Journal of South American Earth Sciences 47 (2013) 166–178

Contents lists available at ScienceDirect

Journal of South American Earth Sciences

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

Molecular organic geochemistry of the Apiay field in the Llanos basin, Colombia

J.E. Cortes [a,b,*], J.E. Niño [a], J.A. Polo [a], A.G. Tobo [a], C. Gonzalez [a], S.C. Siachoque [a]

[a] Antek S.A. – Environmental & Petroleum Geochemistry Laboratory, Calle 25B #85B-54, Bogotá, Colombia
[b] PetroMarkers, Inc. – Petroleum Geochemistry Laboratory, 830 Bay Star Blvd., Webster, TX 77598, USA

ARTICLE INFO

Article history:
Received 8 May 2013
Accepted 13 July 2013

Keywords:
Sesquiterpanes
Hopanes
Steranes
Biodegraded mixed oils
Apiay field
Colombia

ABSTRACT

The bulk properties and molecular organic geochemical composition for crude oils from the Apiay, Suria and Reforma/Libertad producer areas, which integrate the Apiay field located in the southwest area of the Llanos Basin in Colombia were analyzed by gas chromatography (GC/FID), isotopic analysis and gas chromatography/mass spectrometry (GC/MS) analysis.

The main producing intervals in the Apiay field are known as the K2 and K1 units of the Guadalupe Formation, a thick siliciclastic sequence deposited during the Upper Cretaceous to Upper Eocene in a fluvial and transitional marine system. The crude oils analyzed are paraffinic, with saturate fraction >60%, the $\delta^{13}C$ isotopic composition ranging from −26.19 to −25.62 for the saturated fraction, −25.84 to −24.02 for the aromatic fraction, and canonical variable (C.V.) <0.47, which characterized them as non-waxy marine oils. The saturated fraction analyzed by GC/FID presents a unimodal distribution between n-C_{10} to n-C_{33} with n-C_{15} to n-C_{17} as the major peaks. CPI is close or slightly greater than 1.0, Pr/Ph ratio >1.5, low ≈ high molecular weigh hydrocarbons indicating an input of algal/microbial organic matter with a significant input of terrigenous matter (higher plants).

Branched/Cyclic biomarkers, previously separated from n-alkanes by silicalite/ZSM-5 (S-115), were analyzed using SIM-GC/MS. Samples from the Apiay area showed higher concentration of tricyclic terpanes than samples from Suria and Reforma-Libertad, respectively, which suggests an early diagenetic influence of marine saline water, consistent with early generation from marine organic matter. However, the presence of a great suit of sesquiterpanes and diterpanes in all samples confirming an angiosperm input. Ts/Ts + Tm falls in the range of 0.25–0.66, all samples present gammacerane, C_{31}-Hopane isomerization index ranged between 0.50 and 0.71. A predominance of C_{29} over C_{27} and C_{28}-steranes in the Apiay area indicates terrigenous source rock for most of the samples, however samples from the Reforma-Libertad and Apiay areas show mixing characteristics of crude oils originated from marine and terrigenous sources.

Diasteranes are higher than regular steranes, which predicts a siliciclastic lithology for these Upper Cretaceous sourced oils. Thermal maturity, according to 20S/20S + 20R-C_{29} and ββ/αα + ββ-C_{29} steranes and aromatic parameters, suggests that some of the oils were generated in the peak oil window. Biomarker results suggest a transitional fluvio-deltaic depositional environment with a predominance of continental fluvial type facies with marine episodes, which agrees with the marine input (algal/microbial) and with a moderate input of highland organic matter. The norhopane index indicates a greater biodegradation process in the Apiay area that in Suria and Reforma/Libertad areas.

1. Introduction

The Apiay field is one of the most important petroleum producing field under administration of the Colombian Petroleum Company (Ecopetrol S.A.). The field has an area of 15,000 km^2 and is located in the Apiay-Ariari sub-basin of the Llanos basin in Meta,

* Corresponding author. Petromarkers, Inc. – Antek S.A., 830 Bay Star Blvd., Webster, TX 77598, USA. Tel.: +1 713 261 4828.
E-mail address: jcortes@petromarkers.com (J.E. Cortes).

0895-9811/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jsames.2013.07.007

Colombia. Discovered in 1981, at the present time, its original reserves have been estimated in 50,000 barrels of crude oil and 15 million-ft^3 of natural gas (Carta Petrolera, 1999; El Tiempo, 2011).

Various studies of the Apiay field have been reported in the literature. The National University of Colombia has done various studies related with the stratigraphic and the petroliferous potential of the basin, in addition to several petrographic and paleontological studies in oils and source rocks (Mayorga and Vargas, 1995; Varela, 1997; Cabrera, 1999). The Colombian Petroleum Institute (ICP) has done many multidisciplinary studies of source rocks and crude oils samples in the Llanos basin (Tegelaar et al., 1995; Rangel et al., 1996; Rangel et al., 1999). Bonilla (1996) evaluated 82 samples from this basin using SARA, GC/FID, and biomarkers analysis. Luna et al. (1996) studied samples of crude oils and seeps from the Apiay and Castilla fields to characterize its origin, maturity, and biodegradation. Dzou et al. (1999) have reported the application of new diterpane biomarkers to evaluate source, biodegradation and mixing effects on samples from the central Llanos basin. Palmer and Russell (1988) have defined 5 oil families in Llanos basin based on the analyses of 53 crude oils. Ramon et al. (2001) evaluated the evolution of the Cretaceous organic facies in Colombia studying samples from the Llanos basin without including samples from the Apiay field. More recently, Cortes et al. (2010) have used CSIA and GC/MS to differentiate Cretaceous and Tertiary crude oils from the Llanos basin.

