COLOMBIA:
The perfect environment for Hydrocarbons exploration and production

ANH's Approach to Colombian Unconventional Hydrocarbons Resources

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Introduction

Even though, our potential of oil and gas could be (by the end of 2010) around 47 BBOE (thousand millions of BPE) and that we are increasing our daily production (760 kbpd and 1120 Mpcd) toward higher goals, the ANH has already started to study the unconventional resources of HC in Colombia.
First of all, in the Colombian Orinoquia region around 127.000 square kilometers have been assigned for eight TEA contracts looking for heavy oil, for the 2009-2015 period, Colombia has signed 8 contracts with a total inversion around 500 millions of dollars represented in almost 8 thousands km of seismic and 50 stratigraphic wells. Other unconventional hydrocarbon resources which include CBM, gas and oil shale, tar sands, tight gas and gas hydrates are being studied by ANH in order to diversify our objectives and to prioritize the investments.
It is our intention to show what the potentials for each resource are, where they are located and what the main challenges are we will have to overcome to get a successful equilibrium in the exploitation of the different fossil hydrocarbon resources. This paper is based on a study made for the ANH by Arthur D'Little (2008).

Generalities

The complex geologic and tectonic framework of the northwestern corner of South America can be observed in Colombia, where all type of rocks outcrop either in the faulted Andes, oceanic basins or in the Guyana shield. Up to know, the country has made the best efforts to explore conventional hydrocarbons in 23 sedimentary basins, as it can be seen in the Colombian Basins Map (Figure1). As oil and gas consumption increases and conventional resources deplete over time, producers must consider new ways to satisfy the growing oil and gas demand. High oil prices have made the development of unconventional resources economically attractive, which will contribute to satisfying the growing demand for oil. So, the ANH has decided to examine the dynamics of international unconventional oil and gas resources in detail, to quantify the resources' potential within Colombia.
These unconventional resources have received relatively little attention in Colombia to date, due to limited availability of geological information, technical challenges, scarcity of specialized personnel, security concerns, poor regulations and lack of economic incentives (historically low energy prices). However, commercial technologies and new specialized techniques are becoming increasingly available for the exploitation of unconventional hydrocarbons around the world. Given the magnitude of the geological potential, Colombia should be able to attract sophisticated players for these developments.
CBM is the most advanced of these resources in terms of existing developments (Drummond's La Loma project), but some regulatory hurdles will need to be overcome to ensure that the country can capture the full potential.

Methodology

"Unconventional hydrocarbons" is used as a term that represents volumes of hydrocarbons trapped by a convergence of several geologic or physical mechanisms, such as low permeability, abnormal pressure, and adsorption mechanisms. For this study, it was made a review of international development status for the different unconventional resources, from the standpoint of technology and legislation. Nationally, an inventory, essentially bibliographic, was done and then extrapolations were used and averages parameter were assigned in order to get global values, which is expected to serve as a guide.

The results

Coal bed Methane (CBM). The total CBM resource in place in Colombia is located mainly in seven basins and can be estimated at approximately 17.8 Tcf and it is believed that about 7.5 Tcf could potentially be produced with the use of commercially available technologies. Figure 1 captures grouping of carboniferous areas and associates mineable coal volumes with each region, as identified by Ingeominas (2005).

Tar sands. Surface and shallow subsurface manifestations of hydrocarbons are common in much of Central and Eastern Colombia because of the petroleum systems that have been active through time in the rich source rocks deposited within the Cretaceous depositional basins. Based on the data available, the potential in Colombia for tar sand reserves in-place has been estimated at approximately 24-39 Gbbl, depending on the production technology used. Table below shows the main places in Colombia where crude oil could be extracted from tar sands (Figure 2).

Coalbed methane resource potential (from Arthur D.L., 2008)

Region	Mineable coal in place (G mt)[1]	Total Coal in place (G mt)[2]	Gas in place (Tcf)[3]	Recoverable reserves (Tcf)[4]
Guajira	4.5	13.6	4.8	2.4
Cesar	6.6	19.7	6.9	3.4
Cordoba	0.7	2.2	0.8	-
Antioquai	0.5	1.4	0.5	-
Valle del Cauca	0.2	0.7	0.3	-
Huilla	0.0	0.0	0.0	-
Cundinamarca	1.5	4.4	1.6	0.8
Boyaca	1.7	5.2	1.8	0.9
Santander	0.5	1.4	0.5	-
Norte de Santander	0.8	2.4	0.8	-
Total CBM Potential	**17.0**	**51.0**	**17.8**	**7.5**

Notes
1 Source: Ingeominas, 2004. Mineable coal is coal no deeper than 300 meters.
2 Assume mineable coal is one-third of total coal in place
3 Assume standard gas content of 350 scf/ton
4 Assume recoverable rate of 50%
5 Assume areas with less than 1 Tcf of gas in place are not commercially attractive

