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.

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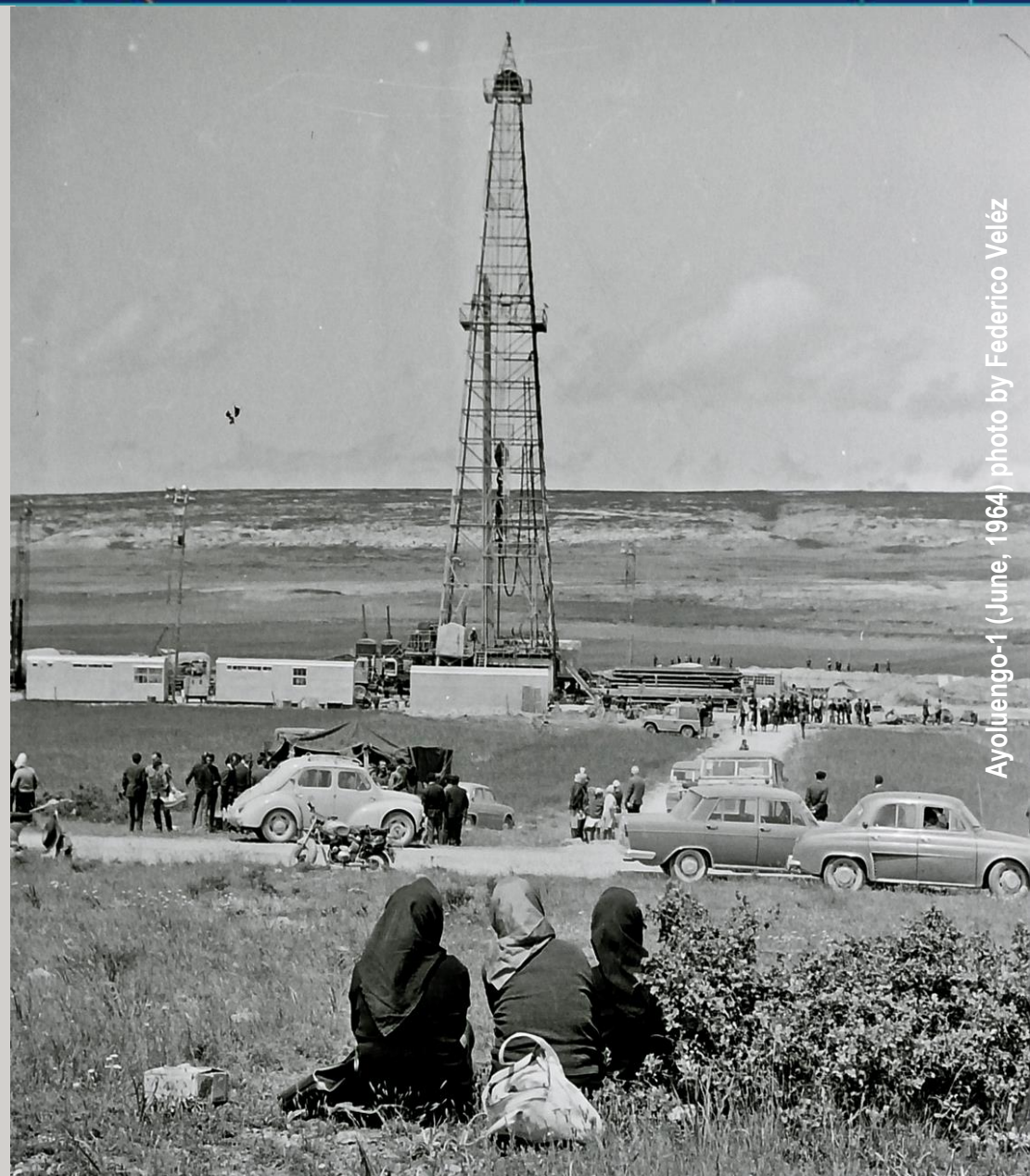
Ayoluengo – The Only Oil Field Onshore Spain

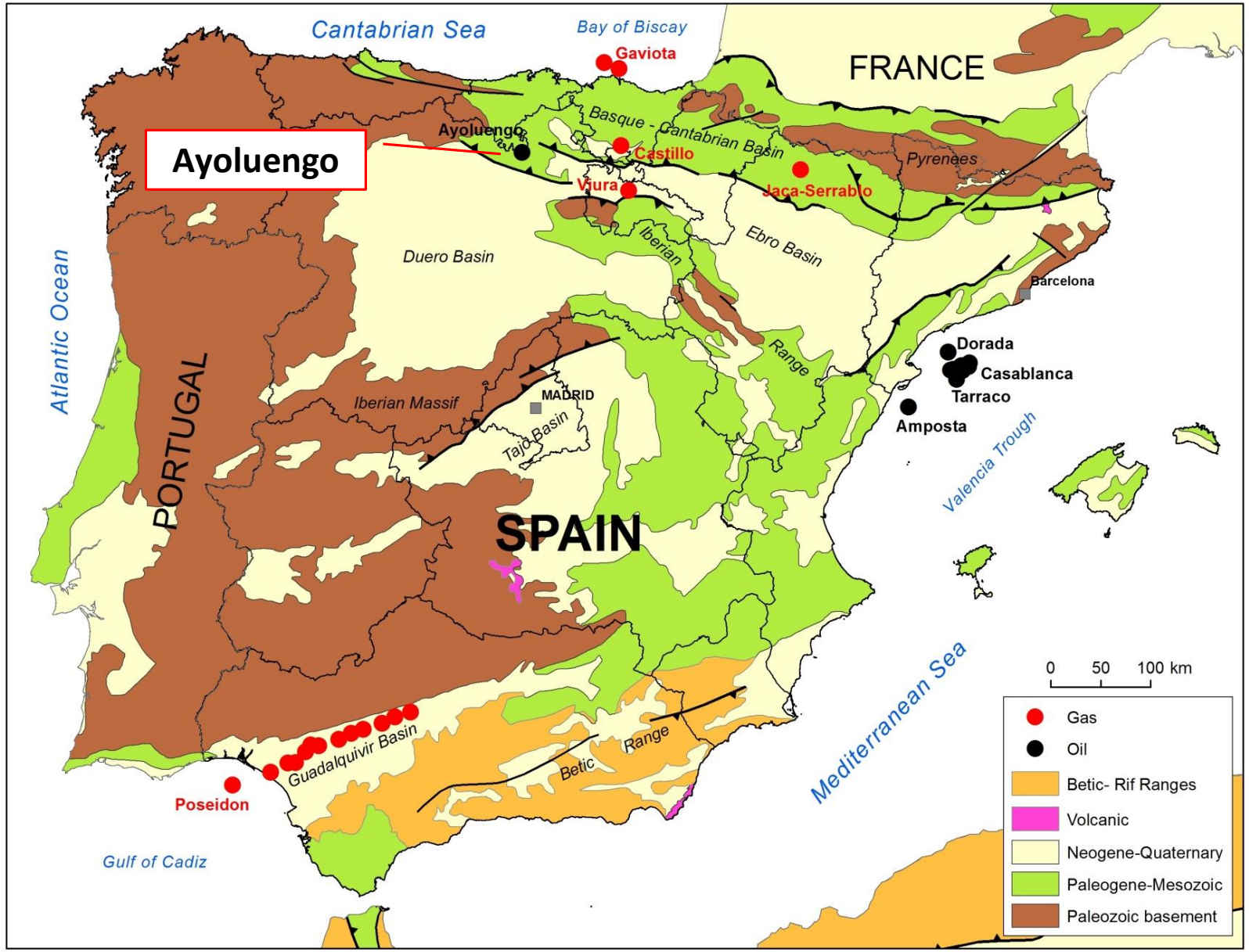
by Jorge Navarro Comet

CEPSA

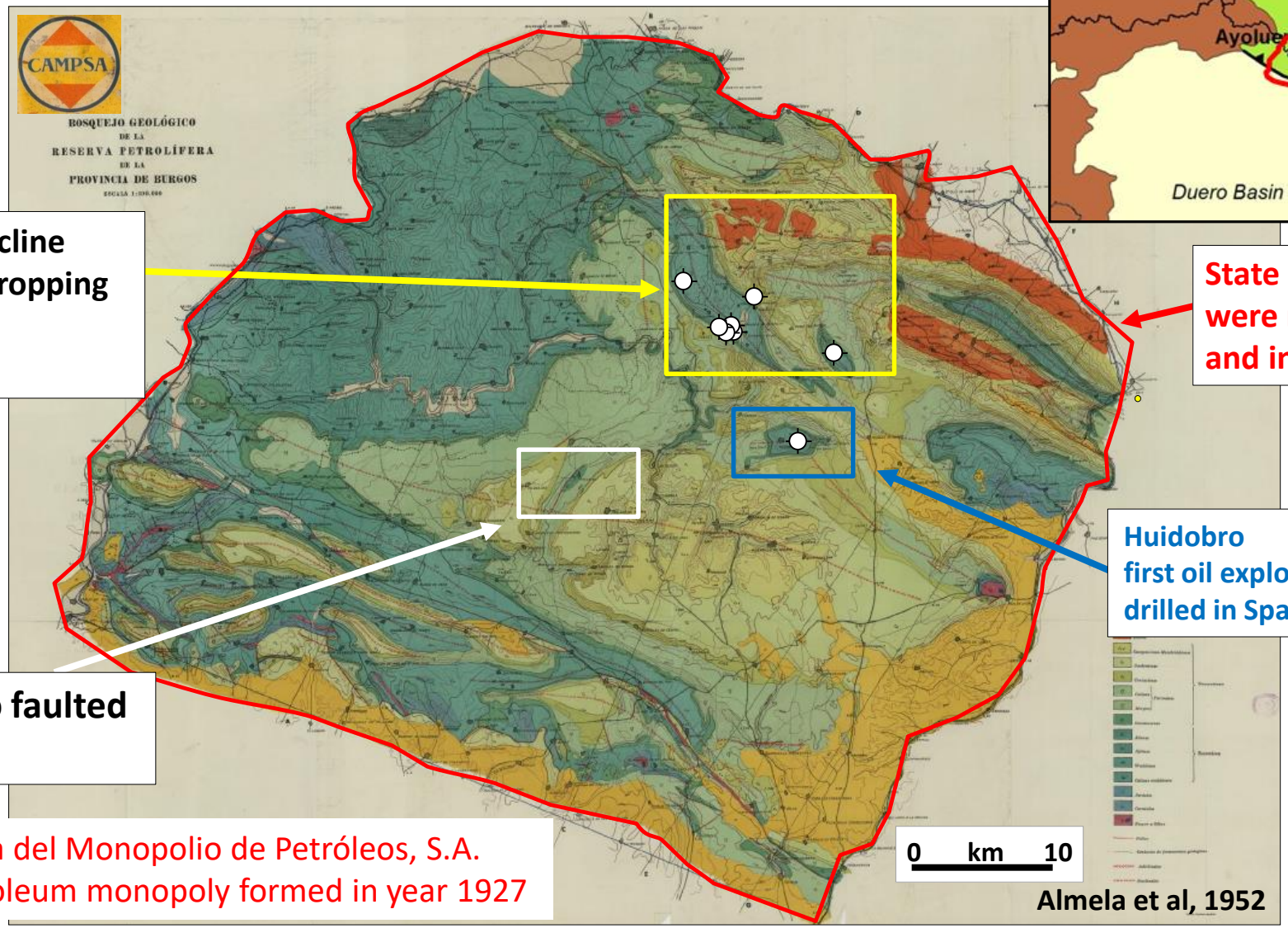


Ayoluengo-1 (June, 1964) photo by Federico Veléz

Ayoluengo a unique oil field onshore Spain



1946. State Petroleum Reserve (2,800 km²) awarded to CAMPSA(1)



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

State Reserve boundaries were mainly based on rivers and infrastructure ¡¡¡

Huidobro
first oil exploration well drilled in Spain (1900)

