# Carbon rich shale and their palaeo-environment in the Cretaceous Llanos Basin, Colombia Newcastle University (Civil Engineering & Geosciences) In partnership with Ecopetrol, Colombia and SINTEF, Norway

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#### **Key Words**

Cretaceous petroleum source rocks in Columbia, Spatiotemporal evolution of palaeo-environments, multi-proxy approach combining field geology, sedimentology geochemistry and modelling

#### **Overview**

The Llanos Basin in central Colombia is a highly complex geological province that has undergone a dynamic tectonic and sedimentary history, challenging the understanding of the current petroleum system and its development in the geological past.

To achieve an improved understanding of the possible source(s) of the petroleum in the Eastern Cordillera, the Foothills and Llanos Basin area, a new framework research program was initiated by Ecopetrol, the national oil company in Colombia, encompassing a wide range of advanced technologies that deliver the level of resolution and specificity to successfully model the generation, migration, trapping, biodegradation and seepage loss of petroleum through geological time at a regional scale.

One central objective of this framework is to establish and quantify the various factors that control source, quality and volume of petroleum trapped within the reservoirs today. To achieve this overarching goal it is identified that the integration of comprehensive geochemical techniques with petroleum system modelling is a crucial step in order to obtain the level of precision demanded by Ecopetrol.

Two industry-funded PhD studentships are available to generate a comprehensive sedimentological and geochemical characterization of organic carbon rich shale from three distinct stratigraphic units in the Llanos Basin, based on new field and analytical work in Colombia, hosted in the School of Civil Engineering and Geosciences at Newcastle University.



Fig. 1. Upper Cretaceous sandstone-shale alternations in the Colombian Andes; organic rich shale beds (insert)

The new data will be used to provide an integrated interpretation of the palaeo-environmental development of the region, both spatially and temporally, and to provide key input variables for Organic Facies modelling, conducted by SINTEF, Norway.

#### **Plan of study**

The studentships will involve extended work and research visits to Colombia (estimated to be up to 10 months in years one and two of the project) to conduct the field sampling and complete the laboratory work under guidance of staff and by using in-house analytical facilities at Ecopetrol. Furthermore, specialized and advanced analyses not feasible in Colombia will be conducted at Newcastle and its collaborative institutions. The project will conduct a comprehensive characterization and assessment based on a broad range of sedimentological, stratigraphic, mineralogical, and inorganic geochemical data.

Main aims of the program include:

- A detailed sedimentological description of the field sections and samples obtained
- Grain size analyses of representative samples for further geochemical analyses;
- Major and trace element distributions for reconstruction of paleoclimate/environment (weathering, runoff, transport energy), ocean redox (anoxia, euxinia), and nutrient cycling;
- Bulk carbon stable isotope and organic geochemical analyses for correlation with global carbon perturbations (Oceanic Anoxic Events, OAE) and identification of sources and maturity of sedimentary organic matter.
- Development of age models utilizing isotope stratigraphy (chemostratigraphy), statistical analyses (cyclostratigraphy), and other biostratigraphic information.

This project will actively contribute to the modelling program at SINTEF, Norway, possibly including training and research visits of 4 month in total to Norway in years 2 and 3 of the program.

#### **Key outcomes**

Major contributions to the reconstruction and 3D model simulation of spatiotemporal facies distribution of the distinctive organic facies occurring through Cretaceous formations, as the possible main source rock units for three oil families accumulated in Tertiary and Cretaceous reservoirs of the Llanos Basin, Colombia.

#### **Methodology**

The project will use a wide range of analytical techniques in geochemistry and sedimentology including grain size analyses, XRF and/or ICP-OES/ICP-MS element for major and trace distributions, AE-IRMS for bulk carbon isotope analyses, Py-GCMS, GC-MSMS, LC-MS for advanced molecular characterization of organic matter, AAS and special extraction lines for Fe and P specification, and possibly 2D-GCMS and MC-ICP-MS for advanced element isotope systems (Mo, S, etc.) at our collaborative institutions.

#### Timeline

The start of the project is planned for spring 2014 (3 year duration)

**Year I**: Field work for sample acquisition and literature review, comprehensive laboratory training, optimization of analytical protocols, start with sample analysis.

Years 2: Progression of sample analysis and start of modelling work in partnership with SINTEF, Norway. Year 3: Data integration, thesis completion, papers for international journals.

### **Training & Skills**

The students will receive a comprehensive training, which is of broad relevance to petroleum systems research. Training will be offered at Newcastle, Ecopetrol (Bucaramanga), and SINTEF (Norway). Beyond the generic skills training at Newcastle's Graduate School and the comprehensive program of the CDT Training Academy, you will gain specialist experience in organic petroleum geochemistry, inorganic and isotope geochemistry, and organic facies modelling at SINTEF, providing a unique and broad skill set targeted at oil/gas and environmental careers, both in the commercial sector and in academia.

## **References & Further Reading**

Villamil, T., 1998. Chronology relative sea level history and a new sequence stratigraphic model for basinal Cretaceous facies of Colombia, Paleoceanographic Evolution and Non-glacial Eustasy, Northern South America. Society for Sedimentary Geology, SEPM Special Publication 58, pp. 161-216.

# Eligibility and application procedures

One studentship is open to UK residents (CI-692). The second project is open to any citizen of a European Union (EU) member state (CI-693). A full award covers tuition fees at the UK/EU rate and an annual stipend of £13,726 (2014-15) for 3 years. A research statement and CV, quoting the project reference number should be sent to: thomas.wagner@ncl.ac.uk . You must apply through the University's online postgraduate application form https://aspire.ncl.ac.uk/Register. In the 'Studentship/Partnership Reference' field, please insert the reference number. See further information under "Funded PhD studentships" at http://www.ncl.ac.uk/ceg/.

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