



ONSHORE
LOWER
CONGO BASIN



2023 LICENSING ROUND REPUBLIC OF ANGOLA

ONSHORE
KWANZA BASIN

ONSHORE KWANZA BASIN

Portfolio
OPPORTUNITIES

Block
KON14

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1. Introduction

The portfolio opportunities describe the general characteristics of Block KON 14, 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 14 is in the east of the Inner Kwanza Basin. With no record of drilled wells, the re-evaluation of the block primarily relied upon correlations wells such as Galinda-1, Galinda-4, Tobias-6, Chio-1, and Quembeje-1, from Blocks KONs 11, 12, 13, and 17, respectively. In 2009-2012, 2D seismic surveys were carried out by the Geokinectics Company.

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 were identified with possible accumulation of hydrocarbons in the Pre-salt and Post-salt. The leads identified from the geological and geophysical data integration present prospective resources estimated from 605 to 1965 MMBO.

2. GEOGRAPHIC Location

Block KON 14 is in the Inner Kwanza Basin. It is bordered by KON 10 to the north, KON 13 to the west, KON 18 to the south, Precambrian basement to the east and defined by the geographic Coordinates parallels $9^{\circ} 32' 58''$ S and $9^{\circ} 50' 19''$ S and meridians $14^{\circ} 09' 28''$ E and $14^{\circ} 28' 44''$ E having a total area of approximately 1021.93 Km². (Figure 1).

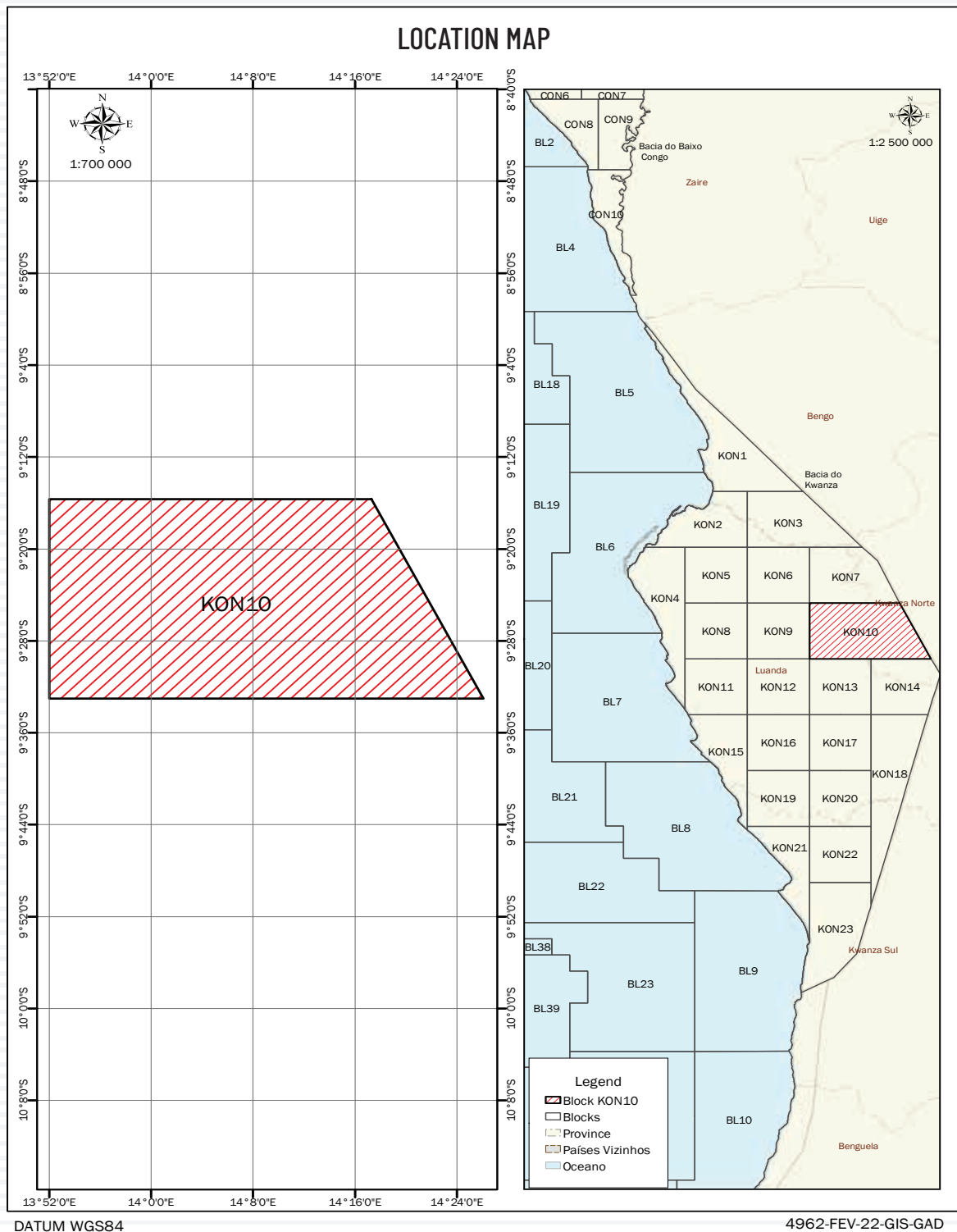


Figure 1: Location map of Block KON14, ANPG 2022

3. GEOLOGICAL Setting

The outcrops of **Block KON 14** are represented by sediments of Precambrian to Eocene age, according to the geological chart of the Onshore Kwanza Basin (Figure 2). The 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.

