



ONSHORE  
LOWER  
CONGO BASIN



# 2023 LICENSING ROUND REPUBLIC OF ANGOLA

ONSHORE  
KWANZA BASIN

ONSHORE KWANZA BASIN

Portfolio  
**OPPORTUNITIES**

Block  
**KON10**

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# 1. Introduction

The portfolio opportunities describe the general characteristics of Block KON 10, presenting the main geological and geophysical aspects from the exploration history, petroleum system, and a series of opportunities identified in the block. This characterization is the result of the survey and framing of existing data, which allowed the seismic interpretation and the elaboration of the geological model by the ANPG/DEX team.

Block KON 10 is in the South-east part of the Onshore Kwanza Basin. In 1959 four (4) exploration wells were drilled by the Sinclair, Petrangol, and Total companies.

In 1998 ENI carried out an aero gravimetry and magnetometry survey. As a result, a total of 132.67 km of 2D seismic was acquired by the Geokinectics Company in the period 2009 to 2012.

Sonangol conducted recent geological mapping and well geochemistry data survey studies in partnership with Obrangol and Previsão Oil companies from 2010-2015 and 2012- 2015, respectively.

The Kwanza Basin is known for its onshore and offshore exploration history of two significant plays, Pre-salt and Post-salt (Albian and Tertiary). The pre-salt petroleum system comprises the shales from Cuvo Formation as source rock, the sands from Cuvo and carbonates from Toca equivalent Formations are the mains reservoirs, and the seal consists of the massive salt. In the post-salt, the Binga Albian source rock comprises carbonate facies with significant quantities of organic-rich matter. As a reservoir, the carbonates of the same Formation are sealed by the shales from Cabo Ledo Formation. Tertiary trough formation occurred progressively from east to west. The onset of salt-raft tectonism at this time created the accommodation space for the deposition of black-colored organic-rich shales (Cunga Gratidão Fm.) that formed an important source rock in the grabens that feed the sandstone channels from the Quifangondo Formation sealed by the intraformational shale of the same Formation. The trap mechanisms for all plays are structural, stratigraphic, and combined.

Structures with possible accumulation of hydrocarbons in the pre-salt and post-salt were identified. The leads identified from integrating geological and geophysical data present prospective resources estimated from 990 to 2 593 MMB0.



## 2. GEOGRAPHIC Location

Block KON 10 is in the southeast part of the Kwanza Basin. It is bordered by Block KON 07 to the north, KON 13 and KON 14 to the south, Precambrian basement (crystalline outcrop) to the East, and Block KON 09 to the East, and defined by the geographic coordinates  $9^{\circ} 15' 36''$  S and  $9^{\circ} 32' 58''$  S and meridians  $13^{\circ} 52' 11''$  E and  $14^{\circ} 26' 00''$  E, having a total area of approximately 1.734,78 Km<sup>2</sup> (Figure 1)

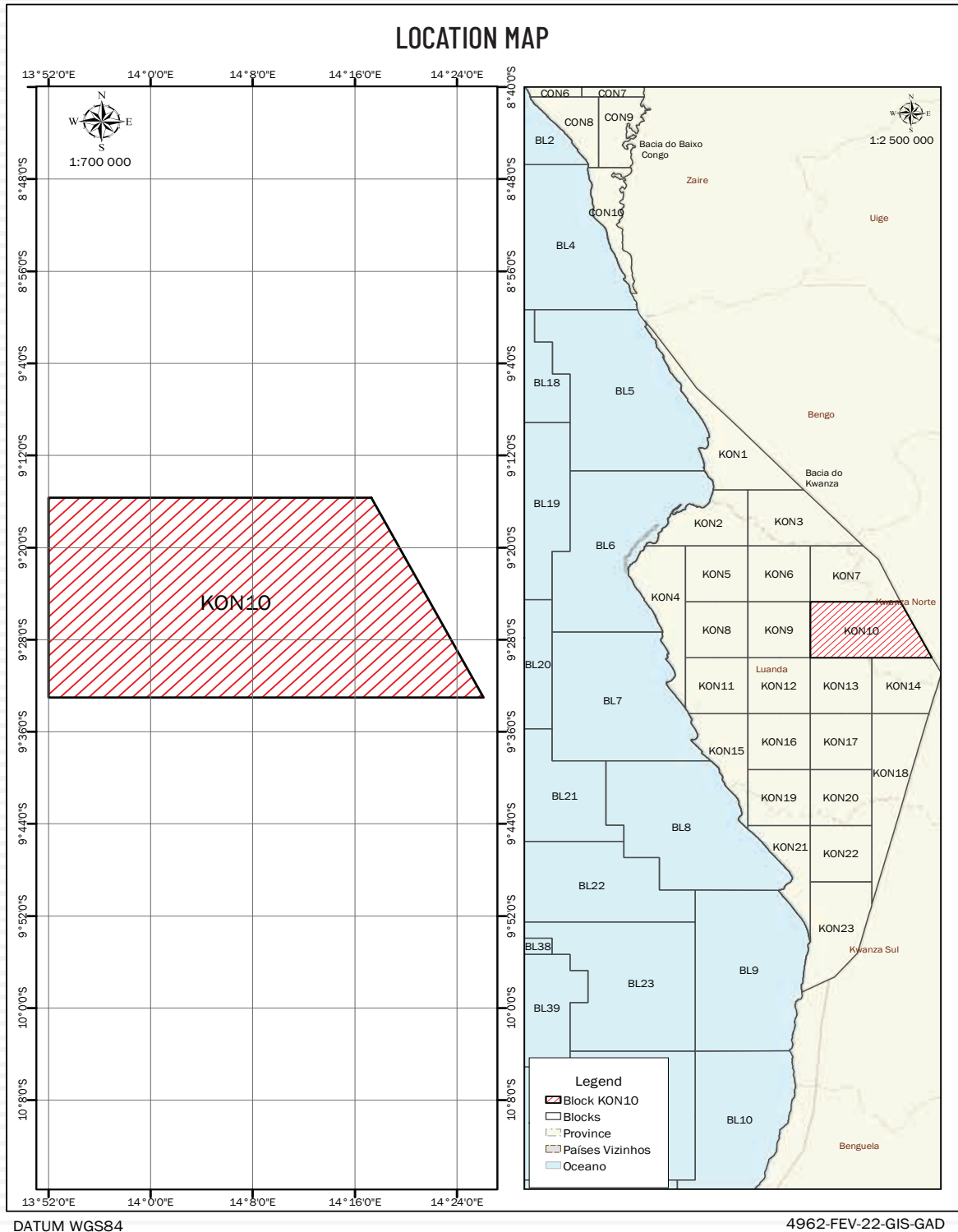
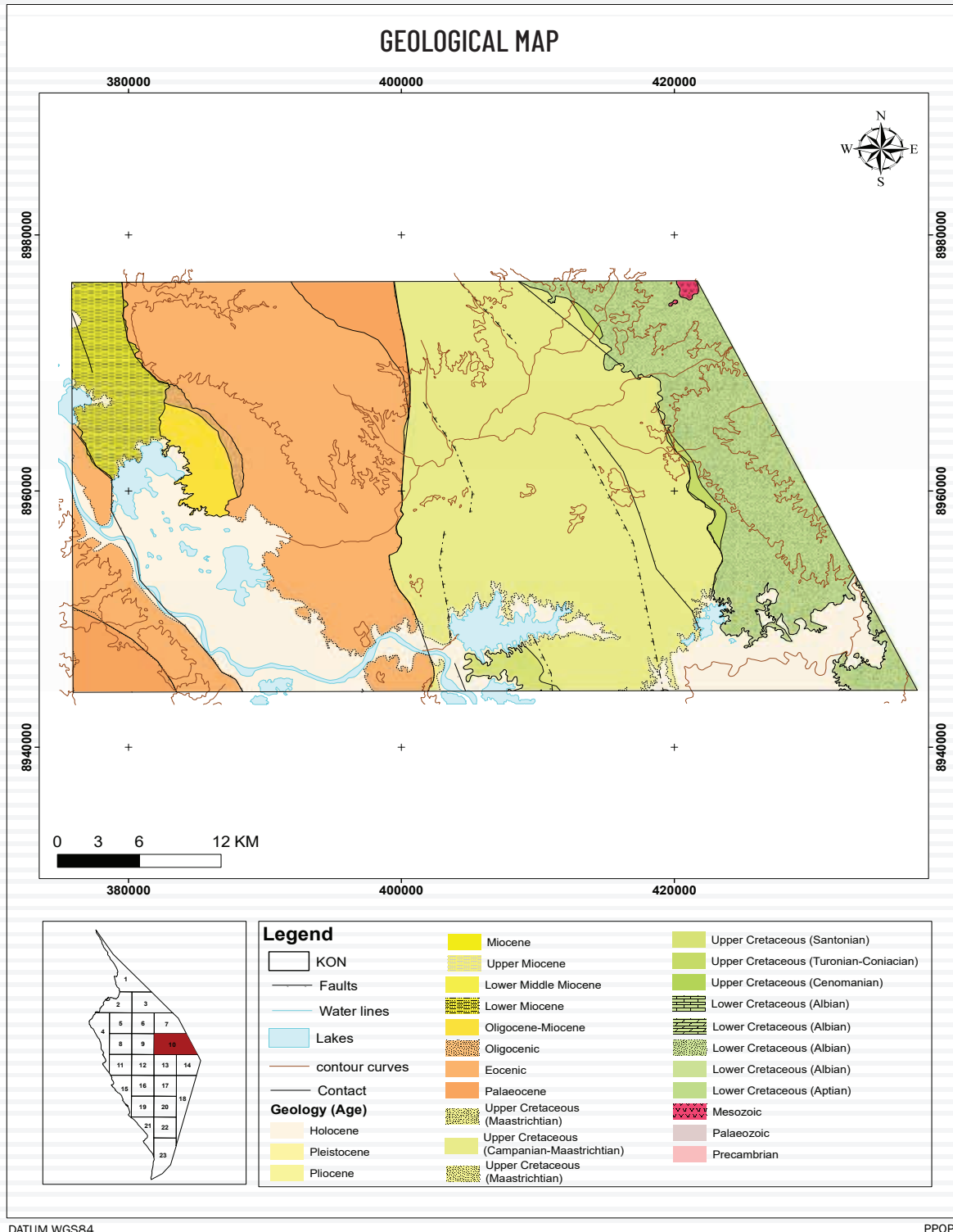


