



ONSHORE
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2023
LICENSING ROUND
REPUBLIC OF ANGOLA

ONSHORE
KWANZA BASIN

ONSHORE KWANZA BASIN

Portfolio
OPPORTUNITIES

Block
KON1

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1. Introduction

The portfolio opportunities describe the general characteristics of Block KON 1, 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 1 is in the northern part of the Onshore Kwanza Basin. Between 1915 and 1932, sixteen (16) exploration wells were drilled in the Caxito region by the Sinclair, Petrangol, and Purifina companies. From 2008 to 2009, the Alrosa Company conducted a 2D seismic survey, acquisition, and processing.

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 main 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 935 to 1617 MMBO.

2. GEOGRAPHIC Location

Block KON 1 is in the northern part of the Kwanza Basin. It is bordered by Precambrian basement (crystalline outcrop) to the north, KON 2 and KON 3 to the south, Atlantic Ocean to the West, and Precambrian basement to the East, defined by the geographic coordinates 7°40'00" and 8°50'00" S and meridians 13°00'00" and 14°00'00" "E, having a total area of approximately 1,575.75 Km² (Figure 1).

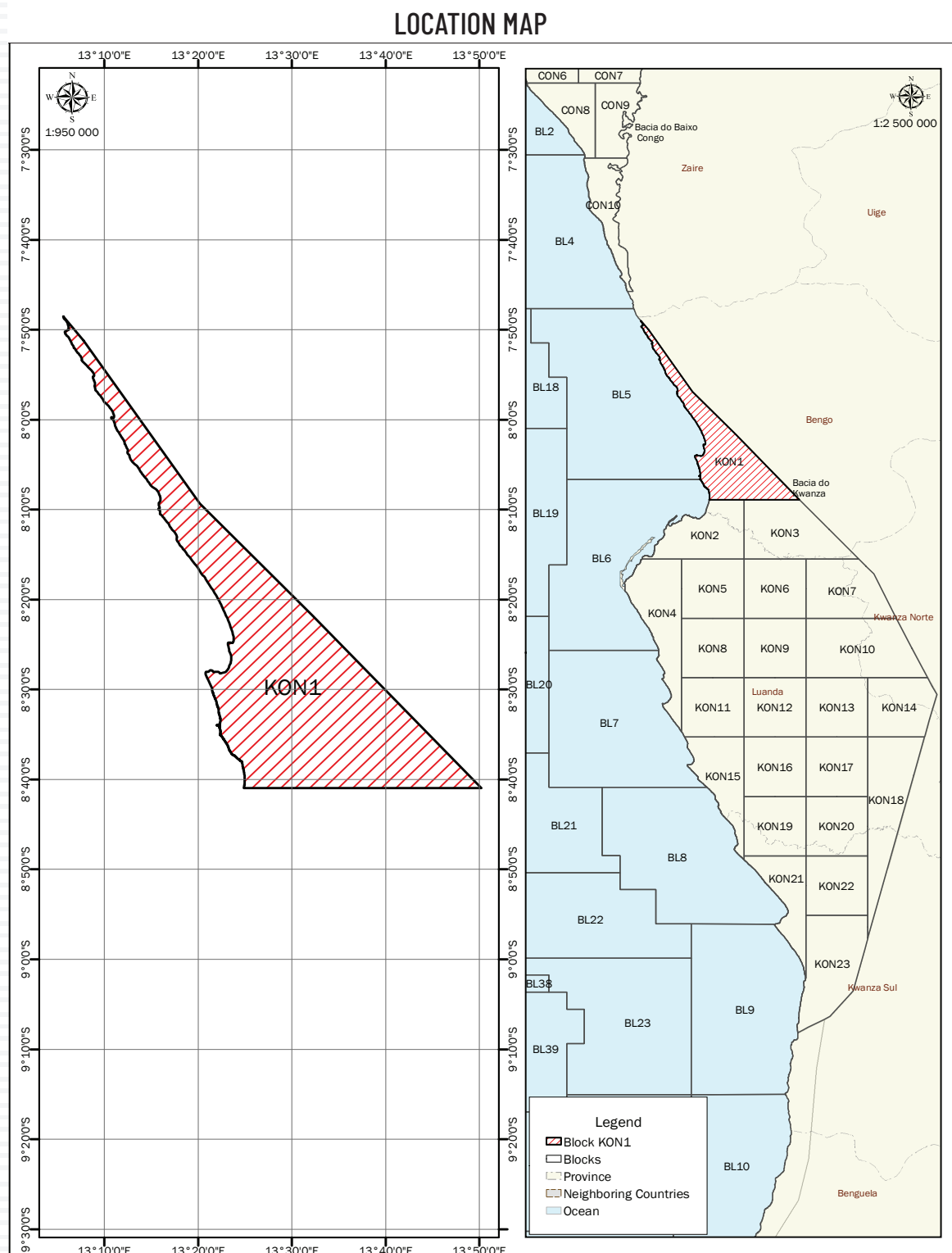


Figure 1: Location map of Block KON 1, ANPG 2022

3. GEOLOGICAL Setting

The outcrops of **Block KON 1** are represented by sediments of Precambrian to Recent age, according to the geological chart of the Onshore Kwanza Basin (Figure 2).

Block KON1 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.

