



ONSHORE  
LOWER  
CONGO BASIN



# 2023 LICENSING ROUND REPUBLIC OF ANGOLA

ONSHORE  
KWANZA BASIN

ONSHORE KWANZA BASIN

Portfolio  
**OPPORTUNITIES**

Block  
**KON7**

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# 1. Introduction

The portfolio opportunities describe the general characteristics of Block KON 7, 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 7 is in the northeast part of the Onshore Kwanza Basin. With no record of any wells drilled, the re-evaluation of the block was based on correlations with the Calomboloca-1 well, Block KON 6. In addition, 2D seismic surveys were carried out by the Geokinectics Company during 2009-2012.

Sonangol conducted recent geological mapping and well geochemistry data survey studies in partnership with Obrangol and Previsão Oil companies from 2010-2015 and 2012-2016, 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 825 to 2 148 MMBO.



## 2. GEOGRAPHIC Location

Block KON 7 is in the northeast part of the Kwanza Basin. It is bordered by Block KON 3 to the north, Block KON 10 to the south, Precambrian outcrop to the east, and KON 6 to the west, defined by the geographic coordinates  $9^{\circ} 02' 40''$  and  $9^{\circ} 15' 36''$  S and meridians  $13^{\circ} 52' 11''$  and  $14^{\circ} 17' 13''$ , having a total area of approximately 1 207.86 km<sup>2</sup> (Figure 1).

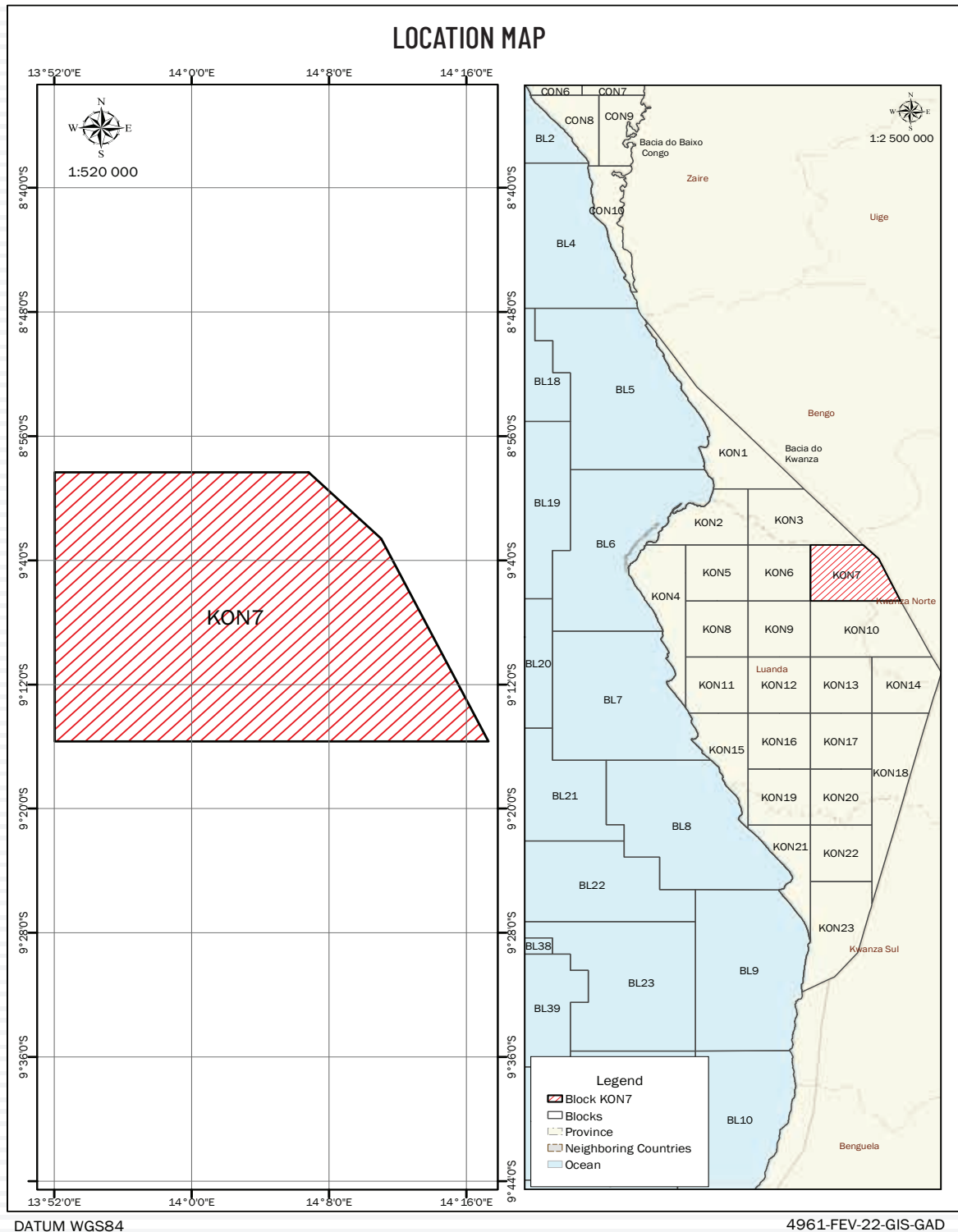
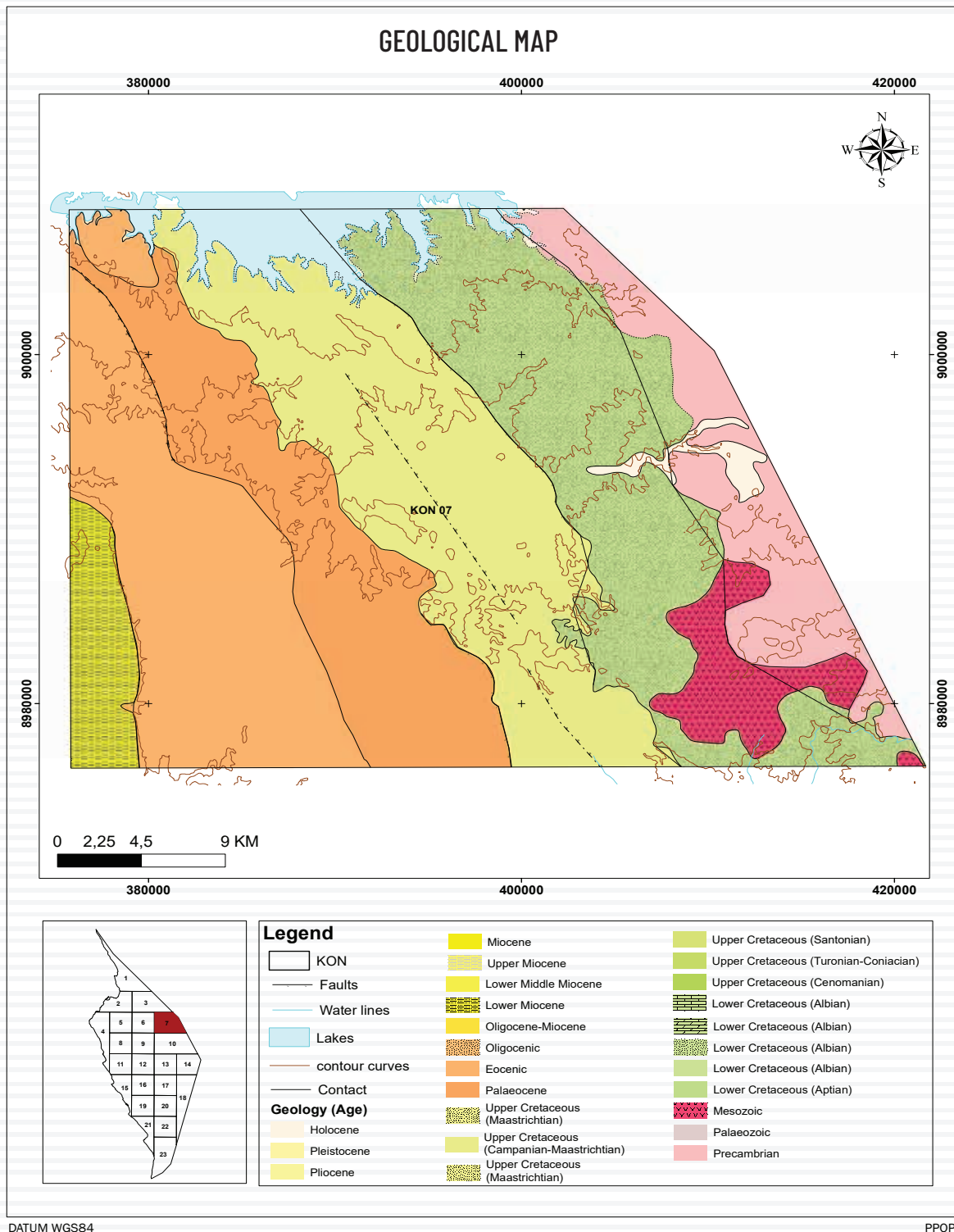


Figure 1: Location map of Block KON7, ANPG 2022

### 3. GEOLOGICAL Setting

The outcrops of **Block KON 7** are represented by sediments of Precambrian to Recent age, according to the geological chart of the Onshore Kwanza Basin (Figure 2).