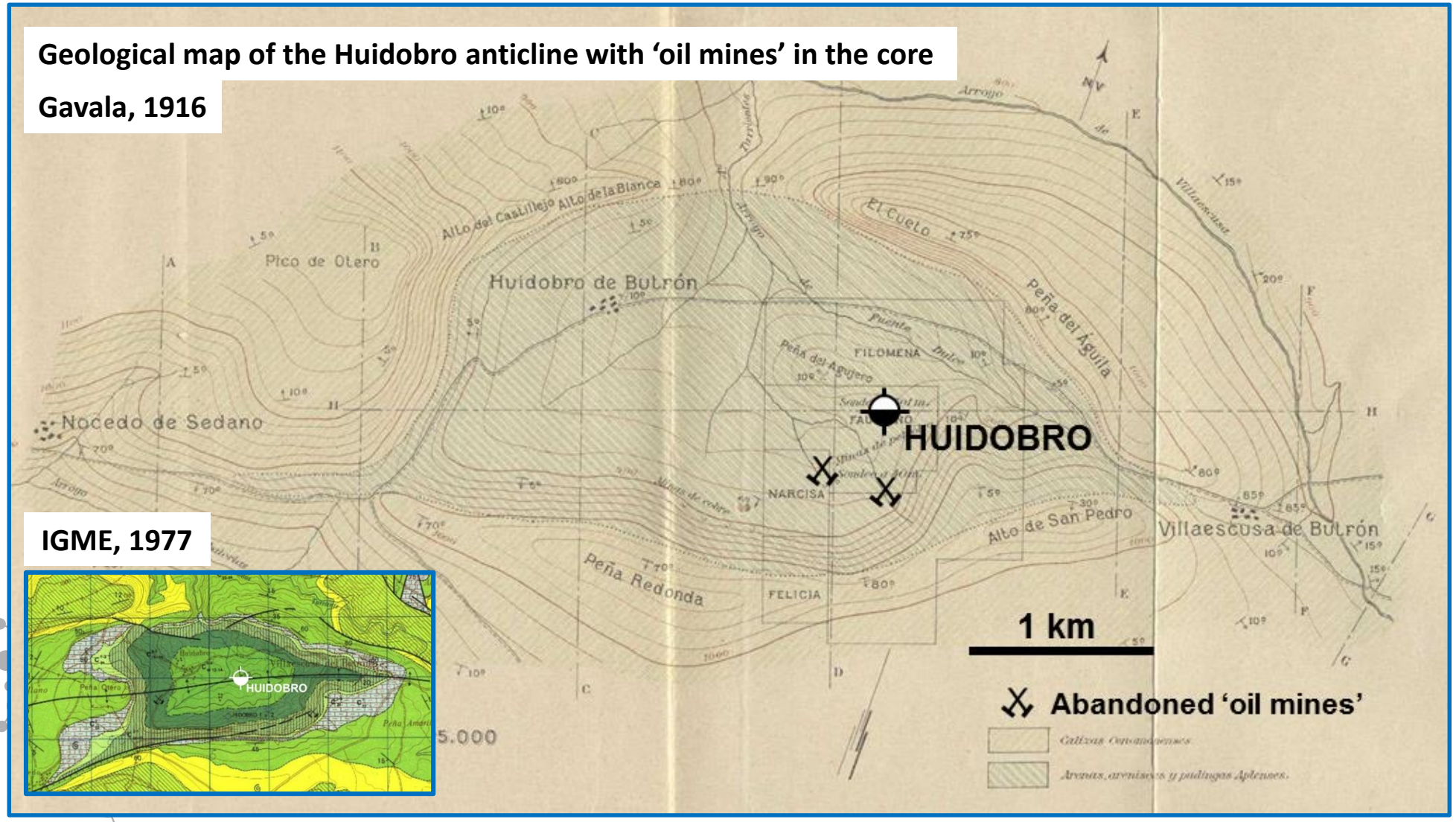
Ayoluengo faulted anticline

(1) Compañía Arrendataria del Monopolio de Petróleos, S.A. Spanish-government petroleum monopoly formed in year 1927

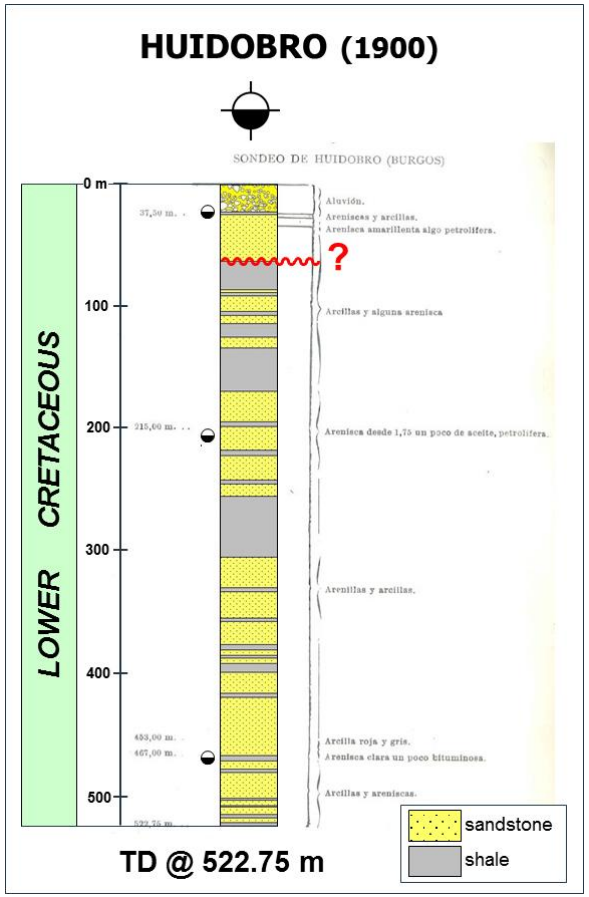
1900. Huidobro, the first petroleum exploration well drilled in Spain

Geological map of the Huidobro anticline with 'oil mines' in the core

Gavala, 1916



IGME, 1977



TD @ 522.75 m

1940s. Zamanzas Valley - Tar sands exploitation by CAMPSA

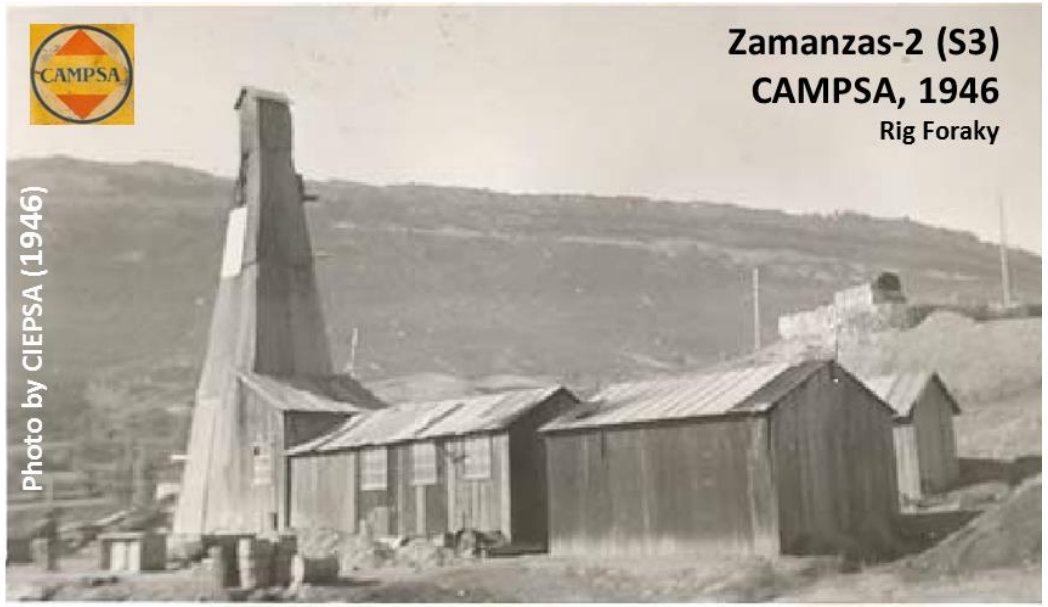
Zamanzas valley

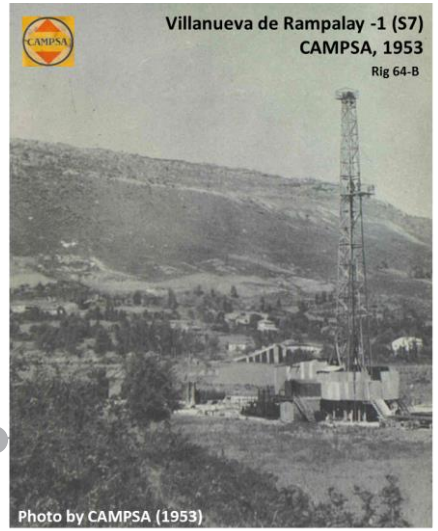
Rudimentary and experimental underground mining.

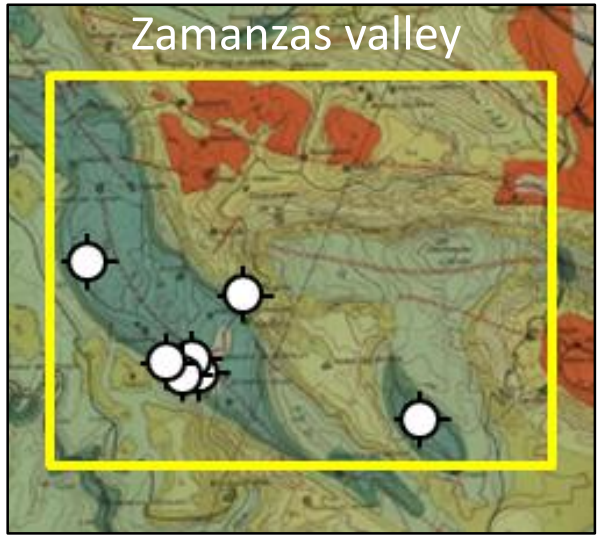
Tar sands crumbled and dumped into water tanks heated by wood fire.

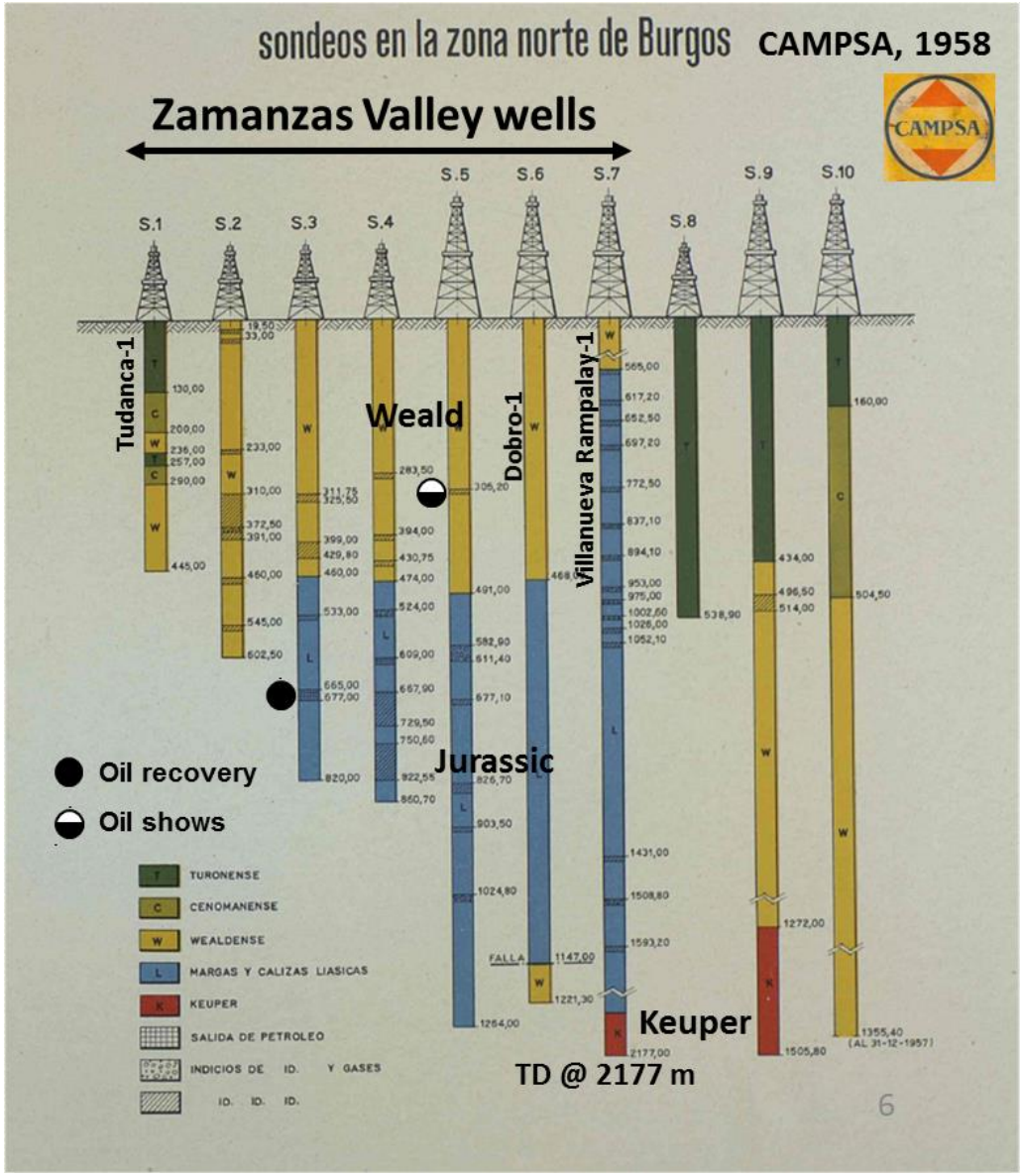
Oil manually collected- 1 to 3 bopd

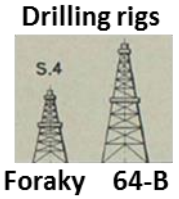
1941 – 1953. Zamanzas Valley - Exploration wells by CAMPSA







