

Proceedings

# CBM Resources Estimations for the Development of Coal Mine Methane in the Asturian Central Basin, Spain <sup>†</sup>

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**Abstract:** New technological development and a best knowledge of the basin allow to have justified expectation to find coalbed methane reserves. Measurements of gas content in unexploited coal seams are made in order to estimate the CBM could revive the economic interest of the Asturian Central Coal Basin (ACCB). According to first estimations based on the studies accomplished, the minimum resources of coalbed methane in the whole of the Asturian Central Coal Basin are in the order of 25,000 Mm<sup>3</sup> and the gas content of the coal seams range from 6 m<sup>3</sup> to 14 m<sup>3</sup>/t. The introduction should briefly place the study in a broad context and define the purpose of the work and its significance.

**Keywords:** resources; CBM; Asturias

## 1. Introduction

The Asturian Central Carboniferous Coal Basin, in northern Spain, is an important area, at a national level, for coal production from the 18th century up to now, when a coal mining closure plan is being applied from the beginning of the 1990's (Figure 1).



**Figure 1.** Location of the Asturian Central Carboniferous Basin.

This coal basin constitutes the biggest productive carboniferous area of the Iberian Peninsula, with an extension bigger than 1500 km<sup>2</sup>. In relation to the antecedents for coalbed methane exploration, in the beginning of the 20th century natural gas has been found in various reconnaissance drills accomplished to locate hidden coal deposits.

These findings together with the existence of surface gas manifestations in some areas of the ACCB, have driven to a first exploration campaign for CBM in the area at the beginning of the 1990's [1]. This exploratory campaign was carried out due to the interest offered by the CBM recuperation projects in the world, and for that purposes a collaborative research focussed to known the possibilities for economical recuperation of coalbed methane (CBM) in the Asturian Central Coal Basin was signed between Unión Texas España and HUNOSA national enterprise [1].

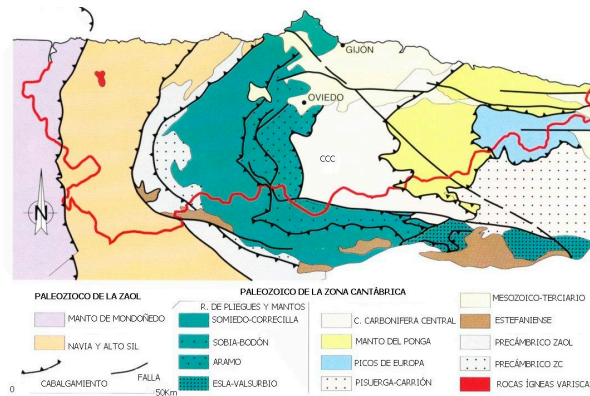
**2. Objective**

The aim is to determine the resource estimates of the gas CBM in the ACCB (Spain).

**3. Geology of Asturian Central Coal Basin.**

The ACCB is a fore-deep basin with many similarities to the Appalachian basin in the USA. It is enclosed in the Iberian Massif, inside the unit named Cantabrian Zone [2]. The stratigraphic column of the ACCB has been traditionally divided into unproductive and productive Carboniferous. Traditionally, the different groups of coal beds and enclosing rocks have been subdivided in an ensemble of lithostratigraphic associations (Figure 2) which have been named "mining packets" [3]. The stratigraphic column of coal basin has been traditionally divided in unproductive and productive carboniferous. The productive carboniferous contains two great coastal ensembles of 3000 m thickness each one, over an extension bigger than 1500 km<sup>2</sup>.

The unproductive Carboniferous (Lena Group) is characterized by a great abundance of calcareous materials and for the scarce presence of coal beds. Estimated thickness is 3500 m and it is formed by alternance of sandstones, limolites and lutites with intercalations of coal beds, some of them sporadically exploited.



**Figure 2.** Geology of Asturian Central Coal Basin [4].

The productive Carboniferous (Sama Group) contains two great coastal ensembles of 3000 m thickness each one. It is formed by alternances of sandstones, limolites and lutites, together with a great number of coal beds which have been exploited since the 18th century. The content in limestones is very scarce and its presence in the stratigraphic sequence is in the form of levels or bed of reduced thickness. Two great conglomeratic ensembles stand up in the middle part of the stratigraphic sequence.

The structural arrangement of the carboniferous materials corresponds with a great basin formed during the Hercynian orogeny. From a tectonic point of view three units separated by important structural accidents can be differentiated. From west to east they are: Riosa-Olloniego Unit, La Justa-Aramil Unit and Caudal-Nalón Unit. The tectonic accidents dividing these units are La Peña and La Carrera faults [4].