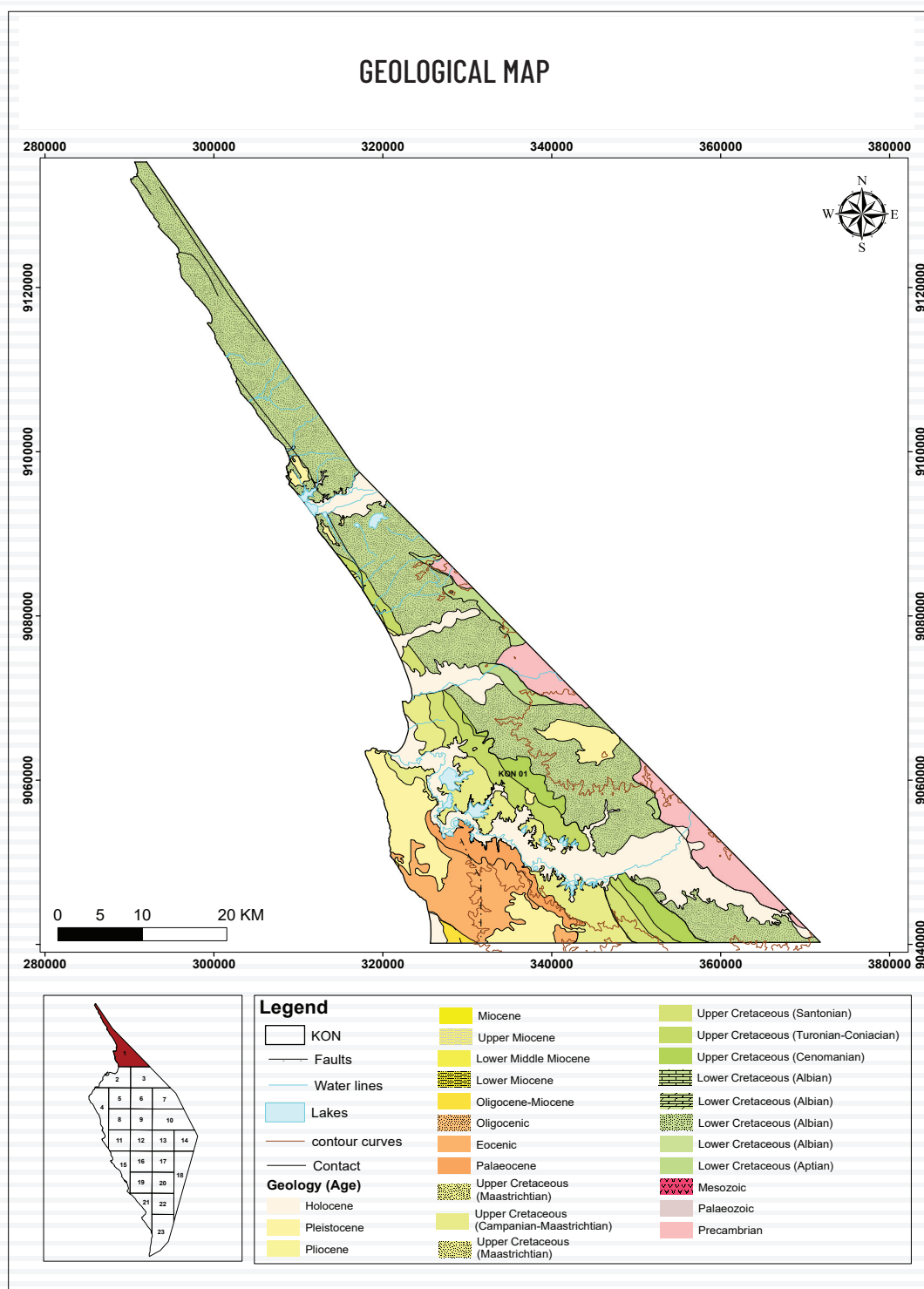


Figure 2: Geological map of Block KON 1, ANPG 2022

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 facilities at the Pre-salt level are represented to the south by the Calomboloca graben, which means 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 shales are potential source rocks, the pinch-out sands of the Cuvo Vermelho, carbonates at the top of the horst, and 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 more excellent evidence in the western part of Block KON 1 (Figure 2), forming the primary seal for this unit (pre-salt).



Figura 3: Crystalline basement (igneous and metamorphic rocks) – Caxito area

Post-salt Unit

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 clays 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 age 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, visible in the outcropping of the same and little structuring.

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

The Precambrian basement dominates the eastern part of the block. 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 cover rock for the mixed-type traps.



Bituminous evidence from Cunga-Gratidão Fm.

Figura 4: Bituminous evidence from Cunga-Gratidão Fm. – Caxito area

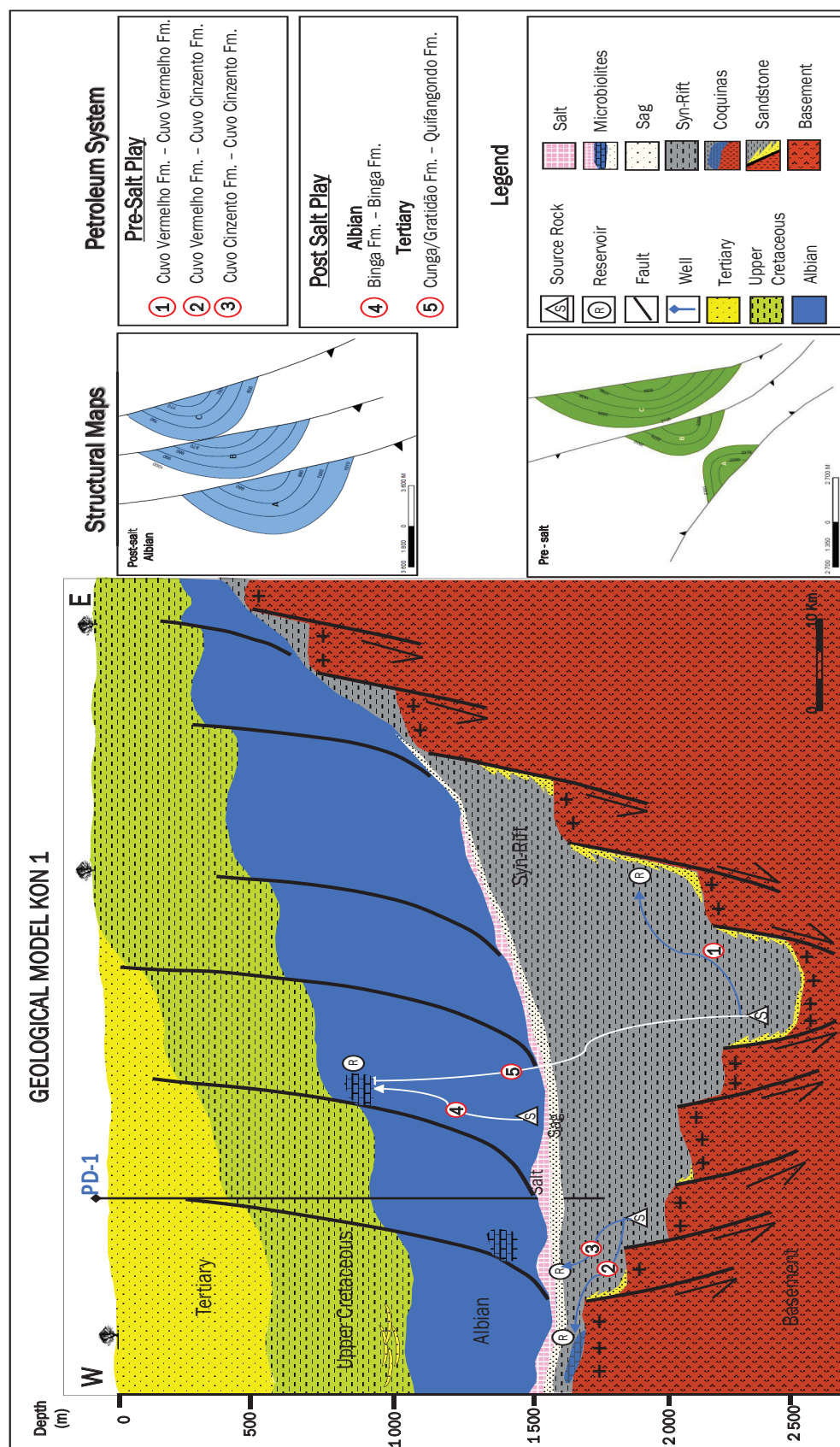


Figure 5: Geological model of the Block KON 1, ANPG 2022

4. EXPLORATION History

The first exploration works on the Block date to 1767, carried out by the Canha e Formigal company. Historical data reports the exportation to Portugal of 49 barrels of oil collected from surface outcrops in the region of Barra-do-Dande.

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, Cacucaco, 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 drilling was motivated by oil seeps in the dolomitic and oolitic limestones of the Binga Formation (Rapports Geologiques CT-1 PD-1e CX-1, 1973-4).

Alrosa company conducted seismic surveys in the Block during 2008-2009, acquiring and processing approximately 244 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).

