THE ORIENTE BASIN: AN OPTIMUM TECTONIC - SEDIMENTARY ENVIRONMENT FOR CRUDE GENERATION AND ACCUMULATION

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INTRODUCTION

The Oriente basin, Ecuador, constitutes the most prolific segment of the Putumayo-Oriente-Marañon oil province. In December of 1997, total original reserves was of 6,124 million barrels of crude. This great oil accumulation is product of the tectonic-sedimentary evolution between the Cretaceous and the present time.

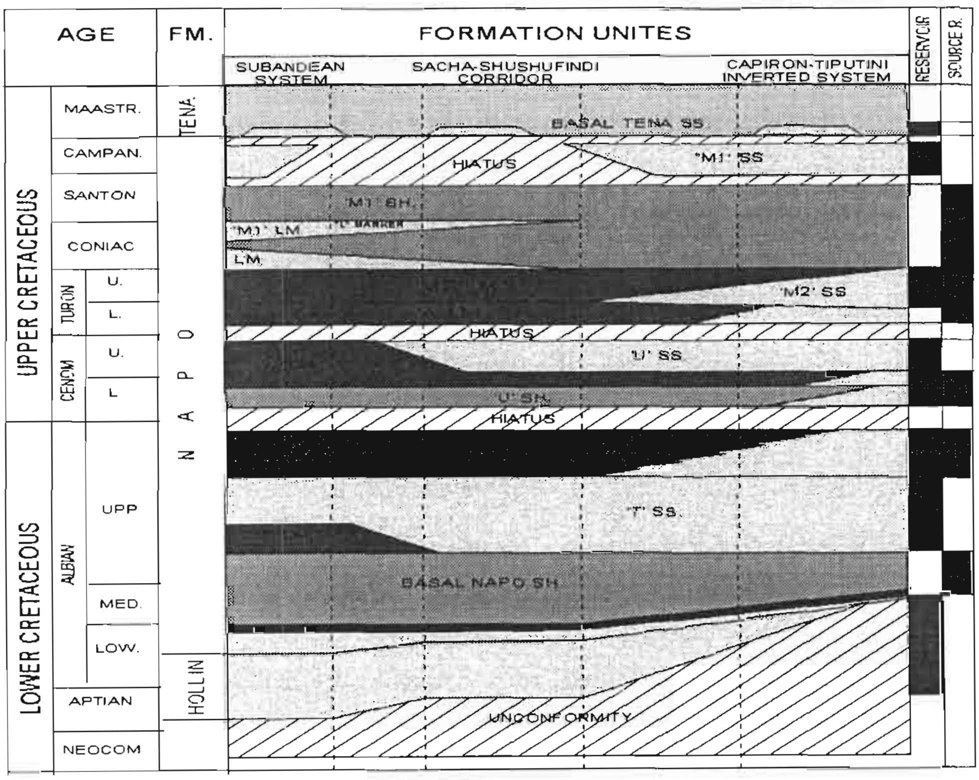
THE SHALY AND CALCAREOUS CRETACEOUS LITHOFACIES (SOURCE ROCKS)

The potential and active source rocks were deposited on a cretaceous platform, in a shallow and half restricted enviroment, with void to scarce presence of bioturbation and pellets. The Napo black shales and interbedded limestones (Basal Napo Shale, "B" and "U" Limestones, "U" and "M1" Shales -Fig. 1), deposited under partially anoxic conditions, constitute rich, potential and active source rocks, whose organic matter content is increased toward the W, reaching the higher values in the NW zone of the basin (greater than 2% of Total Organic Carbon content). Turonian limestones ("A" and "B" Limestones -Fig. 1), comprise mainly black and gray mudstones and wackestones, deposited on a carbonate shelf under quiet waters with partially restricted circulation that create anoxic conditions in certain areas. This conditions change gradually appearing benthic communities. At the end of Turonian time, the basin emersion occurred (Jaillard E., 1997). The Turonian limestones thickens toward the WSW, reaching 400-450'.

THE APTIAN-CENOMANIAN SANDSTONES (MAIN OIL RESERVOIRS)

