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A giant oil seep at a salt-induced escarpment of the São Paulo Plateau, Espírito Santo Basin, off Brazil: Host rock characteristics and geochemistry

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ABSTRACT

An international research cruise named Iatá-Piuna took place on the São Paulo Plateau on May 2013 in the Campos and Espírito Santo basins, off Brazil. The cruise was carried out on board the research vessel (R/V) Yokosuka that hosts the human operated vehicle (HOV) SHINKAI 6500. It aimed at finding chemosynthetic communities, composed of organisms capable of generating their own vital energy by metabolizing organic and inorganic compounds related to seeps. Identification of these organisms could provide information for understanding the origin of life, since they may resemble primitive organisms that existed in the initial stages of life on Earth. During Leg 2 (May 10–24, 2013), however, dives on the northern part of the São Paulo Plateau at the Espírito Santo Basin led to the discovery of a giant oil seep. The seep, ca. 3 nautical miles (ca. 5.6 km) in length is located along an outcrop of Eocene rocks on a salt-induced escarpment of the plateau and at a water depth of ca. 2700 m. The 200 m relief of the seafloor suggests that the seep takes place along an active fault system driven by salt diapirism. The oil was analyzed and identified as a severely biodegraded marine oil, generated by carbonate rocks within a minibasin located to the east of the escarpment. This represents valuable exploratory information because it proves that an active petroleum system is present in the context of minibasins associated with salt diapirism in the area.

1. Introduction

The Iatá-Piuna research cruise was promoted by an agreement between the governments of Brazil and Japan and it was part of an international project named *Quelle 2013 - Quest for the Limit of Life* – that investigates the Southern Hemisphere around the world. The main objective of the Iatá-Piuna cruise was the study of organisms associated with hot and cold seeps, adapted to extreme environmental conditions in the southern Atlantic Ocean, off Brazil. These organisms, components of the so called chemosynthetic communities, synthesize organic and inorganic compounds directly from fluids migrated from great subsurface depths and may provide important information about the origin of life on early Earth.

This article aims to present and discuss findings on Leg 2 (May 10–24, 2013) that occurred on the northern portion of São Paulo Plateau – Espírito Santo basin (Point 6 - Fig. 1). During Leg 2 the cruise searched for cold seeps associated with fluids that migrated from deep hydrocarbon reservoirs or source rocks through faults related to salt diapirism. The dive at Point 6 led to the discovery of a giant oil seep that was sampled and later analyzed being identified as biodegraded marine oil generated by carbonate rocks. This is valuable exploratory information because it indicates that an active petroleum system is present in the context of minibasins associated with salt diapirism in ultra-deep water in the region. This seep is very similar to that described by Jones et al. (2014) at the Angola Margin and represents one of the first published oil seep observations on the Brazilian Margin.

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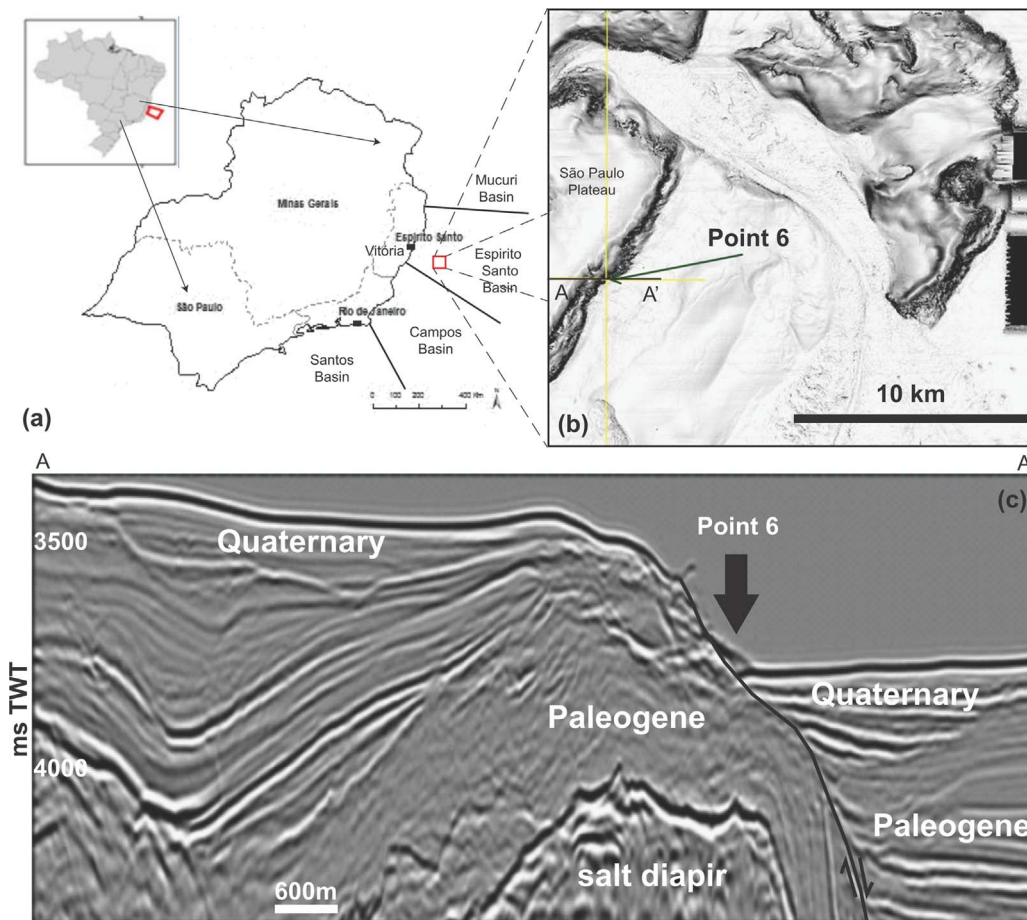


