STRUCTURAL STYLE AND TIMING OF HYDROCARBON ENTRAPMENTS IN THE ORIENTE-MARAÑÓN FORELAND BASIN

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INTRODUCTION

The Oriente-Marañon Basin of Ecuador and Peru (Figs 1 and 2) is one of the most productive of the Subandean basins (Dashwood and Abbotts, 1990). It forms the Subandean foothills and the foreland basin comprised between the Putumayo Basin of Colombia and the Ucayali Basin of Peru.

The Oriente-Marañon foreland basin developed since Late Cretaceous times (Jaillard, 1997). The sedimentary column (Fig. 3) ranges in age from Paleozoic to Recent (Tschopp, 1953). It can be subdivided into three sequences: a pre-Cretaceous series, which is unconformably covered by a continental to shallow marine Cretaceous sedimentary cycle, and a post Cretaceous continental foreland cover.

This paper, based on IRD (ORSTOM), PETROPRODUCCION and PETROPERU regional studies, shows: 1) the structural style and the plays of the Oriente-Marañón Basin; 2) the timing of deformation and its control on the petroleum system.

STRUCTURAL STYLE AND PLAYS

Regional studies (Balkwill et al., 1995; Gil, 1996; Baby et al., 1995, 1998; Rivadeneira and Baby, 1999) showed that main oil fields correspond to Permo-Triassic and Jurassic grabens o half-grabens inverted along three NNE-SSW right-lateral convergent wrench-fault zones which form the plays of the Oriente-Marañón Basin (Fig. 1).

Subandean System

In the western part of the Oriente Basin, the Subandean foothills (Fig. 1) are formed by two échelon NNE-SSW positive flower structures (Baby et al., 1998) still seismically and volcanically active (Napo Uplift and Cutucú Uplift), resulting from dextral wrench faults, and separated by a Quaternary pull-apart (Pastaza Depression).

In Peru, the continuation of the Cutucú Uplift corresponds to the Huaracayo Serrania which forms the western border of the Santiago Basin. The Neogene Santiago Basin corresponds to a piggyback basin deformed by salt tectonics. It was transported to the east on a décollement developed in the Upper Triassic evaporites of the base of the Pucara Group. It is limited from the Marañón Basin by a triangle zone which developed on the pinch out of the evaporites and which express the blockage of the décollement (Fig. 2).

