209 - 214 cm): Not a distinct layer, but glass shards are found in light colored, spherical sediment blobs. Smear slide sample consists of fine grained, translucent acid glass shards.

Tephra Layer 6 (Core 611 – Depth 235 - 240 cm): Glass shards mixed with clayey sediments. Smear slide sample consists of fine grained, translucent acid glass shards.

Unconfirmed core correlations

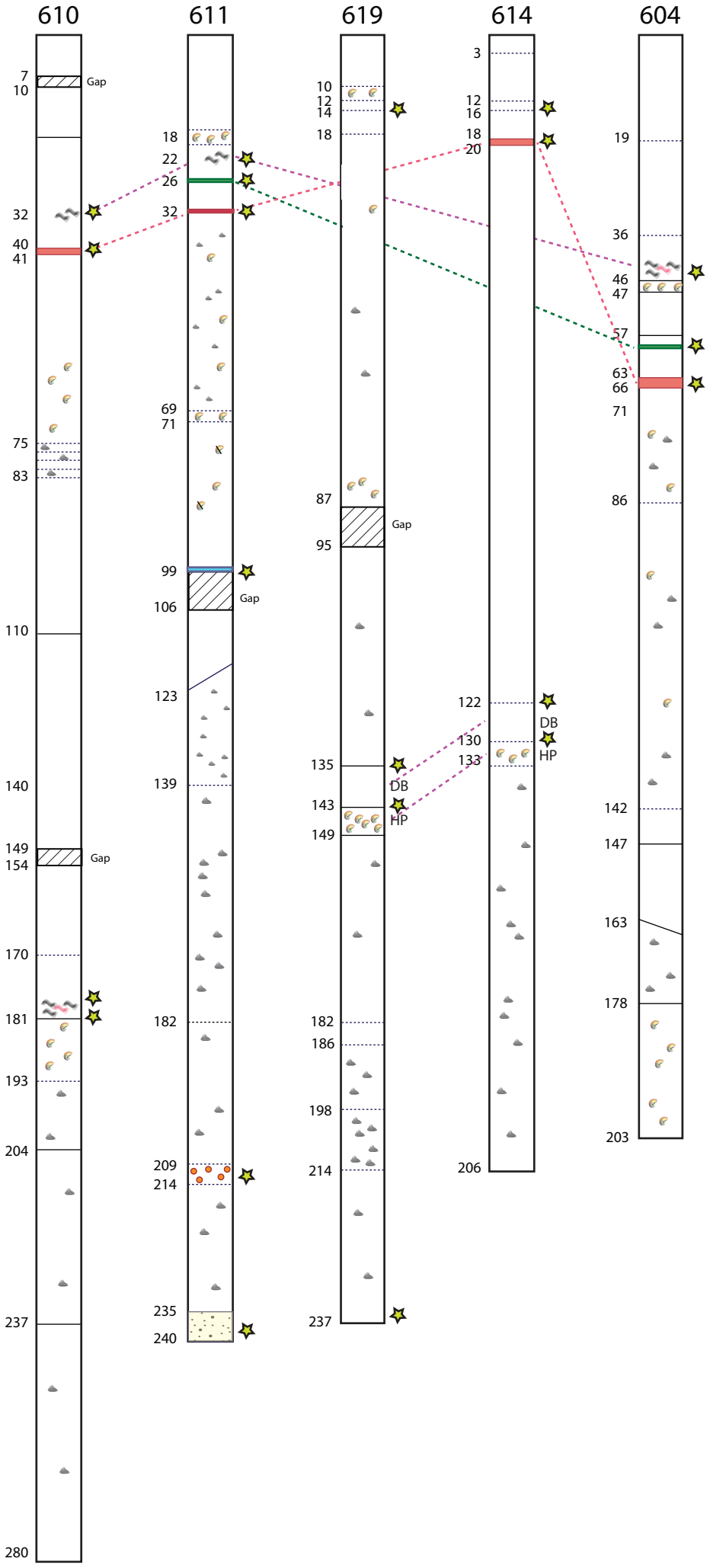

Figure 10.

