Causes and Effects of Fault Slip Events in Louisiana's Coastal Plain, A Geological Perspective

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Five years after his retirement Len Bahr, the former director of Louisiana's coastal program, made a blog post asking the rhetorical question "Where are the Geologists". He wrote "Since its very inception in 1989 Louisiana's coastal restoration program has been dominated by coastal wetland ecologists like me, folks who deal in relatively short-term surface processes, not the long term geophysical and riverine processes that underlie the delta. In other words, the planning expertise has been dominated by those who deal primarily with surface processes on the visible veneer of the delta, not the riverine hydrodynamics and sedimentary processes that created the delta and the underlying tectonic processes and shallow and deep subsidence to which the delta ultimately responds."

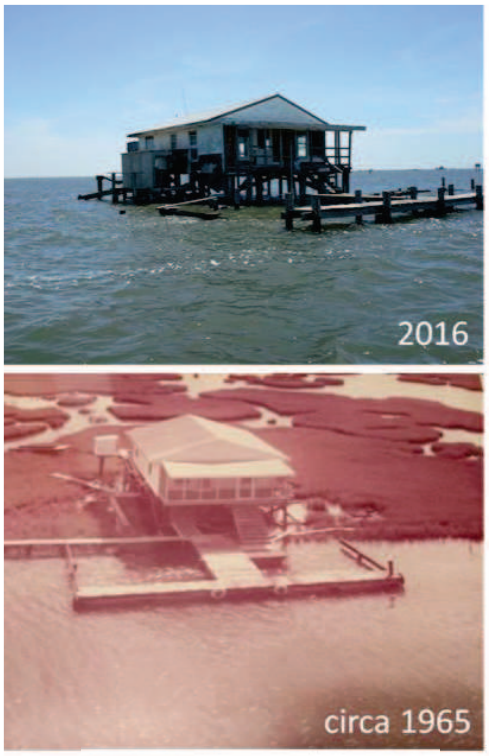

Figure 1

The simplest answer to Len Bahr's question is that subsurface geology had become the purview of the oil and gas industry. Exploration geologists had little interest in depths above 2,000 feet, and ecologists, geomorphologists and even geotech engineers rarely evaluated below the surface more than a few of hundred feet. The result was a subsurface "no man's land" across which almost nobody was thinking about the relationships between deeper tectonic processes and surface morphological processes.

This began to change in the early 21st century with the pioneering work of Harry Roberts at the LSU Coastal Studies Institute and Woody Gagliano of Coastal Environments, Inc. They were the first to use oil and gas industry data to bridge the subsurface gap and extrapolate geological faults to the surface. It was camp owner Pete Hebert who told Woody that he was certain the marshes around his camp on Bayou Ferrand west of Buras had sunk below the water's surface, and were not removed by erosion. Woody was able to get industry seismic profiles across the area, and mapped two faults that appeared to extend to the surface. He made profiles from auger borings across the surface escarpments, and demonstrated that the surface layers of marsh deposits were in fact offset across the faults. We now know that a subsidence event that had been experienced by Pete Hebert was recorded by the Grand Isle tide gauge, just few miles to the south. **(Figure 1**). There is a good case to be made that this was the result of a fault slip event. **(Figure 2)** Unlike earthquakes, fault slip events in a delta plain are "aseismic (no earthquaking) slow slip events". These events may range in magnitude from ruptures of the earth's surface with up to one foot of displacement to offsets that are so low that they manifest themselves as a vertical creeping motion.

By 2014 geologists at Tulane and UT Austin were using a 530-square mile industry 3-D survey to map subsurface geology in Plaquemines Parish not far from Hebert's camp.

Fault Slip Events (continued)

Their study mapped 28 faults and found that "most of the seismically imaged faults appear to extend up to the modern land surface and some affect the modern delta morphology ... several of these faults correspond to abrupt shifts from emergent wetlands to fully submerged areas of open water on the delta surface." They found that the submergence of wetlands along the downthrown sides of faults that reached the surface was major factor in causing wetlands loss. Since then ten research projects at UNO, Tulane and ULL have used 3-D seismic surveys to map faults that appear to extend to the surface. **(Figure 3)** Collectively this research is beginning to provide some of the answers that Len Bahr seemed to be looking for.

