UNCONVENTIONAL GAS IN PARAGUAY

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SUMMARY

This report addresses the advances in the field of non-conventional gas in Paraguay as well as both its technical and commercial perspectives.

It is mainly based on recent publications (April 2011) of the U.S. Department of Energy, including the report ***"WORLD SHALE GAS RESOURCES****: An initial evaluation of 14 Regions outside the United States*", and on exploration data gathered in the country many years ago.

Upon a brief reminder and a definition of this non-conventional natural shale gas, we will address its worldwide importance, particularly for USA, as well as data known in Latin America and finally, the perspectives of this gas in Paraguay, which is called to transform the country's geology map and lead its entrance into the fossil energy, allowing for its energetic independence, without the need for hydrocarbon imports.

In conclusion, we will attempt to show the country's main zones of interest in order to allow oil operators to discuss potential investment opportunities.

INTRODUCTION:

Non-conventional natural gas is transforming US market data and may as well transform the energy situation worldwide, particularly for Latin America emerging countries, and certainly PARAGUAY.

Technological advances and the rising energy prices with an oil barrel at over 100 US$, the expected reduction of nuclear energy sources as a result of the Fukushima catastrophe in Japan, the announcement of progressive reductions in certain European countries, have led to initiate and pursue the accelerated exploitation of this gas new resources. The worldwide gas market will go through transformations, as will the whole energy world. These profound mutations are already underway today in the North American natural gas industry, with significant long term implications over this market, and recent technological advances will assist certain Latin American countries such as Paraguay, in developing their hydrocarbon economy.

I – DEFINITION OF NON-CONVENTIONAL GAS AND SHALE GAS

What is non-conventional gas and shale gas?

They are both natural gas. We find conventional gas inside a depositional porous and permeable rock; we drill a well and it comes out naturally. As for shale gas, it develops within an impermeable clayey rock compressed by overlaying sediments accumulated during early geological periods, such the Silurian and Devonian (Paleozoic), transforming into shale gas. These rocks are so impermeable that gases are trapped inside them, unable to migrate towards deposits. This makes it necessary to set up a whole extraction process, more complex than a simple "pocket" perforation, thus more costly to implement.

During these last years, the increase in total gas resources worldwide is attributed mainly to this shale gas, which has been the object of intense exploration-production efforts.

I – 1 SHALE GAS WORLDWIDE:

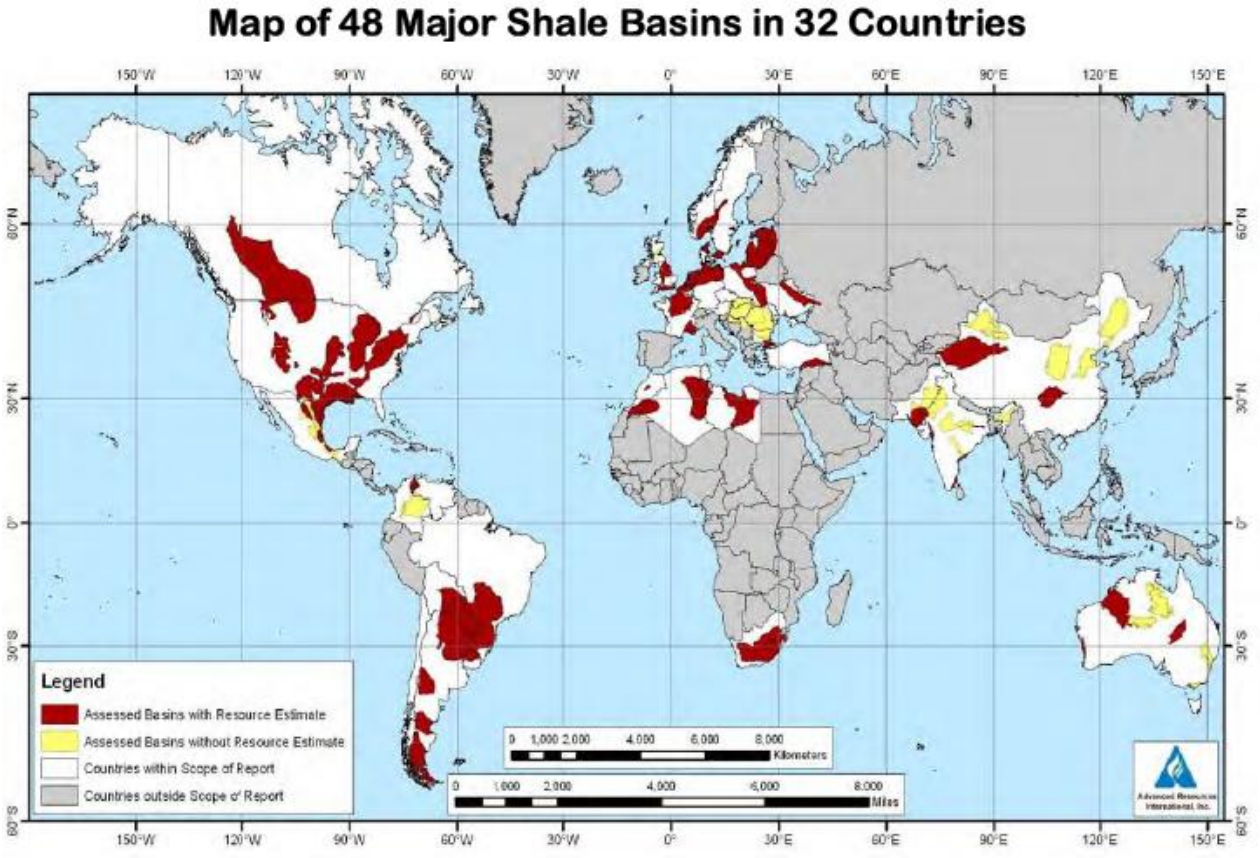

Fig.1

The above map shows a high number of countries with potential shale gas deposits; however America exhibits more extensive areas, particularly in USA, Canada, Argentina and central South America. Further, the Chaco and Paraná basins represent the highest potential for non-conventional gas in Latin America, with Paraguay located right in the center of these basins.

However the exact figures may vary with time, shale gas resources are highly significant.

22 016 Tcf, i.e., 624 Trillion m3 of potential in situ shale gas have been identified, excluding USA resources.

Through the application of the appropriate weighing factors, we can estimate in 5760 Tcf i.e., 1630 Trillion m3, the technically recoverable resources of shale gas (See Table 1).

Risked Gas In-Place and Technically Recoverable Shale Gas Resources: Six Continents

Continent	Risked Gas In-Place (Tcf)	Risked Technically Recoverable (Tcf)
North America	3,856	1,069
South America	4,569	1,225
Europe	2,587	624
Africa	3,962	1,042
Asia	5,661	1,404
Australia	1,381	396
Total	22,016	5,760

Table 1

Once again, in Latin America, essentially in Argentina and in the basin of Chaco-Parana (Paraguay) it's where the potential of this gas is the highest.

