Pine Hall Formation: Type section designated - Dan River basin, Stokes Co., North Carolina: A potential reservoir.

North Carolina Geological Survey
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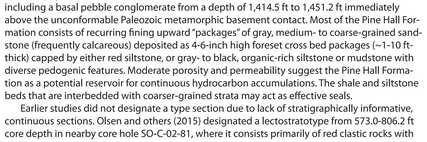
Abstract

The Late Triassic (Norian) Dan River basin, is a continuous gas assessment unit (AU). The rift-lacustrine basin, formed from the opening of the Atlantic Ocean, is filled with Triassic strata divided into five formations that in ascending stratigraphic order are: 1) the Pine Hall, 2) Walnut Cove, 3) Dry Fork, 4) Cow Branch and 5) Stoneville formations.

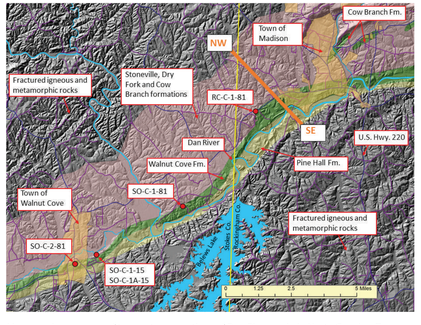
The North Carolina Geological Survey's (NCGS) 2015 "Town of Walnut Cove" drill hole (SO-C-01-15) was continuously cored to a depth of 1,477 ft ending in metamorphic basement rocks (Reid and others, 2015). The core hole investigated the basin's unconventional hydrocarbon resource potential, apparently cored all the Pine Hall Formation, and afforded the opportunity to designate its type section.

We designated the Pine Hall Formation type section from a depth of 423.7 ft to 1,451.2 ft, including a basal pebble conglomerate from a depth of 1,414.5 ft to 1,451.2 ft immediately above the unconformable Paleozoic metamorphic basement contact. Most of the Pine Hall Formation consists of recurring fining upward "packages" of gray, medium- to coarse-grained sandstone (frequently calcareous) deposited as 4-6-inch high foreset cross bed packages (~1-10 ft-thick) capped by either red siltstone, or gray- to black, organic-rich siltstone or mudstone with diverse pedogenic features. Moderate porosity and permeability suggest the Pine Hall Formation as a potential reservoir for continuous hydrocarbon accumulations. The shale and siltstone beds that are interbedded with coarser-grained strata may act as effective seals.

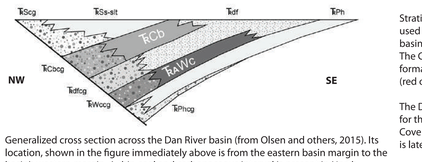
Earlier studies did not designate a type section due to lack of stratigraphically informative, continuous sections. Olsen and others (2015) designated a lectostratotype from 573.0-806.2 ft core depth in nearby core hole SO-C-02-81, where it consists primarily of red clastic rocks with abundant carbonate nodules and mottled strata of pedogenic origin.



Geologic map of the Dan River basin (from Reid and others, 2017).



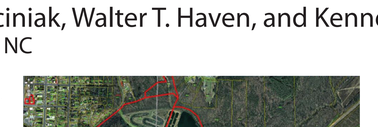
Map showing geology of the southern portions of Dan River basin in North Carolina. Three 1981 core holes (SO-C-01-81; SO-C-02-81; RC-C-01-81) along with "The Town of Walnut Cove" stratigraphic core hole SO-C-01-15 and sidetrack SO-C-01A-15 drilled in June 2015. Generalized cross section line location shown as orange line.



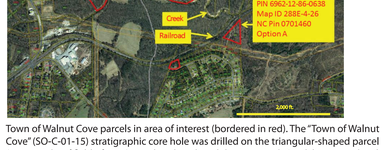
Generalized cross section across the Dan River basin (from Olsen and others, 2015). Its location, shown in the figure immediately above is from the eastern basin margin to the basin's western margin. A thin coal and carbonaceous interval is present in North Carolina but not in the Virginia portion of the basin.

The stratigraphic scheme (in ascending stratigraphic order) used here is based on Olsen and others (2015) and slightly different from that used by Milici and others (2012). Abbreviations are:

- TRScg, Stoneville Formation conglomerate facies;
- TRSs-slt, Stoneville Formation, sandstone-siltstone facies;
- TRCb, Cow Branch Formation;
- TRCbcg, Cow Branch Formation, conglomerate facies;
- TRdf, Dry Fork Formation;
- TRdfcg, Dry Fork Formation conglomerate facies;
- TRWc, Walnut Cove Formation;
- TRWccg, Walnut Cove Formation, conglomerate facies
- THPh, Pine Hall Formation; and
- TRPhcg, Pine Hall Formation conglomerate facies.



Town of Walnut Cove parcels in area of interest (bordered in red). The "Town of Walnut Cove" (SO-C-01-15) stratigraphic core hole was drilled on the triangular-shaped parcel (center right of field of view). A railroad track and the Town Fork Creek lies immediately to the northwest of the parcel.



Wire line core drill used for the Town of Walnut Cove (SO-C-01-15) stratigraphic core hole. The drill rig is a truck mounted Christianson CT-14 core drill. Visible in the photograph are support vehicles, some of the drill rods, cement (covered with black plastic), and logging table (under white tent).

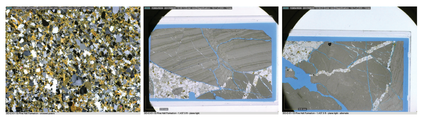
	Deep River basin			Dan River basin	
	Sub-basins				
	Wadesboro	Sanford	Durham		
NEWARK SUPERGROUP	Chatham Group	Sanford Fm.	Sanford Fm.	Stoneville Fm.	
		Cumnock Fm.	Cumnock Fm.	Cow Branch Fm.	
				Dry Fork Fm.	
		Cumnock coal bed		Walnut Cove Fm.	Dan River Group
		Gulf coal bed		Pine Hall Fm.	
		Pekin Fm.	Pekin Fm.	Pekin Fm.	

* Gray shale beds in Wadesboro sub-basin

Conglomerate, sandstone, and mudstone | Sandstone, mud-stone, coal, and carbonaceous shale | Gray mudstone and sandstone, with thin coal beds | Conglomerate, fanglomerate, sandstone, and mudstone

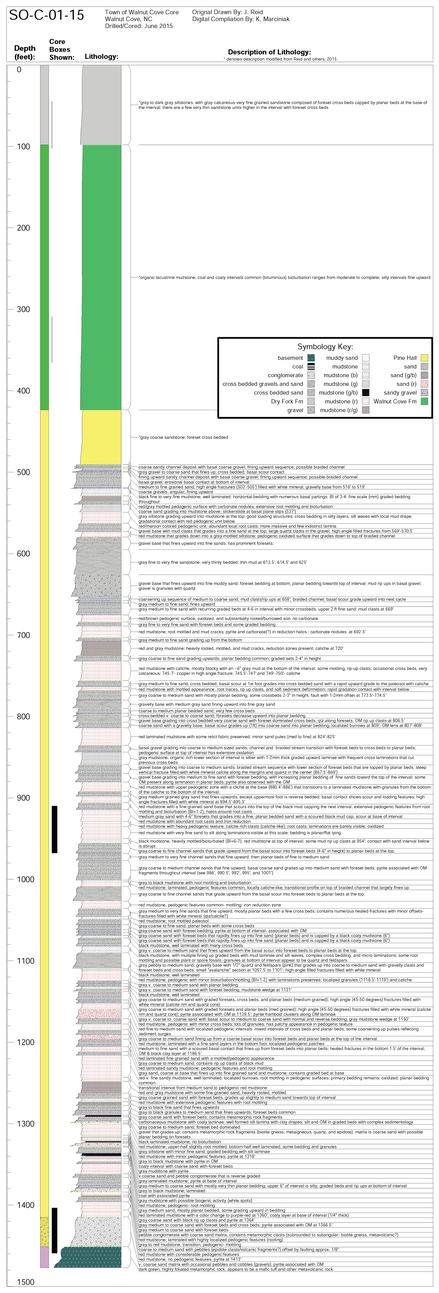
Stratigraphy for the Deep River and Dan River basins; this is slightly different than that used by Milici and others, 2012. The lacustrine strata are colored gray in the Deep River basin part of the figure, and colored green for the Dan River basin portion of the figure. The Cumnock Formation (Deep River basin) and the Cow Branch and Walnut Cove formations (Dan River basin) are the organic source rocks and unconventional reservoirs (red ovals).

The Deep River basin stratigraphy is from Reinemund (1955), and the stratigraphy for the Dan River basin is from Olsen and others (2015). The Cumnock Formation and Walnut Cove Formation are interpreted as early Norian Age (225-227 Ma); the Cow Branch Formation is late-early to middle Norian Age (217-222 Ma) (Olsen and others, 2015).



(a) (b) (c)

Photomicrographs of the Pine Hall Formation from core hole SO-C-01-15: (a) coarse-grained portion of the Pine Hall Formation (cross polarized light - depth 1,284 ft); (b),(c) faulted pebbles in the Pine Hall Formation (SO-C-01-15; depth 1,437 ft) conglomerate (depth 1,437.5 ft). Faults show offset and are filled with carbonate minerals. The faulted nature of the pebbles is consistent with field relations that indicate post lithification faulting of the conglomerates.



Dan River basin scientific drilling objectives

State-funded continuous wire line diamond drill coring in the Dan River basin was undertaken in June 2015 to further evaluate the State's Triassic rift / lacustrine basins for on-shore hydrocarbon potential. Drilling objectives were to provide scientific and technical data to improve the understanding of the Dan River basin including portions of Stokes County, NC.

Reid and others (2015) provided preliminary information about this core hole. The extensive organic-rich, thermally mature lacustrine rocks are a potential gas resource, are gas prone, and are a petroleum system.

Core hole (SO-C-01-15) "Town of Walnut Cove," was drilled in June 2015 on land owned by the Town of Walnut Cove, and was the basin's first core hole since 1981. The core hole is located at 36°17'30.62"N., -80°07'36.87"W. with an approximate collar elevation of 604 ft above sea level. The main core hole was drilled to a depth of 1,477 ft. A sidetrack core (SO-C-01A-15) was drilled from the same collar at 2° from vertical to a depth of 277 ft. The cores are down dip, basinward, and slightly northeast of core (SO-C-02-81) drilled in 1981. There are no known seismic lines or oil and gas wells in this basin.

The core hole penetrated the basement (probable metavolcanic rocks) at a depth of 1,451.2 ft and reached a total depth of 1,477 ft. A pebble conglomerate beginning at a depth of 1,414.2 ft indicated the approaching basement contact. The entire Pine Hall Formation was penetrated. The Pine Hall Formation as cored by this drill hole is designated the new type section for that formation as described herein. The Pine Hall Formation contains previously unknown thin intervals of organic mudstone, more extensive coal, and coaly intervals than noted in earlier geologic reports. It is unknown if these reflect limited local deposition, or more widespread lacustrine strata basinward – a hypothesis to be tested by future drilling. About 325 ft of organic lacustrine sediment (apparently the entire Walnut Cove Formation) was penetrated between 98 ft to 423.7 ft.

The side track core hole (SO-C-01A-15) was drilled about 2° from vertical, and was advanced to a total depth of 277 ft to fully recover a coal and coaly section previously penetrated but partly lost in the main core hole. Beginning at a depth of 253.1 ft, coring recovered at least three feet of coal followed by organic mudstone, and coaly black organic matter and silt stones. Fluid inclusion stratigraphy confirmed the presence of hydrocarbons and helium, and a total petroleum system.

Organic analyses, mineralogy, rock mechanics data, and high pressure air / mercury capillary pressure (MICP) porosity and permeabiltiy data were obtained.

Designation of the Pine Hall Formation type section

Olsen and others (2015) who redefined the stratigraphy of the Dan River basin, described the Pine Hall Formation as "The basal formation of the Dan River basin is the Pine Hall Formation, established by Thayer (1970) that consists largely of coarse clastic rocks and interbedded sandstones and red mudstones. We intend its use to be similar to that intended by Thayer (1970) and Thayer and others (1970). In most areas, there is a lower conglomeritic, largely tan portion and an upper mostly red sandstone and mudstone interval. Locally, silicified logs are present in the tan sandstone dominated units (Emmons, 1856; Stone, 1910; Thayer, 1970; Thayer and others, 1970) and reptile bones occur locally (P. Huber, pers. comm., 2014). The Pine Hall Formation is about 200 m thick in the area of its lectostratotype (below).

The contact with the overlying Walnut Cove Formation is marked by the presence of gray sandstone and mudstone with a much lower frequency of red mudstone. This transition can be seen in detail in both SO-C-01-81 and SO-C-02-81 cores. Where the Walnut Cove Formation is absent, Pine Hall clastic rocks can be differentiated from the overlying Dry Fork Formation by the presence of more abundant red strata in in the Pine Hall. The Pine Hall Formation appears to pinch out against basement in the northern half of the Virginia segment of the Dan River Basin....

Thayer (1970) did not designate a type section for the Pine Hall Formation due to lack of stratigraphically-informative, continuous sections. Therefore, we designate a lectostratotype for the Pine Hall Formation from 174.7-245.7 m (573.0-806.2 ft) core depth, corresponding to 167.8-236.2 m stratigraphic depth, in the SO-C-02-81 core, where it consists primarily of red clastic rocks with abundant carbonate nodules and mottled strata of probable pedogenic origin...."

We designated the Pine Hall Formation type section from a depth of 423.7 ft to 1,451.2 ft, including a basal pebble conglomerate from a depth of 1,414.5 ft to 1,451.2 ft immediately above the unconformable Paleozoic metamorphic basement contact. This designation takes priority over the lectostratotype of Olsen and others (2015).

Moderate porosity and permeability may indicate the Pine Hall Formation as a potential reservoir for continuous hydrocarbon accumulations. The shale and siltstone beds that are interbedded with coarser-grained strata may act as effective seals. See photomicrograph (lower left - this panel) of the typical coarse-grained sandstone of the Pine Hall Formation.

Pine Hall Formation description in the type section

Reid and others (2015; 2017a,b) described the Pine Hall Formation in this drill hole. The basal pebble conglomerate of the Pine Hall Formation above the basement elevation was penetrated at 1,451.2 feet. The pebble conglomerate extends upward to 1,415.5 feet (about 35.7 feet of thickness). There is an abrupt transition at that point upward into red siltstone with laminations and very small scale cross-bedding. Rooting, mottling, and pedogenic features are common.

Most of the Pine Hall Formation consists of recurring fining upward "packages" of gray, medium- to coarse-grained sandstone (frequently calcareous) deposited as 4-6-inch high foreset cross bed packages ~1-10 ft-thick) capped by either red siltstone or gray to black, organic-rich siltstone or mudstone with diverse pedogenic feature. Individual foreset cross beds fine upward and into planar beds as water currents waned. The upper portion of the siltstone sequence frequently exhibits mottled, rooted, and burrowed pedogenic features that range from five to about 40 feet thick.

The succeeding depositional package begins with a similar sandstone "package", indicating the beginning of the next fining upward sequence scours into the top of the previous siltstone. The base of nearly all "packages" is marked by gravely and / or coarse-grained sandstone. Water depths were very shallow. The sandstones probably represent braided channels, and in some cases, very thin, or isolated, distal distributary channels in lacustrine strata.

The gray- to black organic-rich mudstone average about 1-3 feet in thickness. They are commonly laminated; individual laminae fine upward, and there are numerous small-scale cross beds. The gray- to black organic-rich mudstones may occur with or without a red siltstone. Where they occur with a red siltstone, they most commonly cap a fining-upward sequence. Like the red siltstones, they are frequently mottled, rooted and exhibit pedogenic features. Where pedogenic features are extensive, the color of the rock becomes purple or red purple. It is unknown if the organic mudstone was deposited only locally on a fan delta surface, or if it portends thicker organic strata basinward. A step-out basinward core drill hole would be needed to test this.

Fining up to the left

Basal conglomerate

Approximate contact between the Pine Hall Formation and basement.

Black bar on stratigraphic column corresponds to cores.

Persistent thin coals or thin coaly beds or laminae recur throughout the Pine Hall Formation but mostly below a depth of 1,289 feet. Previous workers described some thin coals in the Dan River basin (Stone, 1910; Chance, 1885). However, the coals and coaly intervals encountered in this drill hole are somewhat thicker and more frequent than previously reported.

A few high angle fractures occur in these strata. They are fully healed, up to several inches in length, generally less than one-eigth-inch-wide, and are filled initially with a carbonate mineral followed by vein-center quartz. The transition stratigraphically upward into the Walnut Cove Formation occurs at a core hole depth of about 423 feet where coarse foreset gray cross bedded sandstone gives way to dark gray- to black organic-rich strata of the Walnut Cove Formation. The entire Pine Hall Formation was penetrated.

The lectostratotype for the Pine Hall Formation is from 573.0-806.2 feet core depth in drill hole SO-C-02-81, where it consists primarily of red clastic rocks with abundant carbonate nodules and mottled strata of probable pedogenic origin (Olsen and others, 2015).

Interpreted depositional features

Examples of interpreted depositional features of the Pine Hall Formation are shown in the drill core intervals. The yellow background surrounding the core corresponds to the Pine Hall Formation as shown in the drill log.

The upper core interval shows a typical fining upward sequence. Coarse, basal gravels are incised into the top of the preceding mudstone sequence that capped a previous depositional interval. The gravels fine upward quickly to coarse sand that was transported and deposited in braided streams. Rapidly falling water levels across the tops of the deposited sand features result in planar bedding and small amplitude cross beds.

