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CHARACTERIZATION OF ORGANIC MATTER AND MATURATION OF LATE JURASSIC ROCKS FROM CONSTANCIA AND CIFUENTES FORMATION, CUBA

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Resumo – O objetivo deste estudo foi descrever as principais características da matéria orgânica contida em rochas sedimentares do Jurássico Superior da Unidade Tectono-Estratigráfica Placetas, compreendendo as Formações Constancia e Cifuentes (Bacia Marginal de Cuba).

A combinação do estudo ótico provê uma importante compreensão sobre o tipo de matéria orgânica, uma detalhada informação sobre as variações de diferentes fácies sedimentares e o potencial de geração de petróleo em ambas formações.

Os resultados mostram que, o querogênio das rochas Jurássicas pode ser subdividido em material lenhoso alóctone, presente nas amostras da Formação Constancia e, matéria orgânica autóctone rica em hidrogênio (matéria orgânica amorfa e fitoplâncton) tipo II-III. O querogênio da Formação Cifuentes está dominado por matéria orgânica amorfa com algum material lenhoso (principalmente restos de plantas retrabalhadas) tipo II.

Palavras-Chave: Petrografia Orgânica, Geoquímica Orgânica, Querogênio, Cuba.

Abstract: The purpose of this study was to describe the principal characteristic of organic matter contained in sedimentary rocks of the Jurassic Placetas Tectono-Stratigraphic Unit (TSU), comprising Constancia and Cifuentes formations (northern Marginal Basin of Cuba).

The combined optical/chemical studies have provided important insight on the types of organic matter, detailed information on its variation in different sedimentary facies, and petroleum generation potential of both formations.

Results show that the kerogen from the Jurassic rocks can be subdivided into allochthonous (woody material), which is present in all samples of Constancia Formation, and autochthonous hydrogen-rich organic matter (amorphous organic matter derived from phytoplankton) representing type II-III kerogen. Kerogen from Cifuentes Formation is dominated by amorphous organic matter with some woody material (mainly recycled of plant debris), representing a type II kerogen.

Keywords: Organic Petrography, Organic Geochemistry, Kerogen, Cuba.

Introduction

The Constancia Formation contains variably argillaceous, siliceous and/or organically rich micritic limestones with subordinated calcarenites, sandstones. The upper part of the formation was deposited in an open marine environment, the lower part was deposited in a shallow shelf environment. The Cifuentes limestones were deposited in a highly anoxic marine environment. Source rocks and oils are found in Cifuentes Formation (Sánchez J. R., 1993; Valladares, S. 1995).

Previous geochemical studies concluded that organic-rich shales of the Upper Jurassic Cifuentes and Constancia formations are the source of Cuban Oils (López O., 1997). These units represent deep-water deposition of hemi-pelagic sediments, turbidites deposited on a margin continental shelf and slope under anoxic or dysoxic conditions.

This study focuses on the characterization of the organic matter contained in Constancia and Cifuentes formations, using petrographical and geochemical methods, including vitrinite reflectance, spore color index, fluorescence properties, Total Organic Carbon (TOC) analyses and Rock - Eval Pyrolysis.

2. Sampling and Analytical Techniques

In order to support hydrocarbon exploration in the northern and central areas of the basin by characterizing the organic matter in the pelagic and hemipelagic facies in the Marginal Basin of Cuba, 115 samples were evaluated by study of well samples obtained from three fields. The samples were crushed and homogenized to be submitted for total organic carbon determination (TOC %) and Rock - Eval Pyrolysis, and optical analyses.

Organic Carbon Analysis and Rock - Eval Pyrolysis – about 0.5 g of pulverized rock sample was decalcified with HCl and washed repeatedly with distilled water to eliminate the products of the reaction. The decalcified samples were analyzed using a LECO WR –12 analyzer. The resulting measurements of total organic carbonate expressed as a percentage of the whole-rock weight. Rock - Eval Pyrolysis was performed according to the method described by Espitalié *et al.* (1977).

Kerogen-microscopy analyses were carried out after concentration of the kerogen by treating the samples with HCl and HF to remove carbonates and silicates, respectively (Durand, 1980). For maturity assessments, vitrinite reflectance was measured on particles larger than 10 µm in oil immersion (Stach *et al.*, 1982).

3. Results and discussion

3.1. Cifuentes Formation

The organic carbon content of the source rocks in the Cifuentes Formation ranged from low (0.95 wt. %) to high (9 wt. %), with the majority of samples in the 0.70-6 wt. % range. In the general, the black shales have higher TOC content than the mudstones, limestones and marlstone. The average Rock - Eval Pyrolysis potential (S2) is 0.34 - 15.72 mg HC/g rock for samples with low TOC, suggesting good potential to generate oil and 15 - 83.37 mg HC/g rock for samples with high TOC, indicating excellent petroleum potential. The use of the hydrogen index and the oxygen index determined by Rock-Eval Pyrolysis on total rock has been expressed in terms of sequence top, sequence middle, and sequence bottom on the three wells, Y-18, Y-20, MM-1. The hydrogen (HI) and oxygen (OI) indices fluctuating widely from 24 to 998 mg HC/g TOC, with OI ranging from 10 to 108 mg CO₂/g TOC, respectively.