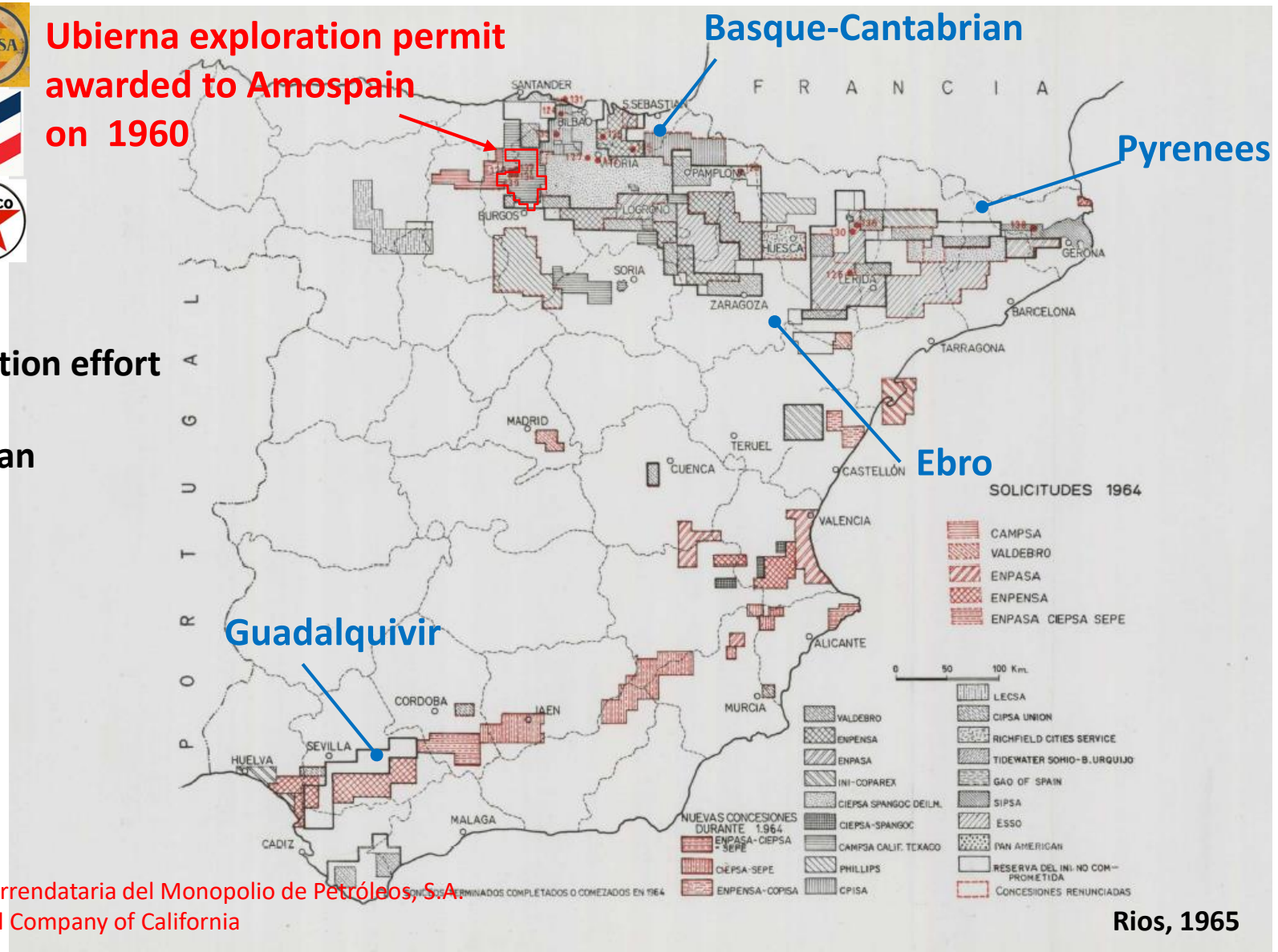




1964. Spain exploration licenses

(1) 50%, (2) 25%, 25%.

Ubierna exploration permit awarded to Amospain on 1960



Rios, 1965

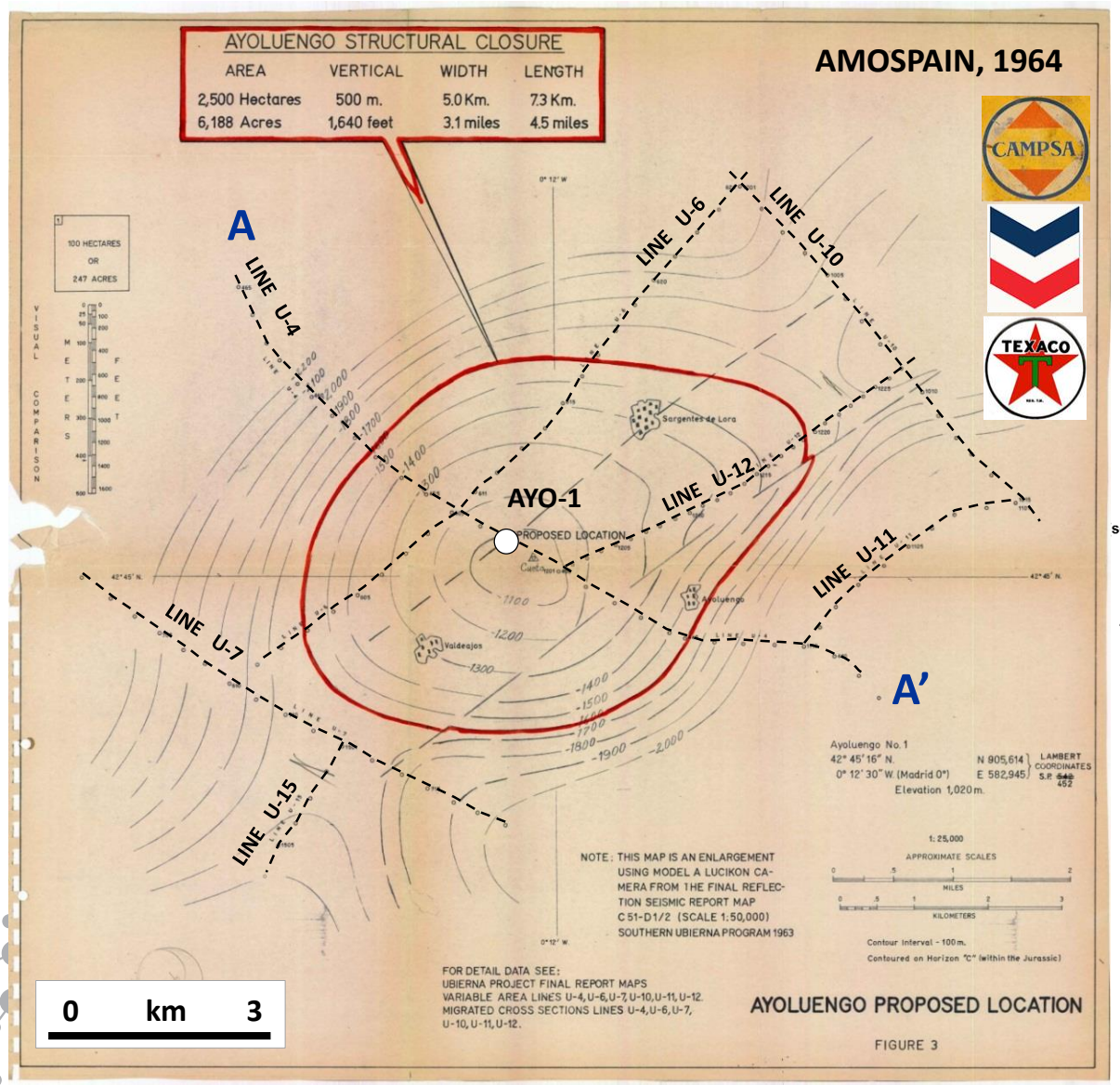
Most of the exploration effort was focused on:

- **Basque-Cantabrian**
- **Pyrenees**
- **Ebro**
- **Guadalquivir**

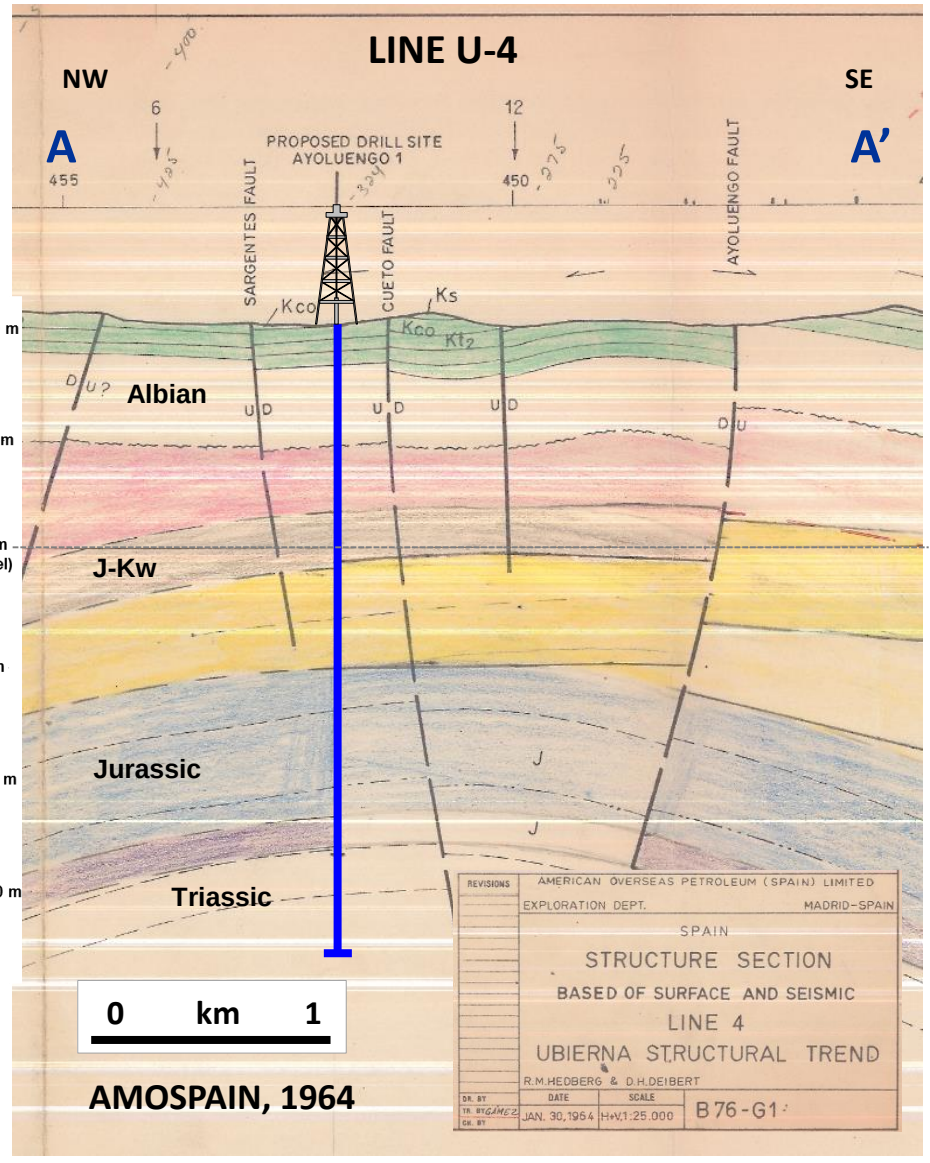
(1) Compañía Arrendataria del Monopolio de Petróleos, S.A.
(2) Standard Oil Company of California