When active sand deposition ceased, silt and mud started to be deposited in shallow, oxygenated water. Small-scale cross-beds and planar features reflect deposition in realtively quiet water. Rooting and burrowing increased as active sediment deposition ceased.

The upper part of the depositional sequence may be red or black reflecting the amount of available organic matter. A pulse of coarse gravel and / or coarse-grained sandstone downcutting into the top of the previous cycle initiates the next fining upward sequence.

Composition of the basal conglomerate

The Pine Hall Formation conglomerate consists of approximately 62% rock clasts and fragments and 38% matrix, with trace quartz veins with calcite. Of the rock fragments and clasts 82% were igneous, metavolcanic, metasedimentary, and sedimentary rock fragments, 17% white quartz clasts and fragments, and 1% other, which includes mudstone and carbonate. The size of rock fragments and clasts ranged from 3 mm by 2 mm to approximately 100 mm by 46 mm; numerous clasts were truncated in size by the core barrel. Carbonate-filled fractures in some pebbles document post lithification faulting. Point counting was conducted on the entire length of the Pine Hall Formation conglomerate penetrated in drill hole SO-C-01-15. A total of 1,055 points were counted.

The matrix (37.8%) is composed of red-brown, grey, and grey-black mudstone to grey fine-, fine to medium-, and medium to coarse-grained sandstone, with a minor carbonaceous (coaly) interval. The sandstone matrix is generally grey in color, contains well-rounded grains, has trace amounts of mica and heavy minerals, trace amounts of pyrite, and minor iron oxide staining. The coarser grained sandstone intervals commonly contain larger fragments of rock and quartz that are subangular- to subrounded. Minor carbonaceous intervals are black in color and commonly contain pyrite bands. Some quartz veins, with possibly calcite (positive dilute HCl reaction), were observed and comprise approximately 0.4% of the Pine Hall Formation conglomerate.

Pine Hall Formation: Type section designated - Dan River basin, Stokes Co., North Carolina: A potential reservoir.

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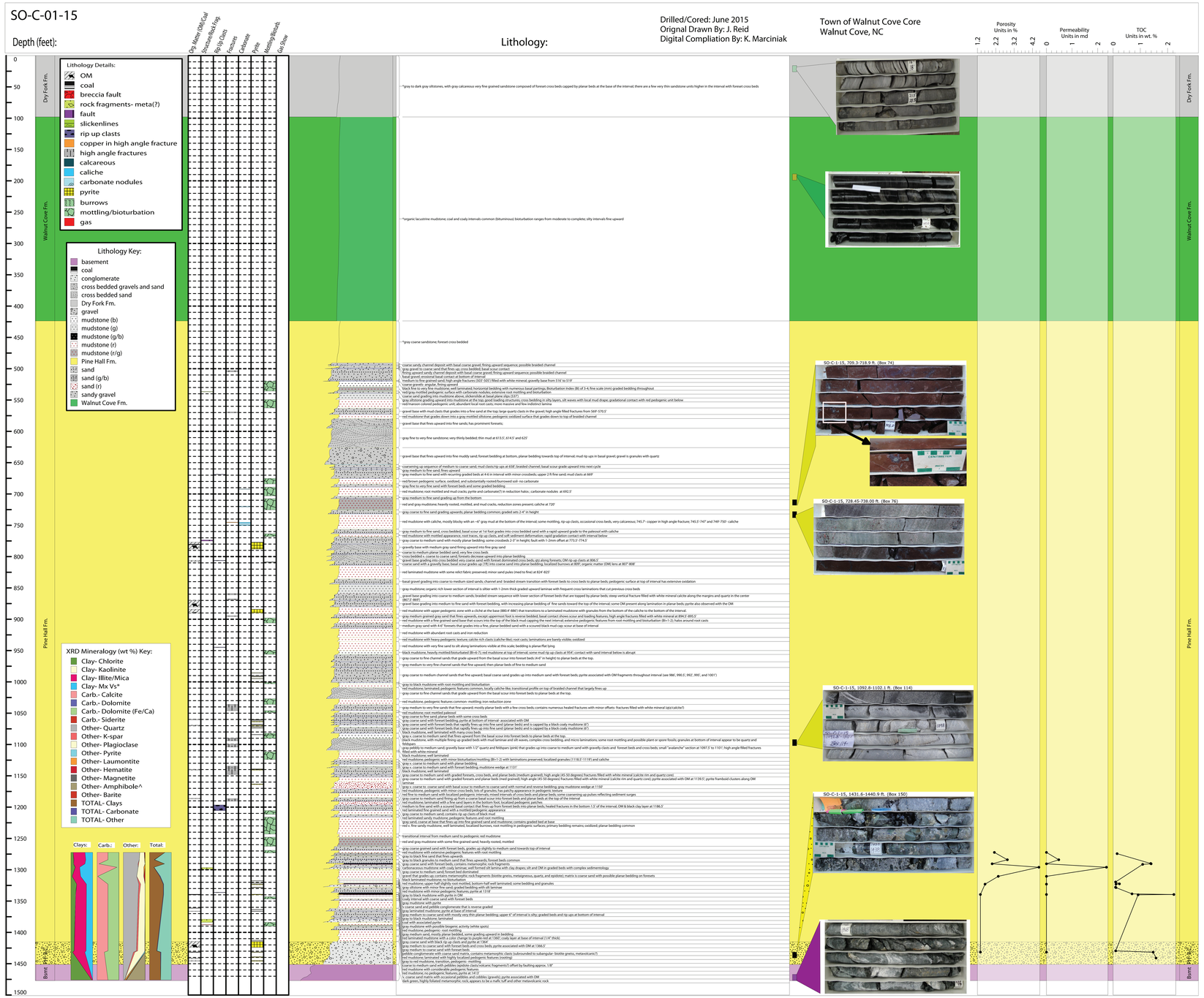
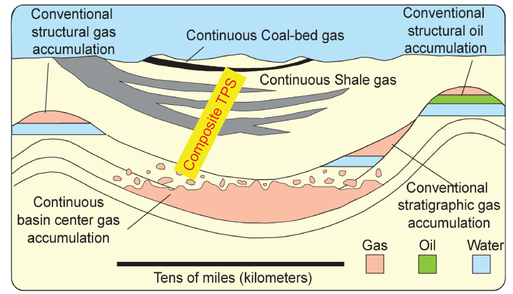


Pine Hall Formation - Panel 2

The Pine Hall Formation as a potential reservoir



Geologic setting of continuous gas and oil accumulations relative to discrete accumulations in structural or stratigraphic traps (modified and adapted from Schmoker and others, 1995).

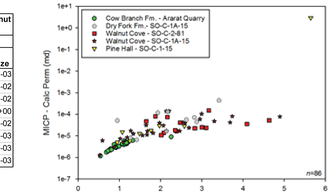
The elements of a total petroleum system (TPS) shown in this diagram are present in both the Deep River- and Dan River basins. Modified from Schmoker and others, 1995. The Pine Hall Formation is a potential reservoir for hydrocarbons in the Dan River basin.

Porosity and permeability of the Pine Hall Formation

Porosity and permeability were determined by MICP to provide pore aperture frequency distribution down to nanometer-scale diameter (see Table 1 and figure below).

Table 1. MICP Porosity and Permeability Results for the "Town of Walnut Cove" core hole SO-C-01015, Pine Hall Formation, Dan River basin.

		Sample analyzed by PoroTechnology					
Num	Well Code	Sample num.	Depth (ft)	Porosity (%)	Perm. (md)	Den (g/cc)	Median Pore Size
30	SO-C-01-15	1272.3	1272.3	2.576	2.81E-05	2.8437	9.11E-03
25	SO-C-01-15	1284	1284	1.071	1.48E-05	3.2823	1.57E-02
21	SO-C-01-15	1290.5	1290.5	1.765	1.77E-05	2.7636	1.02E-02
17	SO-C-01-15	1296	1296	5.646	2.95E+00	2.6596	2.66E+00
14	SO-C-01-15	1310.5	1310.5	1.972	2.95E-05	2.8335	1.24E-02
10	SO-C-01-15	1323	1323	1.488	1.27E-05	2.9051	9.56E-03
4	SO-C-01-15	1339.5	1339.5	0.948	4.99E-06	2.7345	9.09E-03
38	SO-C-01-15	1431.6	1431.6	1.255	5.75E-06	2.7623	5.71E-03



Plot of MICP porosity *vs.* MICP permeability for core holes in the Dan River basin.

Conclusions

The Pine Hall Formation is a potential reservoir for hydrocarbons in the Dan River basin. It is composed of conglomerate, very coarse sandstones to mudstones that form discrete, but recurring, fining upward fluvial deposits. These were likely deposited as an alluvial fan, with possible fan-delta elements that prograded episodically into organic-rich lacustrine environments and deposits. The mudstone beds that are interbedded with coarser grained strata may act effectively as seals.

We designated the Pine Hall Formation type section from a drilled depth of 423.7 ft to 1,451.2 ft, including a basal pebble conglomerate from a depth from 1,414.5 ft to 1,451.2 ft - immediately above the unconformable Paleozoic metamorphic basement contact in drill hole SO-C-01-15.

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Acknowledgements

Ryan A. Channell, Ann T. Shields and Chandler I. Warner assisted with field sample collection and retrieval of samples from the North Carolina Geological Survey's core repository and in aspects of the 2015 core drilling. Ann T. Shields prepared many of the core photographs. Funding for the drilling was provided by the North Carolina General Assembly (FY 2014-15) as part of appropriations to undertake additional geological studies of the Dan River basin. Contact the State Geologist, North Carolina Geological Survey to make arrangements to view the core.

We thank the Commissioners of the Town of Walnut Cove, North Carolina, for permission to drill this stratigraphic core hole on city property. Mr. Monty Stevens, former Town Manager, was our primary point of contact with Town of Walnut Cove and his professionalism and assistance is much appreciated.

Mr. Orus F. Patterson III, Patterson Exploration Services, Inc., Sanford, N.C., was the drilling contractor. Core holes SO-C-01-15 and SO-C-01A-15 were drilled by Ruen Drilling Inc. in June 2015.

Appendices

Appendix 1 is a photographic record of drill core SO-C-01-15 showing the entire intercept of the Pine Hall Formation.
Appendix 2 contains scanned copies of the original field logs.

Suggested citation: Reid, Jeffrey C.; Marciniak, Katherine J.; Haven, Walter T., and Taylor, Kenneth B., 2017, Pine Hall Formation: Type section designated - Dan River basin, Stokes Co., North Carolina: A potential reservoir, North Carolina Geological Survey, Open-file report 2017-03 with appendices.

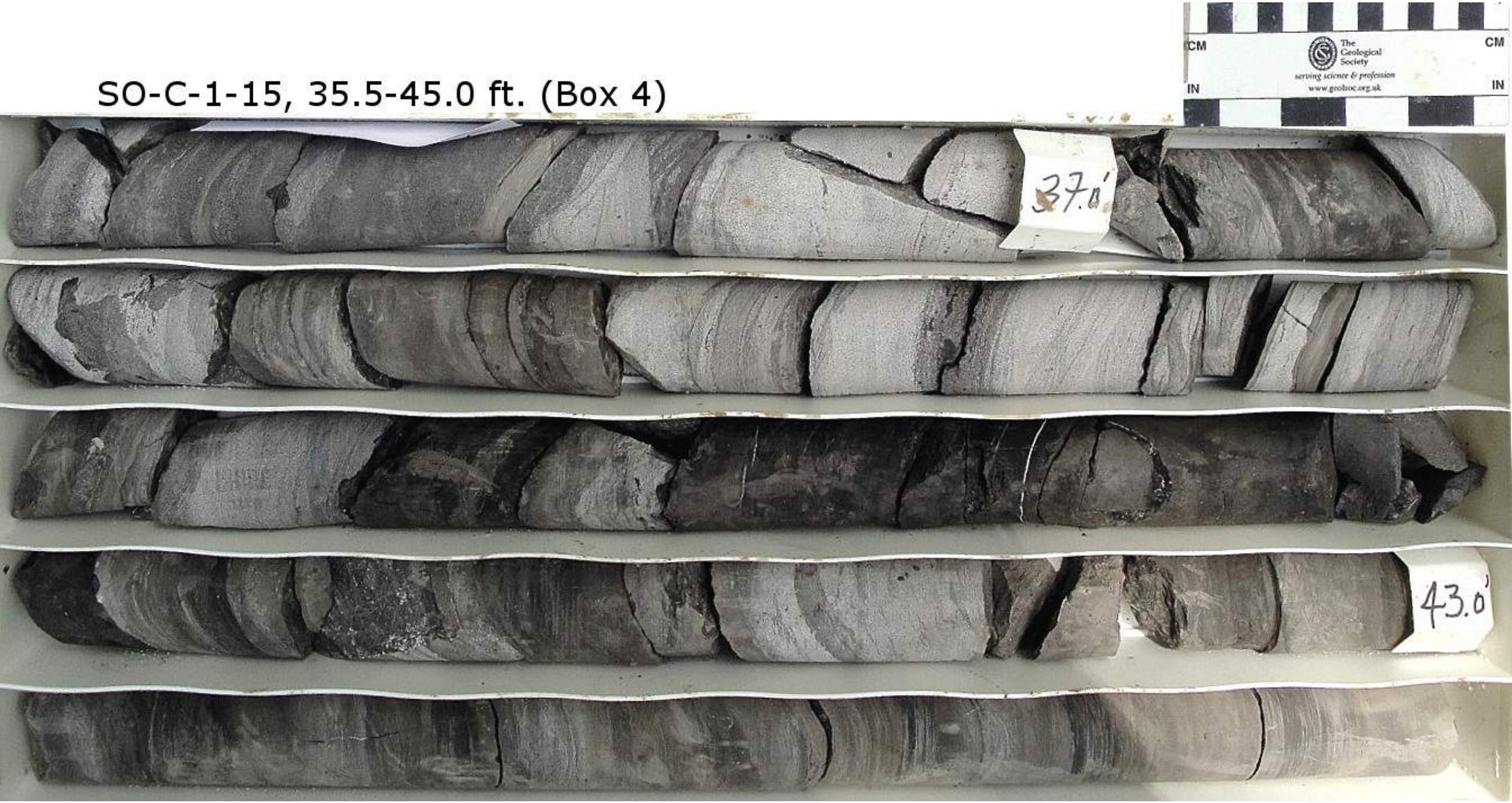
Appendix 1. Core photographs of the SO-C-01-15 “Town of Walnut Cove” core. Core photographs of the sidetrack core hole SO-C-01A-15 are not included because it only penetrated the Walnut Cove Formation.

SO-C-1-15, 0.0-15.7 ft. (Box 1)

SO-C-1-15, 15.7-25.6 ft. (Box 2)

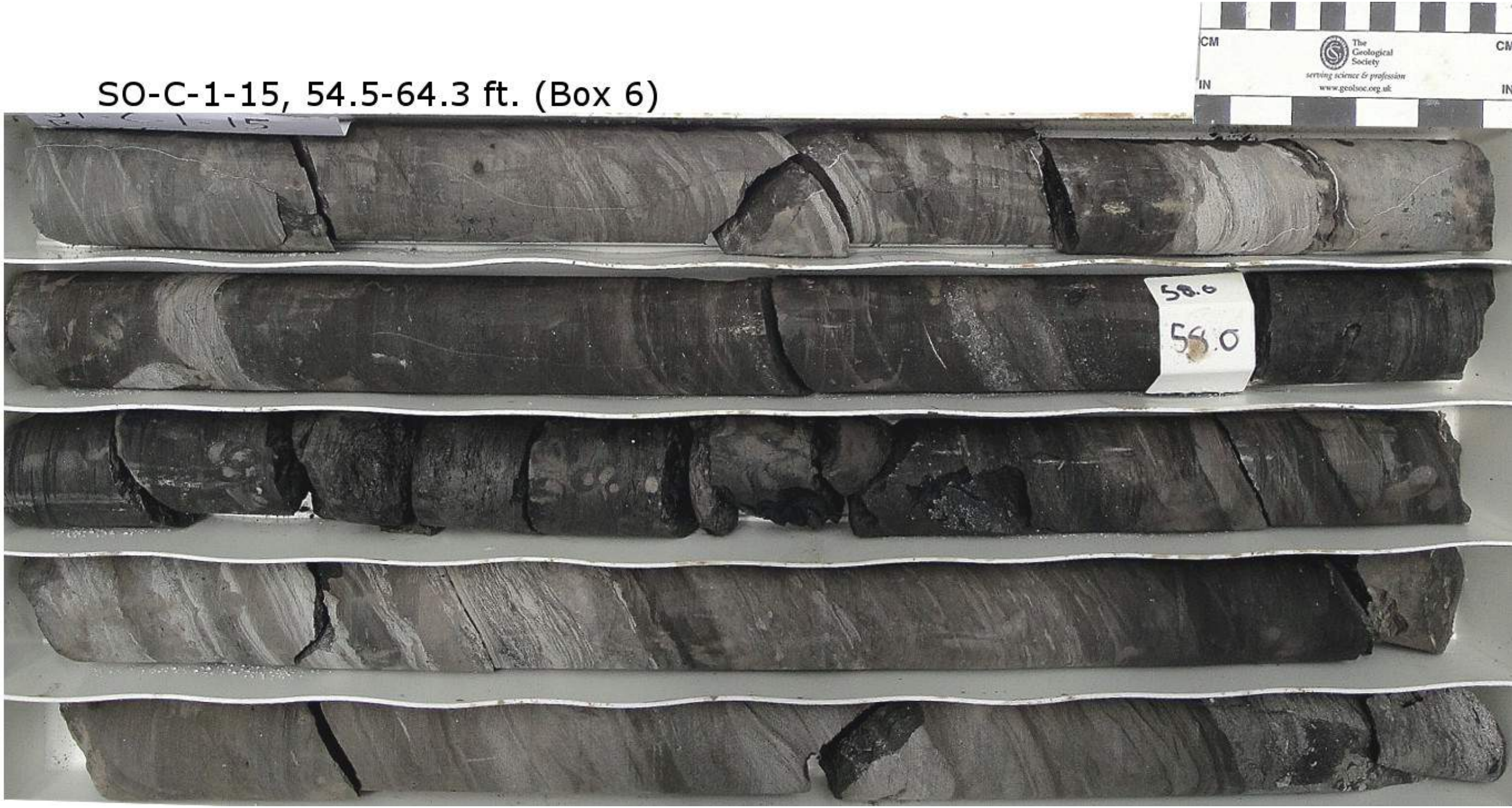
SO-C-1-15, 25.6-35.5 ft. (Box 3)

