

# Contribution to the Study on the Possibility of the Development of the Upper Cenomanian Reservoir of the Tshiende Field

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**Abstract:** In order to carry out hydrocarbon production in the basement, a drilling must be carried out and the latter crosses several layers or formation until reaching the desired objective. At the beginning of the production, the well will have a natural pressure and the oils in a reasonable quantity which will allow to make an exploitation but over time the pressure decreases and the production of oil leaves room for the production of water to show the end oils and in most cases this well is converted from producing well into an injector well to feed other wells or repackaging. In fact, the Tshiende field comprises three reservoirs (Cenomanian, Pinda and Vermelha) that produce and the Cenomanian only produces in its lower horizon. The entire well passes through the Cenomanian reservoir to reach the other two reservoirs. To contribute to the understanding of the geological complexity of the reservoirs of this field, we focused our study on the Cenomanian reservoir. This reservoir did not produce in its superior horizon in the Cenomanian after several tries, but Produces in other fields that the Tshiende field, and that sometimes constitutes the main reservoir in the field Muanda. A new production test in the TS-27 well began on 02/01/2019 in the Cenomanian dedicated upper part using other technique than the previous ones. This has had to prove the feasibility of producing this unknown reservoir. The decision was made to re-evaluate the UC potential and to propose wells to perforate to depend on their positions and history. After an extensive review of Tshiende's potential for superior Cenomanian production, a development program is proposed. Four workovers are proposed to develop the higher Cenomanian potential in the TS-29, TS-22, TS-02 and TS-13 wells.

**Keywords:** Fracturation, Workovers, Litho Facies, Productivity Index, Paker, Tectonic, Frac

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## 1. Introduction

The Democratic Republic of Congo has a huge oil potential in its three sedimentary basins, of which only the coastal basin is currently producing liquid and gaseous

hydrocarbons. Located in the west of DR Congo, in the province of Kongo-Centrale in Muanda, the Congolese coast has an Offshore area of 1,012Km<sup>2</sup> and an Onshore area covering an area of 4,980 km<sup>2</sup> of which only 426 Km<sup>2</sup> is in production by the Perenco-Rep operator (Figure 1).

Considering the mature state of the fields in this western zone of the Republic, some fields have closed their wells following the production of water than oil, the various strategic studies are put in point to improve the production of hydrocarbons in this zone; Our study and contribution focuses on the possibilities of putting the Tshiende field into production in its Upper Cenomanian reservoir.

Despite the accumulations of hydrocarbons, we see a declining eater in this western area of the Republic as production took a certain time some fields closed their wells because the wells no longer produced oil but water, the various studies and techniques are carried out for the optimization of this zone in hydrocarbon, for this reason, we researchers, would like to contribute on the possibilities of the development of the Tshiende field in the upper Cenomanian reservoir. This field has a total of 11 wells drilled by the perenco operator in the formation of Vermelha. These 11 wells produced a cumulative total of 27 MMbp of oil in the previously flooded Vermelha. Pinda formation was

considered a secondary target and well tested in two wells. Similarly, the Kinkasi (Cenomanian) formation has never been fully explored and remains undeveloped.

In view of the above, the following questions guide this study:

1. Is it possible to contribute to the possibility of putting the Cenomanian reservoir into oil production?
2. If so, what are the precautions to consider?

To carry out this contribution, we carried out a sedimentological study of the Cenomanian reservoir where we have identified the distribution of the different litho facies as well as their variabilities in order to explain the phenomenon of emplacement of different types of rocks and establish a clear zonation of the Cenomanian reservoir.

In addition, petrophysical studies on the one hand, performed after logging data acquisition, allowed us to carry out an in-depth analysis on the physical properties of the region and to define the characteristics of lithological sequences impregnated with hydrocarbons.

