Ayoluengo: The Only Oil Field Onshore Spain*

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Abstract

Ayoluengo, commonly cited as the only oil field onshore Spain, is located about 300 km north of Madrid, in the Basque-Cantabrian Basin, a region that concentrated most of the hydrocarbon exploration effort during the mid-20th century. In the early 1960s, seismic allowed identification of a faulted anticline below an Upper Cretaceous carbonate plateau, where the exploration well Ayoluengo-1 was drilled. On June 6, 1964, Ayoluengo-1 tested 85 barrels oil per day from a 5-meter thick sandstone bed of Late Jurassic-Early Cretaceous age at 1350 meters depth. It was the first significant oil discovery in Spain after more than 100 exploration holes. It brought great expectations in the region, presumed to become a prolific ‘black gold’ province.

Oil and gas in Ayoluengo are reservoired within a series of thin lenticular sandstone packages of Late Jurassic-Early Cretaceous age. More than 50 separated reservoir beds are identified. Reservoir properties are fair to good, with porosities commonly ranging 12% to 18%. Most of the individual reservoirs layers are isolated by shales and compartmentalized by faults, which makes Ayoluengo to be considered as not a single field but the grouping of more than 100 independent small fields.

Commercial production started in 1967. Peak production at 5200 barrels of oil per day was reached in 1969 and since then production has gradually declined. Oil is produced by rod pumps, powered by the small amount of produced gas. A total number of 52 wells have been drilled, but ultimately only a few were active. The oil has relative high arsenic and vanadium content, which made it inadequate for refining, so it was sold as fuel oil to local industries in northern Spain. Now, 50 years after the first oil, the field has a cumulative oil production of 17 million barrels of oil. The 50-years production concession expired at the end of January 2017 and the field is now awaiting a bidding process for a new concession to be awarded.

The Ayoluengo oil discovery revitalized the seismic and drilling activity in the region, but subsequent exploration drilling only tested uncommercial oil flow rates. Today, surprisingly the Ayoluengo Field remains as a unique oil discovery, being the only onshore commercial oil field in the entire Iberian Peninsula. This anomalous geological singularity has brought recurrent discussions among petroleum geologists because it is difficult to explain why an oil petroleum system is uniquely working at this particular field within such a vast territory.
References Cited


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Jimenez, S., 2013, Recuperación secundaria en campos de petróleo y su conversión en almacenamientos subterráneos de gas natural, Proyecto fin de carrera, Escuela Técnica Superior de Ingenieros de Minas, Madrid (Spain), 90 p.


Ayoluengo – The Only Oil Field Onshore Spain

by Jorge Navarro Comet

CEPSA
Ayoluengo a unique oil field onshore Spain
1946. State Petroleum Reserve (2,800 km²) awarded to CAMPSA

Zamanzas anticline
Tar sands outcropping
6 wells drilled (1941-1953)

Ayoluengo faulted anticline

State Reserve boundaries were mainly based on rivers and infrastructure

Huidobro first oil exploration well drilled in Spain (1900)

(1) Compañía Arrendataria del Monopolio de Petróleos, S.A.
Spanish-government petroleum monopoly formed in year 1927
1900. Huidobro, the first petroleum exploration well drilled in Spain
1940s. Zamanzas Valley - Tar sands exploitation by CAMPSA

Archeological remains of the tar exploitation

Rudimentary and experimental underground mining.

Tar sands crumbled and dumped into water tanks heated by wood fire.