SO-C-1-15, 35.5-45.0 ft. (Box 4)



SO-C-1-15, 45.0-54.5 ft. (Box 5)

SO-C-1-15, 54.5-64.3 ft. (Box 6)



SO-C-1-15, 64.3-73.0 ft. (Box 7)

SO-C-1-15, 73.0-83.4 ft. (Box 8)

SO-C-1-15, 83.4-92.7 ft. (Box 9)

SO-C-1-15, 92.7-102.4 ft. (Box 10)

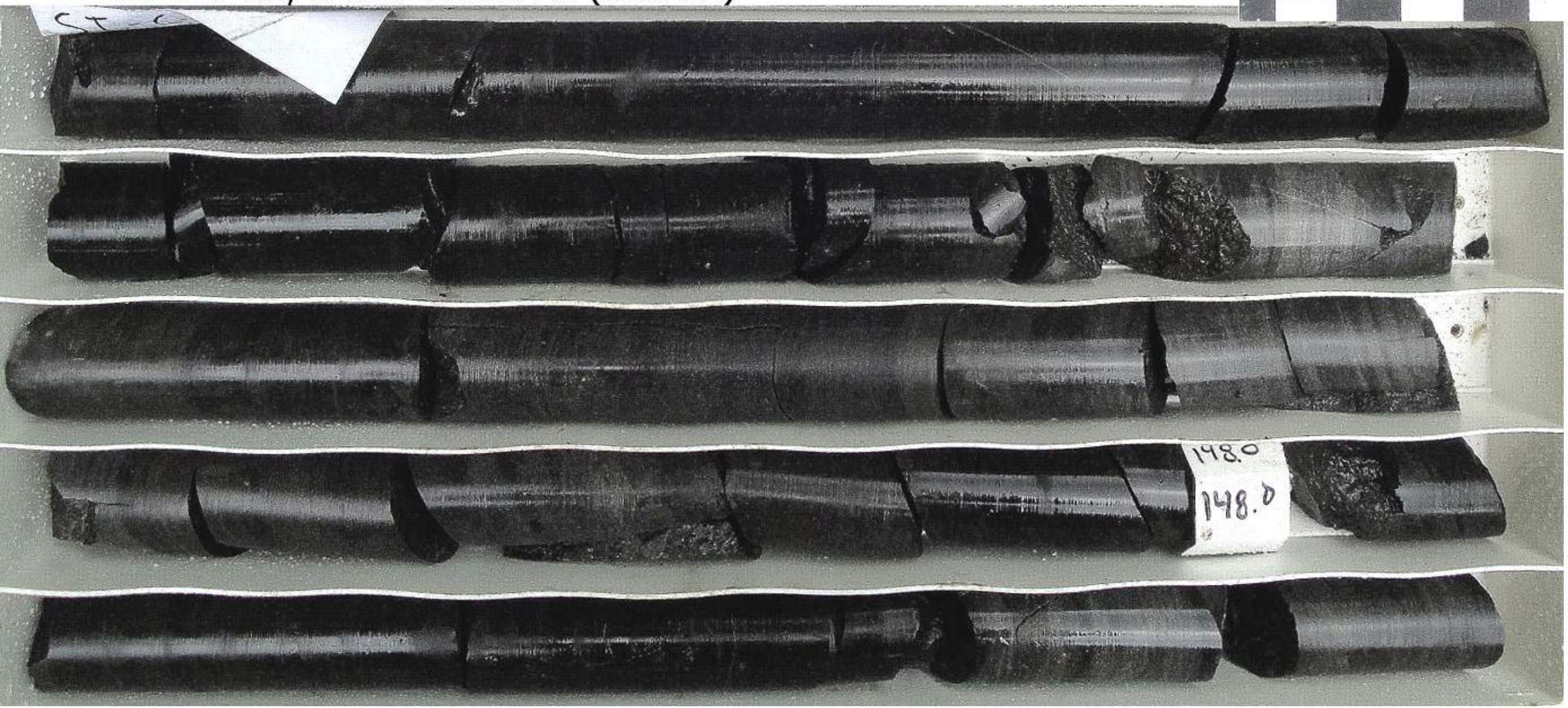
SO-C-1-15, 102.4-111.6 ft. (Box 11)

SO-C-1-15, 111.6-121.7 ft. (Box 12)

SO-C-1-15, 121.7-131.1 ft. (Box 13)

SO-C-1-15, 131.1-140.6 ft. (Box 14)

SO-C-1-15, 140.6-150.1 ft. (Box 15)

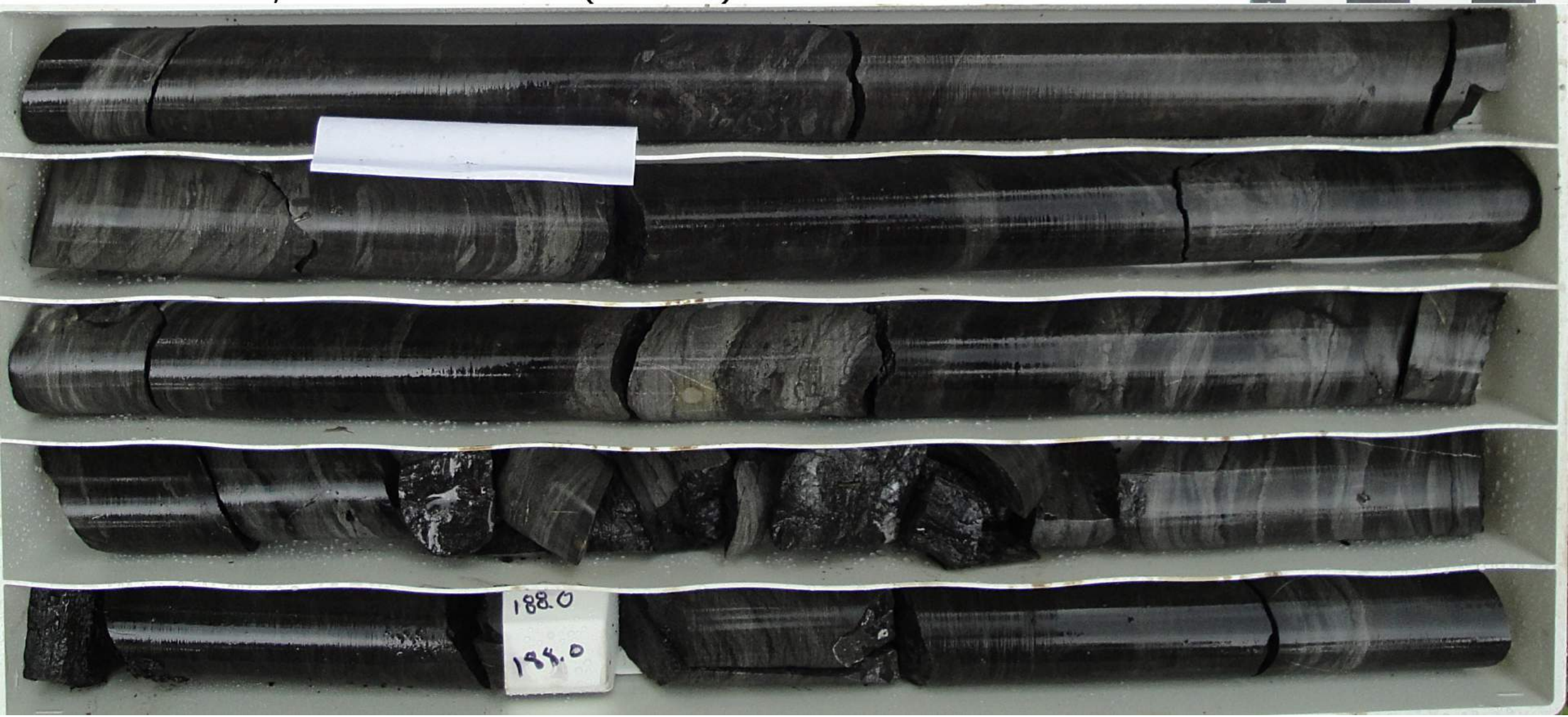


SO-C-1-15, 150.1-159.2 ft. (Box 16)

SO-C-1-15, 159.2-169.8 ft. (Box 17)

SO-C-1-15, 169.8-179.7 ft. (Box 18)

SO-C-1-15, 179.7-189.1 ft. (Box 19)



SO-C-1-15, 189.1-199.4 ft. (Box 20)

SO-C-1-15, 199.4-209.4 ft. (Box 21)

SO-C-1-15, 209.4-219.4 ft. (Box 22)

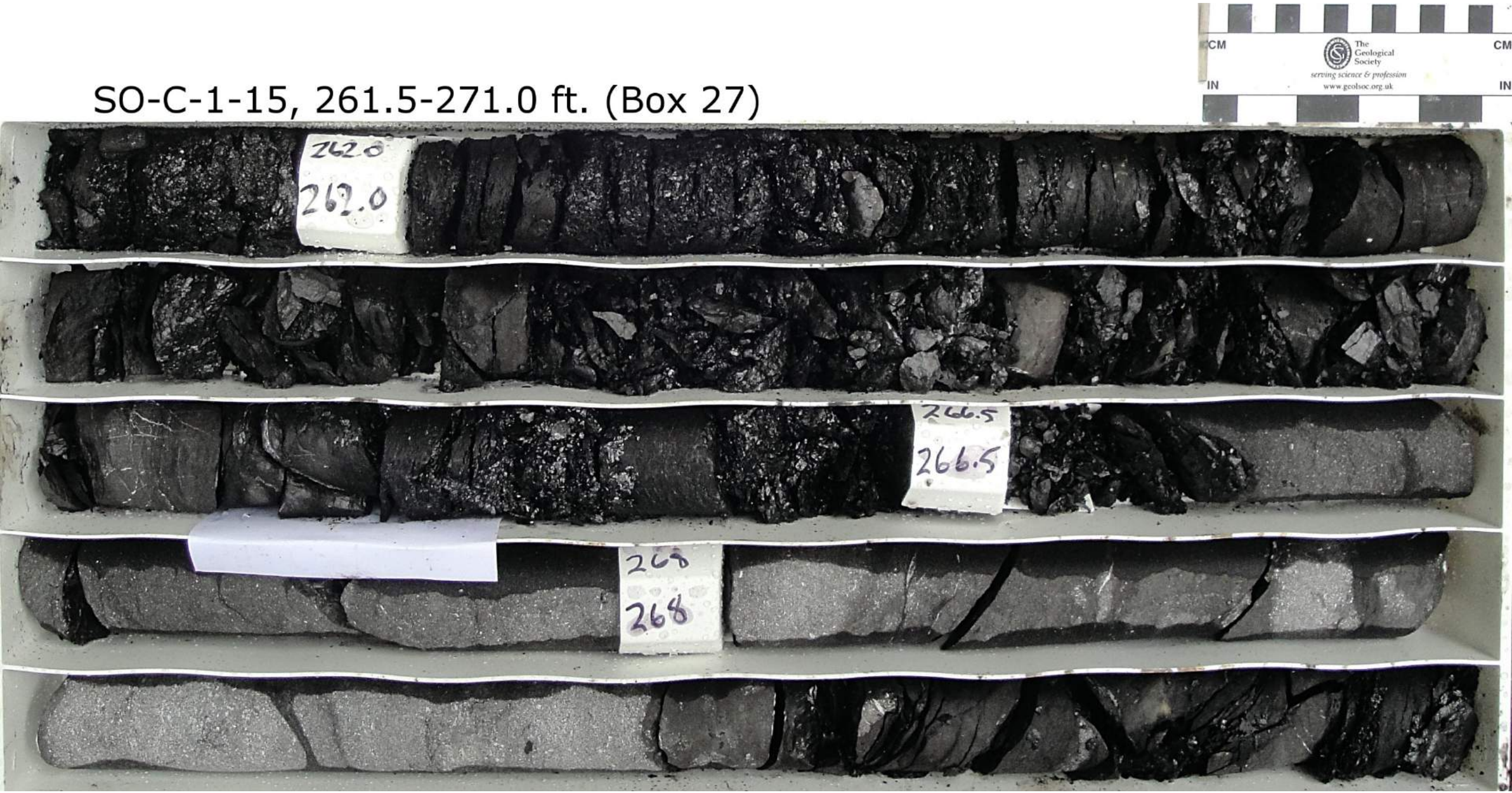
SO-C-1-15, 219.4-229.2 ft. (Box 23)

SO-C-1-15, 229.2-239.1 ft. (Box 24)

SO-C-1-15, 239.1-248.5 ft. (Box 25)

SO-C-1-15, 248.5-261.5 ft. (Box 26)

SO-C-1-15, 261.5-271.0 ft. (Box 27)

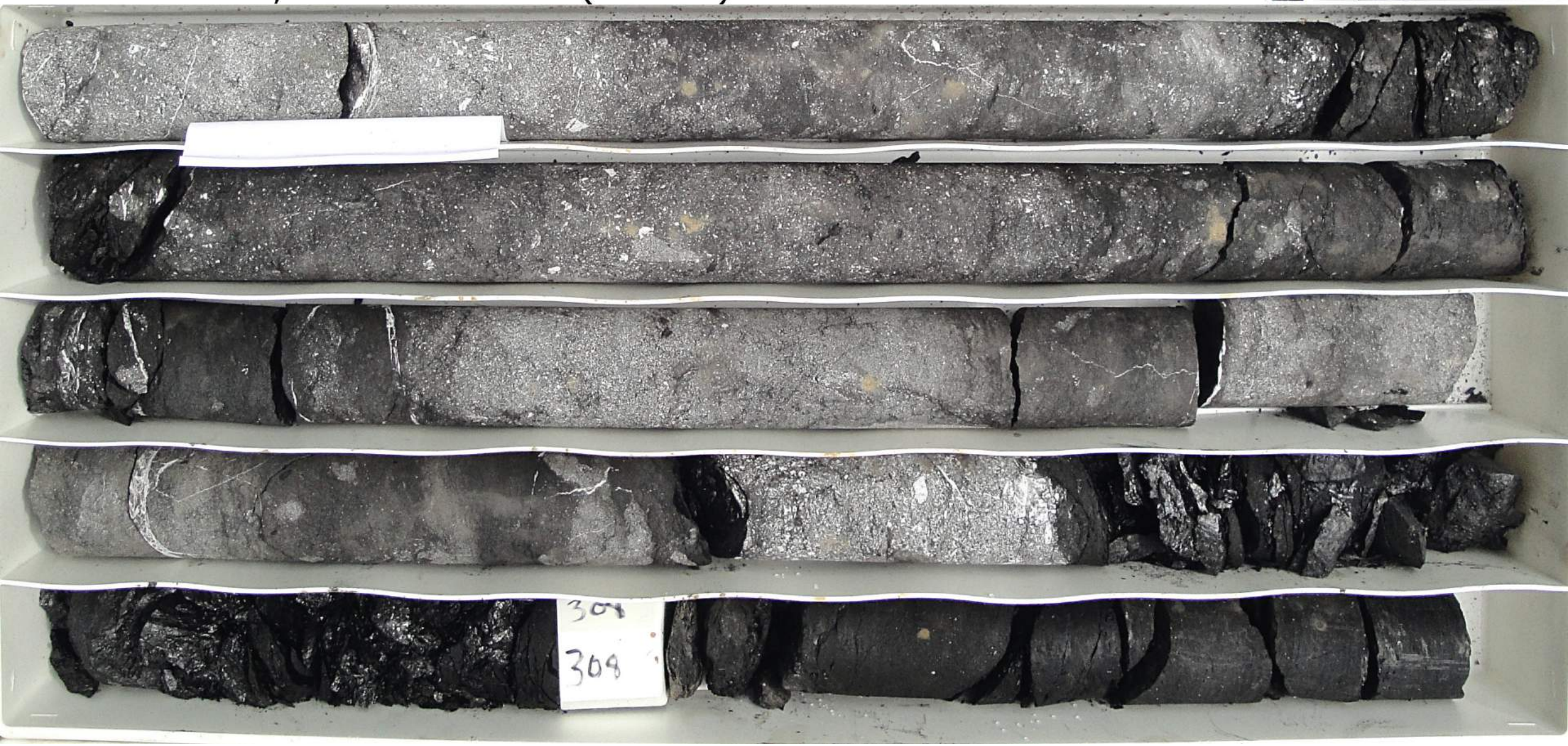


SO-C-1-15, 271.0-280.5 ft. (Box 28)

SO-C-1-15, 280.5-290.3 ft. (Box 29)

SO-C-1-15, 290.3-299.0 ft. (Box 30)