In the period between 1915 and 1932, about sixteen (16) exploration wells were drilled in the Caxito region by Sinclair, Petrangol, Purifina, and Total companies, namely: Dande-1 was the first well drilled by operator Sinclair Oil Consolidated in 1915 without commercial success, Dande-2, Dande-3, Dande-4, Dande-5, Dande-7 and Dande-8, Catanga-1, Caxito-1, Pedreira-1, Elele-1, Bueco-1 and Bueco-2, São Tiago-1, and Tiago-2, Husso-1, and Husso-2.

Seismic acquisition studies were carried out by Petrangol in the period between 1970 and 1973, with the acquisition and processing of approximately 500 line km of seismic, culminating in the identification of the Funda Trough.



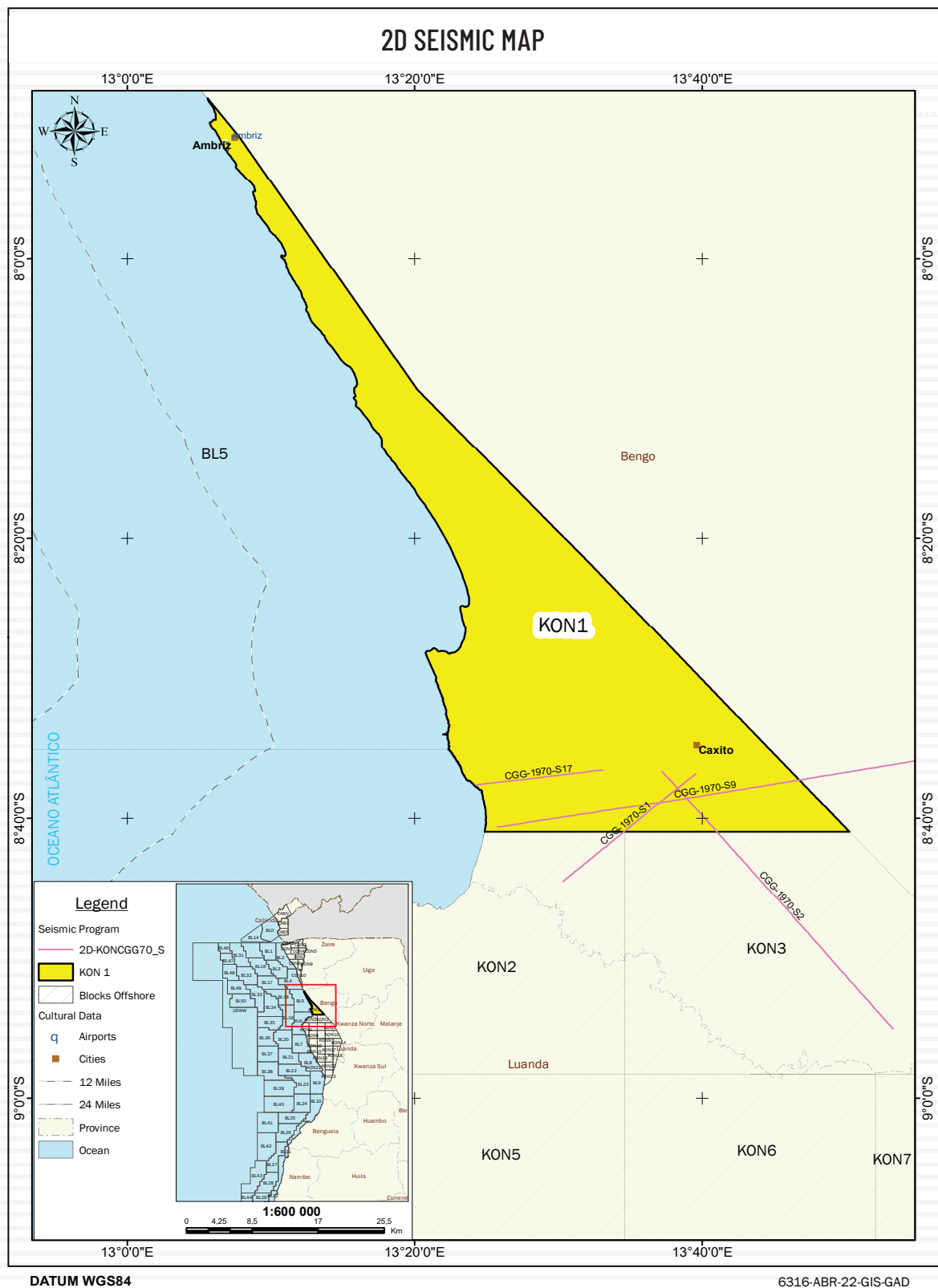


Figure 7: 2D Seismic Data Acquired on Block KON 1, ANPG 2022

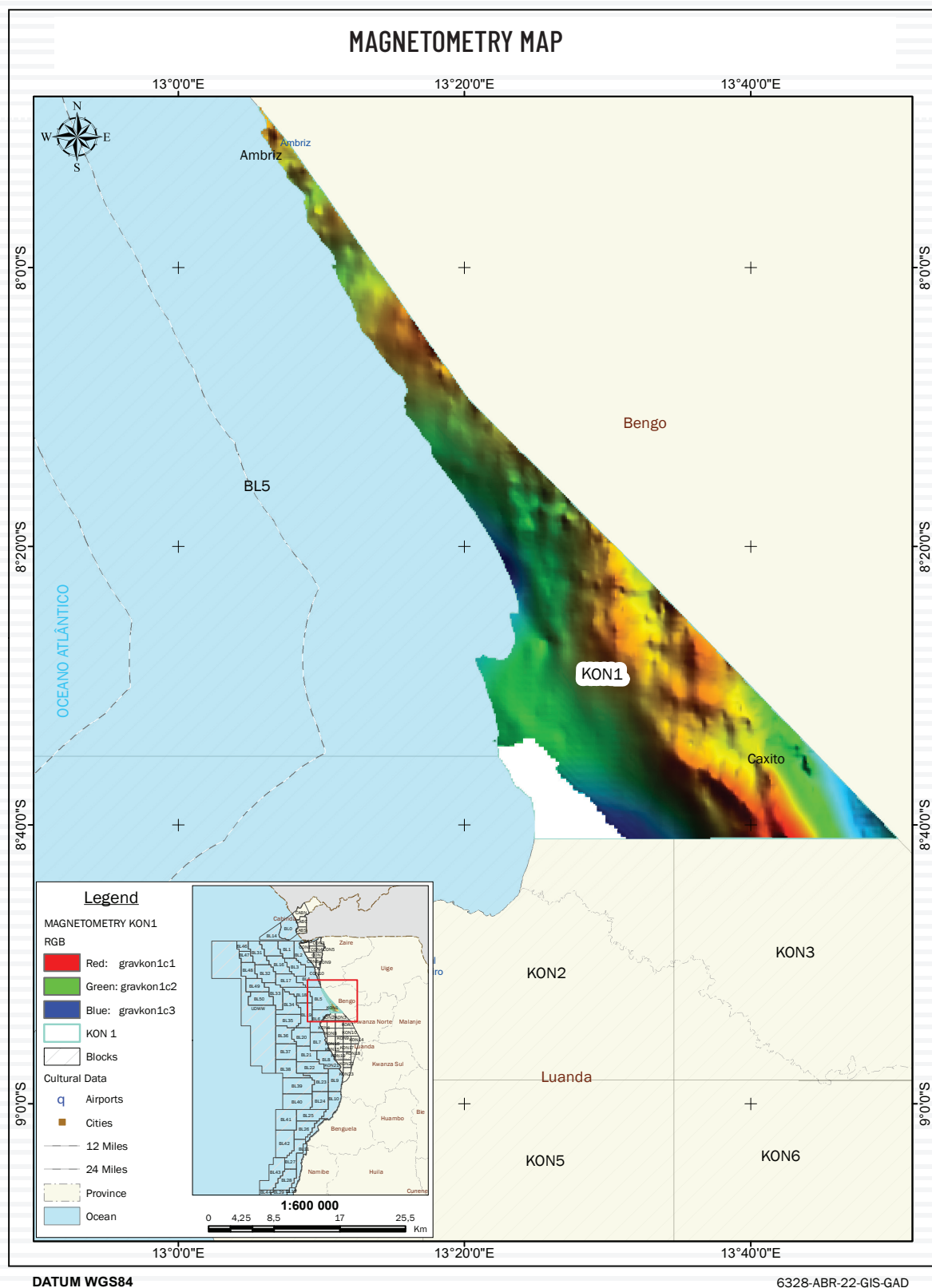


Figure 8: Magnetometry map of the KONA 1, ANPG 2022

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).

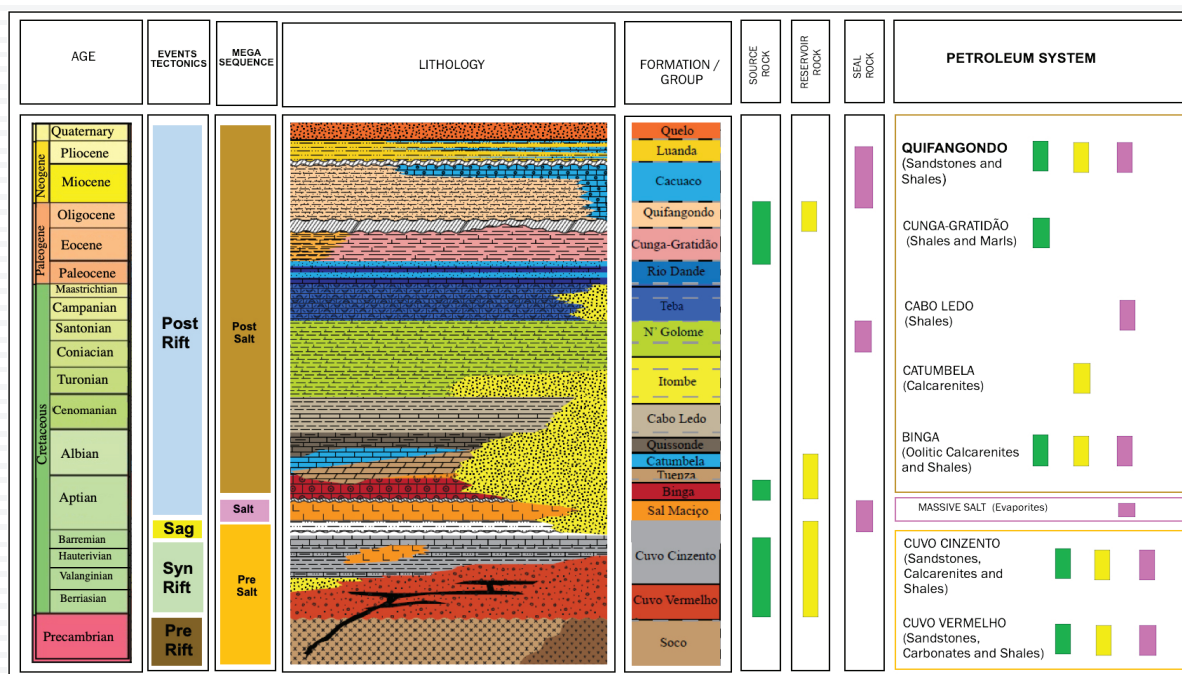


Figure 9: Lithostratigraphic Column of the Onshore Kwanza Basin, ANPG 2022

5.1 Generation and Migration

The source rock consists of shales of the Cuvo Formation and carbonates of the Binga Formation. Migration pathways occur from faulting, salt window, and facies contact.

5.2 Reservoir Rock

Block KON 1, 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 oolitic and dolomitic limestones of the Binga Formation, with partial asphalt impregnations, in some areas, the sands of the Mucanzo Formation are suitable reservoirs in the Albian, the wells drilled also confirm the Catumbela Formation as a proven reservoir in the block.

