A Comparison of Overbank Sedimentation Thickness and Texture in Non-Embanked Floodplains during the 2011 and 1973 Floods along the Lower Mississippi River, USA

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ABSTRACT

The 2011 flood along the Lower Mississippi River established new stage records at various locations from Mississippi (peak discharge of 65,400 m^3/s at Vicksburg, Mississippi) to Louisiana, a segment that includes the Morganza Spillway structure and the Old River Control Structure, which prevents a massive, western avulsion to the Atchafalaya River. This study specifically documents depositional thickness and texture of overbank sediments associated with the 2011 flood at 55 sites between Natchez, Mississippi and St. Francisville, Louisiana, and compares the results with floodplain deposition during the prolific 1973 flood in the same area. Notably, the study sites occur in floodplains that are not protected by flood-control levees (dikes). Also, the study reach has exhibited an alarming trend of increasing stage for a given flood discharge. Results show considerable variability in sediment thickness, ranging from <1 mm to 620 mm with the thickest deposits along natural levees. At some sites on natural levees, however, little sediment was deposited despite being inundated to a depth of about 4 m. Overall, most sites are characterized by less than 10 mm of overbank sediment and are considerably less than thicknesses measured following the 1973 flood. All depositional sub-environments, including natural levees, meander scrolls (point bars), and backswamps, were subject to less sedimentation than the 1973 flood. Additionally, comparisons of texture with the 1973 flood data indicate that natural levee deposits are slightly coarser, minimally thick deposits on meander scroll ridges are finer, and swales and backswamp deposits are somewhat coarser for the 2011 flood sediments. These data indicate relatively energetic, sediment-deprived overbank flow conditions that possibly entrained pre-existing surficial floodplain sediments from proximal sub-environments and transported them to distal zones of the floodplain. The well-documented decline of suspended-sediment loads along the Lower Mississippi River facilitates explanation for the unimpressive sedimentation in 2011, but another causative factor is that the annual peak suspended sediment load (1,046,000 tons/day) for 2011 occurred during a minor overbank event two months prior to the larger flood, whose peak discharge was associated with a suspended sediment load of only 727,400 tons/day. These results have important implications for flood control and environmental restoration efforts because, at present, floodplain sequestration of sediment plays a minor role on both the increase in flood stage along the study reach and does not explain the limited delivery of sediment to coastal environments.

Key Words: 2011 flood, floodplain, Lower Mississippi River, sedimentation

RESEARCH QUESTIONS

(1) What is the thickness and texture of overbank sediments deposited by the 2011 flood in non-embanked floodplains along the Lower Mississippi River?

(2) How do these sedimentary characteristics compare with the prolific 1973 flood in the study area?