SO-C-1-15, 299.0-309.0 ft. (Box 31)



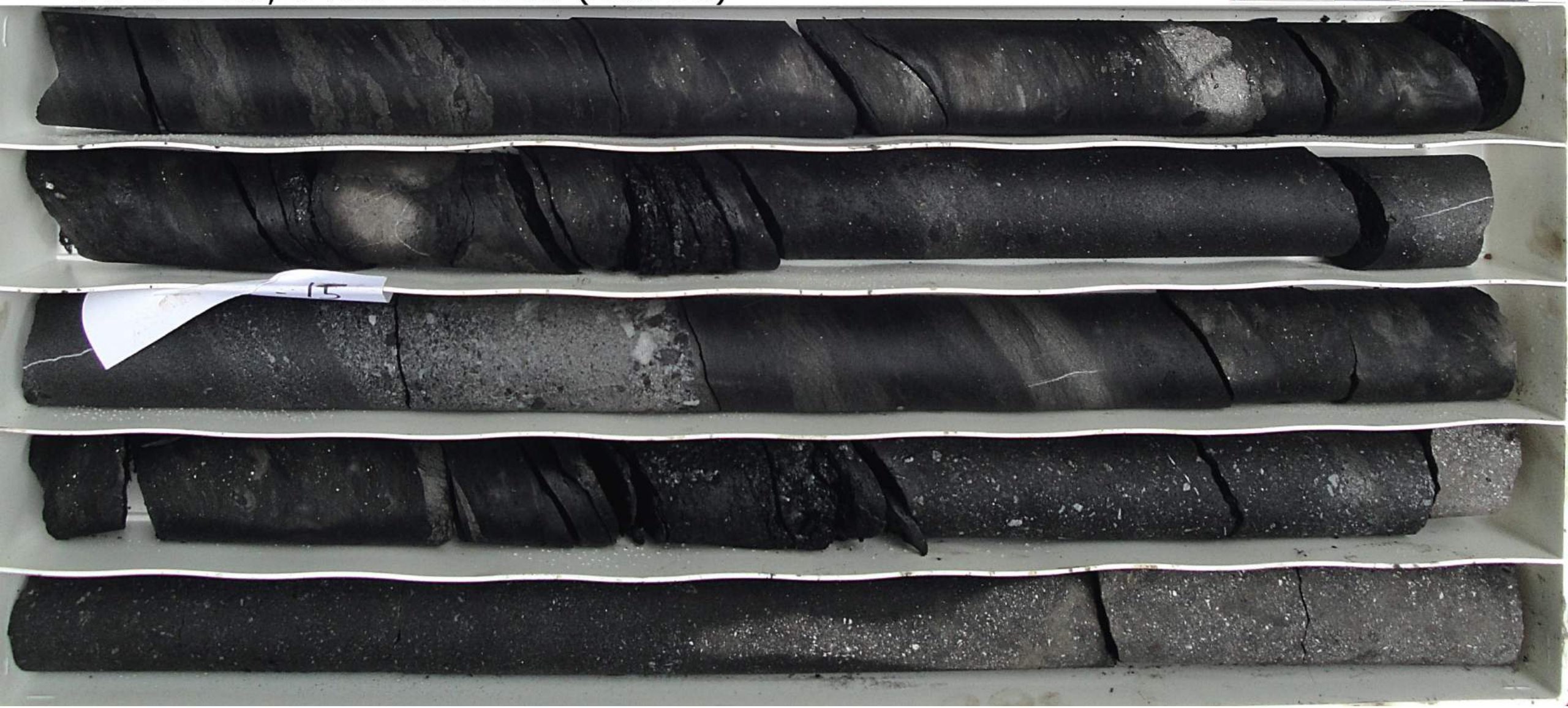
SO-C-1-15, 309.0-318.1 ft. (Box 32)

SO-C-1-15, 318.1-327.7 ft.(Box 33)

SO-C-1-15, 327.7-337.2 ft. (Box 34)

SO-C-1-15, 337.2-346.9 ft. (Box 35)

SO-C-1-15, 346.9-356.4 ft. (Box 36)

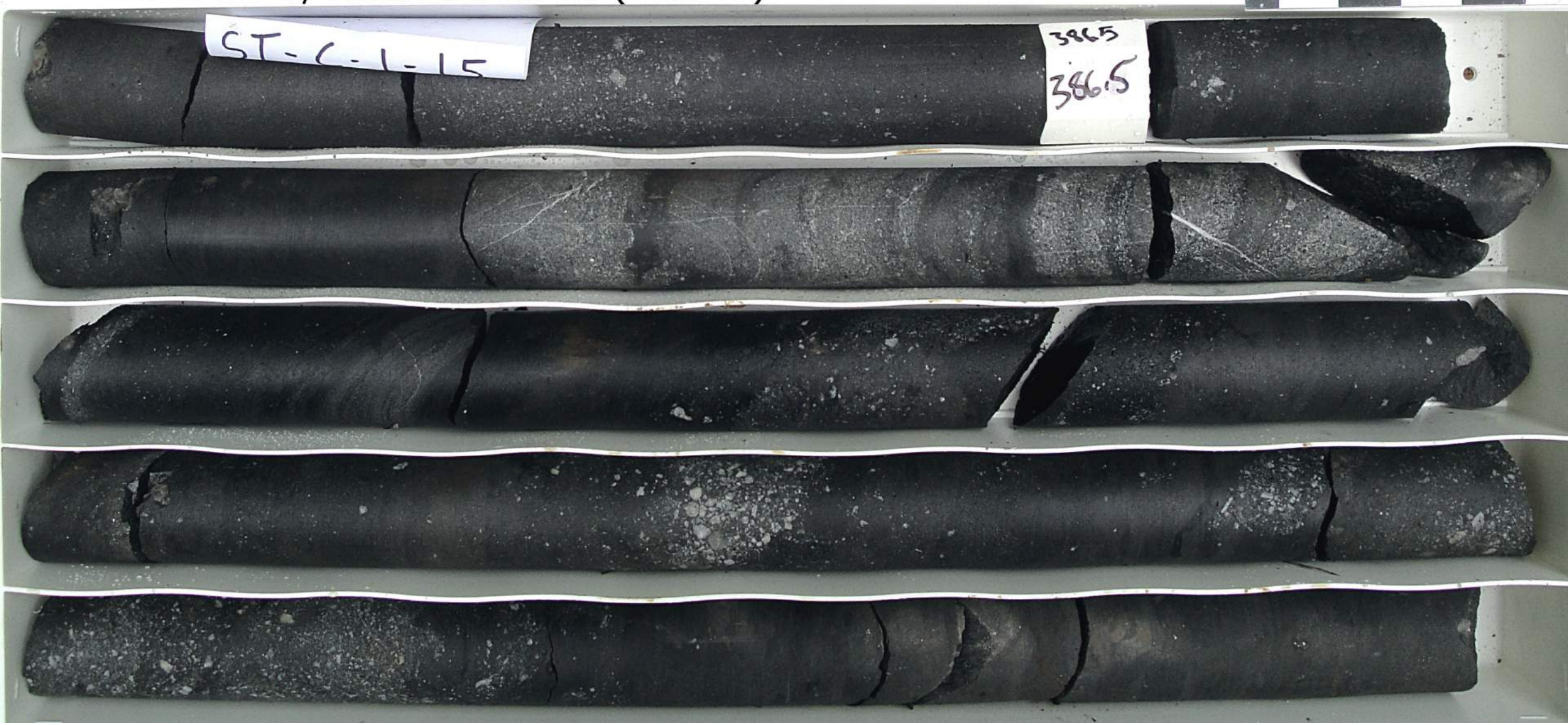


SO-C-1-15, 356.4-365.6 ft. (Box 37)

SO-C-1-15, 365.6-375.9 ft. (Box 38)

SO-C-1-15, 375.9-385.1 ft. (Box 39)

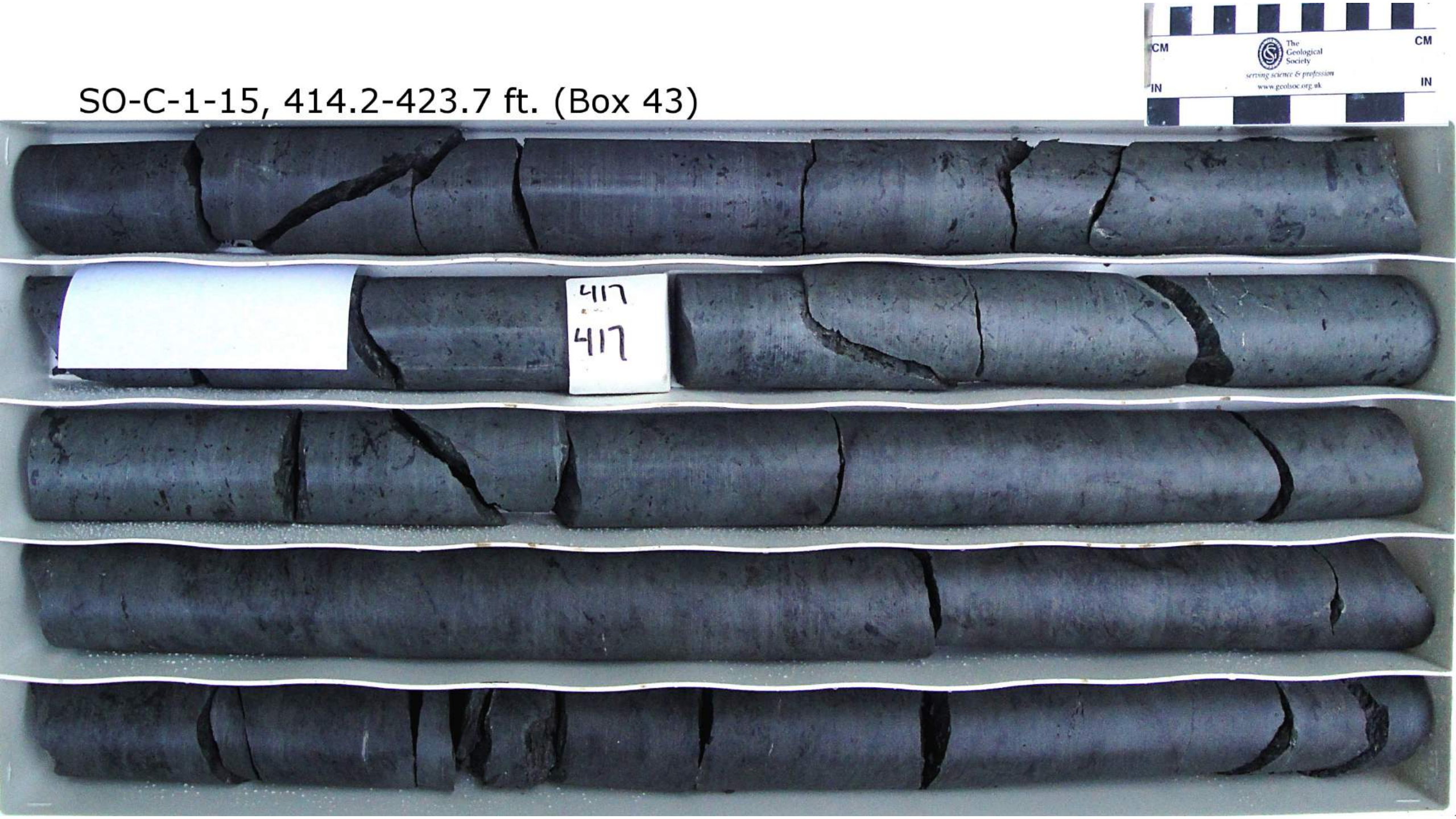
SO-C-1-15, 385.1-394.3 ft. (Box 40)



SO-C-1-15, 394.3-404.3 ft. (Box 41)

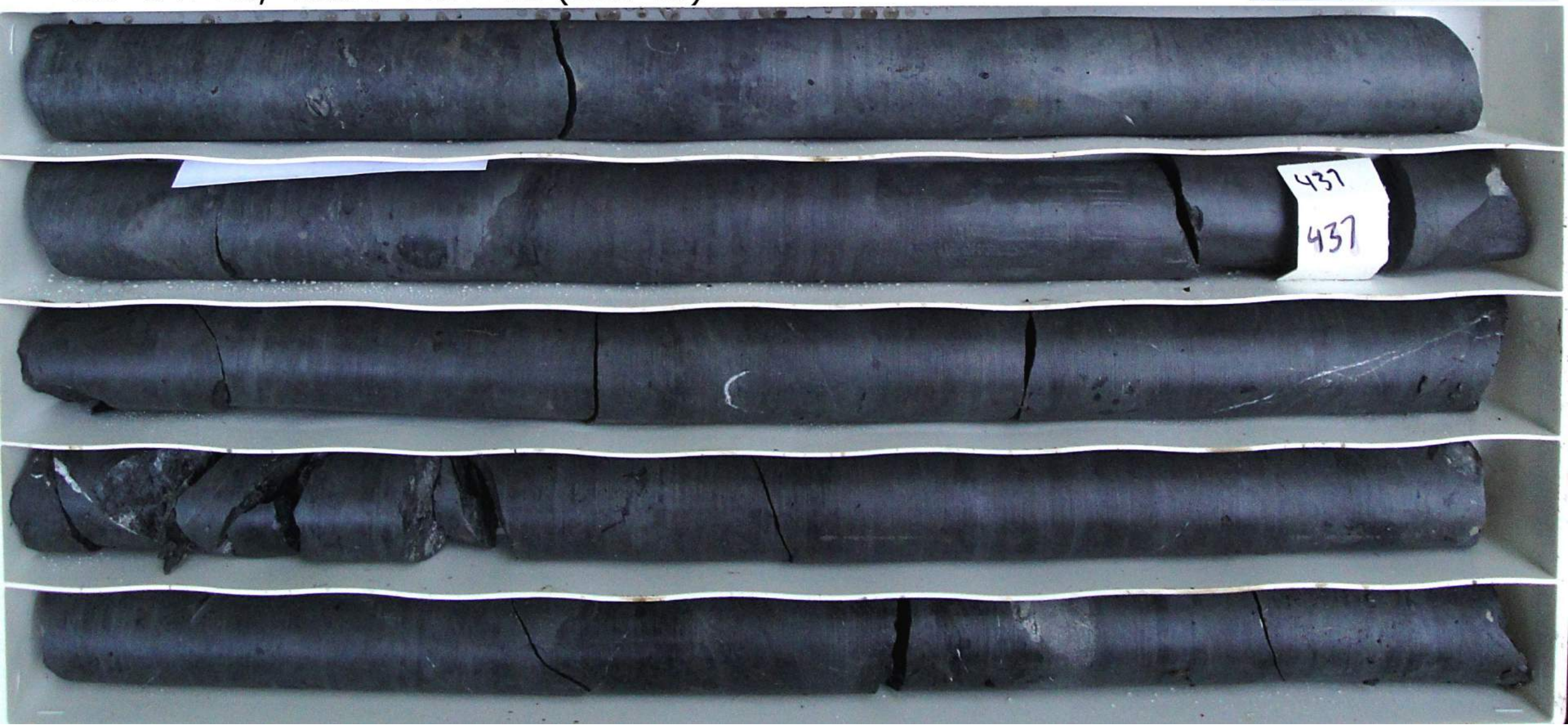
SO-C-1-15, 404.3-414.2 ft. (Box 42)

SO-C-1-15, 414.2-423.7 ft. (Box 43)



SO-C-1-15, 423.7-433.4 ft. (Box 44)

SO-C-1-15, 433.4-443.1 ft. (Box 45)



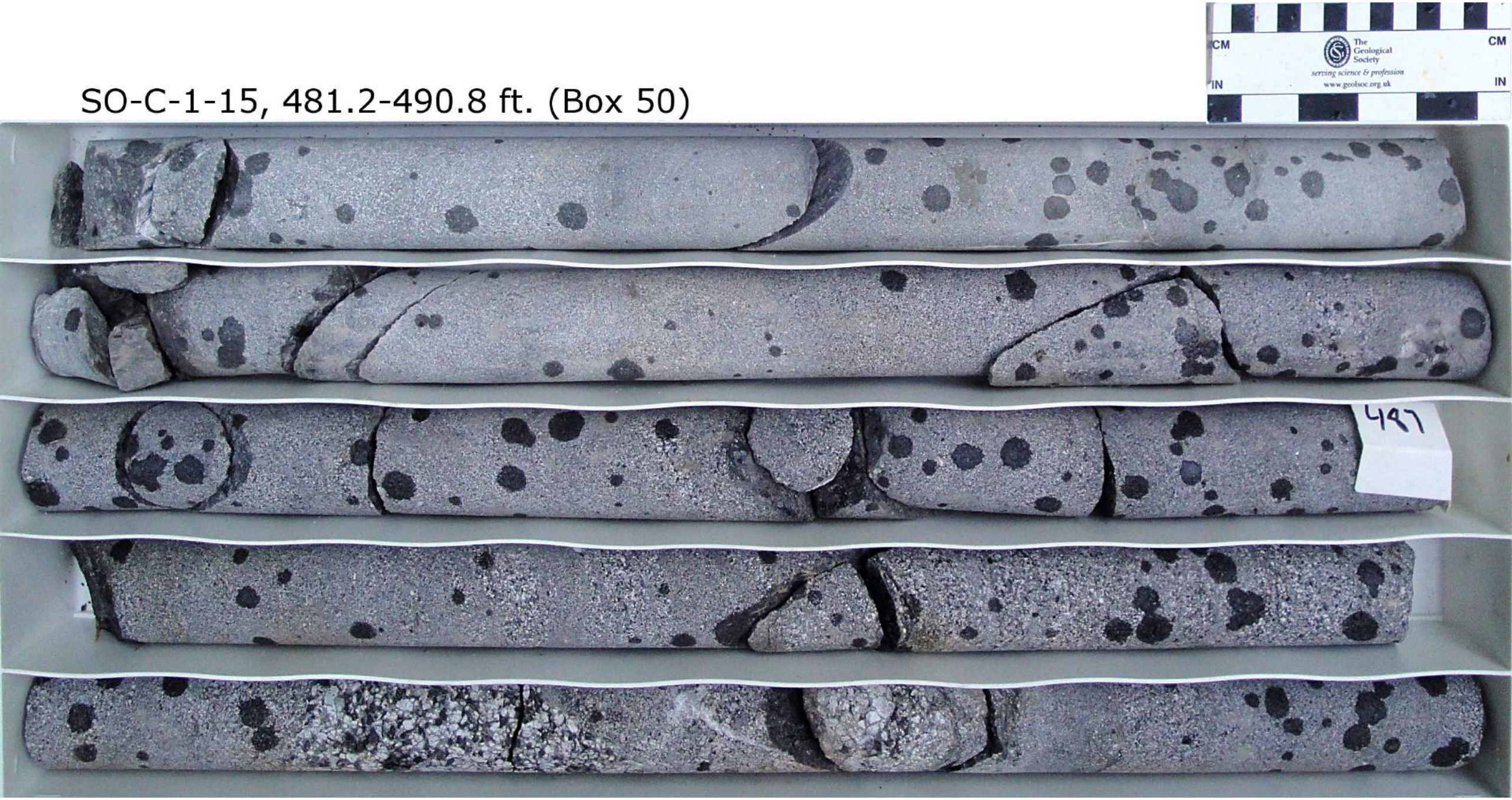
SO-C-1-15, 443.1-452.3 ft. (Box 46)