Its sedimentary history 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 7, ANPG 2022

## Pre-salt Unit

It is marked by distension movements accompanied by volcanic effusions (Neocomian 140 Ma), followed by a period of subsidence due to thermal relaxation of the crust. The unit in Block KON 7 was characterized by horst and graben type structures of Calomboloca to the southeast because of fault systems eradicated in the basement, as well as potential hydrocarbon storage zones; lacustrine carbonates of the Cuvo Cinzento Formation were deposited, and on the flanks of the horsts are deposited sandstone sediments from Cuvo Formation in pinch-out against fault planes as potential reservoirs.

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 that constitutes the primary cover rock at the level of this unit was deposited. The probability of the existence of salt windows will allow for oil migration to the post-salt.

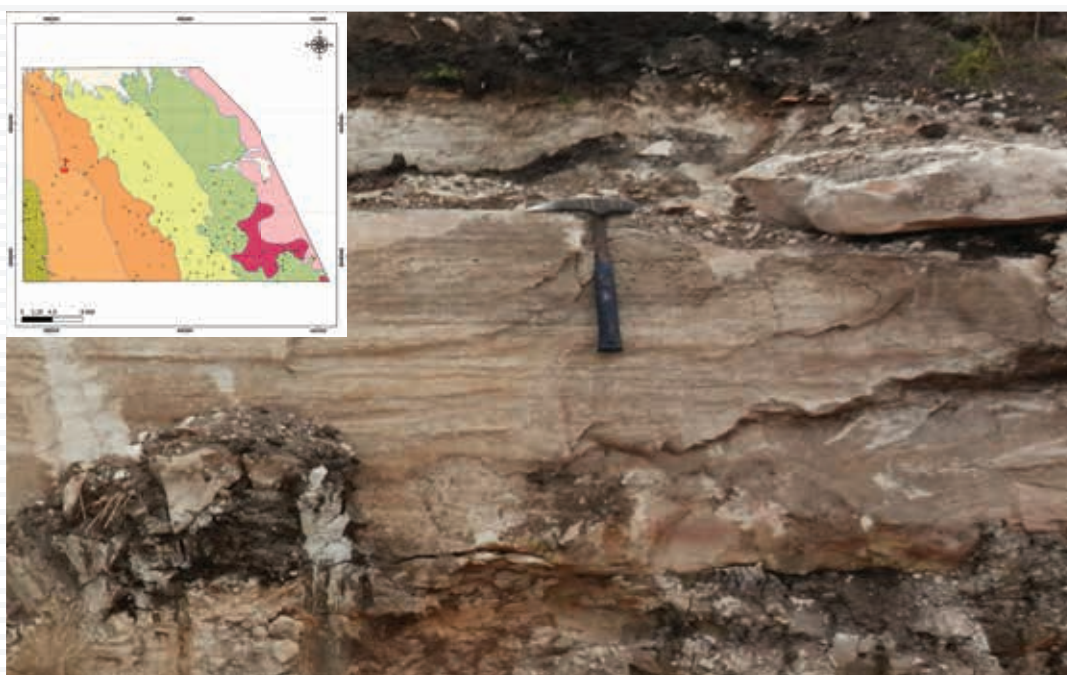
## Post-salt

It comprises formations of Albian to Recent age, influenced by the salt tectonics. Syn-depositional growth faults with listric relicts and the presence of the Calomboloca Tertiary Trough in the southwestern area characterize it.

At the west, the Albian represents generation and accumulation potential in the carbonates of the Binga Formation; at the Tertiary level, the organic-rich black marls of the Cunga-Gratidão Formation deposited at the base of the trough serve as source rock to charge the sandstone channels of the Quifangondo Formation (Figure 3).



**Figure 3:** Igneous and metamorphic rock - Precambrian; Itombe zone



**Figure 4:** Intercalation of Marls and silts - Cunga-Gratidão Formation; Calomboloca zone



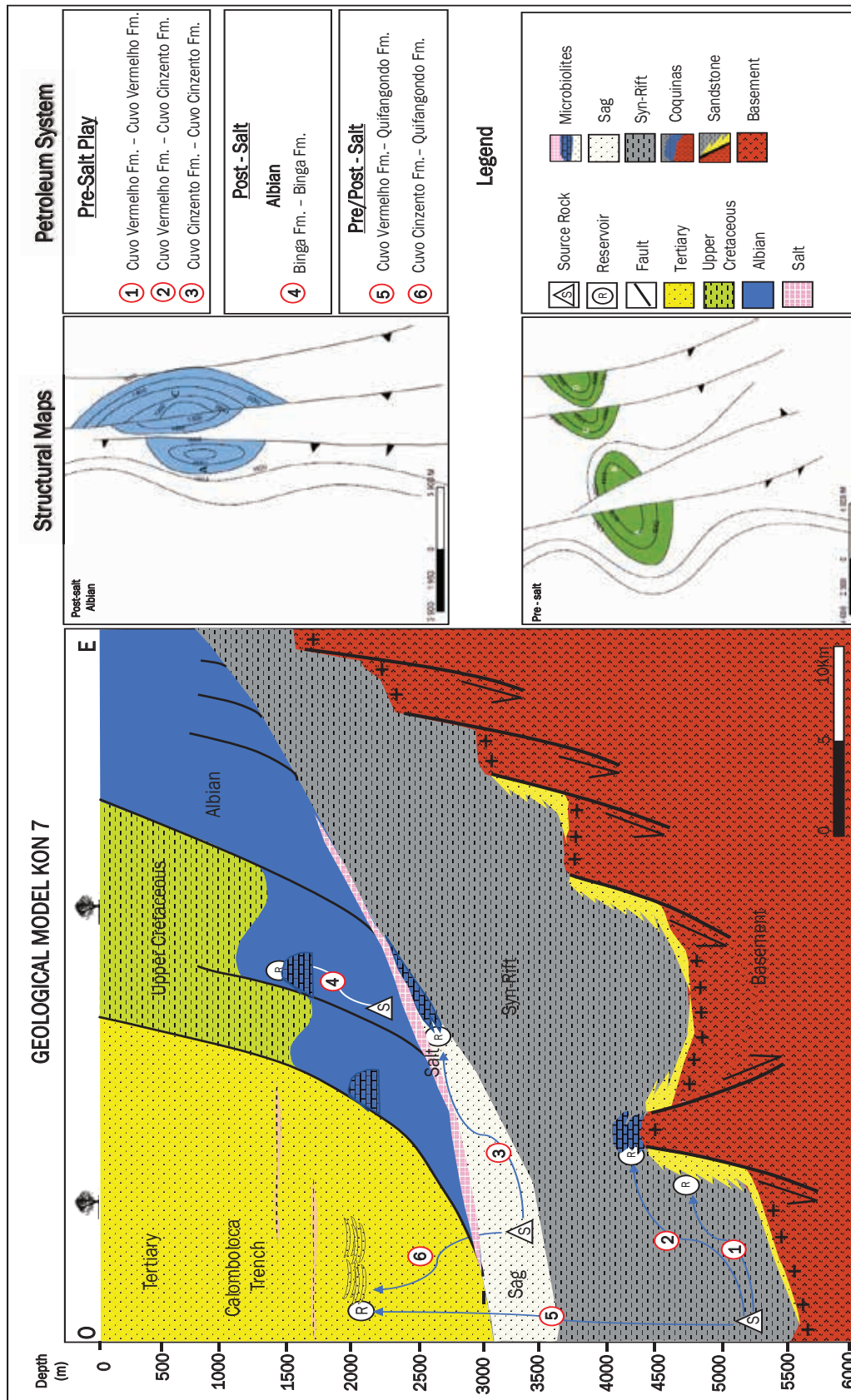


Figure 5: Geological Model of the Block KON 7, ANPG 2022

## 4. EXPLORATION History

The first exploration works on the Block date from 1970 to 1973, with a seismic acquisition carried out by the Petrangol company.