Figure 1: Location map of Block KON10, ANPG 2022

### 3. GEOLOGICAL Setting

The outcrops of **Block KON 10** are represented by sediments of Precambrian to Recent age, according to the geological chart of the Onshore Kwanza Basin (Figure 2).

Block KON10 is part of the Inner Kwanza Basin and its sedimentary history. It is characterized by paleoenvironmental variations between continental, transitional, and marine environments, in which two (2) lithostratigraphic units are evident: Pre-salt and Post-salt play.



**Figure 2:** Geological Map of Block KON 10, ANPG 2022

## Pre-salt Unit

The Pre-salt unit is dominated by the presence of horst and graben-type structures and eradicated faults in the basement in all extensions; the structures at the pre-salt level are represented to the south by the Calomboloca graben, which represents a potential kitchen or accumulation zone, to the southwest (SW) by the Cacuo and Quilengues horsts, which represent the existing structural architecture of the block.

These deep zones present capabilities for accumulation and subsequent transformation of organic matter for a generation which, through identified faults, migrate to the rocks with reservoir potential. The Cuvo Vermelho and Cinzento Formation Shale are potential source rocks, the pinch-out sands of the Cuvo Vermelho carbonates at the top of the horst, and the sands of the Cuvo Cinzento represent the reservoir rocks. In the early Aptian, with the influences of the first marine incursions and high temperatures, a lagoonal depositional system developed, in which the salt layer was deposited with greater evidence in the western part of Block KON 10 (Figure 2), forming the primary seal for this unit (pre-salt).

## Post-salt

The post-salt unit is represented by extensional structures resulting from salt tectonics, marked by a series of listric normal faults and a very clear structuring at the Albian level.

Limestones composed of Shale are potential source rock at the Albian level, and the presence of salt windows give the possibility of the source rock at the pre-salt level, feeding the Albian reservoirs.

The Cenomanian shales are good seals for these Albian reservoirs in a mixed type of trap.

In the Upper Cretaceous, the structures to the west of the block present themselves as more structuring for the reservoir level of this unit, compared to the eastern zone, which is visible in the outcropping of the same and little structuring.

Pelagic-type sediments such as marls, gray shales, and micaceous siltstones are potential sources in this unit, while regressive sandstones of the Itombe and Teba Formations have reservoir potential. The shales of the same formations represent the seal rocks.

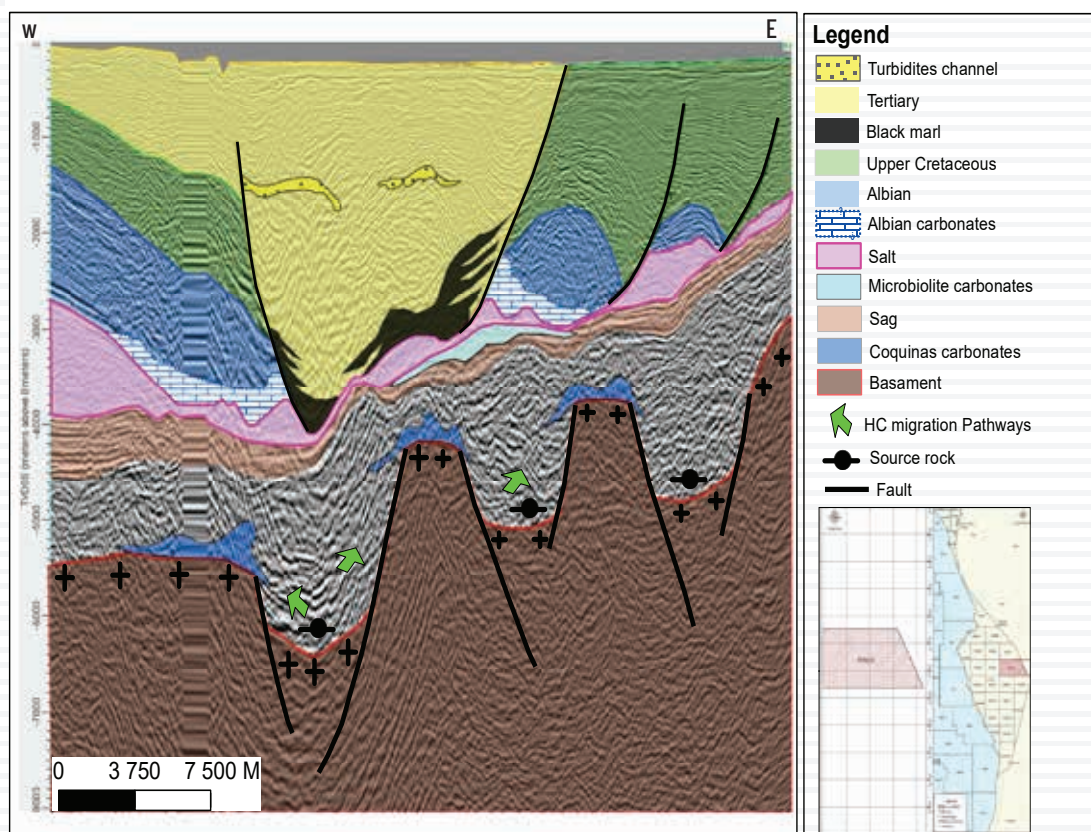
The Tertiary at the level of the Block is not thick, absent in the eastern part, dominated mainly by the Precambrian basement. This settlement of the basement, influenced by the Tertiary sediments, had greater representativity in the west of the Block. The Cretaceous and Tertiary shales may be good source rocks for the sandstone reservoir at this age, and the shales, but of more recent ages, may serve as a seal rock for the mixed-type traps.





**Figure 3:** Cristaline Teba Limestone – Calomboloca area

## GEOLOGICAL MODEL



**Figure 4:** Geological model of the Block KON 10, SKB 220, ANPG 2022

## 4. EXPLORATION History

The first commercial discovery of oil in the Kwanza Basin occurred in 1955, resulting from the drilling of the Benfica-1 well, known as the Benfica field. Other findings followed, represented by the Luanda, Cacua-co, and Galinda fields.

In July 1961, in the continuation of the work started by the Research Mission, the then-operating company Petrangol discovered the first significant field, the Tobias field, in the Cabo Ledo region, which guaranteed Angola's self-sufficiency in terms of crude oil and also contributed to ending the skepticism regarding the existence of the precious 'black gold' in the Angolan subsoil. The peak of exploration activity was primarily driven by the discovery of the Quenguela Norte field, which represents the new play of the Tertiary. In that same decade, the Mulenvos field was also discovered.

By the end of the 1970s, the Légua and Bento fields had been added to the Inner Kwanza Basin discoveries. The first exploration work on the Block was carried out in 1921, by the companies Sinclair, Petrangol, and Total, with the drilling of four (4) exploration wells: Carimba-1, Carimba-2 Muxima-1, and Mututu-1, with the main objectives of the post-salt "play" (Table 1). The Carimba-2 well (1971) targeted the sands of the Itombe Formation and the carbonates of the Cabo Ledo Formation, with a depth of 2488 m.

Geokinectics company conducted seismic surveys in the Block during 2008-2009, acquiring and processing approximately 132.67 line km of seismic. In addition, recent geological mapping and well geochemistry studies were carried out by Sonangol in partnership with Obrangol 2010-2015 and Previsão Oil 2012-2015 (Figures 2, 4, and 5).