This paper presents a detailed analysis of the bulk properties and biomarkers composition crude oils from the Apiay field in order to predict the geochemical characteristics of its source rock, depositional environment, maturity, organic matter origin, and age. The analyses were performed by gas chromatography (GC/FID), bulk isotopic analysis, and gas chromatography–mass spectrometry (GC/MS).

2. Geological setting

Fig. 1 shows the localization of the area study. As it is observed, the Apiay oil field has three producing areas named Apiay, Suria and Reforma-Libertad. Fig. 2 presents a generalized stratigraphic column of the Llanos basin (NHA, 2010; NHA, 2012). The sedimentary column is represented by rocks from the Lower Paleozoic (Cambro-Ordovician), Upper Mesozoic (Upper Cretaceous) and Cenozoic (Tertiary and Quaternary). The units of petroliferous interest are found in the Upper Cretaceous and Upper Eocene rocks (Bohorquez and Valderrama, 1991).

The Cretaceous sequence presents ages ranging from Cenomanian to Maestrichtian, thinning to 1650 feet. This sequence has been divided from base to top in the K2 and K1 operational units. Perez and Bolivar (1985) argue that the K2 unit lies unconformably over Paleozoic rocks with a thickness of 700 feet and is comprised of thick grained of quartz sand; which overlies in transitional contact the K1 unit with a thickness of aprox. 450

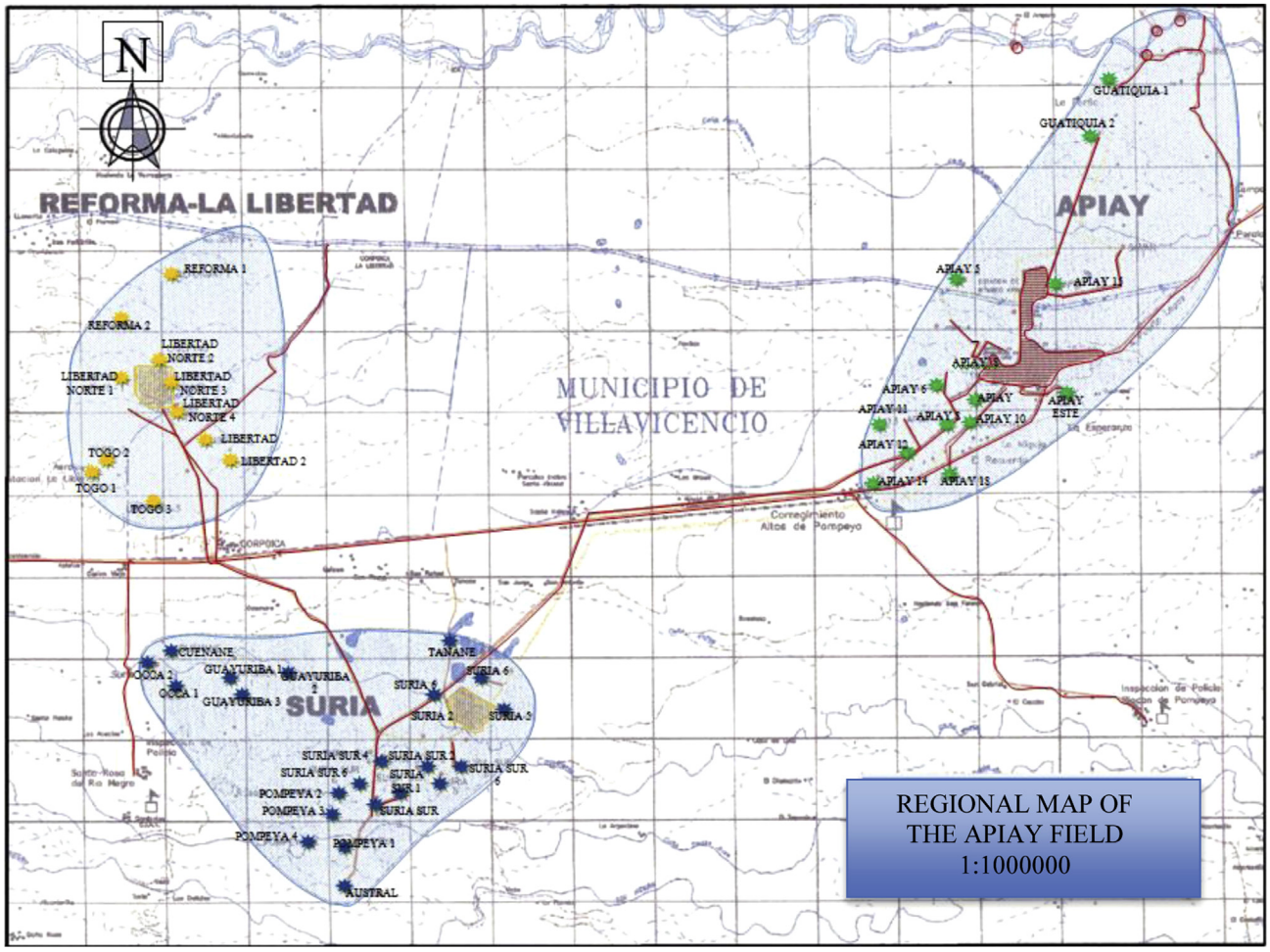

Fig. 1. Regional map and well localization of the Apiay, Suria and Reforma-Libertad areas in the Apiay Oilfield.