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, Cacuaco, and Galinda fields.

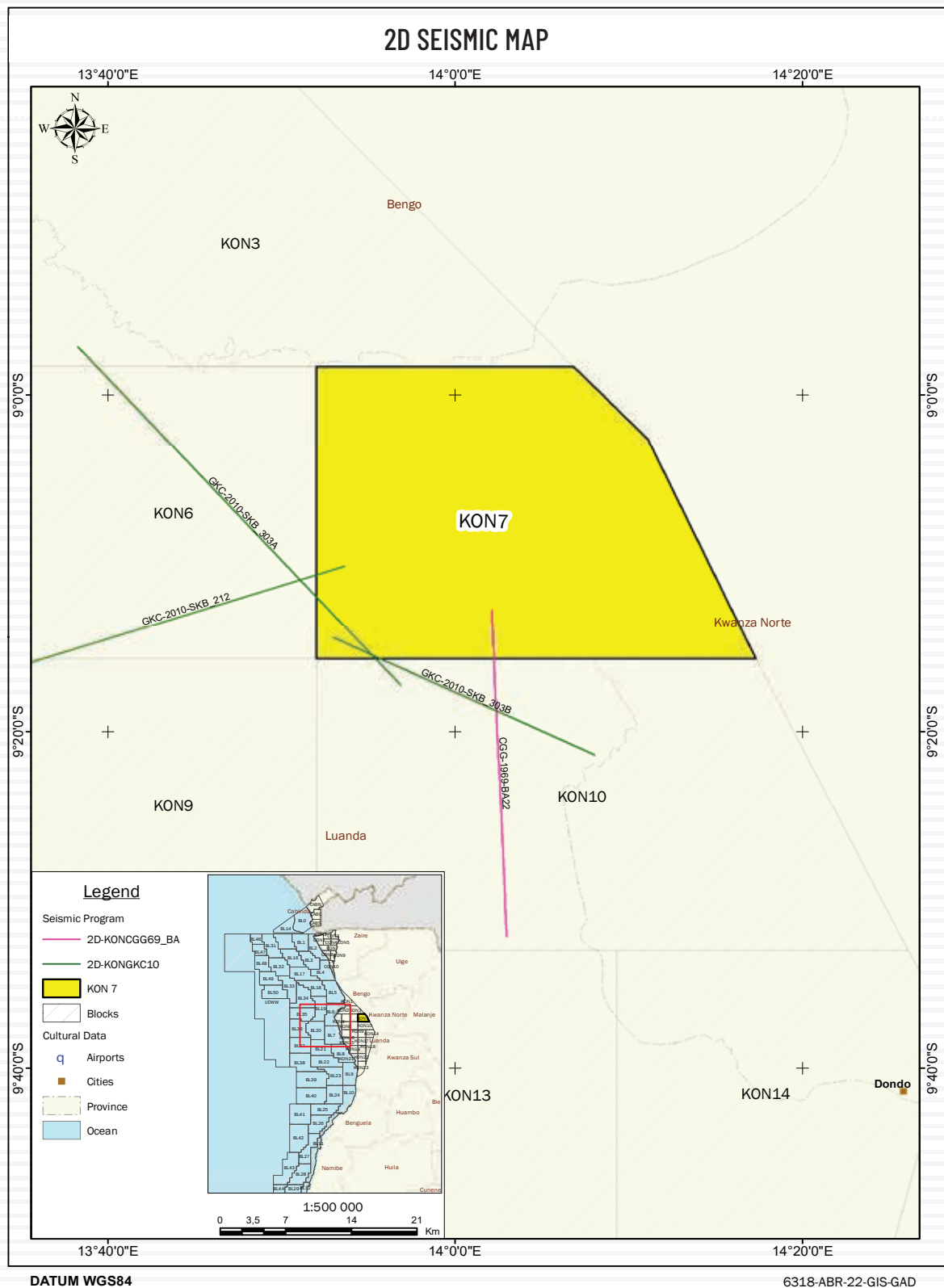
In July 1961, in the continuation of the work started by the Research Mission, the then-operating company Petrangol discovered the first significant field, the Tobias field, in the Cabo Ledo region, which guaranteed Angola's self-sufficiency in terms of crude oil and also contributed to ending the skepticism 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.

Recent geological mapping and surface geochemistry studies were carried out by Sonangol in partnership with the companies Obrangol 2010-2015 and Previsão Oil 2012-2015 (Figures 2, 4, and 5).

In 1998, the ENI company conducted the aero gravimetry and magnetometry survey. In 2009-2012 Geokinectics acquired 151.07 km of 2D seismic.

Block KON 7 has no record of wells drilled; the evaluation of the Block was done in correlation with the Calomboloca-1 well KON 6.



**Figure 6:** 2D Seismic Data Acquired on Block KON 7, ANPG 2022



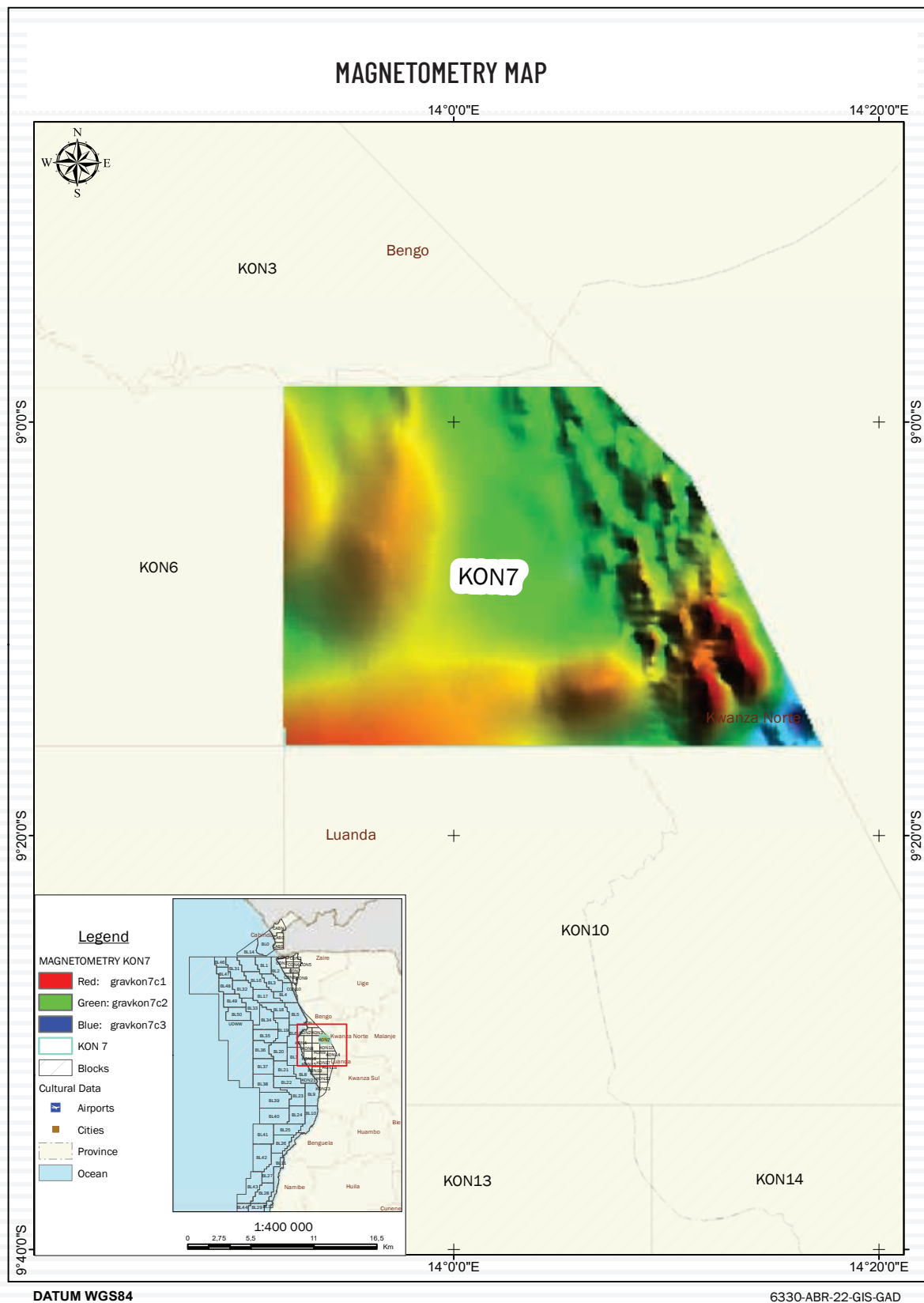


Figure 7: Magnetometry map of the KON 7, ANPG 2022

## 5. PETROLEUM System

With the integration of geological e geophysical data, it was possible to determine the lithostratigraphy and the description of the petroleum system of the two mega-sequences (Pre-salt and Post-salt).

