Investigating a paleo-meander of the Catawba River, Charlotte, North Carolina

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Abstract

The formation of oxbow lakes during meander neck cutoff events is a common fluvial process in sinuous, low gradient streams. Based on analysis of topographic maps and aerial imagery, it appears that Duck Cove, near Charlotte, NC, may be an oxbow lake formed by the straightening of the Catawba River. Duck Cove is a crescent-shaped, shallow body of water adjacent to the Catawba River, to which it is connected at its downstream end by a narrow tie channel. The upstream end of the cove is cut off from the Catawba River by sediment filling the upstream end of the former meander bend. The floodplain between the cove and the river is characterized by low ridges and swales interpreted as scroll bars on the former point bar. In this study vibracoring and GPR were used to examine these possible point bar and channel fill deposits. Three facies occur in the cores, from oldest to youngest: 1) a fining upward sequence of medium to fine sand (point bar deposits), 2) an organic-rich silt to very fine sand (oxbow lake deposits), and 3) thinly bedded, medium to coarse sands at the top of the cores (crevasse splay deposits on the modern flood plain). Analysis of aerial imagery and GPR profiles suggest the presence of an abandoned channel which is consistent with the interpretation that Duck Cove is an oxbow lake. C14 dating of one charcoal sample from the oxbow lake deposits provides a minimum age for the cutoff event and subsequent formation of the oxbow lake at 5377 +/- 60 years BP. Previous work which uses terrace relief (i.e. terrace elevation – river elevation = terrace relief) as a proxy for age places the cutoff event at less than 4000 years BP (Layzell, 2012). The results of this study suggest that the regional curve for terrace relief (Mills, 2000; Figure 1) needs refinement for relatively young terrace deposits.

Methods

Core locations and GPR profile paths were chosen based on analysis of aerial imagery and previous work by Aquino et. al, 2011. Samples were obtained using a vibracoring sytem described by Smith, 1983; 1987. GPR profiles were constructed by using a 100 MHz GPR system. GPR profiles were analyzed for indication of point bars, channel depth and stratigraphy. Core samples analysis were preformed on the retrieved samples

Equipment Used

Vibracoring system (Smith, 1987), two-cycle gasoline engine, flex shaft cable, vibrator head, connector clamp, core catcher, core barrel (6m), A-frame fulcrum lift device, rope, tools, GSSI 100 MHz GPR system. Vibracoring technology is used for the penetration and recovery of saturated sediments when other methods of recovery are less effective. The vibracore is light weight, affordable, and is easily constructed at the coring site. A vibracorer successfully operates by inducing liquefaction of the sediments proximate to the vibracore and using the weight of the core barrel and vibrator to penetrate the saturated sediments. After the penetration of the core barrel to the desired depth or core refusal the system can be removed by using an A-frame, lever bar, and a rope attached to the core barrel via prusik knot to extract the core barrel. After extraction, the cores were described using the Ocean Drilling Program method after Mazzullo and Graham, 1988.