To the northern, the coal basin is covered by Permo-Mesozoic and Tertiary sediments, whereas to the southern limits with another great important tectonic accident: the León fault. To the west, the limit is constituted by the basal overthrust of the Aramo Unit pertaining to the “Región de Pliegues y Mantos” [5]. To the east overlaps over the “Región del Manto del Ponga”, where the base is constituted by the overthrust named “Escama de Laviana”. Structurally, it is about a basin intensively deformed and fractured and affected by two generations or folding phases, which originate great synclines and anticlines forming a typical structure of domes and basins. At a time there are faults of great sizes.

From a hydrogeological point of view it can be considered an aquifer model of multibed type, where the materials forming the stratigraphic series are characterized by a very low porosity and permeability. Porosity and permeability are very low even in the sandstone levels. Coal porosity varies between 6.4% and 8.6% and permeability is in the order of 1 mD. The primary permeability of the not fractured rock massif is very low; it is estimated to be lower than  $10^{-7}$  m/s. In conditions of fractured rock massif the permeability is included into the interval  $5 \times 10^{-6}$  to  $1 \times 10^{-6}$  m/s. The functioning of the multibed aquifer system is deeply altered by the mining exploitations, as well by the abandoned mountain mines as by the underground mining.

#### 4. Methodology

The methodology have been completed following generally accepted guidelines and methods [6,7]. Some factors considered as points of interest in the estimation of the coalbed methane resources of the basin, have been:

- Selection of areas of the Central Coal Basin with important coal resources.
- Number and importance of the unexploited coal beds
- Coal characteristics.
- Historical data about gas concentrations in coal mines.
- Favorable geological formations and structures for methane retention in coal beds.

The resources have been estimated until a maximum depth of 2000 m from surface according the data on coal reserves estimated for the Inventory of Coal National Resources [8]. The CBM resources estimation for selected areas has been made by use of the expression:

$$\text{CBM (m}^3\text{)} = \delta \times S \times e_m \times G \quad (1)$$

where:

$\delta$  = Average coal density (1.6 t/m<sup>3</sup> has been considered for all coal beds).

$e_m$  = Coal bed thickness (m)

$S$  = Average coal bed surface (m<sup>2</sup>).

$G$  = Average methane content in coal bed (m<sup>3</sup>/t).

The coal bed thickness has been obtained from the stratigraphic columns in the different coal mines. For average methane content in coal bed, the average data obtained in the mining degasification essays made in active coal mines managed by HUNOSA National Company, have been used [8]. The resources estimation has been made for equispaciated parallel sections method with intervals of 200 m, as well by coal packages as by depth [9].

Permeability measurements in situ on this drill will allow obtained a first assessment of the permeability of the Asturian Central Coal Basin for coalbed methane development [10].

#### 5. Assessment of Coalbed Methane Resource Potential

A preliminary assessment has tried to define the coal gas resource potential of the Central Coal basin of Asturias [11].

##### 5.1. Coal Characteristics and Geometry

The maturation grade of the coals varies from the north zone of the basin where the volatile content of coals ranges from 35–40% to 20–30%, to the south zone of the basin where the volatile

content ranges from percentages in the order of 20% to less of 10% [12]. Coal from the northern part of the basin is less evolved. In the northern part of the basin coals are from bituminous to sub-bituminous type with high content in volatile, living place to coals of the type hard coal in the south part of the basin. The reflectance of the vitrinite shows a progressive decrease from the north of the basin, with values in the order of 0.78% Rr in Pumarabule Mine, to the south of the basin, with average values of 2.54% in the case of San Antonio Pit Shaft. The ash content is very variable inside each zone, and in general in the whole of the basin. Coal seams are generally thin to moderate in thickness and their geometry is very complex due to the large-scale structural deformation of the area. However, the extensive mining operations and geologic evaluation history has resulted in a thorough understanding of the geometry of the target coal seams [12].

5.2. Coalbed Methane Resource Estimation

CBM resources estimation has been made by zones, according to the subdivision of the ACCB in sectors made in 1984 by ENADIMSA in collaboration with the IGME (Geological and Mining Survey of Spain) [12] with the purposes to evaluate the coal resources. Five sectors have been considered for these purposes: Nalón, Turón, Aller, Riosa-Olloniego and La Justa-Aramil.

Data on CBM resources evaluated for the five mining sectors of the Asturian Central Coal Basin are indicated on Table 1.

**Table 1.** CBM resources (Mm<sup>3</sup> and Bcf units) of the different sectors of Asturian Central Coal Basin [12].

Mining Sector	Coalbed Methane Resources	
	(Million m <sup>3</sup> )	(Billion Cubic Feet)
Nalón	14,000	470
Turón	3900	130
Aller	2000	66
Riosa—Olloniego	4800	160
La Justa—Aramil	1400	45
Total	26,100	870

As part of the exploratory campaign, a research drill named “ASTURIAS CBM#1” has been made in 2004 in a selected site of the La Justa—Aramil Sector [13]

Estimated gas content of coal in the Asturian Central Coal Basin generally varies from 6 to 14 m<sup>3</sup>/t (200 to 470 cf/t). These data are comparable to those of gas content of coal in many commercial coalbed methane fields in the U.S. [13]. The total estimated gas in place for the basin is small, when compared to major coal basins in the U.S. [14] (Table 2).

