

The Santiago Formation: Source rock of the Napo Group in the Oriente Basin?

J. Gaibor [^], P. A. Hochuli [§], W. Winkler [^], & J. Toro [£]

^{*} Geological Institute, ETH Zentrum, Sonneggstrasse 5, CH-8092 Zürich, Switzerland

[§] Paläontologisches Institut und Museum, Universität Zürich, Karl Schmid-Str. 4, CH-8006 Zürich, Switzerland

[£] Vicepresidencia de Petroproducción, Petroecuador, P.O. Box 17-01-5007, Quito, Ecuador

KEYWORDS: Santiago Formation, Ecuador, kerogen, source rock, palynofacies.

Introduction

The sediments of the Santiago Formation are composed of organic rich shales, sandstones and limestones, which were deposited in an extensive back-arc basin [5]. The organic-rich levels of the formation are considered potential source rocks for the oil in the Oriente Basin [2, 5, 9]. We present the results of a study of organic matter from the type locality along the Patuca - Santiago road. The goal of this study is to evaluate the oil source potential based on palynofacies and rock-eval analysis.

Geological setting

The Santiago Formation outcrops only in the Cutucú Uplift, in the southern of the Subandean Zone of Ecuador. This antiform is interpreted as a positive flower structure [6]. The total thickness of the formation is estimated to be between 1000 and 2700 m [3, 8]. The Santiago Formation is a sequence of grey to black limestones and calcareous sandstones, with intercalations of micaceous and bituminous shales [8]. Some dikes, sills and larger intrusions of felsic and diabasic igneous rocks are described [8].

The Santiago Formation is missing in the flat-lying Oriente Basin. However, a portion of the red beds of the overlying Sacha Formation are interpreted as a possible lateral equivalent [6]. The age of the Sacha Formation ranges from Early Triassic to Early Jurassic [2]. The Santiago Formations is unconformably overlain by the continental facies of the Chapiza Formation. The Chapiza Formation has never been directly dated, however, dating of volcanic rocks of the Misahualli and Yaupi Formations, regarded as it is lateral equivalents [6] Middle to Late Jurassic age [7].

The marine sequence of the Pucará Group in northern and central Perú is also interpreted as a lateral equivalent of the Santiago Formation [1, 2, 3]. This group consist of three formations, the Chambara, Aramachay and the Condorsinga Formation [4].

Discussion and interpretation of results

Based on lithological and sedimentological criteria, we subdivide the Santiago Formation into three members. The lowermost Santiago River Member consists of thick beds of grey and black limestones, black marls and sporadic intra-formational breccias. The middle Yuquianza Member consists of black, partly micaceous and/or calcareous shales, and sporadic intercalations of green siltstones. The youngest member, Patuca Member is represented by a clastic sequence including thick beds of grey, green and brown siltstones and

greywackes, and micaceous and/or calcareous black shales. Basaltic lava flows and dikes are found intercalated in the sediments.

Yuquianza Member : In the black shales at the base of this member we find the ammonites *Paltechioceras* sp. and bivalves of the genus *Plicatula* (cf. *P. harapax*), which can be attributed to Late Sinemurian age (oral communication H. Rieber, 2002). The presence of amorphous organic matter fluorescent and non fluorescent suggest that the kerogen in this member is mostly of type III, although there are some intervals where kerogen type II dominates. The Tmax values and the colour of the AOM indicate that the rocks are thermally mature (Fig. 1A and Fig 2). The Rock eval data suggest a moderate to good source potential for some levels (Fig. 1B).

Patuca Member : From the Yuquianza Member to the Patuca member, a shallowing upward trend of the depositional environment can be inferred. This trend is corroborated by the palynofacies assemblages, indicating a change from an anoxic or disoxic to oxic conditions (Fig. 1). During the deposition of the Patuca Member, strong volcanic activity is documented by the occurrence of lava flows and dikes. The presence of non fluorescent amorphous organic matter suggest that the kerogen in this member is mostly of type III. Values of Tmax and the colour of the AOM also indicate the mature state of the organic matter (Fig. 1A and Fig 2). Some levels with anomalously high values of Tmax and a black colour of the AOM, are probable the coeval volcanism. The Rock eval data indicate a poor to moderate source rock potential (Fig. 1B).

Conclusions

Fossil evidence indicates that the organic rich shales of the Santiago Formation are of Late Sinemurian age and partly coeval with the Aramachay Formation of the Pucará Group in Perú.

The presence of volcanic material in the shales of the Yuquianza Member and the volcanic rocks intercalated in the Patuca Member document volcanic activity during the deposition of the upper part of the Santiago Formation.

The Santiago Formation is thermally mature in the studied area, with high values of TOC and kerogen type II and III. The Yuquianza Member has a moderate source potential. The source potential of the Patuca Member is low (kerogen type III and low values of Hydrogen Index). Within the Santiago Formation only the black shales of the Yuquianza Member has oil source potential.

Acknowledgements. A Swiss Government Grant to JG supported this work. We thank H. Rieber for the identification of the ammonites. We also acknowledge G. Taco and M. Gaibor for their collaboration in the field.

