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A Geohazard Perspective of Recent Seismic Activity in the Northern Gulf of Mexico

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Abstract

This paper presents a discussion of the seismic environment of the Gulf of Mexico from the perspective of geohazard assessment and in light of the recent 2006 earthquakes. We provide a summary of the earthquake characteristics and their possible causes, and implications to hazard assessment in the Gulf of Mexico.

Introduction

Fault-related hazard in the Gulf of Mexico is related to movement on both deep-seated crustal faults, and shallow gravity–driven "growth faults." The hazard presented by deep faults is primarily the effects of shaking caused by strong ground motion on facilities and surface slope stability. The primary hazard of growth fault activity is the potential impact of fault rupture on surface facilities and related subsurface structures (e.g. wells and foundation elements). Characteristics of the shallow February 2006 earthquake in the Gulf of Mexico suggests that growth faults also may produce large enough earthquakes with associated strong ground shaking that could represent a hazard to nearby facilities. Therefore assumptions regarding hazard type, magnitude and likelihood of occurrence need reconsideration.

Fault-related hazard in the gulf has traditionally been divided into a very low regional ground motion potential and low to high potential for growth fault rupture that is highly dependant on site location.

Existing regional seismic hazard maps (API, USGS) are discussed briefly, and what kind of information will be useful to consider in future seismic hazard assessments for the region. The paper concludes with implications and recommendations to existing infrastructure and future engineered structures in the northern Gulf of Mexico.

Gulf of Mexico Geologic Setting

The northern Gulf of Mexico represents a Triassic rifted margin overlain by a very thick (5 to 14 km) succession of clastic sediments and minor carbonate. A thick section of salt (Louanne formation) was deposited between the rifted margin and the Cenozoic cover sediments. Salt is extremely weak, and rapid accumulation of sediment has caused the Louanne salt to deform plastically and form diapirs, canopies and multiple detachment surfaces.

Downslope (basinward) gravitational spreading and gliding of cover sediments on the weak salt and shale detachments produces significant faulting and salt-related related deformation of the overlying cover sediments. The geomorphic (seafloor) expression of the salt-related deformation, including growth faults, is strong enough to be recognized on regional bathymetric data (Figure 1).

The deformation that accommodates movement represents a "linked system" of faults, very similar to landslides, with upslope extension accommodated by downdip compression (Figure 2). Although most movement occurred prior to the late Miocene, this movement continues at a low rate in the present geologic environment. For comprehensive descriptions of the tectonic and geologic history of the northern Gulf of Mexico see Salvador (1991); Jackson et al (1995); and Jones and Freed (1996).

Seismic Activity

Historical seismic activity is low in the northern Gulf of Mexico and the region has traditionally been assumed to be seismotectonically quiescent (Figure 1). As a result of the sparse earthquake records, there has been little research on seismic activity and mechanisms in the Gulf of Mexico. Frohlich (1982) discussed the seismic environment in response to the 1978 event, and attributed it to sediment loading. However, there is yet to be a comprehensive evaluation of the seismic environment of the northern Gulf of Mexico.

This absence of a uniform evaluation of seismic hazard for the Gulf is in contrast with other regions of active oil and gas exploration and production such as Sakhalin and the Caspian sea that are recognized by the industry as very seismically active. Due to this awareness, the industry has increasingly employed state-of-the-art hazard analysis and mitigation practices for the development in such areas.

Growth Fault Activity

Growth faults extend from the onshore coastal plains of the Gulf coast from Florida and Louisiana in the east to central Mexico in the west (Figure 1). The presence and ongoing activity of growth faults in the northern Gulf of Mexico is widely recognized and well documented (see Wheeler 1999a; 1999b). The location and activity of individual growth faults