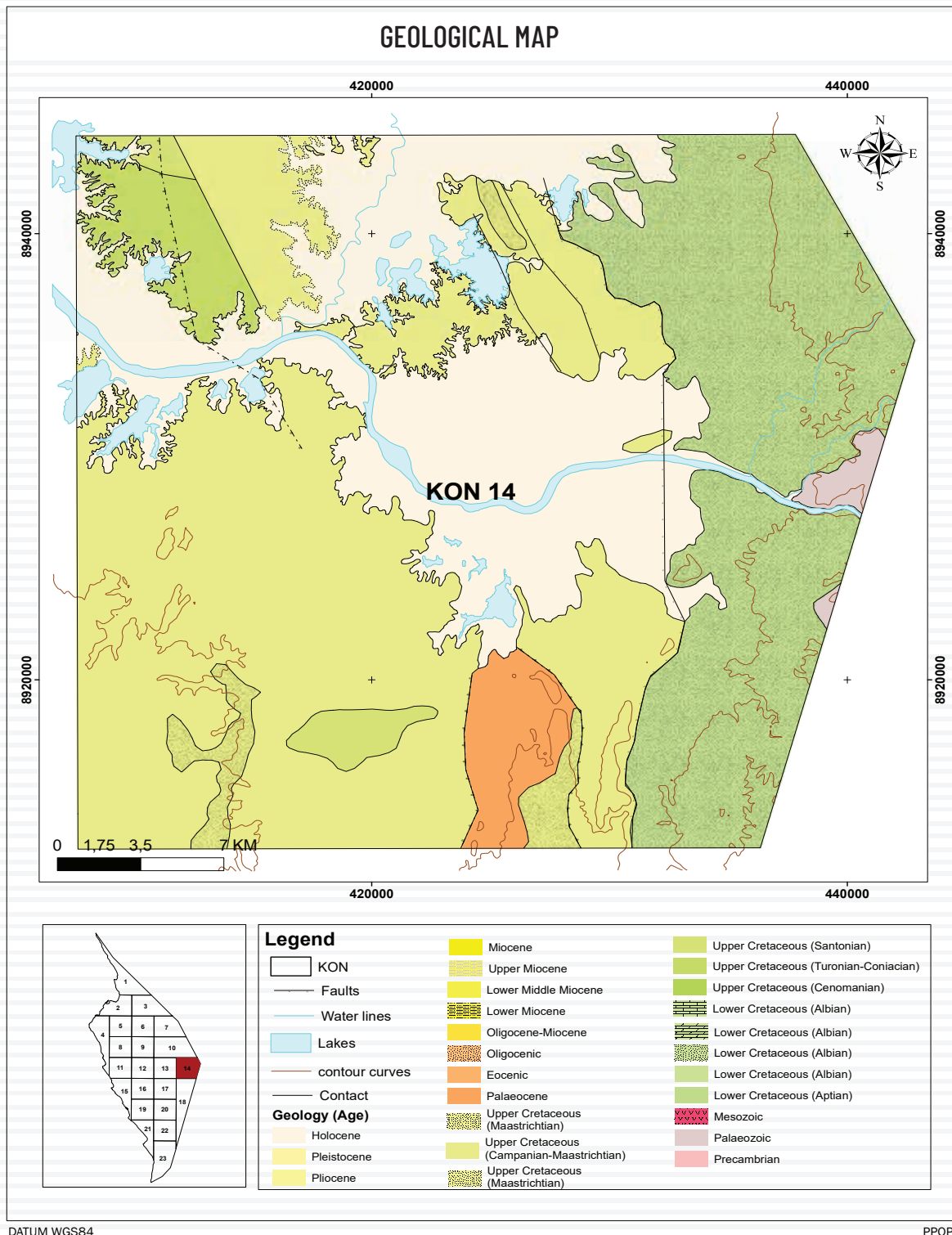


Figure 2: Geological map of Block KON 14, ANPG 2022

Pre-salt Unit

The pre-salt play is affected 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 14 was characterized by a tectonic style of fault systems in the basement forming horsts and grabens type structures with potential hydrocarbon trapping zones (pinch-out, onlap), 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, represented in the northwestern of the Block by the Chio horst, shared with Block KON 13.

In the early Aptian, with the influences of the first marine incursions and elevated temperatures, a lagoonal depositional system developed in which the salt layer that constitutes the main seal at the level of this unit was deposited. The probability of the existence of salt windows will enable oil migration from the Pre-salt to the Post-salt.



Figure 3: Paleozoic Metamorphic Rock, Schists in Kixinje, ANPG 2022

Post-Salt Unit

The post-salt structure of the Onshore Kwanza Basin is dominated by salt tectonics. The Albian level is characterized by extensional structures that were displaced by the influence of salt tectonics and sedimentary overburden, and consequently, the formation of turtle-back structure, supported by normal faults with lithic relict in all extent, overlain by sediments of Cretaceous and Tertiary age.



Figure 4: Lower Cretaceous Mucanzo Block KON 14, ANPG 2022

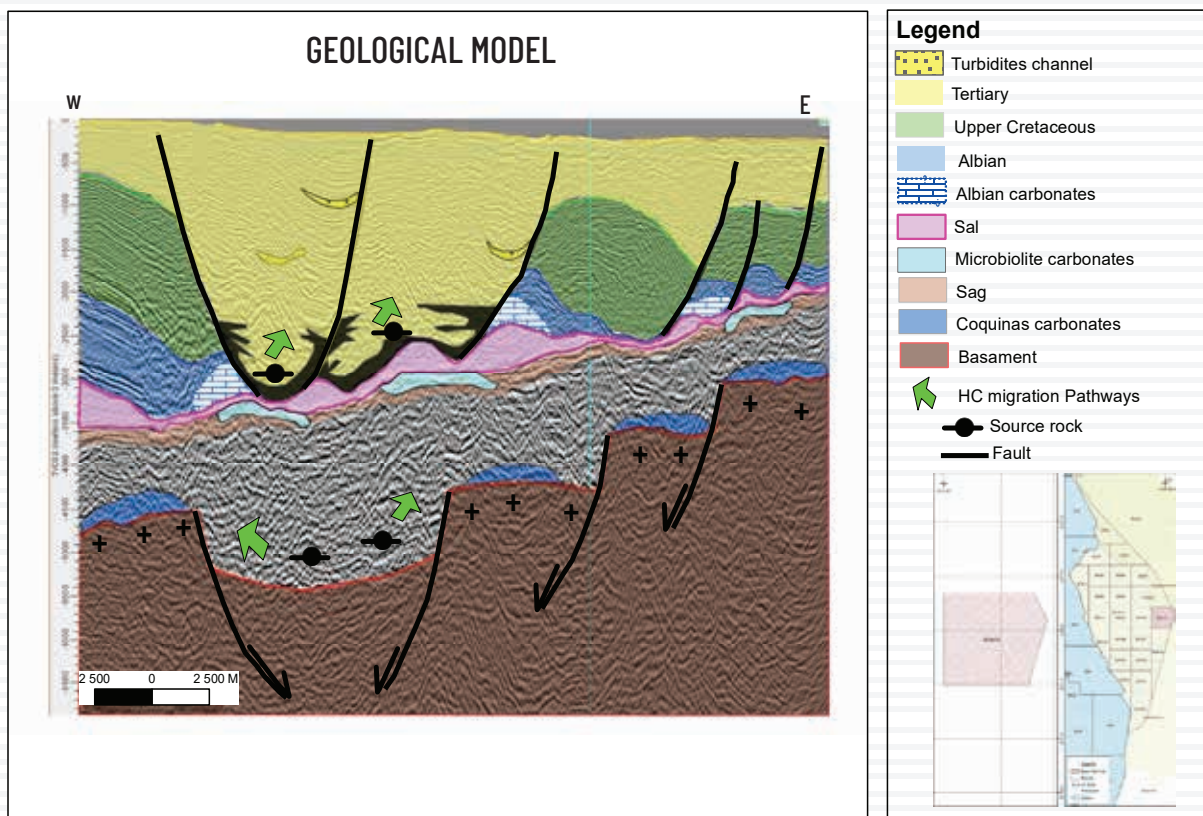


Figure 5: Geological model of the Block KON 14, SKB 224, ANPG 2022

4. **EXPLORATION** History

The first exploration work in the Block dates from 1970 to 1973, with a seismic acquisition by the company Petrangol. In 1998, the ENI company conducted aero gravimetry and magnetometry surveys.

