THE WATER INSTITUTE OF THE GULF

Louisiana Coastal Neotectonics Expert Panel

WORKSHOP 2 SUMMARY

To: Carol Parsons Richards, Louisiana Coastal Protection and Restoration Authority
From:

The Water Institute of the Gulf
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Re: Louisiana Coastal Neotectonics Workshop 2

Introduction

On March 3, 2020, The Water Institute of the Gulf convened a public workshop at the University of New Orleans Technology Park. The workshop served as the second meeting of the Louisiana Coastal Neotectonics Expert Panel. The objective of the workshop was to facilitate discussion of neotectonics processes in coastal Louisiana and their potential effects on coastal restoration planning. The panel members include Dr. John Anderson, Dr. Elizabeth Hajek, and Dr. David Mohrig, all of whom participated in-person. Three experts in the local geology, i.e., Dr. Zhixiong Shen, Dr. Nancye Dawers, and Dr. Mark Byrnes, presented research overviews to the panel. Workshop attendees were asked to sign in to track numbers and affiliations of attendees. Approximately 31 people attended the workshop from government agencies, academia, nonprofit organizations, and private consulting companies.

Workshop Presentations

ZHIXONG SHEN, COASTAL CAROLINA UNIVERSITY

Dr. Shen opened the workshop with a presentation titled *Subsidence of the Mississippi Delta Due to Deep Processes.* Dr. Shen began his presentation with an overview of the Late Quaternary geology of the Mississippi Delta before detailing his work on the Tepetate-Baton Rouge Fault Zone (Shen et al., 2017). This work includes subsurface observations of a fault system which are projected to the surface as well as some surface scarp observations. Sediments were dated by employing Optically-Stimulated

Luminescence (OSL) techniques that detect and quantify luminescence emissions to estimate the amount of time since quartz sediment grains were last exposed to sunlight (Rhodes, 2011). At four late Pleistocene sites there were measurements of the faults using detailed coring and stratigraphic interpretation of transects across fault scarps. Long-term average fault throw rates were estimated to be between 0.03 mm/yr and 0.04 mm/yr at these sites. An additional late Holocene site, measured using the same methods, gave a fault throw rate estimate of 0.22 mm/yr. At six additional sites there were measurements of fault throw using mean levee elevations on each side of the fault. Over approximately 27 to 60 kyr, there was 1.2 m to 1.8 m of fault throw for a rate of 0.02 mm/yr to 0.07 mm/yr. The Tepetate-Baton Rouge Fault Zone is made up of two to three fault arrays with an aggregate rate of 0.7 mm/yr of fault throw during the late Holocene. Data presented from Simms et al. (2009, 2013) comparing the relative sea level rise along the Louisiana MIS 5a shoreline with the same data from the Texas and Atlantic coasts suggest that the Louisiana MIS 5a shoreline is as stable as these other tectonically stable areas of the Gulf Coastal Plain. Dr. Shen also presented data on load induced subsidence in the Mississippi Delta (Chamberlain et al., 2018; Elizabeth Chamberlain, 2017; González & Törnqvist, 2009; Törnqvist et al., 2008). OSL dating of interpreted mouth bar deposits showed a weak relationship between total subsidence and Holocene sediment thickness and a very weak relationship with distance downstream along the Bayou Lafourche abandoned distributary. A stronger relationship, $r^2 = 0.57$, was seen between overburden thickness and total subsidence (Chamberlain, 2017). Overburden thickness is defined as the sediment column above an interpreted mouth bar deposit while Holocene thickness refers to entire thickness of sediment from the surface to the Pleistocene. Overburden thickness is a subset of Holocene thickness. Recently deposited sediments had higher subsidence rates and may cause up to 5 mm/yr of subsidence for every 1 m of overburden thickness. Data from this work also suggested that up to 50% of the elevation gained through overbank deposition is lost to compaction of the deposited sediment and deformation of the underlying deposits. Dr. Shen concluded that Holocene fault slip is likely <1 mm/yr, and the mass of recently accumulated sediments has a greater control on compaction and subsidence, and the mass of recently accumulated sediments has a greater control on compaction and subsidence.

Given that 50% loss of surficial deposit thickness due to compaction at depth is relatively high, during the question and answer discussion, the panel was interested in whether it was possible to predict compaction based on lithology (grain size, porosity, water content, organic content, and mineralogy). Geotechnical analyses and modeling efforts and down-borehole logging methods were thought to be important contributions to inform these predictions; the capabilities of these types of predictions are still under study. Resistivity data and similar measurements might be available from geotechnical design borings, but the data are not organized in a way that would make synthesis possible. As in the first workshop, there was a discussion about what measurements over long time scales tell us about shorter restoration time scales. The panel noted that it remains challenging to compare fault throw rates estimated over different temporal windows and that long-term average throw rates do not necessarily inform estimates of peak short-term throw rates. It was also noted that even in areas that were abandoned by the river hundreds or thousands of years ago, it is hard to find evidence of faults in lidar data, even on levees.