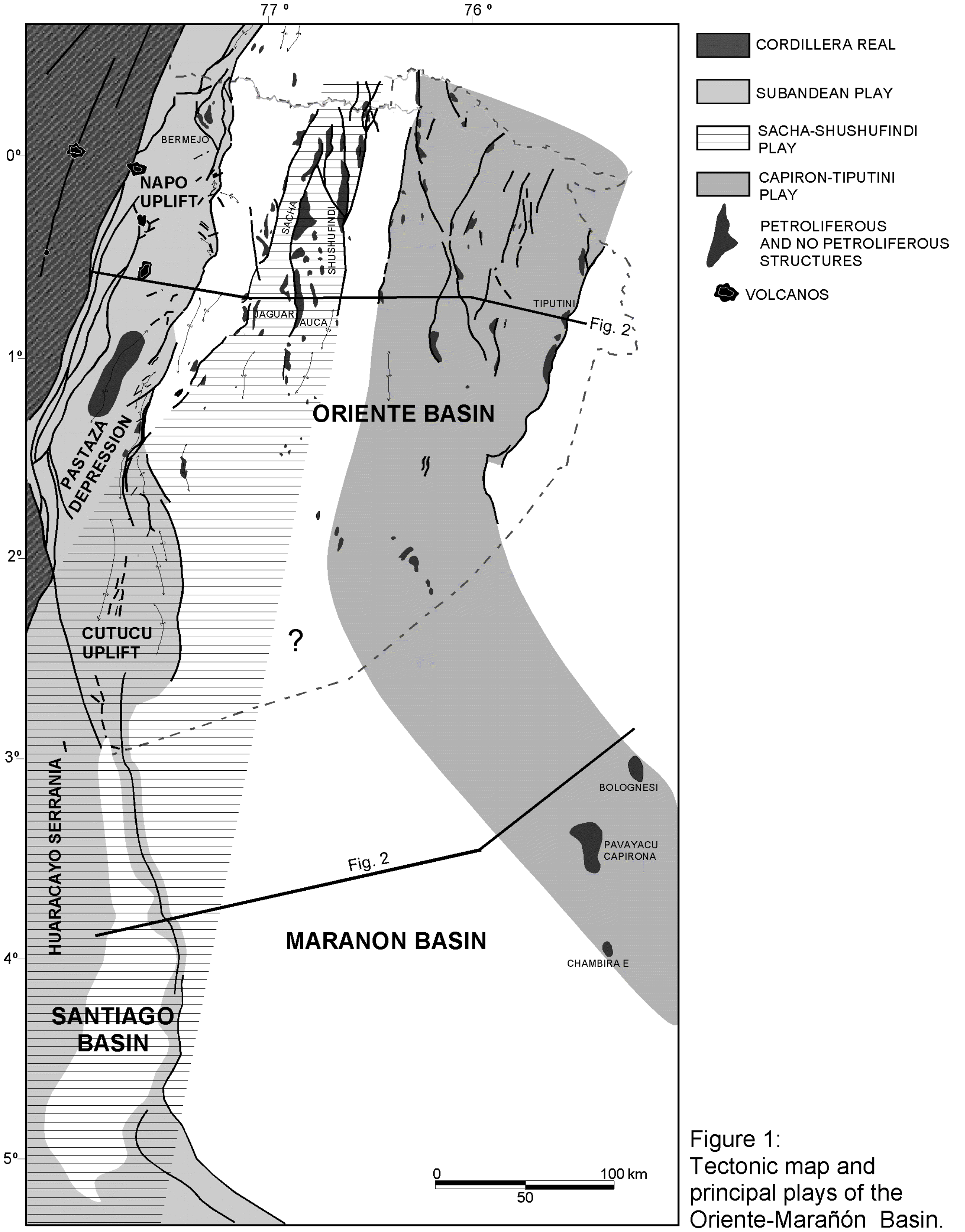


Figure 1:
Tectonic map and principal plays of the Oriente-Marañón Basin.

Actually, the unique productive oil field of the Subandean play corresponds to the poorly eroded positive flower structure of Bermejo, in the northern Oriente.

Sacha-Shushufindi Corridor

In the centre of the Oriente Basin, the Sacha-Shushufindi wrench-fault-zone (Figs. 1 and 2) is the most productive play of Ecuador. It results from the inversion of a NNE-SSW Upper Triassic to Lower Jurassic rift which emerges actually in the Cutucú Uplift and in the Santiago Basin borders. Giants fields as Shushufindi correspond to positive flower structures (Rivadeneira and Baby, 1999).

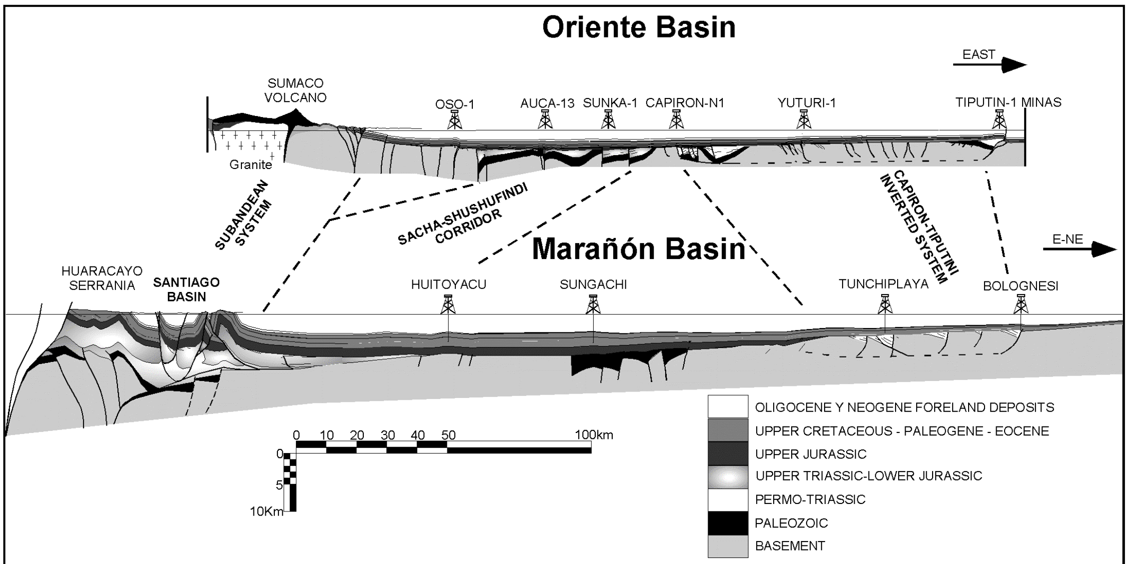


Figure 2: Structural sections across the Oriente-Marañón basins
(see locations in figure 1)