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.

Block KON 14 has no record of drilled wells; however, the evaluation of the Block was done from correlations of neighboring wells.

In 2009-2012 Geokinectics acquired 151.07 line km of seismic. In addition, recent geological mapping and well geochemistry studies in the basin were carried out by Sonangol in partnership with Obrangol 2010-2015 and Previsão Oil 2012-2015 (Figures 2, 4, e 5).

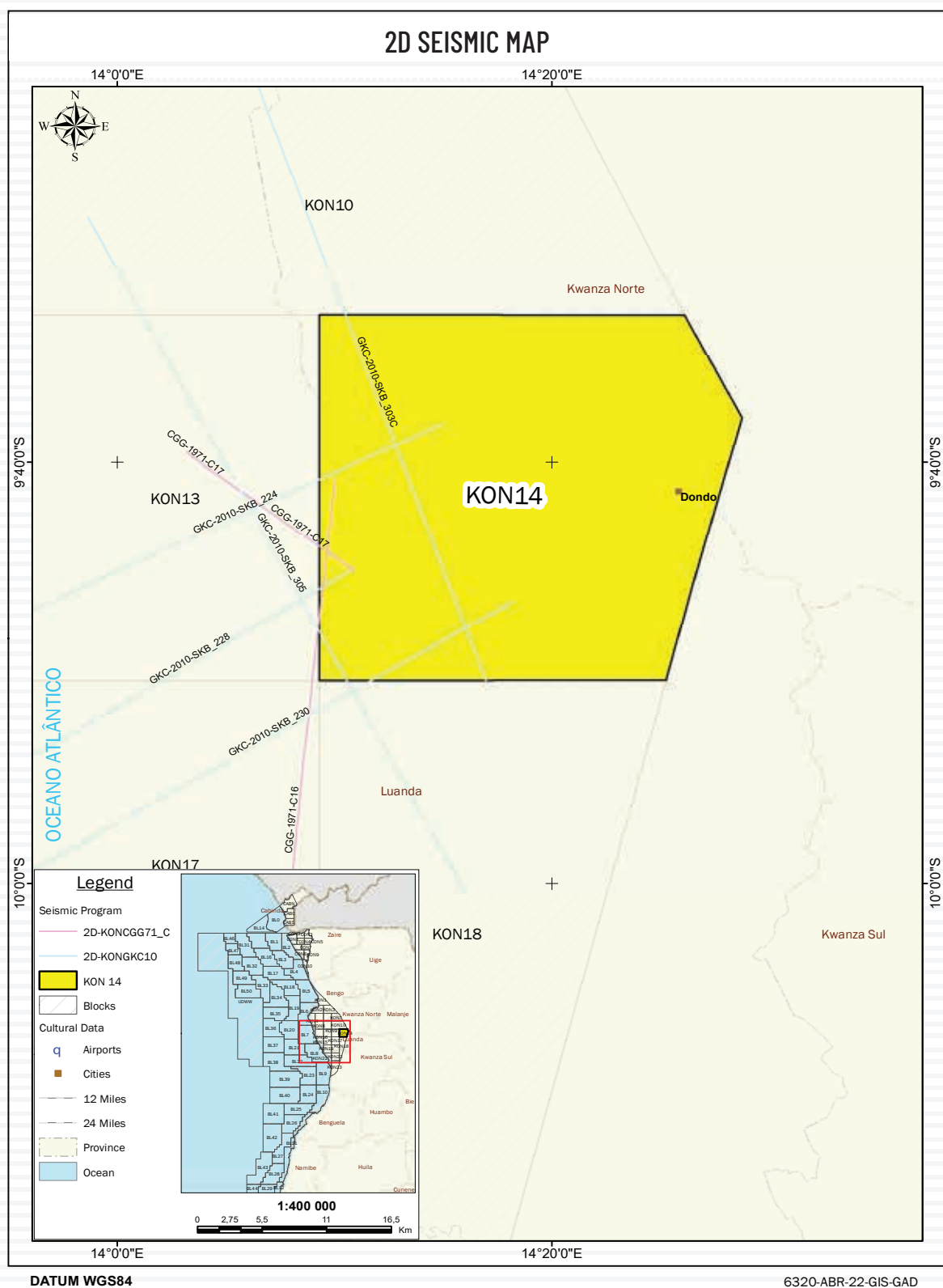


Figure 6: 2D Seismic Data Acquired on Block KON 14, ANPG 2022

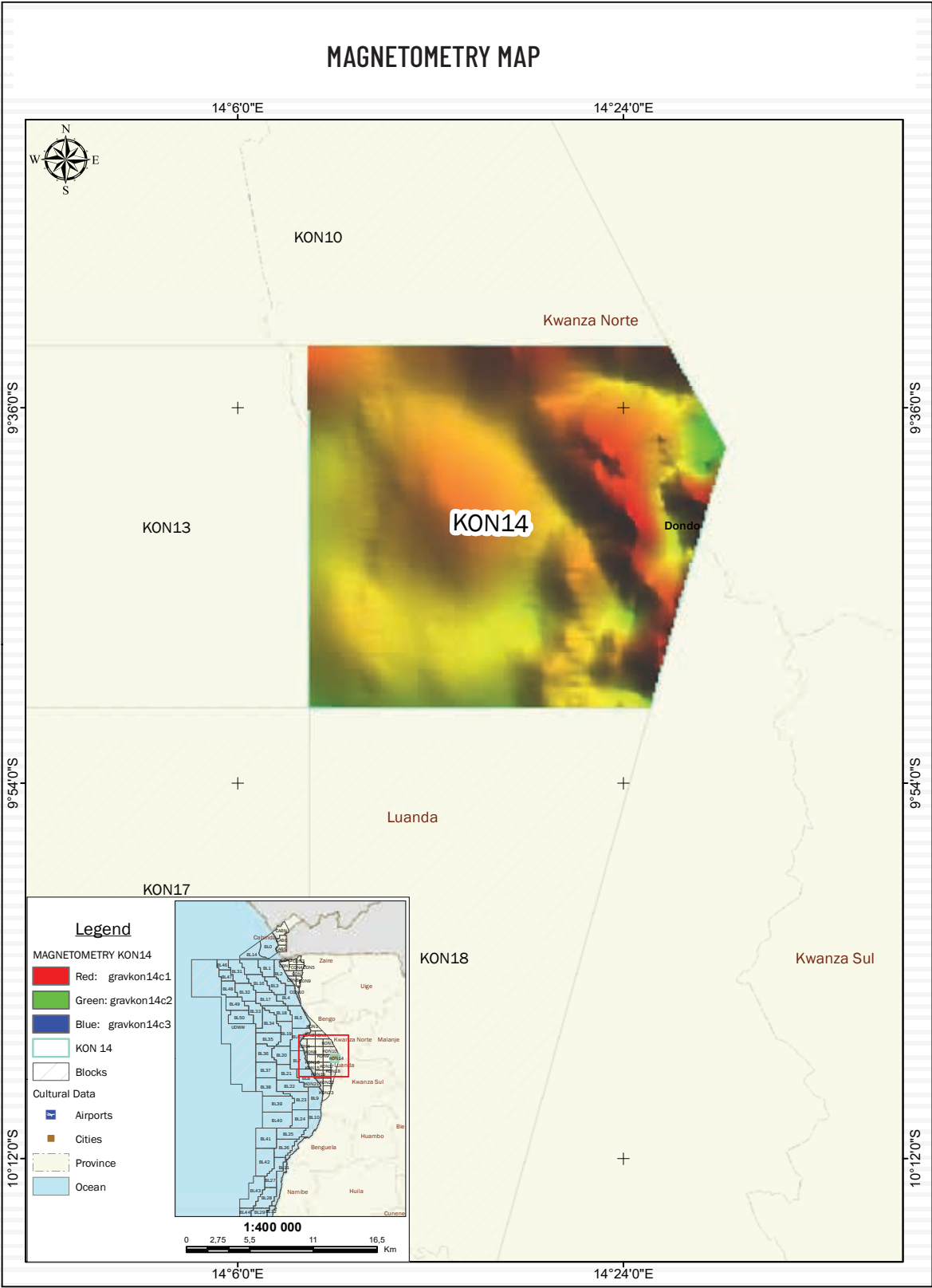
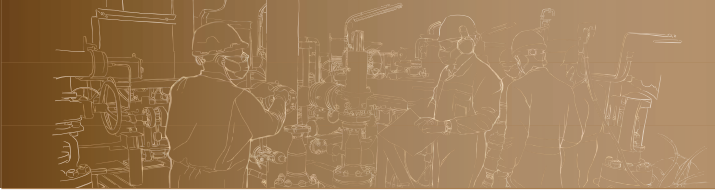


Figure 7: Magnetometry Map of the Block KON 14 ANPG, 2022

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).