STUDY AREA - LOWER MISSISSIPPI RIVER

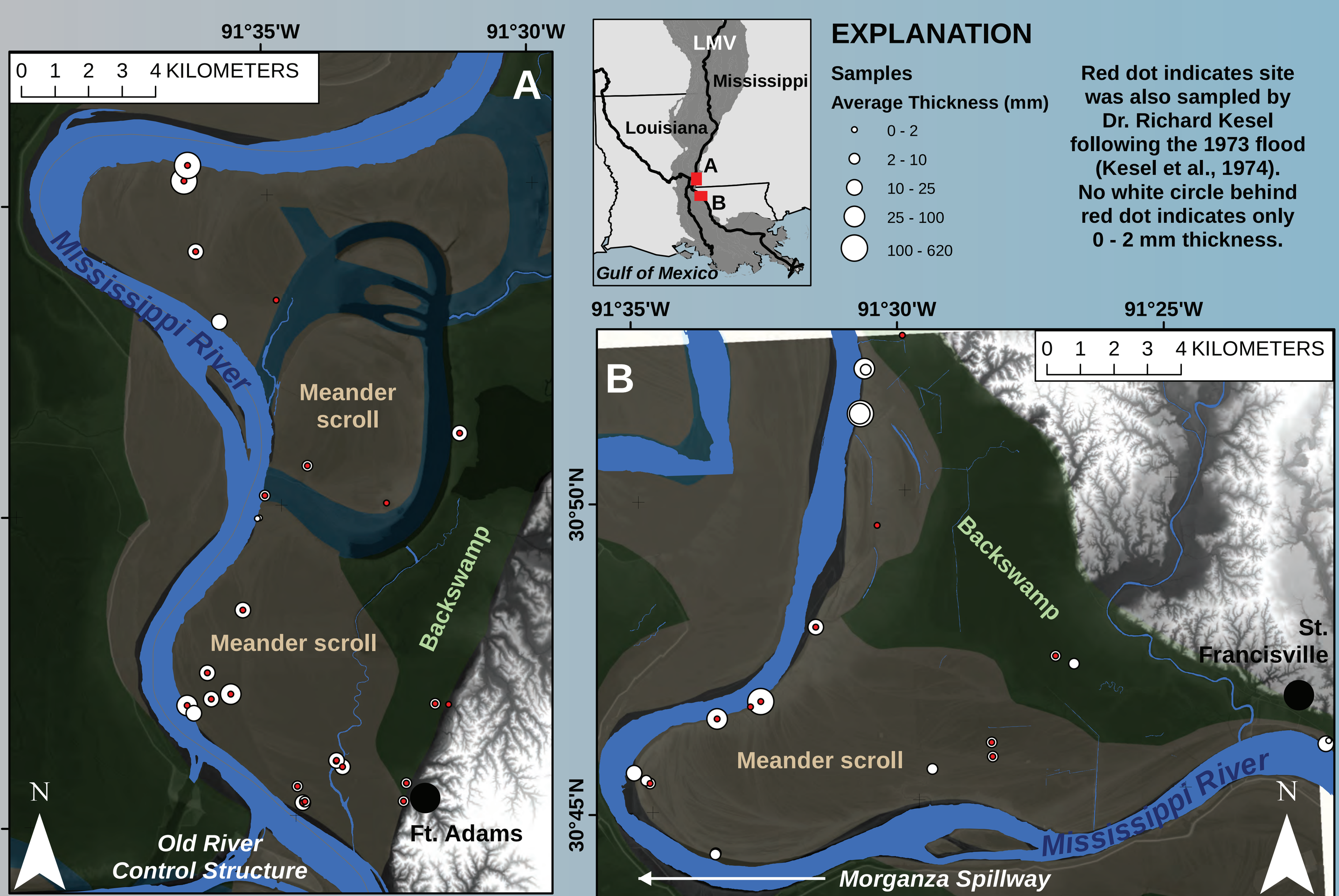


Figure 1. The study areas include non-embanked floodplains along the eastern side of the Lower Mississippi River in Wilkinson County, Mississippi, and West Feliciana Parish, Louisiana. The thickest overbank sediments associated with the 2011 flood occurred along sandy natural levees immediately adjacent to the channel. Thirty-two of fifty-five sites occur at a location previously sampled following the 1973 flood (Kesel *et al.*, 1974).

2011 FLOOD AND METHODS

Figure 2. The 2011 flood exceeded previous stage records between Vicksburg, Mississippi, and St. Francisville, Louisiana. This photo was taken along a flood-control levee in Louisiana one day before the crest (22.06 m) at nearby Red River Landing.

Figure 3. Diligent efforts were made to sample overbank sediment thickness at sites identical to those following the 1973 flood (Kesel *et al.*, 1974). Dr. Richard Kesel accompanied the research team to ensure a sampling approach consistent with the previous study.

Figure 4. Accurate measurements of overbank sediment thickness required field research to be done in August and September 2011, a little over a month following flood recession. Otherwise, additions of organic litter would darken the deposits and make distinction from underlying soils difficult. This sample is discerned from the former surface by a buried organic litter layer.

Figure 5. Relatively thick overbank deposits on natural levees required excavation and identification of a buried fine-grained, organic-rich drape.