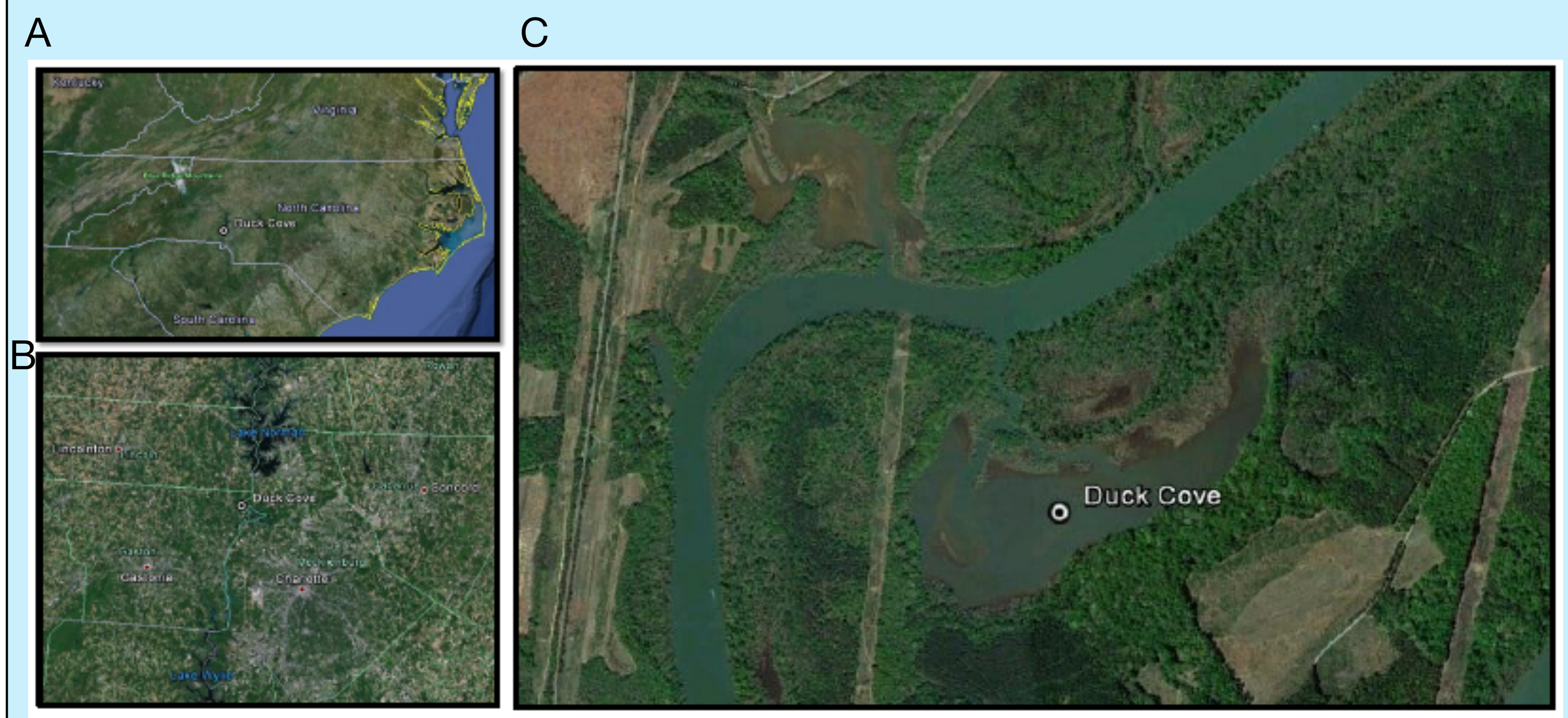

Figure 1. Location of field area. A) Location of North Carolina. B) Catawba River in the vicinity of Charlotte, NC. C) The Neck region and Duck Cove of the Catawba River.

