Sedimentology and Stratigraphic Architecture of Quaternary Paleochannels Along the Inner Shelf of South Carolina

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Abstract

Throughout the Quaternary, numerous high frequency, high amplitude glacioeustatic sea level cycles have left behind a complex network of paleochannels and paleovalleys across the inner continental shelf off the coast of South Carolina. These isolated paleotopographic lows were carved into a substrate of pre-Quaternary rocks and Pleistocene deposits by coastal plain and Piedmont-draining rivers and provided rare accommodation in an overall low-accommodation setting. The distribution, age, composition, and stratigraphic architecture of these sedimentary successions offer insight into both the allogenic and autogenic forces that influenced depositional processes at the time of formation.

As part of a 2015 regional sand resource assessment, a dense grid of high resolution subbottom (Chirp) data was acquired off the coast of Folly Beach, South Carolina by the Bureau of Ocean Energy Management (BOEM). These data provide the spatial resolution required to reconstruct paleochannel connectivity and define the internal stratigraphic architecture of paleochannel and paleovalley successions. Paleochannel fills display concentric, asymmetrical, or horizontal geometries reflecting varying degrees of erosion, aggradation, and accretion. Paleovalleys exhibit vertical relief of up to 10 meters and apparent widths of up to 3 kilometers. Within paleovalleys, individual channels are arranged in both multistory and multilateral configurations that are the result of changes in localized autogenic processes as well as regional allogenic controls that influenced accommodation.

In addition to geophysical data, 52 meters of sediment core recovered from 9 locations provide the control necessary to reconstruct depositional processes associated with this architecture. Detailed physical descriptions including sediment composition, lithology, and physical structures; geochemical analysis; ^{14}C dating; and AAR age estimates of cored intervals reveal channel fill that was deposited during the mid-Holocene and was dominated by tidally-influenced processes in low to mixed energy, estuarine and backbarrier settings.

Seismic Facies

Siesmo-stratigraphic Facies			External Bounding Surfaces Order	Geoacoustic Character	Cross-sectional Geometry		Interpretation
Primary	Secondary				Internal	External	
Paleochannel Facies	Fill Type	Concentric (**c**)		**Chc**	High to moderate amplitude, aggradational, concentric reflectors	Broadly Lenticular	Mud-rich, aggradational fill. Commonly estuarine.
		Horizontal (**h**)		**Chh**	High to moderate amplitude, horizontal to sub-horizontal reflectors		Passively filled, likely fine-grained channel fill.
		Asymmetric (**a**)	4, 5, 6	**Cha**	High to moderate amplitude, uniformally-dipping reflectors		Point bar deposits of meandering fluvial or estuarine channels.
		Chaotic (**k**)		**Chk**	Disorganized, moderate amplitude, discontinous reflectors		High-energy channel deposits
		Transparent (**t**)		**Cht**	Low-amplitude homogeneous fill		Homogeneous channel fill
Horizontally Stratified Facies			5 or 6	**HS**	High to moderate amplitude, horizontal to sub-horizontal reflectors	Highly irregular with erosional upper surface	Fine-grained, non-channelized back barrier or shelf deposits
Indistinct Facies			6	**ID**	transparent to chaotic	any	Transgressive sand sheets and other deposits
Pre-Quaternary Basement			6	**PQ**	Variable. Transparent to high-amplitude horizontal to gently-dipping reflectors	Highly irregular, erosional upper surface. Base is unresolvable	Cretaceous through Pliocene consolidated to lithified sediment of variable lithology.

Table 1. Stratigraphic architecture of paleochannels and shelf deposits based on seismic and core data. Interpretations based on observation as well as concepts from Mitchum et al. (1977) and Gibling (2006).