RESULTS

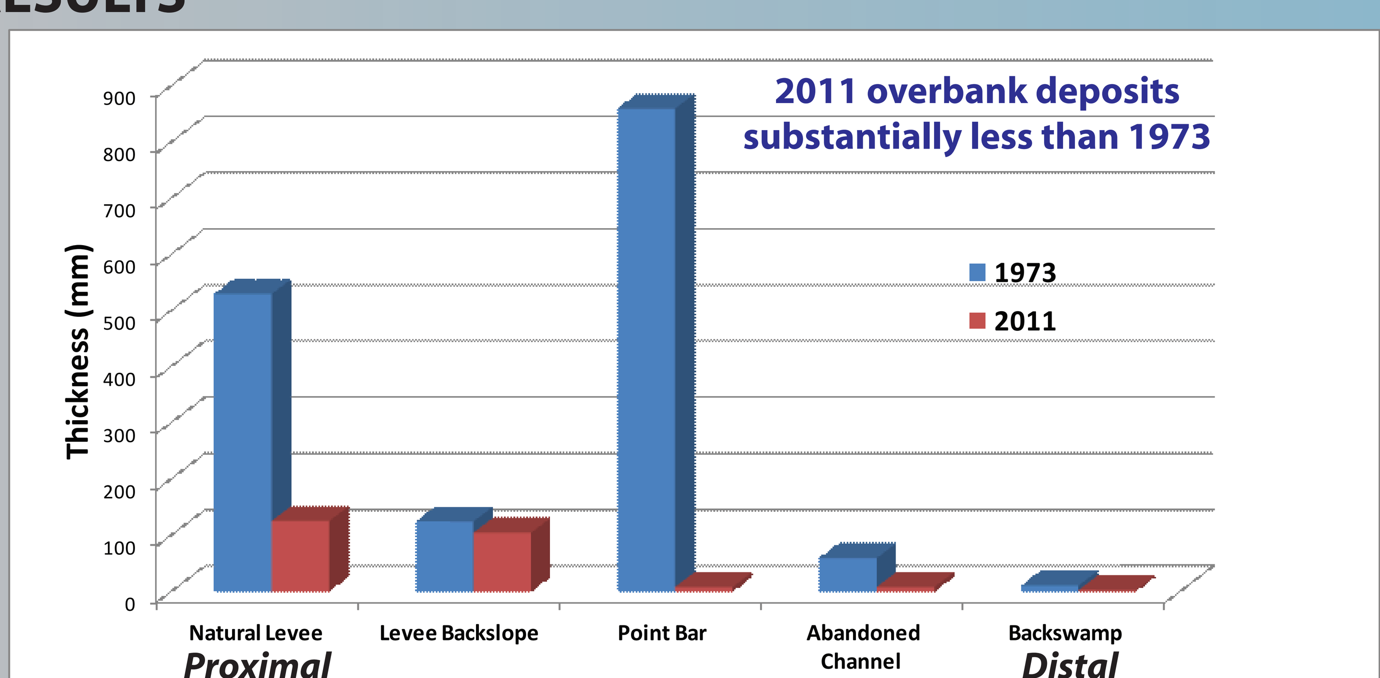


Figure 6. Average overbank sediment thickness (mm) deposited by the 1973 (Kesel *et al.*, 1974) and 2011 Lower Mississippi River floods in various depositional sub-environments in the study area.