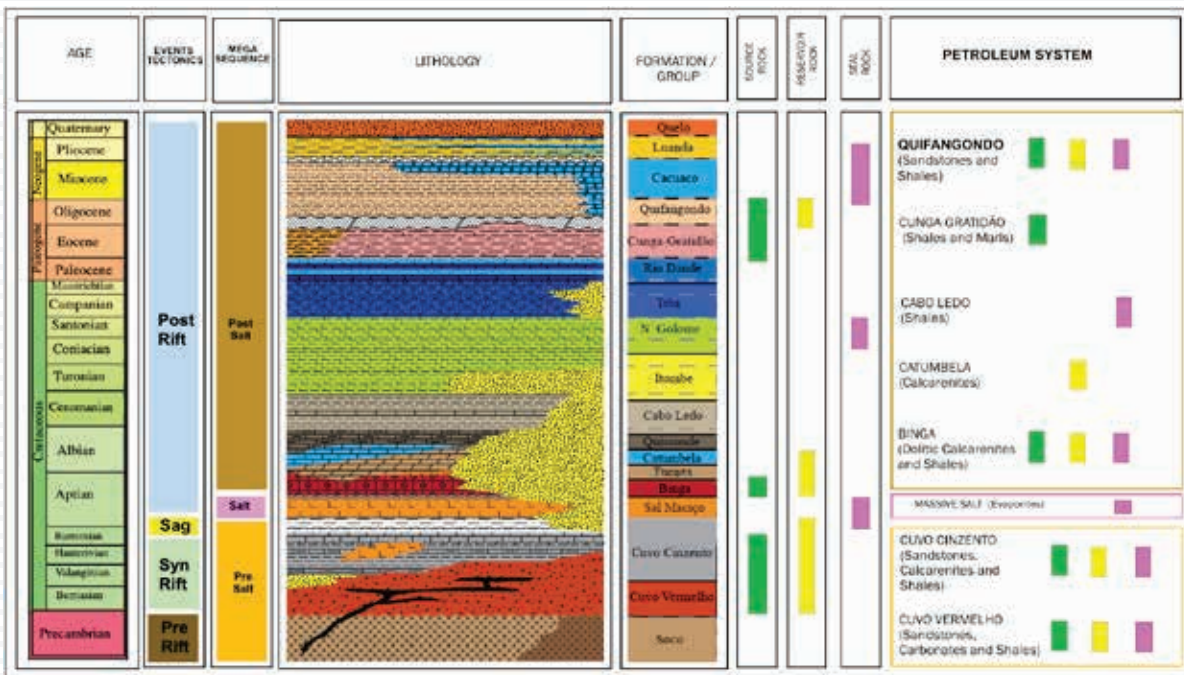


Figure 8: Lithostratigraphic Column of the Onshore Kwanza Basin, ANPG 2022

### 5.1 Generation and Migration

The source rock consists of organic-rich lacustrine shale of the Cuvo Formation in the Pre-salt, carbonates from Binga Formation in the Albian, and black marls of the Cunha-Gratidade Formation in the Tertiary. Migration pathways occur from faulting, salt window, and facies contact.

### 5.2 Reservoir Rock

The Cuvo Formation consists of coquinas on top of the horsts, the sands on the flanks of the horsts, and top of the Barremian are potential reservoirs at the pre-salt level. The main reservoirs identified in the post-salt correspond to the oolitic limestone of the Binga Formation, the sandstones of the Itombe Formation, and the clastic of the Teba Formation of the middle Cretaceous.

### 5.3 Seal Rock

The seal rock for the Pre-salt is the Massive Salt of the Aptian age. The Albian Formations are the overlying Saliferous Tuenza and the Cabo Ledo Formation clays. The seal rock of the Upper Cretaceous reservoirs in the Itombe and Teba Formations are the clays of the same formations. And for the Quifangondo Formation corresponds to the overlying intraformational shales.

## 5.4 Trap

The Aptian Massive Salt layer dominates the seal rock in the pre-salt formations. Similarly, at the post-salt level, the Tuenza Saliferous Formation and the Cenomanian Cabo Ledo Formation shales act as effective seals in the Albian.

## 5.5 Source Rock Occurrence

The primary source rocks identified in the Kwanza Basin are the pre-salt organic-rich lacustrine shales of the Cuvo Vermelho and Cinzento Formations and the post-salt carbonates, black marls of the Binga Formation as well as the Cunga Gratidão Formation. 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 conducted in pre- and post-saliferous units. In the Pre-salt unit in the Calomboloca Graben, the Calomboloca-1 KON 6 well revealed average values of organic content in the mature stage. At the Post-salt level in the Calomboloca Trough, the source rock characterization suggests excellent organic content in the mature stage organic content.

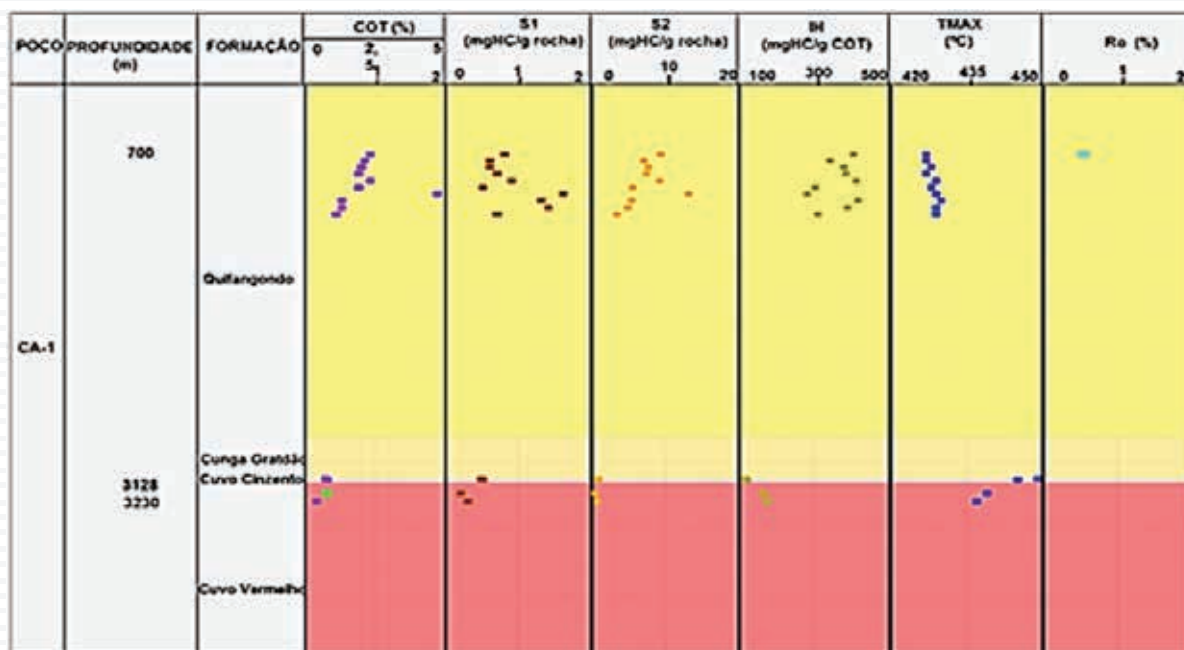
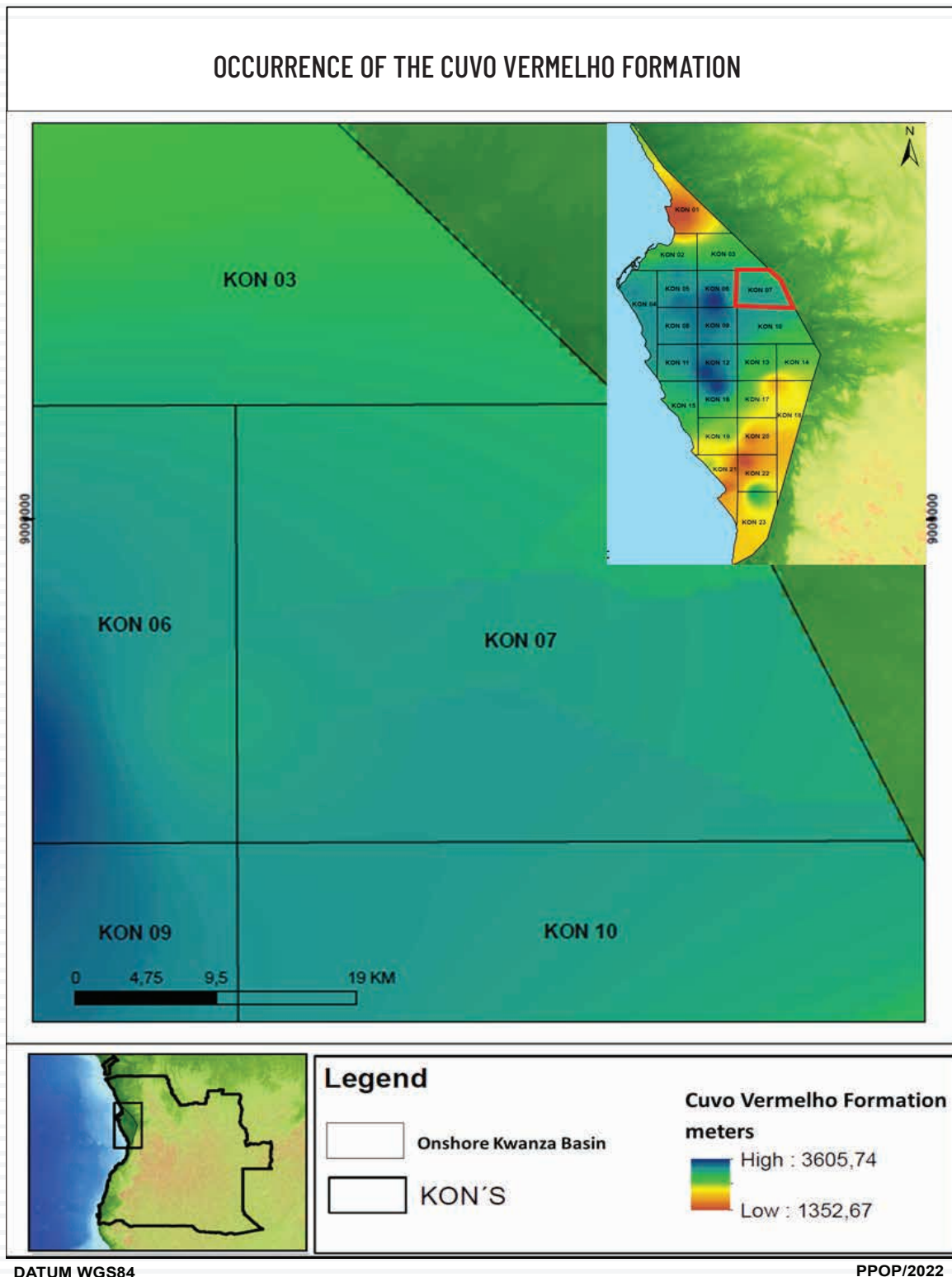