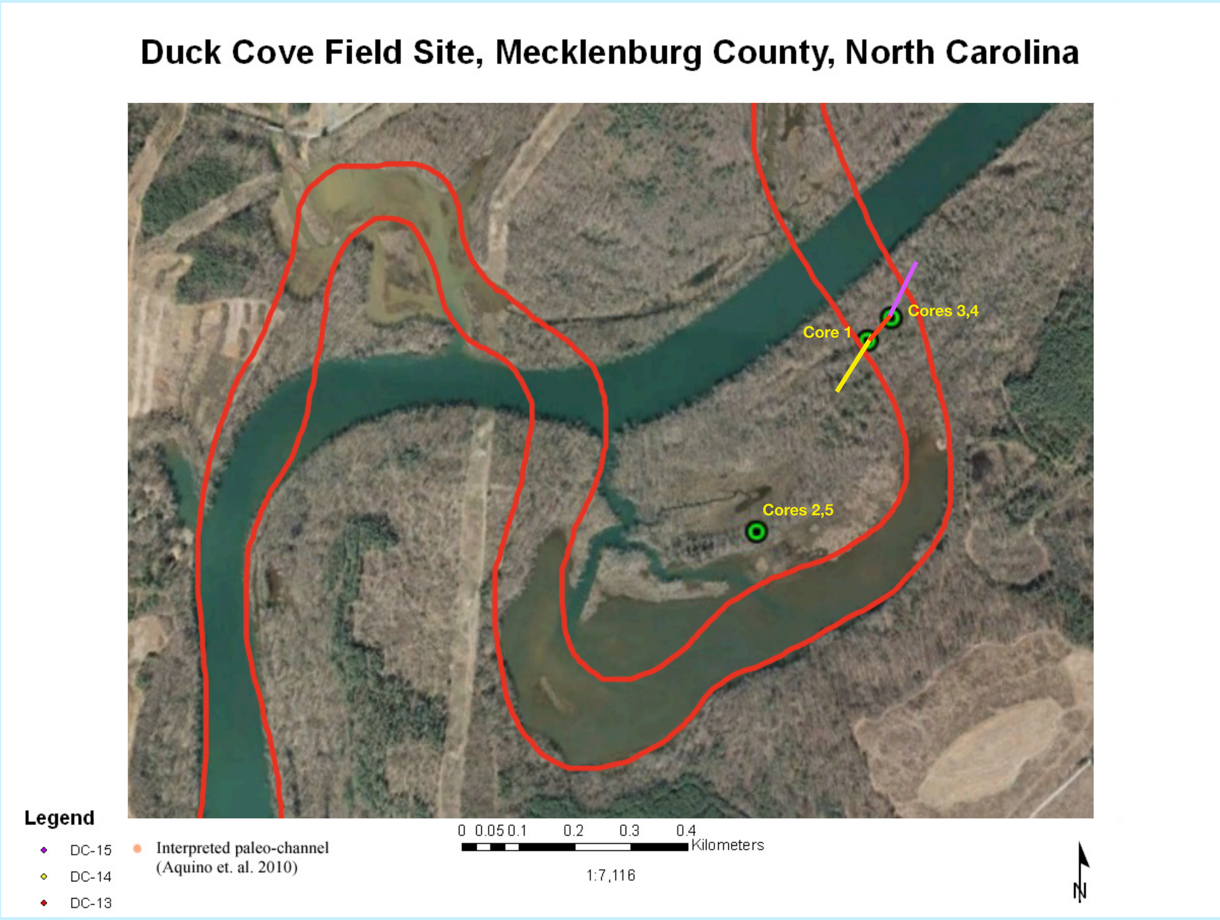

Figure 2. 2012 core locations are numbered 1 through 5. 100 MHz GPR lines include DC-13 (red), DC-14 (yellow), and DC-15 (purple). Paleo-channel highlighted by orange line.

