XII. SPAIN

SUMMARY

The Basque-Cantabrian Basin, located in northern Spain, contains a series of organic-rich Jurassic-age shales with potential for wet gas and condensate, Figure XII-1. In addition, the Ebro (Solsona) Basin, located to the south and east of the Basque-Cantabrian Basin, may also have local potential for shale gas and oil. However, the shale in the Ebro Basin has TOC below the 2% cut-off used in this study and thus was not quantitatively assessed.

Figure XII-1. Selected Shale Gas and Oil Basins of Spain

Source: ARI, 2013

Advanced Resources International, Inc.

The Jurassic-age (Liassic) marine shale in the Basque-Cantabrian Basin contains an estimated 42 Tcf of risked shale gas resource in-place, with about 8 Tcf as the risked, technically recoverable shale gas resource, Table XII-1. In addition, the Jurassic Lias Shale contains nearly 3 billion barrels of risked oil/condensate in-place, with about 0.1 billion barrels as the risked, technically recoverable shale oil resource, Table XII-2.

Table XII-1. Shale Gas Reservoir Properties and Resources of Spain

Basic Data	Basin/Gross Area		Basque-Cantabrian (6,620 mi^2)
	Shale Formation		Jurassic
	Geologic Age		L. - M. Jurassic
	Depositional Environment		Marine
Physical Extent	Prospective Area (mi^2)		2,100
	Thickness (ft)	Organically Rich	600
		Net	150
	Depth (ft)	Interval	8,000 - 14,500
		Average	11,000
Reservoir Properties	Reservoir Pressure		Slightly Overpress.
	Average TOC (wt. %)		3.0%
	Thermal Maturity (% Ro)		1.15%
	Clay Content		Medium
Resource	Gas Phase		Wet Gas
	GIP Concentration (Bcf/mi^2)		49.8
	Risked GIP (Tcf)		41.8
	Risked Recoverable (Tcf)		8.4

Source: ARI, 2013

Table XII-2. Shale Oil Reservoir Properties and Resources of Spain

Basic Data	Basin/Gross Area		Basque-Cantabrian (6,620 mi^2)
	Shale Formation		Jurassic
	Geologic Age		L. - M. Jurassic
	Depositional Environment		Marine
Physical Extent	Prospective Area (mi^2)		2,100
	Thickness (ft)	Organically Rich	600
		Net	150
	Depth (ft)	Interval	8,000 - 14,500
		Average	11,000
Reservoir Properties	Reservoir Pressure		Slightly Overpress.
	Average TOC (wt. %)		3.0%
	Thermal Maturity (% Ro)		1.15%
	Clay Content		Medium
Resource	Oil Phase		Condensate
	OIP Concentration (MMbbl/mi^2)		3.4
	Risked OIP (B bbl)		2.9
	Risked Recoverable (B bbl)		0.14

Source: ARI, 2013

INTRODUCTION

The Jurassic-age rocks of the Basque-Cantabrian Basin crop out in the eastern and western portion of the basin, providing access to valuable information on the geologic setting and reservoir properties of these shales. Analysis of rock samples indicates Type I/II organic matter with TOC values (in immature samples) of up to 25%.[1]

The shales in the Lower Jurassic Comino and Castillo Pedroso formations (Toarcian- and Pliensbachian-age) were deposited under deep marine conditions following tectonic extension. The shales are interbedded within limestones and marls which, much like in the Bakken Shale of the Williston Basin (USA), may provide additional flow and storage capacity for oil and gas expulsed from the maturing shales.[1,2]

