Using the late Holocene stratigraphic record to quantify rates of wetland accretion in the Mississippi Delta: implications to coastal restoration

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100+ Years of Land Change for Southeast Coastal Louisiana

SUMMARY
Coastal Louisiana has lost an average of 34 square miles of land, primarily marsh, per year for the last 50 years. From 1932 to 2000, coastal Louisiana has lost 1,900 square miles of land, roughly an area the size of the state of Delaware. If nothing is done to stop this land loss, Louisiana could potentially lose approximately 700 square miles of land, or about equal to the size of the greater Washington D.C.-Baltimore area, in the next 50 years. Further, Louisiana accounted for an estimated 90 percent of the coastal marsh loss in the lower 48 states during the 1990s. The area shown on this map represents over 75 percent of the total land loss for coastal Louisiana. Backdrop is 2000 TM panchromatic band.
Questions: (1) Which sites have highest sediment trapping efficiency? (2) What is the sediment accumulation rate?
Approach

Investigating lithologic composition and sediment accumulation rate of crevasse-splay deposits using borehole date and optically-stimulated luminescence (OSL) dating, respectively.

A natural analog of river diversions

crevasse splay in the Columbia River, Canada (picture by H.J.A. Berendsen).
Study area

Compare Attakapas Splay with Wax Lake Delta
Wax Lake Delta
Lithology: Attakapas Splay

Clay and silt > 70%

Mississippi River sediment loading: 77-83% silt and clay (Allison et al., 2000; Nittrouer et al., 2008)

~60% silt and clay were trapped!!
~70% sand (Majersky et al., 1997; FitzGerald, 1998, Roberts, 1997)

Only ~10% silt and clay were trapped!!
River diversion

From Louisiana’s Comprehensive Master Plan for a Sustainable Coast
Sediment accumulation rate

OSL dating

- Silty to sandy quartz is used
- Utilizing natural radiation energy accumulated within mineral crystal
- Signal resetting occurs while exposed to sunlight
- Dating the latest depositional events directly
- Age range $10^{-6}$ years
Quartz OSL properties

3 OSL Components
- Measured OSL decay curve
- $\sigma_{\text{fast}} = (1.47 \pm 0.12) \times 10^{-17} \text{ cm}^2$
- $\sigma_{\text{medium}} = (4.58 \pm 0.80) \times 10^{-18} \text{ cm}^2$
- $\sigma_{\text{slow}} = (4.25 \pm 1.84) \times 10^{-20} \text{ cm}^2$

Sensitivity corrected OSL vs Dose (Gy)
- Black squares: Regeneration
- Red circles: Recycling
- Green circles: Natural
Method validation

From Törnqvist et al., 2008
> 3 cm/yr

Napoleonville III-1 0.66±0.03 ka

Napoleonville III-4 1.00±0.14 ka

Napoleonville III-7 1.07±0.07 ka
~ 2 cm/yr

Napoleonville II

Napoleonville II-1  0.65±0.06 ka
Napoleonville II-3  0.73±0.08 ka
Napoleonville II-5  0.81±0.06 ka

Legend:
- peat, clayey peat
- humic clay
- clay, silty clay
- silty clay loam
- silt loam
- sandy loam, sand
Conclusions

- Swamps have higher efficiency than open bay regarding trapping Mississippi River sediments and deserve high priority on river diversions site choosing.

- Quartz OSL dating is suitable for dating samples younger than 1000 yr in the Mississippi Delta.

- Sediment accumulation rates are more than 2 cm/yr for crevasse-splay deposit in the Mississippi Delta.

- Coastal restoration through river diversion has the potential to achieve sediment accumulation rates higher than relative sea level rise in the Mississippi Delta.
Future work