Figura 9: Geochemical log of CA-1 well, ANPG 2017

## Cuvo Vermelho Source

The Cuvo Vermelho Formation shale identified in the Calomboloca-1 well at a depth of 3 290m presents average values of total organic content (TOC) of 0.5%, the 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.

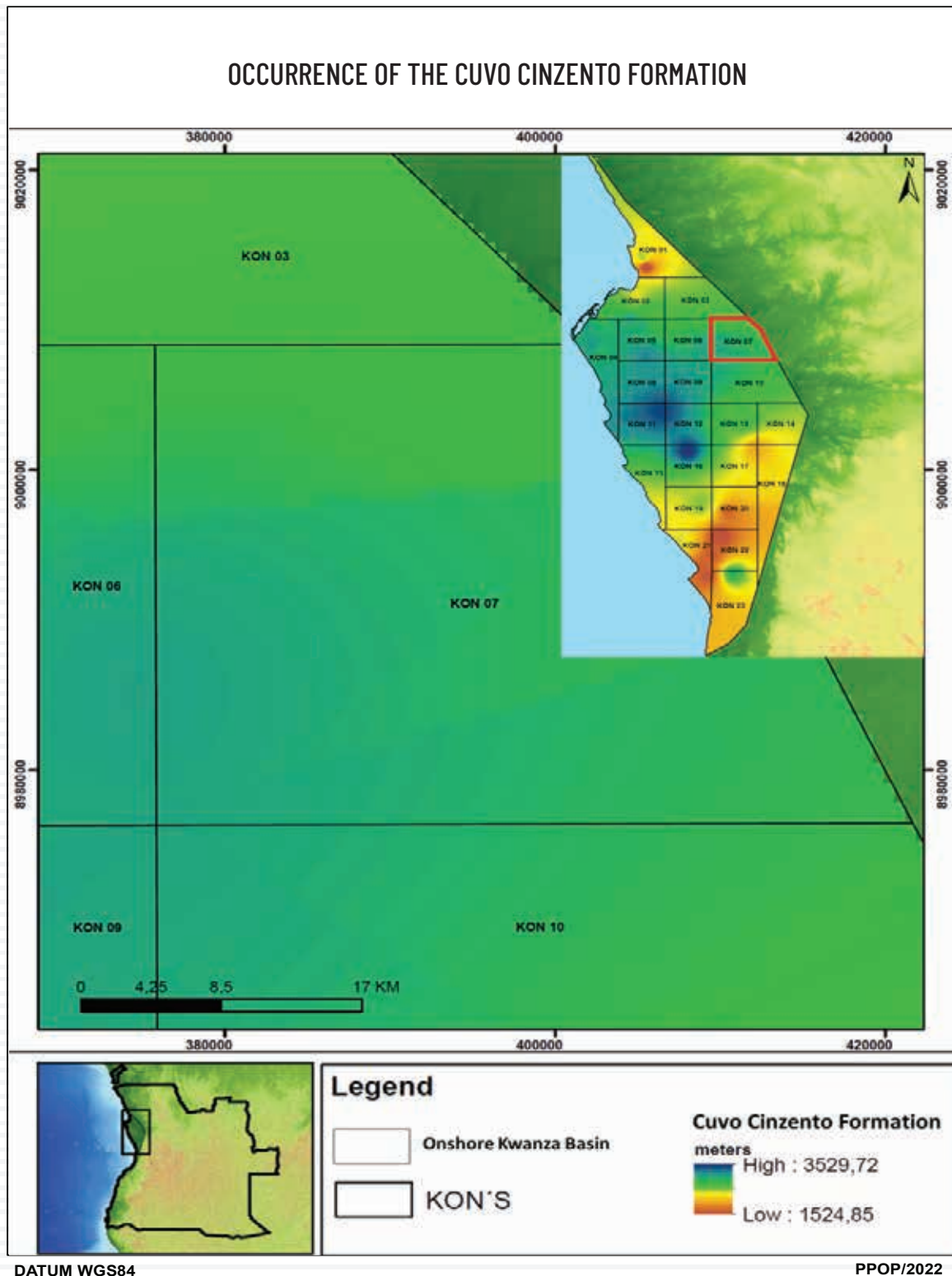


**Figure 10:** Occurrence map of Cuvo Vermelho Fm. source rock



## Cuvo Cinzento Source

The organic-rich shale found in the Calomboloca-1 well at a depth of 3126 - 3128m shows average values of total organic content (TOC) 0.7- 0.75%, HI values 115- 120 mgHC/gCOT, indicating type II/III kerogen, 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 Binga carbonates, proven Albian source rock, are distributed over the block. Geochemical studies conducted in neighboring blocks demonstrate its generation potential.