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

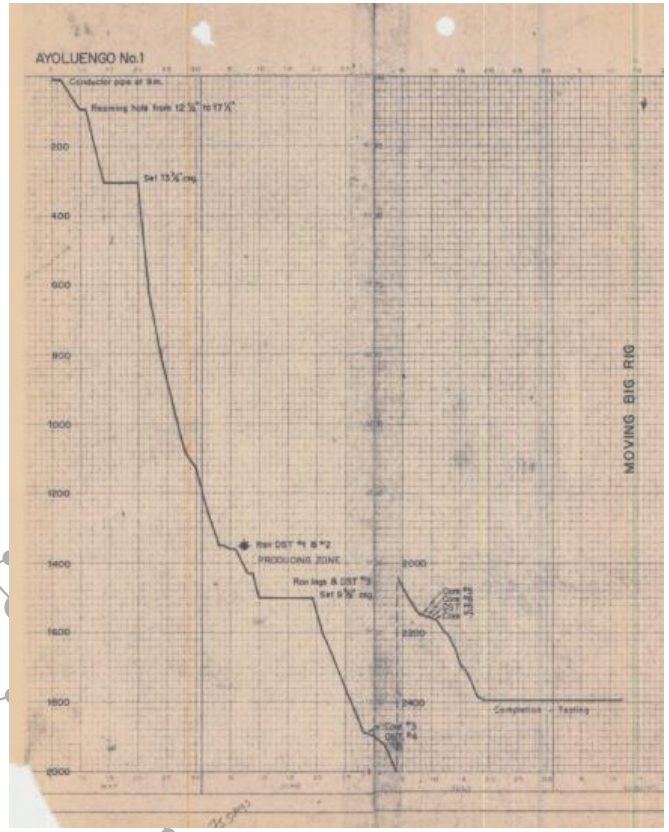


Ayoluengo-1 first oil tested (DST#2)

Upper Jurassic – Lower Cretaceous sandstones

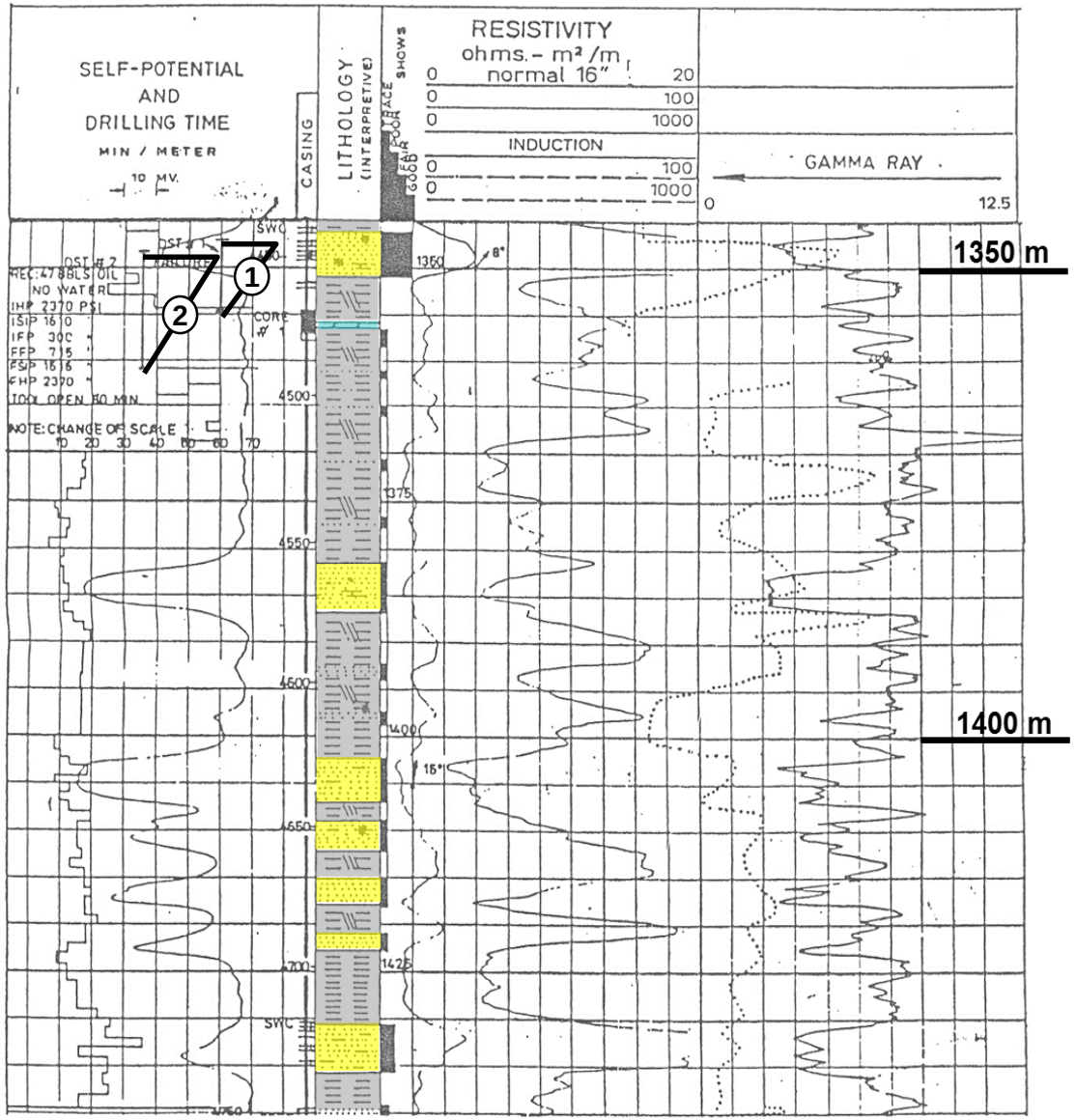
Well spud on 5th May 1964
DST#1 - failed
CORE#1 – Claystone w/some free oil

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

El Alcázar
DIARIO GRAFICO DE LA TARDE

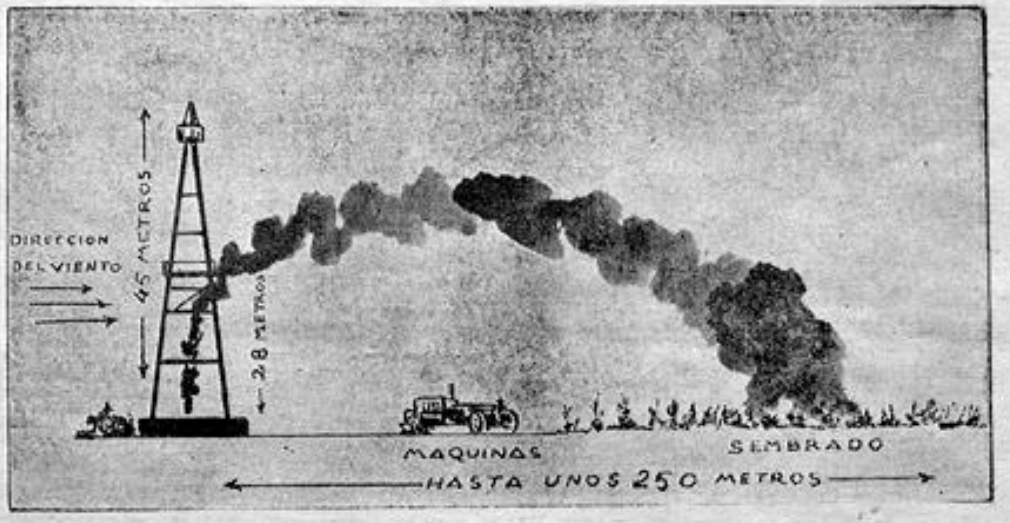
AÑO XXVIII. — N.º 8.726. — DEP.º LEGAL M. 19-1958. — MADRID, 8 DE JUNIO DE 1964. — P.º O.º REDONDO, 22. — TEL. 2473605. — 2,00 PTS.

PETROLEO IMPRESIONES EN MADRID

RATIFICADO

PERO ES NECESARIO EVITAR UN OPTIMISMO EXAGERADO

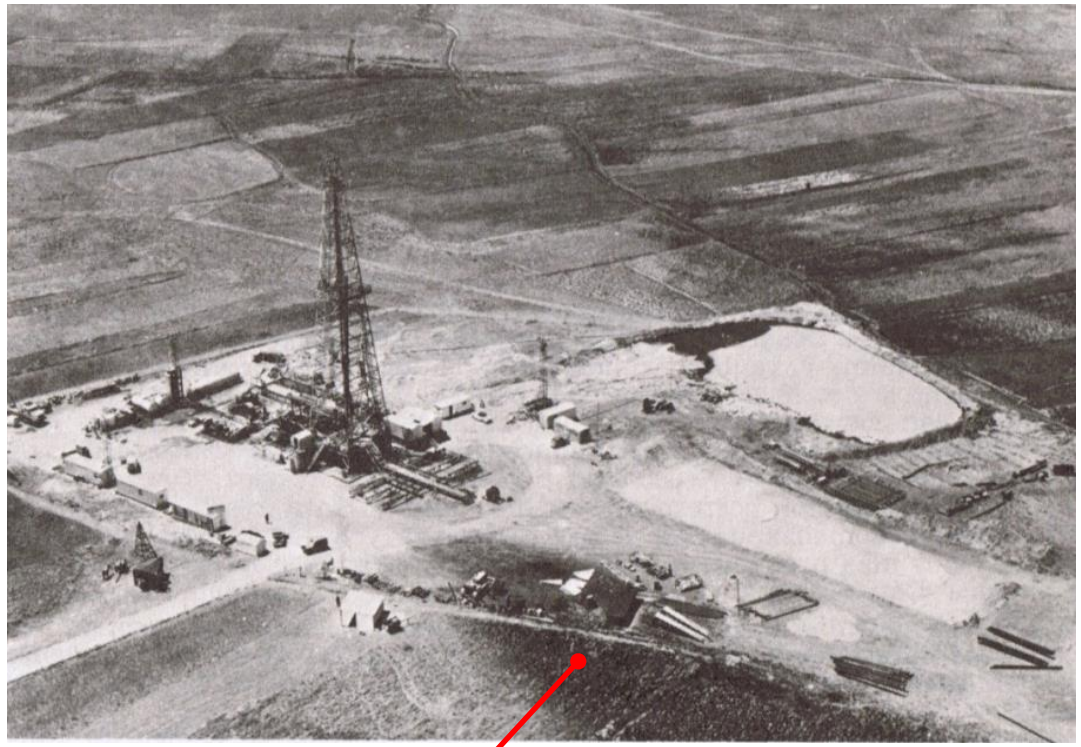
Así fue la primera salida de petróleo



• Donde el sábado a mediodía la palabra ¡Petróleo! [illegible]