SO-C-1-15, 452.3-462.1 ft. (Box 47)

SO-C-1-15, 462.1-471.3 ft. (Box 48)

SO-C-1-15, 471.3-481.2 ft. (Box 49)

SO-C-1-15, 481.2-490.8 ft. (Box 50)

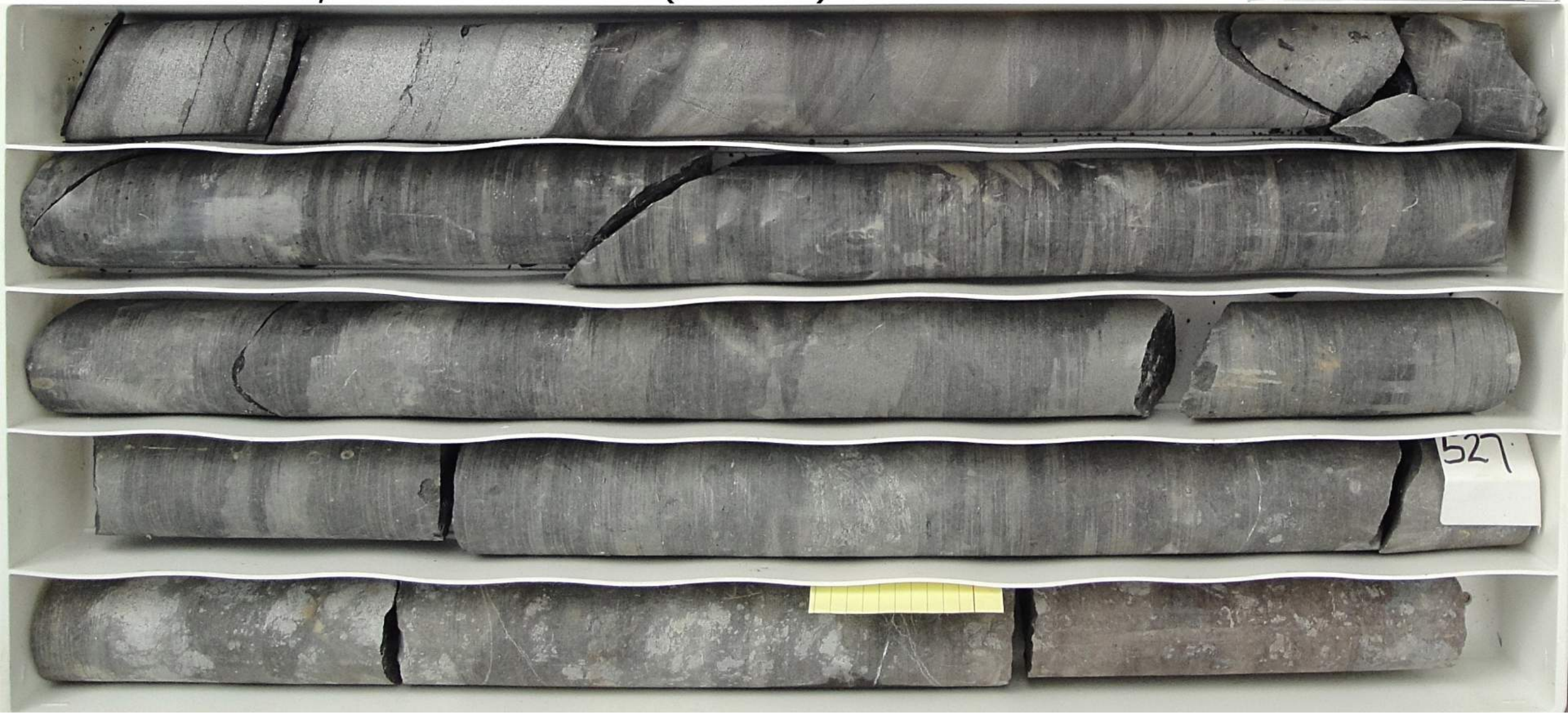


SO-C-1-15, 490.8-500.3 ft. (Box 51)

SO-C-1-15, 500.3-509.6 ft. (Box 52)

SO-C-1-15, 509.6-519.0 ft. (Box 53)

SO-C-1-15, 519.0-528.9 ft. (Box 54)



SO-C-1-15, 528.9-538.8 ft. (Box 55)

SO-C-1-15, 538.8-548.5 ft. (Box 56)

SO-C-1-15, 548.5-557.7 ft. (Box 57)

SO-C-1-15, 557.7-567.0 ft. (Box 58)

SO-C-1-15, 567.0-576.3 ft. (Box 59)

SO-C-1-15, 576.3-585.5 ft. (Box 60)

SO-C-1-15, 585.5-595.1 ft. (Box 61)

SO-C-1-15, 595.1-604.6 ft. (Box 62)

SO-C-1-15, 604.6-614.2 ft. (Box 63)

SO-C-1-15, 614.2-623.6 ft. (Box 64)

SO-C-1-15, 623.6-633.2 ft. (Box 65)

SO-C-1-15, 633.2-643.2 ft. (Box 66)

SO-C-1-15, 643.2-652.1 ft. (Box 67)

SO-C-1-15, 652.1-661.5 ft. (Box 68)

SO-C-1-15, 661.5-671.3 ft. (Box 69)

SO-C-1-15, 671.3-680.8 ft. (Box 70)

SO-C-1-15, 680.8-690.4 ft. (Box 71)

SO-C-1-15, 690.4-700.0 ft. (Box 72)

SO-C-1-15, 700.0-709.3 ft. (Box 73)

SO-C-1-15, 709.3-718.9 ft. (Box 74)

SO-C-1-15, 718.9-728.45 ft. (Box 75)

SO-C-1-15, 728.45-738.0 ft. (Box 76)

SO-C-1-15, 738.0-747.3 ft. (Box 77)

SO-C-1-15, 747.3-757.3 ft. (Box 78)

SO-C-1-15, 757.3-767.2 ft. (Box 79)

SO-C-1-15, 767.2-776.5 ft. (Box 80)

SO-C-1-15, 776.5-785.8 ft. (Box 81)

SO-C-1-15, 785.8-795.4 ft. (Box 82)

SO-C-1-15, 795.4-805.6 ft. (Box 83)

SO-C-1-15, 805.6-815.0 ft. (Box 84)

SO-C-1-15, 815.0-824.3 ft. (Box 85)

SO-C-1-15, 824.3-834.0 ft. (Box 86)

SO-C-1-15, 834.0-843.6 ft. (Box 87)

SO-C-1-15, 843.6-853.0 ft. (Box 88)

SO-C-1-15, 853.0-864.6 ft. (Box 89)

SO-C-1-15, 864.6-872.5 ft. (Box 90)

SO-C-1-15, 872.5-882.5 ft. (Box 91)

SO-C-1-15, 882.5-891.5 ft. (Box 92)

SO-C-1-15, 891.5-900.6 ft. (Box 93)

SO-C-1-15, 900.6-910.1 ft. (Box 94)

SO-C-1-15, 910.1-919.6 ft. (Box 95)

SO-C-1-15, 919.6-929.2 ft. (Box 96)

SO-C-1-15, 929.2-939.1 ft. (Box 97)

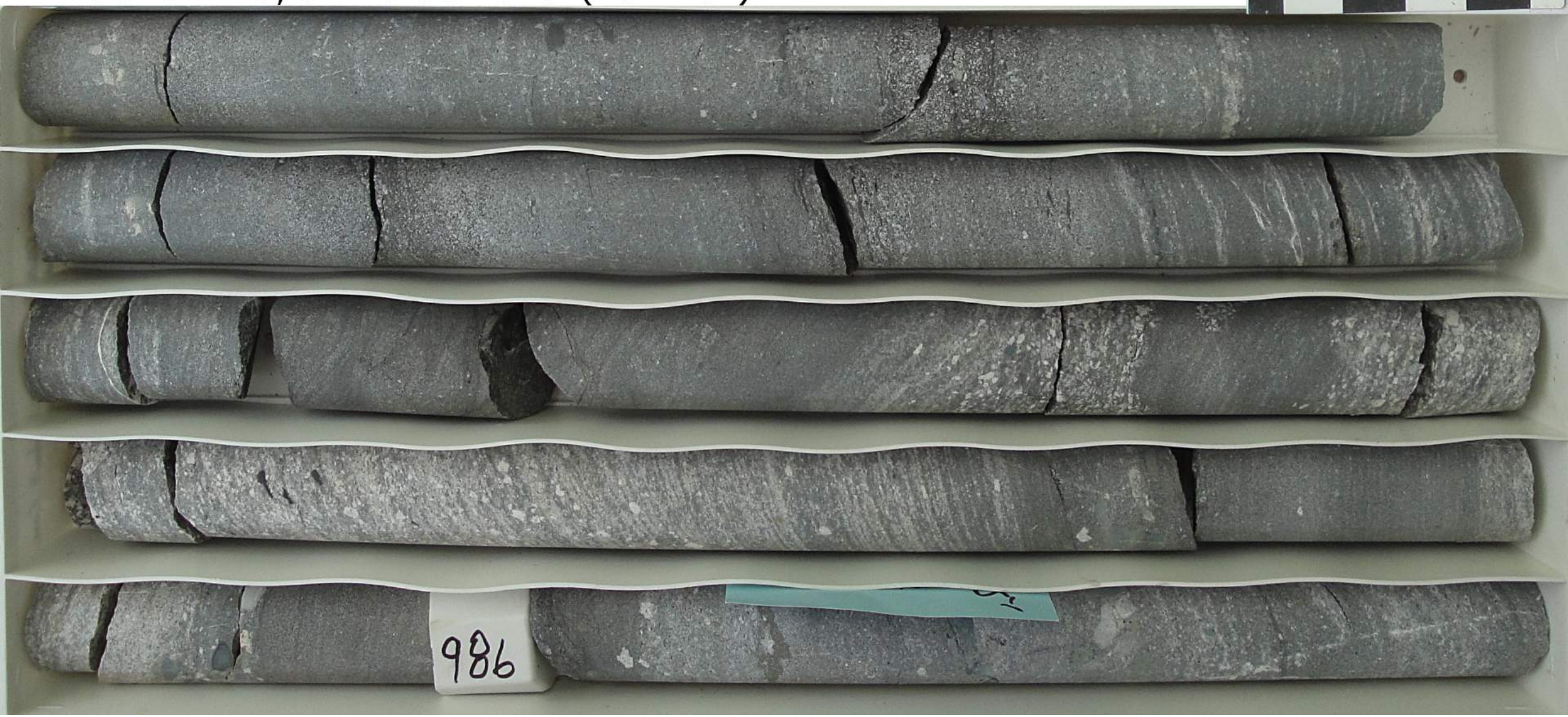
SO-C-1-15, 939.1-948.6 ft. (Box 98)

SO-C-1-15, 948.6-958.3 ft. (Box 99)

SO-C-1-15, 958.3-967.9 ft. (Box 100)

SO-C-1-15, 967.9-977.6 ft. (Box 101)

SO-C-1-15, 977.6-987.3 ft. (Box 102)



SO-C-1-15, 987.3-997.2 (Box 103)

SO-C-1-15, 997.2-1006.9. (Box 104)

SO-C-1-15, 1006.9-1016.3 ft. (Box 105)

SO-C-1-15, 1016.3-1025.7 ft. (Box 106)

SO-C-1-15, 1025.7-1035.6 ft. (Box 107)

SO-C-1-15, 1035.6-1045.0 ft. (Box 108)

SO-C-1-15, 1045.0-1054.9 ft. (Box 109)

SO-C-1-15, 1054.9-1064.6 ft. (Box 110)

SO-C-1-15, 1064.6-1074.0 ft. (Box 111)

SO-C-1-15, 1074.0-1084.6 ft. (Box 112)

SO-C-1-15, 1084.6-1092.8 ft. (Box 113)

SO-C-1-15, 1092.8-1102.1 ft. (Box 114)

SO-C-1-15, 1102.1-1111.8 ft. (Box 115)

SO-C-1-15, 1111.8-1121.5 ft. (Box 116)

SO-C-1-15, 1121.5-1131.0 ft (Box 117)

SO-C-1-15, 1131.0-1140.1 ft. (Box 118)

SO-C-1-15, 1140.1-1149.4 ft. (Box 119)

SO-C-1-15, 1149.4-1158.9 ft. (Box 120)

SO-C-1-15, 1158.9-1168.5 ft. (Box 121)

SO-C-1-15, 1168.5-1178.0 ft. (Box 122)

SO-C-1-15, 1178.0-1188.0 ft. (Box 123)

SO-C-1-15, 1188.0-1197.4 ft. (Box 124)

SO-C-1-15, 1197.4-1207.1 ft. (Box 125)

SO-C-1-15, 1207.1-1216.5 ft. (Box 126)

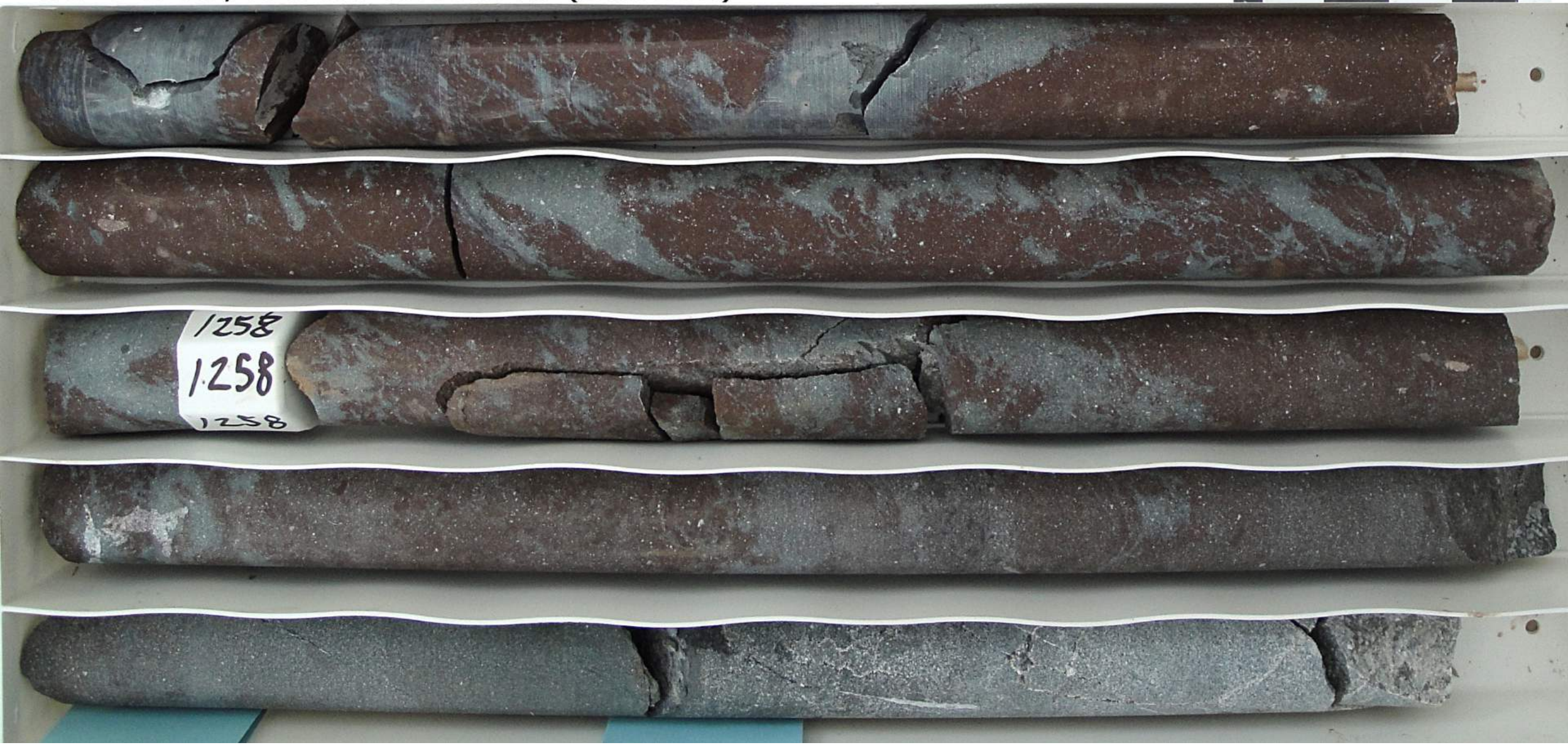
SO-C-1-15, 1216.5-1226.0 ft. (Box 127)