Oil manually collected - 1 to 3 bopd
1941 – 1953. Zamanzas Valley - Exploration wells by CAMPSA

Zamanzas-2 (S3) CAMPSA, 1946
Rig Foraky

Villanueva de Rampaolay -1 (S7) CAMPSA, 1953
Rig 64-A

Zamanzas valley

CAMPSA, 1958
Sondeos en la zona norte de Burgos

Zamanzas Valley wells

Oil recovery

Oil shows

Jurassic

Keuper

TD @ 2177 m
1964. Spain exploration licenses

Most of the exploration effort was focused on:
- Basque-Cantabrian
- Pyrenees
- Ebro
- Guadalquivir

(1) Compañía Arrendataria del Monopolio de Petróleos, S.A.
(2) Standard Oil Company of California

Rios, 1965
Ayoluengo-1 well proposal location

Jurassic horizon depth map (m) based on Ubierna 2D seismic survey (1962-1963)

Structural section based on surface geology and 2D seismic
Ayoluengo-1 first oil tested (DST#2)
Upper Jurassic – Lower Cretaceous sandstones

Well spud on 5th May 1964
DST#1 - failed
CORE#1 – Claystone w/some free oil

DST#2 (1348.2-1360.8 m MD)
6th June 1964
80 bopd 35°API

TD @ 2397 m MD reached 18th July
Completed as discovery on 12th August

AMOSPAIN, 1964
Ayoluengo-1 gusher

8th June 1964

Ayoluengo-1 well blew oil over 30 meters in the air during 10 minutes

Ayoluengo-1 oil spray across drilling site
An Oklahoma oil boom in Spain

ESTE PARAMO PUEDE CONVERTIRSE EN EL OKLAHOMA ESPAÑOL

EL ESCENARIO DEL ACONTECIMIENTO

1. Esquina al noreste, donde se inicia la cuesta, con una gran mancha de pelos. La base se muestra el occidente, de construcción moderna, que el acceso a la cima y el punto de partida, de la cuesta, se realiza por el noreste.
2. Fotos en color de las zonas con mayores concentraciones de petróleo.
3. Caras de reconocimiento en las zonas con mayores concentraciones de petróleo.
4. Escena de la explotación del gas en el desierto.
5. Espacio para el desarrollo de futuras explotaciones petrolíferas.
6. Imágenes de zonas accidentadas y zonas mejoradas.

El Alcázar

by Jesús Hermida

8th June 1964
Ayoluengo-1 well site

Photo taken after first oil flow at Ayoluengo-1

June 1964

Monument at the site of Ayoluengo-1 commemorating the first Spain’s oil well

10th July 2017

Monument funded entirely by the local council
Ayoluengo field stratigraphic column

- **Creataceous**
  - **Upper**
    - Upper Limestones
  - **Lower**
    - Utrillas Fm

- **Jurassic**
  - **Lias**
    - Middle Marls Zone
      - Carniolas
  - **Dogger**
    - Upper Marine Limestones

- **Triassic**
  - **Keuper**

**Key points**:
- **Source rock**
- **Unconformity**
- **Seismic marker**

**Development wells**

**AYOLUENGO-1**

**TD @ 2397 m MD**
Ayoluengo seismic coverage

2D regional seismic coverage

3D seismic survey 70 km² acquired on 1988
Ayoluengo technical highlights

• NE-SW oriented faulted anticline (area 10 km$^2$ / 200 m vertical closure)
• Oil & Gas pooled in thin lenticular fluvio-lacustrine sandstones of Late Jurassic- Early Cretaceous age
• Highly compartmentalized, 100+ independent sandstone beds (commonly < 5 m thick)
• $\text{Av} \ \phi = 18\%$, $K$ up to 1 darcy
• **Oil gravity** 20° to 39° API, low sulphur (0.2%) and high arsenic content (22 ppm)
• Initial GOR = 388 SCF/STB
• Reservoir drive mechanism gas expansion and gravity drainage
• **Formation water** (50,000 ppm)
Ayoluengo depth map - Top seismic marker (m bsl)

Chevron, 1986
1988. 3D seismic line Ayoluengo oil field

A

AYOLUENGO-1

Seismic marker

AYOLUENGO FAULT

TOP KEUPER

B-LIME

TOP DOGGER

Abeger et al, 2006
Ayoluengo structural cross section

Navarro, 2016
(modified from Chevron, 1986)
Ayoluengo fluvio-lacustrine lenticular sandstones (Upper Jurassic-Lower Cretaceous)

