Different Gas Plays with a Huge Potential in the Tarija Basin of Bolivia and Argentina

Belotti, H.J. (Pecom Energía S.A.), C.E. Cruz (Pluspetrol E&P) and R. Giraudo (Repsol-YPF)

Introduction
Three proven gas plays have been identified in the Sub-Andean Thrust Belt and Foothills of the Tarija Basin in Bolivia and northwestern Argentina (Fig. 1). In this gas province, which encompasses an area of approximately 113,000 km$^2$, over 52 TCF of proven and probable gas reserves have been discovered from 76 fields. Almost 39 TCFG (75%) of those were discovered in 3 fields during the last 4 years. The remaining undiscovered reserves expecting to be found in this area are in the order of 60 TCFG.

Gas Plays
The three proven gas plays are: 1) Southern Sub-Andean Ranges, 2) Foothills and 3) Boomerang trend, Figure 1.

1) Southern Sub-Andean Ranges
Covering an area of around 40,000 Km$^2$ comprises a series of north-northeast and south-southwest oriented structural trends. Thin-skinned deformation originated a tectonic eastward verging in sequence wedge. Shortening was transmitted from the basal detachment located at the Silurian Kirusillas shales to the foreland. Important thickness variations were developed within the incompetent Los Monos shales; instead, the overlying Carboniferous and Tertiary units are deformed passively (Belotti et al., 1995; Giraudo et al., 1999).
Main gas reservoirs in the Sub-Andean thrust belt occur in the Devonian Huamampampa and Santa Rosa fractured marine silica-cemented quartz-arenites (Figure 2), deposited during global lowstand episodes, (Stark, 1995). A huge volume of Huamampampa sands was constrained to a coastal ramp setting as lowstand prograding shoreface (Fernandez Seveso et al, 2000). The arenites contain a large numbers of natural fractures connecting the low matrix and micro-fracture porosities. As a result, the average porosity of the system ranges from 2 to 6%. While in Ramos and Aguaragüe fields (Figure 3), the intensively fractured zones are associates to the crest and front limb of the structures, in the San Alberto and San Antonio fields (Figures 5 and 6), the fractured zones are also present in the back limb, due to the higher steep (60-70°) of the western flank. A series of east-west balanced structural cross-sections show the main structural trends of this play (Figures 3 to 5) (Giraudo et al, 1999; Giraudo and Belotti, 2000).
Proved + Probable remaining gas reserves distribution in the **Southern Sub-Andean Ranges** Gas Play is shown in Figure 6 (source: Cámara Boliviana de Hidrocarburos, January 2001). Almost 45.7 TCFG have been discovered from 18 fields and 39 TCFG of those were discovered in 3 fields (Margarita, San Alberto-Itaú and San Antonio) during the last 4 years. The contribution of this play to the total gas reserves discovered in Northern Argentina and Bolivia is 85.6%.

The remaining undiscovered reserves expected to be found in this Play range around 55 TCFG.

2) **The Foothills**

Covering an area of nearly 50,000 Km² comprises a series of north-northeast and south-southwest oriented structural trends at the front of the Sub-Andean Ranges (Figures 1, 3, 4 and 5). An internal detachment, located at the base of Los Monos shales, generates a series of eastward-verging gentle fault propagation folds, as a result of the transmission of the shortening from the Sub-Andean ranges to the east (Figure 5). Gentle anticlines associated to fault propagation folds detached at the Silurian Kirusillas Fm. conform the biggest structure. Two of the most important gas fields discovered between the 50’ and the 60’, Río Grande and Campo Duran Fields, belong to this play (Figures 3 and 8).

Main gas reservoirs in the Foothill occur in the fluvial Carboniferous Taiguati and Tupambi formations and in the Tertiary Petaca Fm. (Fig. 2). The sandstone’s porosity ranges from 14 to 20 %.

**Figure 6: Remaining Gas Reserves in the Southern Sub-Andean Play.**

**Figure 7: Remaining Gas Reserves in the Foothill Play.**

**Figure 8: Time Structure Map from top Carboniferous Taiguati Fm. In Río Grande Field.**
3) **The Boomerang trend**

The sharp bend of the Sub-Andean Thrust Belt in the Santa Cruz Elbow (Figure 1) generates a structural setting with gentle strike-slip related anticlines, that bears a series of gas fields. Within this hinge zone, the Silurian-Devonian sedimentary wedge thins rapidly over a basement structured by Silurian extensional faults. The east-west orientation of the hinge zone coincides with the east-west trend of the Silurian sequence, resulting in the configuration of the Boomerang Hill, oblique to the Andean tectonic transport direction (Welsink et al., 1995).

Proved + Probable remaining gas reserves distribution in the **Boomerang Trend** gas play is shown in Figure 9 (source: Cámara Boliviana de Hidrocarburos, January 2001), where 25 fields have almost 3.7 TCFG. The contribution of this play to the total gas reserves discovered in Northern Argentina and Bolivia is 6.8%.

The remaining undiscovered reserves expected to be found in this Play is less than 1 TCFG.

The fluvial sandstones of Tertiary Petaca Fm., the shallow water Cretaceous Cajones and Yantata Fm. with porosities ranging between 12 to 20% and the fractured marine silica-cemented quartz-arenites of Santa Rosa Fm. are the main gas reservoirs in the Boomerang Trend.

The Caranda anticline located near to the Andean Emergent Thrust Front, is the biggest anticline of this play (Figures 1, 10 and 11).

*Figure 9: Remaining Gas Reserves in the Boomerang Trend Play*

*Figure 10: Structural time map from top Tertiary Petaca Fm. in Caranda Field.*

*Figure 11: Seismic Line in the Caranda Field. See Figure 10 for location*
Source Rocks and Timing

Middle Devonian (Eifelian-Emsian) Los Monos and Huamampampa black shales (Figure 2) are the main source rocks in Southern Sub-Andean Ranges and in the Foothill of south Bolivia and North Argentina. The Average TOC is about 1.2% and the average S1 + S2 is 5 mg HC/g. In the Foothill of Central Bolivia the probable source rocks are the dark gray shales of Lower Devonian (Lochkovian) Santa Rosa and Icla formations, recording the highest organic contents. In the Boomerang Trend, the Middle Devonian Limoncito and Silurian El Carmen dark gray to black shales are the main source rocks (Moretti et al., 1995; Disalvo and Villar, 1999; Cruz et al., 2001).

The Tertiary units deposited during the Andean tectonics triggered the maturation process. Expulsion from the source rocks to the neighboring structural traps occurred primarily within in the last 10 my (Dunn et al., 1995, Moretti et al.1996).
References