WELL	YEAR	TD (m)	RESERVOIR	RESULT
Carimba-1	1921	1 219	Itombe e Tuenza	N/R
Muxima-1	1959	2 450	Binga	Asphalt show
Carimba-2	1971	2 488	Itombe e Cabo Ledo	Gas show
Mututu-1	1974	2 200	N/R	N/R

**Table 1:** Drilled well on Block KON 10

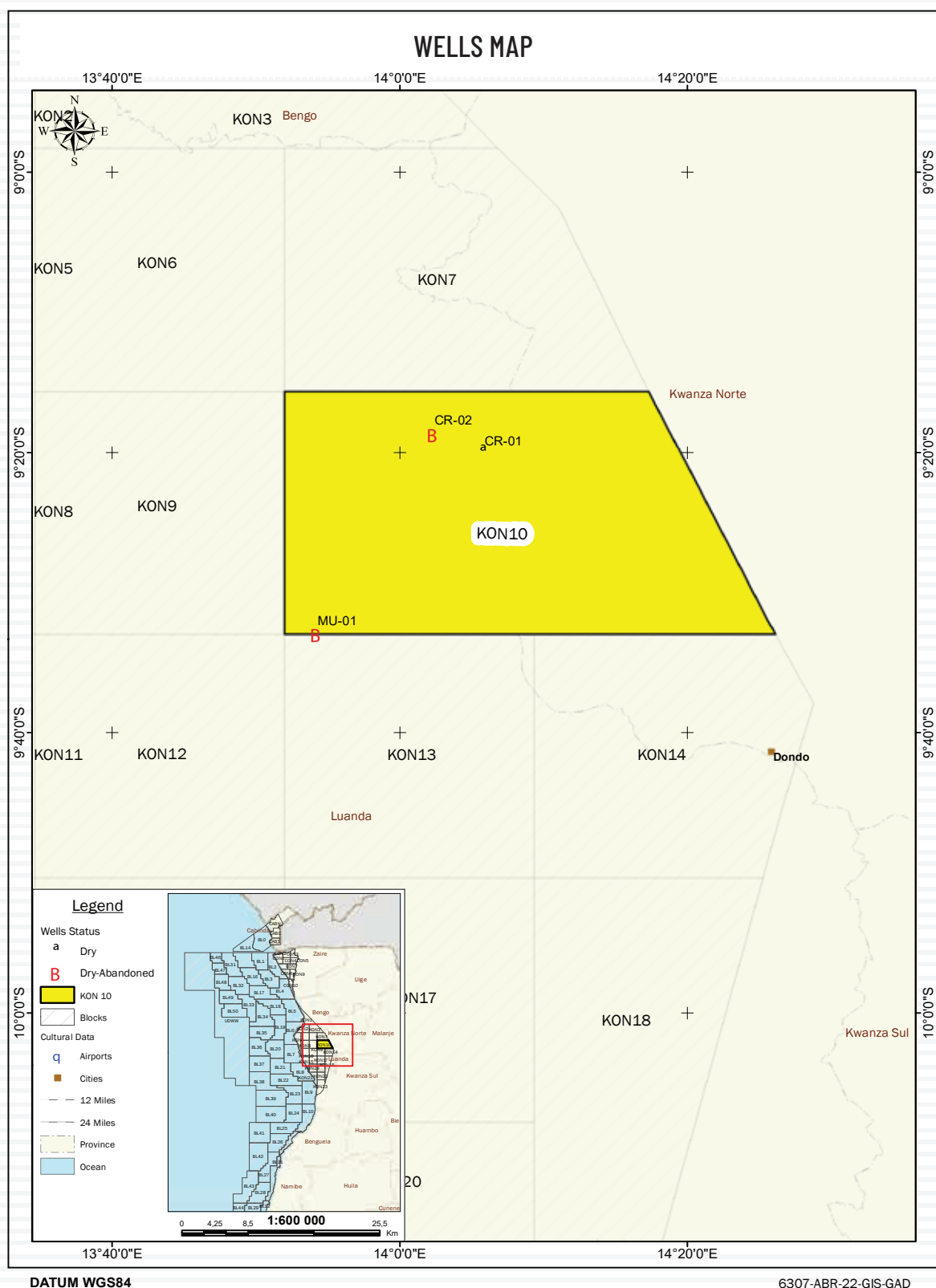
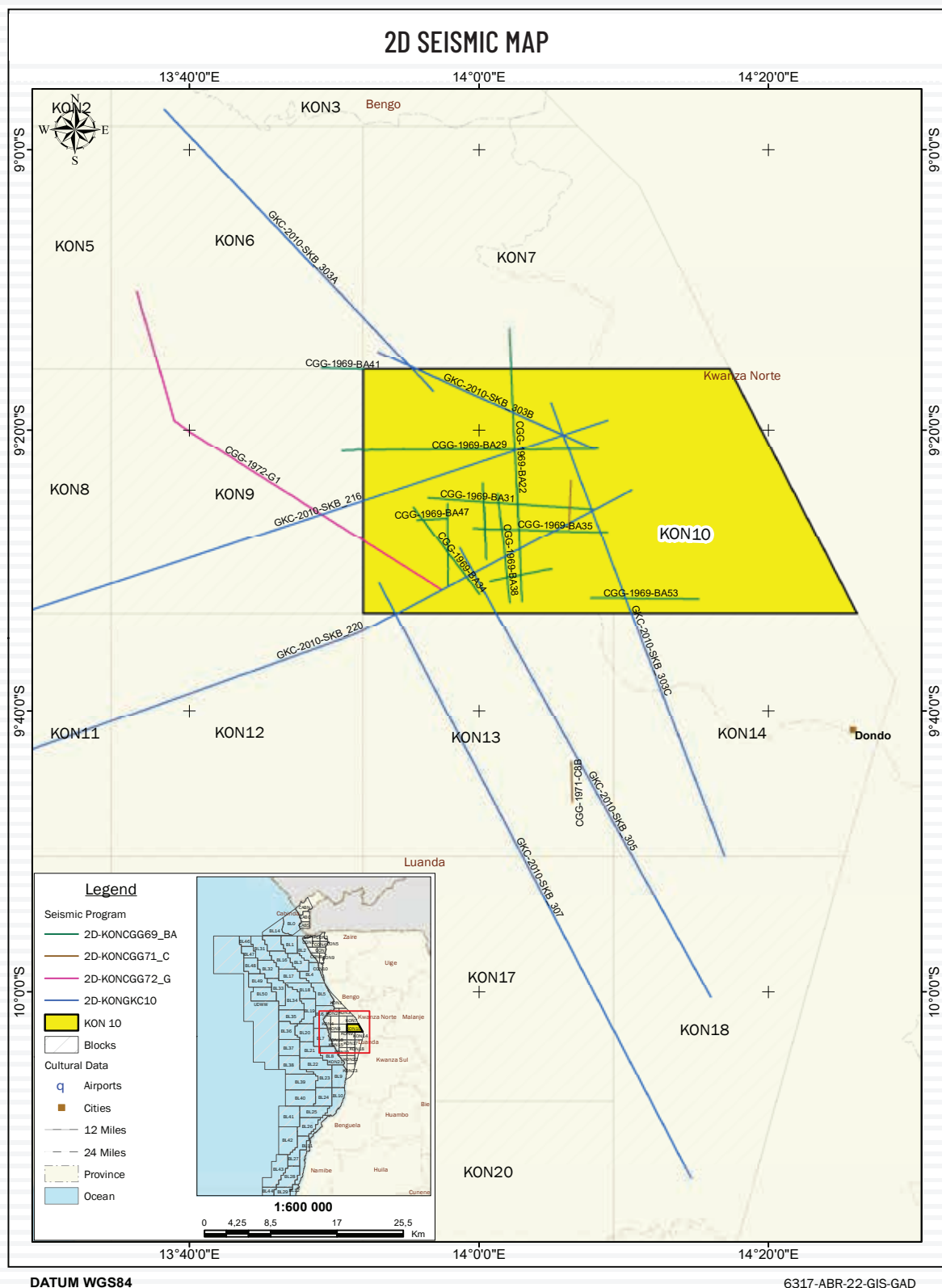
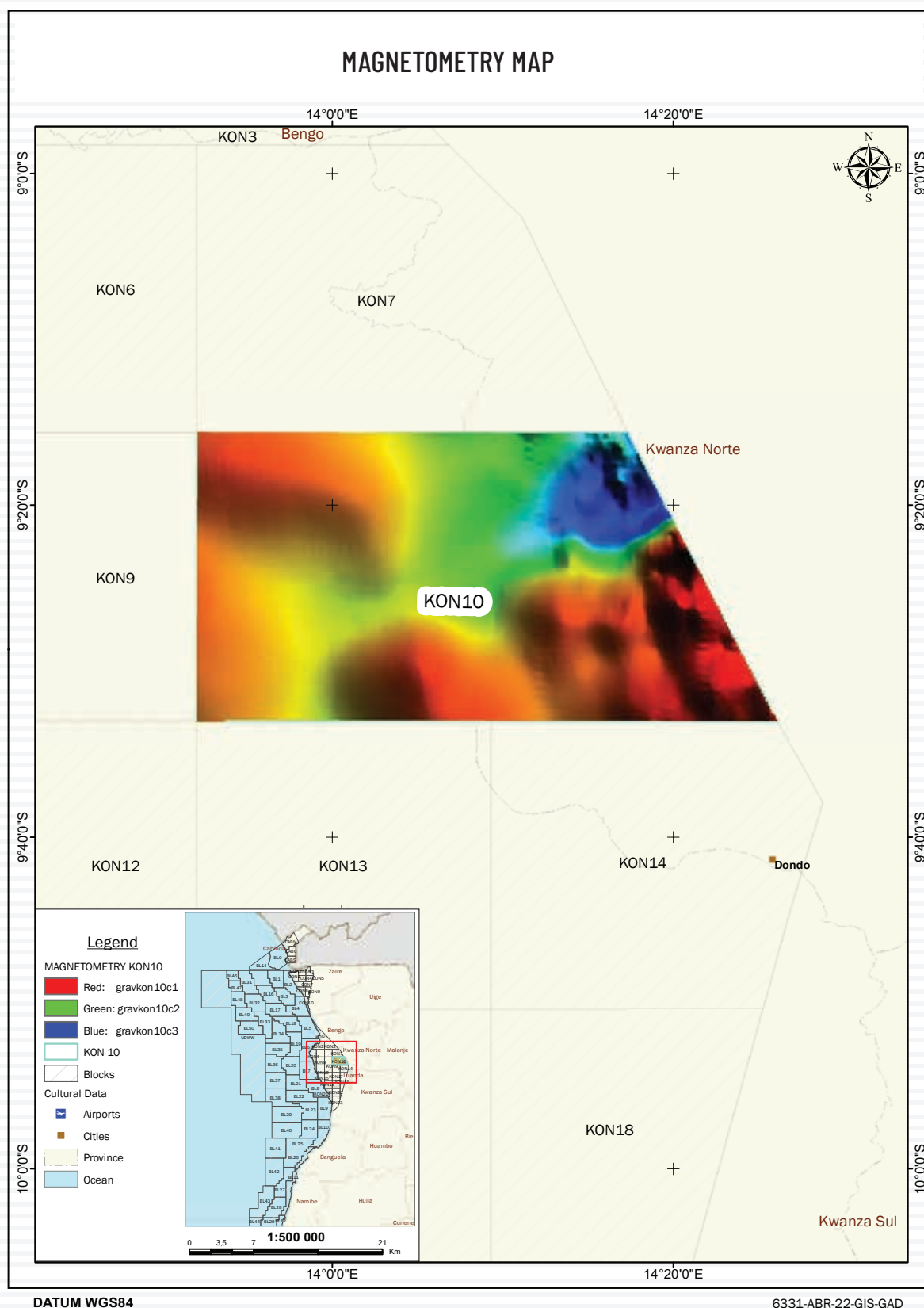