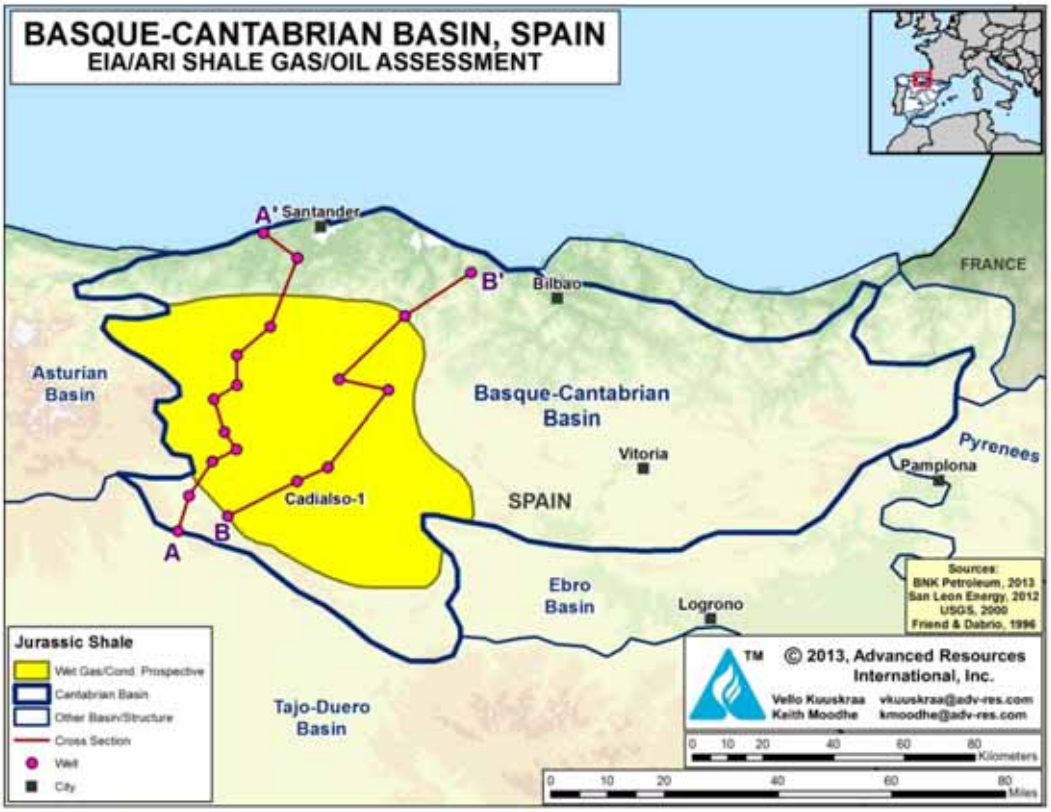
1. BASQUE-CANTABRIAN BASIN

The Basque-Cantabrian Basin covers a large 6,620-mi^2 area along the northern border of Spain. The basin is bounded by faults and thrusts on the east, west and south and by the Cantabrian Sea on the north. The Basque-Cantabrian Basin contains a sequence of formations that hold organic-rich shales of Silurian-Ordovician, Jurassic and Cretaceous age. Of these, the Jurassic (Liassic) shales appear to offer the most potential.

1.1 Geologic Setting

Jurassic Shales. The Basque-Cantabrian Basin contains a series of regionally significant, thick black shales of Jurassic-age, including the Lias Shale at the base of the Lower Jurassic. We have mapped a 2,100-mi^2 higher quality prospective area for the Lias Shale in the western portion of this geologically complex basin. We used information on the erosion of the Lias Shale on the north and south and the 400-m gross Jurassic interval to establish our prospective area, Figure XII-2.[3]