Kerogen types were determined using Hydrogen Index versus Oxygen Index diagrams (Espitalié ET al., 1977). Figures 3.1 A – B indicated a predominance of organic matter types I, II for the Cifuentes Formation. The hydrocarbon source potential (S2) varies mostly from poor (0.9 kg HC/g rock) to good (83.37 kg HC/g rock), and the average Tmax is 429 °C, indicated the transition of immature to mature zone.

Constancia Formation

Contents of Organic Carbon in sandstones from Constancia Formation are relatively poor (0.52 wt. %), some intervals contain moderate organic layers (3 – 4% TOC within the studied interval). Hydrogen and oxygen indices range from 36 to 758 mg HC/g TOC, and from 33 to 106 mg CO₂/g TOC, respectively, indicating predominance of organic matter of types II and III. Figure 3.1C

The average Tmax varies mostly from 413 to 420 °C and shows that the section of the Constancia Formation is thermally immature. The hydrocarbon source potential (S2) is poor to good (0.32 to 31.94 kg HC/g rock), corroborating the variable quality of the organic matter and the relatively low level of thermal maturity.

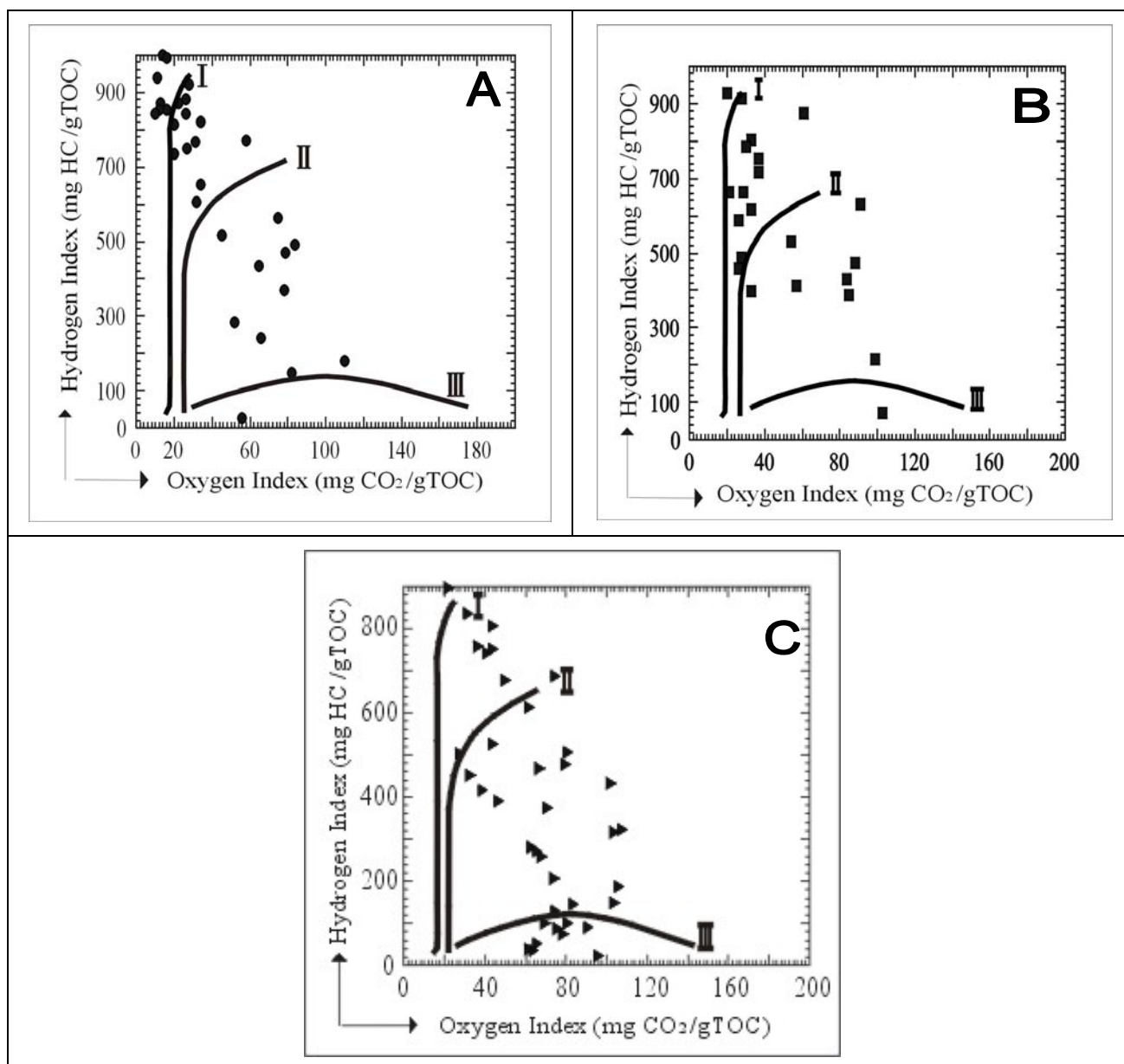


Figure 3.1. Geochemical data on the organic matter type content of the 115 rock samples from the Cifuentes and Constanica formations. Using the Van Krevelen diagram of HI vs. OI. A - Oilfield 1 (Cifuentes Formation); B - Oilfield 1 (Cifuentes Formation); C - Oil field 3 (Cifuentes and Constanica Formation).