Figure 5: Well map of KON 10, ANPG 2022





**Figure 6:** 2D Seismic Data Acquired on Block KON 10, ANPG 2022



**Figure 7:** Magnetometry map of the KONA 10, ANPG 2022



## 5. PETROLEUM System

Based on the results of the wells drilled throughout the Basin, it was possible to determine the lithostratigraphy and describe the petroleum system of the two mega-sequences (Pre-salt and Post-salt).

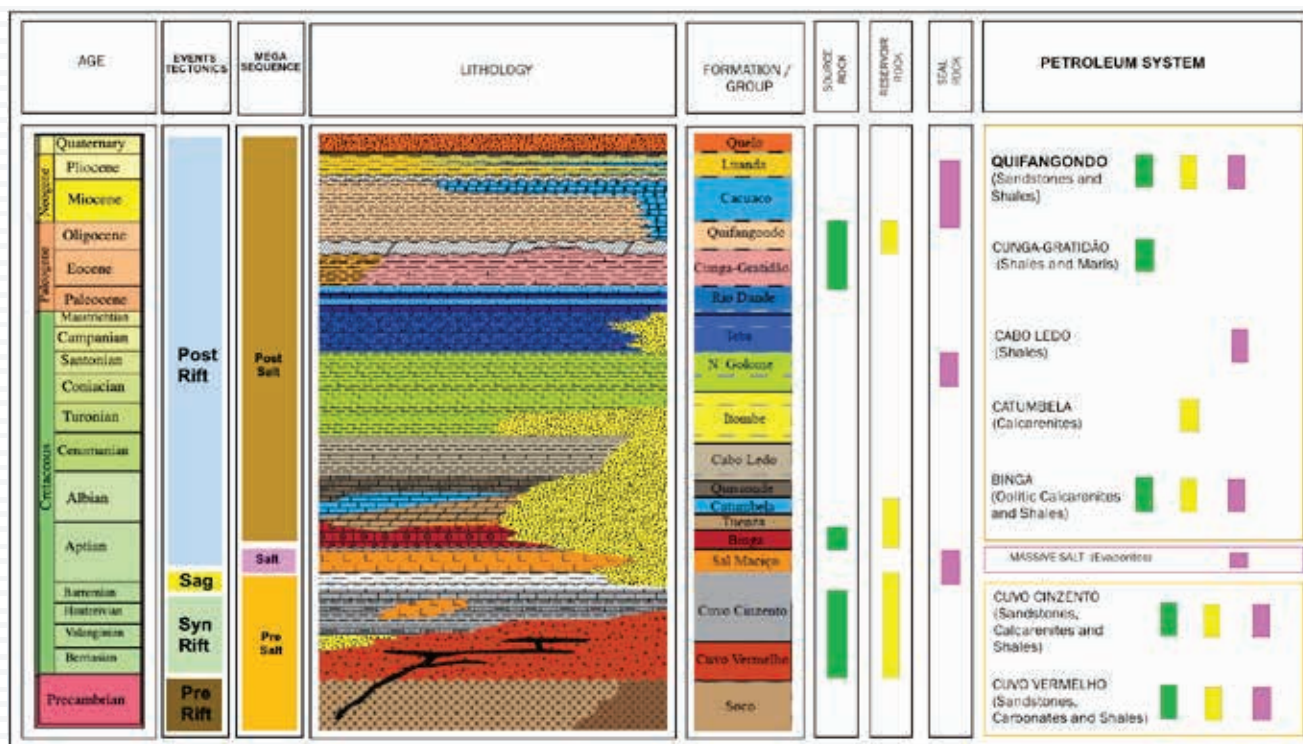


Figure 8: Lithostratigraphic Column of the Onshore Kwanza Basin, ANPG 2022

### 5.1 Generation and Migration

The source rock consists of the organic-rich shale of the Cuvo Formation and carbonates of the Binga Formation. Migration pathways occur from faults and facies contact.

### 5.2 Reservoir Rock

Block KON 10, for its history and the evidence, found more than a century ago, shows reservoir potential in pre-salt and post-salt units. The coquina carbonates on top of the horst, sands on the flanks, and sands on top of the Barremian are the potential reservoirs at the pre-salt level.

In the Post-salt, the main reservoirs identified correspond to the oolitic dolomitic limestones of the Binga Formation and sandstones of the Itombe Formations of the mid-Cretaceous.

## 5.3 Seal Rock

The Aptian Salt layer essentially dominates the seal rock in the pre-salt formations. Similarly, at the post-salt level, in the Albian, the post-saliferous unit, the shales and marls of the N'golome Formation, and the upper Itombe Formation constitute the primary cover rocks.

## 5.4 Trap

Potential trap types in the pre-salt include tilted fault blocks, stratigraphic pinch-out against horst flanks, and truncations in overlying salt layers. Salt movement generally controls post-salt traps, resulting in raft-like and turtle-back structures. Stratigraphic traps are also possible in zones of lateral facies variations.

## 5.5 Source Rock Occurrence

The primary source rocks identified in the Kwanza Basin are the organic-rich shale of the Cuvo Vermelho and Cinzento Formations in the pre-salt and the carbonates of the Binga Formations in the post-salt. The geochemical data from Block KON 6 allowed us to assess the potential of the source rocks. Total Organic Carbon (TOC), Rock-Eval Pyrolysis, and Vitrinite Reflectance analyses were performed in the pre-salt and post-salt units. The pre-salt unit in the Calomboloca Graben shared between Blocks KON 1 and KON 6 revealed average mature stage organic content values. At the post-salt level, the characterization of the Binga source rock suggests excellent mature-stage organic content.