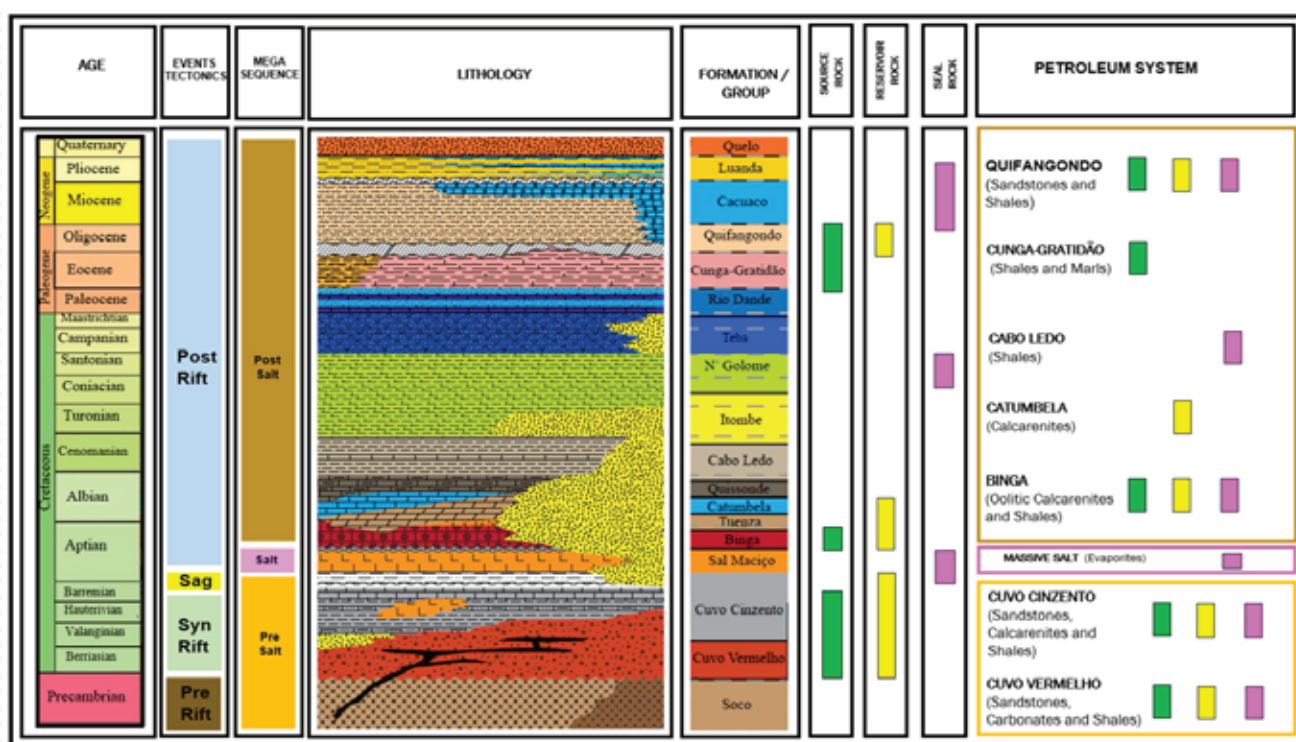
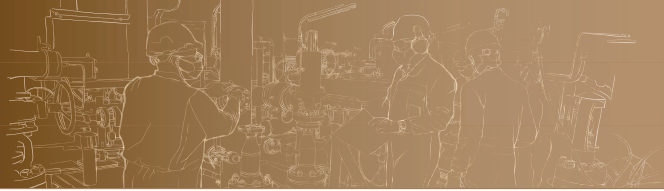


Figure 8: Lithostratigraphic Column of the Onshore Kwanza Basin, ANPG 2022



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-Gratidão 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 shales. 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 Cunha Gratidão Formation. Total Organic Carbon (TOC), Rock-Eval Pyrolysis, and Vitrinite Reflectance analyses were conducted in the two lithostratigraphic units on Blocks KON 11, KON 12, and KON 13. The Chio-1 well from KON 13 revealed good mature stage organic content values. At the post-salt level, the characterization of the Binga source rock suggests excellent mature-stage organic content from marine origin.