The Itombe and Teba Formation of the upper Cretaceous sands has evidence of gas and oil found in the Catanga-1, São Tiago-1, and Pedreira-1 wells.

5.3 Oil Indications

The outcrop located in the Ceramics zone (deactivated Libongos quarry), 1 km from national road number 100 (EN100), is lithologically characterized by oolitic limestones intercalated with silt, impregnated with oil of Lower Albian age, along the outcrop we observed points of micro-oil exudation. The samples in Block KON 1 demonstrate an active petroleum system.



Figure 10: Exudation (A-dry bitumen, B-viscous bitumen), ANPG 2022



Figure 11: Libongo Exudation Point, ANPG 2022

5.4 Seal Rock

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 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

5.6 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 of the Binga 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 performed in the pre-salt and post-salt units. 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.

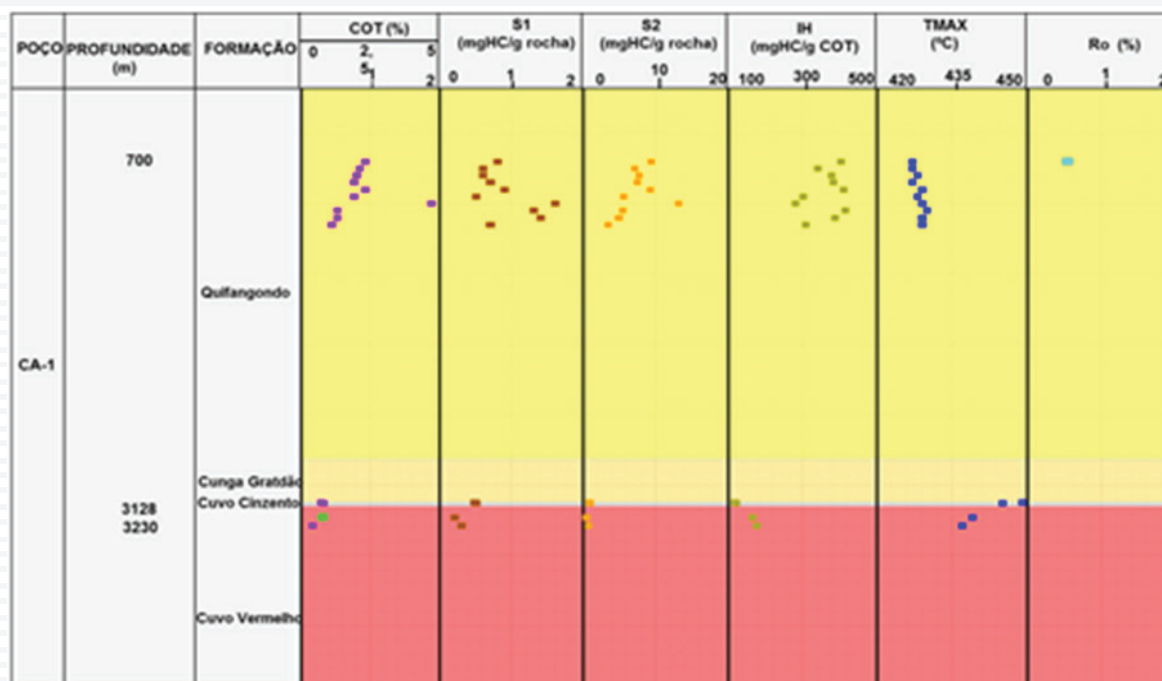


Figure 12: Geochemical Log of the Calomboloca well-1, ANPG 2022

Cuvo Vermelho Source

The shales of the Cuvo Vermelho Formation identified in the Calomboloca graben in well CA-1 at a depth of 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.

