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Sr isotopic compositions of the interstitial water and carbonate from two basins in the Gulf of Mexico: Implications for fluid flow and origin

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ABSTRACT

Strontium isotopic compositions of the interstitial water and carbonate from marine sediments sampled during IODP 308, in two basins (the normally-pressured Brazos-Trinity Basin IV and the over-pressured Ursa Basin) on the northern slope of the Gulf of Mexico, are present in this study. In the Brazos-Trinity Basin IV, the $^{87}Sr/^{86}Sr$ ratios of the interstitial water range from 0.70917 to 0.70954, with carbonates sharing similar or slightly lower values from 0.70851 to 0.70952. The interstitial water above 31 m shows similar $^{87}Sr/^{86}Sr$ ratio close to that of seawater, whereas the interstitial water below 31 m shows more radiogenic $^{87}Sr/^{86}Sr$ ratios, possibly indicating a water/rock interaction between the fluid and silicate component in the deep basin sediments. The Sr-isotope ratios of the carbonates are less radiogenic than the seawater, which may reflect a terrestrial carbonate input (such as limestone) transported through the Brazos and Trinity rivers. In the Ursa Basin, the $^{87}Sr/^{86}Sr$ ratios of the interstitial water range from 0.70887 to 0.70999, those of the carbonate vary from 0.70808 to 0.70930. Both the interstitial water and carbonate show a similar trend of $^{87}Sr/^{86}Sr$ ratios throughout the depth. The $^{87}Sr/^{86}Sr$ ratios of the interstitial water decrease from the sea floor surface to the minimum at the Seismic Reflector S10. A lateral fluid incursion with less radiogenic $^{87}Sr/^{86}Sr$ ratios along the Seismic Reflector S10 can be inferred in the Ursa Basin. It is suggested that the lateral fluid incursion shows a seawater origin, modified by diagenetic reactions including the dissolution of halite. Between the Seismic Reflector S10 and S40, $^{87}Sr/^{86}Sr$ ratios of the interstitial water increase linearly to the maximum. Along the Seismic Reflector S40, a lateral fluid incursion with more radiogenic $^{87}Sr/^{86}Sr$ ratios is again recognized. The fluid may have also originated from seawater, but modified by the diagenesis of terrigenous sediments, likewise characterized by highly radiogenic $^{87}Sr/^{86}Sr$ compositions. A two-dimension fluid-flow model in the Ursa Basin is established.

1. Introduction

Rapid sedimentation creates overpressure and controls compaction-driven fluid flow (Bredehoeft and Hanshaw, 1968; Bethke, 1986; Harrison and Summa, 1991; Judd and Hovland, 2007; Sun et al., 2012; Sun et al., 2014). Near seafloor fluid flow are important to understand because they influence stability of the slope (Flemings et al., 2006). Fluid-flow model can be constructed through fluid pressure (Flemings et al., 2008). The lateral fluid driven by the topography can be recognized through the detection of either pressure measurement or geochemical data (Flemings et al., 2006; Li and Jiang, 2010).

The chemical compositions of pore fluids and sediments can provide valuable information on the fluid sources, fluid pathway, diagenetic reactions and the burial history of the sediments (Teichert et al., 2005; Reitz et al., 2007; Jiang et al., 2015; Ye et al., 2015). For example, strontium isotope is a key tracer for fluid/rock reactions (Stueber et al., 1984; Teichert et al., 2005), fluid pathway (Teichert et al., 2005), fluid mixing patterns and sources (Reitz et al., 2007; Sun et al., 2011). The Integrated Ocean Drilling Program (IODP) undertook Expedition 308, dedicated to the study of over-pressure and fluid flow on the continental slope of the Gulf of Mexico. Drilling at the normally-pressured Brazos-Trinity Basin IV and the over-pressured Ursa Basin (Fig. 1), was revealed an active hydrodynamic environment that provided an insight into the geological processes near the sub-seafloor. A two-dimension fluid flow model in the Ursa Basin was established (Flemings et al., 2006, 2008; Binh et al., 2009; Stigall and Dugan, 2010). This model focused mainly upon the over-pressure driving the fluid flow in the Blue Unit