SUMMARY AND FUTURE POSSIBILITIES:

In past decades several proxy records have accumulated from the North Atlantic indicating abrupt changes in sediment delivery and paleoceanography. The most dramatic changes are seen in grain-size variability and mineralogy associated with postulated iceberg rafting events, Heinrich (H) events. These events along with short lived high productivity (HP) events are found in the cores from the Dreki area, thus indicating that most of the cores span the time period back to Last Glacial Maximum (LGM) and possibly still further back in time. However, detailed dating to constrain robust age model is of primary interest to place the proxy records in time. Geochemical tephra analyses and/or radiocarbon dating on foraminifera are the most feasible options for the task. The Dreki area sediment cores have the potential for several analytical options that can be carried out in the future, such as: total carbon analyses, grain size and mineralogical studies, IRD counts, foraminiferal analyses and paleomagnetic measurements.

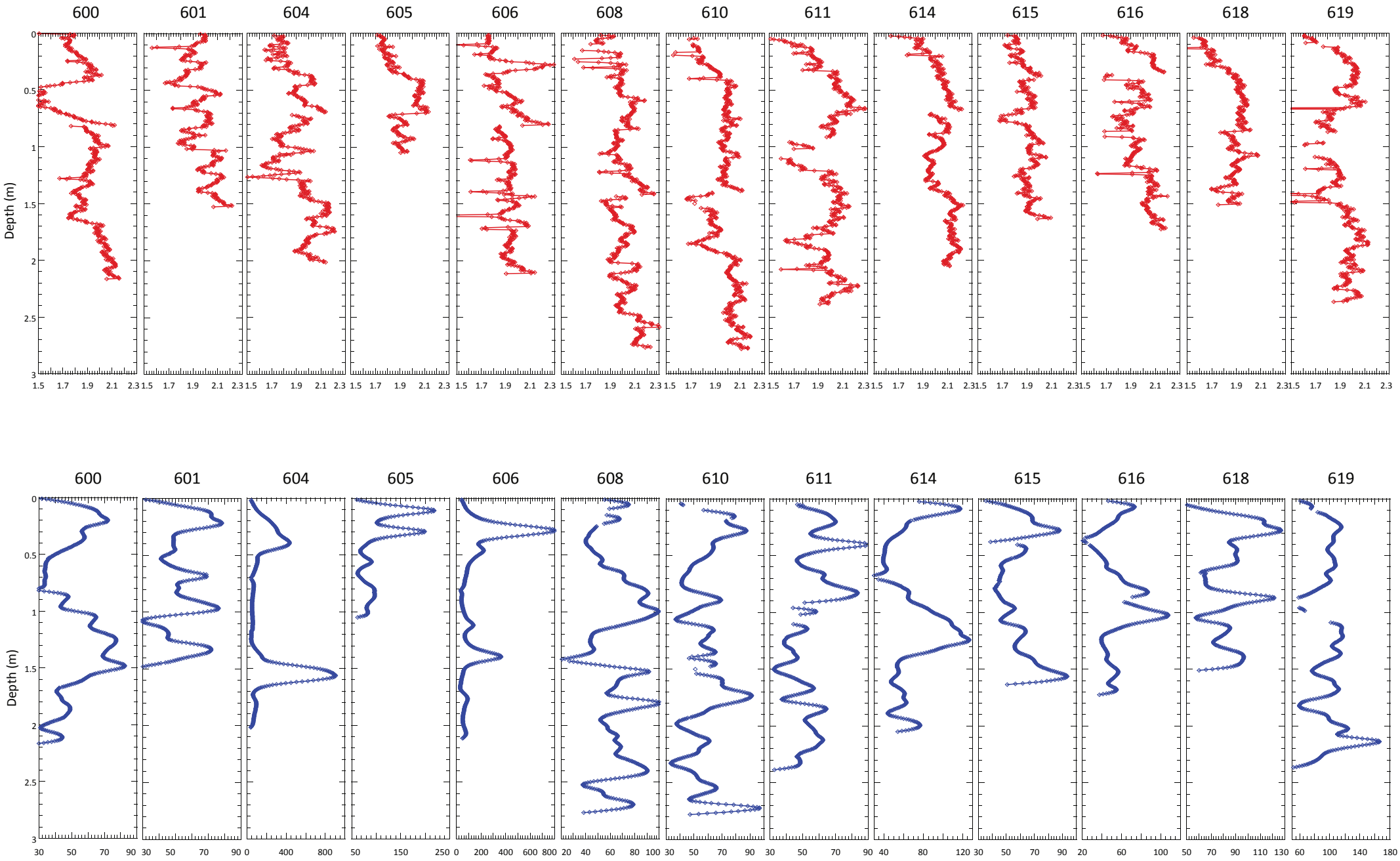

Figure 11.