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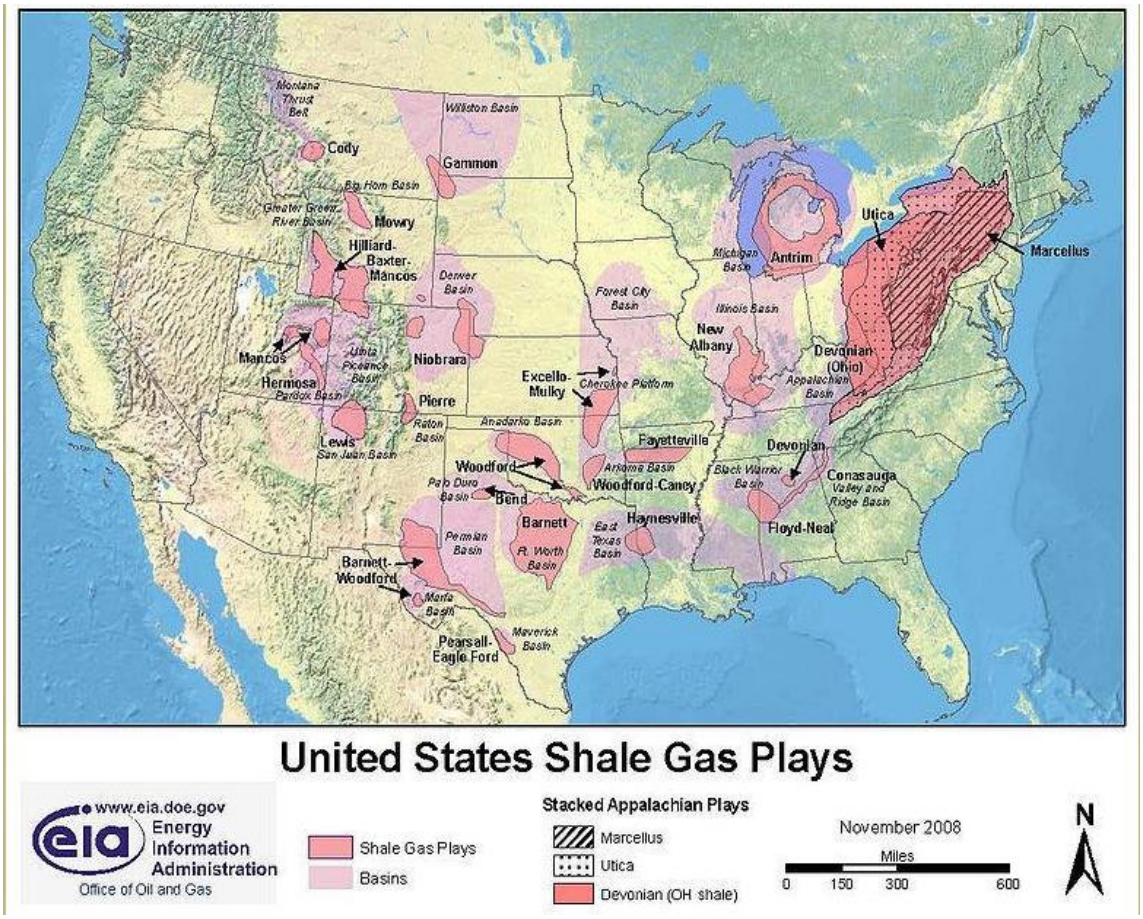
I – 2 SHALE GAS IN USA:

The most recent estimates of shale gas reserves announced by EIA (Energy Information Administration) show 827 Tcf, i.e., 23.4 Trillion m^3, about one third of USA natural gas reserves. A study by this same Agency estimates that by 2,035 Tcf, 46% of USA gas production will come from shale gas. Major findings were located in the Atlantic region, with over 9 Trillion m3 (317 Tcf) with the emerging of "Marcellus Shales" in the Appalachian Basin.

A recent study estimates conventional and non-conventional natural gas potential plus proven recoverable reserves in over 58 trillion m3 (2,050 Tcf), representing an increase of about over 40% for the last two years. Present natural gas annual consumption in USA and Canada goes up to approximately 740 million m3 (26 Tcf), this is, reserves evaluated for almost 80 years' consumption.

Basically, improvements on drilling techniques, in particular horizontal drilling and hydraulic rock fracturing, have permitted the exploitation of shale gas. A whole network of rock gas recovery points has been located just from a single initial drilling, making it possible to develop non-conventional gas production, particularly in USA.

Fig. 2 The following map shows the main areas of unconventional gas in the US.



I – 3 SHALE GAS IN LATIN AMERICA:

In South America, shale gas is located essentially in the South Cone, besides deposits identified north of Venezuela, in the Maracaibo Lake zone (Luna Formation), with 42 Tcf, 11 of which recoverable, and in Colombia, 79 Tcf, 19 of which recoverable in the Catatumbo zone, within same Luna Formation and in the Capacho Formation.

Fig. 3

In the South Cone, shale gas is localized in 3 important zones in Argentina, with exploitation activities presently underway – Neuquén Basin, San Jorge Basin and Magallanes Austral Basin, while the most important zones, the Chaco and Paraná Basins, comprising north of Argentina, east of Bolivia, part of Brazil and almost the totality of Paraguay, are still in project.

In April 2011, USA's EIA - Energy Information Administration - estimated shale gas resources for Argentina in 774 Tcf (21.9 trillion m3), way over its 13.4 Tcf (379.5 million m3) of proven conventional gas reserves.

If we subtract from Latin America potential resources (see Table 1) those estimated for Argentina, we obtain a very significant figure of 3,795 TCF of shale gas in situ in the Chaco-Paraná zone. By applying same percentage between recoverable gas and potential gas in situ, we arrive at a figure of approximately 1,000 TCF of recoverable non-conventional gas, most of it located in Paraguay.

I – 4 SHALE GAS IN PARAGUAY:

The Latin America "South Cone" has great potential for shale gas, now starting to be verified.