NOTA FACILITADA POR LA CAMPSA ESTE MEDIODIA

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 ¡¡

8th June 1964

by Jesús Hermida

Ayoluengo-1 well site

Photo taken after first oil flow at Ayoluengo-1

June 1964

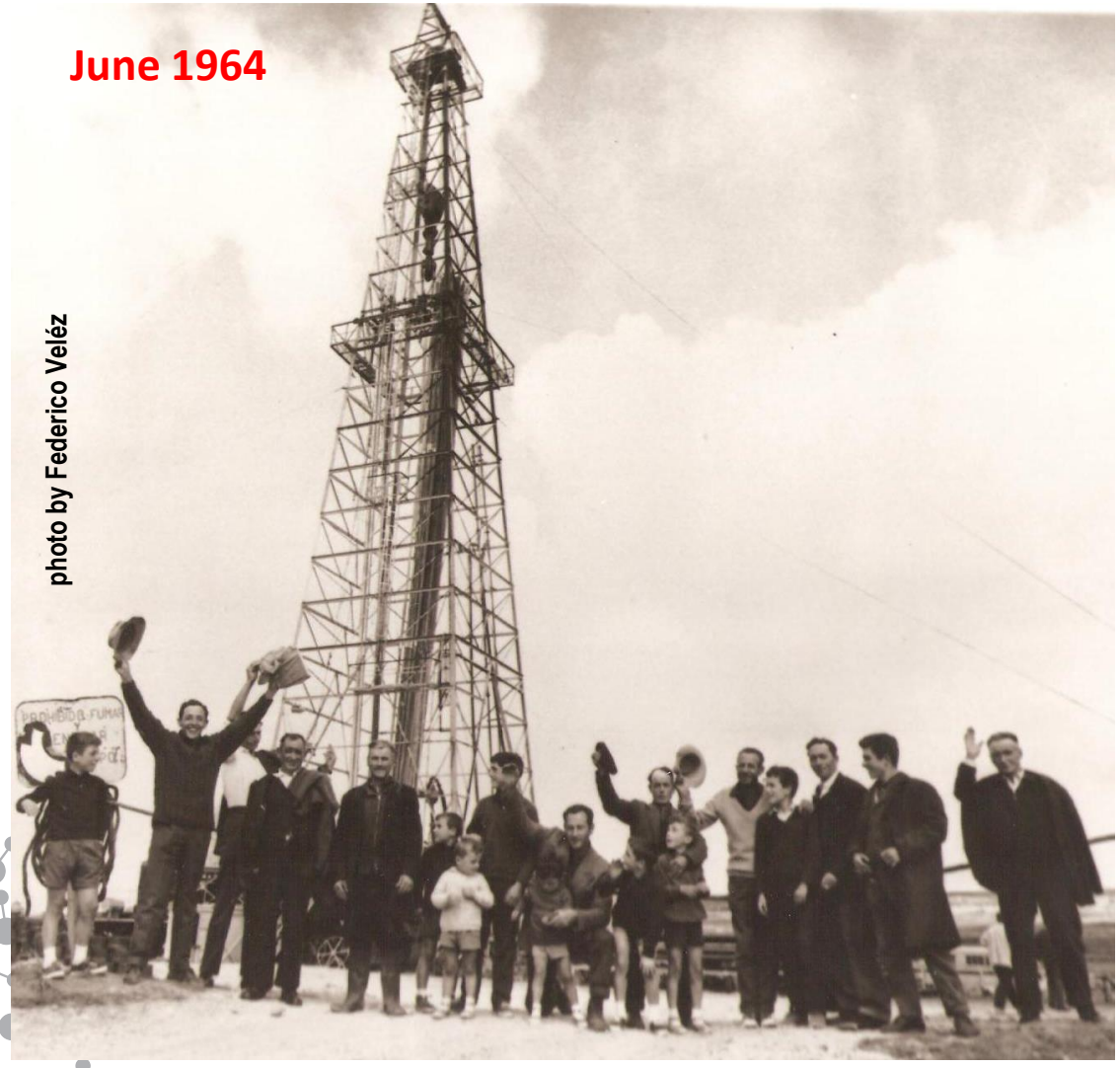


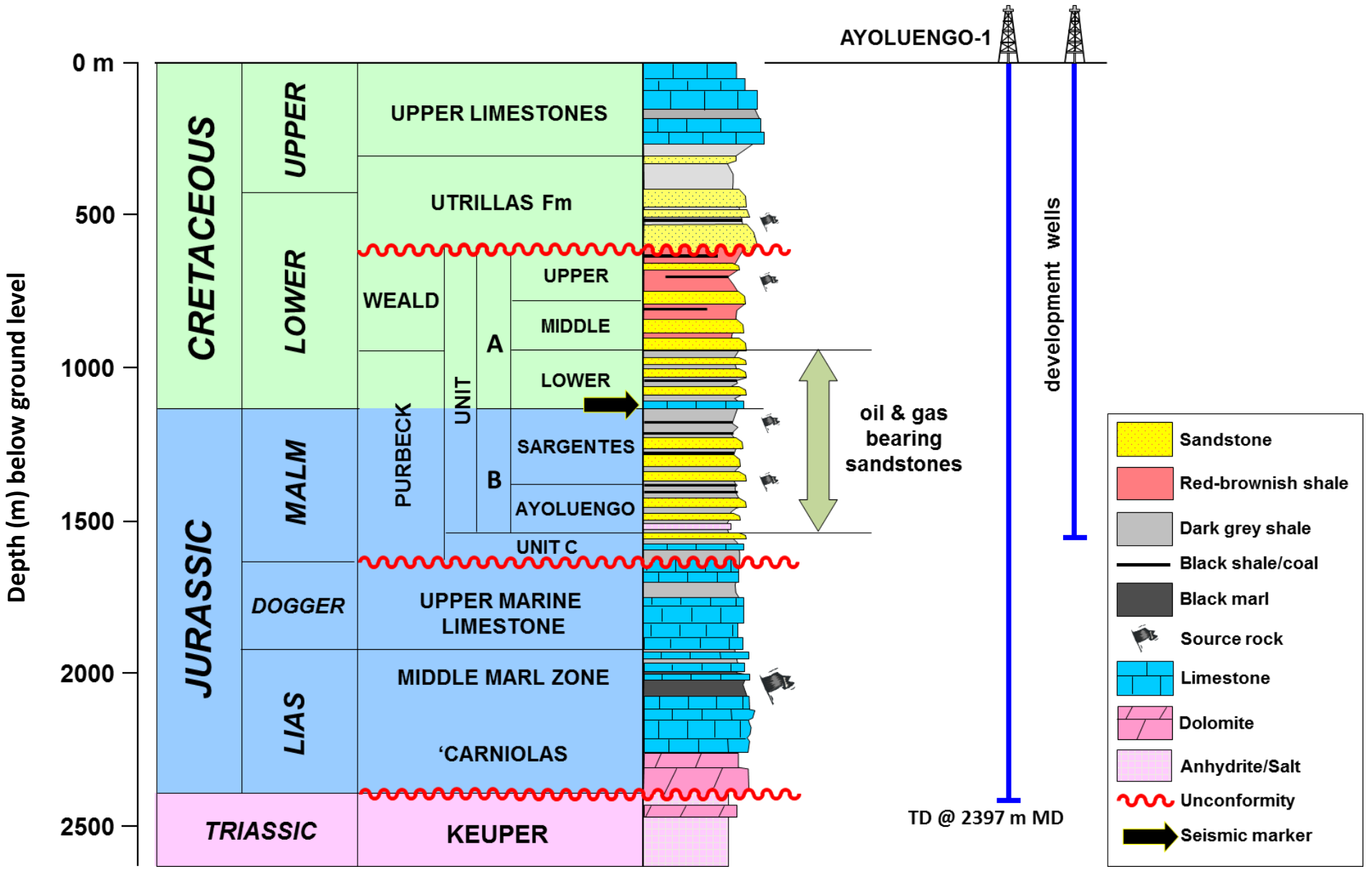
photo by Federico Veléz

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

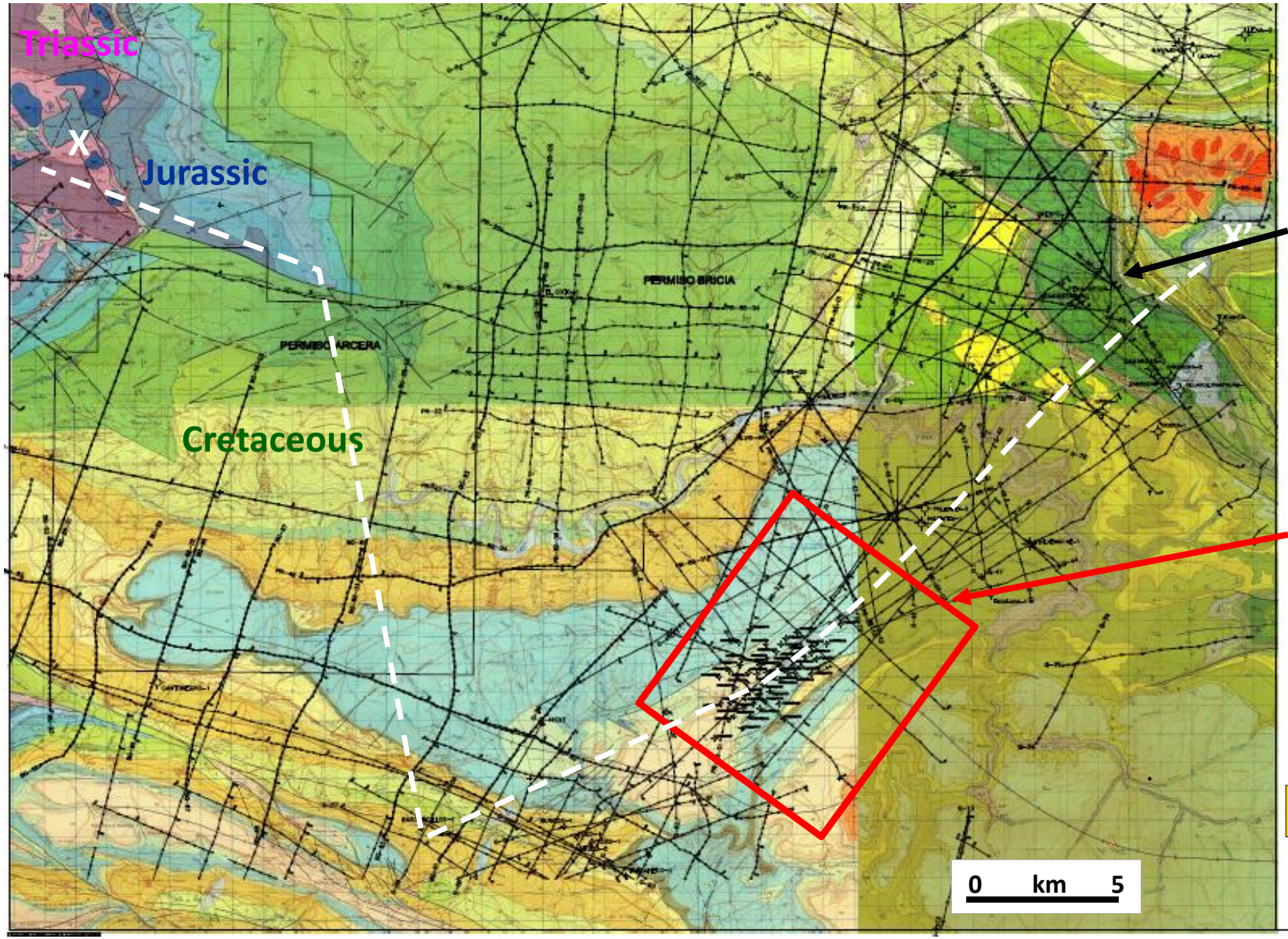
10th July 2017

Monument funded entirely by the local council