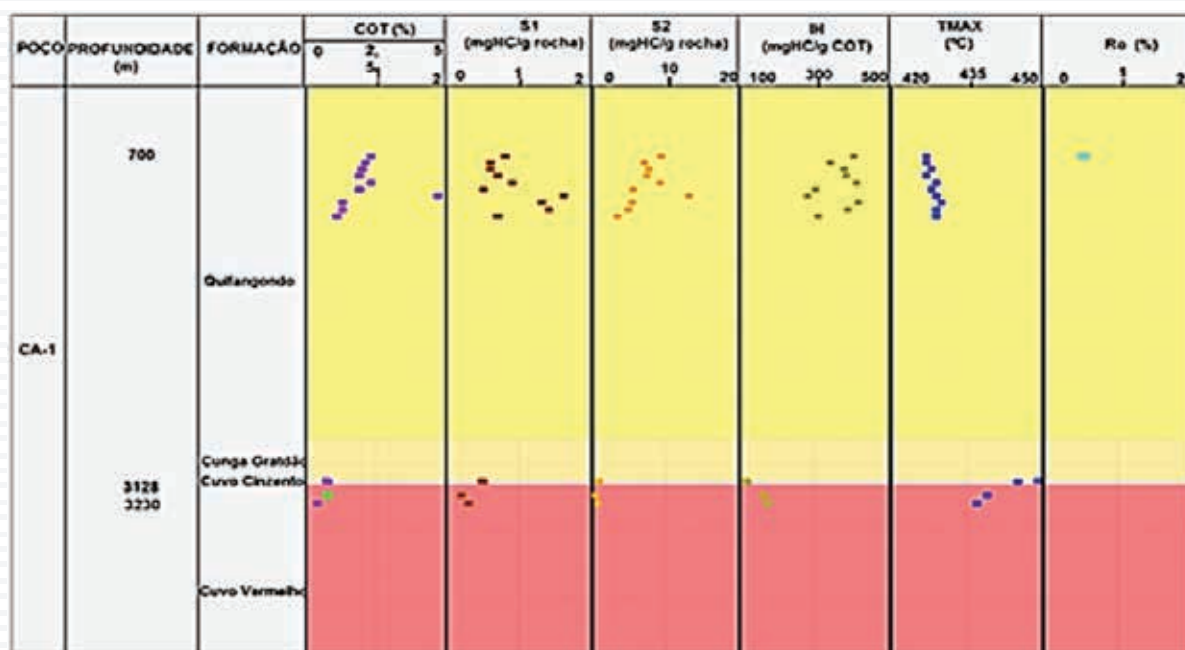


Figura 9: Geochemical Log of the Calomboloca well-1, ANPG 2022

## Cuvo Vermelho Source

The shales of the Cuvo Vermelho Formation identified in the Calomboloca graben in well CA-1 at depth 3 290 m show average values of total organic content (TOC) 0.5, HI values 175 mgHC/gCOT indicate type III kerogen, the parameter indicating maturity Tmax 437 °C shows that the rock is in the mature stage.

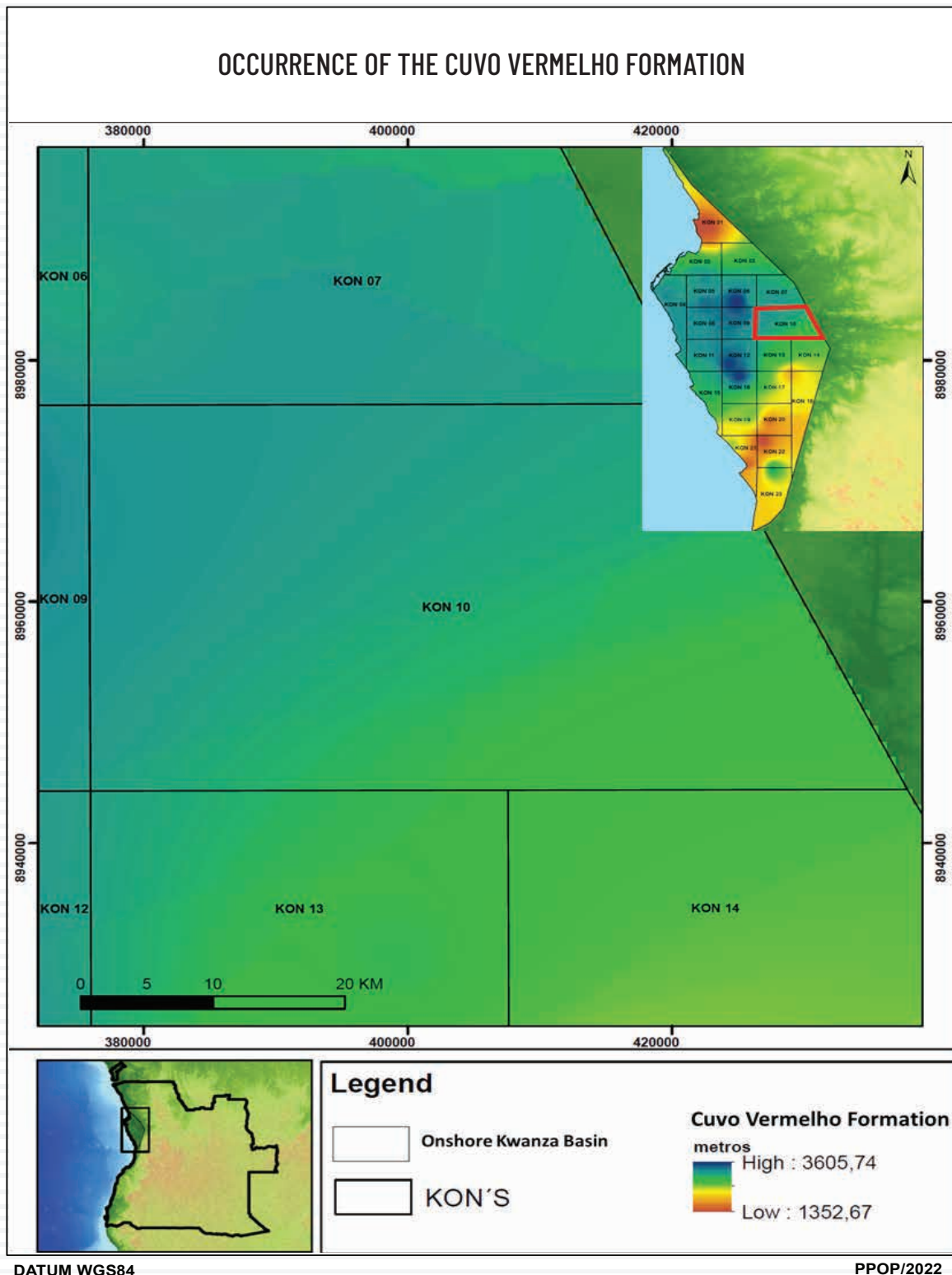
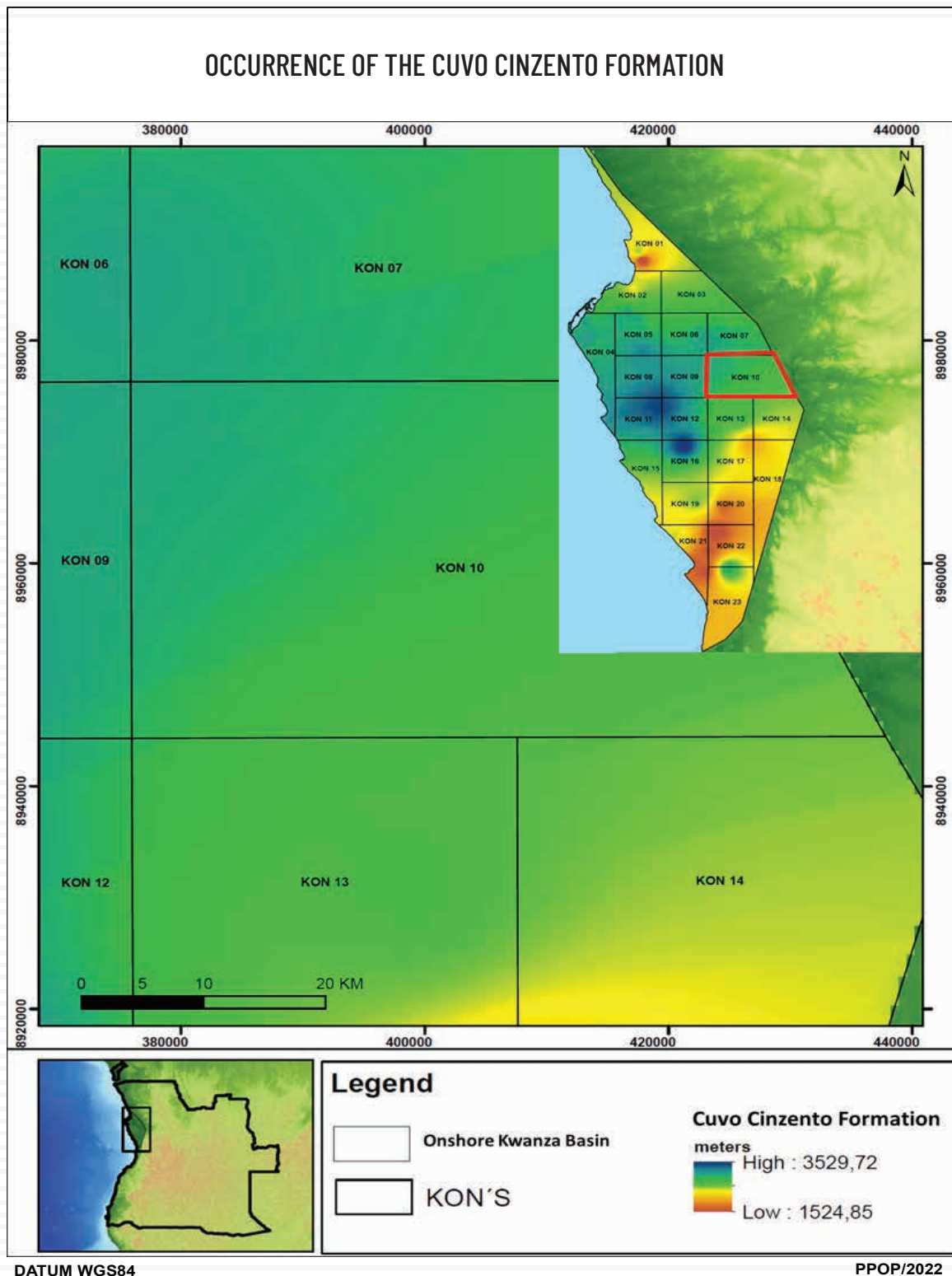