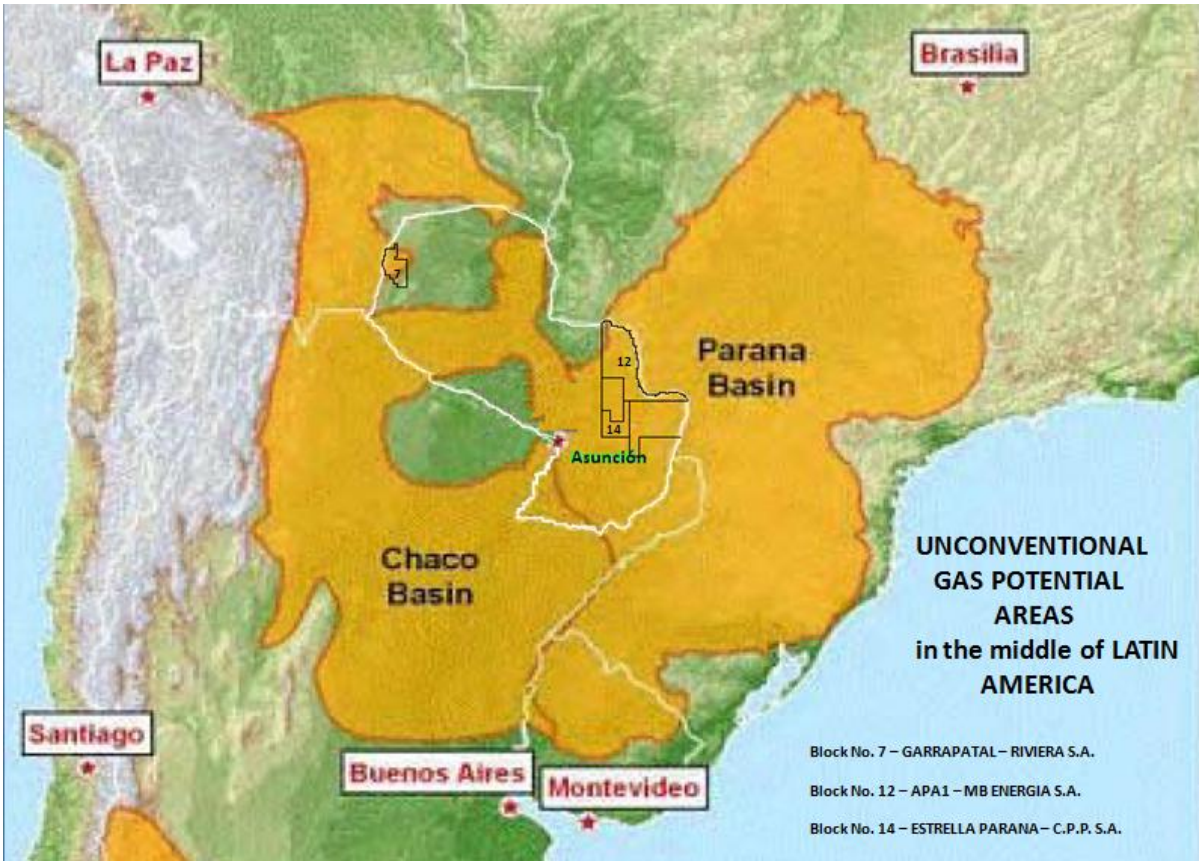
This potential for shale gas is present at the complex borderline Basin of Chaco-Paraná in Brazil and Paraguay, mainly in the Devonian Los Monos Shale Formation.

2.1 Geological characterization: The large area (over 500,000 km2- see previous map) of the complex Chaco-Paraná Basin covers most of Paraguay, an area south of Brazil, a small region of Uruguay, north of Argentina and south of Bolivia.

This is an intracratonic pre basin globally similar to the Neuquén Basin and other South American basins east of the Andes Mountain Range. It contains a thick sequence of essentially marine Paleozoic rocks overlaid essentially by continental Mesozoic deposits.

The Devonian through Carboniferous sediments are arranged in a marine regressive sequence to the west, with transition zone facies and continental facies. Potential shale gas deposits exist in the Los Monos Formation (Devonian), in the Carandayty and Curupayty sub-basins in Paraguay, with 8,000 to 12,000 feet thickness, composed of black shale rich in organic matter, deposited in shallow marine zones.

Fig. 4: Chaco & Paraná Basins



2.2 Shale gas in the Devonian:

<u>Chaco: Carandayty and Curupayty Sub Basins:</u>

Devonian shale was formed from shallow sea muds which were present about 350 million years ago, (during the Devonian Paleozoic age, or even prior to Silurian). Shale is a fine-grain sedimentary rock, easily breakable in parallel thin layers. It is a highly fragile rock not decomposable when wet. This shale often contains natural gas, generally when two layers of black shale form a sandwich with another thin layer of this rock. Due to their numerous properties, natural gas extraction from shale formations is more difficult (thus more costly) than classic natural gas extraction. Most of the natural gas contained in the USA Devonian shale is located in the Appalachian Basin (Marcellus shale). Now, in Paraguay and by extension of the Chaco-Paraná Basin, there are formations identical to Marcellus. Although estimates of natural gas contained in these shales are high, only a small part may be recovered.

Besides, the Chaco basin's structural heights show strong geothermal gradients, therefore constitute highly promising zones for shale gas production.

Of these thick layers, the Devonian shale of the San Alfredo Formation seems the most promising. It comprises a lower section composed by sand and an upper section, clearly thicker, with black shale formed under shallow marine conditions.

An exploration well located in the Curupaity sub-basin measured from 0.3 to 2.1% TOC (Total Organic Matter) in these shales (Lima Shale Formation equivalent to Ponta Grossa Formation in Brazil).