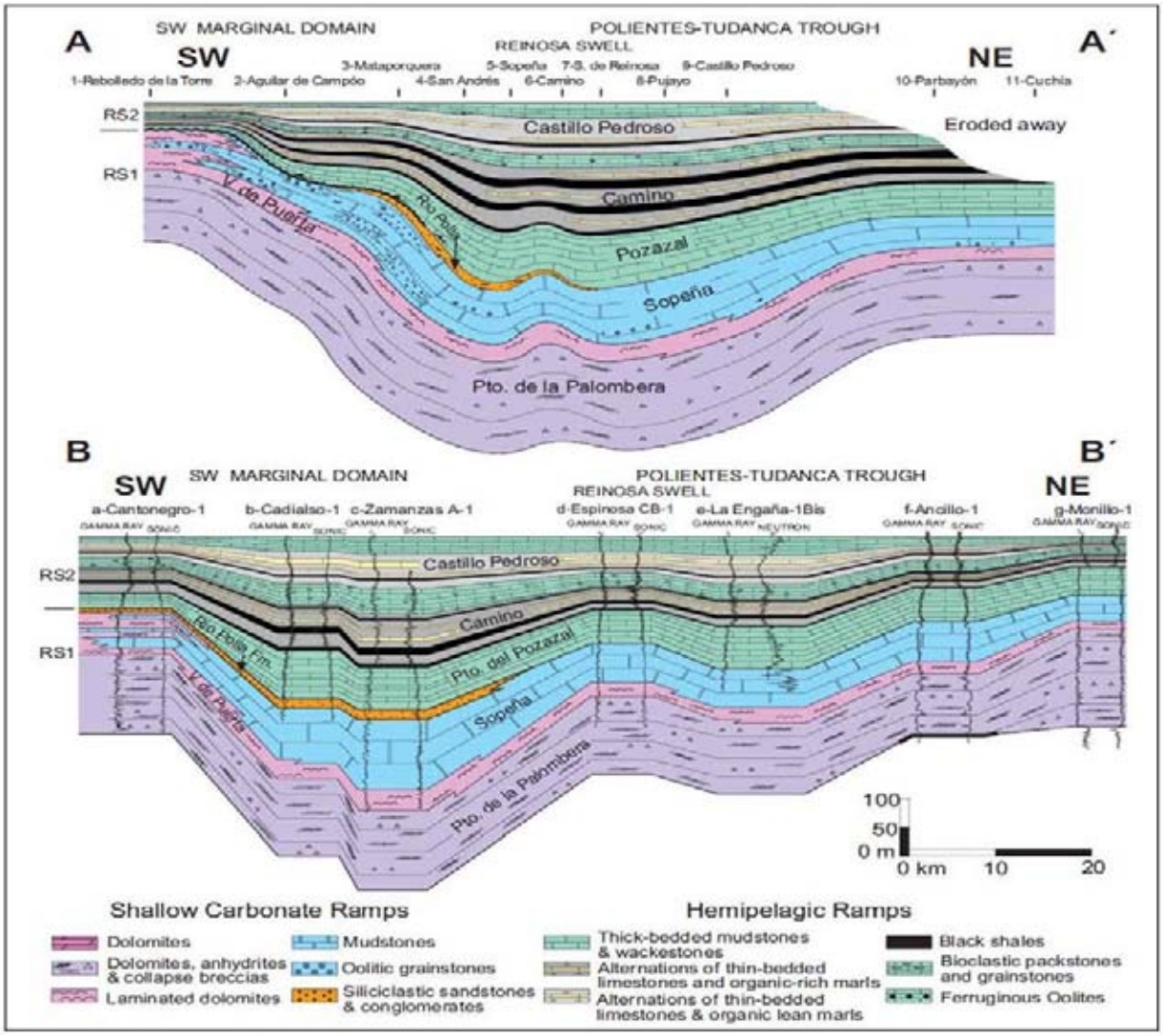
Figure XII-2. Prospective Area of Jurassic Shale, Basque-Cantabrian Basin



Source: ARI, 2013

A series of interbedded black shales and carbonates exists within the Jurassic interval. Figure XII-3 provides two regional cross-sections, A to A' and B to B', identifying the sequence of Jurassic black shales in the prospective area of the basin. Figure XII-2, shown previously, provides the location of these two cross-sections and identifies the key Cadialso-1 well near the south-western end of cross-section B to B'.