Fig. 1. (a) Location map of the study area (small square) showing the Southeast region of Brazil and the geographic limits of sedimentary basins; (b) Location map of Point 6, showing the seafloor relief based on 3D seismic data. São Paulo Plateau is indicated (modified from Schreiner et al., 2009); (c) Seismic profile showing Point 6 location at a 200 m escarpment on the seafloor relief, related to salt diapirism. Note a fault associated with halokinesis and the formation of a minibasin to the east (seismic section kindly provided by ION GeoVentures).

1.1. Geologic setting

The offshore portion of the Espírito Santo basin is located at the southeastern part of the Brazilian Atlantic margin, bounded by the Campos Basin to the south and the Mucuri Basin to the north (Fig. 1). Metamorphic rocks of the São Francisco Craton and part of the Araçuaí Belt (França et al., 2007) constitute the basement. From the Valanginian (ca. 140 Ma) to the Early Aptian (ca. 120 Ma) the sin-rift phase sedimentation is composed of lacustrine carbonates, together with sands delivered by river discharges, and of volcanic events, composed of basalt spills and volcanoclastic rocks (França et al., 2007).

The sag phase occurred during the Late Aptian, when an evaporitic sequence was deposited at ca. 110 Ma, associated to fluvic/deltaic sandstones, deposited in shallow waters. These sediments represent the Post-Rift Sequence of the Espírito Santo Basin (França et al., 2007). The Drift Sequence occurred since the Early Albian (ca. 110 Ma) and is represented by shelf sandstones and shelf carbonates in shallow waters and by shales and turbiditic sandstones in deep waters. These sediments were crosscut by basalts of the Abrolhos Fm. during the Late Paleocene to Late Eocene (62–37 Ma).

Diapiric salt structures are abundant in the Espírito Santo Basin, especially in ultra-deep-waters, and control the deposition of sandy reservoirs and the formation of positive structures that provide oil traps (França and Mohriak, 2008). Several oil fields were discovered in deep and shallow waters, as well as in the onshore portion of the Espírito Santo Basin.

2. Methods

2.1. Selection of the diving site at Point 6

Point 6 was situated at the outer escarpment of the northern São Paulo Plateau, in the Espírito Santo basin. This sampling location was selected on the basis of a 2D seismic profile (Fig. 1), in which a 200-m escarpment on the seafloor relief is observed. The reason for having chosen this location in this context was that the escarpment could represent a pathway for migration of hydrocarbons along a salt wall, potentially forming a habitat suitable for the occurrence of chemosynthetic communities.

2.2. DATA acquisition

Iatá-Piuna cruise used the support vessel R/V Yokosuka from the Japan Agency for Marine Earth Science and Technology (JAMSTEC), dedicated to the human operated vehicle HOV SHINKAI 6500. Four dives were performed at Point 6, identified as #1343, #1345, #1346 and #1347 (Fig. 2). Samples of rocks, oil, sediments, water and marine organisms were collected using SHINKAI 6500 manipulators, baskets, push-cores, slurp gun and Niskin bottles. All materials were brought on board of R/V Yokosuka for sub-sampling, identification and packaging. The submersible HOV SHINKAI 6500 is equipped with digital cameras for photos and movies of high-resolution quality. The lights of the SHINKAI 6500 can illuminate ca. 50 m ahead, providing good seafloor visibility.

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