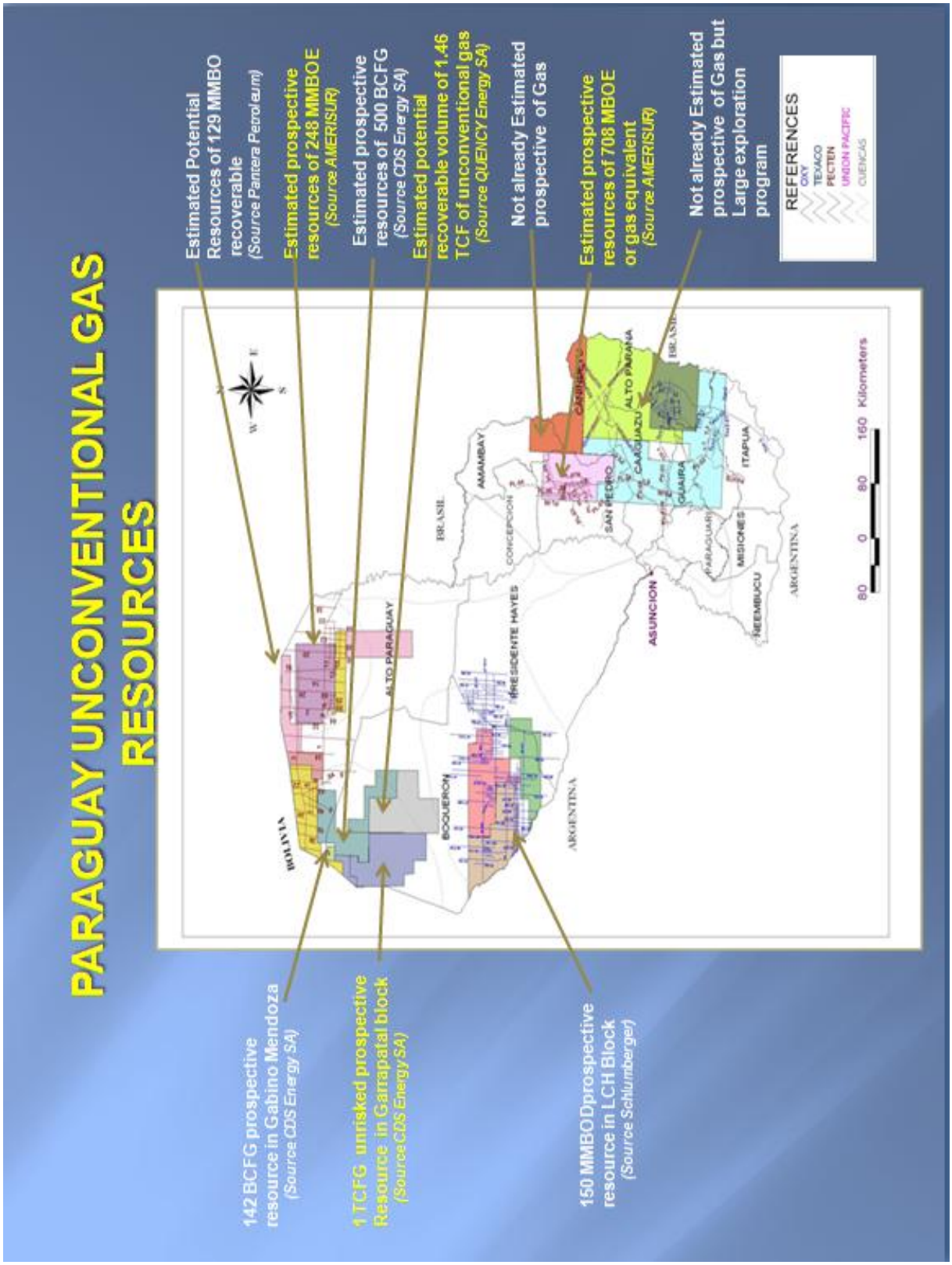


Fig. 5 Potential of unconventional in Paraguay

2.3 Exploration Work in Paraguay

A great deal of seismic work has been developed in this basin, 17,000 km of 2D (map Fig. 6) along with the drilling of 49 wells

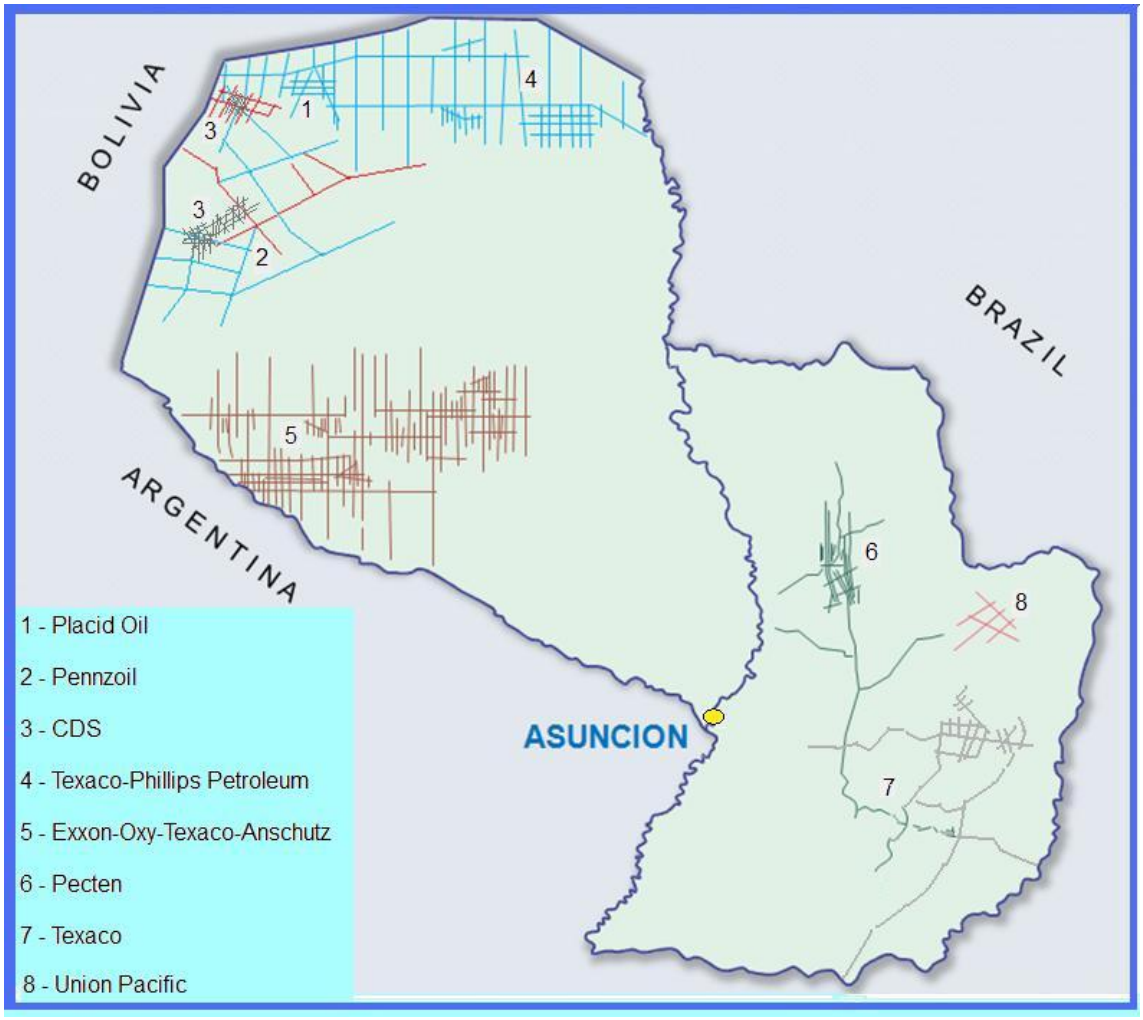
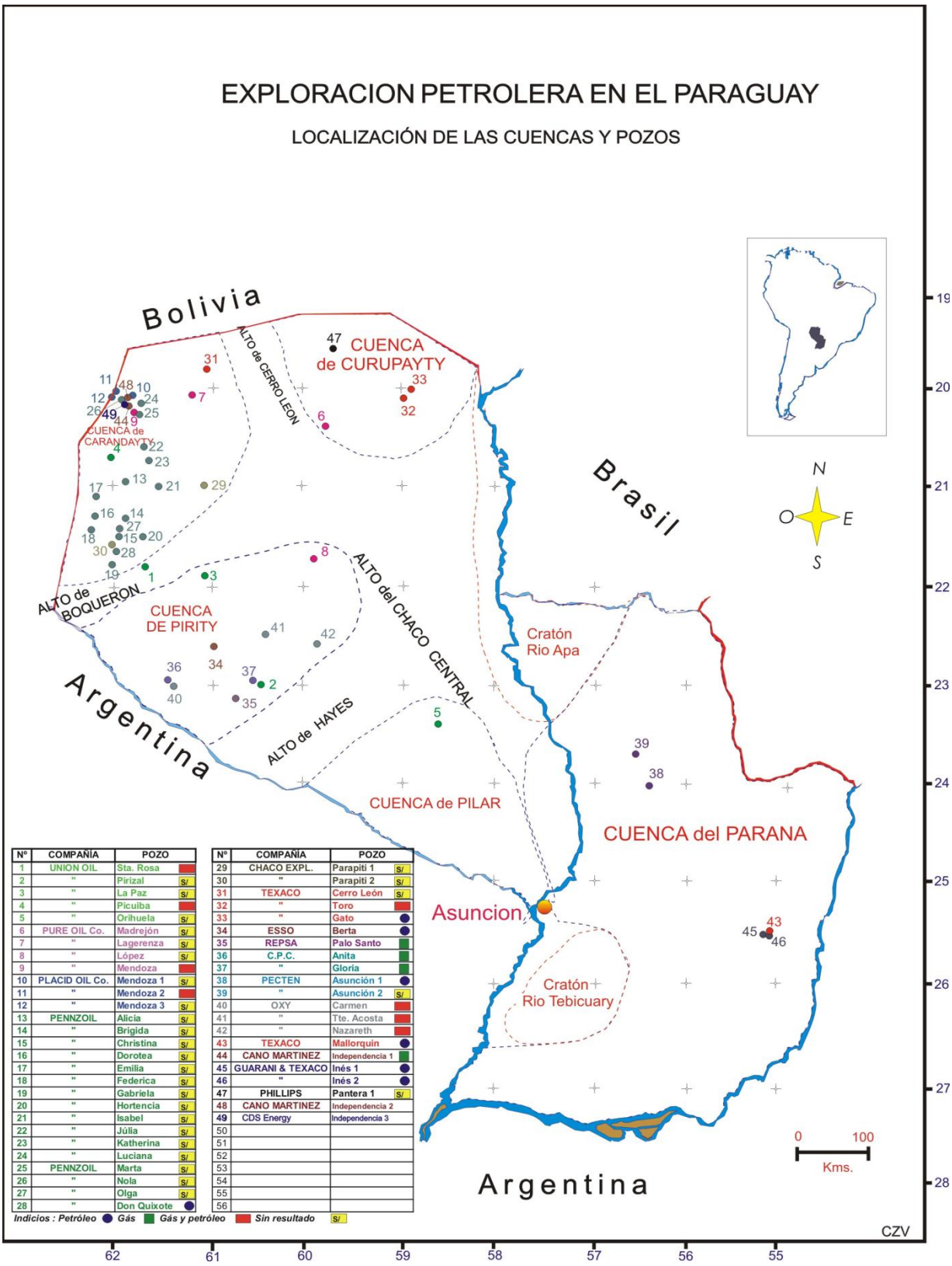