Figure 10: Occurrence map of Cuvo Vermelho Fm. Source rock

## Cuvo Cinzento Source

The shales at the level of this formation identified in well CA-1 at a depth of 3126 – 3128 m show average values of total organic content (TOC) 0.7- 0.75%, HI values 115-120 mgHC/gCOT, indicating kerogen type II/III, the parameter indicative of maturity Tmax 445-449 °C suggesting that the rock is at the peak of the oil window.



**Figure 11:** Occurrence map of Cuvo Cinzento Fm. Source rock



## Binga Source

The carbonates of the Binga Formation, a proven Albian source rock, are distributed along the entire length of the Block. Furthermore, geochemical studies carried out in surroundings blocks prove its generation potential.

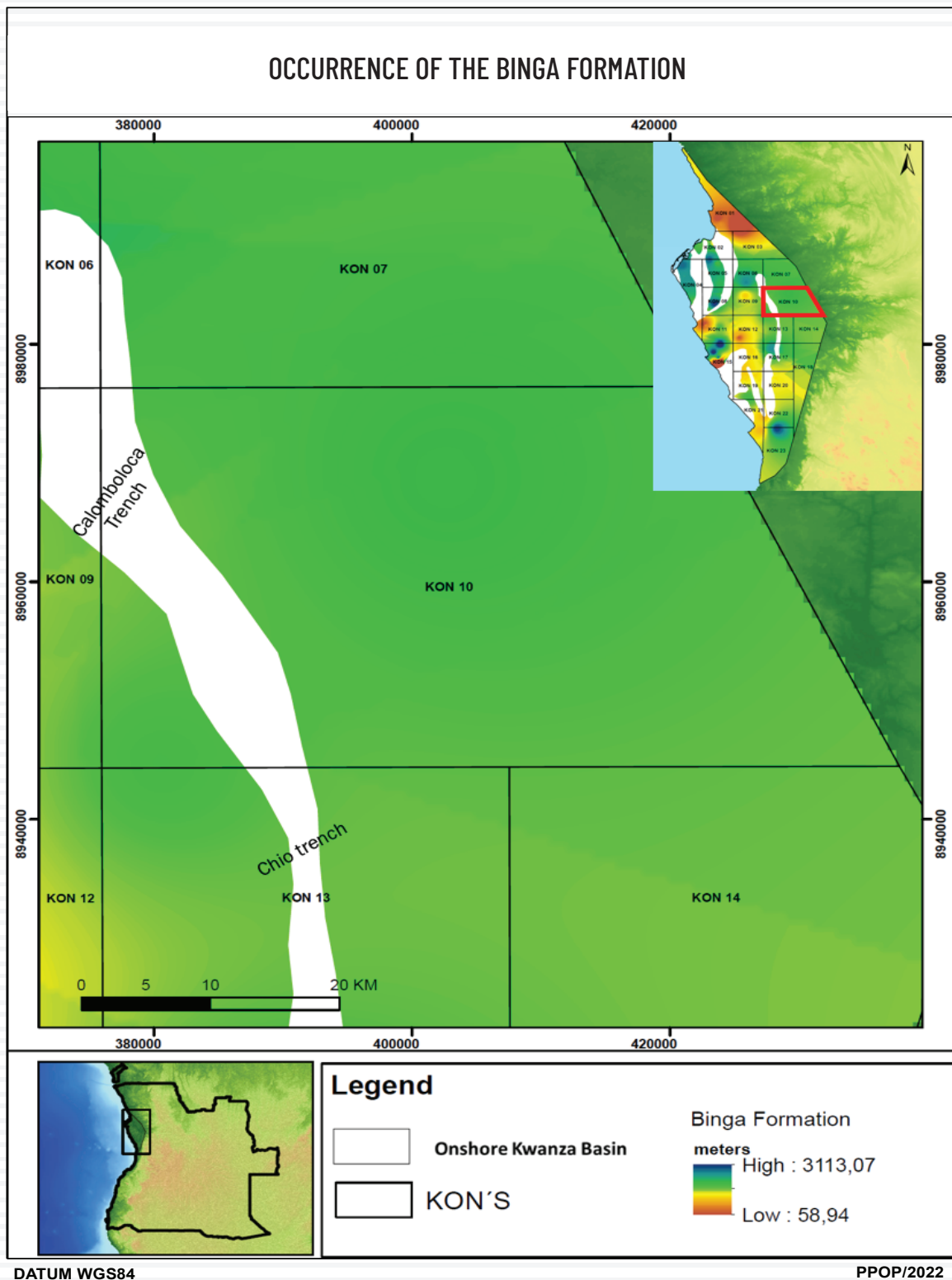


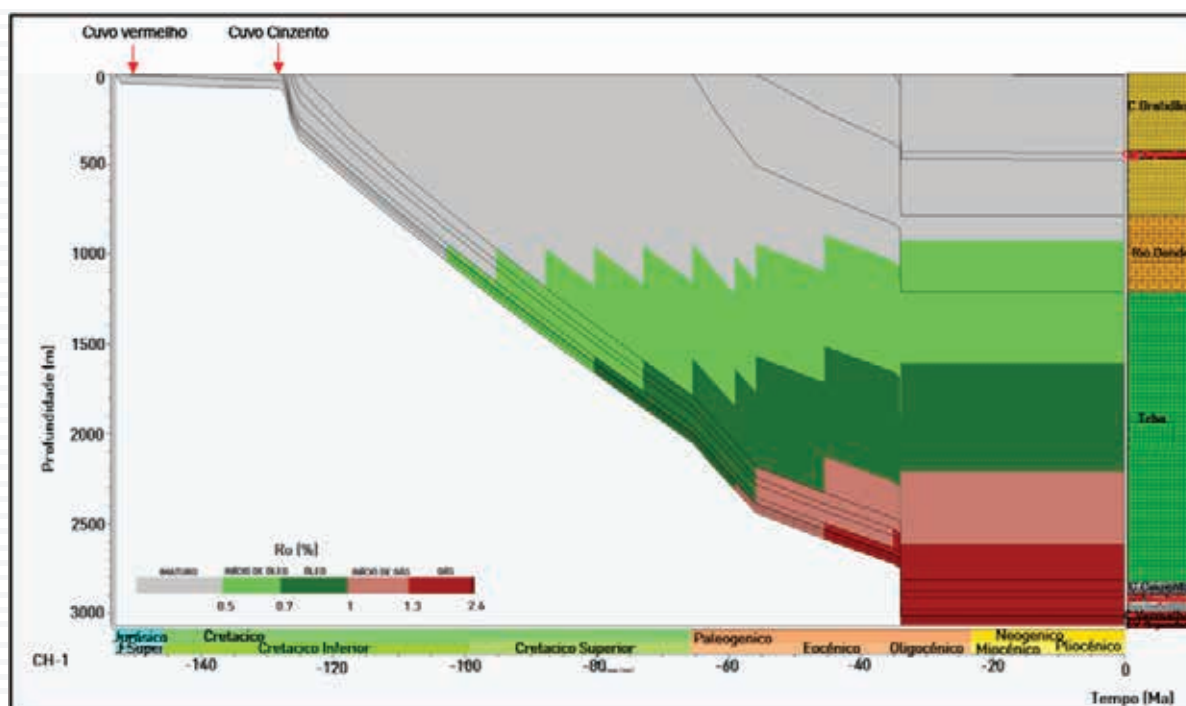
Figure 12: Occurrence map of Binga Fm. Source rock

KON	WELL	SAMPLE	FORMATION	Depth (m)	Ro (%)	TOC (%)	S1	S2	TMax (°C)	IP	HI (mg HC /g COT)	OBS
13	Chio 1	Core	Cuvo Cinzento	2829,1	1,11	1,83	0,25	1,16	465	0,17	63,38	Mature Source Rock
		Core	Cuvo Cinzento	2829,9	n/r	1,06	0,16	0,73	458	0,17	68,86	Mature Source Rock
		Core	Cuvo Vermelho	2869.90	0,57	1,35	0,64	2,77	441	0,18	205,18	Source Rock at the beggining of maturation

**Table 2:** Geochemical Analysis of Cuvo Vermelho & Cinzento Formations

## 1D Model

The Calomboloca-1 well shows that the Cuvo Vermelho Formation was deposited in the Lower Cretaceous. The thermal evolution of the generating facies at 1 000 to 2 500 m reached the oil window from Upper Cretaceous to the Oligocene and the gas window at depths of 2 500 to 4 000 m from Oligocene to the present. On the other hand, the Cuvo Cinzento Formation was deposited in the Lower Cretaceous, having reached oil window depths of 1 000 to 2 400 m in the Upper Cretaceous to Oligocene and gas window depths of 2 400 to 3 800 m from the Oligocene to the present day.