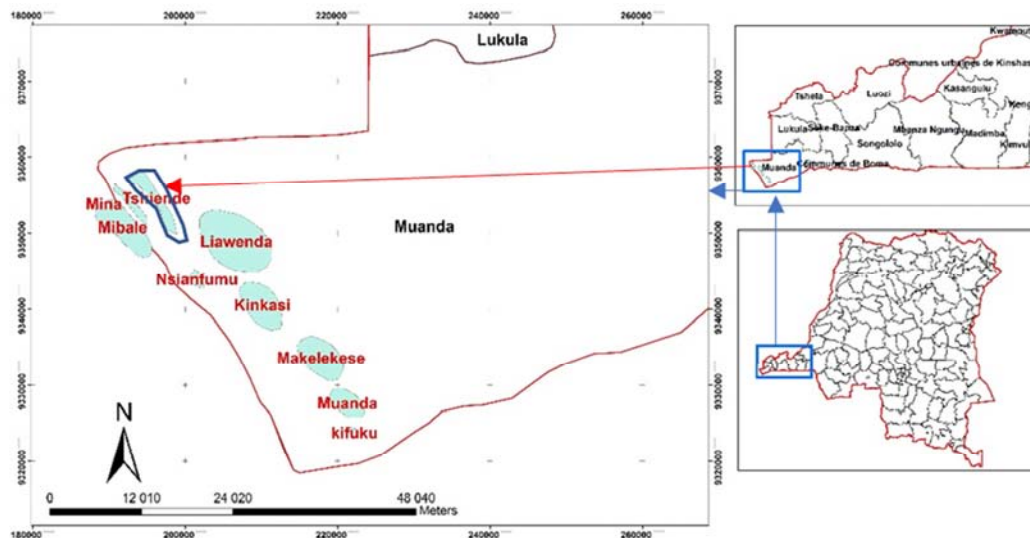


Figure 1. Localisation of Tshiende field in the coastal basin of the Democratic Republic of Congo.

## 2. Material and Method

### 2.1. Material

To complete this article, we used a laptop that contains:

Excel: For the development of certain histograms and tables;

Word: For the final formatting of the article;

ArcGis: A geographic information system for the development of different maps related to the study area;

Petrel: Petrel software for the good development of the structural diagrams of the tank;

### 2.2. Method

To carry out this contribution, we carried out a sedimentological study of the Cenomanian reservoir where we have identified the distribution of the different litho-facies as well as their variabilities in order to explain the

phenomenon of setting up different types of rocks and to establish a clear zonation of the Cenomanian reservoir.

In addition, petrophysical studies on the one hand, performed after logging data acquisition, allowed us to carry out an in-depth analysis of the physical properties of the region and to define the characteristics of lithological sequences impregnated with hydrocarbons; and structural, on the other hand, allowed us to detect the structure of our field of study.

## 3. Geological and Structural Aspect of the Reservoirs

The main parameters that seem to control the deposition of the Cenomanian can be divided into 3:

1. Clastic entry: the northern part of the study area from which the clastic input originates is mainly composed of a silico-clastic lagoon complex.

2. Tectonic activity: the proximal part (Liawenda and Kinkasi fields) consisting of anticlinal traps is raised while the distal part consisting of inclined fault blocks is more governed by salt tectonics.
3. The relative change in sea level is linked as a result of

tectonic activity.

At the end of this Cenomanian stratigraphic model, the paleo-shore remains quite similar to the current one in the North-West-South-East direction (see Figure 2). (Florence BOUTELIER, 2015).

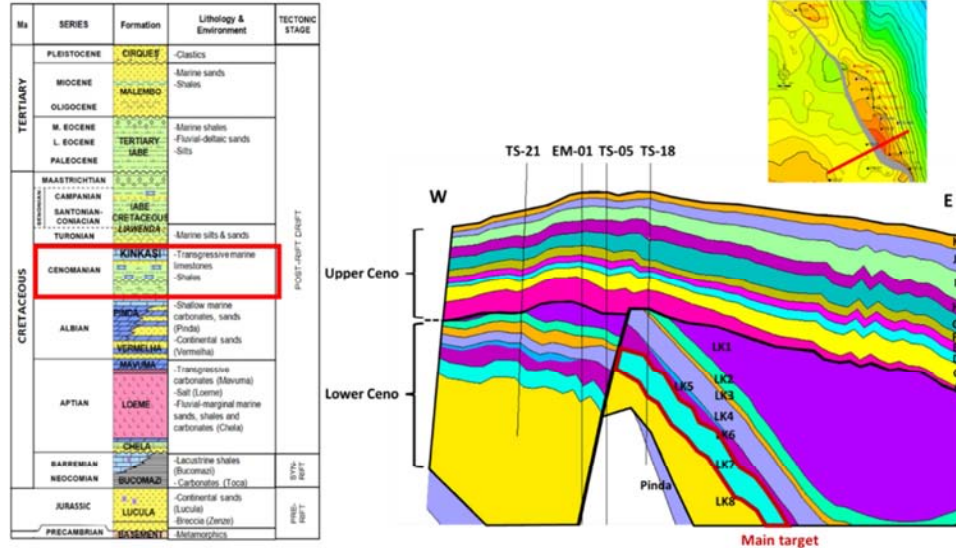


Figure 2. Litho stratigraphie du réservoir Cénomaniens de Tshiende (Perenco-Rep, 2019).