Figure 1. A) Basic stratal geometries as summarized in Mellett et al. (2013) from concepts defined by Mitchum et al. (1977) which form the basis for the seismo-stratigraphic facies used in this study. B) Paleochannel and paleovalley architecture from Gibling (2006). C) Conceptual model of tide-dominated estuarine fill within an incised valley displaying the prominant tripartite sequence stratigraphic interpretation defined by lower fluvial LST (Lowstand Systems Tract), intermediate estuarine TST (Transgressive Systems Tract), and upper marine HST (Highstand Systems Tract) deposits. From Dalrymple and Choi (2007) based on Dalrymple (1992).

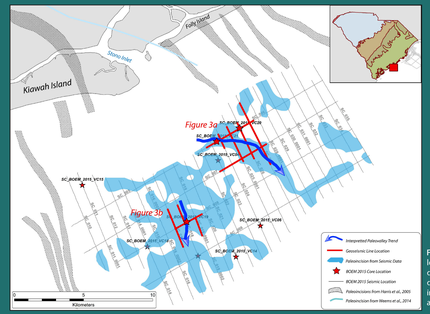

Figure 2. Base map showing location of seismic and core data used in this study, general distribution of paleoincisions, interpreted paleovalley trends, and relevant previous studies.

Seismic Data and Interpretation

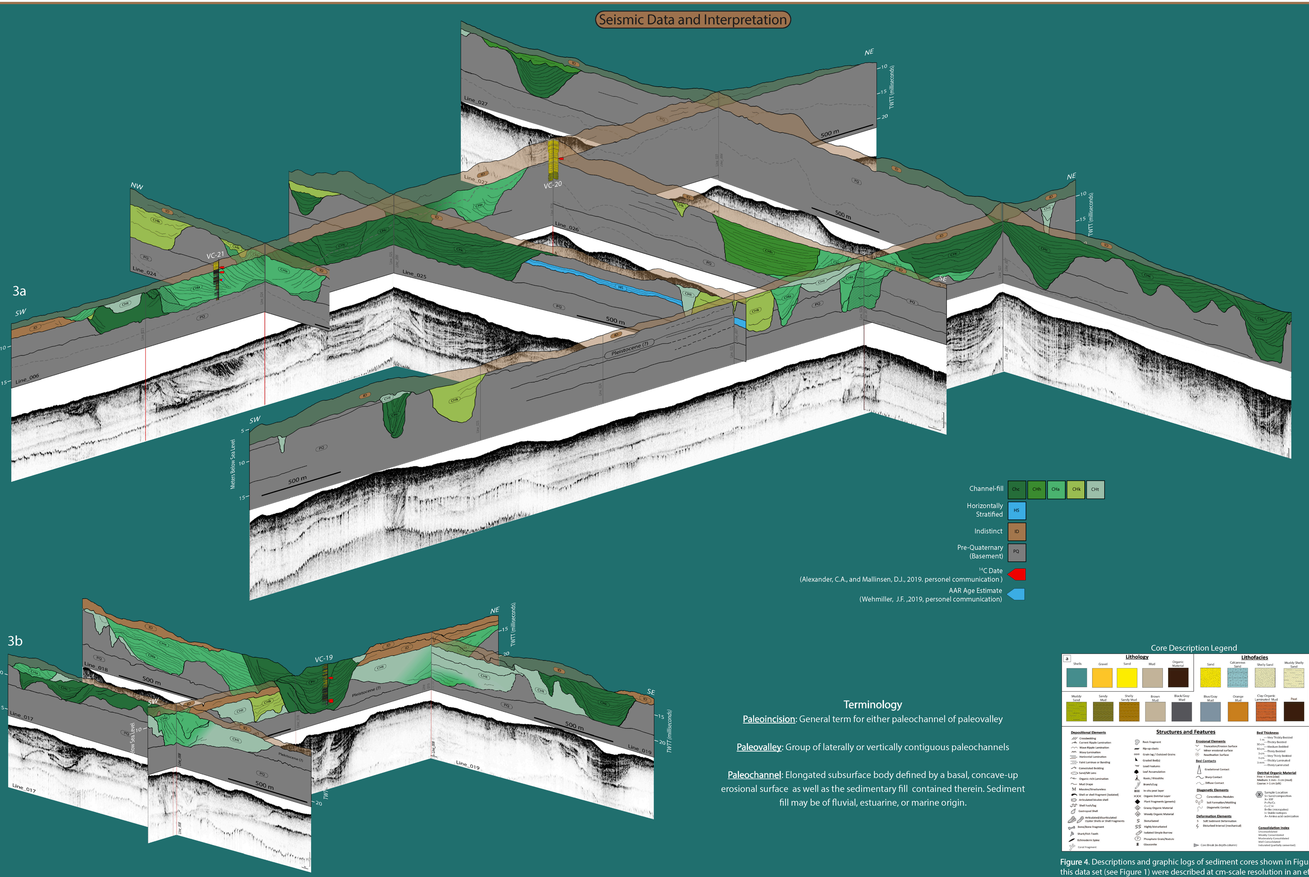

Figure 3. A) and B) High-resolution seismic and intepretive geoseismic lines from the BOEM Folly-Kiawah data set. Locations shown in Figure 2.

Terminology

Paleoincision: General term for either paleochannel of paleovalley

Paleovalley: Group of laterally or vertically contiguous paleochannels

Paleochannel: Elongated subsurface body defined by a basal, concave-up erosional surface as well as the sedimentary fill contained therein. Sediment fill may be of fluvial, estuarine, or marine origin.

Sediment Cores

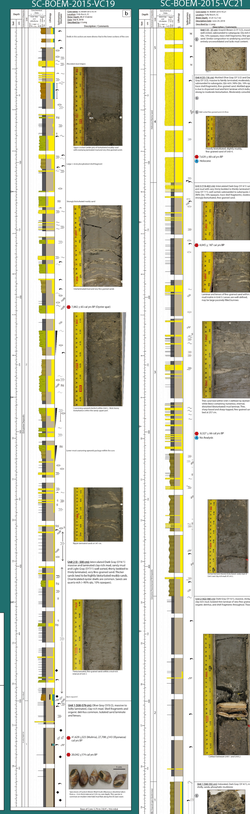

Figure 4. Descriptions and graphic logs of sediment cores shown in Figure 3. In total, 9 cores from within this data set (see Figure 1) were described at cm-scale resolution in an effort to better understand the environmental conditions during deposition. Cores within paleochannels and paleovalleys are overwhelmingly mud-rich and exhibit a range of lithologies