Ayoluengo field stratigraphic column



Ayoluengo seismic coverage



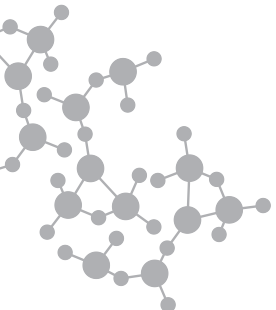
2D regional seismic coverage

3D seismic survey
70 km^2
acquired on 1988

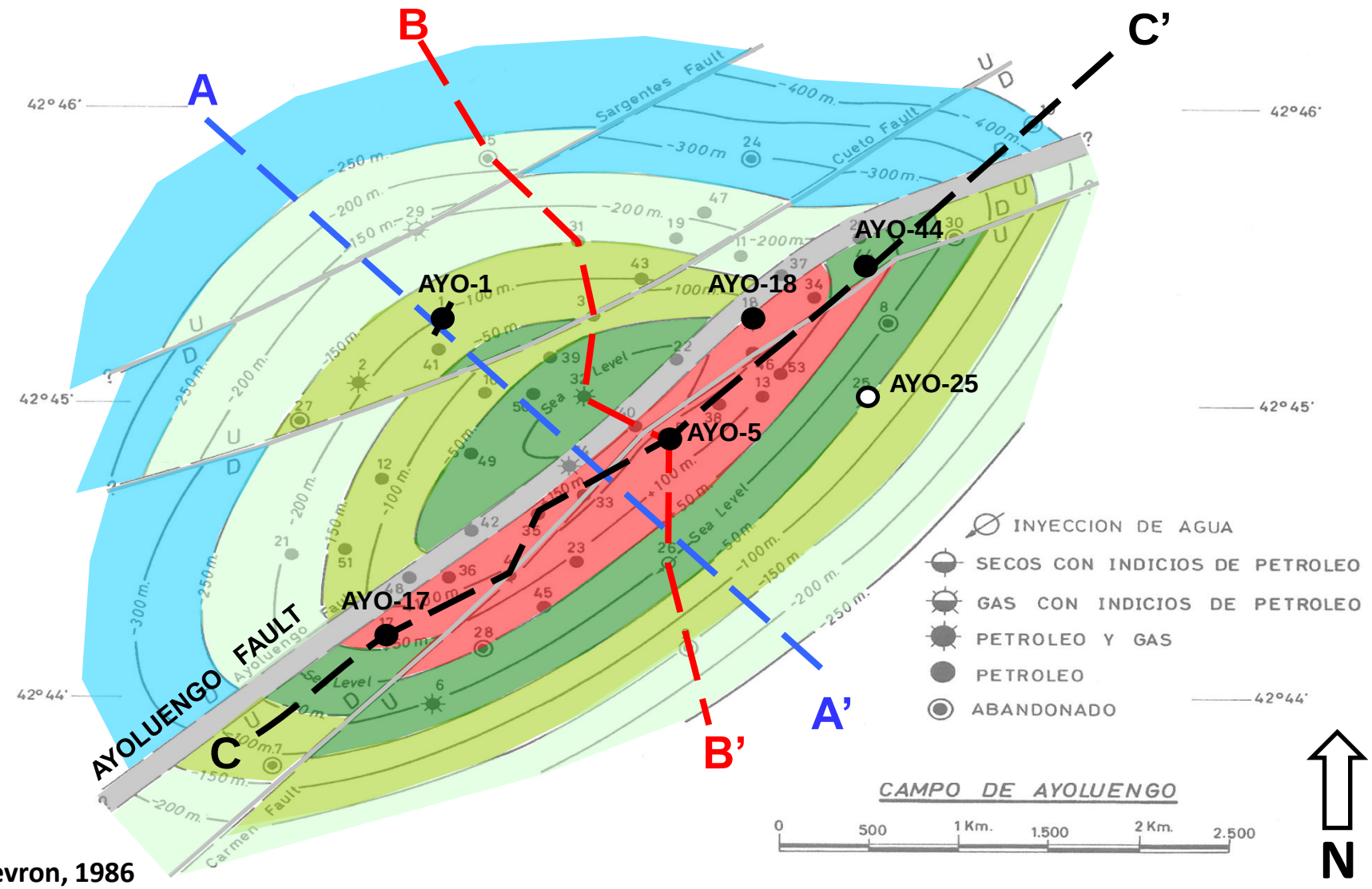
IGME –MAGNA
Spain Geological Map
1/50,000

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)
- Av Ø = 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)

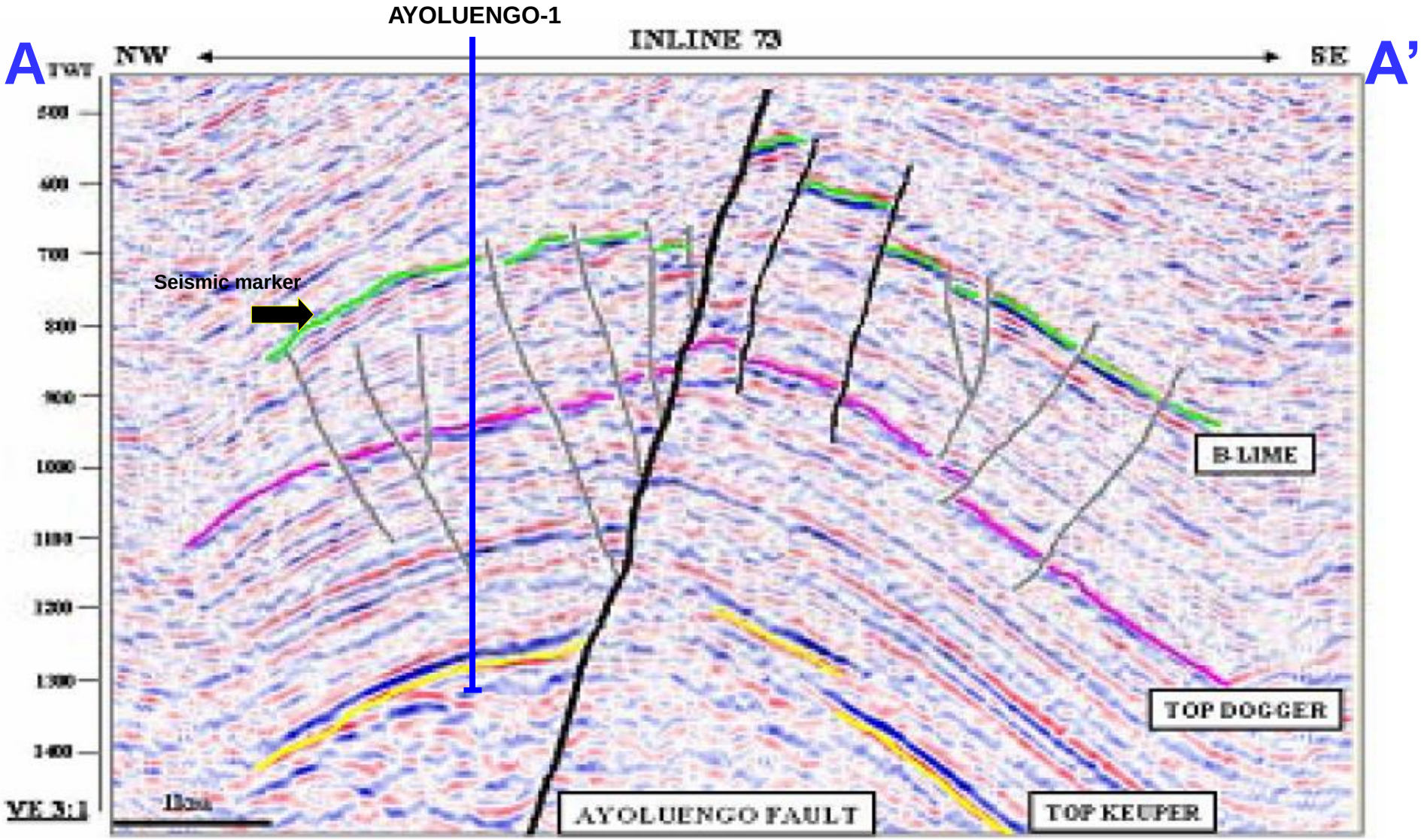


Ayoluengo depth map - Top seismic marker (m bsl)