Fig. 6 2D Seismic survey in Paraguay



N°	COMPAÑIA	POZO	
1	UNION OIL	Sta. Rosa	
2	"	Pirizal	s/
3	"	La Paz	s/
4	"	Picuiba	
5	"	Orihuela	s/
6	PURE OIL Co.	Madrejón	s/
7	"	Lagerenza	s/
8	"	López	s/
9	"	Mendoza	
10	PLACID OIL Co.	Mendoza 1	s/
11	"	Mendoza 2	
12	"	Mendoza 3	s/
13	PENNZOIL	Alicia	s/
14	"	Brigida	s/
15	"	Christina	s/
16	"	Dorotea	s/
17	"	Emilia	s/
18	"	Federica	s/
19	"	Gabriela	s/
20	"	Hortencia	s/
21	"	Isabel	s/
22	"	Júlia	s/
23	"	Katherina	s/
24	"	Luciana	s/
25	PENNZOIL	Marta	s/
26	"	Nola	s/
27	"	Olga	s/
28	"	Don Quixote	

N°	COMPAÑIA	POZO	
29	CHACO EXPL.	Parapiti 1	s/
30	"	Parapiti 2	s/
31	TEXACO	Cerro León	s/
32	"	Toro	
33	"	Gato	
34	ESSO	Berta	
35	REPSA	Palo Santo	
36	C.P.C.	Anita	
37	"	Gloria	
38	PECTEN	Asunción 1	
39	"	Asunción 2	s/
40	OXY	Carmen	
41	"	Tte. Acosta	
42	"	Nazareth	
43	TEXACO	Maliorquin	
44	CANO MARTINEZ	Independencia 1	
45	GUARANI & TEXACO	Inés 1	
46	"	Inés 2	
47	PHILLIPS	Pantera 1	s/
48	CANO MARTINEZ	Independencia 2	
49	CDS Energy	Independencia 3	
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Fig. 7: 49 All exploration wells drilled in Paraguay

Devonian and Silurian mother rocks, the object of non-conventional exploration, are present throughout Northeast Paraguay. The most prospective area is located facing the Carandayty basin, surrounded to the north by the Izozog Arch, to the East by the Cerro León heights and to the south by the uplift which separates this basin from the Pirity graben (dip zone).

In general, the Chaco Basin main mother rock lays in the San Alfredo Group Formation (Devonian), particularly the Los Monos and the Icla Formations. A second deeper gas source belongs to the La Paz Formation (Silurian). These formations contain mainly shales with an original TOC of 1.5% and 2.5%, enough for hydrocarbon production. In the Carandayty, all hydrocarbons have been "broken" (chemically modified into gas) at depths below 2 km). It is important to search for shale gas in overlaying zones acting as topseal rocks which prevent gas leaks. Topseals north of the basin are the Carboniferous T-2, and Shales T-3 from the Tupambi Formation, both known as efficient gas trappers. Further to the South, in the Garrapatal block, and in the block belonging to Hidrocarburos Chaco, as well as in the PG&E Block, the T-2 and T-3 are covered by topseals formed by the Permian clayey shale and the Cretaceous clayey limestone, which improve capturing potential.

a) Curupayty Basin:

The Curupayty Basin has similar stratigraphy and same background as the burial of the hydrocarbon rich zone of the South-Andean basin (see fig. 8 and 9). It is located facing the main compression zone, with numerous hydrocarbon findings (Oil and Gas).

Hydrocarbon load is favorable in this sub-basin due to the high thickness of the Devonian mother rocks; these mature Devonian mother rocks have expelled hydrocarbons for 140 million years.