Table 1 below explains the deposition formations of each layer in different depths

Table 1. Litho stratigraphy of the Cenomanian reservoir (Perenco-Rep, 2009).

Formation / Zone	TOPS M md Mud line	TOPS M TVSSc	Description
Kinkasi Céomanian K	1329	-1307	Limestone: compact and microcrystalline, whitish, clay, dark gray and Compact laminate. Moderately hard, soft, plastic, carbonate and clay. Medium to low visible oil exposures
J	1345	-1323	Shale / dark gray clay, compact, laminate, soft plastic, moderately hard, sticky, swelling, and lamellar, silty and colloidal. Limestone: microcrystalline, silty and flexible in place and friable. Stone to light gray, cemented, carbonate or clay. low oil numbers.
G	1409	-1388	Limestone: microcrystalline and bioclastic presence.
F	1439	-1415	Clay: greenish gray, laminated, moderately hard, soft plastic.
E	1457	-1433	Alternation of beige vacuolar limestone with green limestone and green clays.
D	1479	-1454	Earth stone, light gray to dark gray, carbonate, clay, limestone, white with microcrystalline matrix, sandy, moderately hard, bioclastic. dark gray shale to greenish gray.
C	1499	-1474	Alternation of white microcrystalline limestone, silt, sometimes limestone with gray and brown clay-limestone, marly, silty and sometimes brownish limestones
A	1538	-1512	microcrystalline white to gray, sometimes brown clay and limestone.
Lower Kinkasi LK1	1545	-1519	Alternation of gray to green silty marl and argillites or loamy green clays with gray limestone.
Lower Céno LK7	1672	-1647	Clay / shale: light gray to greenish gray, smooth, soft to hard, block, elongated and fissile, amorphous, plastic with angular breakage.
Lower Céno LK8	1719	-1693	Lime stone / silt: light gray cement, ranging from white to brownish gray, rounded, moderately sorted, friable, clay and carbonate. No good oil ratings.
			Limestone: white, light gray and microcrystalline silicon stone, limestone and clay in part, uniform graduation.
			Clay / shale: light gray to gray, silty, soft to hard, elongated, flat and fissile, plastic to angular rupture.
			Stone: light gray, greyish to rounded, moderately sorted, carbonated and good oil marks.
			Clay / clay shale: light gray to gray, occasionally green, density, soft to hard, sub-block, flat and fissile, amorphous, plastic with angular rupture. Light gray cement stone, whitish to brownish gray, rounded, moderately sorted, friable, clay and carbonate. Low oil indexes



Horizon selection results from the integration of well control survey EM-01 and TS-05, respectively. The thickness of the Kinkasi Formation (in purple) (see Figure 2) increases offshore due to salt tectonic structures and very pronounced rafting.

Structures with a large inclination towards the Offshore increase the storage space and allow to have a greater thickness of deposit. The Cenomanian fault largely comprises the Cenomanian basic unit and the Top Pinda.

The TS-05 well has a greater thickness of the Kinkasi formation due to its downstream position on an inclined fault block with respect to the EM-01 well.

Tshiende is a rotated fluvial block divided into two main compartments by a listric defect. The fault cuts all layers below the Upper Cenomanian.

The Tshiende structure is a 3-way immersion structural trap against the main Tshiende listric fault. This typical trap is produced in many fields in the DRC, especially off the coast where gravity slip is located.

The structure is bounded on the east by another listric fault, the Tuilili fault, which seems to merge with the main Tshiende fault in the south direction.

These listric defects take root in the Aptian anhydrite, Loème formation and stop at the summit of the Lower Cenomanian. However, this structural heritage creates a 4-way structure at the top of the Upper Cenomanian.

The Tshiende block is cut by several smaller synthetic and antithetical intra-block faults that compartmentalize the field. These minor defects are limited to the lower Vermehla section (see Figure 3).

Four inconsistencies are recognized in the succession of Tshiende:

1. Between the top and the bottom Vermehla
2. Between Pinda Fm and Upper Vermehla: local erosion by subsidence on the wall.
3. Pinda-Lower Cenomanian (LK8)
4. Between the Upper Cenomanian and the Lower Cenomanian (LK1-A)

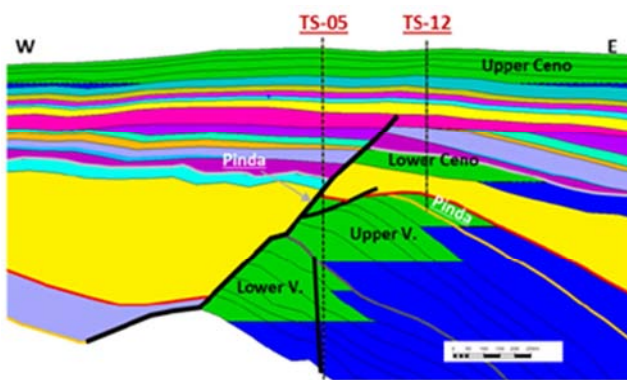


Figure 3. Structure de Tshiende (Perenco-Rep, 2016).