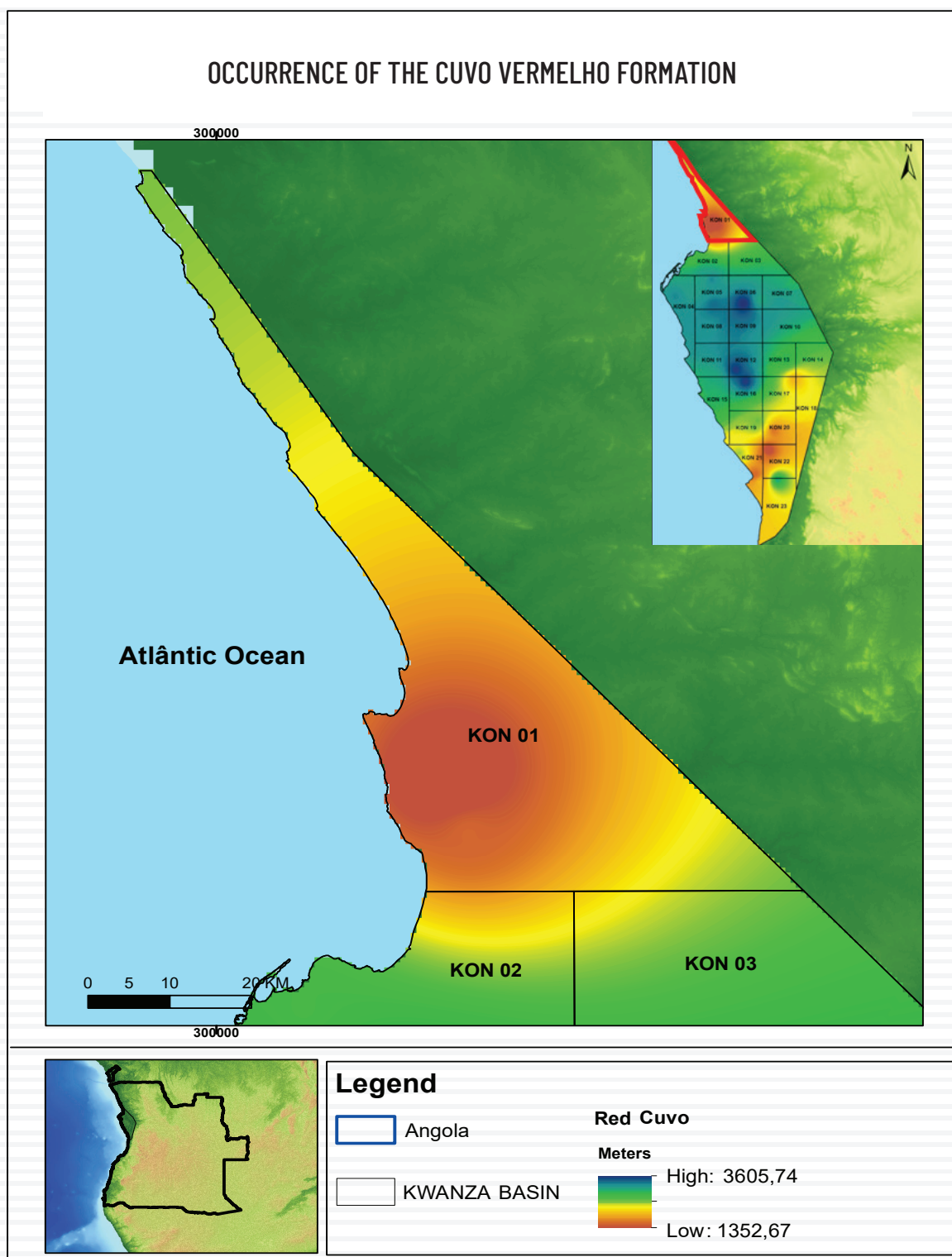


Figure 13: Occurrence map of Cuvo Vermelho Fm. Source rock

Cuvo Cinzento Source

The shales of Cuvo Cinzento 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 indicate 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.