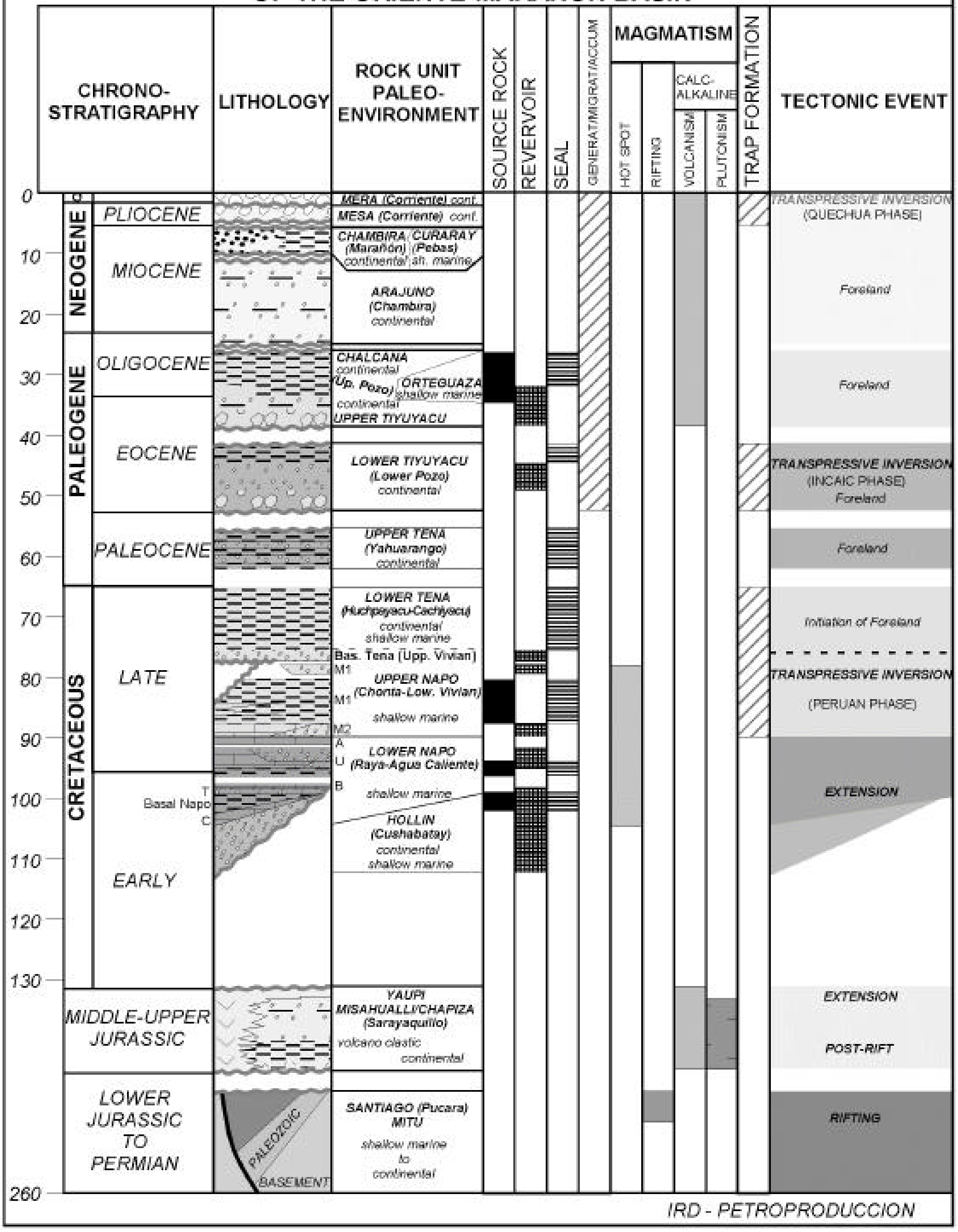
In the southern part, the Cutucú Uplift and the Santiago Basin corresponds to the superimposition of the Sacha-Shushufindi Corridor and the Subandean System (Fig. 1). The intersection of these two tectonic domains induces an intense seismic activity.