and sedimentary structures indicative of tidal influence including alternating mud-sand couplets, thin-thick bedding, mud drapes, and limited bioturbation (Dalrymple and Choi, 2007; Desjardins et al., 2012; Feldman and Demko, 2013.) as well as shells of intertidal species including brown mud snails (Illyanasa obsoleta, dwarf surf clams (Mulinia lateralis), oysters (Burg, E., Harding, J., and Kelley, P., 2019, personal communications).

Preliminary Results

1) Paleochannel fill is predominantly mud rich and heterolithic, containing sedimentological and paleontological indicators of having been deposited in low-energy, tidally-influenced, brackish water settings.

2) The youngest generation of paleochannels in this area were infilled during the mid-Holocene (~4 - 8 ka) following the stabalization of sea level.

3) Mud-rich paleochannel fills are a significnat component of the local geologic framework and are commonly exposed on the modern seafloor, potentially influencing local morphodynamics and serve as a source of fine-grained sediment.

4) The most common types of paleochannel fill in this area are concentric or horizontal, which, along with observations from sediment cores, suggests systems dominated by suspension sedimentation.

5) Most larger paleochannels (> 1km) occur as part of paleovalley systems rather than in isolation which may suggest a stratigraphic control on drainage network development.

6) Individual paleovalleys can be correlated throughout the data set based on paleochannel architecture and paleochannel associations within each paleovalley.

7) Depth of incision is typically limited to the depth of Pleistocene sediment defined by the top of the pre-Quaternary section (Paleocene or Miocene in this area as defined by Weems et al. ,2014 and Harris et al., 2005).

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