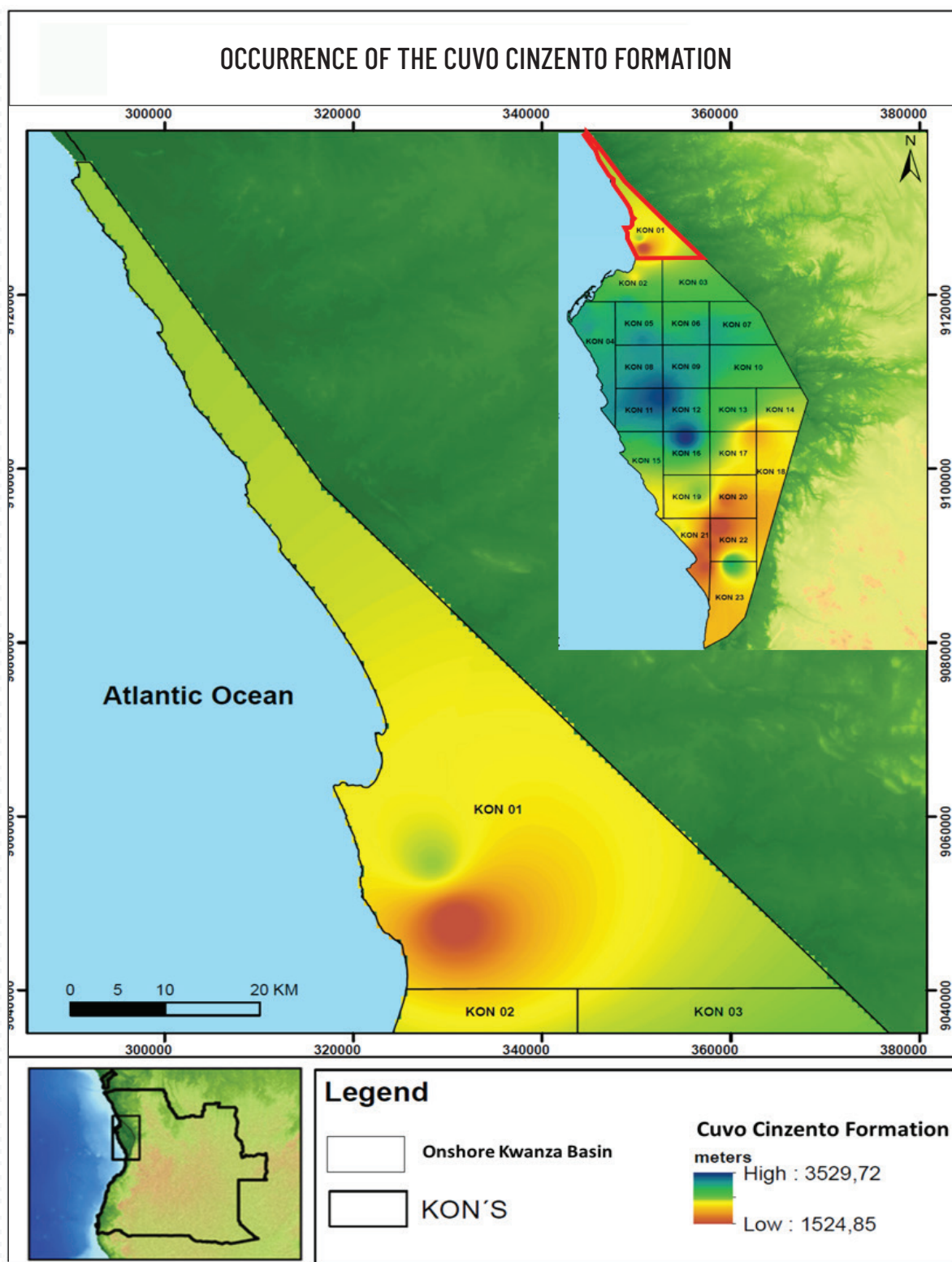


Figure 14: Occurrence map of Cuvo Cinzento Fm. Source rock

Binga Source

The carbonates of the Binga Formation, a proven Albian-level source rock with good geochemical characteristics, are confirmed by exudation, indicating hydrocarbon generation in the block.

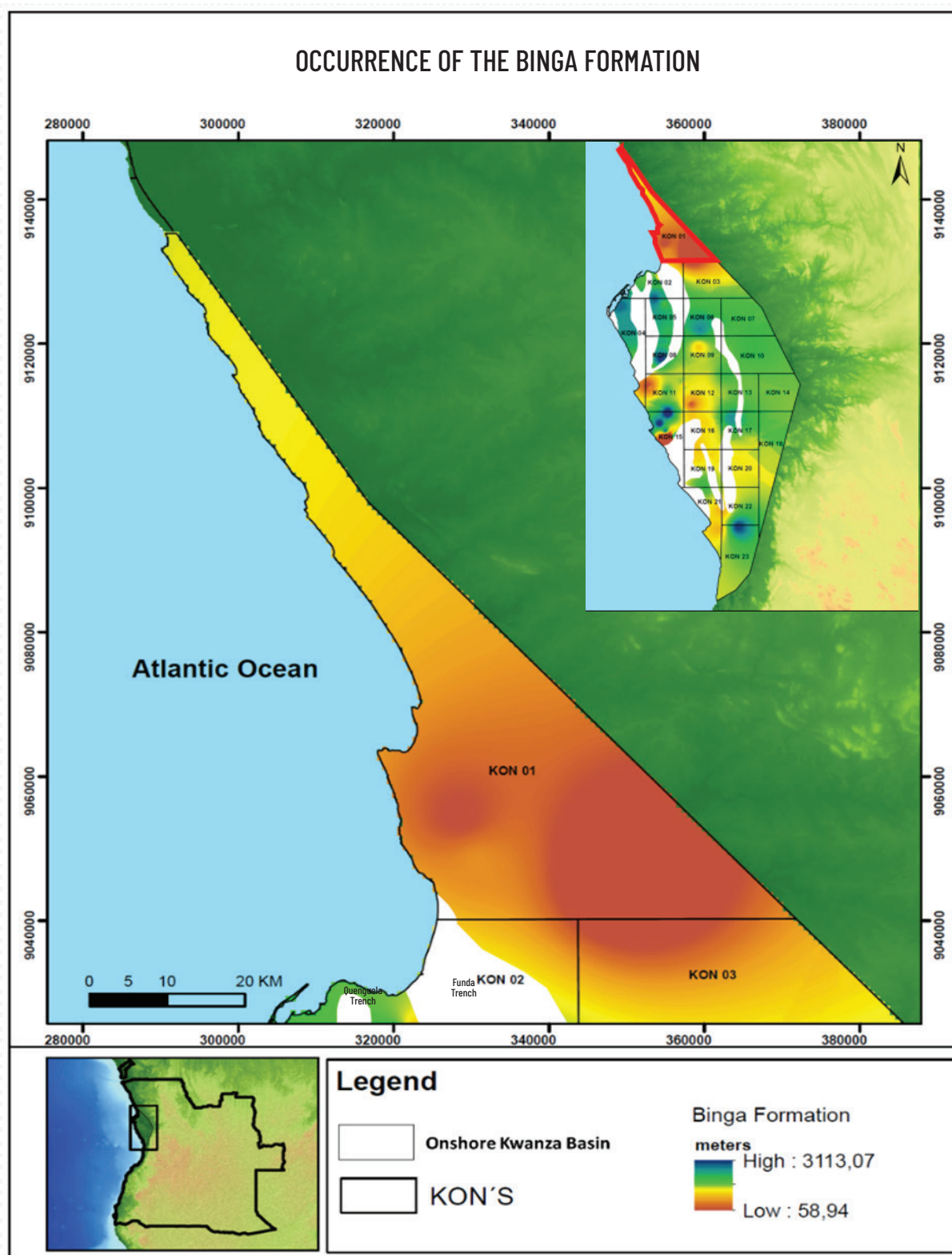


Figure 15: Occurrence map of Binga Fm. Source rock

Cunga-Gratidão Source

The marl from the Cunha-Gratidão Formation, 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 indicative maturation parameter Tmax 437 °C shows that the rock is in a mature stage.