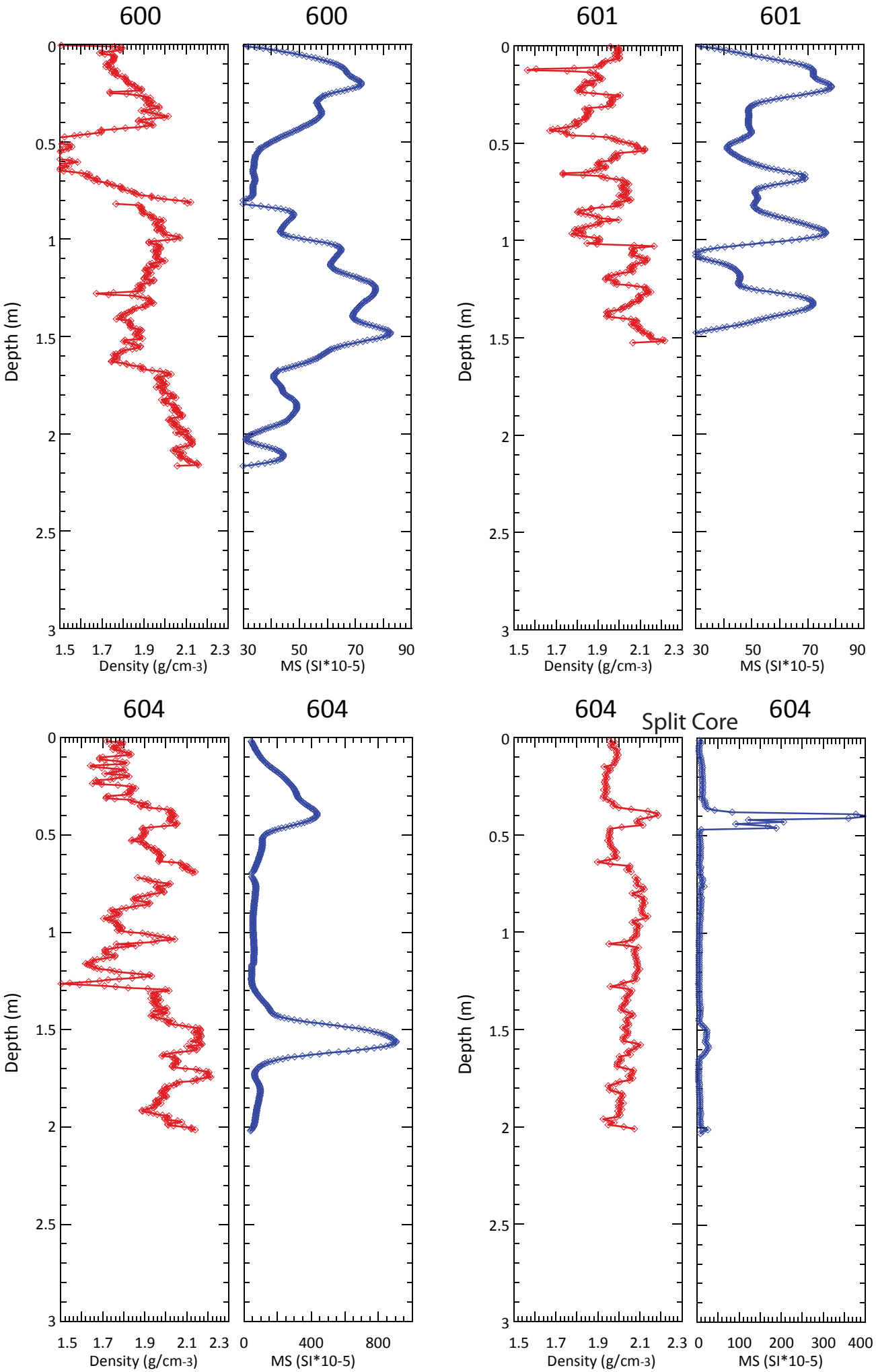
600
600
601
601
604
604
604
Split Core
604
Depth (m)
0
0.5
1
1.5
2
2.5
3
1.5 1.7 1.9 2.1 2.3
Density (g/cm-3)
30 50 70 90
MS (SI*10-5)
0 400 800
0 100 200 300 400

