THE WATER INSTITUTE OF THE GULF

Louisiana Coastal Neotectonics Expert Panel

WORKSHOP 1 SUMMARY

To: Carol Parsons Richards, Louisiana Coastal Protection and Restoration Authority
From:
The Water Institute of the Gulf
Mike Miner, Diana Di Leonardo, Brendan Yuill
Neotectonics Expert Panel
Elizabeth Hajek – Chair
John Anderson
David Mohrig

Date: March 9, 2020
Re: Louisiana Coastal Neotectonics Workshop 1

Introduction

On December 2, 2019, The Water Institute of the Gulf convened a public workshop at the University of New Orleans Technology Park. The workshop served as the first meeting of the Louisiana Coastal Neotectonics Expert Panel. Dr. John Anderson and Dr. David Mohrig of the panel attended the workshop in person. Dr. Elizabeth Hajek participated remotely via webinar. Three local experts in subsidence and faulting, i.e., Torbjörn Törnqvist, Bryan Stephens, and Mark Kulp, presented research overviews to the panel. Brian Lezina, CPRA Division Chief, Planning and Research, presented on the structure, function, and science of the Louisiana Coastal Master Plan.

Workshop Presentations

The opening presentation of the workshop was given by Brian Lezina of CPRA. Mr. Lezina presented on "*CPRA and how we incorporate geosciences into our coastal program*". The presentation was an overview of the Louisiana Coastal Master Plan and the science that contributes to the plan. The Louisiana Coastal Master Plan is a high-level document that is updated, by law, every 6 years. It is separate from the Annual Plan which lays out more detailed specifics of the CPRA coastal program and budget on a shorter timescale. The Coastal Master Plan has large investments in marsh restoration and structural work, both of which are potentially influenced by subsidence. The Coastwise Reference Monitoring System (CRMS) is an important part of the coastal program consisting of 391 measurement stations. Maintaining these stations costs $10 million annually. CPRA also funds a significant amount of research, executed by internal (agency) and external scientists and engineers, to support its mission identified in the Master

Plan, Annual Plans, and additional science programs. A recently started, large-scale effort by CPRA is the Lowermost Mississippi River Management Program which is focused on managing the lowermost section of the Mississippi River in terms of sediment management, dredging, and subsidence.

The next presentation was given by Dr. Torbjörn Törnqvist from the Earth and Environmental Sciences Department at Tulane University. Dr. Törnqvist presented on "*Louisiana's coastal subsidence problem: An overview with special reference to deep crustal motions"*. The presentation focused on the results of the research that is detailed in several publications (Frederick et al., 2019; Jankowski et al., 2017; Shen et al., 2017; Yu et al., 2012). The research focuses on the different components of subsidence in Louisiana as measured by CRMS and Continuously Operating Reference Stations (CORS) (Jankowski et al., 2017), micropaleontology (Frederick et al., 2019), optically stimulated luminescence (OSL) data (Shen et al., 2017) and radiocarbon dating (Yu et al., 2012). Results from these studies suggest that much of the subsidence in Louisiana is related to shallow (within ~25 m of the surface) sediment compaction, and that over long time scales (thousands of years or more) fault related subsidence occurs at rates around 0.03 mm/yr. Glacial isostatic adjustment related subsidence is expected to be in the range of 0.5 m/yr to 1 mm/yr (Yu et al., 2012). Loading induced changes in elevation are likely driven by ocean loading (due to sea level) and shelf loading (from shelf deposited sediments). During the time reserved for questions, the importance of defining the timescale of measurement was discussed. Dr. Törnqvist acknowledged that many of the subsidence rates that he presented have different timescales of measurement that could affect the interpretation of the rates. Throw rates along faults in the recent past could be much higher than those measured over thousands of years. Probably peak values may be important for evaluating risks on planning timescales. It was noted that compaction is likely related to dewatering of the sediments but is potentially different in terrigenous sediment versus organic sediment.

The third presentation was given by Bryan Stephens from the Bureau of Ocean Energy Management (BOEM), Regional Framework Unit and was titled *Subsurface Controls on Natural Subsidence Patterns in South Louisiana.* Mr. Stephens presented interpretations of the deep-seated structure of the Mississippi Delta sediments and neotectonics based on extensive seismic data. Mr. Stephens' interpretation of the deep-seated geological structure focused on identifying general patterns in the regional salt dynamics and suggests that these dynamics may be a significant driver of subsidence. The Gulf coast is a segmented continental margin that with lineaments from Pangea-age transfer-fault systems that continue to influence the basin. Salt structures may have more influence west of the Mississippi River. One main discussion item was the need for a detailed map of the depth to the Holocene-Pleistocene surface. It was noted that there is a lot of data in Louisiana that has never been synthesized, but an excellent starting point would be the Louisiana Geological Survey report by Paul Heinrich. The study looked at thousands of borings in Louisiana to estimate the Holocene-Pleistocene surface (Heinrich et al., 2015).

The final presentation of the day was given by Dr. Mark Kulp from the University of New Orleans, Earth and Environmental Sciences Department. The presentation was titled *Old data used in new ways: Industry-Based seismic data used to evaluate the effect of Cenozoic faults on Holocene Strata of the Mississippi Delta Plain*. Dr. Kulp presented work by several students using industry seismic data as well as shallow chirp seismic data from Lake Pontchartrain. Industry seismic data that is released to academia is typically limited to the top 1.5 seconds of data and comes with limits on who can view the data as well as some limits on publishing. Data from Lake Pontchartrain suggests slip rates of 0.01 cm/yr to 0.07 cm/yr. These slip rates are much higher than those measured over thousands of years for other faults in Louisiana. It is expected that the timescale of measurement is important for interpretation of these rates. The Lake Pontchartrain Basin Foundation (LPBF) has also collected repeat Real Time Kinematic Differential GPS surveys across the Highway 11 bridge that show differential movement across the bridge where a shallow fault is expected to occur. The panel suggested that satellite imagery and drone data could be helpful to track recent motion and lineations visible in aerial photographs. Existing machine learning algorithms developed for mapping channels could be useful for this type of work.

