Sedimentary Geology 342 (2016) 237–253

Contents lists available at ScienceDirect

Sedimentary Geology

journal homepage: www.elsevier.com/locate/sedgeo

Submarine channel evolution linked to rising salt domes, Gulf of Mexico, USA

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ARTICLE INFO

Article history:
Received 21 March 2016
Received in revised form 27 June 2016
Accepted 28 June 2016
Available online 9 July 2016

Editor: J. Knight

Keywords:
Gulf of Mexico
Neogene
Submarine channels
Salt dome
Channel geometry

ABSTRACT

An examination of halokinetics and channel evolution together in a deepwater system provides an opportunity to investigate how submarine channel morphology is locally affected by rising salt domes. The study area is located in the northern Gulf of Mexico (GOM), directly off the Louisiana continental slope in a prominent salt dome region. The influence of salt growth on submarine channel evolution is relatively understudied, particularly in the GOM. Utilizing high-resolution 3D seismic and well data and seismic geomorphology techniques, a long-lived (~3 Myr) Plio-Pleistocene submarine channel system has been investigated to show a relationship between variable phases of salt motion and planform morphology of preserved submarine channels.

Our data suggest that local salt motion acts as a driver for submarine channel evolution. During the late Pliocene, when salt moved upward at a relatively fast rate, channels show distinct entrenchment with narrow channel belts and overall less sinuosity. When salt motion slowed down at the beginning of the Pleistocene, channels aggraded rapidly with preserved levees, and moved toward an equilibrium state with the expansion of channel belt widths. As our results indicate, the rate of salt diapirism exerted a first-order control on channel location and morphology and distribution of reservoir-prone units. This study cautions against readily invoking allogenic factors (e.g., sea level and climate) in explaining changes in submarine channel behavior and associated fan sedimentation, particularly in regions with salt tectonics.

1. Introduction

Submarine channels exhibit a dynamic response with respect to changes in seafloor topography (Posamentier, 2003; Deb et al., 2012; Gamboa et al., 2012; Gamboa and Alves, 2015). Channels are extremely sensitive to even minor changes of both slope and sediment load (Damuth et al., 1988; Gee et al., 2007). This sensitivity can be seen not only in erosive power, but also in the overall location and morphology of the channel. For example, channels adjust by migrating toward structural lows, and increases in channel slope can lead to a decrease in meander intensity (Schumm and Khan, 1972; Alves et al., 2014). Thus, changes in topography directly influence channel morphology.

In the Neogene Gulf of Mexico (GOM), while there is a plethora of studies on submarine channels (e.g., Posamentier, 2003; Nelson et al., 2010; Snedden et al., 2012) and stratigraphic architecture of salt minibasins (e.g., Mallarino et al., 2006; Madof et al., 2009), the influence of salt domes on submarine channel evolution is poorly documented. A number of studies have examined the interaction of salt movement and channel evolution in other regions. For example, Gee and Gawthorpe (2006) examined amplitudes of 3D seismic data to investigate control of salt domes on channel styles and geometries in offshore Angola, showing that channel geometry can change with proximity to salt structures in accordance with the associated depositional lows created by salt evacuation. Loncke et al. (2006) illustrated the interaction of sediment, salt tectonics and paleotopographic features in the Nile deep-sea fan based on multi-channel seismic and gravity data. Gamboa et al. (2012) used statistical analysis techniques to correlate geometries of channel confluence with topographic confinement created by salt domes in the Espírito Santo Basin, Brazil, suggesting that increasing lateral confinement influences channel confluences. While these studies are important, they leave lingering questions about the effects of salt diapirism rates and associated accommodation space on the stability, sinuosity and overall morphology of submarine channels.

Submarine channels are difficult to identify and interpret properly due to poor seismic visualization, limited seismic resolution, and pitfalls of time slice interpretation (Clark and Pickering, 1996). A better

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http://dx.doi.org/10.1016/j.sedgeo.2016.06.021