**Table 2.** Comparison of total gas resource and gas resource concentration between the major coal basins of the U.S. and the Central Coal Basin of Asturias [14].

Coal Basin	Gas In Place (Billion m <sup>3</sup> )	Gas Resource Concentration (Million m <sup>3</sup> /km <sup>2</sup> )
Black Warrior (U.S.)	570	50–200
Central Appalachian (U.S.)	140	30–100
San Juan (U.S.)	2400	200–800
Raton (U.S.)	290	50–200
Uinta (U.S.)	290	50–400
Powder River (U.S.)	1100	10–50
Asturias Central Coal Basin (Spain)	26	3–218

## 6. Potential Coalbed Methane Development

One of the critical components in successful coalbed methane production is the flow potential of the coal, which is a combination of permeability, relative permeability, and reservoir pressure [14].

An important fact to consider for coalbed methane development is that the Central Coal Basin of Asturias has been continuously mined since the 18th century. Accordingly, most of the shallow, easy-to-mine coal (<400 meters in depth) has been extracted throughout the basin.

Recently, improved equipment has reduced the time and cost associated with performing multiple hydraulic stimulation treatments in a single well. The most widely used operation for this type of stratigraphic setting is the use of coiled tubing and a downhole straddle assembly.

The drilling of wells parallel to the bedding of a coal seam is an established technique for degasification of coal prior to mining. However, this technique is normally performed from within the underground mining operations. The application of drilling long wellbores parallel to the bedding of a coal seam is a recent advance in coalbed methane drilling and completion technology. This is contrasted against the historically normal procedure whereby a well is drilled at right angles to the bedding with a subsequent hydraulic fracture placed within the bedding of a coal seam.

Based on the results obtained to date in the U.S. for drilling in-seam wells, this appears to be an approach that should be considered for development of the gas resources that have been identified in the coal seams of the Central Coal basin of Asturias. From a single well site on the surface, numerous in-seam wells could be drilled. The ability to keep the drill bit in a coal seam is proven technology, so the ability to drill in-seam wells in the complex structural setting of this basin should not pose a problem. In some settings, a well drilled in this manner would be closer to a vertical well than to a horizontal (which is normally the situation in the U.S. coalfields).

Given that coal seams are thin to moderate in thickness, a successful coalbed methane development project will probably rely on the production of gas from multiple coal seams.

The strong structural deformation—folding and faulting—will affect the drilling and completion operations.

## 7. Conclusions

After the preliminary study accomplished about the potential exploitation of coalbed methane in the Asturias Central Coal Basin it can be inferred that this basin constitutes an interesting area in order to carry out an in deep study in some favorable sectors.

From all geological units, Barros in “La Justa–Aramil” Sector is the most interesting, given the scarce mining activity developed in the area, the presence of a great density of coal beds close to surface, the favorable rank of coals and the simple geological structure. Main mining packs are Sotón, María Luisa and Canales.

- Sotón mining pack has a total thickness of 400 m, the number of coal beds ranges from 8 to 12, and accumulated coal beds thickness is comprised between 10.5 and 14 meters.
- María Luisa mining pack has a total thickness of 300 m, the number of coal beds ranges from 6 to 9, and accumulated coal beds thickness is comprised between 6.5 and 8.5 m.
- Canales mining pack has a total thickness of 800 m, the number of coal beds ranges from 8 to 12, and accumulated coal beds thickness is comprised between 12 and 15 m.

The new technologies in guided drilling, which were not possible to apply on the first coalbed methane exploration campaign developed in the basin on the 1990s, supposes on nowadays a new option for the development of the CBM industry in the zone.

According to first estimations, the minimum resources of coalbed methane in the whole of the Asturian Central Coal Basin are in the order of 25,000 Mm<sup>3</sup> (~0.9 Tcf) and the gas content of the coal seams range from 6 m<sup>3</sup>/t to 14 m<sup>3</sup>/t (200 to 470 cf/ton).

Coalbed methane development allows reviving the economical interest of the Asturian Central Coal Basin.

However, the gas resource concentration in some areas of the Central basin is equal to or greater than areas in the U.S. with commercial coalbed methane production (such as the Powder River,

Central Appalachian, and Black Warrior basins). Accordingly, the basin is not large enough for numerous production companies to operate as we see in some of the U.S. basins. It is large enough, though, for one or possibly two companies to operate successfully.

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