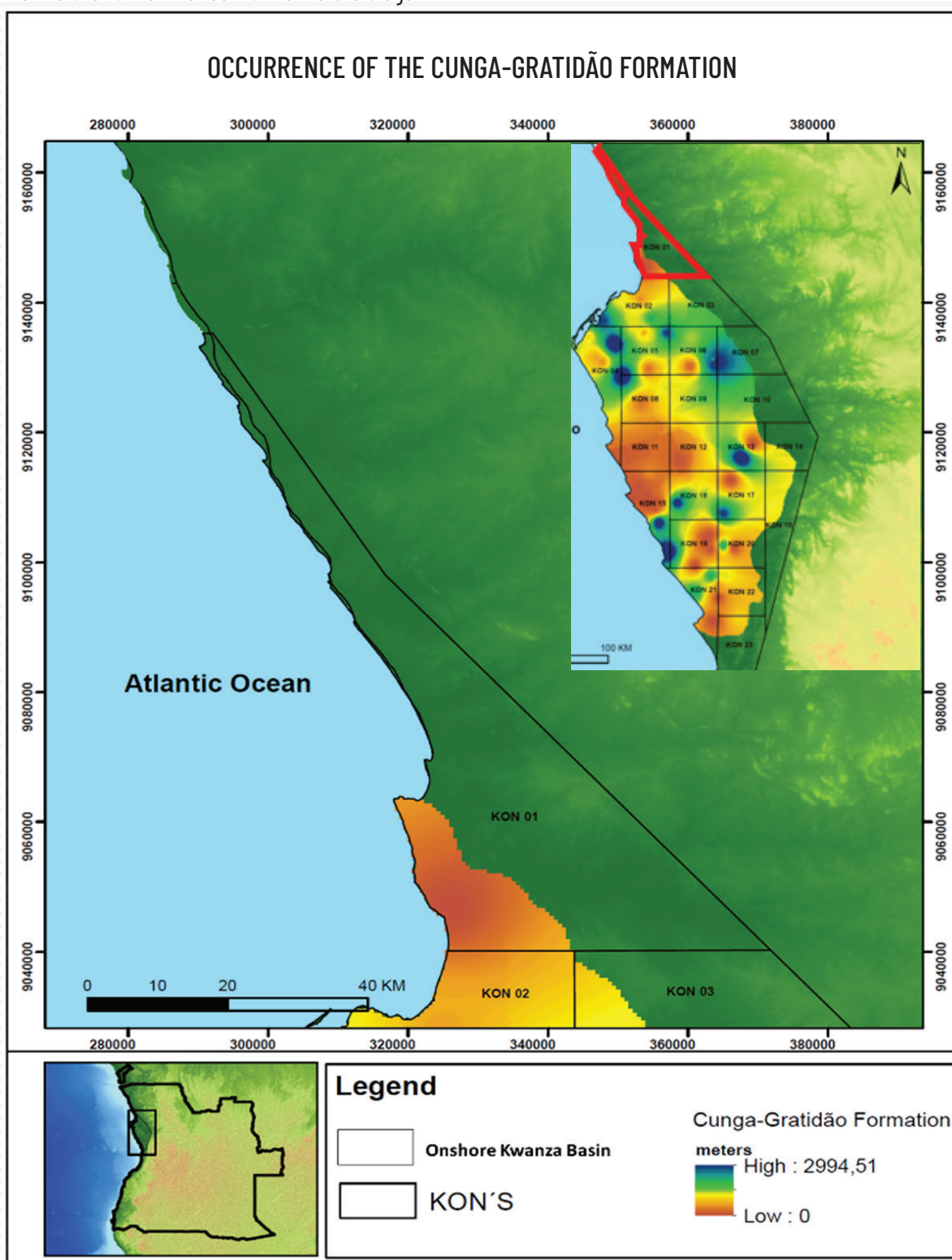


Figure 16: Occurrence Map of Cunha-Gratidão Fm. Source rock

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.

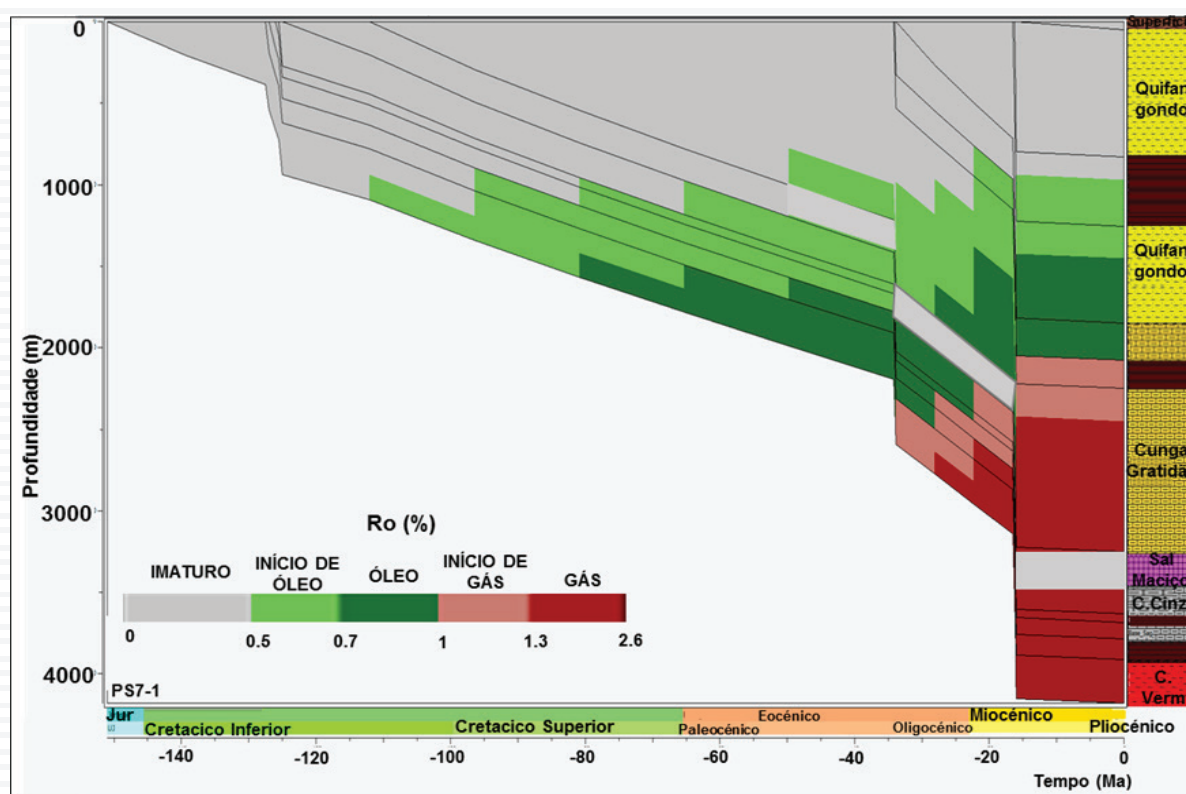


Figure 17: Maturation profile of Calomboloca - 1 well

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 Lead 1

Located twest of the block and is evidenced by the strong amplitudes of the Cuvo Formation carbonates at the top of the horsts (equivalent to the Toca Formation in the Lower Congo), representing the probable reservoir at the Pre-salt level. The organic-rich shale of the same Formation as the source rock and the cap rock is the intraformational shales of the Cuvo Formation; the traps are of mixed type.