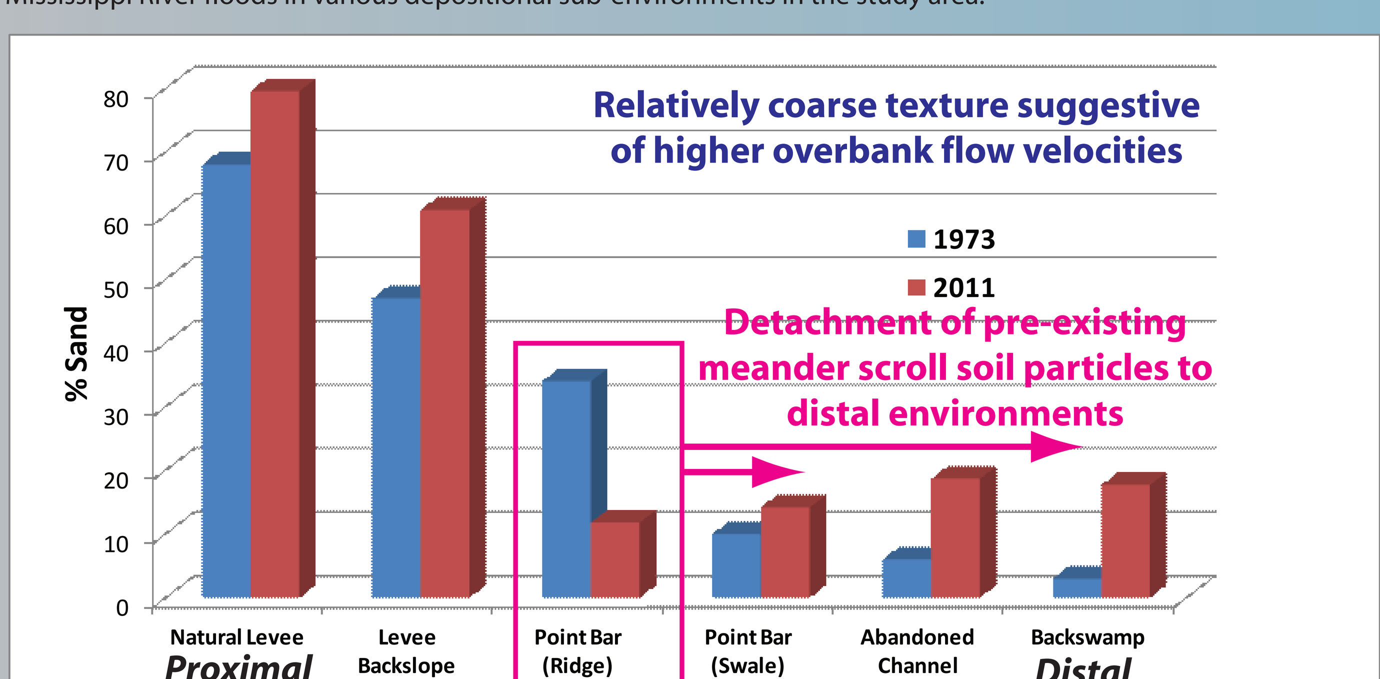


Figure 7. Average % sand content of overbank sediments deposited by the 1973 (Kesel *et al.*, 1974) and 2011 Lower Mississippi River floods in various depositional sub-environments in the study area.