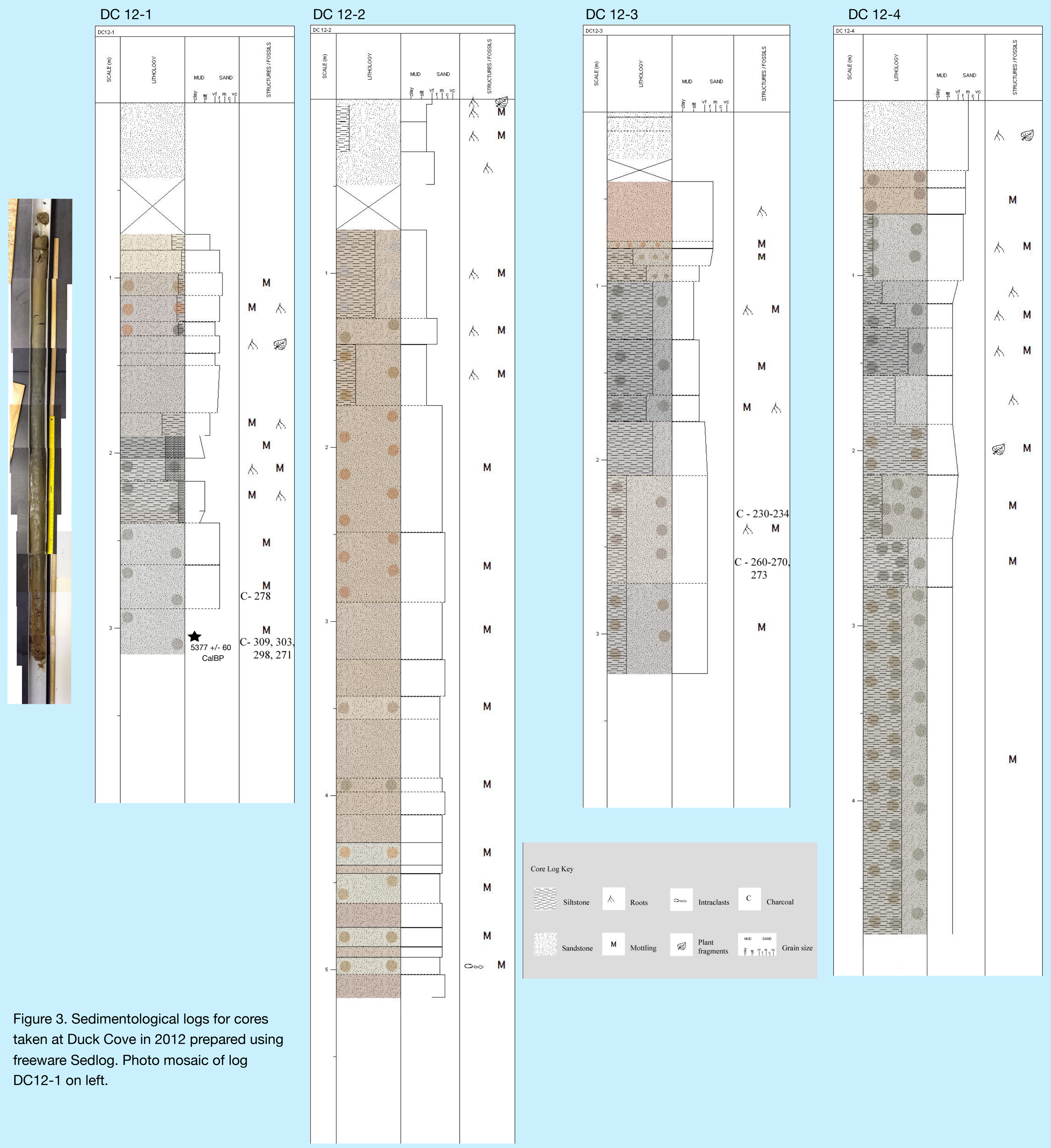

Figure 3. Sedimentological logs for cores taken at Duck Cove in 2012 prepared using freeware Sedlog. Photo mosaic of log DC12-1 on left.