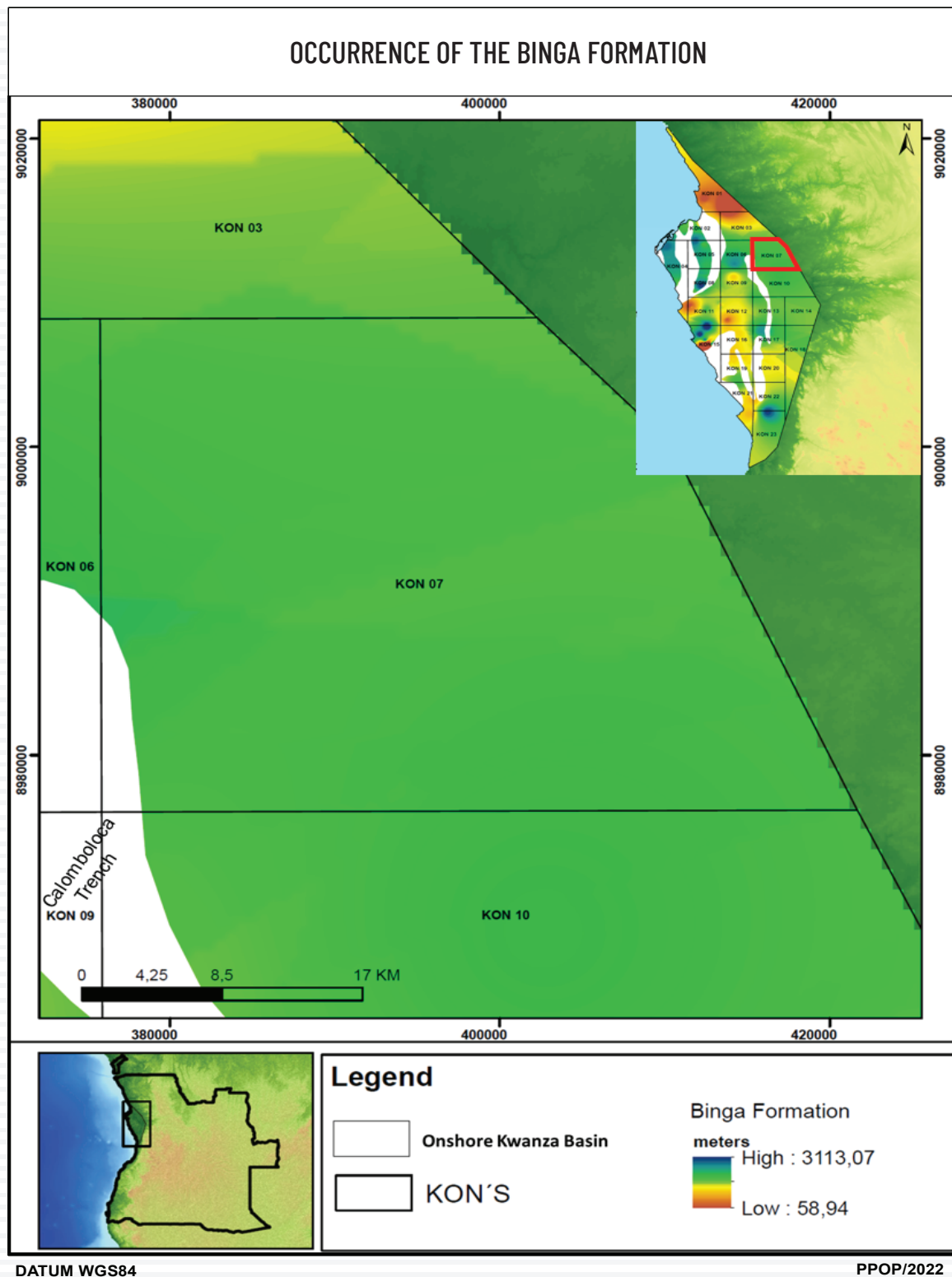
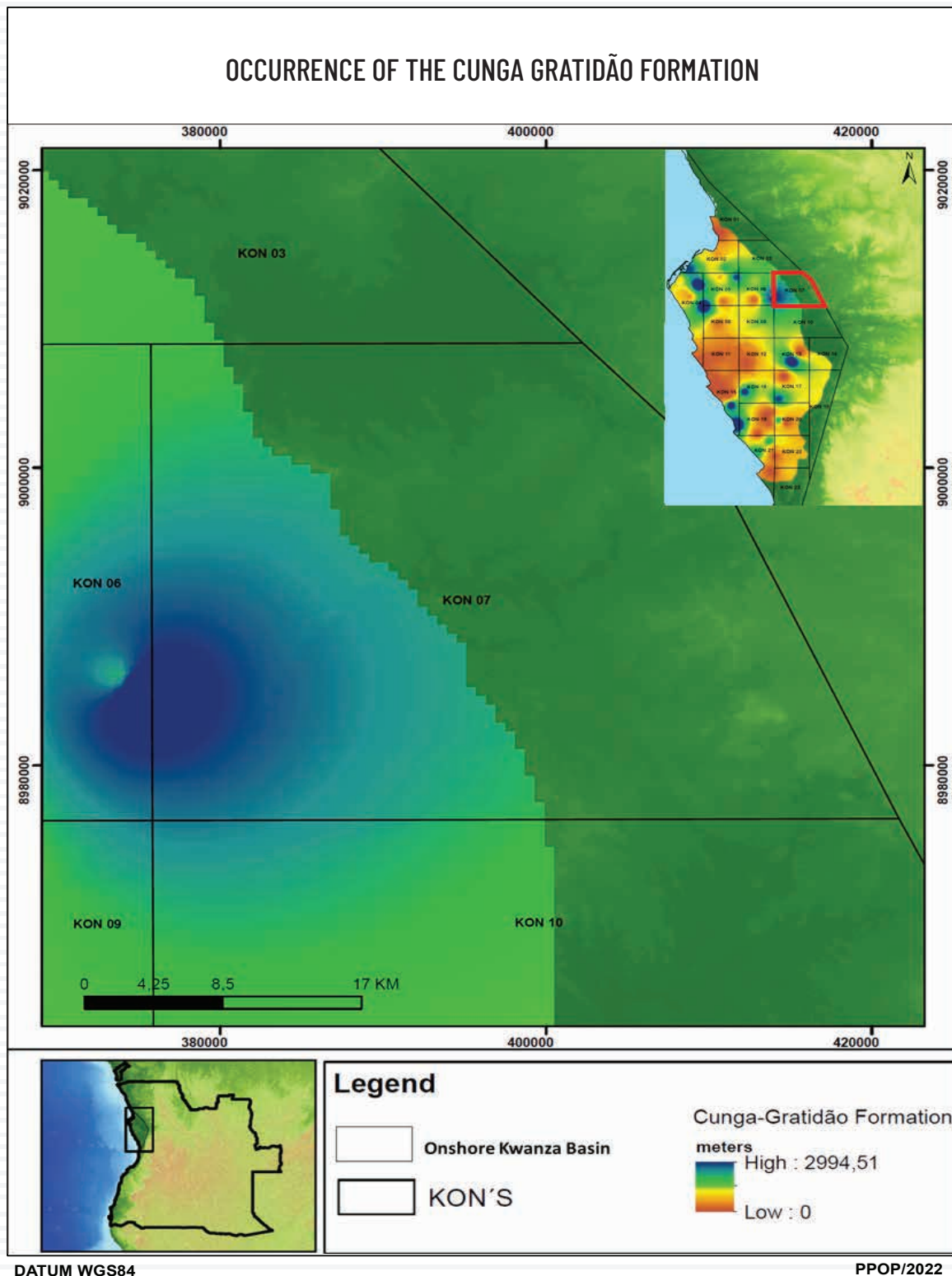


Figure 12: Occurrence map of the Binga Fm. source rock

## Cunga-Gratidão Source

The Cunga Formation marl, at a depth of 3128 m, presents organic content values of 5.38%, indicating excellent petroleum potential; the S1 and S2 parameters, 3.61-4.5 mgHC/gCOT, suggest good petroleum potential, the IH values 494.82 mgHC/gCOT indicate type II kerogen, the maturation parameter Tmax 437 °C shows that the rock is in a mature stage.