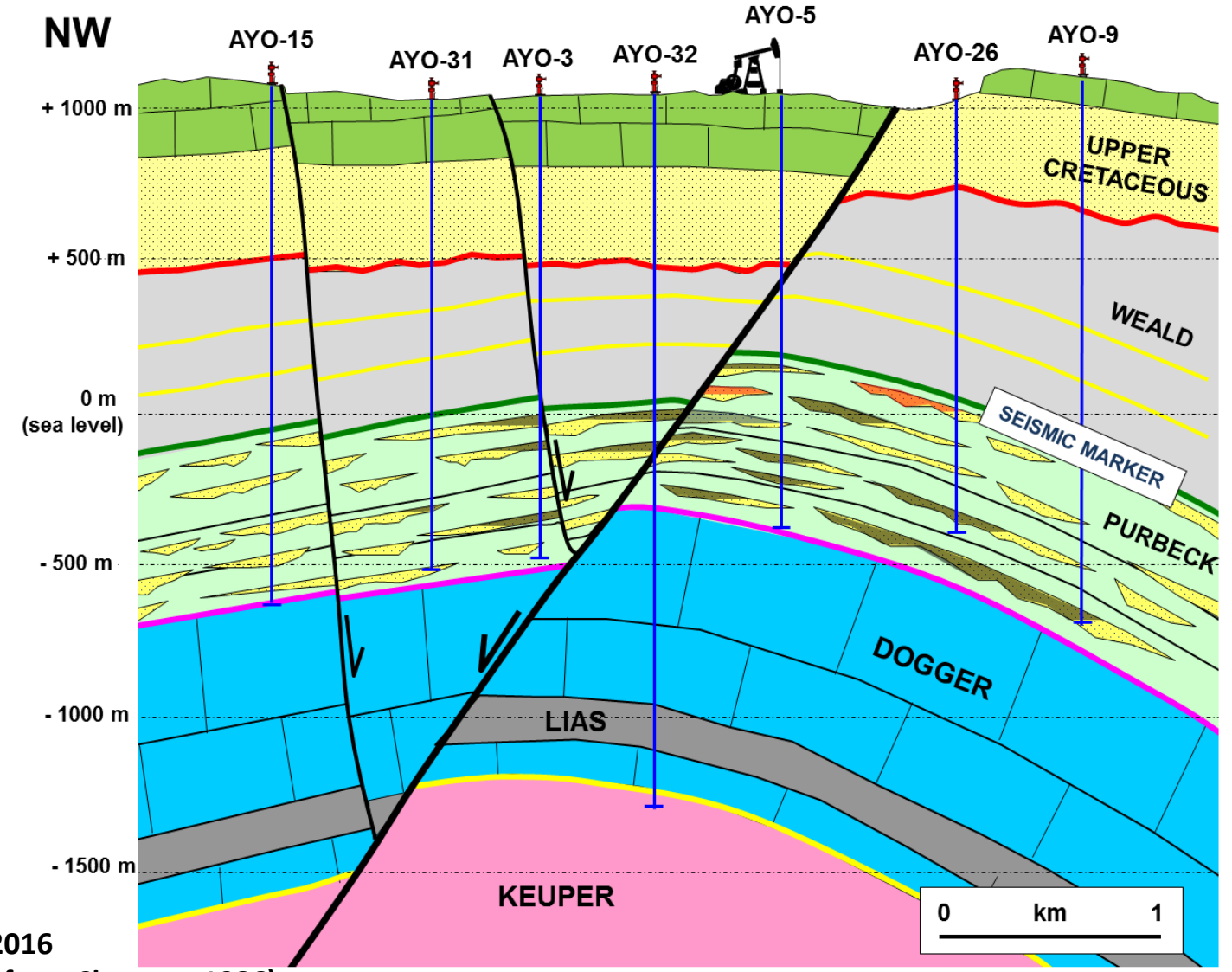
Chevron, 1986

1988. 3D seismic line Ayoluengo oil field



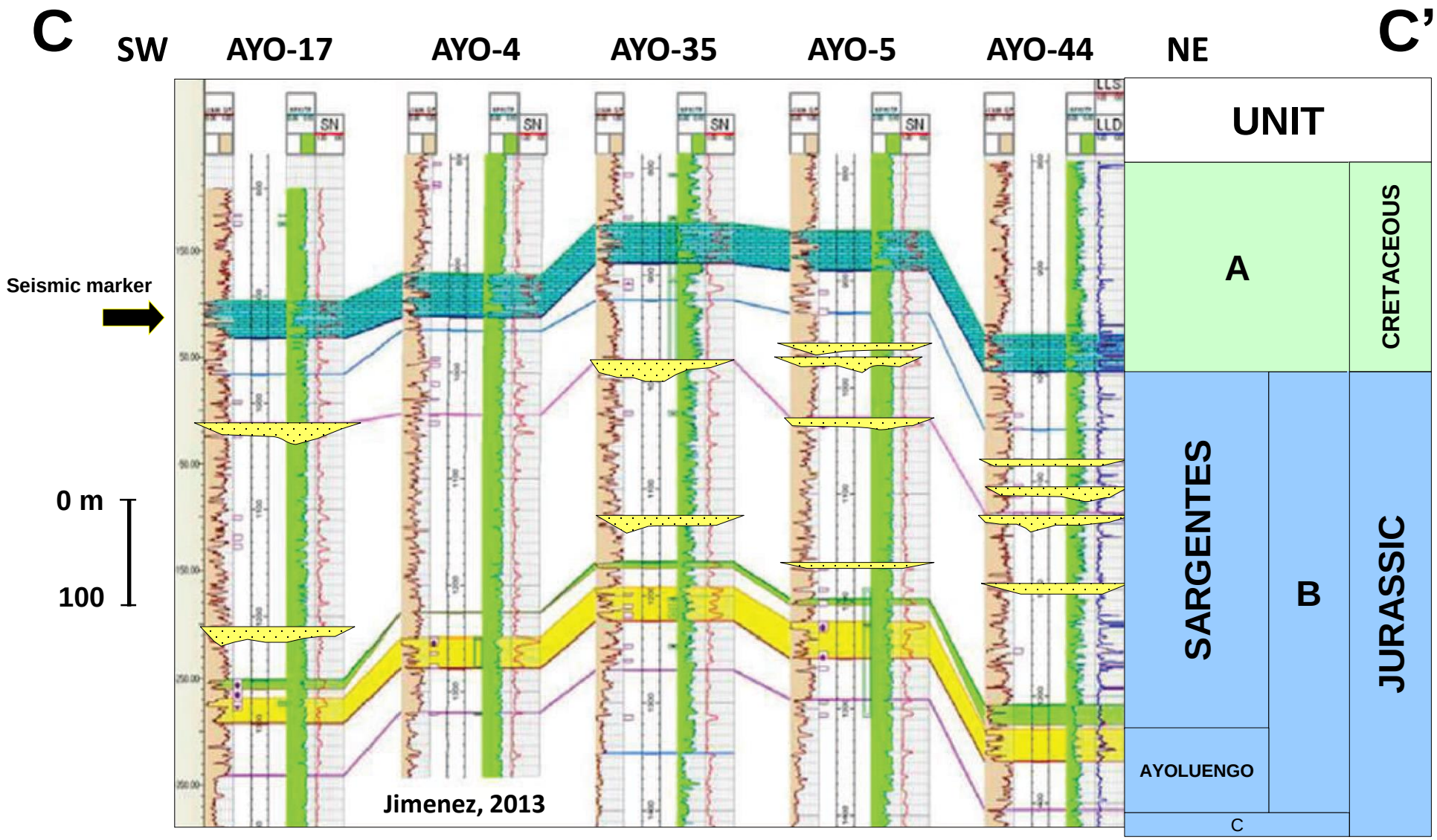
Abeger et al, 2006

Ayoluengo structural cross section



Navarro, 2016
(modified from Chevron, 1986)

Ayoluengo fluvio-lacustrine lenticular sandstones
(Upper Jurassic-Lower Cretaceous)

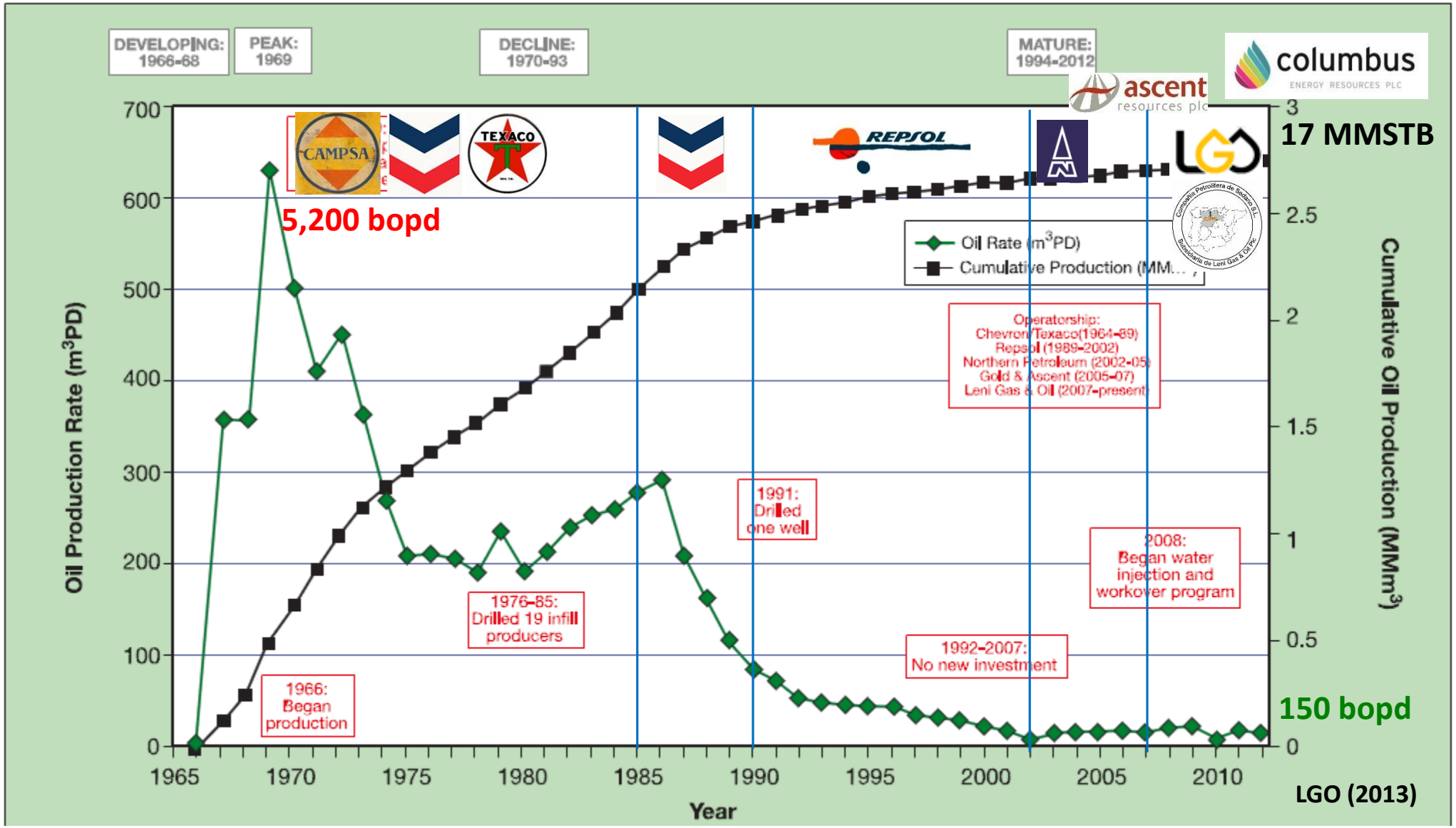


Ayoluengo production highlights

- **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 31st 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 31st 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

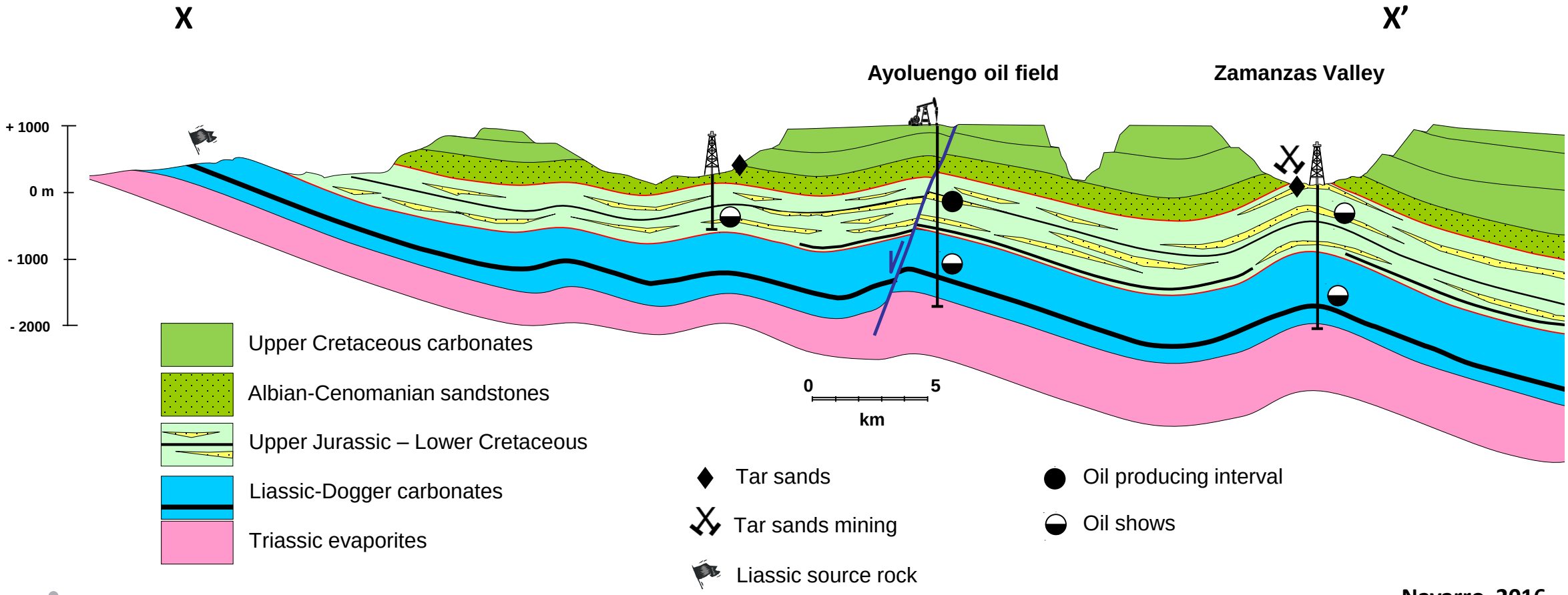
Ayoluengo production history



Ayoluengo field production facilities

12th August 2017. Demonstration by the unions and local villagers supporting the field re-opening

Schematic regional cross section



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)

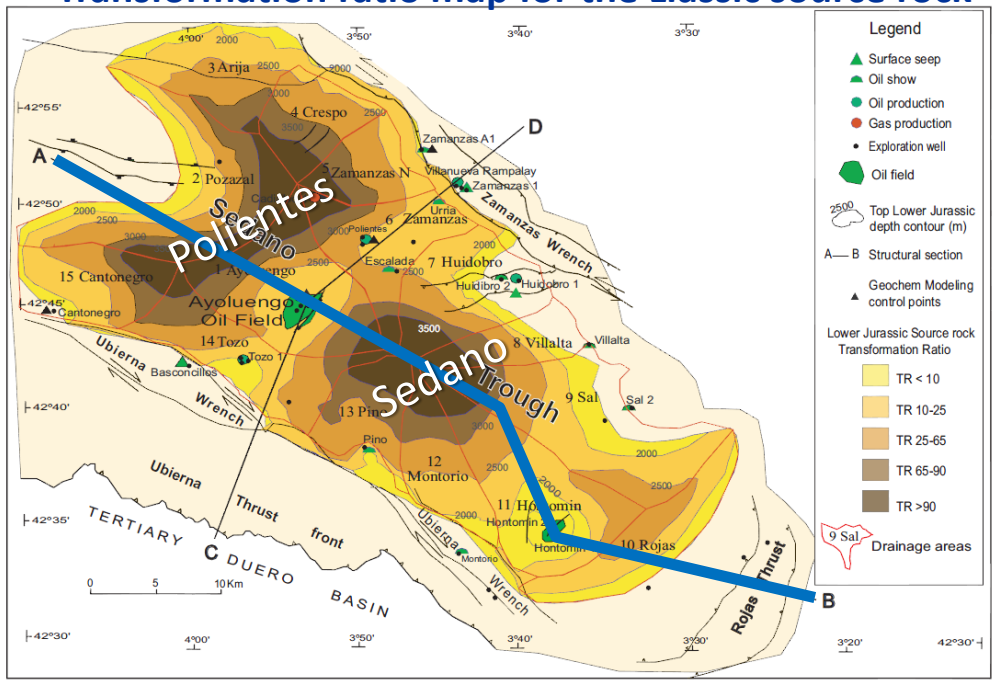
Ayoluengo nodding donkey


Reservoir analogue is nearby outcropping
R
Barcena de Ebro (Cantabria)
15 km NW from Ayoluengo