**Figura 13:** Maturation profile of Calomboloca - 1 well

## 6. EXPLORATION Opportunities

### 6.1 Identified Leads

As described below, the geological and geophysical data acquired allowed the identification of leads in both plays.

#### 6.1.1 Pre-salt Lead

##### Lead 1

The sandstone of the Cuvo Cinzento Formation characterizes the reservoir sealed by the evaporites of the Aptian. As a charge, the Cuvo Vermelho Formation shale facies, deposited in the grabens, constitute the possible source rock.

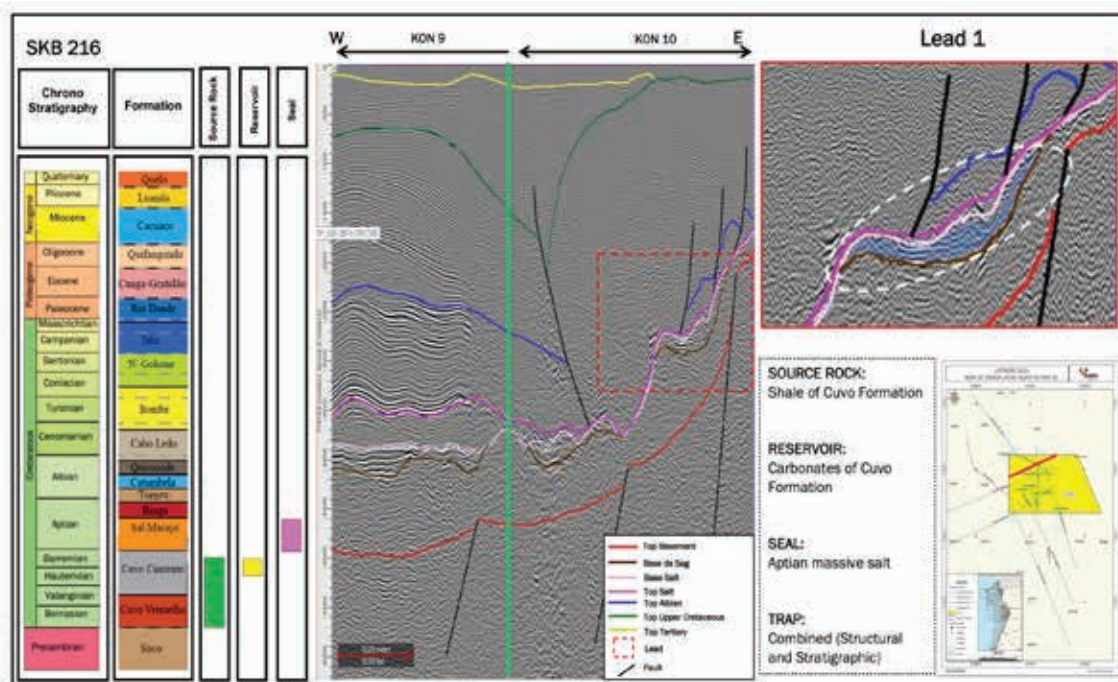


Figure 14: Lead 1, ANPG 2022

#### 6.1.2 Post-salt Lead

##### Lead 2

Albian's oolitic limestones of the Binga Formation characterize the reservoir. The carbonate facies of the Binga Formation constitute the source rock, with the shales of the Cabo Ledo Formation as the cover rock.



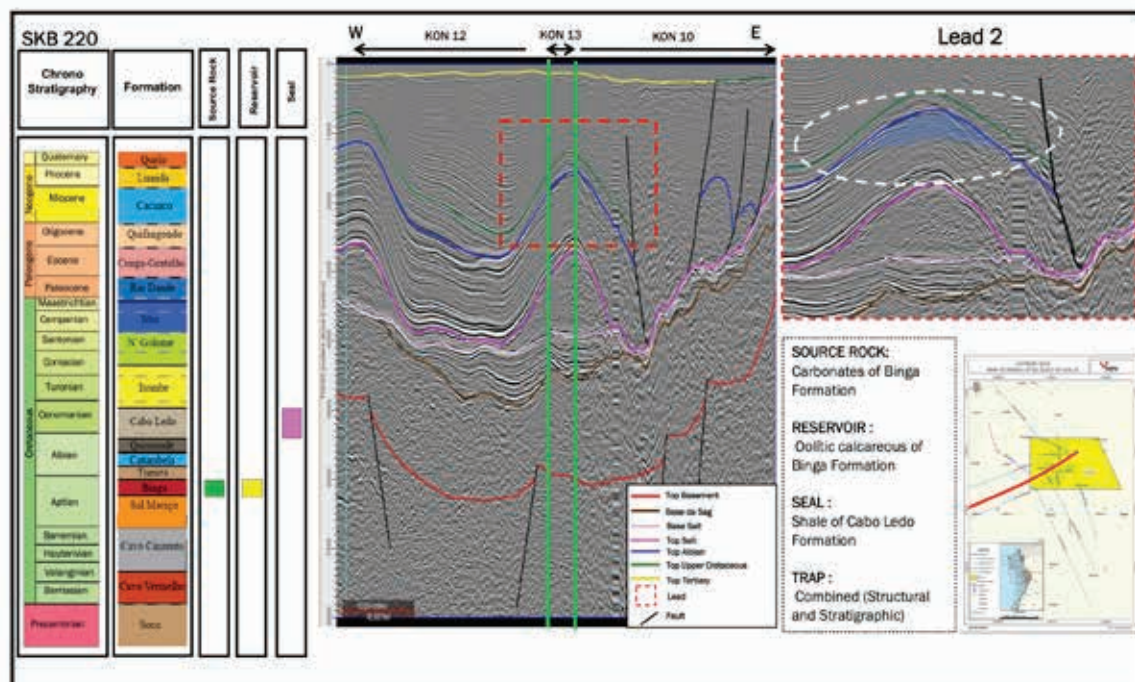


Figura 15: Albian Lead 2, ANPG 2022

## Lead 3 & 4

Located in the northwestern part of the Block, the reservoir is characterized by oolitic limestones of the Binga Formation, possibly fed by the argillaceous carbonate facies of the same formation, having as cover rock the shales of the Cabo Ledo Formation.

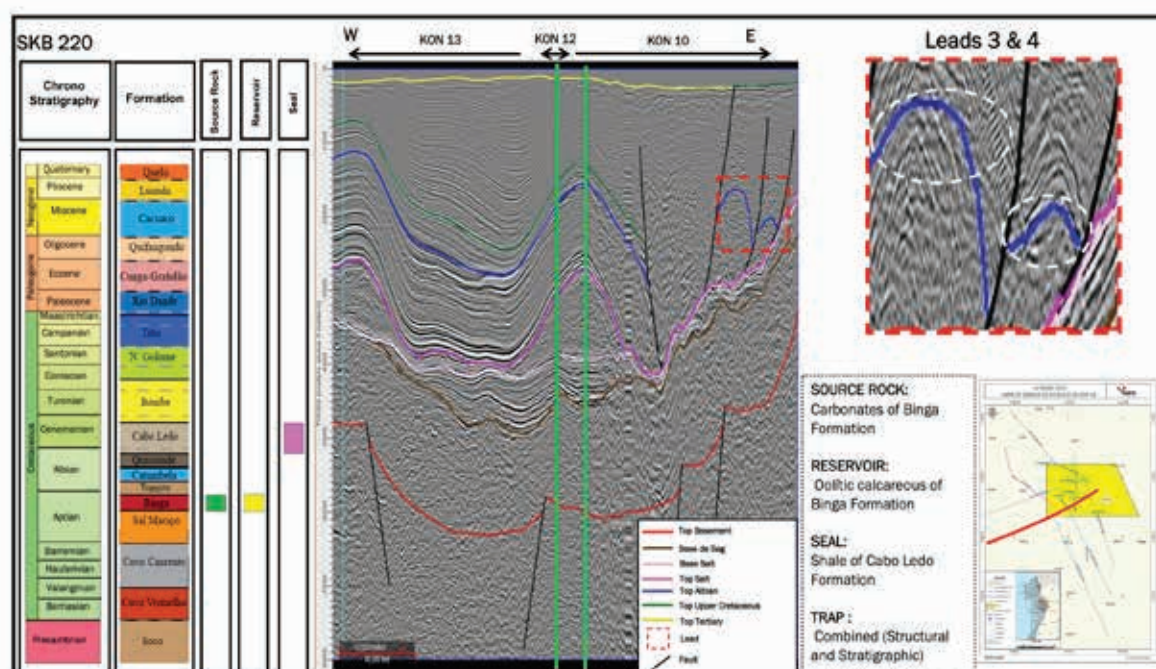


Figura 16: Albian Lead 3 & 4, ANPG 2022



## Lead 5

Located in the southwestern part of the Block, in the Tertiary Trough, sandstones of the Quifangondo Formation characterize the reservoir; the source rocks are the black marls of the Cunha Gratião Formation; due to the presence of salt windows in the Block, the generation could occur from the organic-rich shale of the Cuvo Formation in the pre-salt. Therefore, the cover rock consists of the intraformational shales of the Quifangondo Formation.