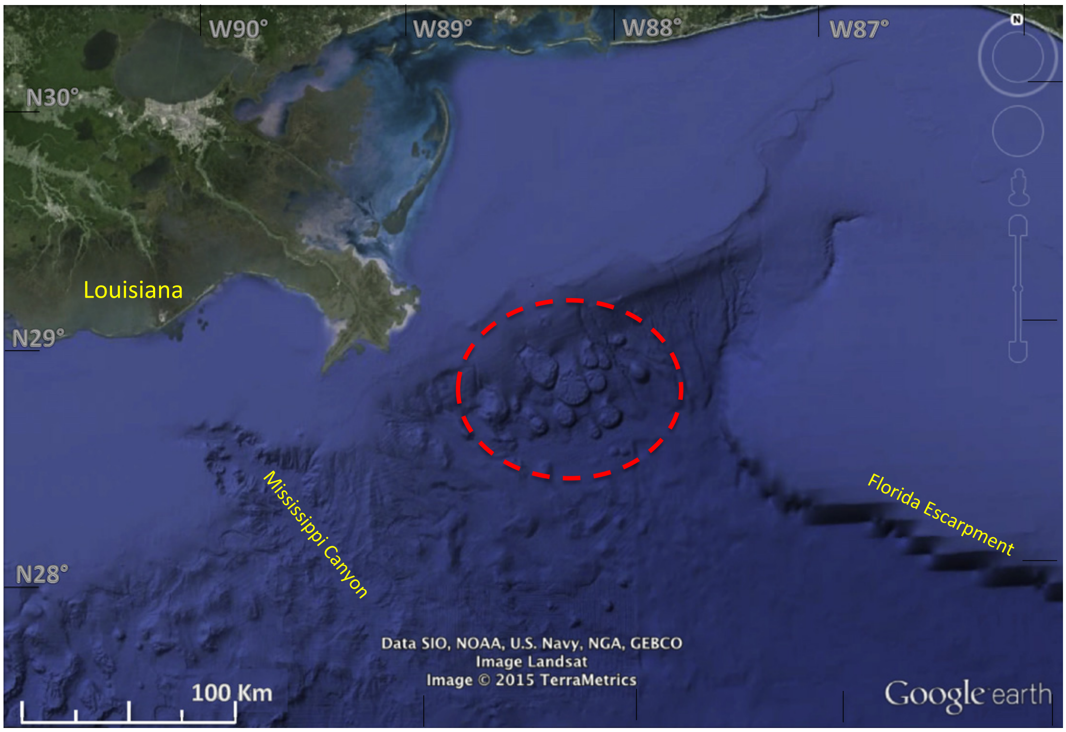

Fig. 1. Location map of the northern Gulf of Mexico (GOM) basin, USA. 3D seismic data (Fig. 2) utilized in this study is located within the red circle. (Image modified from Google Earth).

understanding of channel interaction with changing topography requires improved techniques with high-resolution data. This study aims to reduce analysis pitfalls by using high-resolution 3D seismic data with vertical limits of detection as low as ~7 m, performing multiple attribute analyses, and by employing horizon slices of coeval surfaces instead of time slices.

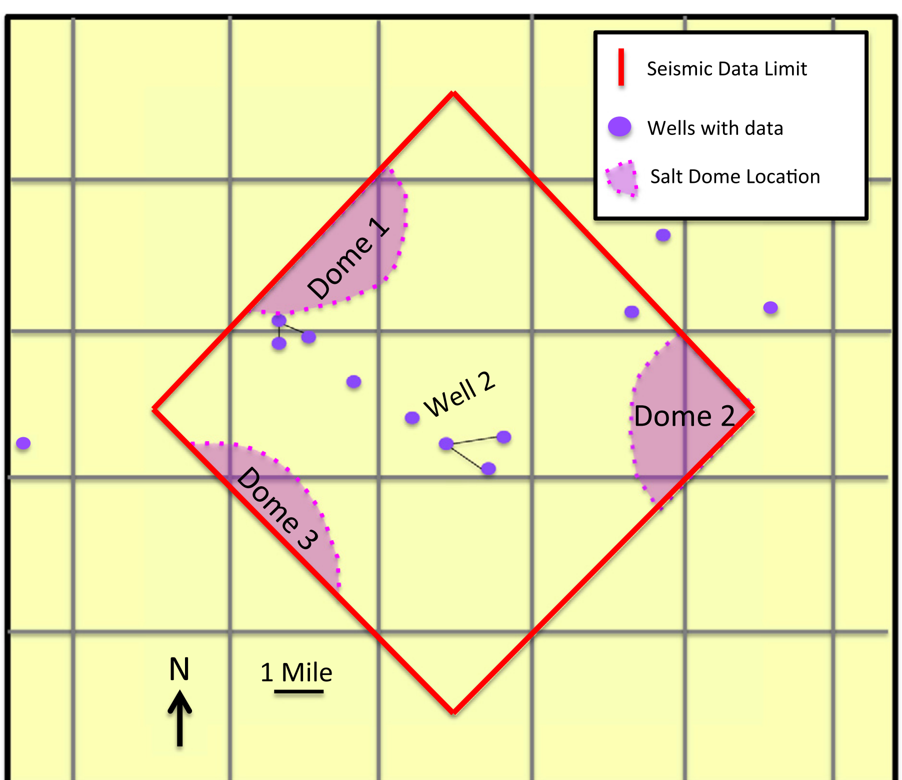

Fig. 2. The 3D seismic and well data used in this study. Note the location of three salt domes. For a generalized location of the study area, see Fig. 1.)