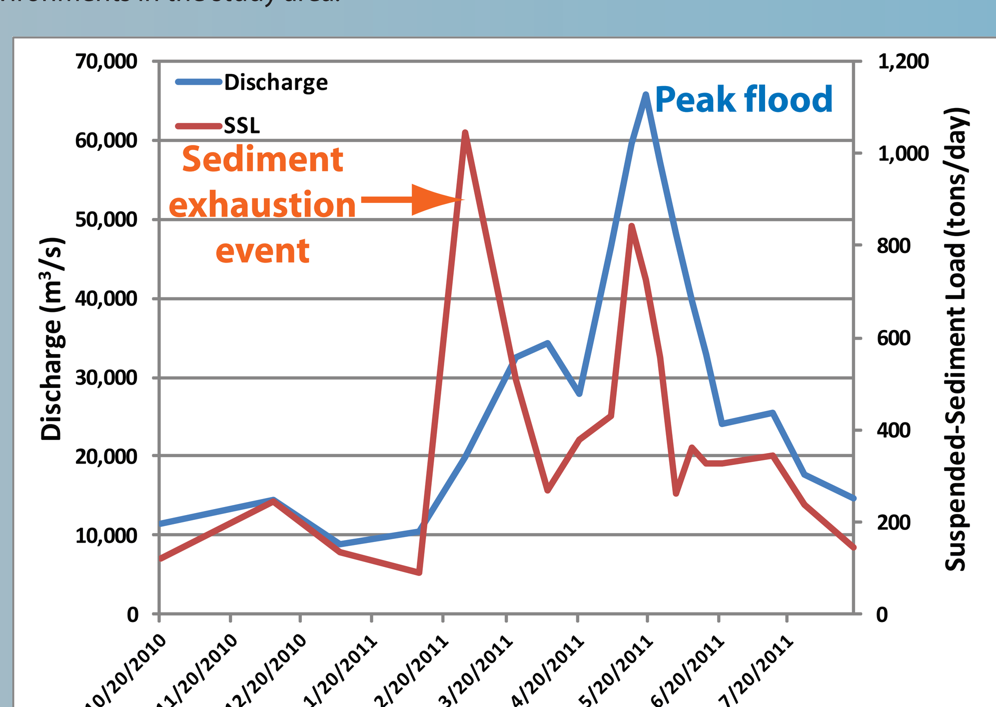
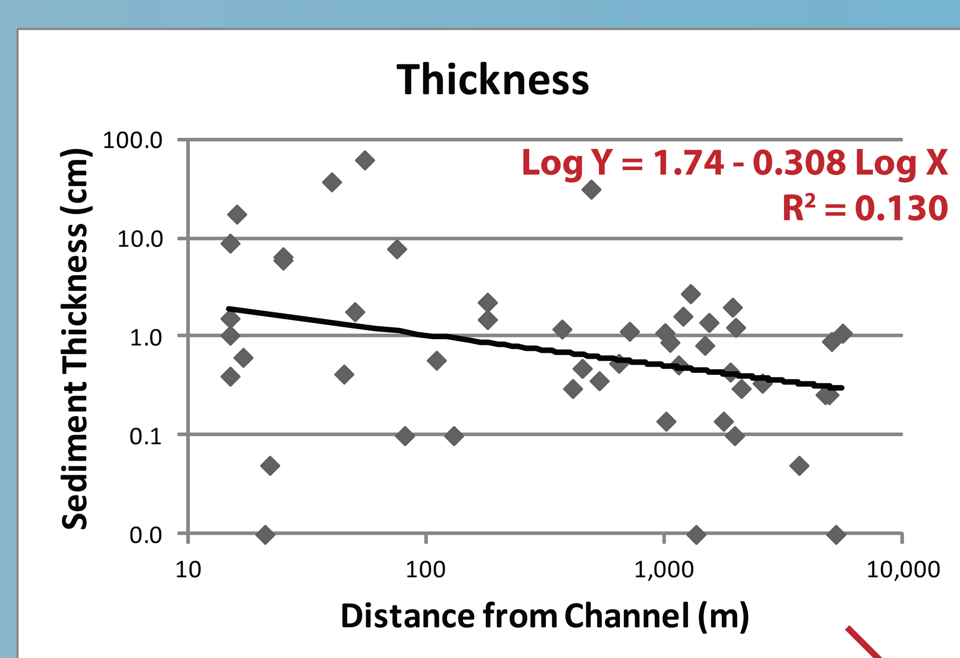
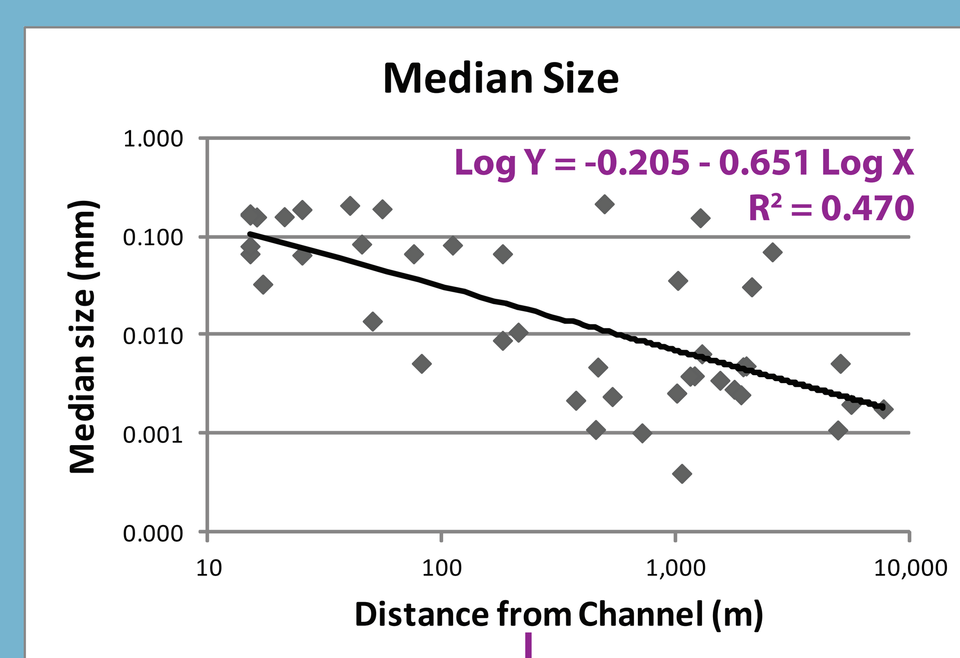


Figure 8. Measured discharge (m^3/s) and suspended-sediment loads (metric tons / day) for the Lower Mississippi River between October 2010 and August 2011 (data courtesy of the U.S. Geological Survey).





Figures 9 - 10. Sediment thickness (cm) and median particle size (mm) of overbank sediments deposited by the 2011 Lower Mississippi River flood in the study area. There is considerable variability of sediment thickness with distance from the river channel, in part because of the relatively minor amount of deposition, but also suggestive of localized scour and recessional fine-grained drape deposits. Particle size is characterized by a better-defined decreasing trend with distance from the channel.