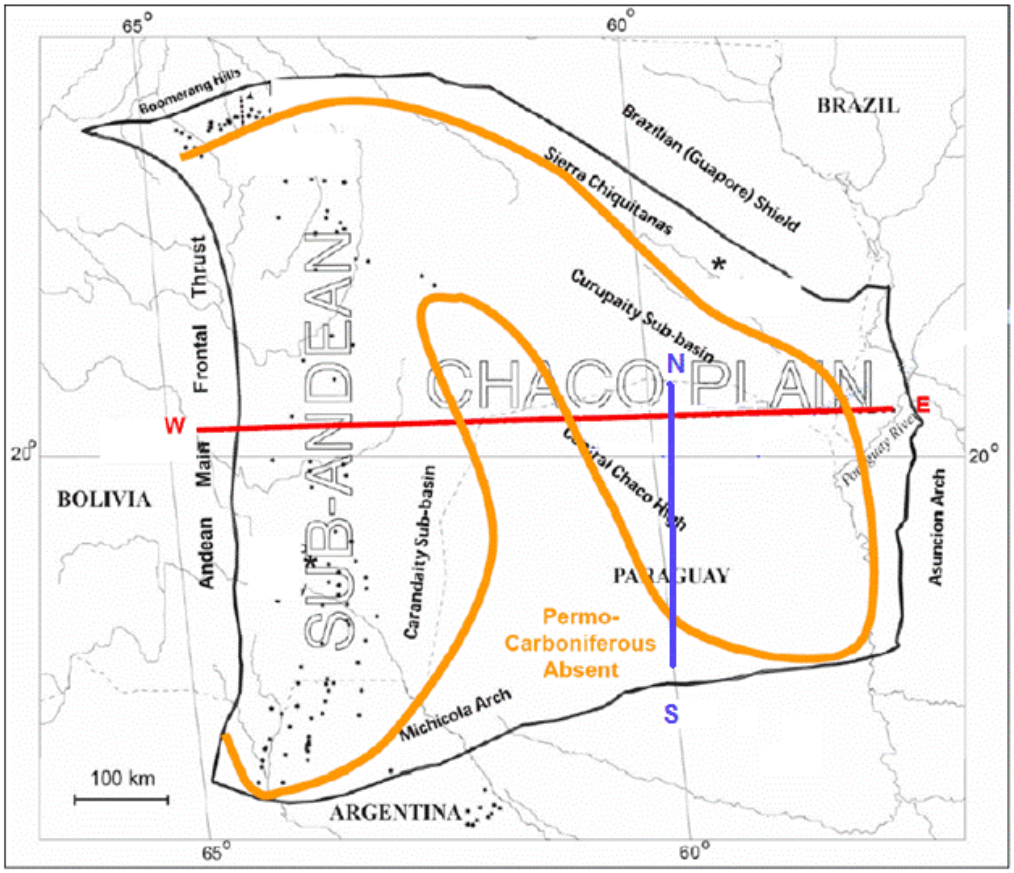

Fig. 8: Location of the Chaco basin in relation with the Andean sub-basin.

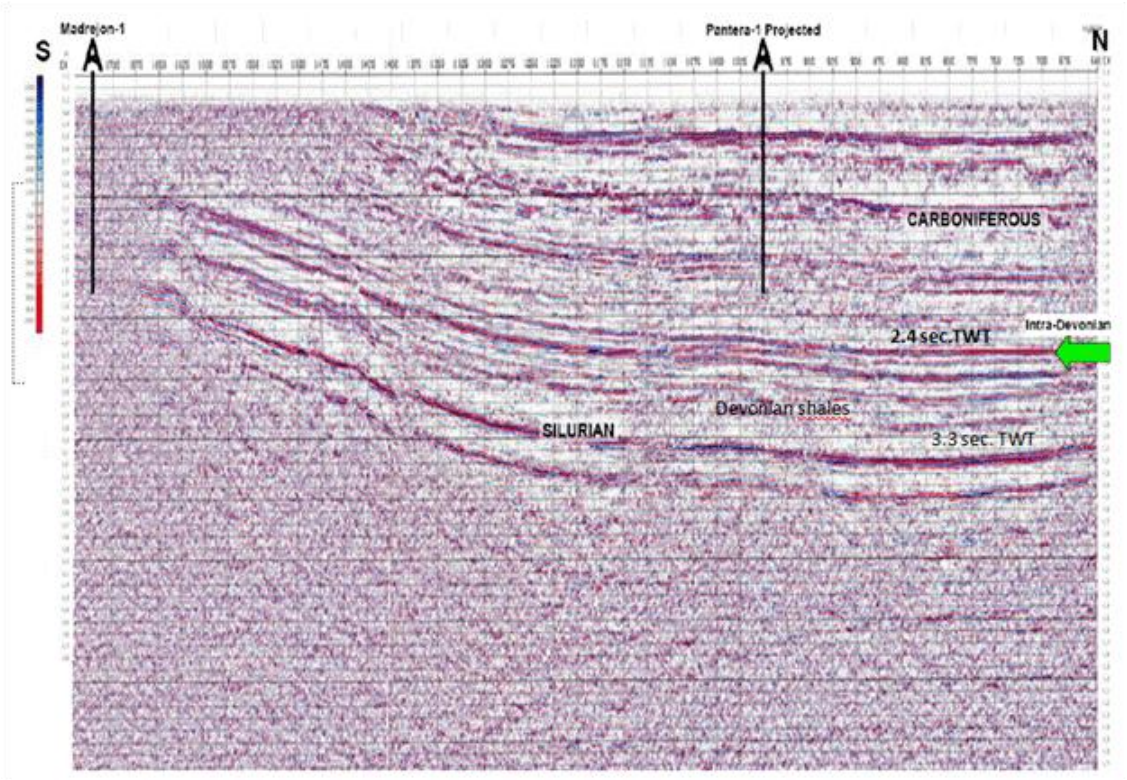

Fig.9: Seismic line North-South crossing Curupayty Sub-basin.

b) Paraná Basin

Paraguayan Area of the Parana large basin:

By the same token, in the Paraguayan zone of the Paraná basin, the Los Monos Formation shale depths can reach below 10,000 feet (3,000m) at deep synclinals such as the San Pedro trench.

East of the San Pedro Block, located south of the APA1 block, next to the Brazilian border, thicknesses are more significant (3000m to 4000m, refer to the thesis of the outstanding Brazilian geologist Gustavo Ari – 2007 which has allowed for the re-launch of exploration activities in this zone). An important thermal gradient at highly elevated pressures, as well as the high percentage of TOC, have make it evident to favor the formation and establish the presence of shale gas in the Devonian.