Cuvo Vermelho Source

The Cuvo Vermelho Formation shale at 2869.9 m depth shows good total organic content (TOC) values of 1.35%, and S1 and S2 parameters suggest medium petroleum potential. The HI values indicate type III kero-gen. Parameters indicating maturity Tmax 441 °C and Ro 0.5% show that the rock is at the beginning of the maturity stage (Table 1).

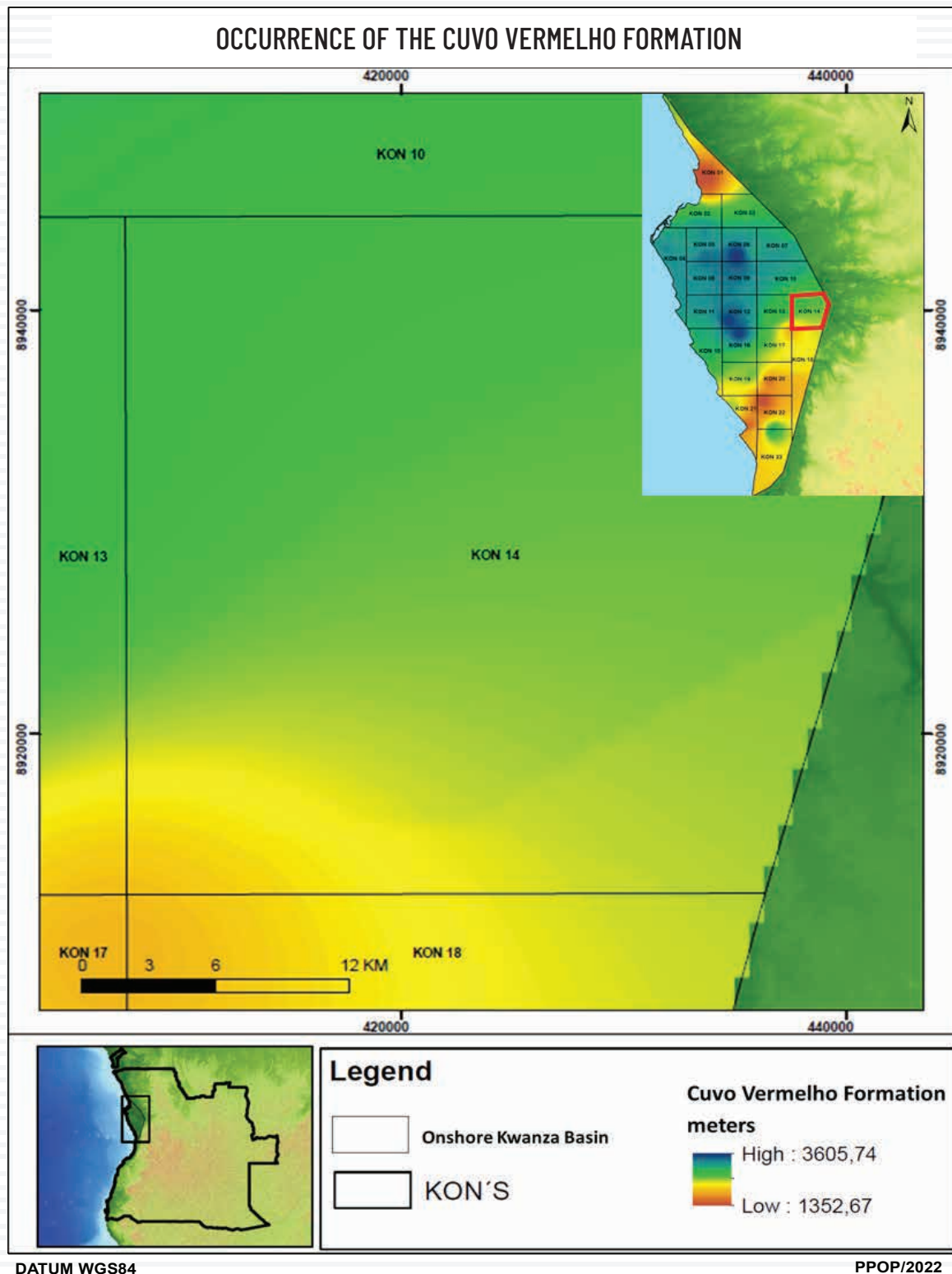


Figure 9: Occurrence map of Cuvo Vermelho Fm. Source rock

Cuvo Cinzento Source

The Cuvo Cinzento organic-rich shale at 2 829.1 to 2 829.9 meters depth shows good total organic content (TOC) values of 1.06 to 1.83%; the S1 and S2 parameters suggest medium petroleum potential. HI values indicate type III kerogen. Parameters indicative of maturity Tmax 458 to 465 °C and Ro 1.1% show that the rock is at the end of the maturity stage (Table 1).