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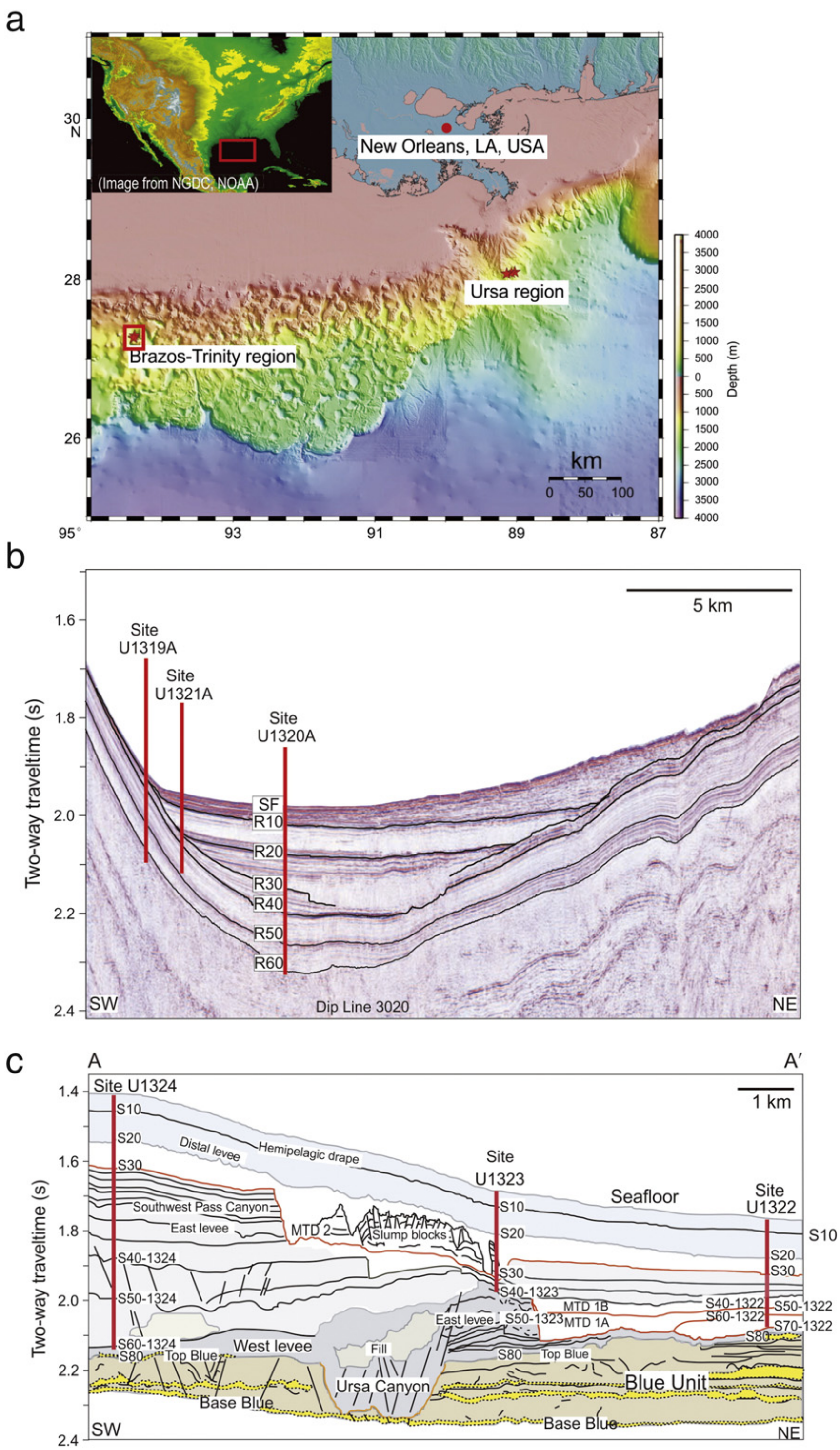

Fig. 1. (a) Location of the normally-pressured Brazos-Trinity Basin and the over-pressured Ursa Basin. (b) 2-D schematic seismic profile of the Brazos-Trinity Basin IV and the sampling sites. (c) 2-D schematic profile of the Ursa Basin showing the sampling sites.
Modified from Flemings et al. (2006).

(shown in Fig. 1c) at the bottom of the basin. The model characterizes upward flow above 200 m and downward flow below 200 m at Site U1324, but the source of upward and downward flow is puzzled.

In addition, a lateral fluid along the Seismic Reflector S10 at shallower depths was also recognized (Flemings et al., 2006; Li and Jiang, 2010), however the source of this lateral fluid incursion is still unknown. In this study, Sr isotopic compositions of the interstitial water and carbonate from sediments recovered in the normally-pressured Brazos-Trinity Basin IV and the over-pressured Ursa Basin in the Gulf of Mexico during IODP308 drilling are reported and compared. Attempts are made to demonstrate Sr isotope behaviors as an indication