## 4. Results and Interpretations

Tshiende field was historically a Vermehla producer.

Following the decline of the production from this formation, Perenco decided to exploit Pinda and the Lower Cenomanian on this field. The Upper Cenomanian was at first not tested.

In 2006, a Vermehla well TS-02 was perforated in LK and Upper Cenomanian (UC) after the installation of a bridge plug to isolate the Vermehla. Weak production (Figure 4) was found. This well produced and is producing in commingled, giving no proves of UC production (Figure 5).

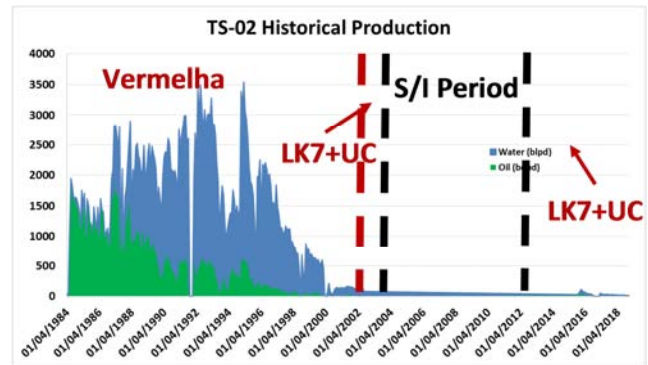


Figure 4. TS-02 Historique Production.

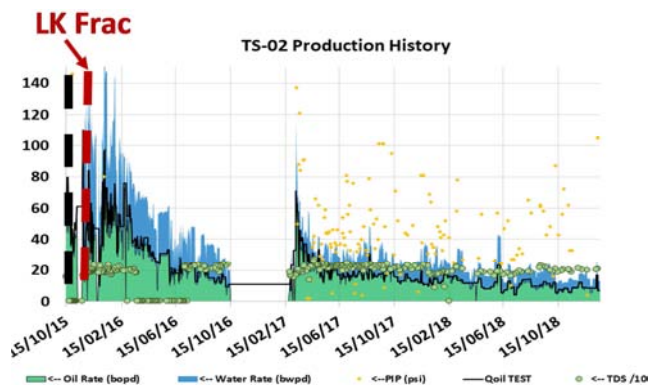


Figure 5. TS-02 current production.

In 2016, a historically LK7+Pinda well, the TS-13, was perforated in the UC. No changes of production were observed. To prove UC producibility, a bridge plug was set to isolate the Pinda and the LK7. This operation dramatically stopped the production (Figure 6).

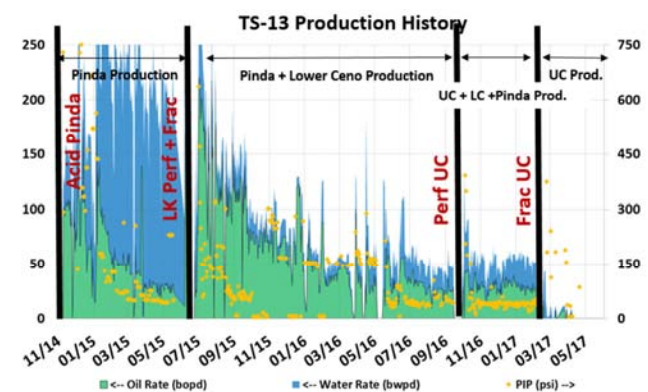


Figure 6. TS-13 Production history.