NANCYE DAWERS, TULANE UNIVERSITY

The second presentation was given by Dr. Nancye Dawers, titled *An overview of Quaternary faulting in southeastern Louisiana and its interaction with salt.* Dr. Dawers began with a discussion of the geologic history of the underlying salt structure of the Louisiana coast. An important feature of the salt bodies in the underlying structures is the ability to flow viscously. Salt bodies below about 2 km depth should still be flowing (directional displacement), if connected to a supply (relatively large salt deposits). Salt is also virtually incompressible in contrast to highly compressible siliciclastic sediments. Much of the data presented by Dr. Dawers was from 2D seismic data originally acquired to inform oil and gas exploration.

Miocene deltaic deposits lie on top of pre-Eocene salt deposits. Since deposition of the salt, up to 50% of the deposit has been removed by dissolution. Thus, the thickening of sediment layers that are associated with fault zones may be associated with increased accommodation space due to both tectonics and salt removal (dissolution and migration). North of the coastal region, there is a southward stepping fault zone, likely with a stepped counter-regional fault zone to the south. Some faults in Louisiana, such as the St. Rose fault and the Gentilly fault can been inferred at the surface using aerial imagery and lidar data (Dokka, 2011); other faults are only identifiable using subsurface data. The locations and sizes of salt deposits in Louisiana are not fully known. Salt underlying the Louisiana coast may also intrude into other stratigraphic layers and impact surface processes. For example, faults and a salt dome associated with the Lafitte area may have influenced the course of Bayou Barataria (Deblieux, 1962).

Dr. Dawers presented several examples of faults in Louisiana, and their effects on the landscape. In Central Louisiana, the Golden Meadow fault zone is the northern boundary of a stepped counter regional fault zone (Akintomide & Dawers, 2017; Kolvoord et al., 2008). There is a graben in this area due to a subsidiary fault of the Golden Meadow fault, which probably led to the development of Catfish Lake on the western side of the fault zone. Marsh breaks trace the fault through this area. Holocene sediment deposits are thicker inside this graben. Faults through coastal Louisiana sediments likely slip through slow or aseismic slip. Slow slip is differentiated from true aseismic slip in that the latter is a constant slip, while slow slip propagates over days or months. An example of a slow slip event in Louisiana is the movement on the Vacherie fault in 1943. A surface rupture above the Hester salt dome took two days to propagate across 2 km and slip 20 cm down dip. The rupture threatened the Mississippi River levees near Vacherie, LA. No record of the slow slip event was recorded at the Loyola University seismic station in New Orleans. This event can aid in interpreting the likely behavior of other faults in Louisiana and emphasizes that areas with significant salt volumes should be considered in coastal planning. Current work by a PhD student at Tulane University, Akinbobola Akintomide, would create a Late Pleistocene structure map and map Holocene faults that extend to the top of Terrebonne Bay using data from a 3D seismic mega-survey. This work may be able to also map the base of the Holocene.

During the time for questions, it was emphasized that the salt supply, i.e. connection to deeper salt feeders, is important for salt motion. Salt feeders can operate as shear zones. Studies of subsurface salt are focused offshore, but there are probably not a significant number of undiscovered salt domes along the Louisiana coast. Current research on slow slip is focused on subsidence zones, but factors that favor slow slip are high fluid pressure and low elasticity. In subduction zones, slow slip events show some periodic behavior and may be prone to remote triggering such as by earthquakes in other parts of the world.