Tar sands potential in Colombia (from Arthur D.L., 2008)

Region	Area (sq km)[1]	Net pay (meters)[2]	Initial Volume in Place (acre-feet)[3]	Initial Volume in Place (Mbbl)[4]	Oil in place (Mbbl)[5]	Reduction factor[6]	Recoverable reserves[7] SAGD (Mbbl)	Recoverable reserves[7] Mining (Mbbl)
1 Florencia	460	50	18,646,403	144,659	20,252	30%	7,088	11,625
2 San Vicente	656	50	26,591,393	206,296	28,881	30%	10,109	16,578
3 Rio Guejar	350	50	14,187,481	110,066	15,409	30%	5,393	8,845
4 Sogamoso	40	20	648,571	5,032	704	30%	247	404
5 Rio Nare	50	60	2,432,140	18,869	2,642	30%	925	1,516
Total Tar Sands	**1,556**		**62,505,987**	**484,921**	**67,889**		**23,761**	**38,968**

Notes
1. Outcrop measurement from Ingeominas geological map
2. Colombia field observation and measurements by Industry sources
3. 1 sq km = 247.11 acres; 1 meter = 3.28 feet
4. 1 acre foot = 7,758 barrels
5. Oil in place = volume x porosity x (1- water saturation)
   Porosity assumed at 20% per on-site Colombia field observation and measurements per Industry sources; water saturation assumed at 30%
6. Accounts for bitumen ore sterilized due to environmental protection corridors along major rivers, small isolated ore bodies, and the location of surface facilities; Each reduction is thought to represent about 10% of the total area
7. SAGD recoverable rate assumed at 50%; Mining recoverable rate assumed at 82%; Source: Alberta Energy Resources Conservation Board, 2008