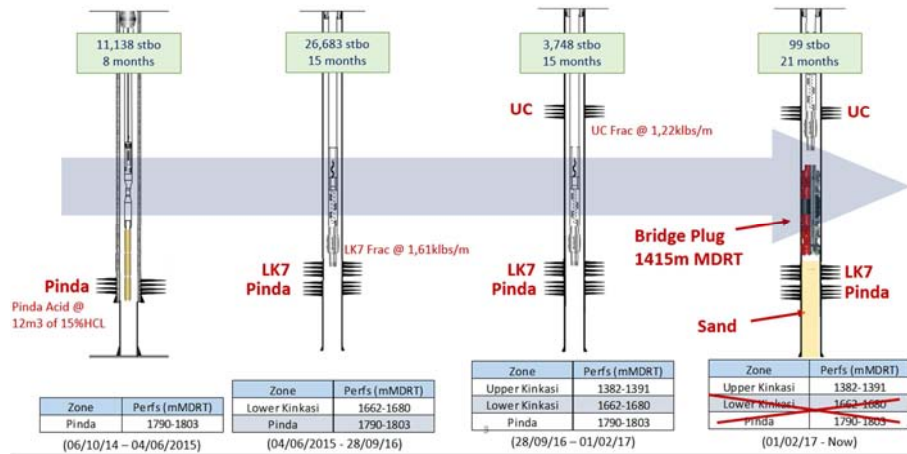


Figure 7. TS-13 Perforation and completion evolution.

Despite stimulation and activation, the well was hardly producing water.

Following the results of these two wells, the Upper Cenomanian appeared to be not producible.

TS-27 was planned as LK7 development well initially. After drilling, the well gave medium oil shows in the initial target, the Lower Cenomanian, but good shows in the Upper Cenomanian (figure 8).

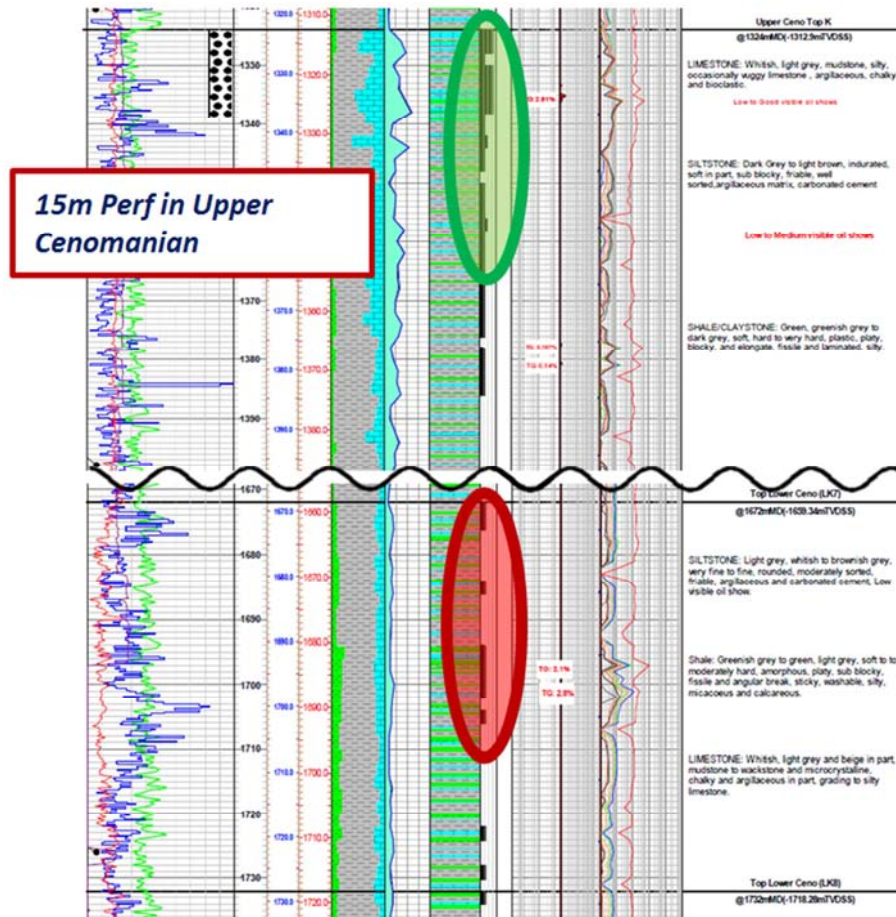


Figure 8. TS-27 Litholog.

Looking at these results, decision was taken to take the opportunity to develop only UC to prove feasibility or unfeasibility to produce the UC.

The interval perforated was 1324-1339m MDRT (-1312 to 1327m TVDSS, ODT at -1390m TVDSS). A 2.5klbs/m frac

was done on the interval (37,500lbs of proppant).

A gauge was ran in hole three days before the start of production to follow the pressure evolution of the TS-27.

The well was then put on production.

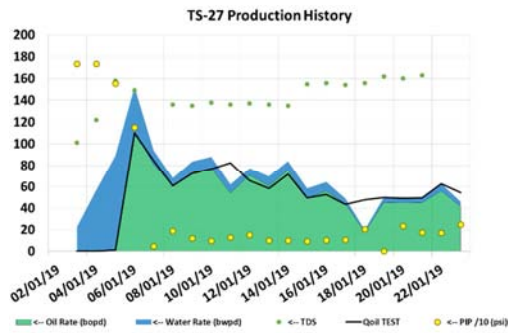


Figure 9. TS-27 Production History.