Capirón-Tiputini Inverted System

To the east of the Oriente Basin, the Capirón-Tiputini play (Fig. 1) is an inverted system of pre-Cretaceous half-grabens, which continues in the Marañón Basin. This inverted system differs from the Sacha-Shushufindi Corridor. Inverted faults correspond to listric faults branched to a deep detachment which appears in some seismic sections as described Balkwill and al. (1995). In the Bolognesi structure of Peru (see location in Fig. 1 and Fig. 2), a deep well showed that the half-graben deposits corresponds to the Permo-Triassic Mitu Formation (Gil, 1996).

Therefore, the Capirón-Tiputini play is inherited from a Permo-Triassic extensional basin, whereas the Sacha-shushufindi play corresponds to the inversion of a Late Triassic-Lower Jurassic rift. This difference of inheritance appears on the tectonic map to (Fig. 1). Towards the south, the Capirón-Tiputini Inverted System changes in orientation and is parallel to the chain, while the Shacha-Shushufindi Corridor conserves its NNE-SSW orientation and disappears obliquely in the Santiago Basin.

FIG. 3 - TECTONO-STRATIGRAPHIC UNITS AND PETROLEUM SYSTEM OF THE ORIENTE-MARANON BASIN



TIMING OF TRAP FORMATION

In the Oriente-Marañón foreland basin, reflection seismic data show syn-tectonic sedimentation which recorded 3 stages of inversion and trap formation.

Turonian-Maastrichtian

This inversion is well illustrated in the Shushufinsi field (Rivadeneira and Baby, 1999), where seismic data show that the Upper Napo and the Lower Tena formations sealed the structures. This phenomenon appears principally in the Sacha-Shushufindi Corridor, and probably in the Santiago Basin where some transpressive faults seem to control the sedimentation of the Chonta Formation (Fig. 2).

This transpressive deformation is known as Peruvian phase (Jaillard, 1993).

Early Eocene

This second stage of transpressive inversion, which corresponds to the Incaic phase of Andean deformation, is marked by the unconformity of the base of the Lower Tiyuyacu Formation (see Fig. 3). Syn-tectonic sedimentation of the Lower Tiyuyacu Formation sealed the principal structures of the Capirón-Tiputini Inverted System (Rivadeneira et al., 1999). It is associated with a strong subsidence of the foreland basin.

Pliocene-Quaternary

It corresponds to the stronger transpressive deformation of the basin and is responsible of the Subandean uplift, still active.

During this period, subsidence has been recorded only in the Marañón Basin. In the northern part, the Oriente foreland basin seems to uplift.

SOURCE ROCKS AND OIL GENERATION

The Upper Cretaceous shales, marls and limestones (Albian-Campanian) are accepted as main source rocks (see Fig. 3).

In the southern part, source rocks maturity is due to subsidence of the Cenozoic foreland basin (Mathalone and Montoya, 1995), while in the northern part it is produced by a continental mantle plume (Barragan et al., 1997) contemporaneous with the Turonian-Maastrichtian tectonic crisis.

Two peaks of oil generation and expulsion are evidenced (Bernal, 1998). The first one occurred in the Lower and Middle Eocene, in a foreland basin which extended to the west of the present basin limits. Upper Eocene to Oligocene times correspond to a period of erosion and poor subsidence, where oil expulsion stopped. During the Neogene, the second peak of oil expulsion occurred with the return of the foreland basin subsidence, and the western part of the petroleum system was progressively deformed and destroyed by the Andes uplift.

In the Upper Triassic to Lower Jurassic inverted rift, the Santiago and Pucara Formations are thick shallow marine series with good source rock potential.

CONCLUSIONS

The conclusions and the characteristics of the Oriente-Marañón petroleum system are resumed in the Figure 3.

It is obvious that the more productive fields correspond to the Upper Cretaceous traps (Sacha-Shushufindi play). Considering the Upper Cretaceous formations as the main sources rocks, the critical moment appears in the Eocene.

The Santiago-Pucara formations seem to have an important potential source rock in the southern part, but have been poor studied. Some oils of the reservoir of the Cretaceous series base (Hollín and Cuchabatay Fms.) can come from this pre-Cretaceous source rock.

ACKNOWLEDGMENTS

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