**Figure 13:** Occurrence map of Cunga-Gratidão Fm. Source rock



## 1D Model

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

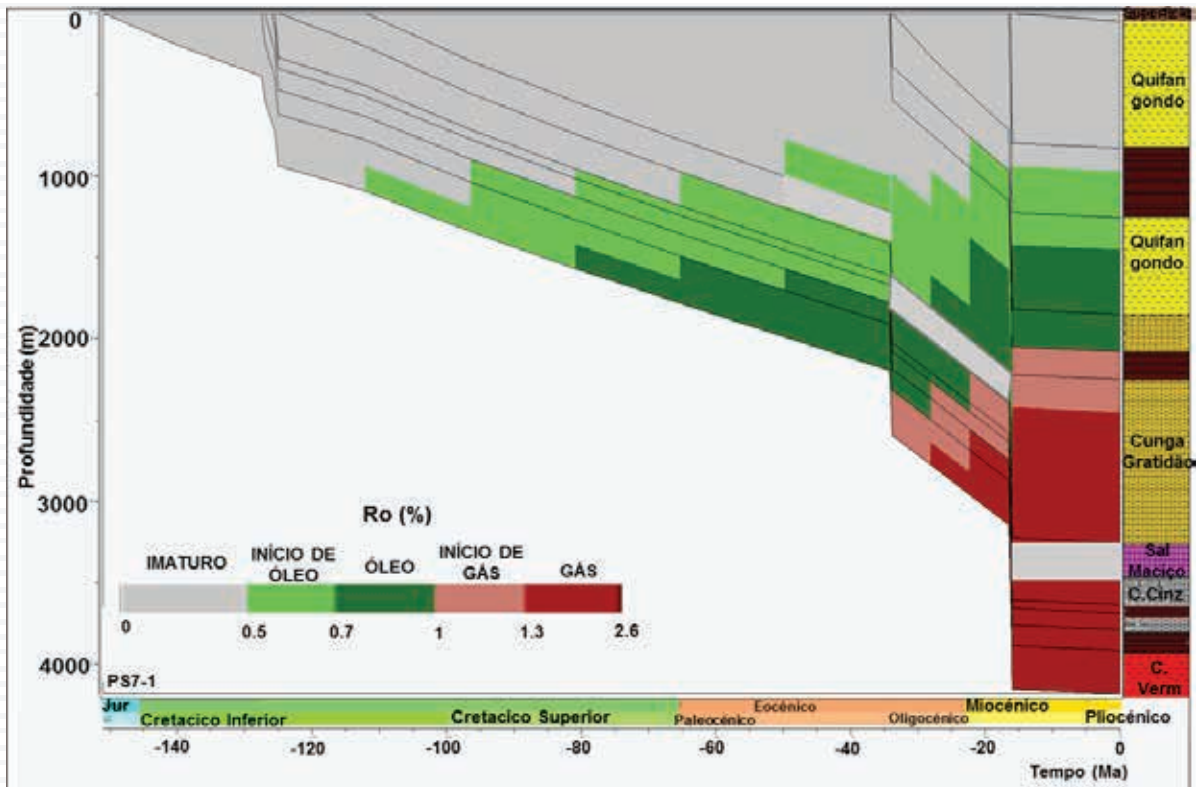


Figure 14: Maturation profile of Calomboloca - 1 well, ANPG 2022

## 6. EXPLORATION Opportunities

### 6.1 Identified Leads

The geological and geophysical data acquired allowed the identification of the pre-and post-salt leads described below.

#### 6.1.1 Pre-salt Plays

The Pre-salt Play is formed by sandstone reservoirs corresponding to the Cuvo Formation, charged by the organic-rich shale of the same formation. The cover rock comprises the Cuvo Formation's intraformational shales, presenting a mixed-type trap.

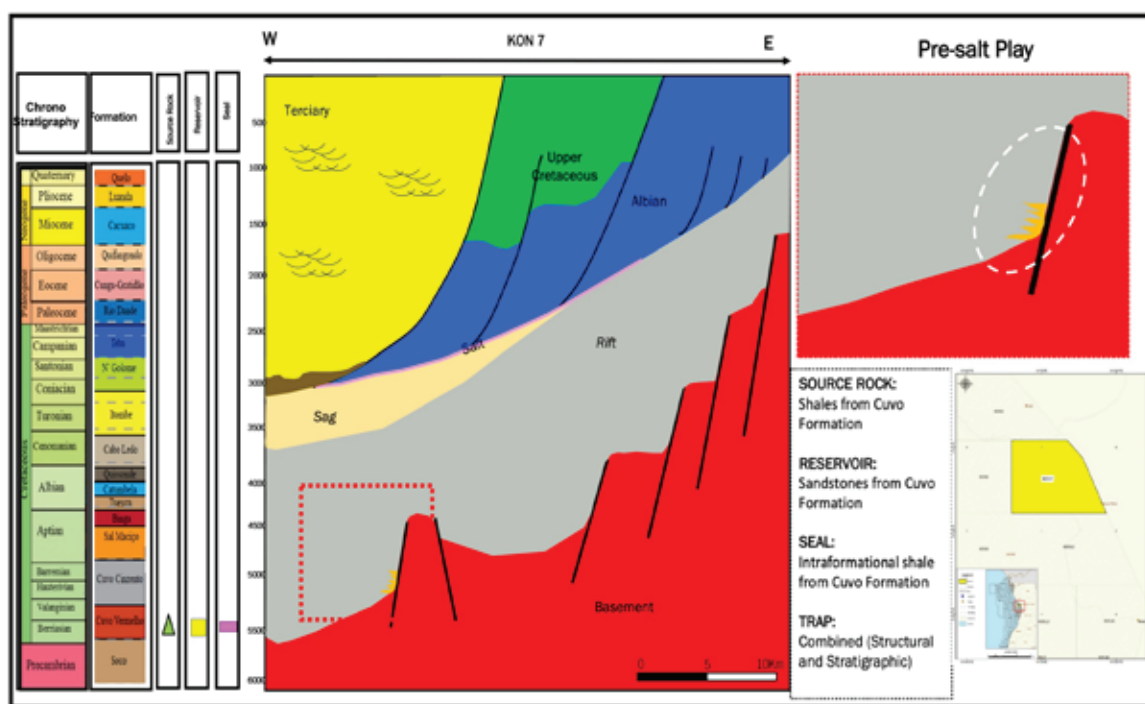


Figura 15: Pre-salt Sandstone Reservoir, ANPG 2022

The Cuvo Formation lacustrine carbonates reservoir deposited at the basement high can be charged by organic-rich shale. Therefore, the intraformational shale of the Cuvo Formation represents the cover rock for this reservoir in a four-way dip closure.

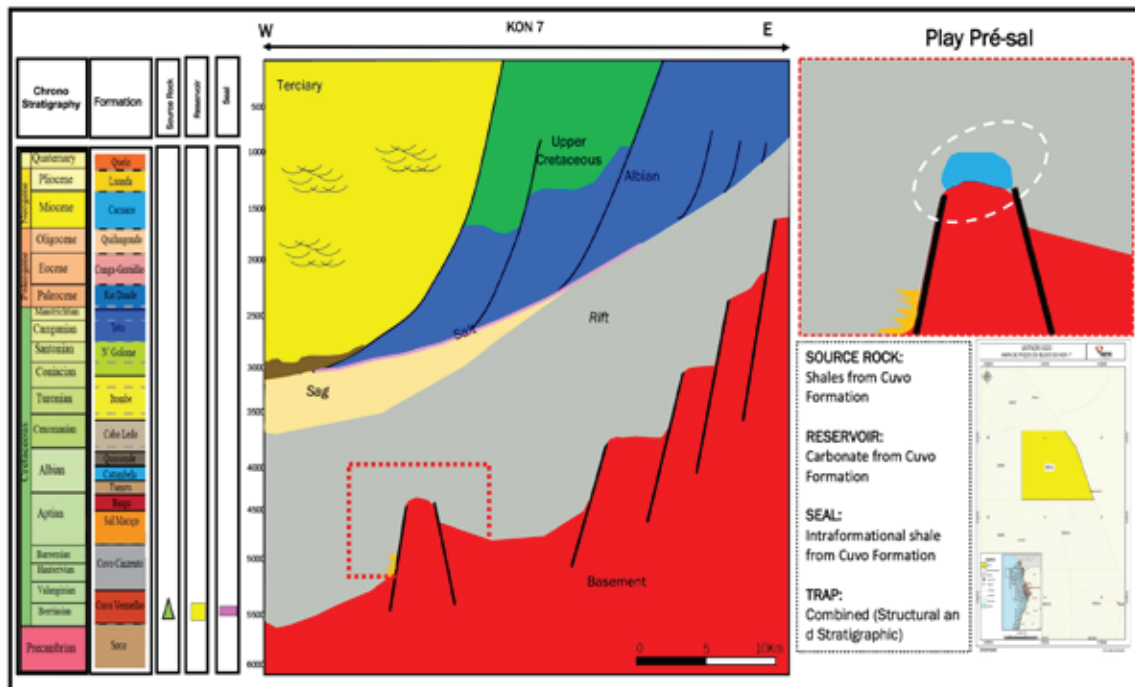


Figure 16: Pre-salt, Carbonate Reservoir, ANPG 2022

Organic-rich shale of the Barremian age, corresponding to the Cuvo Formation, with the sandstones and carbonates reservoir deposited along the Sag in the upper Barremian. In a mixed-type trap, the Massive Salt of the Aptian age represents good cover rock for these reservoirs.

