Introduction

Napoleonville Salt Dome is located near Bayou Corne, Assumption Parish, southeast Louisiana. Caverns in salt domes such as this one are used for brine mining and storage of hydrocarbons and industrial waste. Beginning in June 2012, residents of Bayou Corne reported unusual gas bubbling in surface waters and frequent tremors. The parish requested the assistance of the United States Geological Survey (USGS) to monitor the continuous seismic activity. A temporary network of broadband seismic stations was established which revealed a complex and rich sequence of numerous seismic events. On August 3, 2012, a large sinkhole (Figure 2.24.1) was reported close to the western edge of the salt dome leading to an emergency declaration and evacuation of nearby residents. The sinkhole, filled with a slurry of water, crude oil and debris, has since swallowed Cypress trees and has been growing in surface area ever since (presently > 20,000 m²). Subsidence, bubbling of natural gas and intermittent seismicity have been observed in the region. Preliminary investigation suggests that sidewall collapse of a cavern, OXY GEISMAR #3, might be a possible cause of the sinkhole. Readers are referred to public briefings reports on the Department of Natural Resources, Louisiana website for further details (http://dnr.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=1051).

Data and Methodology

Figure 2.24.2 shows velocity waveforms of a seismic event on August 1, 2012 as recorded at five USGS stations. The records primarily show that strong surface waves and waveforms of multiple events are quite similar to each other, indicating closely spaced hypocenters and a repetitive source process. Three of these stations, LA01, LA02 and LA08, are on the sedimentary strata surrounding the sinkhole and show similar waveforms, but are quite different from waveforms at stations LA03 and LA09, which are on sedimentary deposits over the salt dome. The difference in waveforms is reflected in the available seismic velocity models (William Ellsworth, personal comm.), which show the salt dome to be a fast half-space, overlain and surrounded by slow layers of sediments with velocities smoothly increasing with depth. To study source mechanisms of these events, we perform six-component point source seismic moment tensor inversion allowing for both deviatoric mechanisms and volume changes (Minson and Dreger, 2008). Due to the uncertainties in travel-time locations and depths owing to lack of clear seismic phases in waveforms and presence of numerous seismic events, we employ the grid search approach of Kawakatsu (1998) which continuously scans the seismic wavefield and performs moment tensor inversion of low frequency waveforms assuming virtual sources distributed over a 3D grid. For a given window of data, the source location and moment tensor solution which give the best Variance Reduction (VR), a measure of normalized fit between observed and synthetic waveforms, is assumed to be the true seismic source. We assume that seismic paths to stations LA01, LA02 and LA08 conform to sediment velocity model and seismic paths to stations LA03 and LA09 conform to salt dome velocity model. Fundamental Green's functions for the 1D velocity models are computed using FKRPROG (Saikia, 1994). Displacement records are bandpass filtered between 0.1 to 0.2
Hz, which simplifies the waveforms while maintaining the signal to noise contrast for larger events. The same causal filter is used for Green's functions. Then, the moment tensor inversion is performed for each grid point using 25-seconds data windows with time steps of 0.25 seconds. Here we discuss results for 5 hours of data from 17:00 hours to 24:00 hours on August 01, 2012. We were able to detect 23 events using a threshold of 70% VR during this time period. The details of the moment tensor solution and corresponding waveform fits for one of the events are shown in Figures 2.24.3. This event was located at -91°14’22”E, 30°01’12”N, depth 0.47 km and centroid time 20:52:39.00 hours. The solution fits the data very well at 84% VR and can explain most of the strong radial and vertical components. We find a dominant volume increase component in the solution (Isotropic > 70%). The distribution of VR in space (Figure 2.24.4) shows that our location is well constrained. All solutions are quite similar showing a dominant volume increase component (Isotropic 64-74%) and are concentrated at a depth of ~ 470 m at the western edge of the salt dome, very close to the present location of the sinkhole. Magnitudes range from $M_w 1.3$ to 1.7.

**Discussions**

The moment tensor solutions are opposite to what one would expect in a collapse environment, if the energy release were purely due to gravity-driven tectonic collapse alone. However, the presence of large volume increase components as well as occurrence of harmonic tremors and long period events in the region indicates the role of fluids in controlling the seismic source processes, which can be inferred to be due to tensile failure of a near-vertical crack, or a crack-double-couple on a normal fault in the salt. Future work will include studying sensitivity of moment tensor solutions to velocity models, modeling waveforms at higher frequencies and possible explanations of the source mechanisms in terms of physical processes and their relationships with the sinkhole.

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**References**