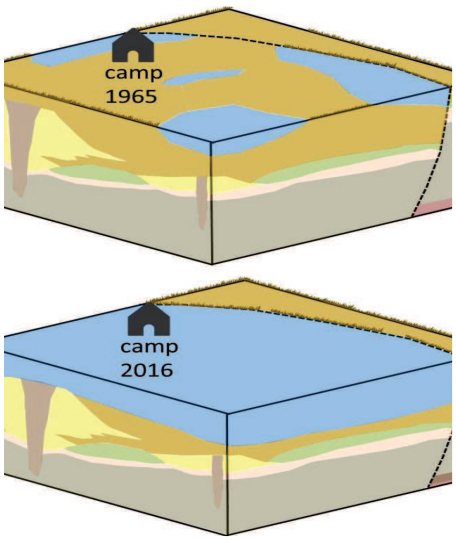

Figure 2

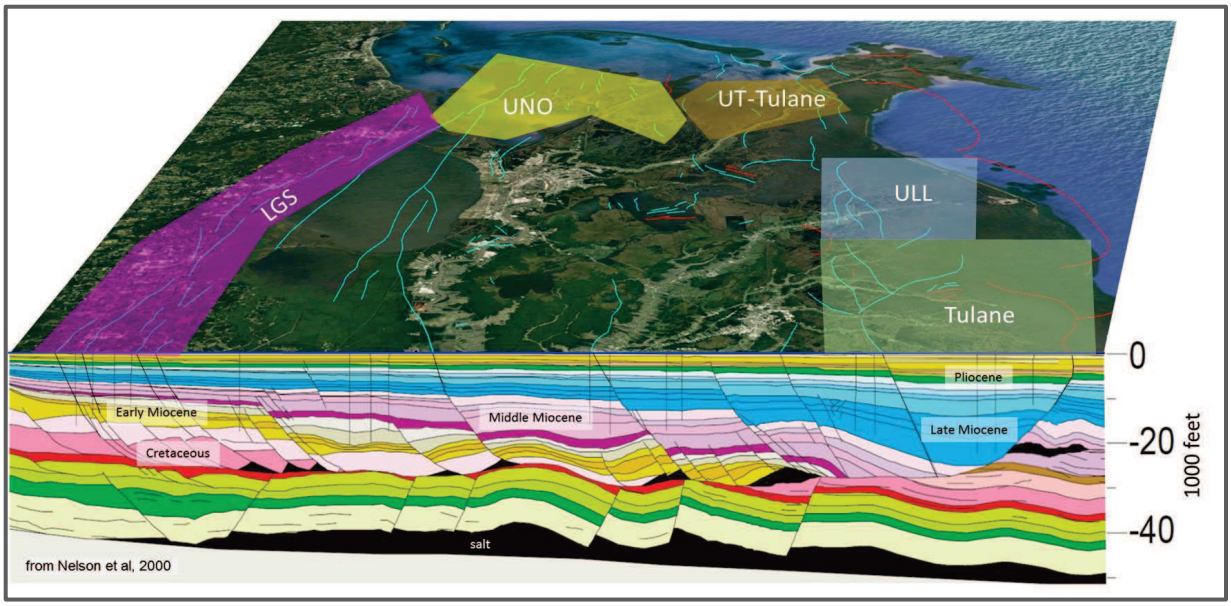

Figure 3

Wetlands loss in coastal Louisiana is best characterized as an event that generally peaked between 1970 and 1990. The map in **Figure 4** is an overlay of the surface traces of the known faults (cyan) and the distributary channel networks (dark blue) onto the USGS Land Area Change Map. The bright red and orange color patches delineate the hot spots of wetlands loss. The distributary channel networks are vestiges of the multiple historical lobes of the Mississippi River Delta.

The River changed course on average about once every 500 years, always seeking out the best place to deliver its sedimentary load. There appears to have been a genetic relationship between the fault traces and the fan-like architecture of the distributary channels. Each delta lobe tended to fan out across the faults it was crossing, perhaps because fault-driven subsidence provided the accommodation capacity that the river was seeking. Primary sedimentary loading would have occurred at the point where the channels cross the faults. Sedimentary loading may have provided a trigger mechanism for a fault slip event in the late 20th Century, which would in turn have caused submergence of the marsh surface along the fault.