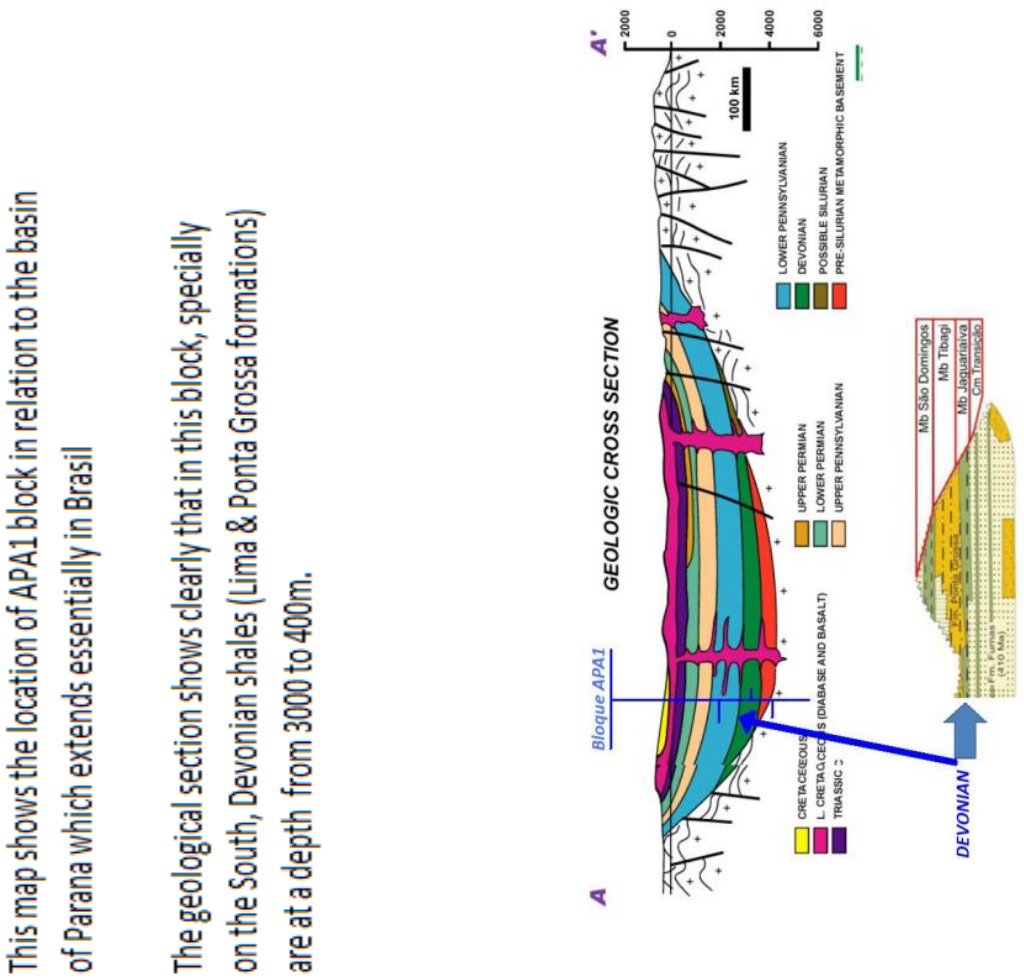

Fig. 10 Cuenca de Paraná

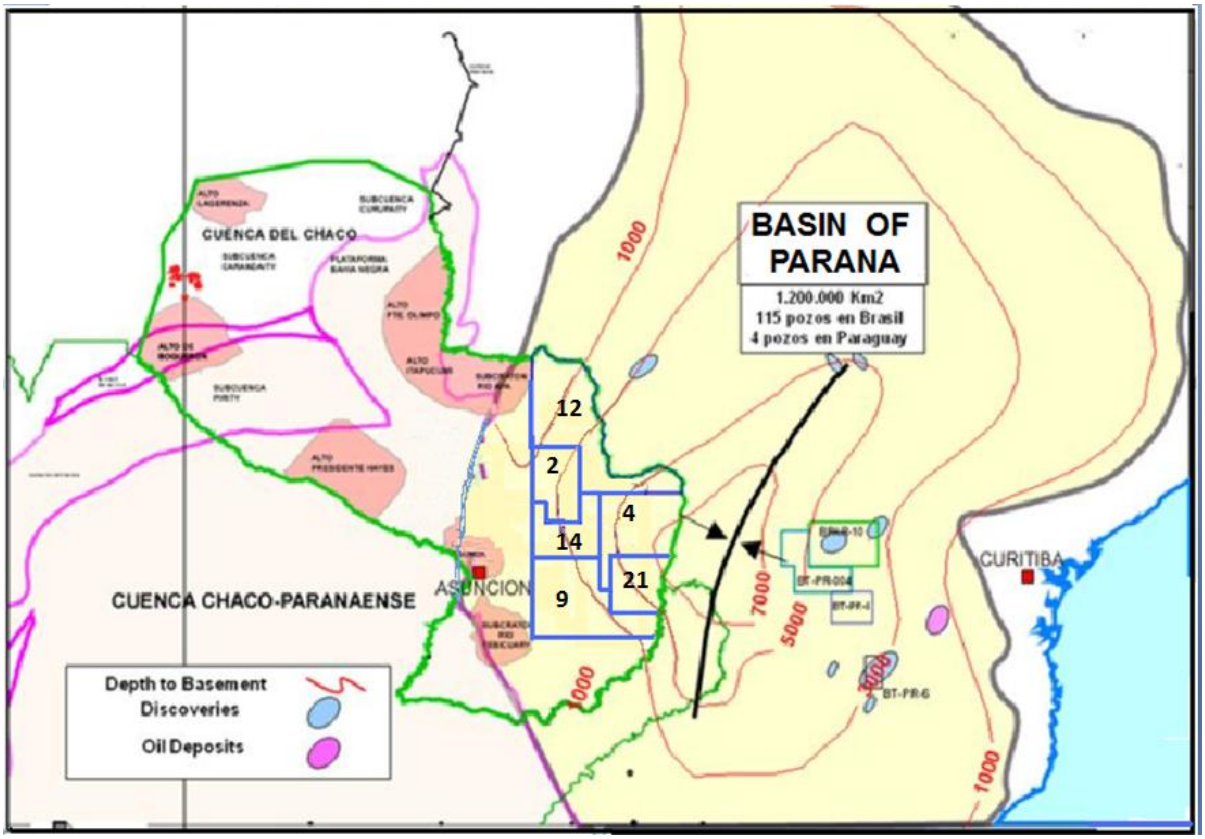

Fig. 11: Main concessions in Eastern Paraguay.

The main blocks attributed to oil companies east of Paraguay which have really great interest either for Unconventional Gas or Unconventional Oil are shown in the map of Figures 11 & 12, mainly including Block Nº12 APA1 of MB Energía S.A., Block 14 ESTRELLA PARANA of Compañia Petrolera Paraguaya, block 9 ALTO PARANA of A.E.T. Paraguay S.A. and Nº21 to LAN OIL S.A.

The SAN PEDRO block Nº2 (Amerisur) is located in the shallower zones (approximately 3,000m) as part of the ESTRELLA PARANA block.

An important part of the ALTO PARANA-CANIDEYU block Nº 4 (Bohemia S.A.) is located in deeper zones, as is the case south of the APA1 block, therefore with higher potential for shale gas, due to stronger pressures.