TS-27 has successfully started production (Figure 9).

TS-27 proved it is possible to produce oil from the Upper Cenomanian. Decline profiles have been created based on the TS-27 start of production (Figure 10).



Figure 10. TS-27 Decline profile.

This profile is close to the Muanda field profile for the Upper Cenomanian.

#### 4.1. Development Strategy

Decision was taken to reevaluate UC potential and propose wells to perforate depending to their positions and historic (Figure 11).

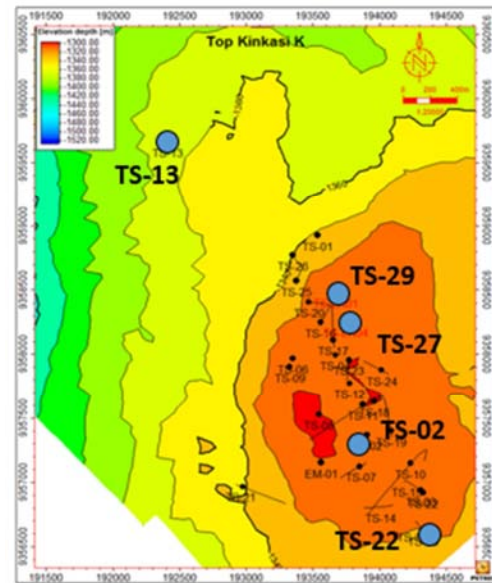


Figure 11. Top Kinkasi map.

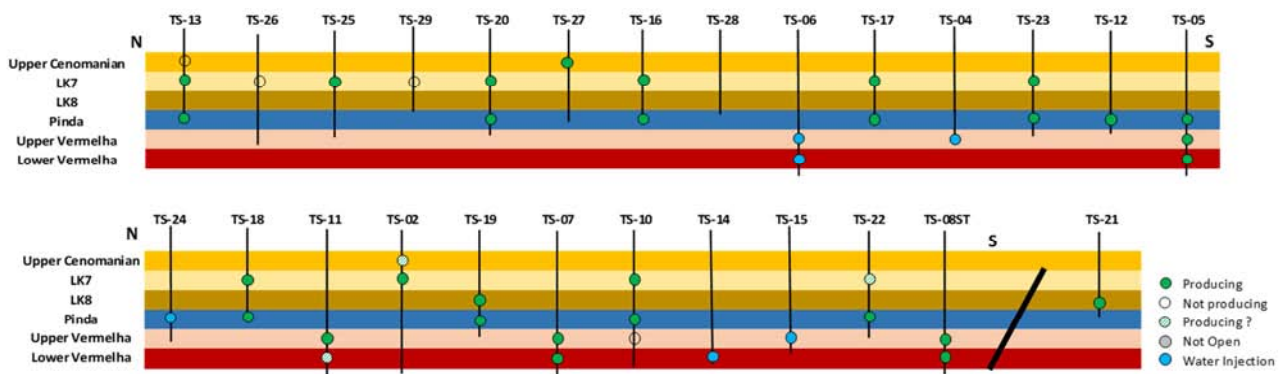


Figure 12. Producers and Injectors on Tshiende field from North to South.

#### 4.2. Upper Cenomanian Development in an Already EXISTING AFE

TS-29

TS-29 is as well a LK7 planned development well. Following drilling, similar shows have been seen in LK7 than in TS-27. Nevertheless, oil shows in the Upper Cenomanian appeared to be good as well.

The interval of perforation proposed is 1336-1356m MDRT (-1323 to -1343m TVDSS) (Figure 13). The theoretical ODT is 47m TVDSS below our perforation (-

1390m TVDSS). A frac of 4.5klbs/m could then be done (90,000lbs). Boron would be use to identify the frac propagation characteristics in the Upper Cenomanian.

The frac operation will be done with boron inside the proppant with a concentration of 1.5lbs for 1000lbs. So 135lbs of Boron are required. A PNN log has been run before the frac and another one will be done after the stimulation in order to appraise the frac extension in the Upper Cenomanian. This result will help to define the frac size for the other UC development stimulations.