Figure 12

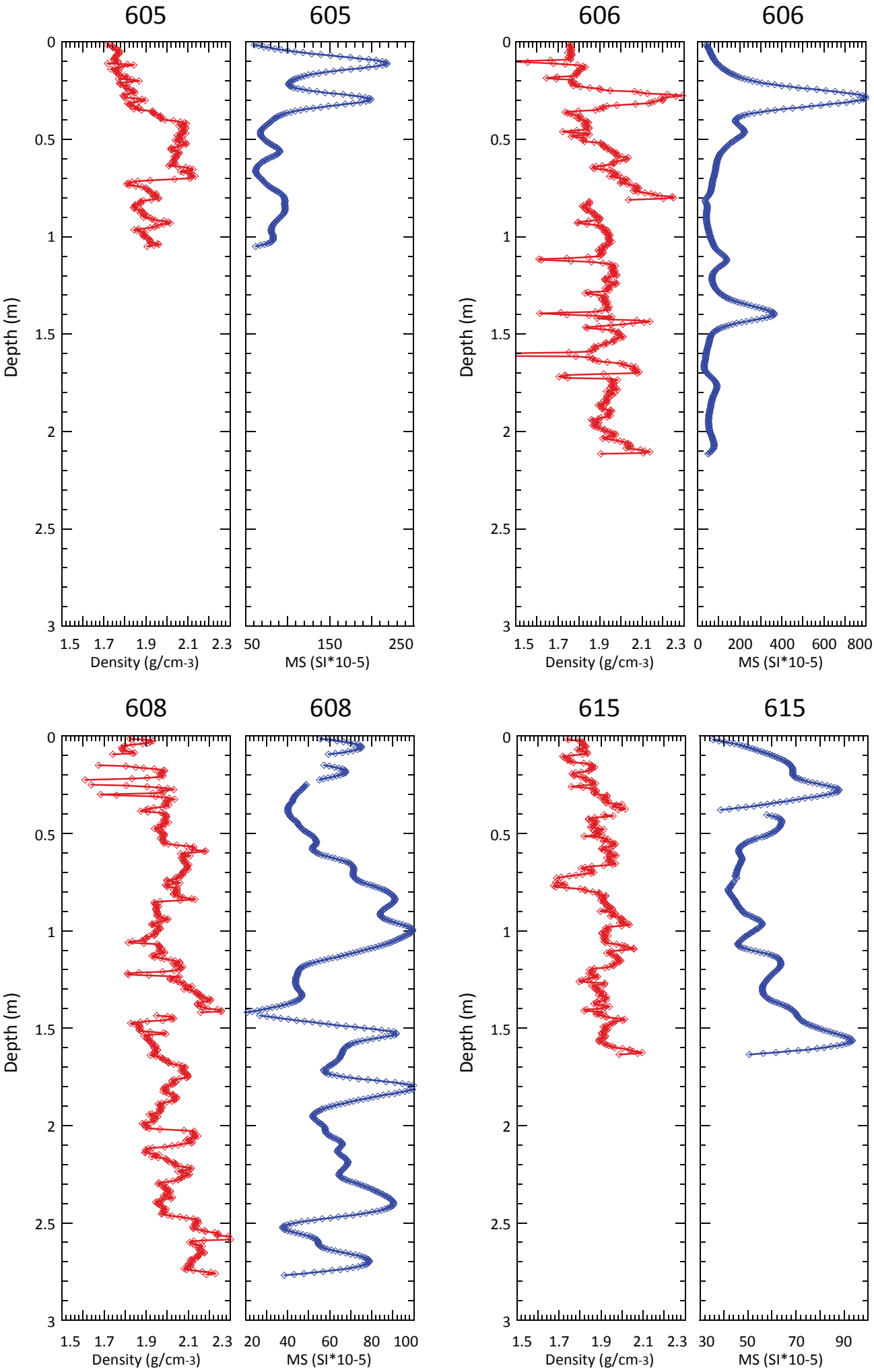
605
605
606
606
608
608
615
615
Depth (m)
0
0.5
1
1.5
2
2.5
3
1.5 1.7 1.9 2.1 2.3
Density (g/cm-3)
50 150 250
MS (SI*10-5)
0 200 400 600 800
20 40 60 80 100
30 50 70 90