Fault Slip Events (continued)

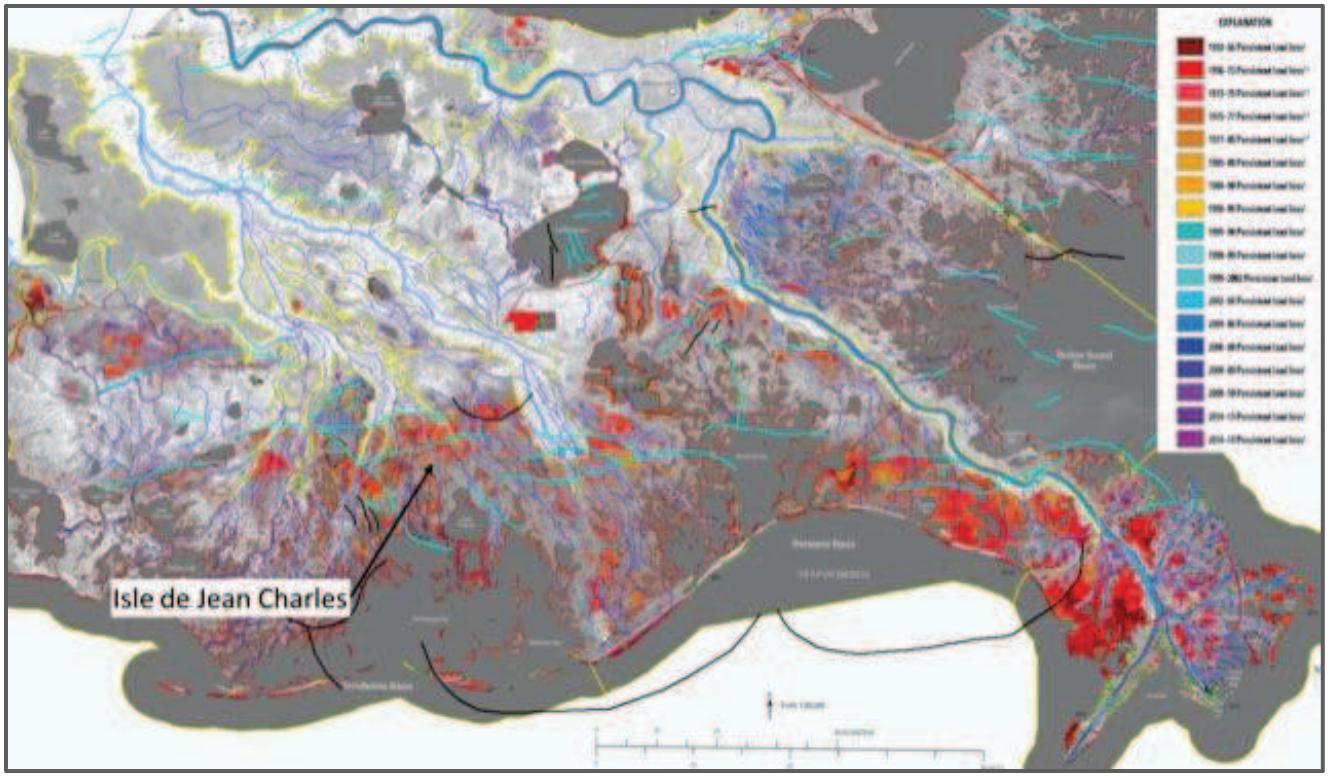

Figure 4

The Native American community of Isle de Jean Charles in Terrebonne Parish located in **Figure 4** is within one of the hot spots of wetlands loss of the late 20th Century. Subsidence rates along faults in this area have been estimated to have been as high as 20 millimeters per year during the submergence. The US Department of Housing and Urban Development has provided funding for the relocation of the residents of the community under a program intended to help those impacted by climate change. Several major media outlets have designated the residents of Isle de Jean Charles as "America's first climate refugees". While the funding program is an important and effective means of providing for relocation, it is important not to lose sight of the subsurface geological processes that contributed to the submergence of the community.

It may turn out that it can be demonstrated with some certainty that the late 20th Century wetlands loss event was associated with a subsidence event caused by fault slip. Much more work is needed in this area of research, and hopefully there will be many more conversations between geologists and ecologists about the relationships between surface and subsurface processes.

Editor's Note: On January 26, 2022 the author, Chris McLindon, presented a virtual seminar titled "Faulting in the Barataria Basin" upon which this paper is based. To view the recording visit: https://youtu.be/vvsTGGXWn58