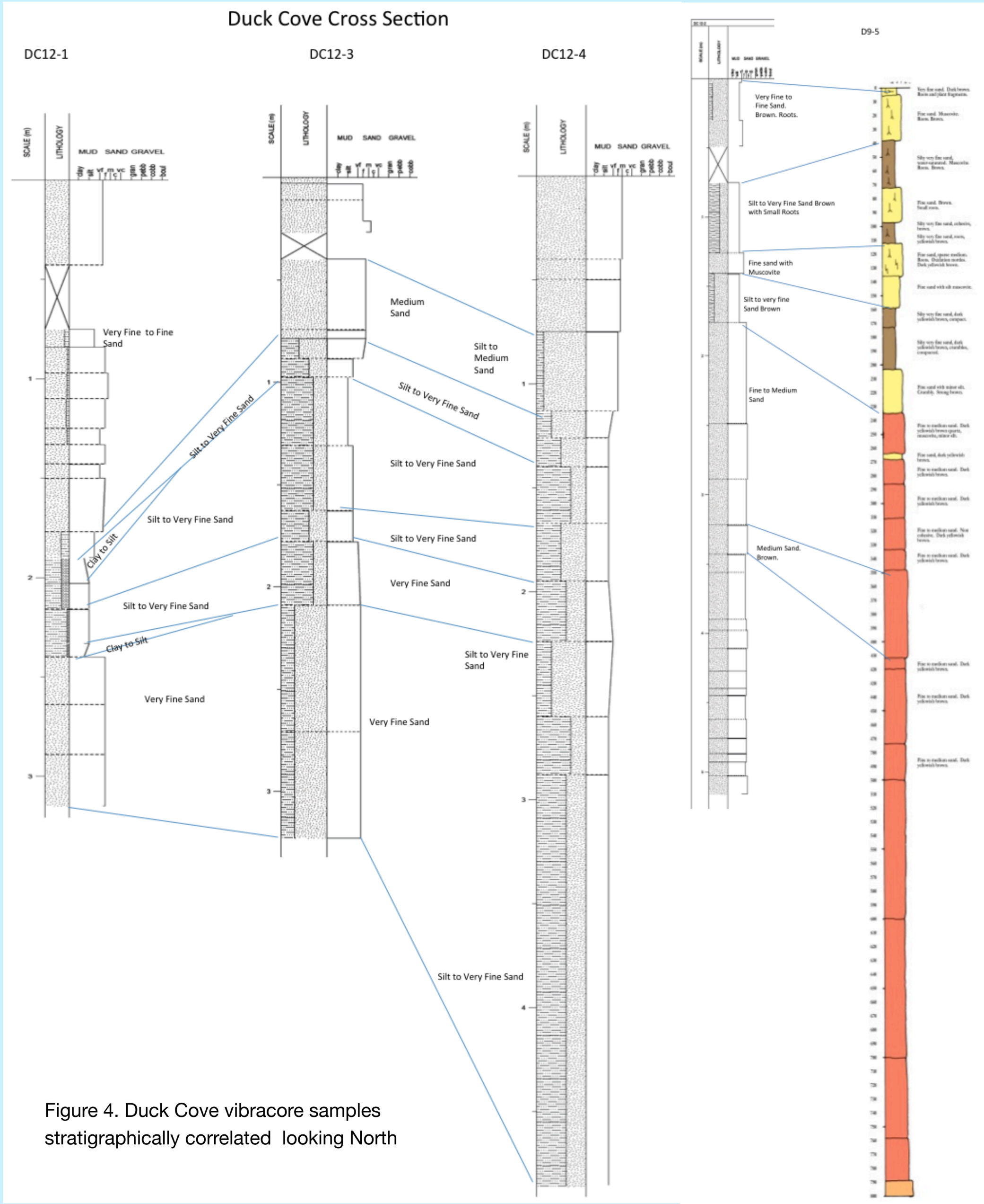

Figure 4. Duck Cove vibracore samples stratigraphically correlated looking North

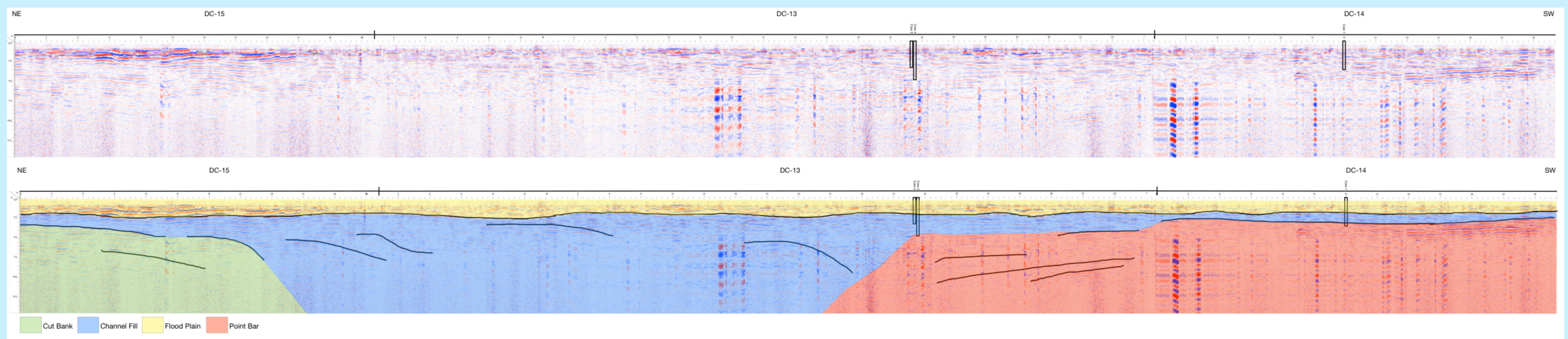

Figure 5. Stitched GPR profiles of DC-13, DC-14, and DC-15 trending NE-SW. Top image: uninterpreted GPR profile with core locations and depths. Bottom image: interpreted profile with facies highlighted.