Figure 13

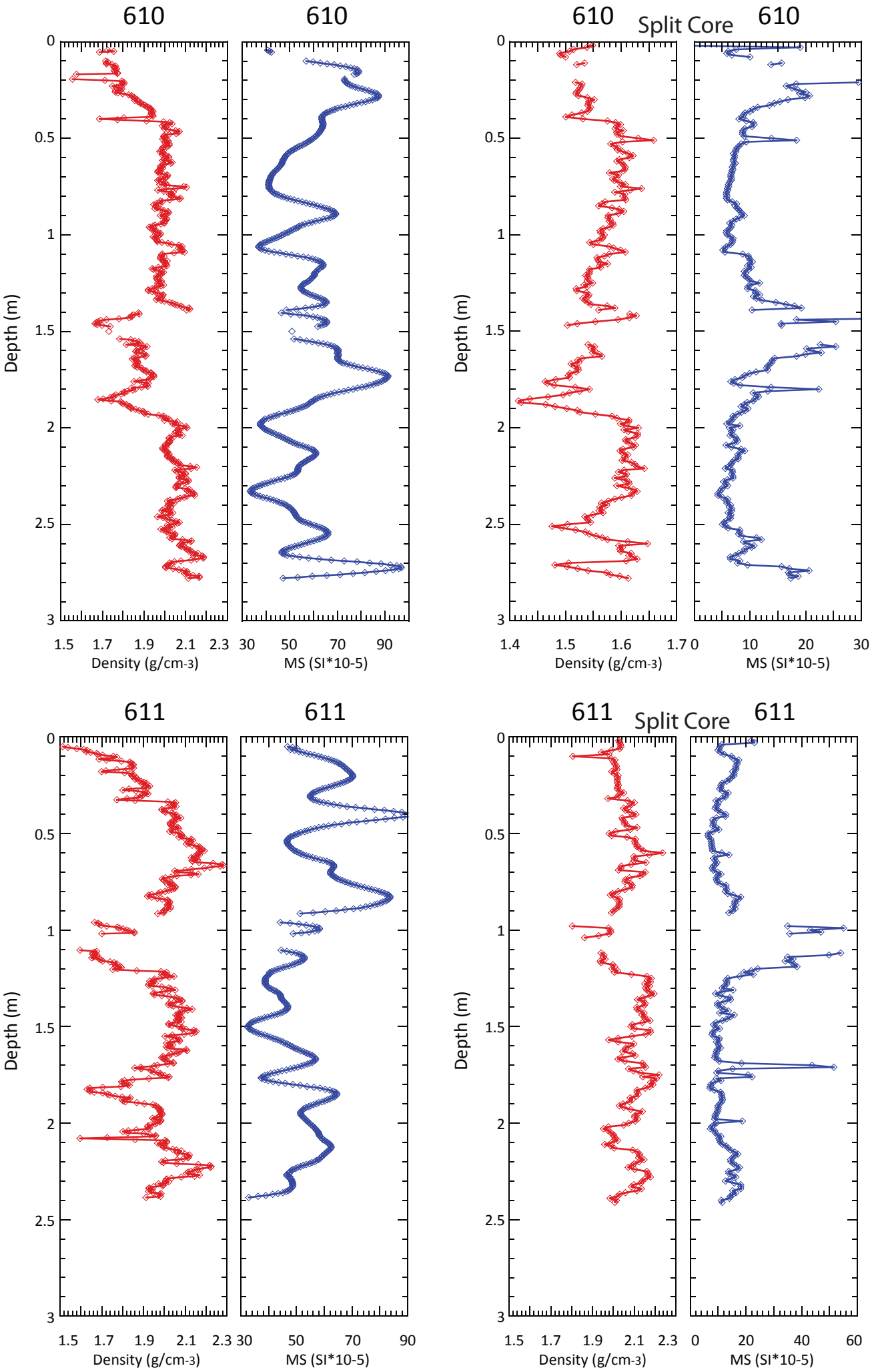
610
610
610
Split Core
610
611
611
611
Split Core
611
Depth (m)
Density (g/cm-3)
MS (SI*10-5)