References

- Baby, P., Rivadeneira, M., Bernal, C., Christophoul, F., Davila, C., Galarraga, M., Marocco, R., Valdez, A., Vega, J., Barragan, R., 1998. American Association of Petroleum Geologist Bulletin 82 (10), 1889.
- Díaz, M., Baby, P., Rivadeneira, M., Christophoul, F., 2003. In: Memorias del VIII Simposio Bolivariano – exploración petrolera en las Cuencas Subandinas, Cartagena, Colombia, 208-222.
- Geyer, O., 1974. Neue. Jb. Geologische Paläontologische Mh (H.9), 525-541.
- Louhman, D.L., Hallam, A., 1982. Sedimentary Geology 32, 161-194.
- Pindell, J., Tabbutt, K., 1995. In: Tankard, A.J, Suarez, R., Welsink, H.J. (Eds.), American Association of Petroleum Geologist Memoir 62, 101-128.
- Rivadeneira, M., Baby, P., 1999. La Cuenca Oriente: estilo tectónico, etapas de deformación y características geológicas de los principales campos de Petroproducción. pp. 88.
- Ruiz, G., Thesis Swiss Federal Institute of Technology, Zürich, pp. 260.
- Tschopp, H.J., 1953. American Association of Petroleum Geologist, Bulletin 37 (10), 2303-2347.
- Vallejo, C., Hochuli, P.A., Winkler, W., Von Salis K., 2003. Cretaceous Research 23, 845-859.

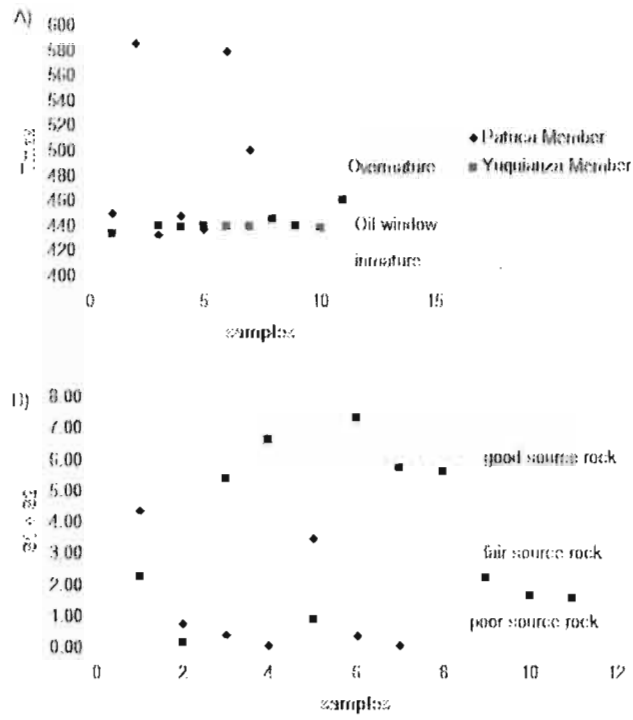


Fig.1: Results of Rock Eval analysis of the members of Santiago Formation. A) Values of Tmax show the mature stage. B) Values of S1 + S2 show the source potential

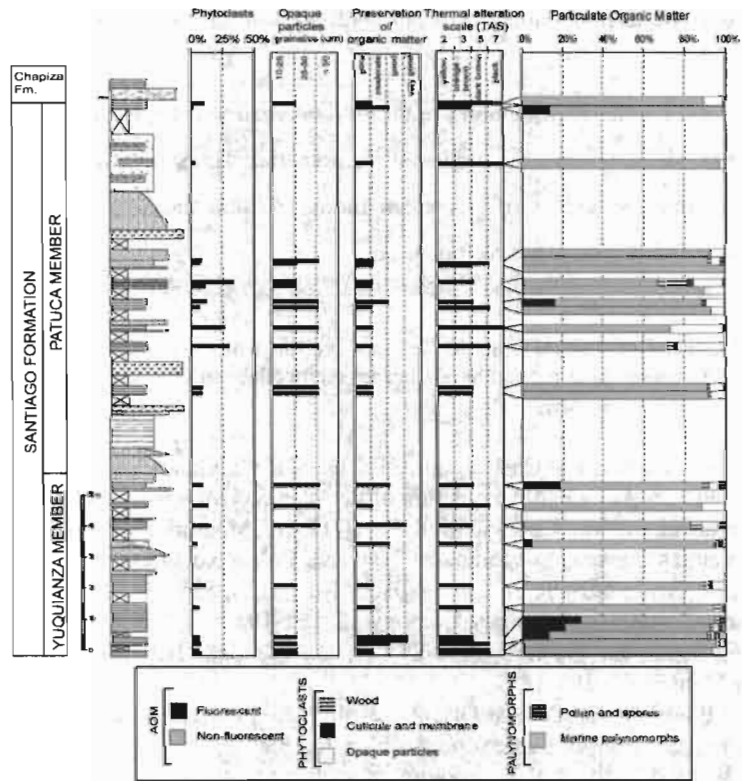


Fig. 2: Results of the Palynofacies Analysis