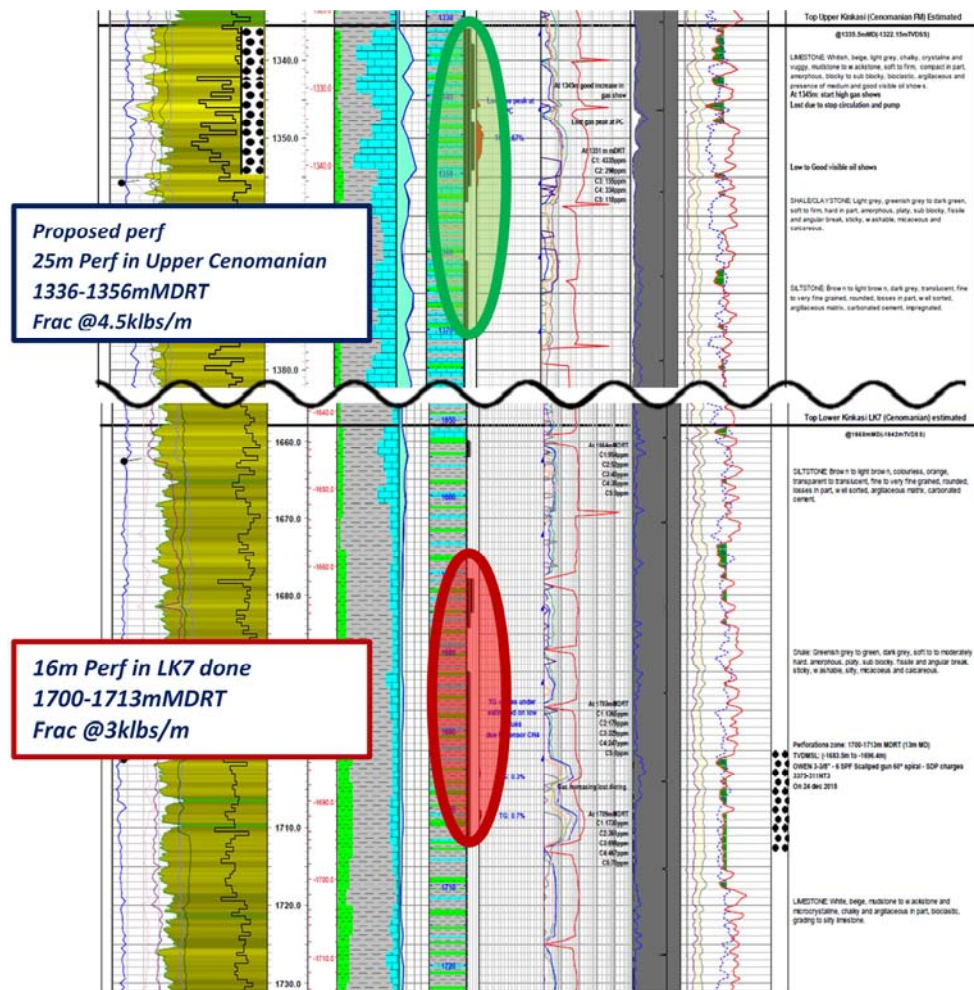


Figure 13. TS-29 Lithology.

#### 4.3. New AFE Upper Cenomanian Development

This part describe workovers being part of a non-existing, and therefore proposed, AFE.

TS-22

TS-22 is a LK7 + Pinda producer, producing in commingled since the beginning (Figure 14).

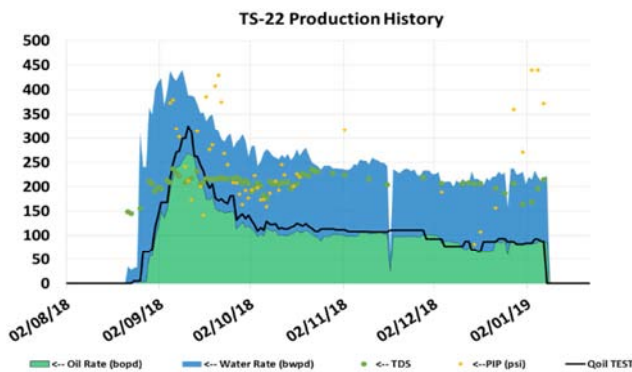


Figure 14. TS-22 historical production.

TS-22 showed medium oil shows during drilling throughout the Upper Cenomanian. Below is the TS-22 Litholog in the Upper Cenomanian (Figure 15).