4. Organic Matter and Spore Preservation

The composition of organic matter in sediments and sedimentary rock reflect the enormous number of variables that influence the terrestrial or aquatic environments in which it is generated, its transport to the depositional site, and its alteration once deposited. Global scale, time, climate, tectonics and changes in sea level affect the character and geographic occurrence of organic matter.

4.1. Cifuentes Formation

The microscopical analyses of organic matter under blue-light excitation from Cifuentes Formation showed the predominance of orange-fluorescing amorphous kerogen associated with bright yellow-fluorescing telalginite (Plate 1, Fig. 1). Some intervals contain particulate organic matter derived from land plants, generally in form of degraded phytoclasts. Samples generally have two populations of spore coloration: low maturity (spore color yellow to light orange; SCI 3.0) and high maturity (spore color brown; SCI 6.0-7.0). The linings of planispiral foraminifers are generally predominant. The lining are typically dark orange to brown in color (Plate 1, Fig. 2). Vitrinite reflectance

measurements were complicated by the low abundance of vitrinite particles in most samples. The Samples analyzed have two vitrinite populations, varies mostly from 0.25 % to 0.68 % Ro.

4.2. Constancia Formation

The microscopical analyses of organic matter indicated a predominant woody material for the Constancia Formation. The woody organic matter is composed primarily of structured phytoclasts (Plate1, Figs. 3-4), amorphous organic matter is rare under blue-light excitation from Constancia Formation.. Samples generally have two populations of spore coloration: low maturity (spore color yellow to light orange; SCI 2.5) and spore color light orange to dark orange, SCI 5.5 (Plate 1, Figs. 5-6). Vitrinite reflectance measurements vary mostly from 0.3 to 0.63 % Ro.

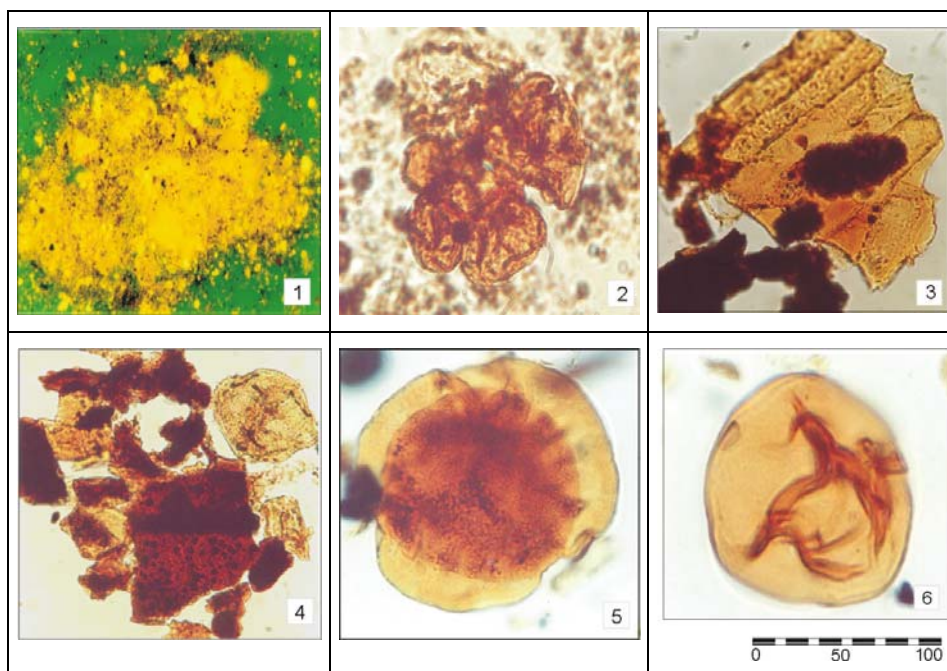


Plate 1 - 1. Strongly fluorescing massive-granular amorphous organic matter, Cifuentes Formation; 2. Amorphous organic matter with foraminifer test, Cifuentes Formation; 3 - 4. Black and brown wood, cuticles and some amorphous organic matter, Constancia Formation; 5-6 Pollen and Spore grains, Constancia Formation.

5. Conclusions

Preliminary results of petrographical and geochemical characterization of the organic matter in Jurassic sediments from Placetas Tectono-Stratigraphic Unit, Cuba indicate that the organic matter in the marine sediments from Cifuentes and Constancia formations have poor to good source rock generative potential. kerogen types I, II are predominant in the Cifuentes Formation, whereas kerogen type III is predominant in the Constancia Formation.

The differences observed in Cifuentes and Constancia formations kerogen variation tend to reflect variations in the state of preservation of these types I, II, III organic matter, affect in quality and in quantity. These alternations are linked to regular fluctuation in oxygen content within the depositional environment, which ranges from dysaerobic to anaerobic cycles.

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