SO-C-1-15, 1226.0-1235.4 ft. (Box 128)

SO-C-1-15, 1235.4-1244.7 ft. (Box 129)

SO-C-1-15, 1244.7-1254.0 ft. (Box 130)

SO-C-1-15, 1254.0-1263.1 ft. (Box 131)



SO-C-1-15, 1263.1-1272.3 ft. (Box 132)

SO-C-1-15, 1272.3-1282.0 ft. (Box 133)

SO-C-1-15, 1282.0-1291.4 ft. (Box 134)

SO-C-1-15, 1291.4-1300.7 ft. (Box 135)

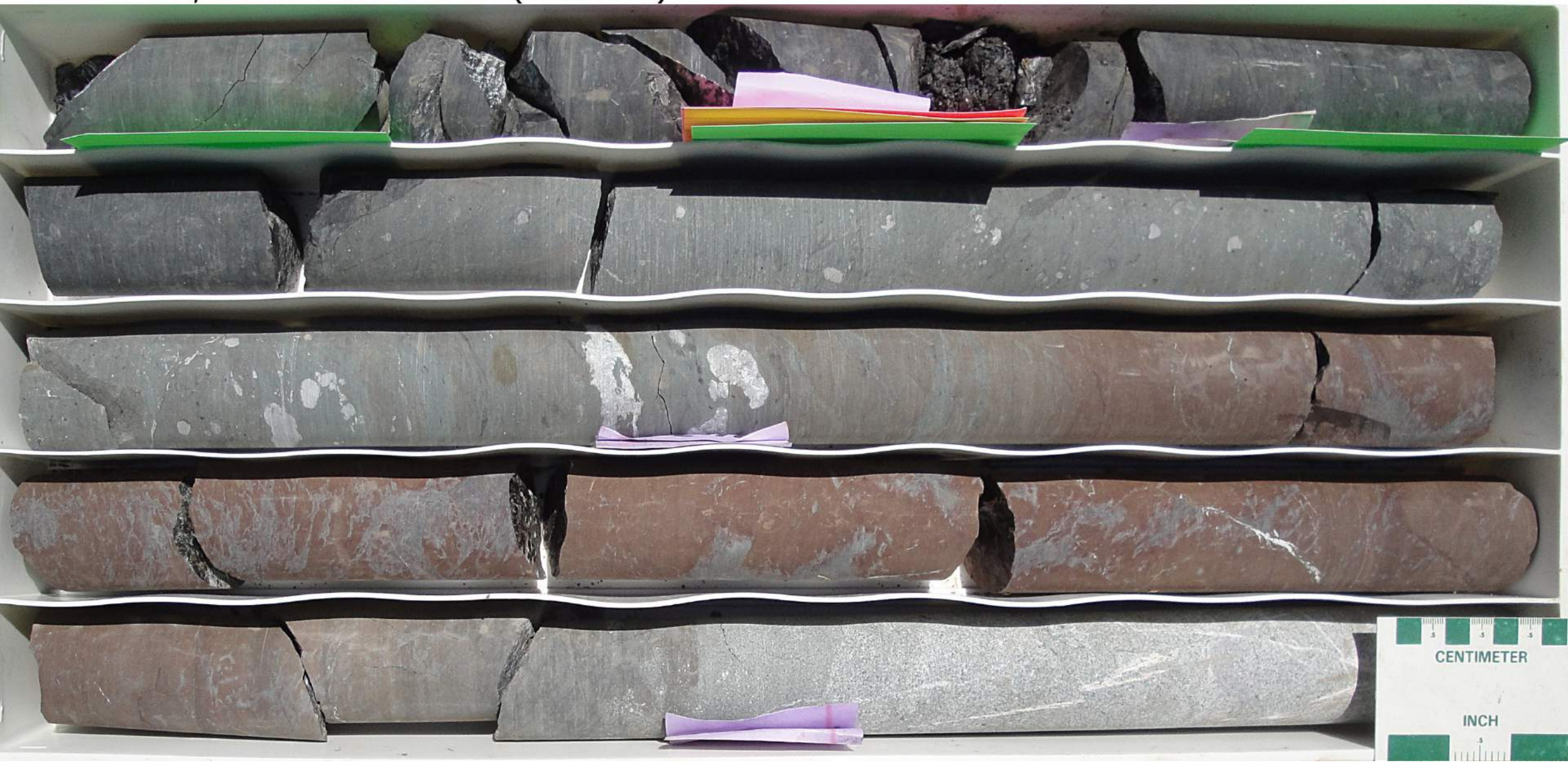
SO-C-1-15, 1300.7-1310.1 ft. (Box 136)

SO-C-1-15, 1310.1-1319.5 ft. (Box 137)

SO-C-1-15, 1319.5-1328.2 ft. (Box 138)

SO-C-1-15, 1328.2 - 1338.3 ft. (Box 139)

SO-C-1-15, 1338.3-1347.7 ft. (Box 140)



SO-C-1-15, 1347.7-1357.0 ft. (Box 141)

SO-C-1-15, 1357.0-1366.2 ft. (Box 142)

SO-C-1-15, 1366.2-1375.7 ft. (Box 143)

SO-C-1-15, 1375.7-1385.0 ft. (Box 144)

SO-C-1-15, 1385.0-1394.4 ft. (Box 145)

SO-C-1-15, 1394.4-1403.5 ft. (146)

SO-C-1-15, 1403.5-1413.0 ft. (Box 147)

SO-C-1-15, 1413.0-1422.4 ft. (Box 148)

SO-C-1-15, 1422.4-1431.6 ft. (Box 149)

SO-C-1-15, 1431.6-1440.9 ft. (Box 150)

SO-C-1-15, 1440.9-1450.2 ft. (Box 151)

SO-C-1-15, 1450.2-1459.1 ft. (Box 152)

SO-C-1-15, 1459.1-1467.65 ft. (Box 153)

SO-C-1-15, 1467.65-1477.0 ft. (Box 154)

Appendix 2. Field core descriptions of the SO-C-01-15 “Town of Walnut Cove” core.

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT 50-C-1-15 CORE NO. 50-C-1-15 page 1 of ___

SITE/LOCATION Walnut Cove

DESCRIBER ___ DATE 13 June 2015 Reviewer ___

Depth	Bedding	Principal Grain Size — Clastics (MUD: Peat, Clay, C — 2 — M, Silt, Z — 62.5; SAND (microns): vf — 125, f — 250, m — 500, c — 1000, vc — 2 mm; GRAVEL (mm): granules — 4, pebbles — 64, cobbles — 256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. enviriomment	Remarks	Recovery

Depth marks: 485, 490, 495, 500, 505, 510, 515, 520, 525, 530, 535

Sand to granular; Congl "ind" ~493

490.8

cm → granular; ang. fining up

Basal gravel / erosion & fill

499

7" basal lag gravel fining up

-N4

-N4 inside

medium to fine sand

fining

gravelly, fining up to ~ silt

-N3

graded up silty-sand 6"

Black fn- to v. fn. siltstone to mudstone — well laminated "Breaks" on basal plane slicks

144 stable

N5

Pedogenic surface mottled red/gray w/ carbonate nodules w/ extensive root mottles & probable bioturbation

Remarks:

Prob. small channel fill w/ basal coarse gravelly (mat[illegible]) fining up

Braided channel?

[illegible] upward. Top of sequence w/ v. thin mm - cm graded up beds

→ small channel sequence w/ basal gravel; fining up to v. thin. bedded - shallow. One basic braided channel packet.

csc. gravels - angular fining

Bedding horizontal

Bioturbation ~ 3-4 scale

Lots of graded bedding - mm scale

Env. — quiescent "pond" on side of braided channel - sitting on top of red pedogenic interval

↑ ↓ Pedogenic surface

Extensively rooted & carbonate concretions around roots

P	C	M	Z	vf	f	m	cs	vcs	gran	pebs	cob	bould
.5		1.0	1.5	2	3	4	5	6	7	8	9	10

Continue to top of next page

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT _____ CORE NO. So-C-1-15 page 2 of ___

SITE/LOCATION _____

DESCRIBER _____ DATE _____ Reviewer _____

Depth | Bedding | Principal Grain Size (Clastics: MUD — Clay, Silt; SAND — microns: vf, f, m, c, vc; GRAVEL — mm: granules, pebbles, cobbles, boulders) | Lithology | Color (GSA Chart) | Fossils | Accessories | Sed. strictires | Sorting | Roundness | Fractures / joints | % recovered | Porosity | Shows | Dep. envirionment | Remarks | Recovery

535.7

537 slickenside bed plane slip

539.3

gray siltstone - fining at top to mudstone

Good landing structures: cross bdng in silt, silt waves w/ local mud drape picked

549.3

Red mottled pedogenic surface with abundant localized Root casts,
* More "massive" & few indistinct "laminae"

562.7

steep fracture with fill

gravels & mud mud clast

scouring large ftg gravels - lenses

573

Red pedogenic - massive, not mottled - rather massive bedding, if any original is gone.

579.5

gray mottled

banded

N5

5YR 3/2

5YR 4/1

Remarks:

ENV: small channel - on top of mudstone fining upward into sand and with gleyed soil into a pedogenic rooted mottled sand Abars (orange/brown)

ENV. - gray siltstone w/ some sandy fine wavy-small-scale silt bedding, cupped beds upward to OM mud drapes.

gradational downward to red pedogenic unit

- Nadational contact down to red pedogen

ENV. pedogenic surface, grades down to fining up channel, and up to gray silt - small pond or channel fill w/ water mud

ENV. - small braided channel

ENV. pedogenic oxidized surface grades down to top of braided channel

Grades upward into gray s.s. & m.s. w/ HS

P | C | M | Z | vf | f | m | cs | vcs | gran | pebs | cob | bould
.5 | 1.0 | 1.5 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. SO-C-1-15 page 3 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth	Bedding	Principal Grain Size – Clastics (MUD: Peat, Clay, C–2, Silt, M, Z–62.5; SAND (microns): vf–125, f–250, m–500, c–1000, vc–2 mm; GRAVEL (mm): granules–4, pebbles–64, cobbles–256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. envirionment	Remarks	Recovery
585		prominent forests													ENV. - Braided channel w/ series grading up intervals to thin bar-capping sands, prominent foresets. Overall sns. disappears & towards	
590		mostly quartz-rich gravels v angular; fossils; thin sands													NOTE - less and less fine-grained sands capping channels w/ depth of hole but many exceptions	
595		595.1		N6											SNN: Braided stream sequence with occasional influx (basal gravelly units) that fine upward to planar bedding (bar caps). Also occasional mud rip up from v. thin black mud layers - exp. 614.4.	
600																
605																
610		v. thin bedded, prom. minor xbeds; f-med ss														
615		mdstne; mdstne		N3												
620				N6												
625		mdstone; ~626.0; silty to sltly muddy													Braided stream sequence series of upward channels w/ grading up sequences capped by plane bedding. Upper interval grades up into a thin silty/muddy transition with overlying sequence	
630				N4												
635																

P | C | M | Z | vf | f | m | cs | vcs | gran | pebs | cob | bould

.5 | 1.0 1.5 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. 50-C-1-15 page 4 of ___
SITE/LOCATION ______
DESCRIBER ______ DATE ______ Reviewer ______

Columns: Depth | Bedding | Principal Grain Size — Clastics (MUD: Peat, Clay, C – 2 – M, Silt, Z – 62.5; SAND (microns): vf – 125 – f – 250 – m – 500 – c – 1000 – vc – 2 mm; GRAVEL (mm): granules – 4 – pebbles – 64 – cobbles – 256 – boulders) | Lithology | Color (GSA Chart) | Fossils | Accessories | Sed. strictires | Sorting | Roundness | Fractures / joints | % recovered | Porosity | Shows | Dep. envirionment | Remarks | Recovery

Depth marks: 635, 640, 645, 650, 655, 660, 665, 670, 675, 680, 685

from here up all SSM & graded beds at 1-3+ inch scales

some reg. cross bedding

Mostly planar bedding
abdt black mud rip-up clasts in basal section

mud rip-ups

gravelly base w/ 3 of granule

653'

coarsens up to mp - up mudclasts - dy/ris

graded bedding rip-ups

mudclasts/rip-up

658

660.7

upper 2' fn. sand

xbds

Recurring graded beds @ 4-6" interval

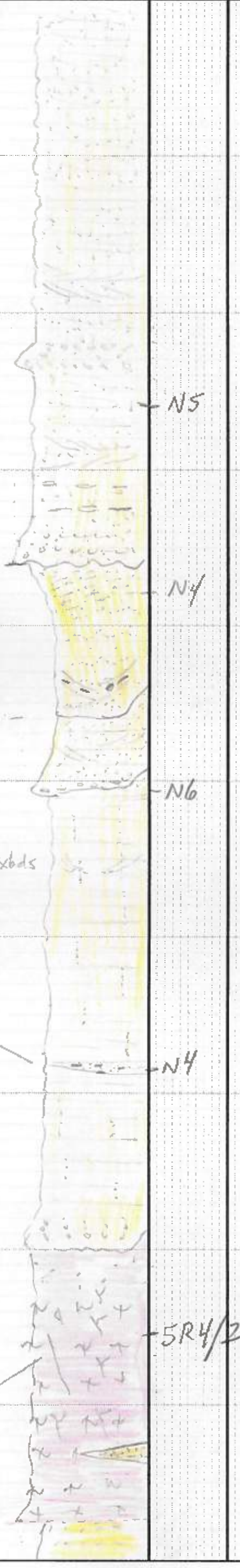
w/ mudclasts

Recurring graded beds at 4"-6" ... complete size

... quartz-feldspar ... at base

675.3

Pedogenic rooted mudcracked ... mass ... noboddy ... a geo... prob ... graded bed



Remarks:

- 653
(ENV) - mud to fn sand grading up into mud fragments - fine silt waves w/ crossbedding.
graded bed recurring sequence bar top - braided sequence

- 658
(ENV) - Braided channel, basal scour grades upward to next cycle

660.7

ENV. pedogenic surface poss. on side of braided channel; oxidized subaerial rooted, burrowed - soil.
No carbonate

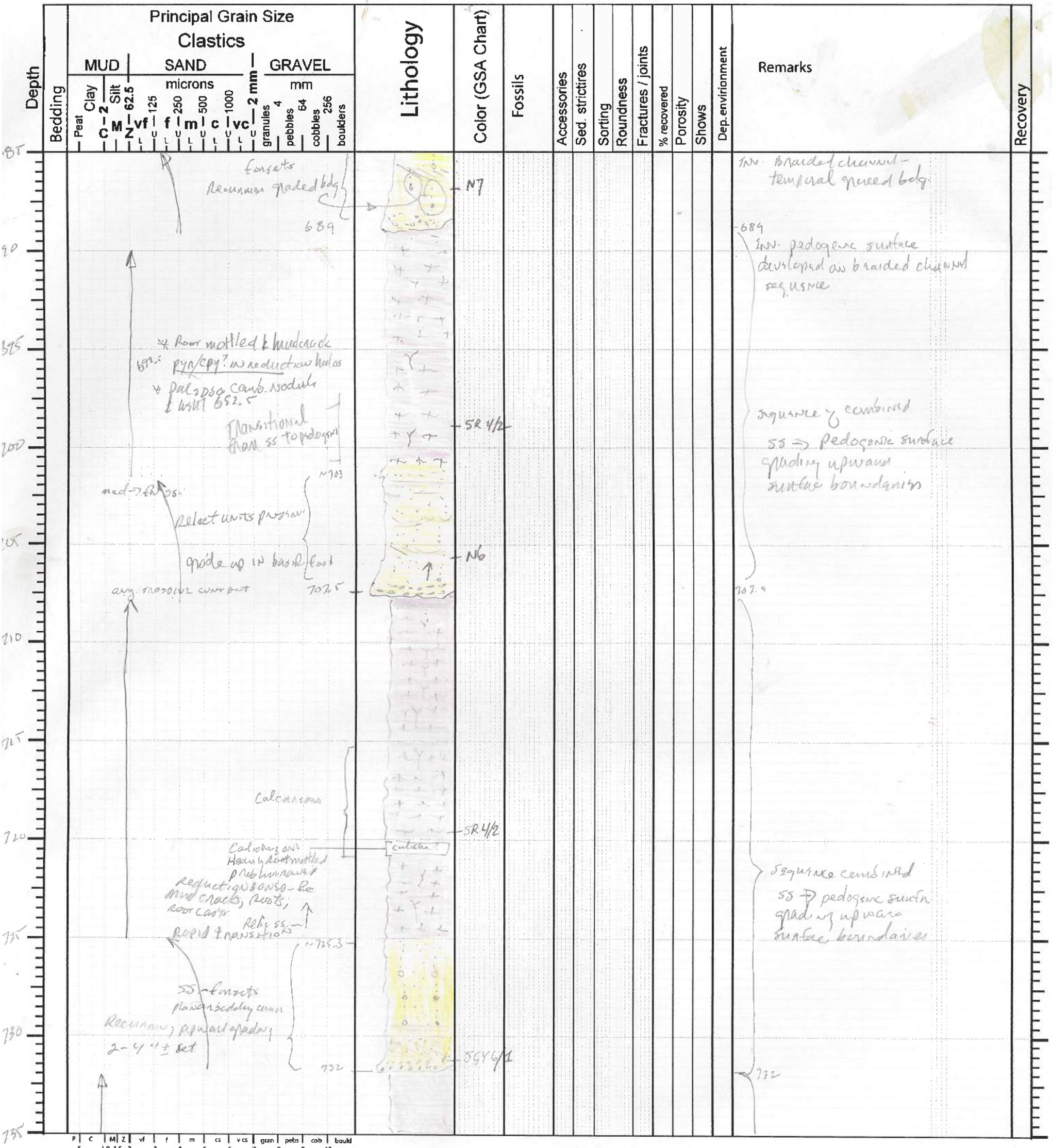
P | C | M | Z | vf | f | m | cs | vcs | gran | pebs | cob | bould
.5 | 1.0 | 1.5 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT _____ CORE NO. SO-C-1-15 page 5 of ____

SITE/LOCATION _____

DESCRIBER _____ DATE _____ Reviewer _____



* Note 758-768 - spectacular transition from sand → graded bed.