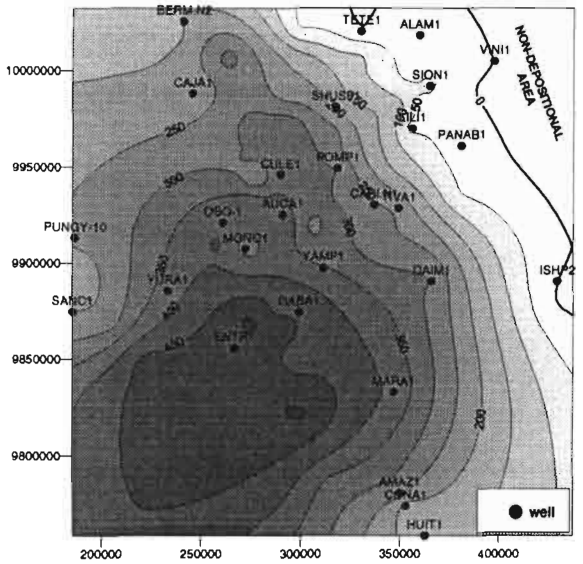
In Late Aptian-Early Albian Hollin basin had a SW- NE orientation, and were deposited quartzose, massive, cross-bedded sandstones with interbedded silty and clayey layers with amber, coal and plant remains in the middle and uppermost section. In the depocenter at the SW of the basin, sedimentary thickness surpass 500', and the section progressively thins toward the eastern-northeastern flank of the basin, until disappearance (Fig. 2). These sediments express a fluvial enviroment, type braided, with channel facies and minor overbank levee and crevasse splay. Thereafter, over a regional condensation surface, were deposited glauconitic calcareous sandstones, interbedded with calcareous black shales of the uppermost Lower Albian (Basal Napo Sandstone) in an estuaries and tidal flats environment.

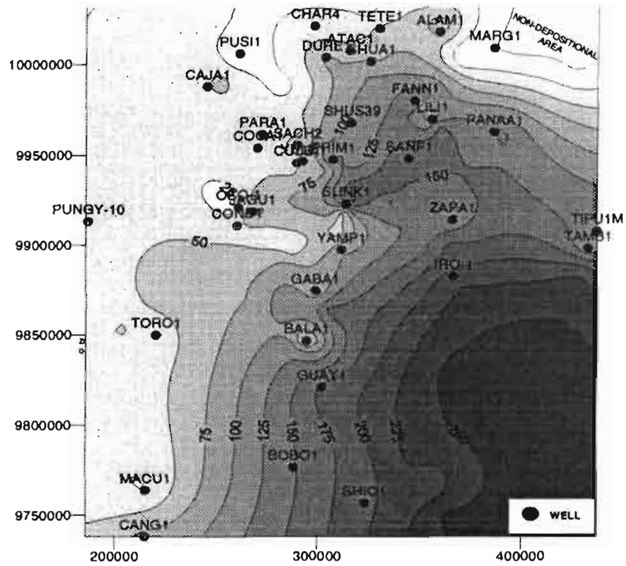
The Upper Albian "T" and Cenomanian "U" sandstones (Fig. 1) consist of quartzose sandstones, in part glauconitic, which were deposited in predominantly fluvial enviroment to the east basin border, ranging westward and vertically to estuaries and deltas with tidal influence. To the westernmost, it was a domain of a well-developed shelf enviroment with glauconitic sandstones, muds and limes. The "T" and "U"



sandstone basin axis change of an SE-NNW (Fig. 3) to the E-W orientation respectively (Fig. 4). The "T" sandstone thins to the NE and disappears (Fig. 3).

Fig. 1. Generalized time-space distribution of the Cretaceous stratigraphic units showing major source rocks and reservoir intervals (Petrocanada, 1987; Jaillard E., 1997; Christophoul F., 1999).





Figs. 2 and 3: Net sand isopach maps of Hollín Fm. and "T" sandstones (in feets).

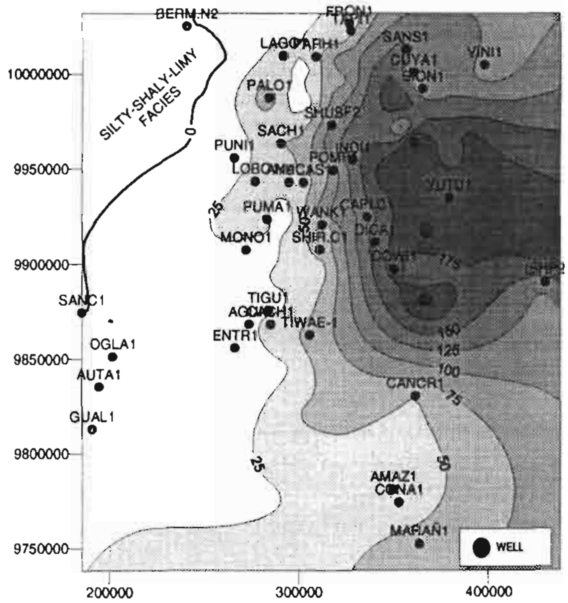


Fig. 4. Net sand isopach map of the "U" sandstone (in feet).