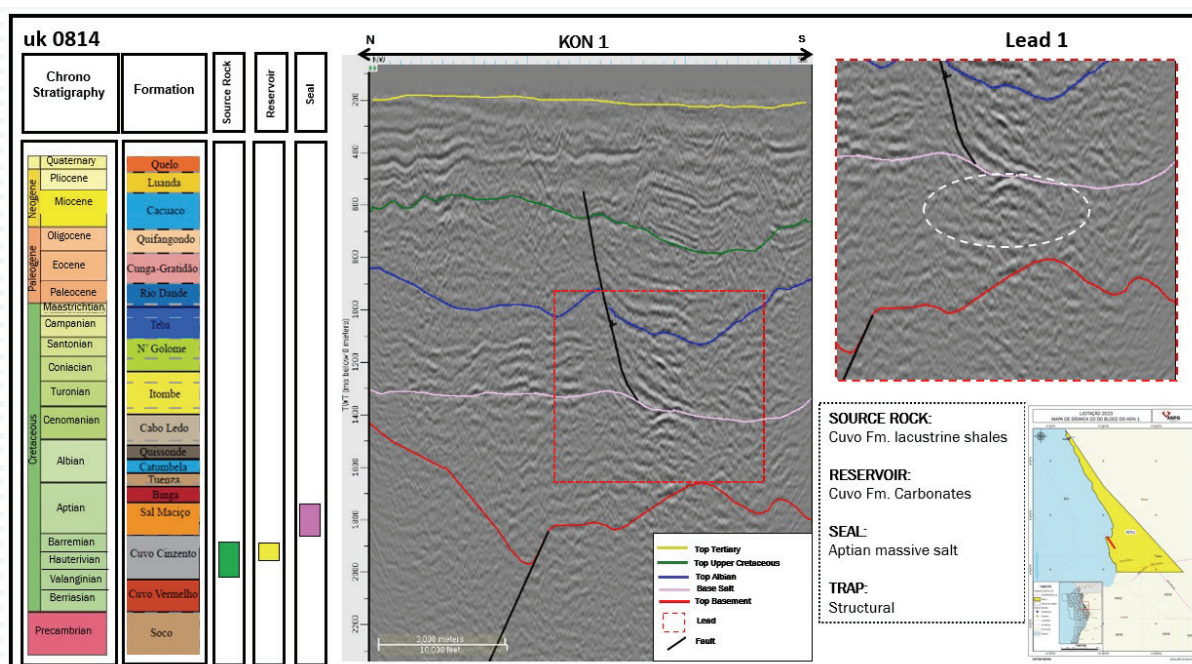


Figure 18: Lead 1, ANPG 2022

6.1.2 Post-salt Lead 2 & 3

Located north of KON 2 and KON 3 is an acreage where both Albian carbonates and pre-salt carbonates can be targeted. A series of rollover-shaped structures, supported by a set of normal syn-depositional faults, lithologically consisting of transitional marine oolitic and dolomitic limestone of Binga Formation as shown in figures 19 and 20.

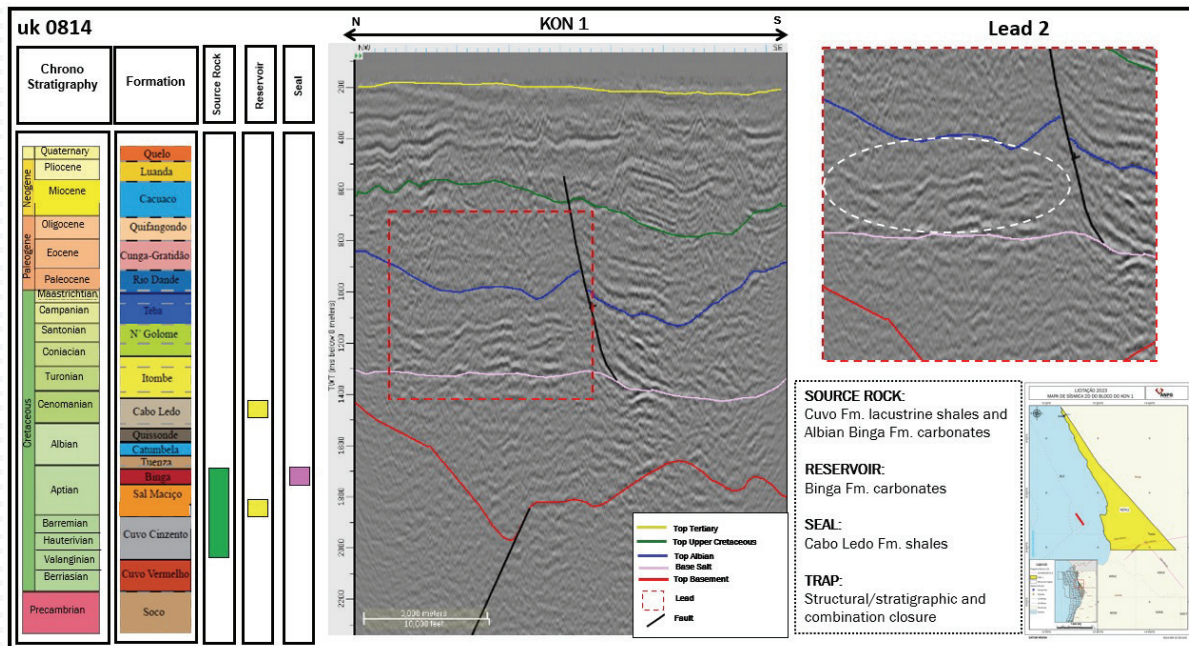


Figure 19: Albian Lead 2, ANPG 2022

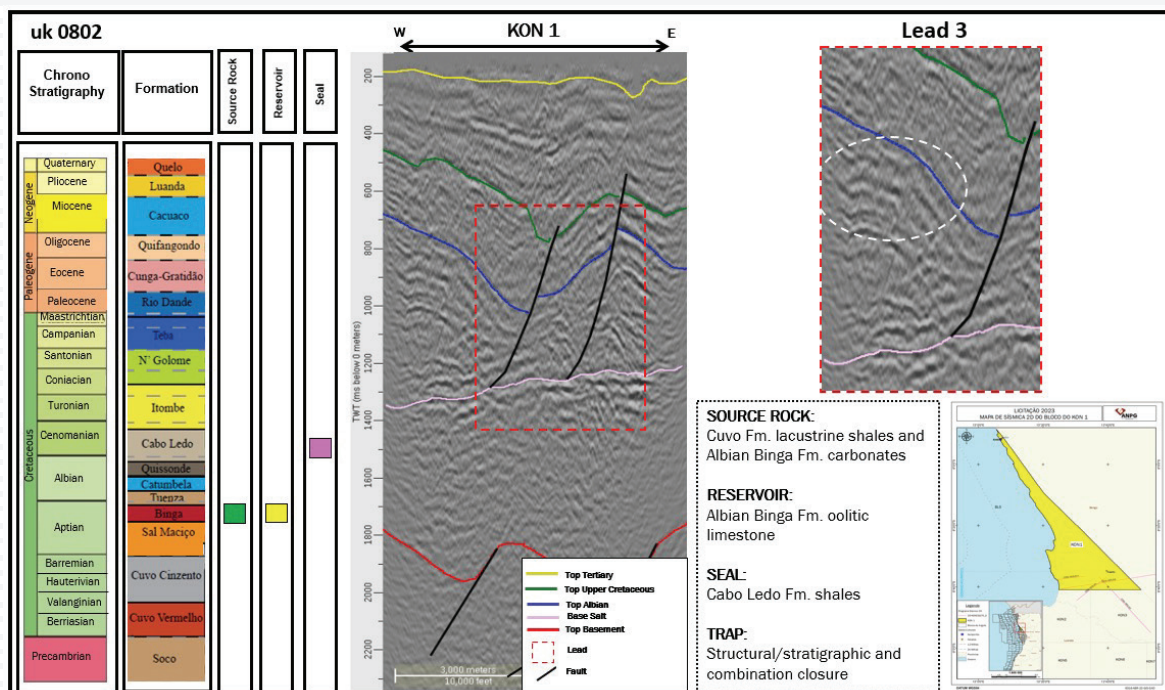


Figure 20: Albian Lead 3, ANPG 2022

7. FINAL Remarks

After reassessing Block KON 1, it became evident that the Inner 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 main 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 main 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 KON 1





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