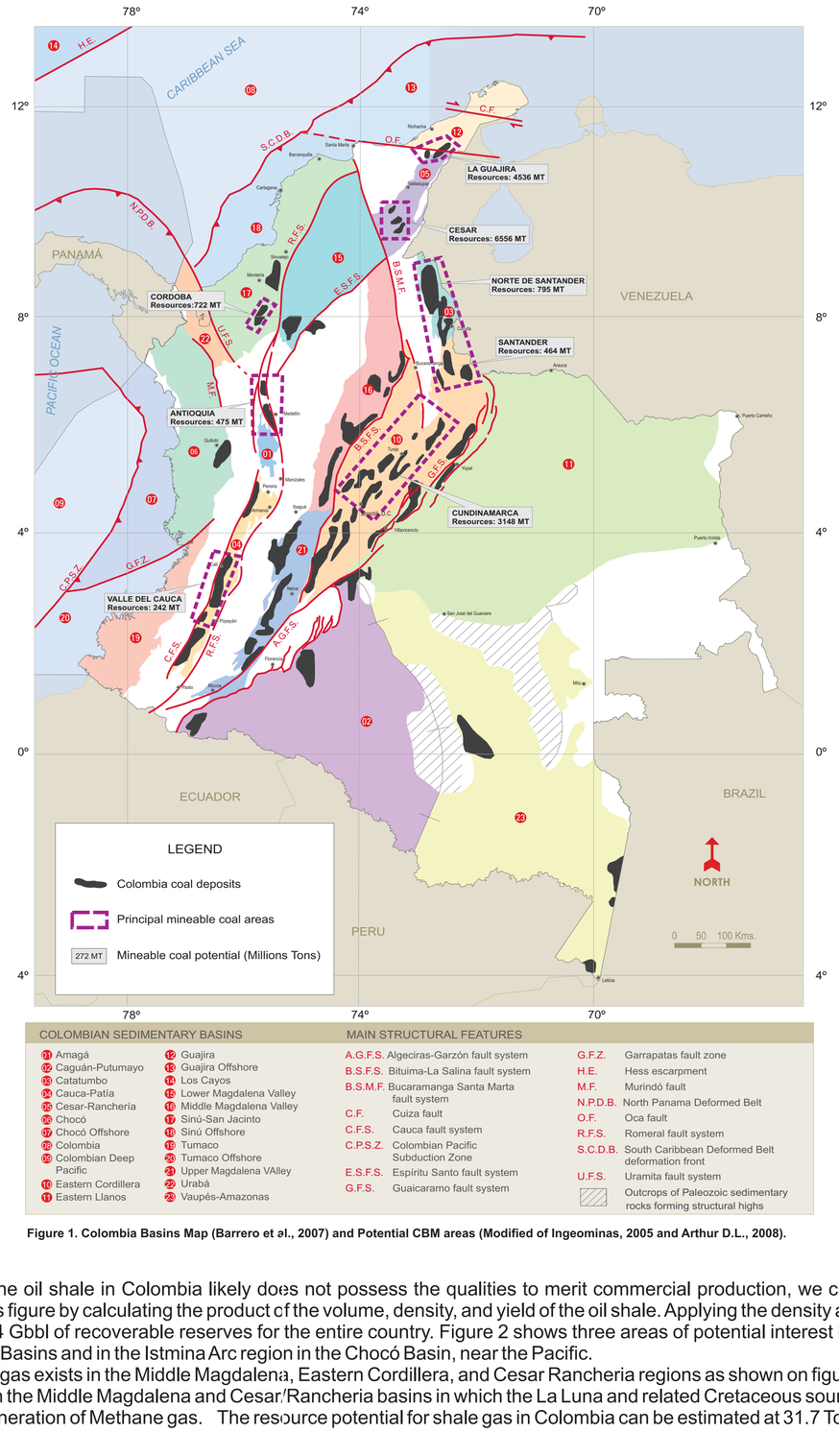
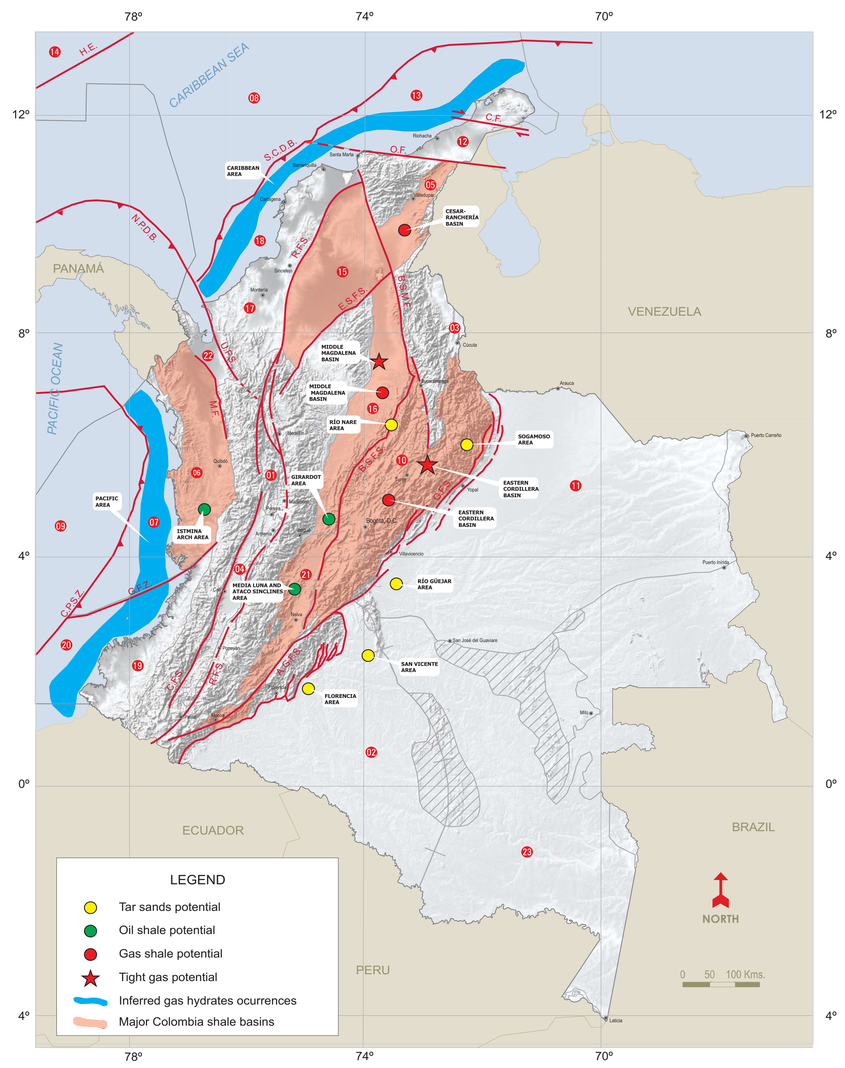


Figure 1. Colombia Basins Map (Barrero et al., 2007) and Potential CBM areas (Modified of Ingeominas, 2005 and Arthur D.L., 2008).



Figuea 2. Colombia unconventional hydrocarbons potential areas (Modified of Arthur D.L., 2008).

Oil and Gas Shale. Though the oil shale in Colombia likely does not possess the qualities to merit commercial production, we can produce a potential recoverable reserves figure by calculating the product of the volume, density, and yield of the oil shale. Applying the density and oil yield to the shale volume produces 14 Gbbl of recoverable reserves for the entire country. Figure 2 shows three areas of potential interest located at the Magdalena Middle and Upper Basins and in the Istmina Arc region in the Chocó Basin, near the Pacific.
Colombia's potential for shale gas exists in the Middle Magdalena, Eastern Cordillera, and Cesar Rancheria regions as shown on figure 2. The red circles identify the areas within the Middle Magdalena and Cesar/Rancheria basins in which the La Luna and related Cretaceous source rocks may be thermally mature for the generation of Methane gas. The resource potential for shale gas in Colombia can be estimated at 31.7 Tcf recoverable natural gas reserves.

