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Research paper

Natural gas hydrates in the Rio Grande Cone (Brazil): A new province in the western South Atlantic

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ABSTRACT

The Rio Grande Cone is a large-scale fanlike feature in the continental slope of the Pelotas Basin, Southern Brazil, where ubiquitous world-class bottom simulating reflectors (BSRs) are readily observed in seismic records. With the purpose of searching for natural gas hydrate deposits in the Cone area, four oceanographic cruises were carried out between May 2011 and July 2013, leading to the discovery of two pockmark fields, active faults and gas hydrates in shallow sediments. Multichannel seismic, multibeam echo sounder, side scan sonar and sub-bottom profiler records were used to map the shallow section and select sites for piston core sampling. Gas hydrates were recovered in several piston cores within muddy sediments collected inside pockmarks displaying high backscatter in the multibeam and side scan sonar data. We present two representative piston cores where numerous levels of gas hydrates occur, along with degassing features, authigenic carbonate and soupy sediments. Gas dissociated from gas hydrate samples is dominantly methane (>99.78%) with minor quantities of ethane. The chemical and isotopic compositions of the gas strongly suggest a biogenic origin for the analyzed samples. These new findings are regarded as strong enough evidence to consider the Rio Grande Cone as a new gas hydrate province.

1. Introduction

Understanding the distribution of natural gas hydrate deposits, their inventory and overall characteristics is of major interest considering their potential as an energy resource, key role in global climate change and associated geohazards. Natural gas hydrates may prove to have substantial economic value owing to the enormous quantity of combustible gas (mainly methane) hosted in their clathrate structure. Speculative estimates of the amount of gas contained in worldwide gas hydrate deposits range from 2.8×10^{15} to 8×10^{18} m^3 of gas (Collett et al., 2009).

The interest on the exploration of natural gas hydrates as an energy resource has grown in recent times, particularly as the demand for fossil fuels, largely based on conventional reserves, is increasing at a faster pace than new discoveries. Production of gas from gas hydrates has already been accomplished in pilot tests at Nankai Trough (southeastern Japan; Fujii et al., 2015), and in the Mallik Field (northwestern Canada; Dallimore at el., 2002; Dallimore and Collett, 2005; Dallimore et al., 2012).

In addition to their potential economic importance, gas hydrates may play a key role in climate change events, as their massive dissociation on a global scale could cause the release of enormous quantities of greenhouse gases with high warming potential (Dickens et al., 1997; Haq, 1998; Kennett et al., 2000; Hunter et al., 2013). The role of natural gas hydrates in triggering geohazards is also a subject of great concern given their potential to cause submarine landslides (Driscoll et al., 2000; Hovland et al., 2002; Mienert et al., 2010) and other shallow section instabilities with adverse impacts on hydrocarbon drilling and production operations (Milkov et al., 2000; Hovland and Gudmestad, 2001; Ruppel et al., 2008; McConnell et al., 2012).

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Gas hydrate provinces have been identified in several areas around the globe within marine and lacustrine sediments, and deposits associated to permafrost areas in polar regions. The identification of such provinces is accomplished by using geophysical indications, geochemical evidence and/or direct recovery and sampling. The most widely used geophysical indication is the presence of bottom simulating reflectors (BSR) in seismic records (Shipley et al., 1979; Katzman et al., 1994; Gehrmann et al., 2009). Geochemical parameters, such as the variation in interstitial fluid salinity associated to hydrate dissociation or formation, are also employed (Ussler et al., 2001; Coffin et al., 2007). From the 113 provinces mapped worldwide, gas hydrates have been recovered in 44 sites at inland seas and lakes (Japan Sea, Black Sea, Caspian Sea, Lake Baikal and Mediterranean Sea), onshore continental areas (Mackenzie Delta and North Slope) and throughout the Pacific, Indian and Atlantic oceans (Collett et al., 2009; Kvenvolden and Lorenson, 2010). The South Atlantic, in particular, has at least 8 sites in which the occurrence of gas hydrate has been inferred by seismic records (BSR), including three areas in Brazil, notably in the Amazon and Rio Grande cones. Yet the recovery of natural gas hydrates has only been reported in the eastern South Atlantic along the Niger Delta and Congo Fan (Brooks et al., 2000; Collett et al., 2009; Kvenvolden and Lorenson, 2010).