MARK BYRNES, APPLIED COASTAL AND ENGINEERING

Dr. Mark Byrnes of Applied Coastal gave the final presentation of the day, entitled *Recent Subsidence Trends for Barataria Basin, LA*. The presentation focused on a recent publication of the same name (Byrnes et al., 2019). There is a large range in subsidence rates measured throughout south Louisiana marshes (Jankowski et al., 2017; Reed & Yuill, 2017). Many rates are calculated using water level trends from tide gauges and also by reoccupation of benchmarks that are often along roads. Roadside benchmarks are less useful for estimating subsidence rates within marshes where coastal restoration would take place. Water level analysis to estimate subsidence rates in Barataria Basin results in a very large range of values (-4.1 mm/y to 38.9 mm/yr). Benchmarks at many Coastwide Reference Monitoring Stations (CRMS) have records that are now long enough to use for subsidence studies. During the analysis of this data, Byrnes et al. (2019) noticed that rods with different foundation depths had very similar subsidence rates. This finding was not consistent with the assumption that rods subside at the same rate as the sediment column below them. This led to a review of the data from a recent study conducted of the background subsidence rates and consolidation rates and amounts resulting from a large beach nourishment project at Caminada Headland (Gahagan & Bryant Associates, Inc., 2013, 2016). In order to accurately isolate consolidation rates for different stratigraphic layers, rods were installed with a borros anchor which has curved prongs to prevent settlement of the rod as well as with a sleeve along the entire rod length to prevent drag due to skin friction. Benchmarks measured for 24 hours every 2 days allowed the study to estimate background subsidence rates. The results of this study showed that the largest amount of consolidation occurred in the top layer. The casing of the all rods also settled at the same rate as the Holocene, regardless of the depth of the rod. This led to a relative decrease in the casing height relative to the benchmark. Building on these results, Byrnes et al. (2019) considered the effect of downdrag forces along the entire length of benchmark rods, finding that according to geotechnical and geodetic literature, rods that are not sleeved along their total length will subside at the same rate as the entire sediment column (e.g. Abdrabbo & Ali, 2015; Bozozuk, 1972; Chao et al., 2006; Huang et al., 2015; Shinkle & Dokka, 2004). Analyzing the CRMS benchmark data with this new assumption, Byrnes et al. (2019) found that subsidence velocities in Barataria Basin ran from 2 to 7 mm/yr and correlate with Holocene sediment thickness. Dr. Byrnes recommended establishing a Louisiana Subsidence Network that is surveyed every 2-5 years and deep and shallow benchmarks using anchors and sleeves to monitor Holocene and pre-Holocene subsidence.

During the time for questions, the panel wondered if the top of the casing for oil wells could be used as a benchmark or if obtaining a decadal scale subsidence rate based on Holocene thickness and lithology were possible. Given that RSETs are an important part of coastal monitoring in Louisiana, their installation was discussed. RSETs are installed by driving a metal rod to refusal, similar to the method of installing benchmarks. Although Swales et al. (2016) found RSET tables to be stable in their research area, they also state that RSETS should not be assumed stable in all locations.

A new publication (Cahoon et al., 2020), published a few weeks after this workshop, disagrees with some of the findings of Byrnes et al. (2019). Further research is clearly needed to resolve these disagreements.

Afternoon Panel Discussion with CPRA

During the afternoon discussion members of CPRA, the panelists, and the speakers discussed the presentations from Workshop 2. When it comes to marsh subsidence, the main concern for CPRA from a planning scale perspective is what happens at the marsh surface (e.g.: Are marshes able to keep up with the current rate of subsidence?). Holocene lithology across the Louisiana coast is variable, but a simplified, generalized version may be helpful to understanding subsidence trends. There is a lot of variability in the shallowest deposits. Many studies of Louisiana lithologies in the context of geotechnical properties exist, but they need synthesis to be more useful, including a comparison of how specific lithologies might have variable contributions to subsidence and how that might change as a function of overburden thickness. If sediment is grouped by organic content, sand content, or similar, it may help to better predict Holocene subsidence. There is, overall, a disconnect between geotechnical data and other subsurface data that makes it difficult to use the different datasets together. Efforts should be made to aggregate and synthesize existing data.

Next Steps

The panel expressed interest in additional information about how subsidence estimates influenced the model results for the master plan. In particular, the panelists were interested in what the model was sensitive to and how it is sensitive to subsidence. Although CPRA knows that the Basin-wide Delft3D and Integrated Compartment Models used to inform planning are very sensitive to subsidence, there has not been any quantitative analysis. Appendix C (C3-24, section 8.2) was sent to the panel to provide further information on this topic. Additional questions may be answered in future via webinar. Panelists also noted that based on the presentations to date, the thickness and lithology of Holocene deposits is a dominant factor in determining subsidence rates, and that a detailed stratigraphic model that incorporates geotechnical facies (e.g. Kolb & van Lopik, 1966) would be important for informing a refined subsidence map. Panelists were also directed to the USACE Lower Mississippi Valley Mapping resource (https://lmvmapping.erdc.usace.army.mil/ and https://lmvmapping.erdc.usace.army.mil/Coastal-Plain.htm) and the Louisiana Sand Resources Database (LASARD) for more information on lithology types in Louisiana.

Due to the COVID-19 pandemic, it is likely that the third workshop will be held virtually.

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