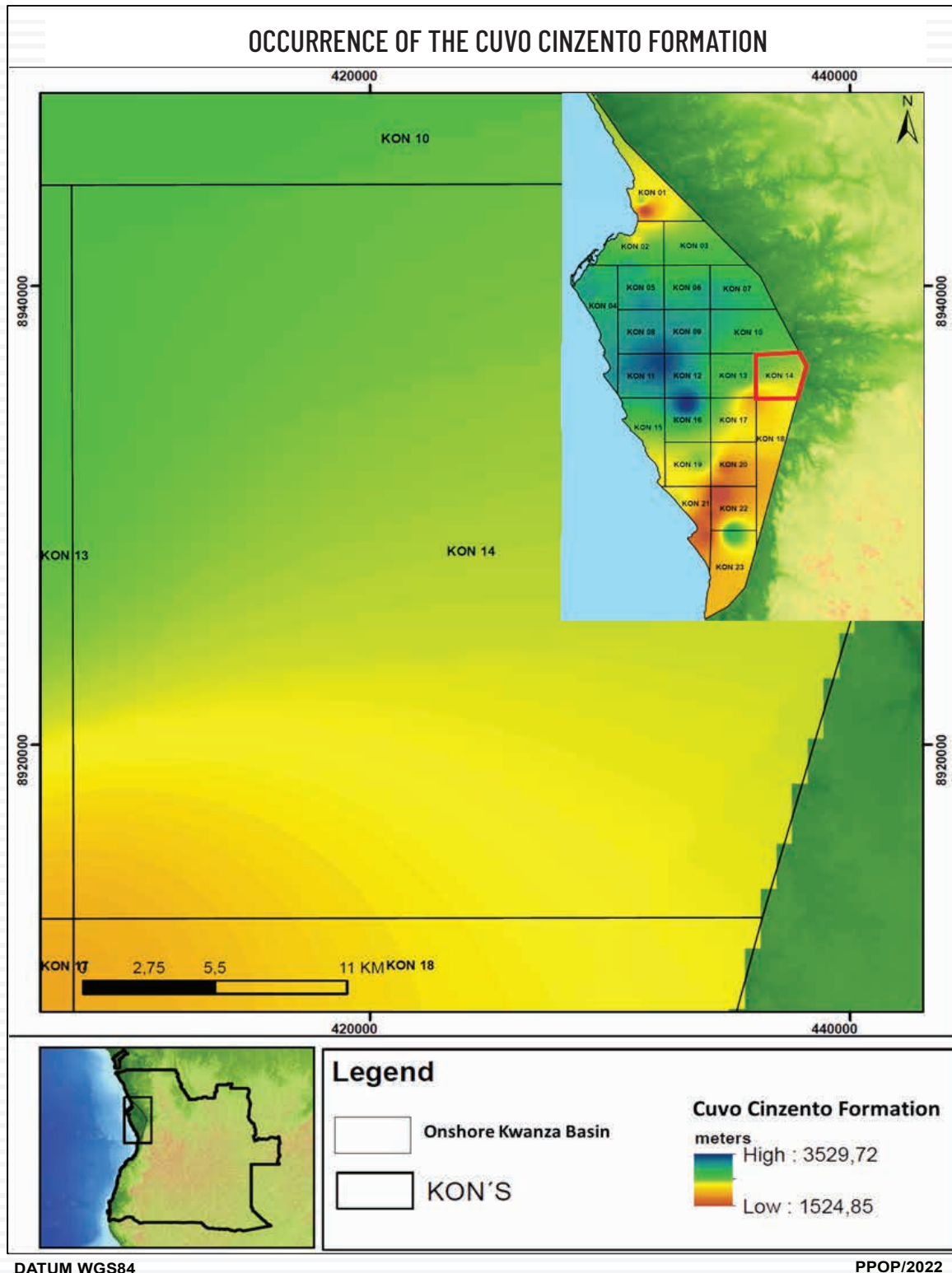


Figure 10: Occurrence map of Cuvo Cinzento Fm. Source rock

Binga Source

The Binga carbonates, proven Albian source rock, are distributed over the block. Geochemical studies conducted in neighboring blocks demonstrate its generation potential.

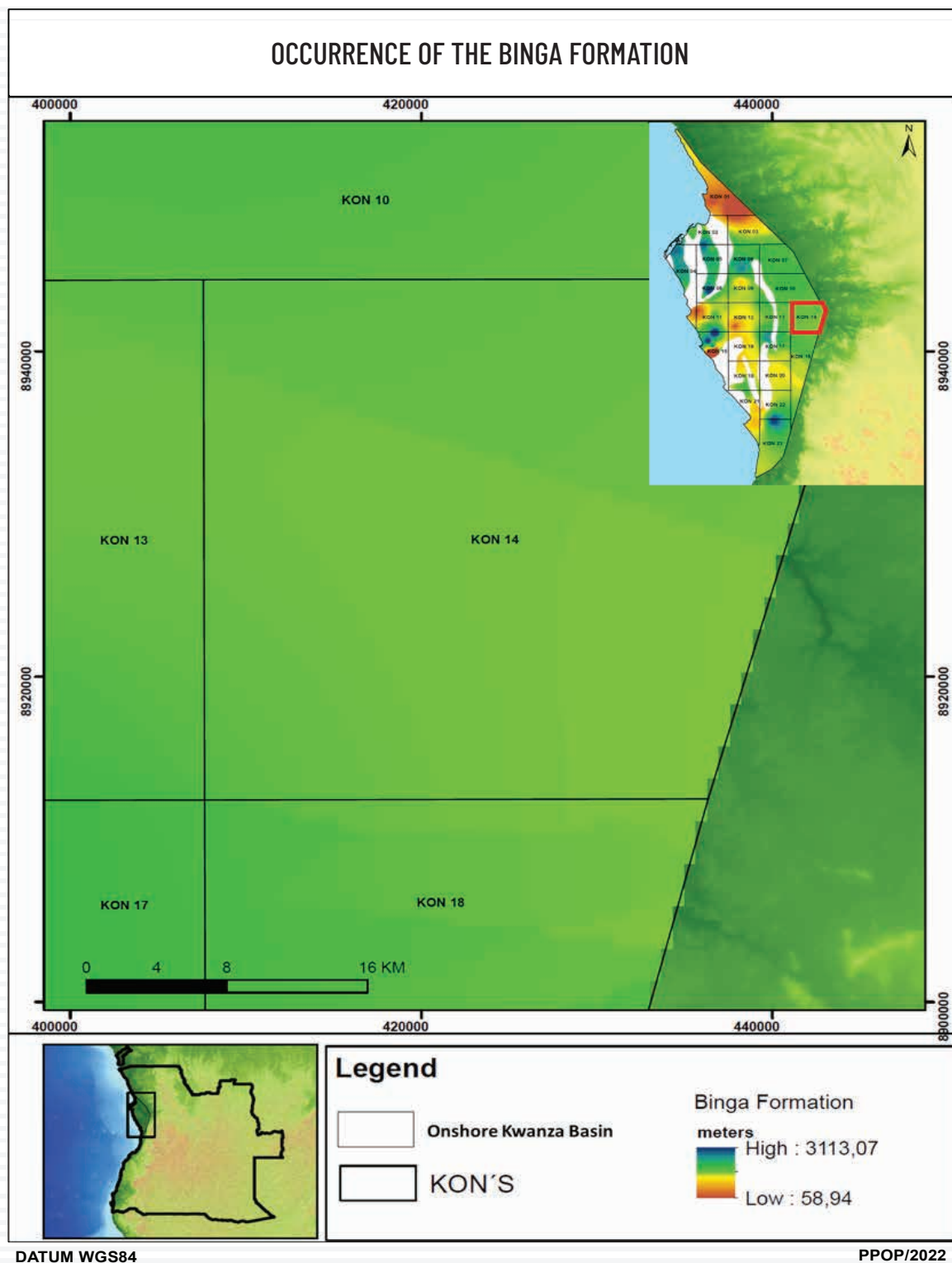


Figure 11: Occurrence map of Binga Fm. Source rock

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 1: Geochemical Analysis of Cuvo Vermelho & Cinzento Formations

1D Model

The Chio-1 well shows that the Cuvo Vermelho Formation was deposited in the Lower Cretaceous. The thermal evolution of the generating facies at depths of 900 to 2 300 m reached the oil window of the Lower Cretaceous to Paleocene and the gas window at depths of 2 300 to 3 000 m from the Paleocene to Present Day. On the other hand, the Cuvo Cinzento Formation, deposited in the Lower Cretaceous, reached oil window depths of 1000 to 2200 m in the Upper Cretaceous to Paleocene and gas window depths of 2200 to 3000 m from the Paleocene to the present day.