Figure 14

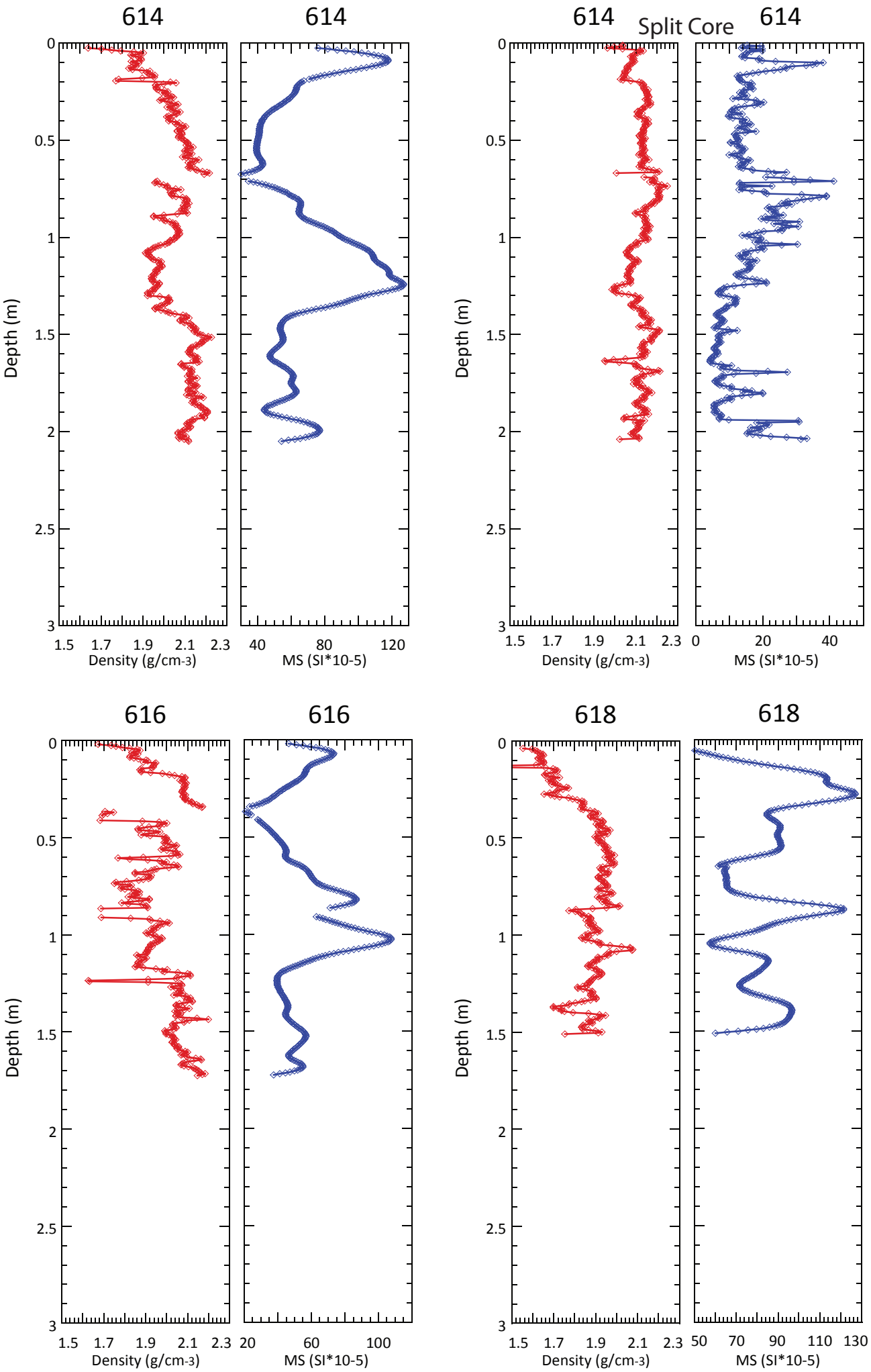
614
614
614
Split Core
614
616
616
618
618
Depth (m)
0
0.5
1
1.5
2
2.5
3
1.5
1.7
1.9
2.1
2.3
Density (g/cm-3)
40
80
120
MS (SI*10-5)
0
20
40
20
60
100
50
70
90
110
130