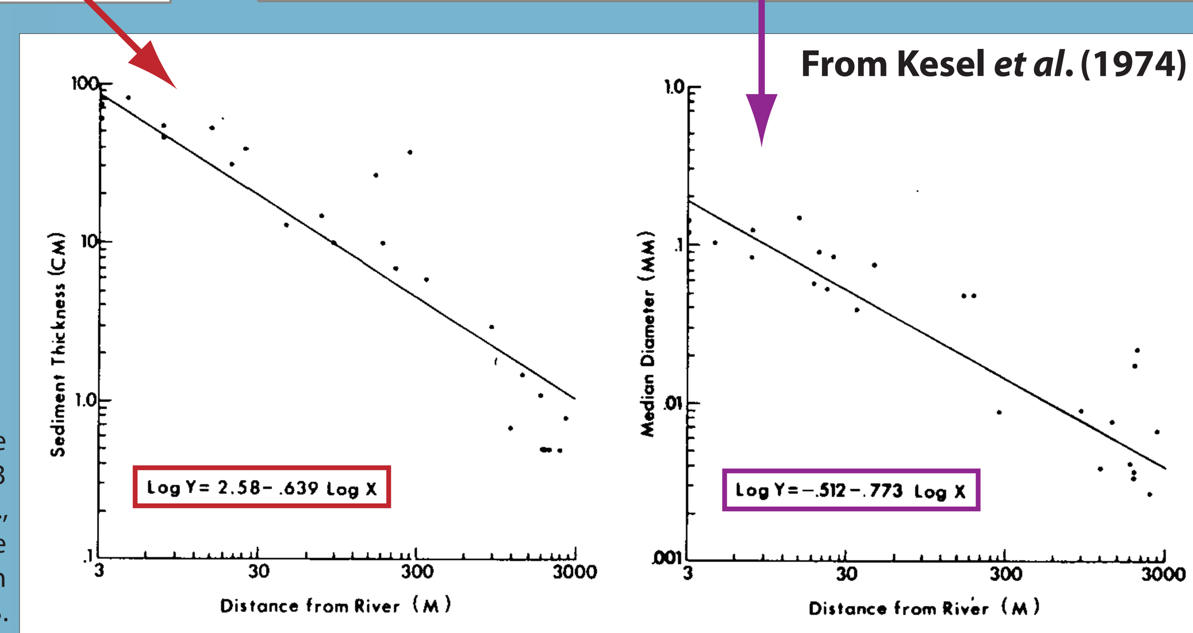


Figure 11. Sediment thickness (cm) and median particle size (mm) of overbank sediments deposited by the 1973 Lower Mississippi River flood in the study area (Kesel *et al.*, 1973). A cursory comparison with the 2011 data above (Figures 9 and 10) indicates better defined trends with distance from the river channel in 1973.

CONCLUSIONS

The relatively thin overbank sediment measurements indicate that the prolific May – June 2011 flood along the Lower Mississippi River did not transport large volumes of sediment into non-embanked, alluvial floodplain environments. The sediment thickness results presented here are comparable to depositional thicknesses in floodplains along the Upper Mississippi River during the great 1993 flood (<20 mm average) (Gomez et al., 1995, 1997; Magilligan et al., 1998), indicating that extreme floods are not always associated with profound geomorphic adjustments in floodplain settings. Interestingly, suspended-sediment load data (Figure 8) just upstream of the study areas indicate a peak load (1,045 metric tons / day) during a relatively minor high-flow event from late February to March, whereas the peak measured load during the larger May – June flood was 843 metric tons / day. Apparently, sediment exhaustion during the earlier 2011 event contributed to the minor amounts of floodplain deposition observed in this study. The particle-size data indicate that flow velocities across the floodplain were likely higher in 2011 than 1973, which is quite plausible considering the evidence for increasing channel-bed elevations in the study area (Wasklewicz *et al.*, 2004). Although less sediment was deposited on natural levee crests and levee backslopes in 2011, % sand increased for both sub-environments, which indicates more energetic flow conditions. The fine-grained "film" on meander scrolls likely was deposited only during the waning stage of the flood, possibly representing final evaporation of ponded water stranded over saturated soils. If energetic, sediment-deprived overbank flow occurred across meander scrolls, then it is quite plausible to assume pre-existing soil particles were detached (stripped) from the ridge surfaces and subsequently transported to distal floodplain environments. Evidence for this phenomena can be observed in the relatively coarse 2011 backswamp deposits (18% sand) when compared to 1973 (3% sand), suggesting a nearby excavated source instead of simply muds derived from evaporation of stranded flood water.

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