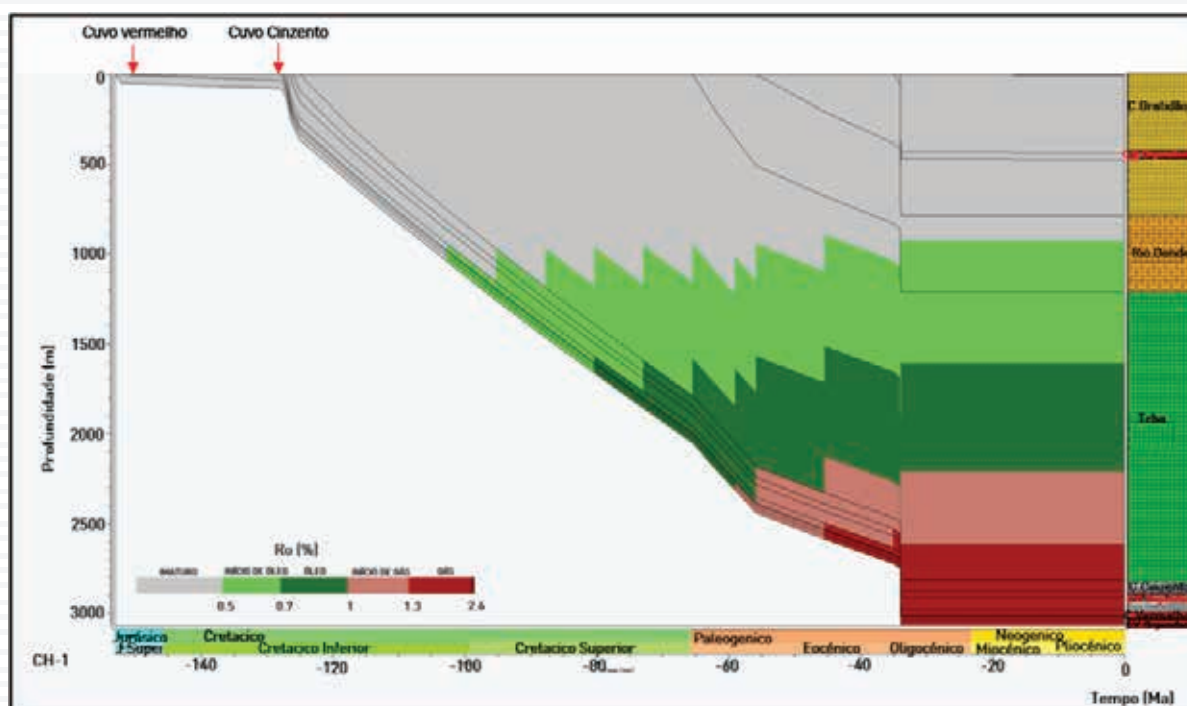


Figura 12: Maturation Profile of Chio-1 Well, ANPG 2022

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 Leads

Leads 1 & 2

Located south of the Block, is a double target; the reservoir corresponds to sands and carbonates of the Cuvo Formation, having as source rock the organic matter-rich clay facies of the same formation deposited at the bottom of the grabens and as cover rock the evaporites of the massive salt Formation, in a mixed type trap.

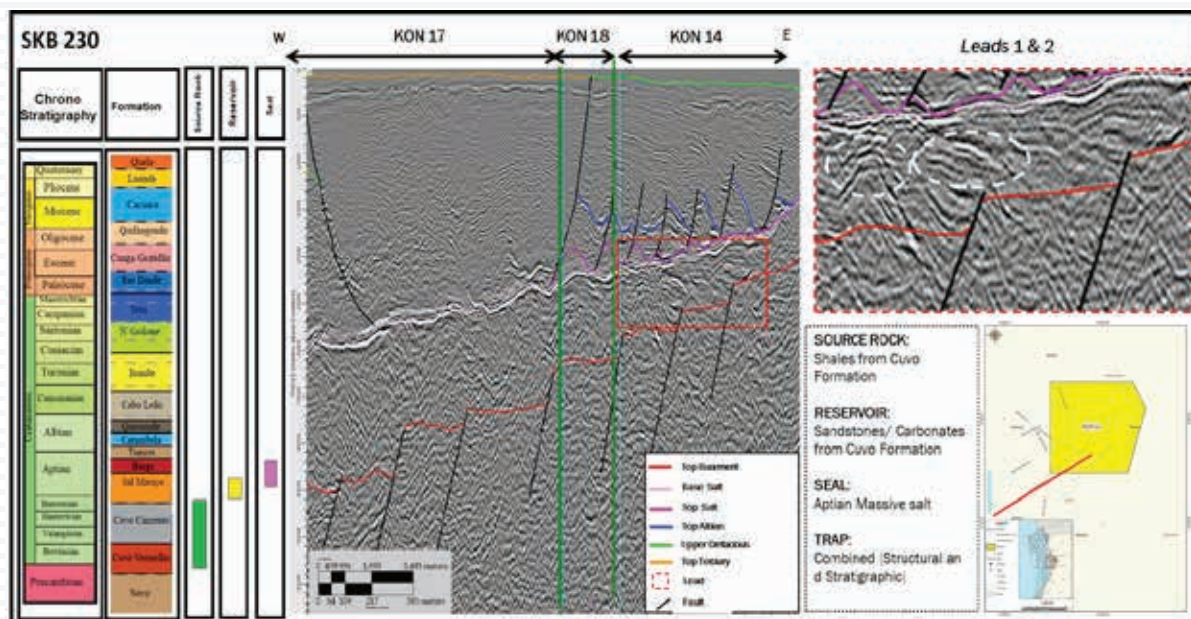


Figure 13: Pre-Salt Lead 1, ANPG 2022

6.1.2 Post-salt Lead

Leads 3 & 4

Located to the west of the block, it is a double target. First, it has as its reservoir the oolitic limestones with raft-like structures belonging to the Binga Formation of the Albian age, interconnected by a set of normal syn depositional faults influenced by salt tectonics. The Tuenza saliferous Formation and the Cabo Ledo Formation shales provide this lithostratigraphic unit's seals.