Seismic marker

0 m
100

Jimenez, 2013
Ayoluengo production highlights

• **First oil in 1967.** Oil production peaked in 1969 (**5,200 bopd**)  
• 52 wells drilled (2 deep holes)  
• Since 2007 **LGO’s**\(^{(1)}\) Spanish subsidiary, **CPS**\(^{(2)}\) is the field operator (100%)  
• 17 million barrels oil, cumulative production as of 31\(^{st}\) January 2017  
• Oil is treated (by removal of water) and sold as fuel oil to a glass factory in Burgos  
• Gas is either used for the oil heater, pump motors and generate electricity  
• Water produced on site is re-injected  
• Oil sales averaged 86 bopd in 2016 from ~10 producing wells.  
• **Production Concession terminated at midnight on 31\(^{st}\) January 2017.** The field was temporary shutdown after 50-years continuous production. Currently is pending in a new Concession granting by a process of public tender.  

\(^{(1)}\) LGO Energy plc changed the company’s name to Columbus Energy Resources plc on 15th June 2017  
\(^{(2)}\) Compañía Petrolífera de Sedano  

https://columbus-erp.com/
Ayoluengo production history

5,200 bopd

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<td>17 MMSTB</td>
<td>150 bopd</td>
<td>5,200 bopd</td>
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Oil Production Rate (m³PD)

Cumulative Oil Production (MM³)

1968: Began production
1969: Drilled 19 infill producers
1975-85: Drilled 19 infill producers
1981: Drilled 1 well
2008: Began water injection and workover program
1992-2007: No new investment

Ownership:
- Chevron/Texaco (1962-82)
- Northern Petroleum (2003-06)
- Gold & Ascent (2006-07)
- Lneo Gas & Oil (2007-present)
Ayoluengo field production facilities
12th August 2017. Demonstration by the unions and local villagers supporting the field re-opening.
Schematic regional cross section

- Albian-Cenomanian sandstones
- Upper Cretaceous carbonates
- Upper Jurassic–Lower Cretaceous
- Triassic evaporites
- Liassic-Dogger carbonates
- Liassic source rock
- Tar sands
- Tar sands mining
- Oil producing interval
- Oil shows

Ayoluengo oil field
Zamanzas Valley

Navarro, 2016
Ayoluengo: an excellent ‘boot’ camp for petroleum geoscience students

- 52 wells (2 deep wells) + 2D / 3D seismic available
- Flat terrain, easy to run any simple geophysical operation: reflection/refraction seismic, gravimetry, geo-electrics,...
- Spectacular area for petroleum geology with easy access to outcrops: reservoir, source rock, tar sands, text-book anticlines, world-class salt diapirs, ....
- Oil museum was opened on March 2015 with conference and meeting rooms available
- Located inside ‘Las Loras’ UNESCO Global Geopark, recently endorsed (May 5th 2017)
- Good accommodation facilities nearby and ............ ....excellent food !!!
Oil Museum (Sargentes de la Lora, Burgos)

Ayoluengo nodding donkey
Reservoir analogue is nearby outcropping

Barcena de Ebro (Cantabria)
15 km NW from Ayoluengo
Oil sourced from Liassic black shales

Santiurde de Reinosa (Cantabria)
40 km NW from Ayoluengo
Oil sourced from Liassic in two adjacent troughs? ... but it requires a complex migration pathway: lateral and then vertical thru faults.

Transformation ratio map for the Liassic source rock

Beroiz & Permanyer (2011)
World class source rocks are present in Spain

- Black shales (Liassic), Cantabrian Basin
  Ayoluengo source rock

- Armancies Fm (Eocene), Eastern Pyrenees
  Riutort oil mine

- Escucha Fm (Albian), Iberian Range
  Coal and carbonaceous shales

- Miocene oil shales, Iberian Range
  Rubielos de Mora
Is Ayoluengo field a geological singularity?

Why a petroleum system is uniquely working at this particular point and nowhere else in 500,000 km²?
Next holidays in Spain, come and visit Ayoluengo!

Muchas gracias