Figure 15

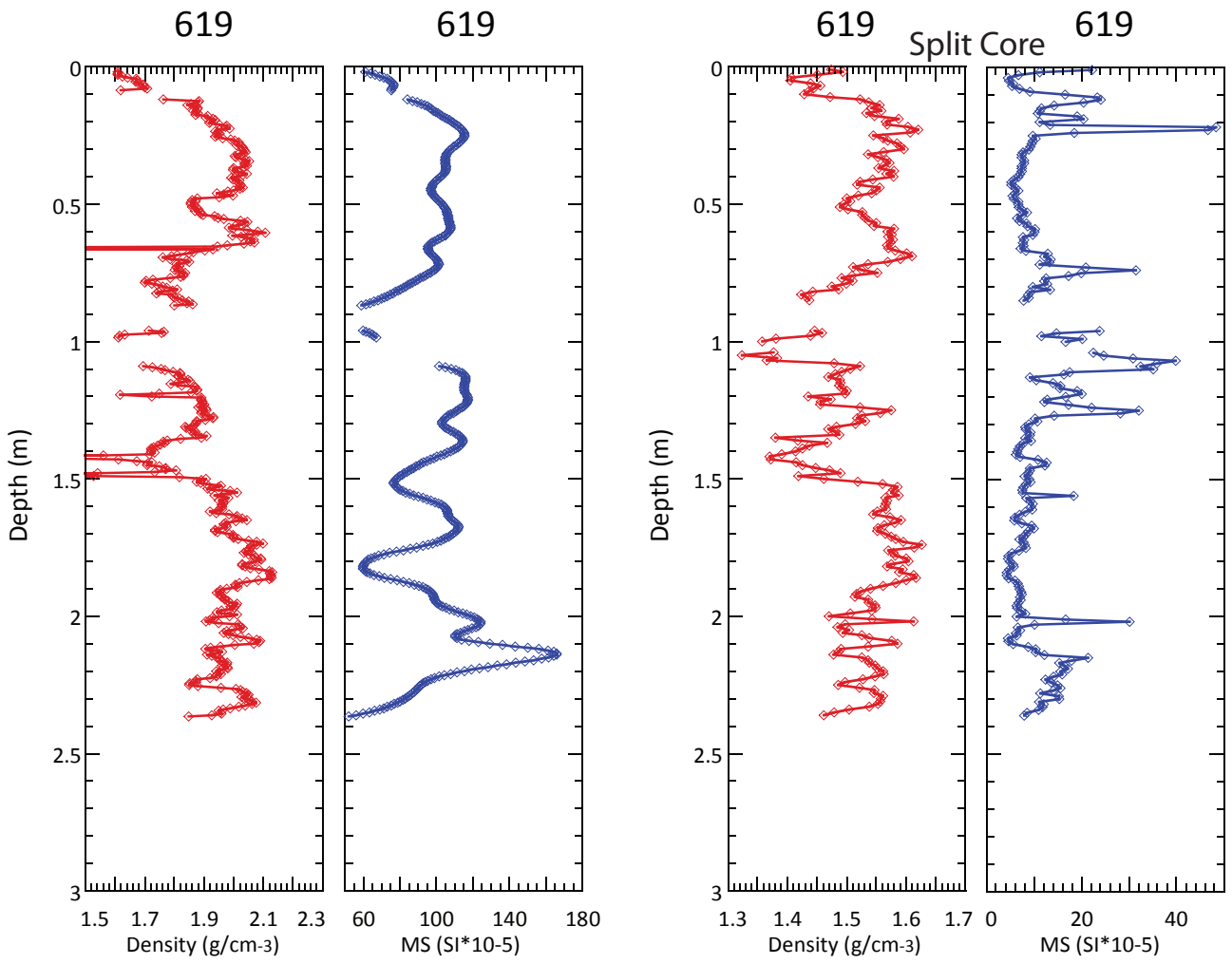
619
619
619
Split Core
619
Depth (m)
0
0.5
1
1.5
2
2.5
3
1.5 1.7 1.9 2.1 2.3
Density (g/cm-3)
60 100 140 180
MS (SI*10-5)
1.3 1.4 1.5 1.6 1.7
Density (g/cm-3)
0 20 40
MS (SI*10-5)

Figure 16

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