Channel Migration Model

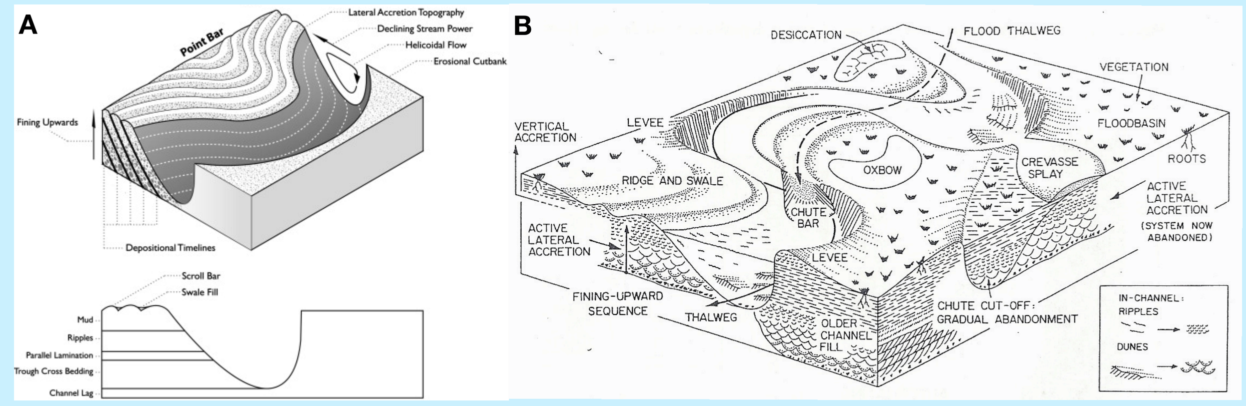

Figure 6. Block diagram showing morphological and sedimentological elements of (A) a meandering river bend and (B) meander river system. Walker (1976)

Meandering Channels

Once a bend in a steam develops, typically in low gradients, differential velocity structures within the channel flow develop by centrifugal forces. Higher velocities occur on the outside of the developing bend, increases the ability to erode unstable banks, while lower velocities on the inside of the bend results in the deposition of sediment. Helical flow within the steam channel creates fining upward point bar with larger bed forms, i.e. small dunes, occurring at the base of the point bar and smaller bed forms, i.e. ripples, developing on the upper portions of the point bar. Lateral accretion of the point bar creates an asymmetrical ridge and swale topography known as scroll bars on the top of the point bar that form parallel to the meander. During flood events the stream may overflow its banks and develop levees as suspended sediments are deposited due to a decrease in water velocity as it spills out onto the floodplain. Crevasse splays form where a stream breaks its levee and deposits sediments on the floodplain. The continued cut bank erosion and point bar deposition increases the sinuosity of the meander until a meander neck cutoff event straightens the channel. Other morphological features associated with a meander neck cutoff event are oxbow lakes. The oxbow lake may remain connected to the stream channel via a tie channel until sediment fills these features.

Vibracoring Process

Attaching vibrator head to core barrel

Raising core barrel into position

Adding weight to core barrel

Core barrel at maximum penetration

Prussic knot used for extracting core barrel

A-frame and lever used forextracting core barrel

Extracting core barrel

Extruding core from barrel

Extruded core

Running DC-15 with 100 MHz GPR antenna

Discussion

All cores exhibit fining upward sequences from medium to fine sand, which is characteristic of point bar deposits (Figure 7). GPR profiles across the inferred paleo-channel reveal dipping beds located at the channel margins, structures which are consistent with fluvial channel deposits. GPR profile analysis and previous work by Diemer et al. 2011 indicate vibracore samples did not fully penetrate point bar sediments. The upper portion of the core samples consist of more recent scroll bar swale infill and floodplain sediments. Charcoal from DC-1 at a depth of 290 cm (located in channel fill deposits) returned an age of 5377 +/- 60 calendar years BP. This C14 date provides a minimum age of the channel cut-off event. Previous soil chronosequence work by Layzell et al., 2012 indicates the youngest terrace deposits (3m above modern channel) are ~4±0.5 Ka. In 1924 the Mountain Island Lake dam was constructed south of Duck Cove to create a reservoir for Mecklenburg County. As a result, the Catawba River stream level upstream of the dam is likely higher than prior to the dam's construction as evidenced by apparent back flooding of low lying areas (Figure 1). Layzell's chronosequences may have been calibrated using terrace heights above the modern stream level as opposed to pre-dam stream level (Layzell et al., 2012). This would result in a decrease of the terrace height relative to stream level and, consequently, a decrease in interpreted terrace age. Layzell et al., 2012 have accounted for a 13% terrace age error due to unexplained variances which will place their youngest terrace age closer to the C14 date. However, Mills' method mentions that the accuracy of the chronosequence decreases in more recent ages and variances may be greater than 13% for younger terraces.

References

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