Afternoon Panel Discussion with CPRA

Following the presentations, CPRA and the panel took part in a closed-door discussion. This discussion allowed a larger number of CPRA personnel to interact with and answer questions from the panel. The local expert presenters and Water Institute staff also participated in the discussion.

CPRA personnel offered additional details of the Master Plan process and the science that contributes to it. Model improvements for 2023 are planned for 9-10 areas including hydrology, habitat suitability, soils, barrier islands, and risk assessment. In 2012 and 2017, there were 17 different subsidence zones with a range of values for each zone. The process is being refined for the 2023 Master Plan, including an update of the CRMS subsidence analysis that covers both shallow and deep processes. CRMS stations show a very wide range of subsidence values, leading to large error bars on subsidence estimates. Subsidence shows broad, regional patterns across Louisiana, but because it is associated with a wide variety of different processes, local patterns are highly variable. The deep component of subsidence shows more predictable variability, on longer wavelengths. At the same time, the modeling in the Master Plan is very sensitive to choices related to subsidence. In the future, subsidence may become a boundary condition made up of a shallow and deep value to better capture the effects of different subsidence processes. A more robust error analysis is also planned for the 2023 Master Plan. Projects in the Master Plan compete for planning prioritization. The planning and prioritization are directly affected by decisions in the modeling and data analysis phases. The maps from the Master Plan are used in the feasibility analysis.

There is a need for more data points from borings, well logs, etc. that could help map the Holocene-Pleistocene surface. Industry seismic data may be of limited help because it is only from select locations, reprocessing the data to be useful at shallower depths is expensive, and does not have sufficient stratigraphic resolution to image the Pleistocene-Holocene surface. There appears to be a particular gap in boring data from bays, leaving the relationship between porosity and depth in these settings uncertain; observations from bays in Louisiana and from similar environments outside Louisiana are likely to be useful.

Louisiana already collects a large amount of data on subsidence in the coastal zone. Any additional data collection should be considered carefully to make sure that it is adding unique information. Work by Molly Keogh (Keogh & Törnqvist, 2019) demonstrated that 40 carefully chosen RSETs for measuring surface change could produce an average shallow subsidence rate that was comparable to the average shallow subsidence rate of the 274 RSETs with long data records used by Jankowski et. al (2017). InSAR data in Louisiana is also being used by the Jet Propulsion Laboratory to study subsidence in Louisiana but is not of decision quality yet. More broadly, there are important issues of comparing average rates derived from different methods and timescales of observations. Better understanding of uncertainties around the spatial and temporal averaging of subsidence measurements might be useful for improving predictions.

There are many spatial, temporal, and stratigraphic scales and rates that are relevant to the issue of subsidence in Louisiana. These scales and rates, and their relationships to each other, will be important to illustrate in any final report. A series of maps showing millennial time scales (deep seated structures), centennial time scales, and decadal time scales would be useful for geologists, engineers, and policy makers.

Next Steps

Several questions were raised during the discussions that will help guide the panel's next steps. They include:

- What is the data that already exists and what data can be collected in the near term?
- Are there any other academic partners we could reach out to?
- Should experts from other areas of the country to world be engaged?

The panel would also like to learn more about the Master Plan process and the science that is incorporated into planning and decision making. To this end a webinar will be planned for January 2020 which will cover aspects of the Master Plan such as feasibility studies for Master Plan projects, the current thinking on the subsidence approach for 2023, and the types of data that CPRA does and does not use in planning. CPRA personnel who are invited to present are Jim Pahl and Catherine Fitzpatrick. Topics that would contribute to the panel's understanding of the Master Plan include post Master Plan feasibility analysis and the draft CPRA subsidence analysis strategy for 2023.

The next workshop in this series is planned to take place in early 2020 and may be in a different format than Workshop 1, based on consultations with the panel. Potential local expert participants are: Nancye Dawers, Zhixiong Shen, Mark Byrnes.

References

Frederick, B. C., Blum, M., Fillon, R., & Roberts, H. (2019). Resolving the contributing factors to Mississippi Delta subsidence: Past and Present. *Basin Research*, *31*(1), 171–190.

Heinrich, P., Paulsell, R., Milner, R., Snead, J., & Peele, H. (2015). *Investigation and GIS development of the buried Holocene-Pleistocene surface in the Louisiana coastal plain* (Technical) (p. 140). Louisiana State University.

Jankowski, K. L., Törnqvist, T. E., & Fernandes, A. M. (2017). Vulnerability of Louisiana's coastal wetlands to present-day rates of relative sea-level rise. *Nature Communications*, *8*, 14792.

Keogh, M. E., & Törnqvist, T. E. (2019). Measuring rates of present-day relative sea-level rise in low-elevation coastal zones: A critical evaluation. *Ocean Science Discussions*, 1–19.

Shen, Z., Dawers, N. H., Törnqvist, T. E., Gasparini, N. M., Hijma, M. P., & Mauz, B. (2017). Mechanisms of late Quaternary fault throw-rate variability along the north central Gulf of Mexico coast: implications for coastal subsidence. *Basin Research*, *29*(5), 557–570.

Yu, S.-Y., Törnqvist, T. E., & Hu, P. (2012). Quantifying Holocene lithospheric subsidence rates underneath the Mississippi Delta. *Earth and Planetary Science Letters*, *331–332*, 21–30.