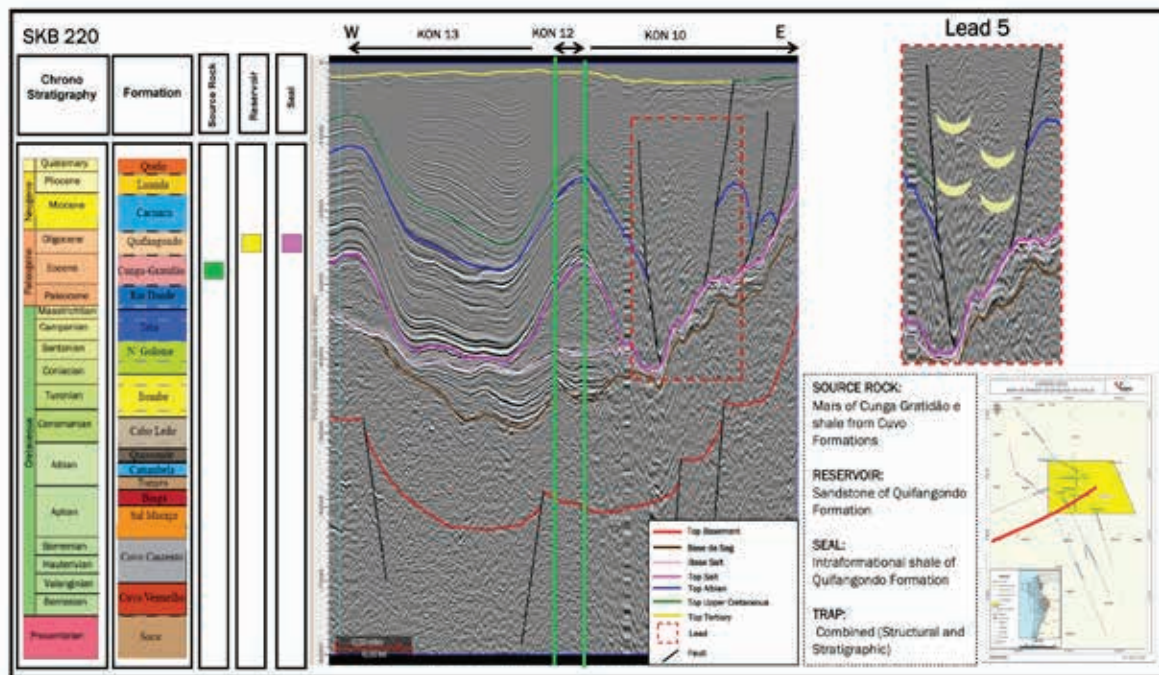
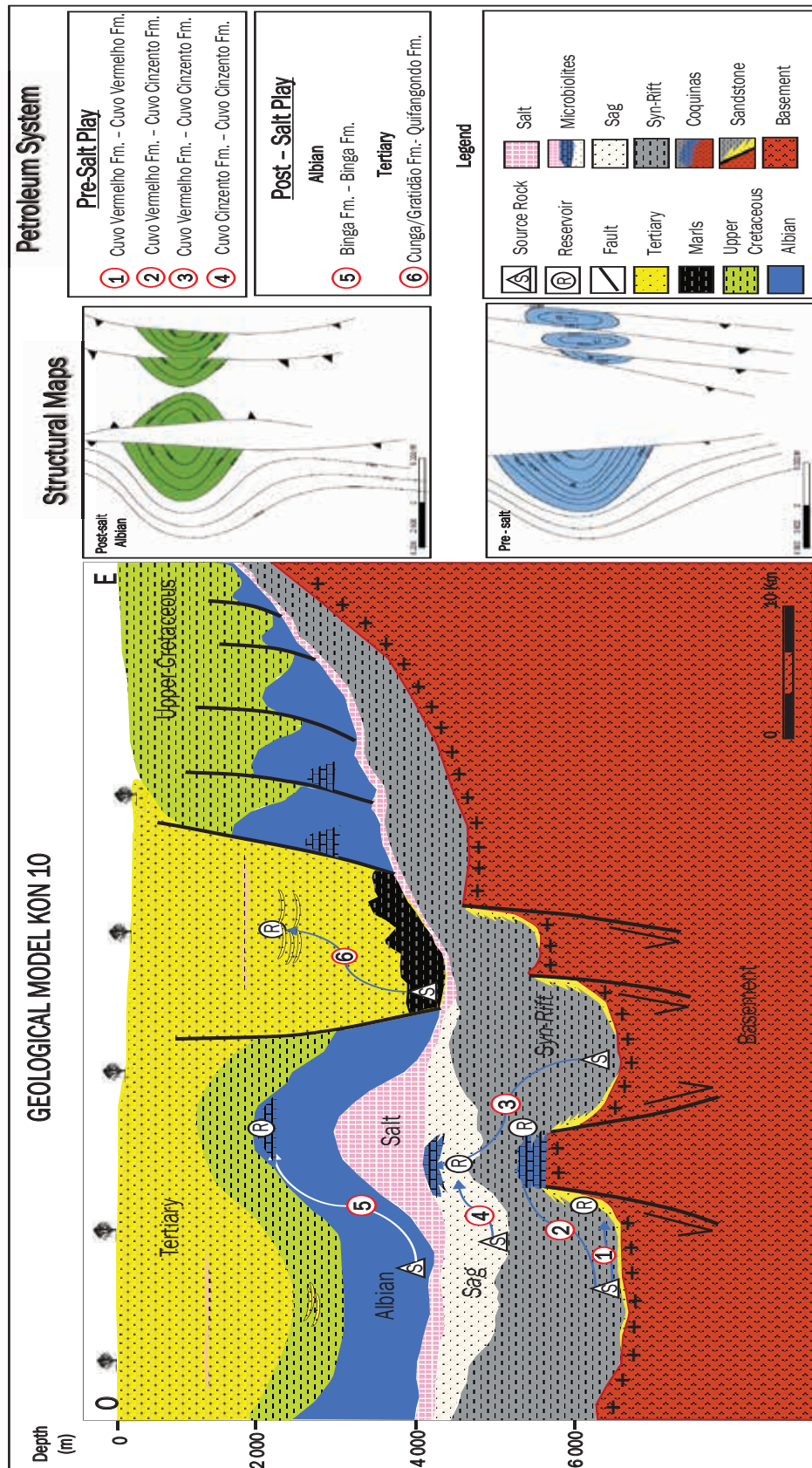


Figura 17: Albian Lead 5, ANPG 2022



## 7. FINAL Remarks

After reassessing Block KON 10, it became evident that the Onshore Kwanza Basin has a solid potential to be exploited in pre-salt and post-salt plays in a region widely known as having a proven, functional, and active petroleum system.

In the Pre-salt, the primary source rock is the Cuvo Formation, equivalent to the Bucomazi in the lower Congo Basin. The reservoirs are the sands and carbonates of the same formation equivalent to the Lucula, Toca, and Chela Formations in the lower Congo Basin.

In the post-salt, the Albian age carbonates of the Binga Formation are the primary source rock, and the carbonates of the same formation are the reservoir rock. In the Tertiary, the source rock is the black marl of the Cunga-Gratidão Formation, and the reservoir is the sandstone channels of the Quifangondo Formation.

The ANPG encourages the companies to invest in this block through additional studies to ensure the discovery of the real potential, which should allow for the boosting of exploration activity aiming to revert the production decline observed over the last decade.

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# BACIA TERRESTRE DO **KWANZA**



BLOCO  
**KON 10**



# ANGOLA



ANPG  
Agência Nacional de Petróleo, Gás e Biocombustíveis  
E-mail: [licitacao2023@anpg.co.ao](mailto:licitacao2023@anpg.co.ao)  
+244 226 428 602  
[geral@anpg.co.ao](mailto:geral@anpg.co.ao) | website: [www.anpg.co.ao](http://www.anpg.co.ao)

Edifício Torres do Carmo-Torre 2, Rua Lopes Lima, Distrito Urbano da Ingombota,  
Município de Luanda, República de Angola