Colombia shale gas potential (from Arthur D.L., 2008)

Basin	Area (sq km)[1]	Net pay (meters)[2]	Gas in place (Tcf)[3]	Recoverable reserves (Tcf)[4]
1 Mid Magdalena	7,500	100	289.5	29.0
2 Eastern Cordillera	500	100	19.3	1.9
3 Cesar Rancheria	200	100	7.72	0.8
Total Shale Gas	**8,200**		**316.5**	**31.7**

Notes
1. Mid Magdalena area estimated from Robertson's Research Llanos and Middle Magdalena Basins Geochemical Study; Cesar Rancheria area estimated from Ecopetrol maps
2. Colombia field observation and measurements by Industry sources
3. Standard gas content assumed at 100 bcf/sq mile derived from average Barnett Shale formation with 100 meter thickness; 1 sq km = 0.386 sq mile
4. Recoverable rate assumed at 10%

Colombia oil shale potential (from Arthur D.L., 2008)

Region	Net area (sq km)[1]	Net pay (meters)[2]	Density (kg/m³)[3]	Oil yield (gallons / ton)[4]	Recoverable reserves (Mbbl)[5]
1 Upper Magdalena					
Girardot Media Luna and Ataco Sinclines	128	30	1,720	25	4,334
2 Pacifico					
Istmina Arch	123	50	1,720	35	9,677
Total Oil Shale	**251**				**14,011**

Notes
1. Outcrop measurement from Ingeominas geological map
2. Colombia field observation and measurements by Industry sources
3. Density derived from Jordan Oil Shale density; source: USTDA Oil Shale report on Jordan, 2008.
4. Yields adapted from Wyoming and Utah shale yields of 25 gallon; Pacifico formation contains higher organic content and lower maturity than Girardot Cretaceous shale; source: E&P Magazine, Unconventional Oil Technology, July 2008
5. Recoverable reserves = volume x density x yield; 1 ton = 907.2 kg, 1 bbl = 42 gallons

Other Unconventional Resources in Colombia. For tight gas there are good possibilities in the Eastern Cordillera and Middle Magdalena Basin and related Sub-Basins(Figure 2) that might be suitable for finding considerable volumes of hydrocarbon dispersed within the low permeability and porosity reservoirs that occur in the section from Berrasian-Valanginian time through Aptian-Albian when the very rich source rocks were widely developed. A gross approach shows that it could be found a total gas in place figure of 1.2 Tcf.
It also should be mentioned that gas hydrates can be found offshore in both the Pacific and Caribbean sides of Colombia(Figure 2). Assuming that 164 cubic meters of methane gas can be derived from one (1) cubic meter of methane hydrate, approximately 400 Tcf of gas could be in place in both Colombian coasts(Arthur, 2008).

Colombia tight gas potential (from Arthur D.L., 2008)

Region	Area (sq km)[1]	Gross pay (meters)[2]	Pay Volume (acre-feet)[3]	Pay Volume (Tcf)[4]	Gas in place (Tcf)[5]
Eastern Cordillera/Mid Magdalena	4,000	200	648,570,555	28.3	1.2
Total Tight Gas Potential	**4,000**		**648,570,555**	**28.3**	**1.2**

Notes
1. Outcrop measurement from Ingeominas geological map
2. Colombia field observation and measurements by Industry sources
3. 1 sq km = 247.11 acres; 1 meter = 3.28 feet
4. 1 acre foot = 43,560 cf
5. Gas in place = volume x porosity x (1- water saturation)
   Porosity assumed at 6% per on-site Colombia field observation and measurements per Industry sources; water saturation assumed at 30%

Hydrate potential in Colombia (from Arthur D.L., 2008)

Basin	Area (sq km)[1]	Net pay (meters)[2]	Gas content (m^3 natural gas/ m^3 hydrate)[3]	Gas in place (tcf)[4]
Caribbean	37,500	1	164	217.1
Pacific	37,500	1	164	217.1
Total Gas Hydrate Potential	**75,000**			**434.2**

Notes
1. Rough area estimates from Ecopetrol 2008 Unconventional Resources presentation
2. Net pay assumed at 1 meter, could be much higher
3. USGS
4. Gas in place = Area x net pay x natural gas content
   1 cubic meter = 35.3 cubic feet

Conclusions

Colombia has significant medium to long term potential for production of unconventional hydrocarbons such as coal bed methane, tar sands, gas shale, and tight gas. Potential for oil shale and gas hydrates in the medium term are more limited. Presently the government has made a big effort to exploit Heavy oils in its Orinoquian region.

References

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