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT _____ CORE NO. 50-C-I-15 page 6 of ___

SITE/LOCATION _____

DESCRIBER _____ DATE _____ Reviewer _____

Depth | Bedding | Principal Grain Size (Clastics: MUD — Clay, Silt; SAND — microns: C, M, Z, vf, f, m, c, vc; GRAVEL — mm: granules, pebbles, cobbles, boulders) | Lithology | Color (GSA Chart) | Fossils | Accessories | Sed. strictires | Sorting | Roundness | Fractures / joints | % recovered | Porosity | Shows | Dep. envirionment | Remarks | Recovery

735
740
745
750
755
760
765
770
775
780
785

mostly blocky
all red mudstones has
mottling, some nip-ups,
occ. crossbedding,
pedogenic structure
745.7 - coppsn staining
in fract and fracture

red mudstone w/
pedogenic & caliche
v. calcareous

caliche
caliche

5R 4/2

5R 4/2

sequence combined
as → "mudstone" →
pedogenic structure
gradational contact up
from scoured base.
Braided?

763.5

Thins to bed mud
grades up into root?
763.6

gray
m-fn. sand, well
x-bedded, basal scour
at 15± feet, grades
immed. up. to well
x-bedded sand. with
a rapid upward grad.
to paleosol - Reddened
w/ calicite.
763.5

5GY 4/1

mottled pedogenic
& rooted
many red mud nipups
soft sed., poss. base 768
rapid grad. contact

5R 4/2

768

pdaward bed thins
up 2-3" high x beds

fault up w/ ~2mm offset

N6

coaly laminae bed
coaly laminae bed

780

Med-ss
fining up
abdt x bds
2-3" scale
thin sands

781

P | C | M | Z | vf | f | m | cs | vcs | gran | pebs | cob | bould
.5 | 1.0 | 1.5 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

sequence of Braided stream
w basal erosion & coc bottom
rapidly grades upward into
shoaling Plinthite cross-beds
& Plinthic bedg + gentle
crossbeds.

followed variably by nip-up
sequence of soft red mud
fragments, then
supposed pedogenic
structure

pyr = red
Hi-angle fracture/veinlet, white mineral filling

777 – 788 interval w/ OM + pyr-out staining, flakes, plant

Note – see previous page for special note on 758-768 20150614 – J

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. SO-G1-15 page 1 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth	Bedding	Principal Grain Size – Clastics (MUD: Peat, Clay, C, 2, Silt, M, Z, 62.5; SAND (microns): vf, 125, f, 250, m, 500, c, 1000, vc, 2 mm; GRAVEL (mm): granules, 4, pebbles, 64, cobbles, 256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. envirionment	Remarks	Recovery
785		snd lens; granular to med grass – scoun bars – xbeds @ 2-4" scale; pyr asstd w/ om; pyr + om – red om		N5; coaly lamina/bd – om –; om dots											pyr asstd w/ om throughout unusual. om – flakes, grains staining rk nearby possibly basement rx.	
790		planar bedding, few xbeds													ENV	
795		xbedding foresets decrease upward to planar bdding		N5												
800		mod. abundant om rip-up – blk mud frags, clasts		N7											braided channel complex grading upward to grainsize & shallowing capped by planar bedding below shutoff	
805		dominated w/ foresets xbddg w/ qtz on avalanche face; om rip-up clasts		N3 (OM)												
810		localized burrows														
814		Planar bddg; Basal scour, grades up lithic granule gravel to cse sand		N7												
815		Roots, burrows? bioturbation?														
820		laminated red siltstone – claystone – appears to have relic fabric preserved.													Pedogenic surface developed on top of braided stream	
825															~824-825 – minor sand pulse m-f. sand	
828				828'	5R 4/2											
830																
835																

P .5 | C | M 1.0 | Z 1.5 | 2 | vf 3 | f 4 | m 5 | cs 6 | vcs 7 | gran 8 | pebs 9 | cob 10 | bould

continue to top of next page @ 835.4 – transitional grades / mud contact

~~423~~ 424 − 98 = 326

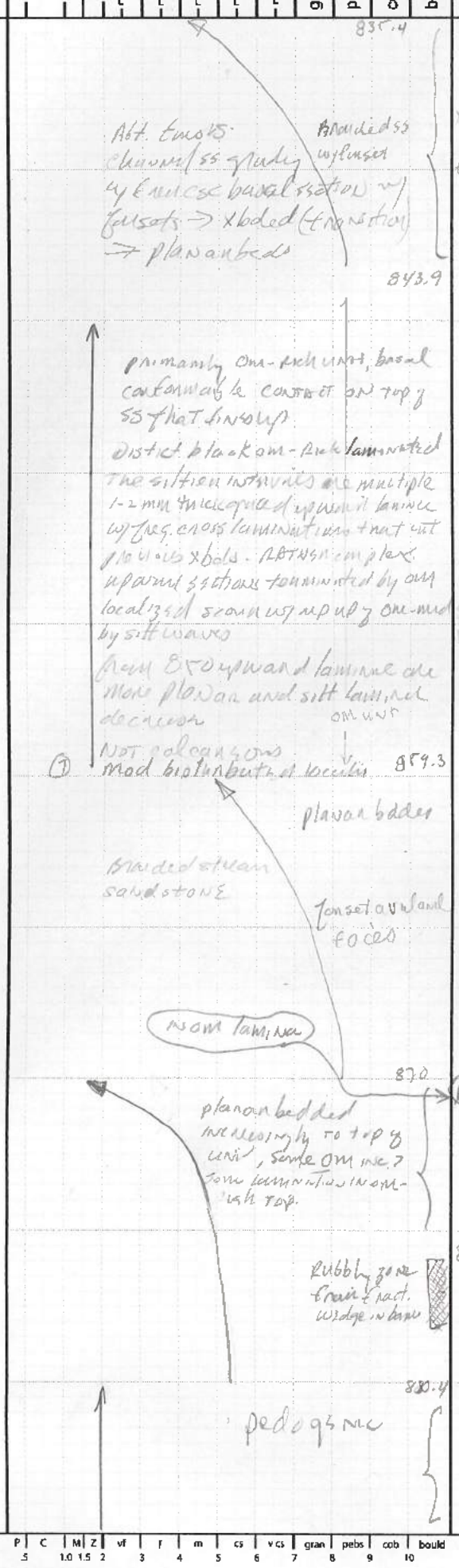
NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT _____ CORE NO. SO-C-1-15 page 8 of ____

SITE/LOCATION _____

DESCRIBER _____ DATE _____ Reviewer _____

Depth | Bedding | Principal Grain Size: Clastics — MUD (Peat, Clay, C, M, Z, Silt) | SAND (microns: vf, f, m, c, vc) | GRAVEL (mm: granules, pebbles, cobbles, boulders) | Lithology | Color (GSA Chart) | Fossils | Accessories | Sed. strictires | Sorting | Roundness | Fractures / joints | % recovered | Porosity | Shows | Dep. envirionment | Remarks | Recovery



ENV. Braided stream channel sandstone transitional to soil above Red-Mangum soil

NOTE – EXTENSIVE oxidized pedogenic surface developed on top of this

ENV - quiescent fine. OM accumulation in small depression adjacent to main braided channel complex

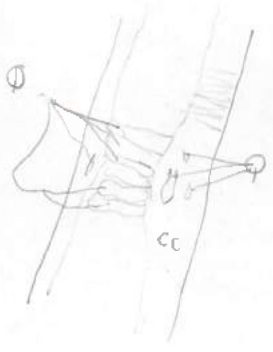
Ripup - locally 859, 857

- SHARP but NOT SCOURED / ERODED contact

ENV - Braided channel w/ basal surge & esc grains fining up

NOTE: A, B - steep VERTICAL fractures healed, closed, filled w/ qtz±cc looks like calcite filled ⓔ Then next (CONTACT w/ qtz) inset below & paralleling ⓐ 10X hand lens

ENV. - Braided channel cut into top of red mudstone w/ pedogenic fabric ss (esc) grades up into shoaling planar bedding then capped by somewhat gray → black salty claystone/siltstone - (FeS_2) at top & pH-sk contact



Vein filling detail ⓒ 10X hand lens.
ⓔ N869 Peat

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT _____ CORE NO. 50-C-1-15 page 9 of ___

SITE/LOCATION _____

DESCRIBER _____ DATE _____ Reviewer _____

Depth | Bedding | Principal Grain Size: Clastics — MUD (Clay, Silt) | SAND (microns: vf, f, m, c, vc) | GRAVEL (mm: granules, pebbles, cobbles, boulders) | Lithology | Color (GSA Chart) | Fossils | Accessories | Sed. strictires | Sorting | Roundness | Fractures / joints | % recovered | Porosity | Shows | Dep. envirionment | Remarks | Recovery

185

pedogenic + caliche

Red laminated claystone - siltstone w/ granules

190

m. grained ss. - gen fining up, but appears to trappears normal graded w/ fold of ST3 geometry

ST3 ? & ? — high angle fract. w/ whitebilling

scour base w/ londs

195

Red mudstone

ext. pedogenic floating rooting w/ halos and mottles + bioturbation 1-2? (iron)

grad cont.

200

planar bedded m-fines

205

4-6" fining cycl

210

cycles upward

scour base

215

Red claystone/siltstone

Abd. root casts (fe-reduction halos)

220

225

Red mudstone

HEAVY pedogenic - calcite - mix ~~mud~~ clots

caliche-like "

Root casts - lamination

Barely visible - ~~bur~~ oxd

230

235

P | C | M | Z | vf | f | m | cs | vcs | gran | pebs | cob | bould

.5 1.0 1.5 2 3 4 5 6 7 8 9 10

caliche

-5R 4/2

-N6

-5R 4/2

-N4

-N7

-5R 4/2

SNN - Temporal channel breaks on levee bank

ENN - Braided channel - rapidly quiescent w/ pedogenic oxidation

ss ⇒ claystone, Rapid aggradation

ENN. small channel in braided stream

ENTIRE SEQUENCE - scour ⇒ grades up to fines ⇒ mudstone capped w/ pedogenic features in red claystone/siltstone

1 sequence

ENN. minor pond developed at top of avulsed braided channel

- But this part emerging int (oxidizes)

This was the final v. shallow oxidized bar tops? Early channels?

Then succeeded black carbonaceous & channel comp.

929-939 mostly pedogenic - note black interval was a wet depression. water level change led to oxidation

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. SO-C-1-15 page 10 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth	Bedding	Principal Grain Size – Clastics (MUD: Peat, Clay, C – 2, M, Silt, Z – 62.5; SAND (microns): vf – 125, f – 250, m – 500, c – 1000, vc – 2 mm; GRAVEL (mm): granules – 4, pebbles – 64, cobbles – 256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. envirionment	Remarks	Recovery
35															ENV. v. slightly emergent - sidey channel on lateral to it	
140		Red - claystone-siltstone v. fn. sand to silt - laminated & somewhat structures visible at this scale - Basically flat-lying														
45																
150		950. grades rapidly ↑ to Red mudstone - subaerial; Black, bioturbated mudstone; Bioturbation 6-7, some mudcups		N5											ENV. - prob. small shallow temporal pond on top of channel ss - burrowed some mudcup - a minor energy pulse	
155		956		mod. abrupt contact											mod abrupt contact	
		planar bedding; planar bds														
160		960 Thin m-f ss sands		N7											Small fining upward channel sequence - shoaling vertically.	
165		foresets - 4-6 ft													foresets ⇒ xbds ⇒ planar bds w/ shoaling	
		minor om-rich mud drape on top of channel - 968													temporal pond development surface w/ OM & Bioturbat.	
70																
		planar beds - fn-medium		N5											ENV - braided sstn	
175																
		977														
180		PYR. ASST W/ OM frags in ss		N5											fining upward braided stream sstn	
185																

P | C | M | Z | vf | f | m | cs | vcs | gran | pebs | cob | bould

.5 | 1.0 | 1.5 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. 50-C-1-15 page 1 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth	Bedding	Principal Grain Size — Clastics (MUD: Peat, Clay, C, 2, M, Silt, Z, 62.5 / SAND microns: vf, 125, f, 250, m, 500, c, 1000, vc, 2 mm / GRAVEL mm: granules, 4, pebbles, 64, cobbles, 256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. envirionment	Remarks	Recovery
985		pyn w/ om														
990															Braided channel seq. OM mudstone in up-up w/ pyn	
995		Consists 4-6" fining up w/ small sand lens capping bars. m → csd. ss.		N5												
1000		1001														
1005		Red laminated mudstone / siltstone pedogenic features common – locally caliche-like – transitional profile on top of braided channel that largely fined up		5R 4/2											gray-black mudstone w/ rooting & likely bioturbation	
1010		Rapid gradational contact 1009.5														
		Crossbedded med gray ss. planar & crossbedded														
1015				N4											Braided channel sequence w/ basal scour, fining up shoaling shut off of sed influx followed by subaerial exposure with pedogenic features (caliche + rooting) maybe burrows. all followed by wetting & small pond developed w/ OM-rich mud burrowed + pedogenic (minor features)	
1020																
1025		1027		N6												
1030		Red pedogenic mottle developed on thin braided channel – root mottled														
1035				5R 4/2												

P C M Z vf f m cs vcs gran pebs cob bould
.5 1.0 1.5 2 3 4 5 6 7 8 9 10

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. SD-C-1-15 page 12 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth | Bedding | Principal Grain Size — Clastics: MUD (Peat, Clay, C – 2, M, Silt, Z – 62.5) | SAND (microns: vf, 125, f, 250, m, 500, c, 1000, vc, — 2 mm) | GRAVEL (mm: granules, 4, pebbles, 64, cobbles, 256, boulders) | Lithology | Color (GSA Chart) | Fossils | Accessories | Sed. strictires | Sorting | Roundness | Fractures / joints | % recovered | Porosity | Shows | Dep. envirionment | Remarks | Recovery

1035

Red pedogenic surface 1036 w/ Fe-red zones & mottling

fn-med snd. - fairly shallow water based on a few x-bds + mostly planar bedding

1040

Assorted fractures w/ minor offsets - white min. filling - qtz maybe some cc

1045

1046

Red - root mottled paleosol

Rapid transitional contact ~ 1049 to paleosol

1050

planar bdded w/ some cross-beds

1055

1056

foreset dominated

1060

"Coaly" — 1062 - 1062.5 OM claystone blk

basal foreset grade to fn rapidly upward ↑

v. compressed pattern

1065

Highly laminated w/ silt wave xbds and grade up bds/lam → 1065.0 - .5

mostly forsets w/ planar toward top

minor fault offset ~ 2 mm.

1069

1070

om. blk. mudstone well laminated, many xbds

1072

planar cross-bedded

1074

1075

foreset crossbedded

1080

1082

multiple fining up graded bed

blk siltstone w/ mud lamina

1085

Color (GSA Chart): N5; 5R 4/2; N5; N1; N6; N2; N4; pyrite sm; N3; N7; N3

Remarks:

Env. minor braided channel - maybe pretty shallow w/ chute-like fast current → shuts down followed by pedogenic time w/ roots etc

Env. Braided channel complex with re-occurring channel occupation punctuated by localized periods of sedimentation quiescence → OM-rich black clay accumulation in highly localized depressions followed by development of a short pedogenic and emergent red claystone that is rooted.

— minor coaly laminae

— OM-blk claystone

— minor pond or temporal swamp

— NOTE pyr grains assoc w/ OM in both coarse ss and in the OM-rich sections & mud drapes to top of sequence.