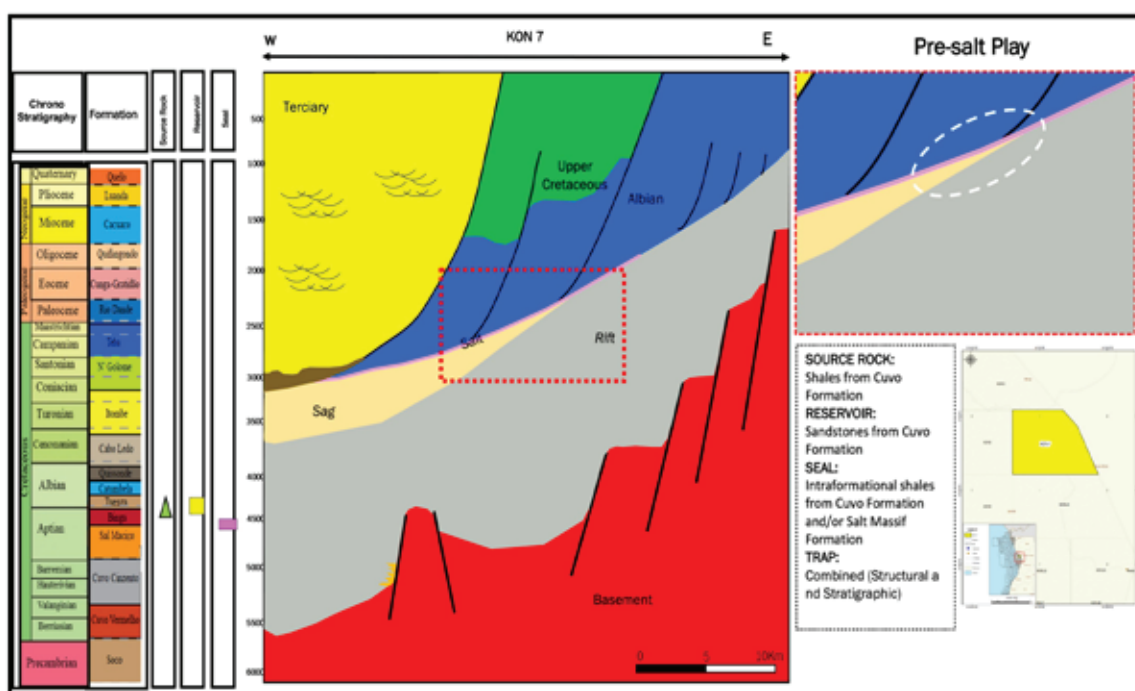


Figure 17: Pre-salt Reservoir Sandy and Carbonate Reservoir, ANPG 2022

## 6.2 Post-salt Play

The Post-Salt Play consists of Oolitic Limestone reservoirs corresponding to the Binga Formation, having as source rock the clays of the Binga Formation rich in organic matter. On the other hand, the seal rock is constituted by the intraformational clays of the Cabo Ledo Formation, and it presents a mixed-type trap.

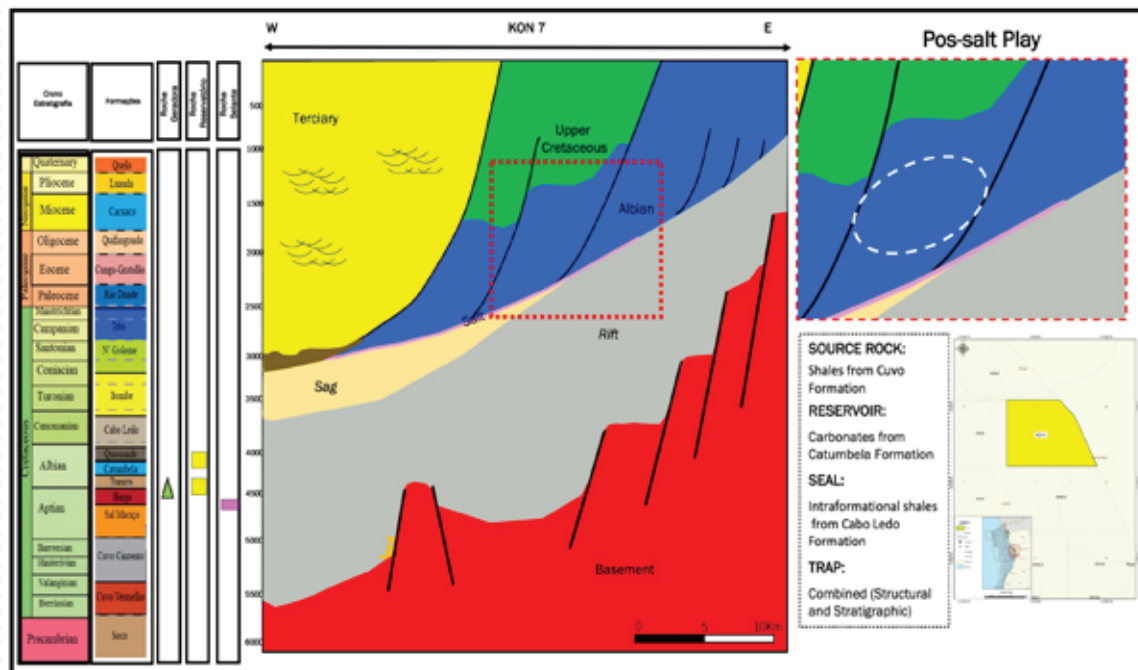


Figure 18: Post-salt, Albian oolitic carbonates, ANPG 2022

At the Tertiary level, the sandstone channel reservoirs of the Quifangondo Formation are fed by the black marls of the Cunga-Gratidão Formation, deposited at the base of the Calomboloca Trough. The overlying intraformational clays represent the cover rock for these reservoirs in a mixed-type trap.

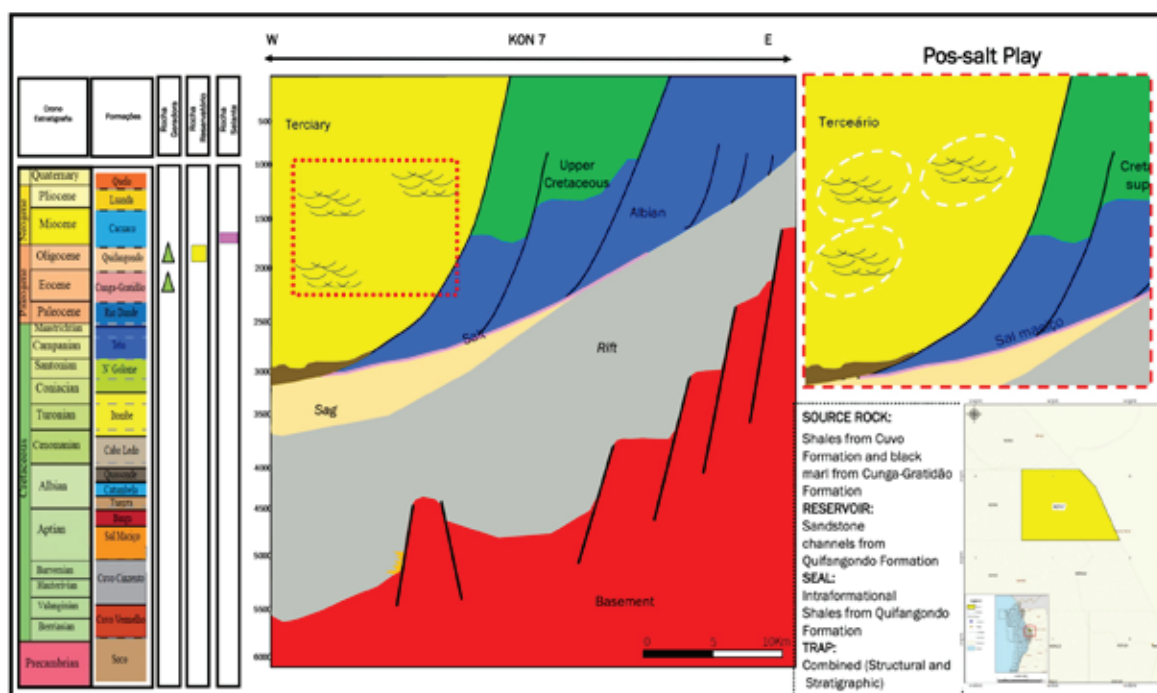


Figure 19: Post-Salt, Arenitic facies of the Quifangondo Formation, ANPG 2022

## 7. FINAL Remarks

After reassessing Block KON 7, 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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# ONSHORE KWANZA BASIN



BLOCK  
**KON7**



# ANGOLA



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