Figure XII-3. Cross-Sections Through Prospective Area of Basque-Cantabrian Basin



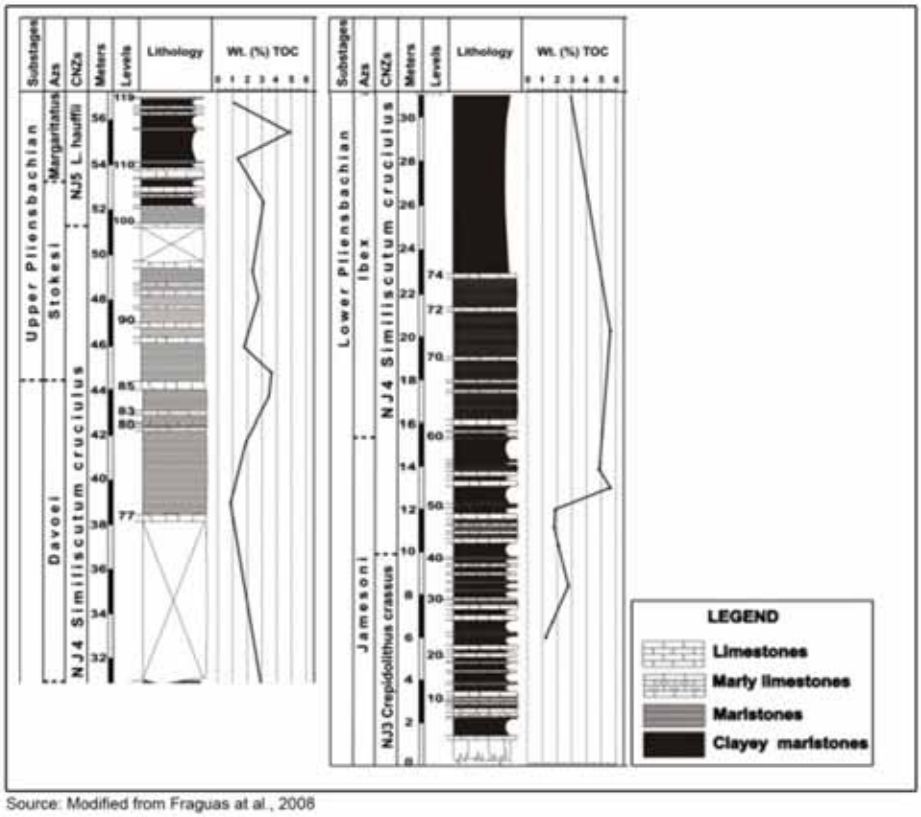
Source: Quesada, S., 2005.

1.2 Reservoir Properties (Prospective Area)

Jurassic (Liassic) Shales. The Cadialos-1 well (shown on Cross-Section B-B'), drilled to 12,000 ft, provided valuable information on the organic-rich Lias Shale. The shale has a gross thickness of 280 ft with a net thickness of 30 to 50 ft, TOC values of 2% to 4% and a thermal maturity (R_o) of 1.2%. The well also intersected a shallower Jurassic Shale at about 9,500 ft with a gross thickness of 400 ft and a net thickness of about 100 ft. This shallower Jurassic Shale has a TOC of about 2% and a thermal maturity (R_o) of 1.1%.