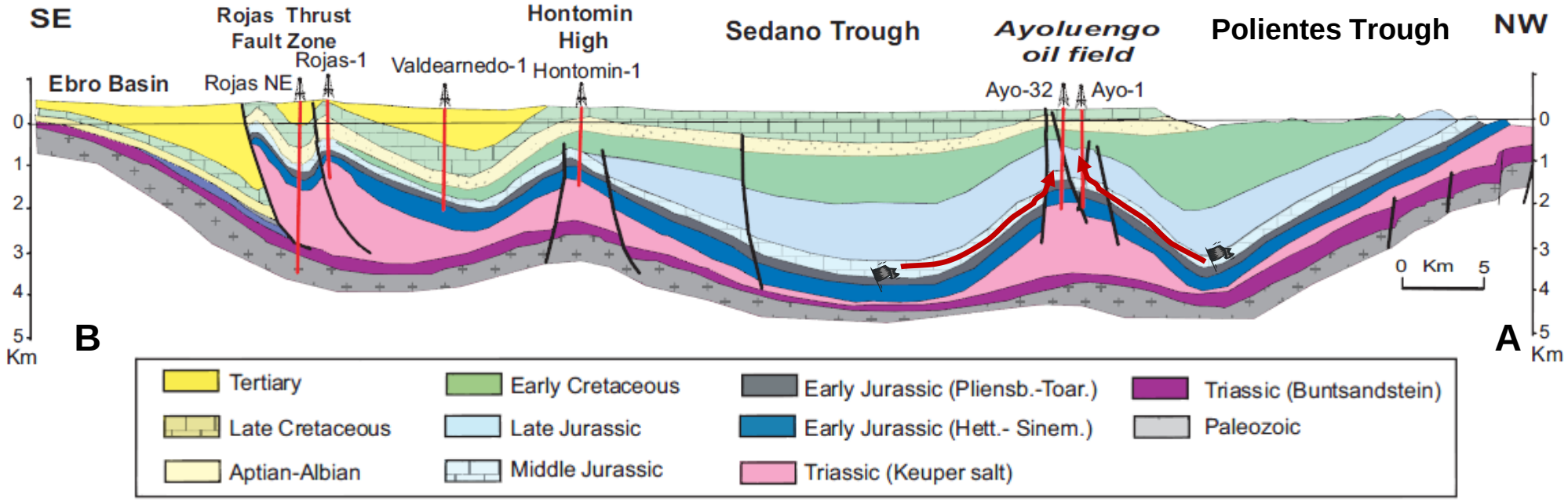
Oil sourced from Liassic black shales

Santiurde de Reinosa (Cantabria)
40 km NW from Ayoluengo

Transformation ratio map for the Liassic source rock

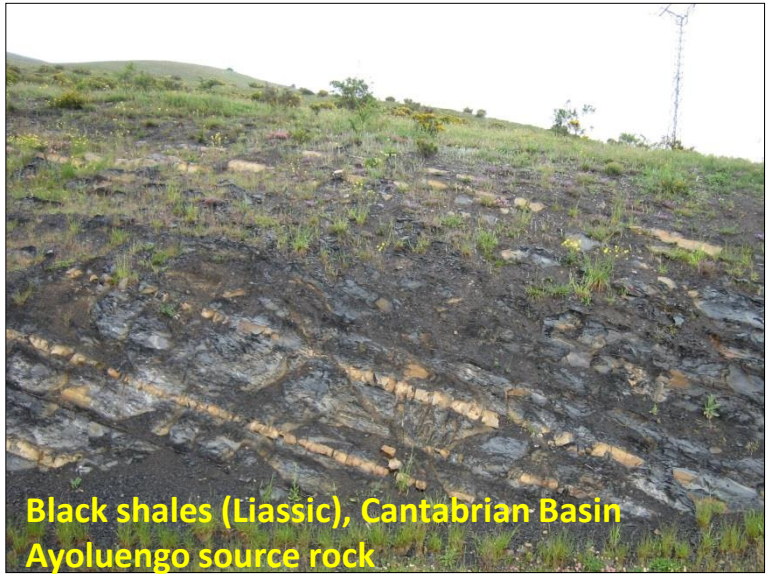


Oil sourced from Liassic in two adjacent troughs ? … but it requires a complex migration pathway: lateral and then vertical thru faults

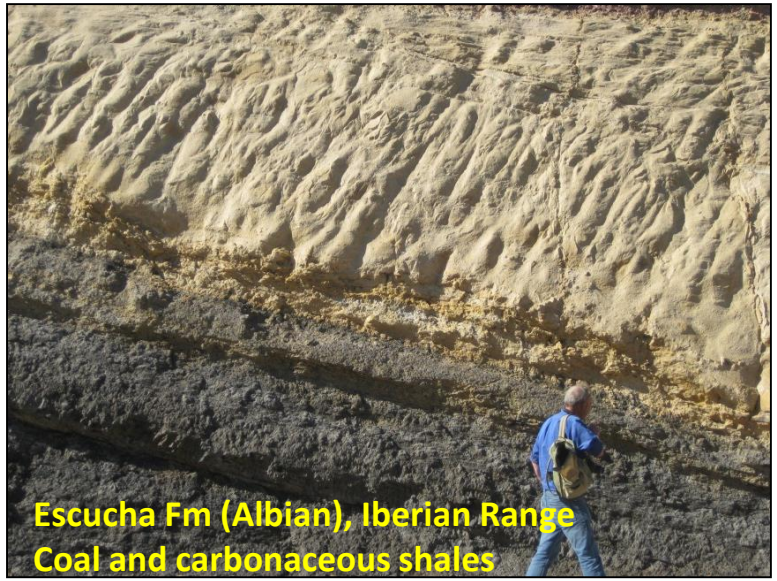


Beroiz & Permanyer (2011)

World class source rocks are present in Spain

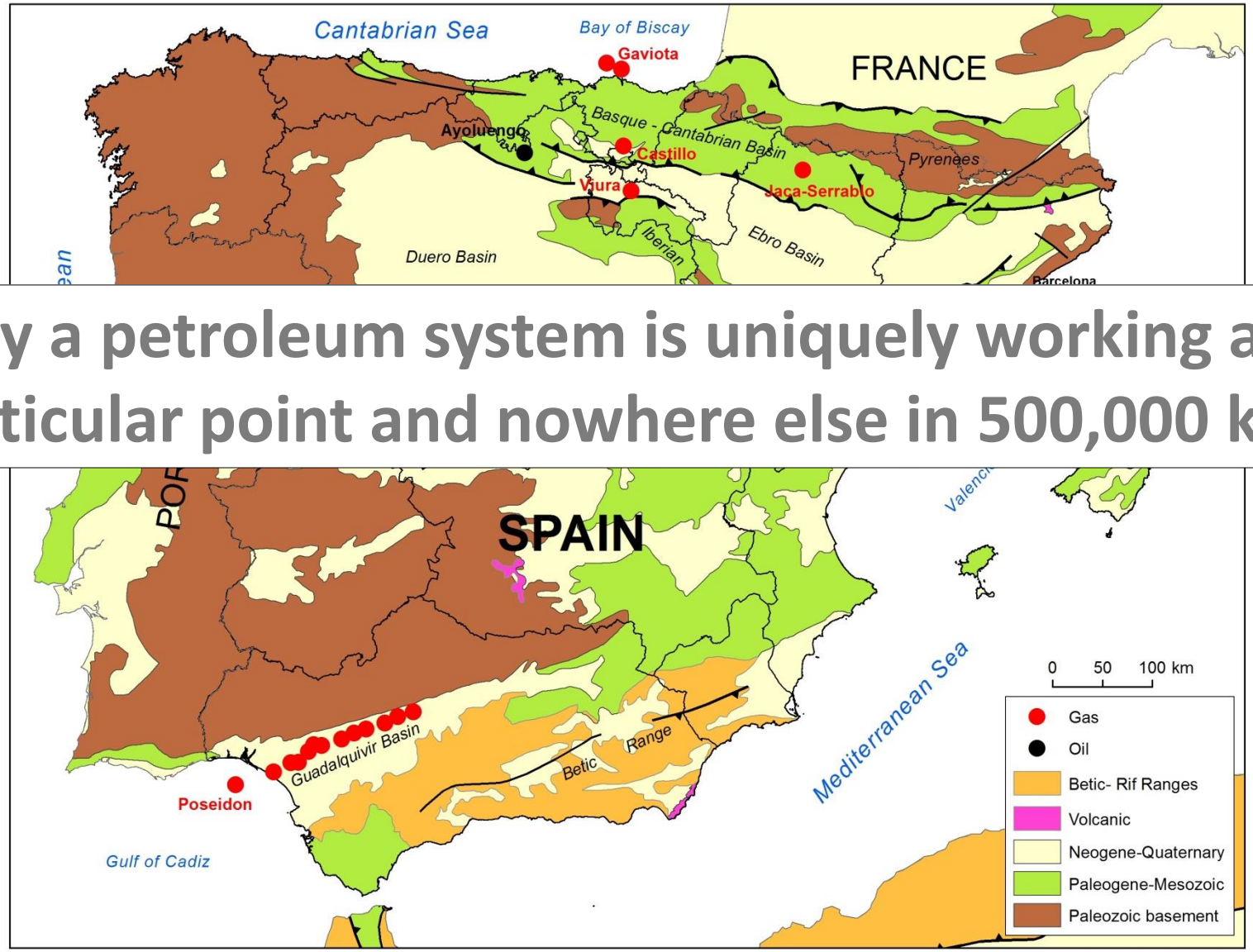

Black shales (Liassic), Cantabrian Basin
Ayoluengo source rock


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 !

CEPSA

Muchas gracias

February 2016

EXPLORER
HISTORICAL HIGHLIGHTS

Spain's Oldest and Only Onshore Oilfield

By JORGE NAVARRO COMET

The Ayoluengo field was the first commercial oil discovery in Spain and more than 50 years later remains the only onshore oilfield in the Iberian Peninsula.

The field was discovered in 1964 and is still producing. It is located about 300 kilometers north of Madrid in the southern part of the Basque-Cantabrian Basin, a geological region where natural oil seeps, tar sands and asphalt have been recognized in outcrops since the early 20th century. This region was considered highly promising and most of the hydrocarbon exploration efforts in Spain during the 1940s and 1950s were focused here.

The Compañía Arrendataria del Monopolio de Petróleos Sociedad Anonima (CAMPSA), the Spanish-government petroleum monopoly created in 1927, was in 1946 granted the hydrocarbon exploration rights for a 2,800 square-kilometer area north of Burgos. With light rigs, CAMPSA drilled some shallow stratigraphic wells, all based on surface geological surveys, as no reflection seismic was available resulting in many of the outcropping

Geological map of the Iberian Peninsula showing the Ayoluengo oil field location, about 300 kilometers north of the city of Madrid and within the Basque-Cantabrian Basin.

– an agricultural terrain mostly dedicated to growing potatoes and locally known as "Loras." Although this faulted anticline was suspected from surface mapping, it was the first properly matured seismic prospect to be tested north of the Burgos area.

The Well at Ayoluengo

The location of the first exploration well was carefully chosen jointly by Amospain and CAMPSA's engineers and geologists. It was named Ayoluengo-1, as per the small village nearby, and located some 15 kilometers southwest of the Zamanzas Valley, where previous shallow exploration drilling by CAMPSA had been concentrated. The well was designed as a 3,500-meter deep test of the Cretaceous sandstones, the Lower Jurassic marine carbonates, which had commonly recorded oil shows in the old CAMPSA wells, and the Triassic section.

The well was spudded on May 5, 1964. From 990 to 1,346 meters' depth, numerous poor shows of oil were observed, none worthy of further interest.