P | C | M | Z | vf | f | m | cs | vcs | gran | pebs | cob | bould

.5 | 1.0 | 1.5 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

granules look to be feldspar and quartz.

multip

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. 50-C-1-15 page 13 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth	Bedding	Principal Grain Size – Clastics (MUD: Peat, Clay, C – 2, M, Silt, Z – 62.5; SAND microns: vf, 125, f, 250, m, 500, c, 1000, vc, – 2 mm; GRAVEL mm: granules, 4, pebbles, 64, cobbles, 256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. envirionment	Remarks	Recovery
1085		more organic-rich mudstone with granules - lots of normal graded up beds w/ complex relations crossbedding of silt waves & micro laminations granules in lower part - fining up 1090	min. bioturb on root. m		pos plant fossil - sponges?										look for potential sponges — nodules? poss phosphatic ???	
1090		ss. - crossbedded & forsets; 40-50° fractures healed - qtz cores w/ cc rims		N7												
1095		m sandstone crossbedded & small avalance forsets 1097.5													ENV - Braided stream channel complex w/ small depression on top in which OM & black mud accumulated in more emergent position	
1100		med sand 1101-1102 forsets & xbeds; qtz core cc rim													- black carb plant - platy unknown - OM? or biot??	
1105		m -> csc ss w/ gravelly clasts mostly forset avalance; ~1/2" qtz & kfeld (pink) angular clasts lower foot grading up = inc. current fill 1109.5		N7												
1110		Black laminated mudstone/siltstone no rooting or bioturbation noted in field 1111.5	abrupt change	N2												
1115		Red pedogenic mudstone/siltstone granules - localized caliche - rooted - poss. bioturbation (weak) 1-2 pnt lamination preserved locally granular		5R4/2												
1120		1124													ENV. small braided channel complex w/ scoured base into OM pond - quickly fines up after initial high energy on the first planar sand followed upward by emergent & pedogenic formation - Then a water rise filled a depression w/ water from clay stun land	
1125		planar bedded med. ss 1128		N5												
1130		forsset laminated - ss 1131.5; OM - dk gray siltstone w/ dk mud lamination many normal graded beds 1134.5	mudstone wedge	N6, N3												
1135																

P | C | M | Z | vf | f | m | cs | vcs | gran | pebs | cob | bould
.5 1.0 1.5 2 3 4 5 6 7 8 9 10

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. 50-C-1-15 page 14 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth | Bedding | Principal Grain Size — Clastics: MUD (Peat, Clay, C, 2, Silt, M, Z, 62.5) | SAND microns (vf, 125, f, 250, m, 500, c, 1000, vc, 2 mm) | GRAVEL mm (granules, 4, pebbles, 64, cobbles, 256, boulders) | Lithology | Color (GSA Chart) | Fossils | Accessories | Sed. strictires | Sorting | Roundness | Fractures / joints | % recovered | Porosity | Shows | Dep. envirionment | Remarks | Recovery

1135

m-csc grained ss - mostly foresets + crossbeds

planar beds - m-sand ss

N4

1140

ss. foresets in m→csc ss 4-6 inch foresets

- coaly laminae w/ assoc pyr

pyr framboid clusters along OM lamina

- N8

Nearly all foresets - m-csc sand

1145

planar bedds m. sand {1146.5 – 1148}

m→csc sand - normal & reverse graded

1150 — N4 gray mudstone — N5

1st increase ⇒ waning - final reverse grad

minor erosion on pedogenic surface below 1152.5

Red + pedogen laminated w/ minor xbeds - lots of granules - pedogenic patches in interval

1155

— 5R4/2

1160

Red — cross-bedded f.-m. ss. w/ localized pedogenic intervals - mixed interval of sands w/ xbds and planar beddy in sands

less pedogenic

1165

some of these coarsen up-ward reflecting sed surface

minor pedogenic surface

1171

1170

— 5R4/2

grayish fining up m. to csc. ss. - foresets at base but crossbeds w/ a few planar at top as shoals 1177.5

1175

— N5

Also coarsens up as reverse graded bd

v. pedogenic

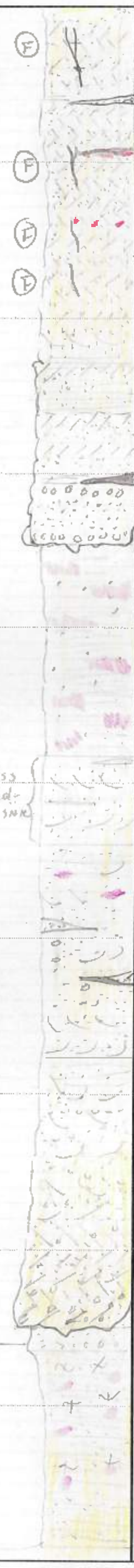
1180

— 5R 4/2

Red laminated siltstone - f. ss. w/ localized pedogenic patches

Red laminated f ss.

1185



Remarks:

Healed 3/8 wide fracture w/ qtz core & cc fringes - zoned

Env - braided channel w/ variable energy influx & water depths mostly advancing braided bars punctuated by shoaling upward during low water & OM-dk. clay accumulation during quiescent wet periods. No pedogenic feature

initial normal graded then planar
capped by reverse graded

Env. - braided channel w/ point grading upward from csc. ss to f-m. ss. punctuated by brief subaerial pedogenic soils (v. thin)
Basal lag has v. csc. angular pebbles of lithified sed etc
more pedogenic feature in emergent surface finer grained sed as channel cutoff

P | C | M | Z | vf | f | m | cs | vcs | gran | pebs | cob | bould
.5 | 1.0 | 1.5 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10

(F) fracture high incline ~ 45-50° - healed filled w/ cc + qtz. - qtz core

• Pyrite - generally assoc w/ OM & coaly intervals

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. 50-C-1-15 page 15 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth	Lithology description	Color (GSA Chart)	Remarks
185	m-f. gray ss - planar bdds; shaling		
	1186.5 — m. grained gray ss w/ foresets - fining up; Healed fractures	dm blk clay; N4	Env. - small braided channel w/ rapid energy decrease but continued to flow - temporal quiescence w/ pedogenic features - prob. rooting during sub-aerial exposure - local shoaling and late energy surge w/ reverse graded bedding top
190	1190.5 — But mostly mud. pedogenic features		
195	Red laminated f. grained ss upper 4-ft. mottled & sandy pedogenic	5R 4/2	
	m. ss - gray	N5	Env. - Braided channel - grade upward into emergent - red laminated f. grained ss to clayey? upper few feet w/ pedogenic features - rooting, etc.
200	1199.5		
	gray ss. - coarse-med. rip-up clasts - blk muds		
205	1205.5 — Red laminated f. grained ss ± clay? rooted & incipient pedogenic features - bleaching etc.	5R 4/2	
210	1211.5 — gray locally coarse (at base) grading finer upward into red siltstone - f. grained ss; Basal lag; graded beds; 1216	N5	Env. braided channel - fines upward w/ emergent oxidized & incipient pedogenic process
215			
220	Red siltstone to v. f. grained ss localized pedogenic features	5R 4/2	
225	Red silt to v. f. sand well laminated w/ localized rooting in a pedogenic surface - degree of burrowing unknown as primary bedding remains		Env. - Braided channel grading up to short interval of oxic to underwater → fine-grained emergent oxidized w/ pedogenic features.
230			
235			

P C M Z vf f m cs vcs gran pebs cob bould

.5 1.0 1.5 2 3 4 5 6 7 8 9 10

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. 50-C-1-15 page 16 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth	Bedding	Principal Grain Size – Clastics (MUD: Peat, Clay C 2, Silt M Z 62.5; SAND microns: vf 125, f 250, m 500, c 1000, vc 2 mm; GRAVEL mm: granules 4, pebbles 64, cobbles 256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. envirionment	Remarks	Recovery
235		Red, laminated to thin bedded silt – v. fine sand, planar bdg common – oxidized, root mottling & poss. burrowing in various intensity														
240		(continued)		5R 4/2												
		1243														
245		transitional interval from m. csc sand → start of pedogenic red silt st. 1248													see above - bottom of p. 15 fn snv	
250																
255		Red to gray – extensively root mottled and poss. bioturbated? silt → fn. sand. ss														
260		~1262.5		Planar bedded m. ss												
265		Foresets in csc gray ss grades up slightly		N6												
270		1269 gray to black; Dom. red siltstone – claystone extensive pedogenic features w/ root mottling – 1273		5R 4/2												
275		gray to black fn. ss. grades upward		N3											snv – braided channel fining up into shoaling ss. → exposed to air siltstone / v. fn. ss. w/ root motled. almost a point bar at braided channel scale.	
280		1278		N5												
285		1284 csc - m. sand w/ foresets														

P | C | M | Z | vf | f | m | cs | v cs | gran | pebs | cob | bould

.5 1.0 1.5 2 3 4 5 6 7 8 9 10

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ____________ CORE NO. JO-C-1-15 page 17 of ___

SITE/LOCATION ____________

DESCRIBER ____________ DATE ____________ Reviewer ____________

Depth	Bedding	Principal Grain Size — Clastics: MUD (Peat, Clay, C – 2, M, Silt, Z – 62.5) / SAND microns (vf – 125, f – 250, m – 500, c – 1000, vc – 2 mm) / GRAVEL mm (granules – 4, pebbles – 64, cobbles – 256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. envirionment	Remarks	Recovery
1285		csc ss. w/ forsets & metamorphic rx fragments Halo fault AT base of contact Biot. xst, metamudstn? (1289.5)		N8											* Also - contains OM-rich blk claystone/coaly rip-ups from int below	
				Breccia - fault											calcite & qtz fill. complex relationship	
1290		carbonaceous coaly int (1291.5)		N2											(INT) localized depression w/ OM accumulation coaly interval is "swampy" pot. time correlation; localized byp	
		carbonaceous mudstone w/ v. coaly laminae - well formed silt lamina & clay drapes - silt/OM are all graded beds w/ complex sedimentation, brown & moving bottom w/ temporal question (1292)		N7											(F) fracture @ 45° - zoned passage now w/ cc @ walls + qtz core - top & bot w/ qtz only	
1295		csc - to med sand - gray - forset bed dominate; planar bed (1296.5)			No displacement on fracture.										(INT) braided channel w/ sufficient energy to move (and round) pebble - graded rapidly up. to forset beds capped by planar bedding - terminated by darker planar bedded m ss.	
		cgl - graded up containing metamorphic rock fragments inc. biot gneiss metagneiss, qtz & epidote-brg. RF cgl pebbles - matrix - csc sand w/ poss planar on forsets & relics (1299)		N3												
1300		gray laminated siltstone no bioturbation		Transition down to red pedogenic silt												
1305		Red siltstone upper ½ is slightly root mottles - no root mottles or burrows well laminated - some xbeddy & granules		5R 4/2												
1310				5R 4/2												
1315		(1314.2) gray siltstone w/ minor sand (fn). graded bedding of silt laminae		N3												
		(1317.5) Red siltstone; minor pedogenic features		N3												
1320		(1319.5) gray to black siltstone		5R 4/2; N3	- Pyrite in OM.											
		coal w/ ripups in lower forset (1321.5–1322)		N2												
		csc-v. ss - forset (1322.5)		N6												
		coaly int (1323.6)		N2												
		gray siltstone (1323.8)		N4												
1325		v. csc. ss w/ pebble cgl at base reverse graded up (reverse grade)		N4												
		gray mudstone - lamination (1327.5–1328.7)		N4												
1330		gray - med. to csc sand upper 6" silty - mostly planar bedding v. thin bedded		N5												
1335																

P .5 | C | M 1.0 | Z 1.5 2 | vf 3 | f 4 | m 5 | cs 6 | vcs 7 | gran 8 | pebs 9 | cob 10 | bould

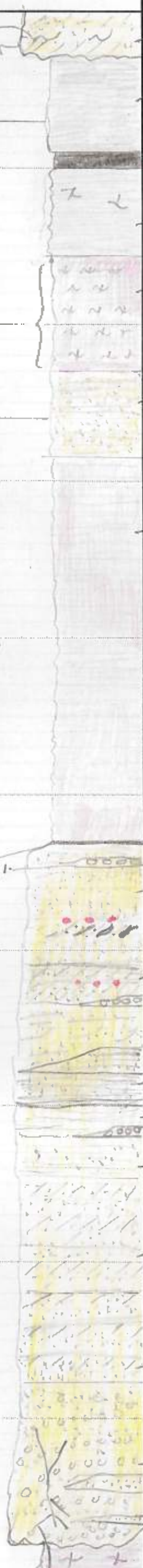
NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ______ CORE NO. 50-C-1-15 page 18 of ___

SITE/LOCATION ______

DESCRIBER ______ DATE ______ Reviewer ______

Depth	Bedding	Principal Grain Size — Clastics (MUD: Peat, Clay C, 2, Silt M, Z, 62.5; SAND (microns): vf 125, f 250, m 500, c 1000, vc, 2 mm; GRAVEL (mm): granules 4, pebbles 64, cobbles 256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. envirionment	Remarks	Recovery
1335		graded bds, ripups, sharp erosive surface w/ cm cap 1335.5		N5												
		gray to black laminated siltstone to claystone		N3, N2												
1340		1339.5–1340.0 – coal		– w/ PyR												
		gray siltstone w/ poss. biogenic activity (white spots) on sum rock – transitional down 1343.0		N5												
1345		Red pedogenic rooted mudstone 1346.5		5R 4/2												
		gray m. grained ss. mostly plane bedded some grading upward in bed 1349		N4												
1350–1360		Red laminated mudstone/siltstone with a purple-red color change from 1360 → to contact punctuated by pedogenic features; rest no pedogenic feature 1361.5		5R 4/2												
		Coaly seam < 1/2"		cgl.												
1365		1364.5 Black mud rip-up w/ csc sand		N5												
		1366		N2	Pyrite in OM.											
		gray m-csc ss. xbds + plane		cgl, N7, N5												
1370				N4, cgl, N6												
1375		Foresets & crossbeds capped by planar bedding – m-csc gray ss 1376		N7												
		m-csc gray ss. w/ foresets 1379		N7												
1380–1385		predominantly pebble cgl. w/ csc sand matrix, metamorphic clasts – subrounded to sub-angular. Biot. gneiss, metavolc? 1384		N6												



P C M Z vf f m cs vcs gran pebs cob bould
.5 1.0 1.5 2 3 4 5 6 7 8 9 10

isolated fracture, has sand beams in section

last 6" more root mottling

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT _____ CORE NO. 50C-1-15 page 19 of ____

SITE/LOCATION _____

DESCRIBER _____ DATE _____ Reviewer _____

Depth | Bedding | Principal Grain Size — Clastics: MUD (Clay, Silt) | SAND (microns: vf, f, m, c, vc) | GRAVEL (mm: granules, pebbles, cobbles, boulders) | Lithology | Color (GSA Chart) | Fossils | Accessories | Sed. strictires | Sorting | Roundness | Fractures / joints | % recovered | Porosity | Shows | Dep. envirionment | Remarks | Recovery

385
- red laminated siltstone w/ highly localized rooting / pedogenic
- straight to wavy to nodular pedogenic
- 1394
390
- m. ss. cpay dominated by thin beds of planar bedding and/or ripple & graded beds
- SANDstone w/ pebbles, spherochasts & vne? partly offset by fracturing N. 78° E. fossils
- coal-paper-thin
- 1396
395
- red siltstone with considerable pedogenic features
1400
1405
- red laminated siltstone no pedogenic features
1410
- 1413.5 PYRON F
- well on top of Basal cgl. 1414.5
1415
- planar m-ss. cpay - planar beds
1420
- START of Basal cgl.
1425
1430
- 1431.6 2-3 inches of coaly PYR fragments in ss
- coaly interval 6" w/ pyr
- 1434-1431 - graded upward cg.
1435

Lithology	Color (GSA Chart)	Remarks
	5R 4/2	
	5R 4/2	(SNV) Braided channel / grades up into shoaling water (planar) bdg w/ 3rd. shoot-off transitions to slight pedogenic development in the oxidized (red) siltstone section
	5R 4/2	- (SNV)
	5B 7/1	
	N6	
	N2	

- 1413.5 PYRON F
- 1414.5
- 1416.2 w/ PYR
- 1417.3 PYR
- 1419.3 PYR
- 1420.2 PYR
- 1421 PYR
- 1421.5 PYR
- 1422.2 PYR
- 1434 PYR
- 1432 PYR w/ (OM)

Bedding: Peat | C | M | Z | vf | f | m | c | vc | gran | pebs | cob | bould

254.5 - 258 - Lost core

280 - Bubbles w/ soap

- odors - same interval ~280

Red mudstone - mottled — often pedogenic

cgl —

Basement —

coal —

ss —

gray mudstone —

~~Red siltstone clast~~

PYR —

NORTH CAROLINA GEOLOGICAL SURVEY

PROJECT ____________ CORE NO. 50-C-1-15 page 20 of ____

SITE/LOCATION ____________

DESCRIBER ____________ DATE ____________ Reviewer ____________

Depth	Bedding	Principal Grain Size – Clastics (MUD: Peat, Clay C, 2, Silt M, Z; 62.5; SAND microns: vf 125, f 250, m 500, c 1000, vc; 2 mm; GRAVEL mm: granules 4, pebbles 64, cobbles 256, boulders)	Lithology	Color (GSA Chart)	Fossils	Accessories	Sed. strictires	Sorting	Roundness	Fractures / joints	% recovered	Porosity	Shows	Dep. envirionment	Remarks	Recovery
1435		pebble w/a few cobble gravels w/ v.csc sand matrix		5B 5/1											Basal cgl. – Pine Hall	
1440				14328 (F) pyr												
				OM – rotted load/flame structure cgl												
1445				N2; coal lamina 1445.25; coal laminae 1445.75 – pyr assoc w/ both; N2											Sample – VOC vial collected pollen?	
				5B 7/1												
1450		unconformity – angular basement contact 1451.2		5G 2/1; MRF + entrained – ssd. processes visible immed. above contact												
				5G 4/1											Basement – dk green highly foliated metamorphic rock – appears to be a mafic tuff + other metavolcanic rock.	
1455		N/A														
1460		1462		5G 4/1												
1465																
1470																
1475		TD 1477														
1480																
1485																

P .5 | C | M 1.0 | Z 1.5 | 2 vf | 3 f | 4 m | 5 cs | 6 vcs | 7 gran | 8 pebs | 9 cob | 10 bould