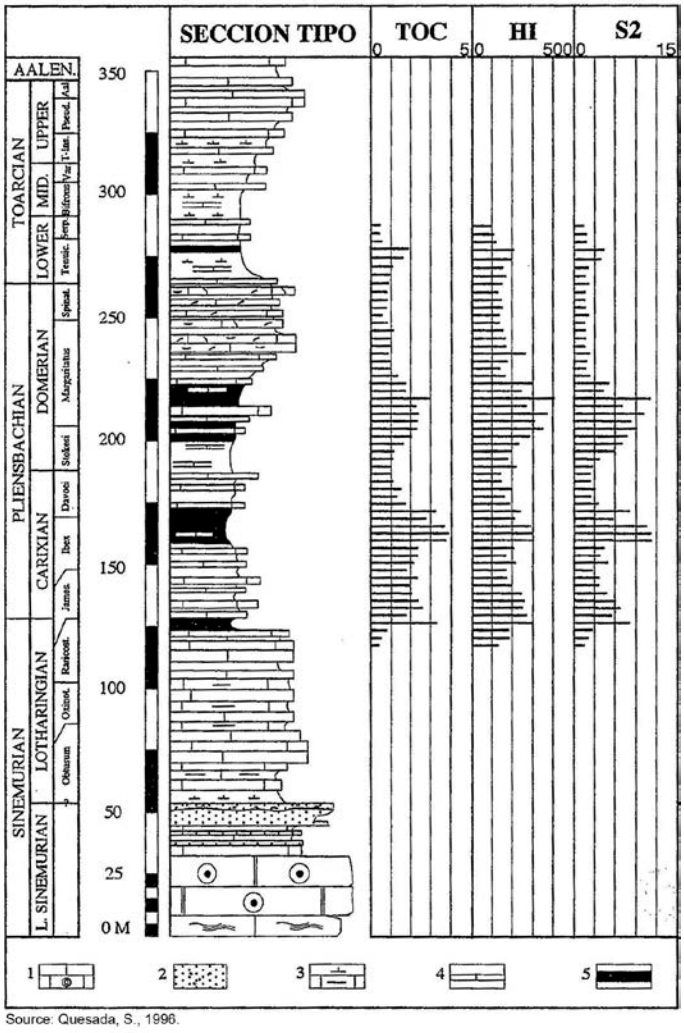
Figures XII-4 and XII-5 provide additional information on the TOC and thermal maturity values for the Jurassic (Pliensbachian) Lias Shale in the northern portion of the prospective area near the Poliente-Tudanca Trough.[4,5,6]

Figure XII-4. TOC Values in the Pliensbachian Interval of the Jurassic



Source: Modified from Fraguas at al., 2008

Figure XII-5. TOC Values in the Pliensbachian Interval of the Jurassic



Source: Quesada, S., 1996.

1.3 Resource Assessment

The entire package of Jurassic shales, including the Lias Shale, within the 2,100-mi^2 prospective area of the Basque-Cantabrian Basin has a resource concentration of about 50 Bcf/mi^2 of wet shale gas and 3 million barrels/mi^2 of shale condensate.

The risked resource in-place within the prospective area is estimated at 42 Tcf of wet shale gas and 3 billion barrels of shale condensate. Based on moderate reservoir properties, we estimate risked, technically recoverable resources from these Jurassic shales of 8 Tcf of wet shale gas and 0.1 billion barrels of shale condensate.

1.4 Recent Activity

Several companies hold leases and are actively exploring the Jurassic Shales in the Basque-Cantabrian Basin. For example, San Leon Energy (who acquired Realm Energy and its oil and gas concessions in Spain) has two concession areas, totaling over 210,000 acres in the basin. In addition, BNK Petroleum has a 380,000-acre Jurassic Shale concession in Castillo y Leon and hopes to spud an exploration well in this area during 1Q 2013, pending approval.[7]

HEYCO Energy and Cambria Europe, along with the Basque Energy Board, announced a USD $138 million exploration program in 2011.[8] No further information is available on the activities or results of this exploration program.

2. OTHER SHALES OF THE BASQUE-CANTABRIAN BASIN

Ordovician and Silurian Shales. The presence of the Ordovician and Silurian shale interval, a major source rock in the Middle East and North Africa, has been well established in Spain in outcrops and boreholes. To further assess the resource potential of these shales, a total of 24 new samples of the Lower Silurian Formigoso Formation and Middle Ordovician Sueve Formation was gathered from twelve different outcrop locations in the provinces of Asturias and Leon during May 2010.[9]

Nineteen of the twenty-four samples had TOC values less than 1% and no sample recorded a TOC above 2%. In addition, the remaining kerogen type was mostly inertinite.[9] Based on the results of this geochemical work, the investigators concluded that the Lower Paleozoic (Ordovician and Silurian) shales in this part of the basin have poor potential for shale gas and oil. As such, these shales were excluded from further assessment.[9]