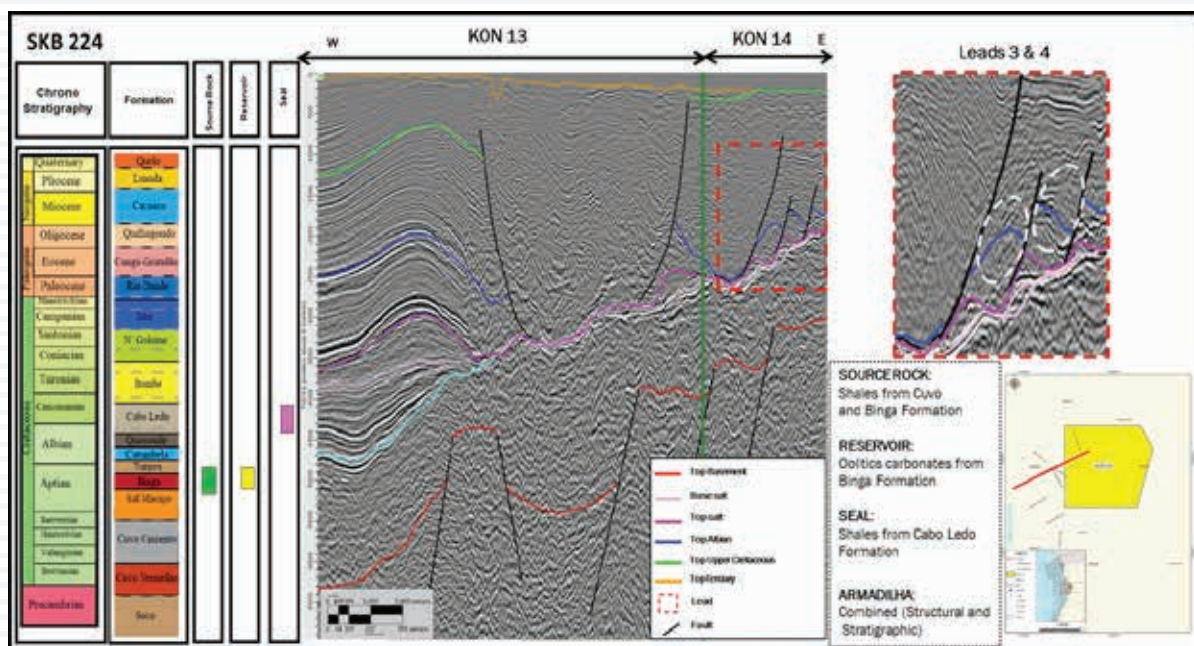


Figura 14: Albian Oolitic limestone, ANPG 2022

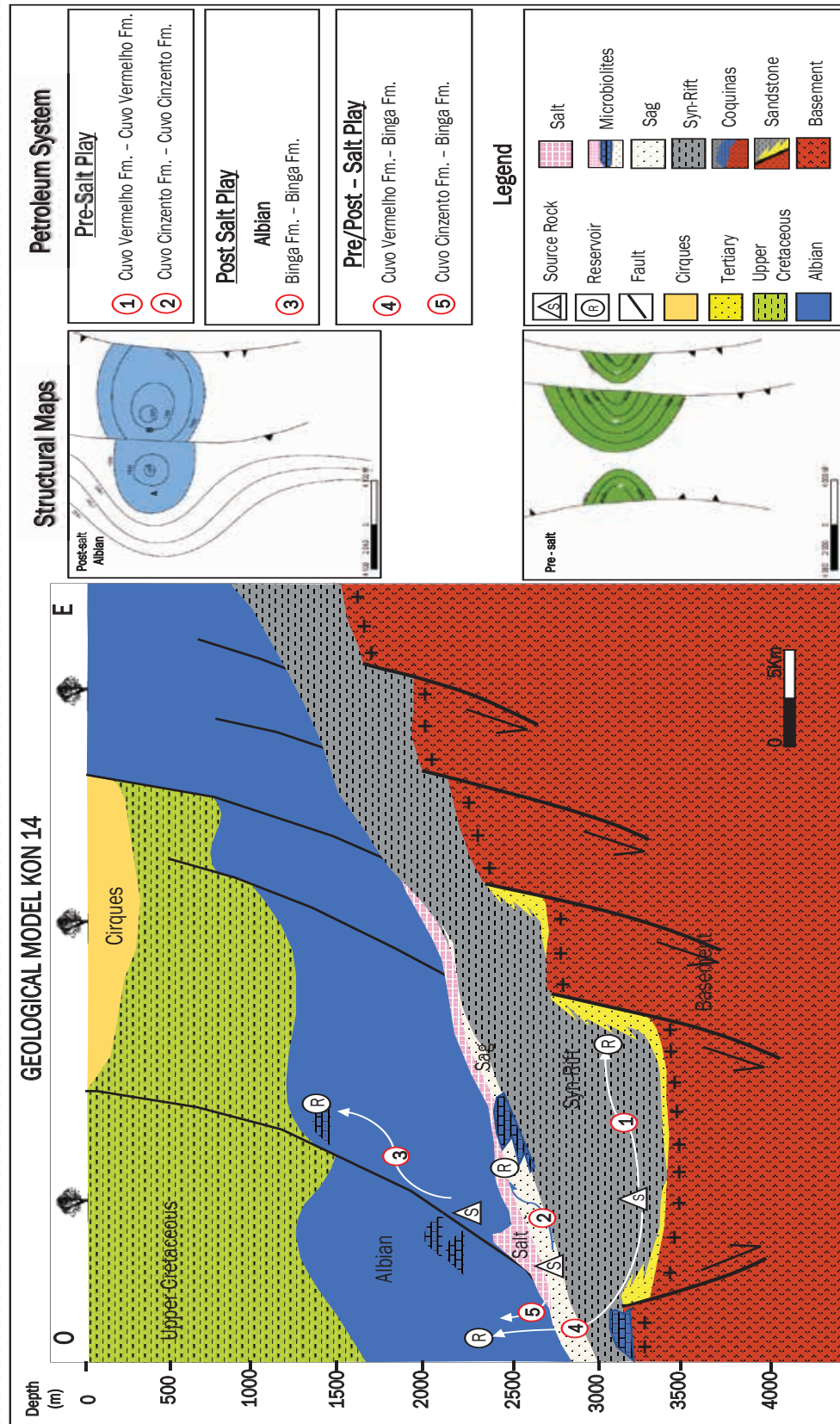


Figure 15: Geological model of the Block KON 14, ANPG 2022

7. FINAL Remarks

After reassessing Block KON 14, 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 KON 14



ANGOLA



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

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