The presence of widespread BSRs in the Rio Grande Cone, Pelotas Basin, was previously reported by Fontana (1989), Fontana and Mussumeci (1994), Sad et al. (1997, 1998), suggesting the presence of gas hydrate deposits in a large portion of the cone area covering nearly 45,000 km^2 within water depths of 500 m to 3500 m. Despite such indications, the Rio Grande Cone remained unexplored for many years thereafter. A more recent time-frequency spectral signature study performed by Oliveira et al. (2010) in seismic lines from the Rio Grande Cone associated spectral anomalies to the possible occurrence of gas hydrate accumulations above the BSR and free gas zones, gas flux features and gas reservoirs below the BSR. Furthermore, studies carried out in the Uruguayan portion of the Pelotas Basin to the southwest of the Rio Grande Cone identified a large area displaying highly continuous BSRs in seismic records (Tomasini et al., 2011a,b). This portion of the Pelotas Basin may represent a sizeable gas hydrate occurrence contiguous to the Rio Grande Cone area.

Renewed interest in investigating natural gas hydrates as an energy resource in Brazil has led to a new research study in the Rio Grande Cone with the purpose of sampling and characterizing gas hydrate deposits in the area. Such study, which resulted from a joint effort between PETROBRAS and the Pontifical Catholic University of Rio Grande do Sul (PUCRS – CONEGAS Project), included the collection of geophysical, geological, geochemical, biological and oceanographic data from 2011 to 2013.

In this paper we present and discuss some of the data collected during the four oceanographic cruises completed thus far, unveiling

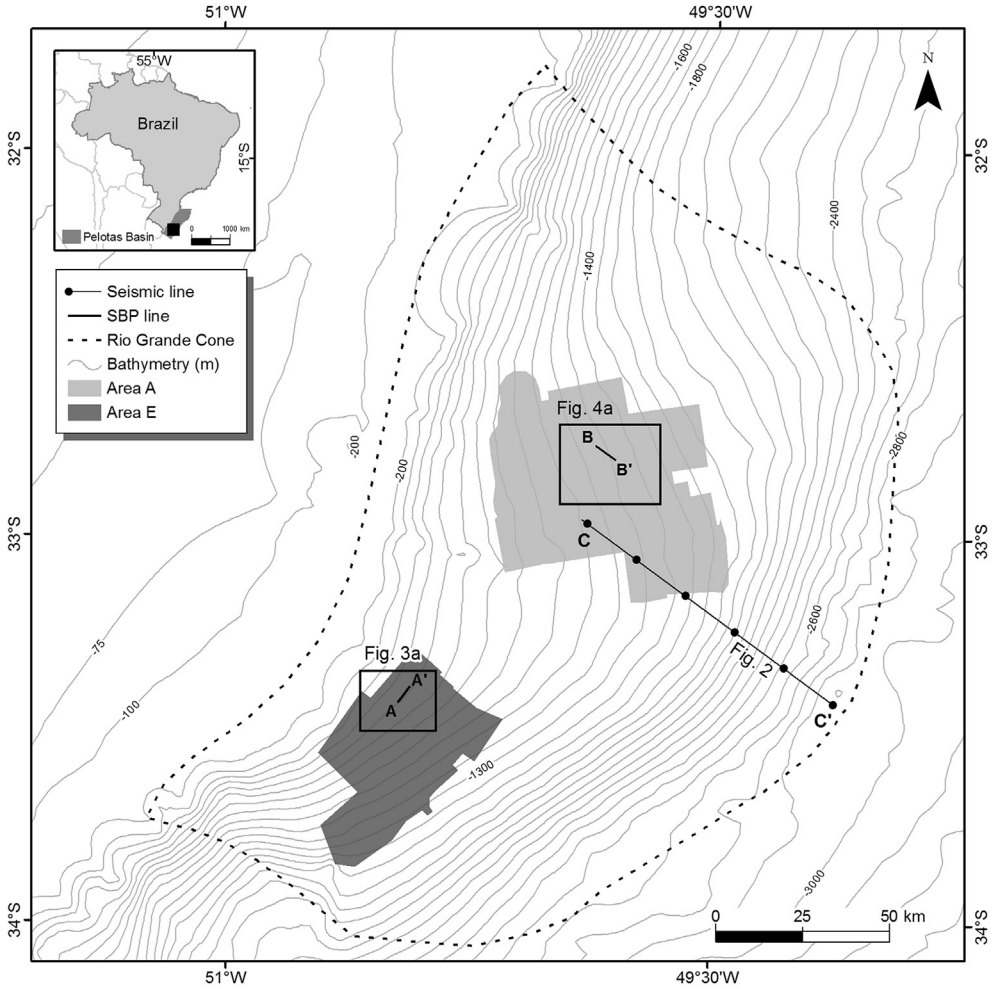

Figure 1. Location map showing the study areas (E and A) in the Rio Grande Cone, Pelotas Basin (Southern Brazil). For detailed maps of the study areas see Figures 3a and 4a. Lines A–A′ and B–B′ refer to SBP (Sub Bottom Profiler lines) shown in Figures 3b and 4b, respectively. Line C–C′ is the regional 2D seismic line shown in Figure 2.