Cretaceous Shales. The thick Cretaceous-age (Albian-Cenomanian) Valmaseda Formation contains the Enara Shale, which hold an estimated 185 Bm^3 (6.5 Tcf) of shale gas based on a study of 13 wells in the Gran Enara field in northern Spain. A shale gas exploration program has been proposed.[10] However, no details in the TOC or other properties accompanied this initial shale gas assessment. San Leon Energy's separate characterization of the Valmaseda Formation and the Enara Shale indicates that the TOC, while up to 3.6% locally, averages only about 1%. As such, these shales were excluded from further assessment.

3. EBRO BASIN

The Ebro (Solson) Basin is located to the south and east of the Basque-Cantabrian Basin in the northeast portion of Spain. The shale potential in this basin has been evaluated based on 30 older petroleum wells, twelve of which penetrated the Paleozoic section. The wells identified a shale sequence at 1,650 to 4,000 m depth, with a thickness of 50 to 100 m and a thermal maturity ranging from 1% to 2% R_o, placing these shales in the wet to dry gas window. However, because the TOC of these shales averages only about 1%, the Paleozoic shales in the Ebro Basin were excluded from further assessment.[4]

A series of younger Eocene-age reservoir intervals also contain thermally mature shales. These mostly Middle Eocene shales are deposited as thin layers of shale interbedded within low-porosity sandstones. Again, however, the TOC values in these Eocene shales averaged less than 1%, therefore these shales were excluded from further assessment.[4]

REFERENCES

[1] Gibbons, W. and Moreno, T., 2002. "The Geology of Spain." The Geological Society of London, ISBN 1-86239-110-6.

[2] Suárez-Ruiz, I. and Prado, J.G., 1995. "Characterization of Jurassic Black Shales from Asturias (Northern Spain): Evolution and Petroleum Potential." Composition, Geochemistry and Conversion of Oil Shales, NATO ASI Series Volume 455, 1995, pp 387-393.

[3] Quesada, S., Robles, S. and Rosales, I., 2005. "Depositional Architecture and Transgressive–Regressive Cycles within Liassic Backstepping Carbonate Ramps in the Basque–Cantabrian Basin, Northern Spain." Journal of the Geological Society, London, vol. 162.

[4] San Leon Energy, Investor Presentation, 2012.

[5] Fraguasa, A, and Erbab, E., 2010. "Biometric Analyses as a Tool for the Differentiation of Two Coccolith Species of the Genus Crepidolithus (Pliensbachian, Lower Jurassic) in the Basque-Cantabrian Basin (Northern Spain)." Marine Micropaleontology, vol. 77, Issues 3–4, December, p. 125–136.

[6] Quesada, S., Robles, S. and Dorronsoro, C. 1996. "Characterization of the Liassic Source Rock and Its Correlation with the Oil of the Ayoluengo Field on the Basis of Gas Chromatography and Carbon Isotope Analyses (Basque-Cantabrian Basin, Spain)." Geogaceta, vol. 20 (1), p. 176-179, ISSN: 0213683X.

[7] BNK Petroleum Investors presentation, 2011.

[8] Oil & Gas Journal, 2011. "Thick Shale Gas Play Emerging in Spain's Cantabrian Basin", May 12.

[9] Maio, F., Aramburu, C. and Underwood, J., 2011. "Geochemistry of Ordovician and Silurian Black Shales, Cantabrian Zone, Asturias and Leon Provinces, Northwest." AAPG Search and Discovery Article #50529, posted December 19, 2011, adapted from poster presentation at AAPG International Conference and Exhibition, Milan, Italy, October 23-26, 2011.

[10] Platts, 2011. "Spanish Basque Region Reports 185 Bcm of Shale Gas Finds in Alava." 17Oct2011/919 am EDT/1319 GMT, www.platts.com accessed March 7, 2013.