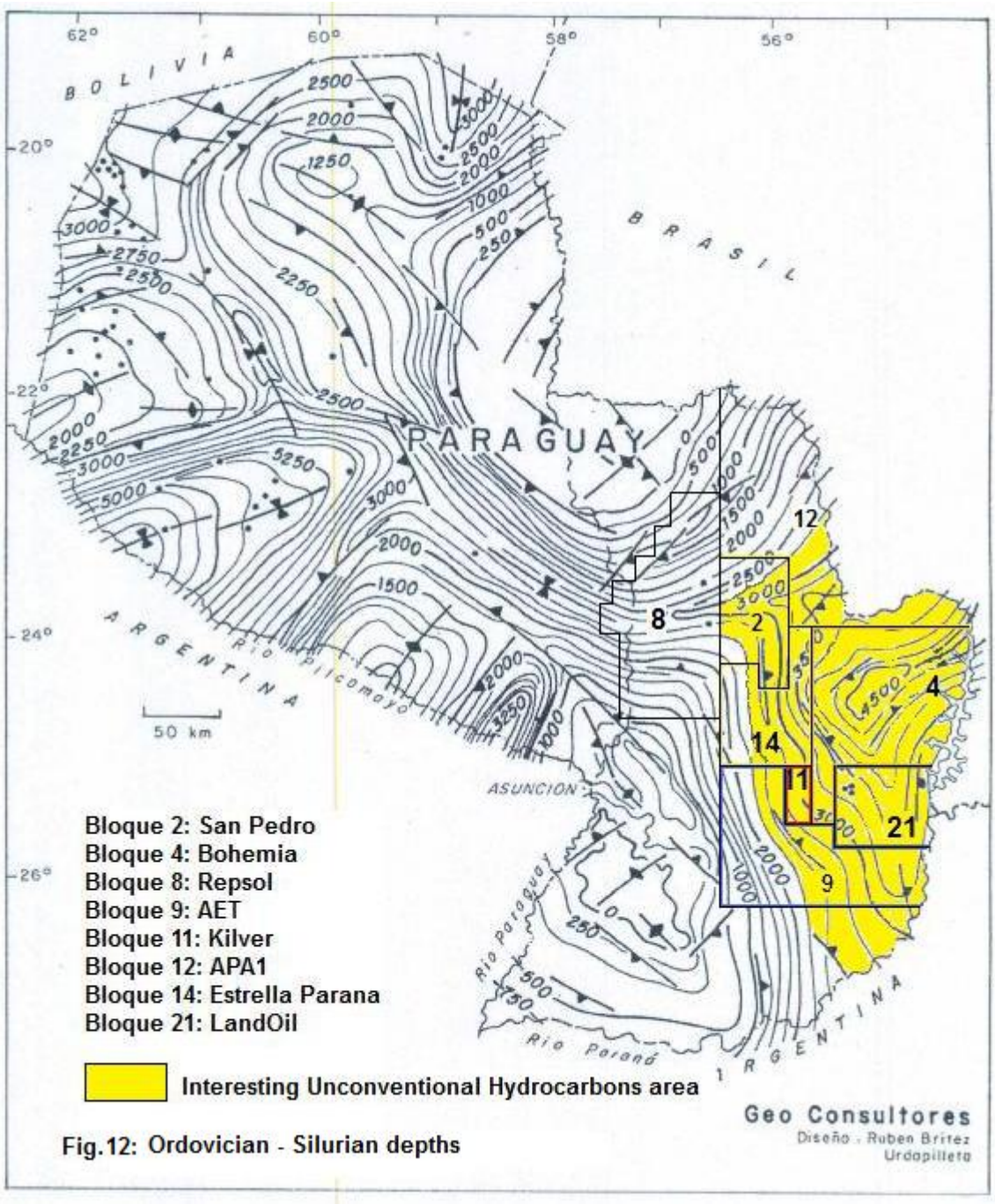

Fig.12: Ordovician - Silurian depths

II - RECOMMENDATIONS AND CONCLUSIONS:

Certainly, the two most prospective zones for conventional gas are:

a) – The CARANDAYTY basin, essentially the GABINO-MENDOZA block, the GARRAPATAL northern part, the Eastern PG & E block and also north of the HIDROCARBUROS CHACO block.

Devonian shales are thick (1500 to 2000 m) and deep, 2500m to 4000 m.

These shales are identical to the USA MARCELLUS reservoirs, major holders and producers of this non conventional gas.

Initially, the well Independencia III (GM-05-5001) will have to be deepened; this well was drilled back in year 2005 and abandoned for financial reasons at 1635 m depth before reaching the Devonian.

1 to 3, even 4 MCFGD are estimated after fracturing and stimulation. For obvious environmental reasons, injections are to be performed only with water produced from the site deep aquifer located at 270/300 m depth, where water is abundant.

This Chaco area is scarcely populated, mainly by Guaraní natives, who would benefit from the infrastructure and works to overcome their isolation.

Numerous wells will have to be drilled in these areas to be able to produce important quantities of gas, some several tens of millions cubic meters per month to supply the local Paraguayan market and to achieve the development expected by the thermoelectric power station authorities (Loma Plata 150 MW and Asunción 750 MW).

Estimations announced by the various companies which have explored these zones, shown in Fig. 5, are reasonable, not to say modest.

b) – The Paraná Basin

This is certainly the richest basin in potential shale gas.

The Devonian prospective section (shales and sandstones) turns thicker at the Paraguayan side of the Paraná basin.

The part of the basin located in Paraguay is not covered by thick basalt layers and according to the available data base, it is the largest prospective observed within over 25 km2. (Source: GUAPEX S.A.)

Besides, the thickening of the Silurian section (mother rocks) increases the potential volume of hydrocarbon generated.

Example in Brazil close to Paraguay border: Gas field of BARRA BONITA

The accumulation of gas in BARRA BONITA has an area of 17 square kilometers and is represented by a structural trap with high-level reservoir sandstones that is sealed by good rocks. The sandstones have about 7% porosity of the matrix.

The discovery of the well was possible with a first vertical drilling and evaluation well and the second well was diverted to correctly intercept the network of fracture. The

evaluation of formation inside other wells showed higher productivity than 200,000 cubic meters per day (7,000,000 CCTP / d) in each.

II – 1 RECOMMENDATIONS:

Airborne magnetometric and airborne gravity surveys will have to be conducted (or previous survey to be bought from GETECH or from Paraguayan Geographic Military Service) in the deeper zones, namely south of the APA 1 Block, along the Brazilian border as well as north of the BOHEMIA block, east of the ESTRELLA PARANÁ block and specially in the South of the Parana Basin in Alto Parana of A.E.T. Paraguay S.A. and LAN OIL blocks. (See fig. 11)

Also, a fractal math survey will have to be performed using the comparison between Gravi. & Mag. to be able to define the zones of interest.

Once the interesting zones have been defined by that method (or equivalent) it is recommended to acquire on these specific areas a geochemical land survey.

This geochemical prospecting survey aimed to identify possible geochemical anomalies may be related to the accumulation of hydrocarbons in the blocks of the Paraná Basin (Paraguay Portion).

Analytical results must be treated applying statistical methods in order to obtain background concentrations of free and adsorbed gases and thereby delimit the possible anomalous zones and that related to the microbiological results.

Than to drawn iso-values maps in order to better delineate anomalous areas especially, to observe the distribution of their preferential directions and their interrelationships, and finally, to correlate possible migration routes and / or hydrocarbon accumulations in the area of CPP, MB Energy, AET and LAN OIL blocks.

Further to that two previous methods, and having clearly identified and delimited the interesting zones, it is recommended to acquire 2D or 3D seismic at the deepest zones of interest, but the seismic images in this basin with volcanic intrusions will require a deep geological modeling run in specialized equipment for this type of seismic which is certainly easier to interpret in depth than in time.

Finally, to be able to extract great quantities of shale gas the most promising zones will have to be drilled, requiring the application of vertical and horizontal drillings, fracturing and water flooding.

II – 2 ECONOMICAL DATA (*)

Gas production in Paraguay is a national priority.

Great quantities will be necessary for:

- Domestic market

- Cement and steel production, presently using imported fuel-oil and vegetal carbon, a cause for great deforestation.

- Supplying thermo-electrical power stations.

- Exports to the Brazilian, Uruguayan and Chilean markets, all major dependants.

In conclusion, the profound changes actually taking place within the natural gas industry in North America will have significant long run implications for this market and the latest technological advances may and must allow for Paraguay's economic development.

(*) *see separate Memo.*