STRUCTURAL TIMING

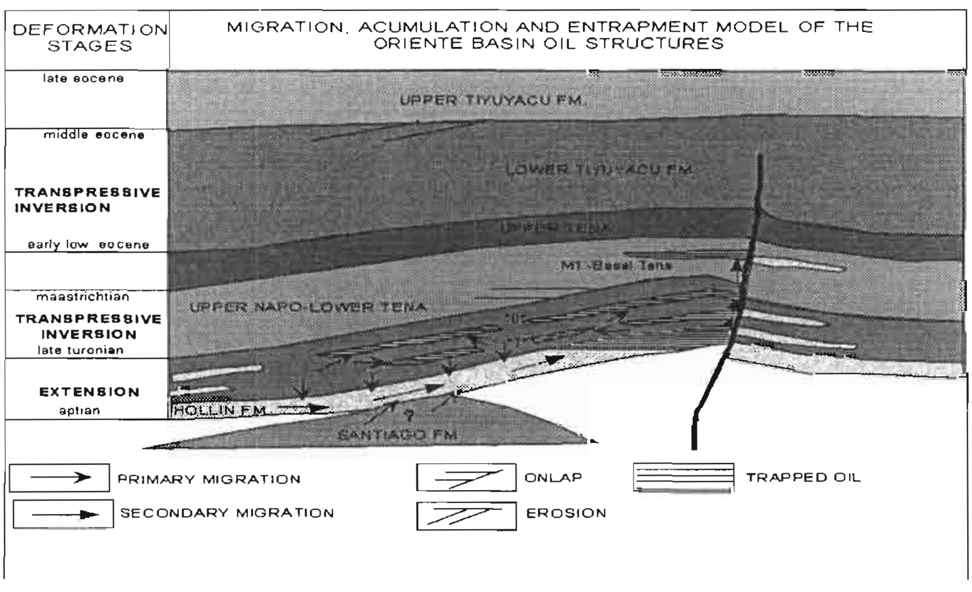
Two transpressive stages are responsible for the formation of the anticlines (Baby et al., 1999) which constitute the oil fields:

- the first is developed between the Late Turonian and the Maastrichtian times, and corresponds to the Peruvian phase, which *forms the first oil structures* of the basin (Fig. 5), and, is responsible for the uplift of local structures located in the zone of the current Napo Uplift and Pastaza Depression, and
- the second during the Lower to Middle Eocene, contemporary with the Incaic phase, is responsible for the *final formation of the more oil productive structures* (Fig. 5) and the integrated system: *Andean mountain chain – foreland basin.*

ORIENTE BASIN OIL SYSTEM

The Oriente Basin of Ecuador had a propitious time-space evolution for the generation and accumulation of oil.

- First, the *Hollin-Napo is a "correct" interstratified sequence* of potential and active source rocks (shales and limestones) and reservoirs (sandstones), developed as a result of cyclic sedimentary basin evolution in short transgressive-regressive events.
- Second, the presence of an *" intra-continental hot spot"* (Barragán R., 1999), during nearly all the Cretaceous, creates favorable thermal conditions that accelerate the maturation of the shales and limestones of Basal Napo and the "T" and "U" sequences, which in the Eocene, due to the subsidence of the basin by effect of the raising of the Andes, enter to the zone of "mesocatagenesis" and expel hydrocarbons (Bernal C., 1998).
- Third, *the structural timing*, when at the beginning of the Upper Eocene, most of the Oriente basin anticlines were formed, before the expulsion and migration of crude.
- Fourth, *the structures were preserved*, preventing the remigration and destruction of the accumulated crude, with exception of the fields of the Subandean zone, deformed and in same cases destroyed



(Fields of the Napo Anticline) by effect of the strong erosion, as a result of the Quechua tectonic crisis of the Andean orogeny.

Fig. 5. Schematic model of trap formation, migration and accumulation of HC in the Oriente Basin

POINTS IN DISCUSSION

1. The role of the black shales and limestones of the Jurassic Santiago formation (Fig. 5), as potential source rocks of part of the Oriente crude (Investigation to be developed within the Petroproduccion-IRD Project).
2. A secondary hydrocarbon migration with two stages: - a first lateral migration trough the Hollín sandstones, and - a second vertical hydrocarbon migration within the structures, across the faults, redistributed to the upper reservoirs (Fig. 5).
3. The presence or absence of crude in Hollín sandstones in the fields of the basin. The analyses of the tectonic evolution of each field will allow to explain that.

REFERENCES

Baby P., Rivadeneira M., Christophoul F., Barragán R., 1999. Style and Timing of Deformation in the Oriente Basin of Ecuador. ISAG 99, This issue.

Barragán R. And Baby P. 1999. A Cretaceous hot spot in the Ecuadorian Oriente Basin: Geochemical, Geochronological and Tectonic indicators. ISAG 99, this issue.

Bernal C. 1998. Modelo Teórico de Generación y Migración de Hidrocarburos de la Formación Napo en la Cuenca Oriente Ecuador. Tesis de grado. Archivo Petroproducción. 99 p.

Jaillard E. 1997. Síntesis Estratigráfica y Sedimentológica del Cretaceo y Paleógeno de la Cuenca Oriental del Ecuador. Petroproducción-ORSTOM edition 164 p