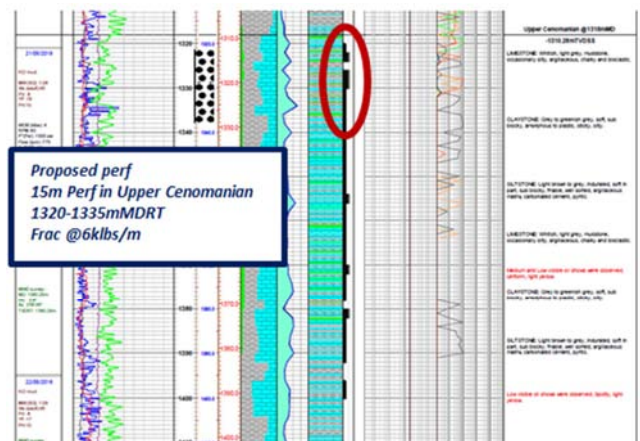


Figure 15. TS-22 UC Lithology.

TS-22 does not have the best oil shows seen on the wells going through the Upper Cenomanian. But this well is located on the other side of the dome shape structure made by the Upper Cenomanian formation (Figure 16), and a perforation and development in this well would be a good appraisal of the extension of the UC potential.

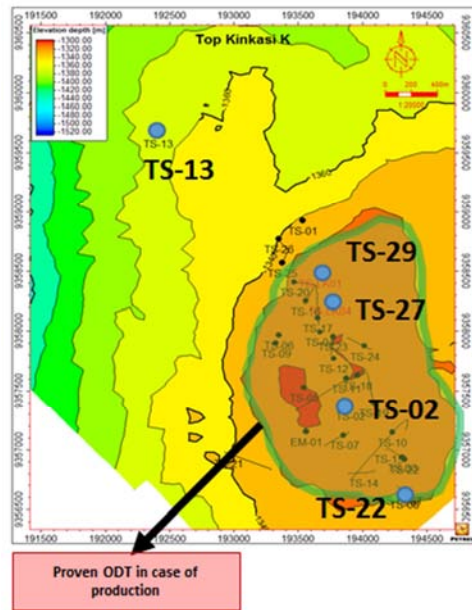


Figure 16. ODT definition in case of TS-22 UC production.

The interval 1320-1335m MDRT is proposed for perforation (-1312 to -1326m TVDSS). There is 64m TVDSS between the ODT and the bottom perforation.

A frac at 6klbs/m is recommended (the frac size will be adjusted thanks to the frac extension study on TS-29) for a total at 90,000lbs of proppant. Boron will be used at 1.5lbs of boron per 1000lbs of proppant concentration, with a total mass of boron of 135lbs.

#### Ts-13

As described before, several attempts have been done already to produce TS-13 in the past. However, it appeared that the proppant used for the TS-13 stimulation was the 12/20 Texas Silicates. It has been proven that this proppant could be crushed under the closure pressure present on Tshiende field at this depth, leading to a poor fracking results and closure of the created fractures.

TS-13 is therefore candidate for a refrac operation that will be done with a more resistant proppant, the Carbolite proppant. This well is interesting: if this well produces oil, it

could unlock a large unexploited oil potential all over the Tshiende area (Figure 17).

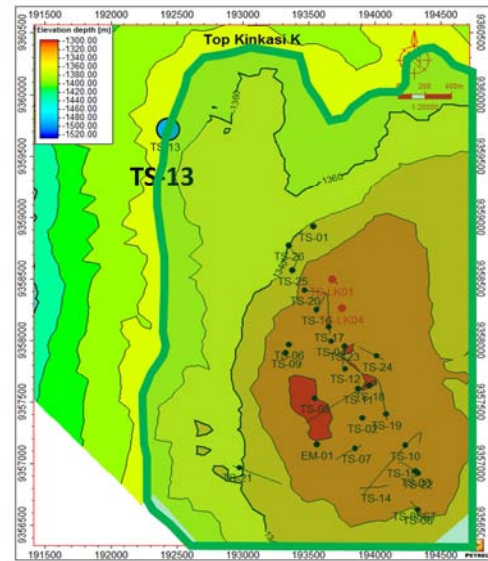


Figure 17. Top Kinkasi map with conservative OWC in case of TS-13 oil production.

Similar volume of proppant could be used, with 22,500lbs of proppant for a frac size at 2.5klbs/m (interval = 1382-1391m MDRT, -1374 to -1383m TVDSS).

#### Ts-02

TS-02 was fraced only in LK7 with 12/20 Texas Silicate (frac size at 1.14klbs/m) in November 2015.

It has never been proved that TS-02 was producing from the Upper Cenomanian. No oil shows were identified at the time of drilling, however the data are of poor quality (Figure 18). The well being located at the top of the structure (Figure 19), it has been decided to frac the Upper Cenomanian in an attempt to produce it.

The ODT being -1390m TVDSS, approximately 24m TVDSS below the bottom perforation, a 2klbs/m frac (90,000lbs, (1321-1366m MDRT) perforated interval) with Carbolite proppant could be done.

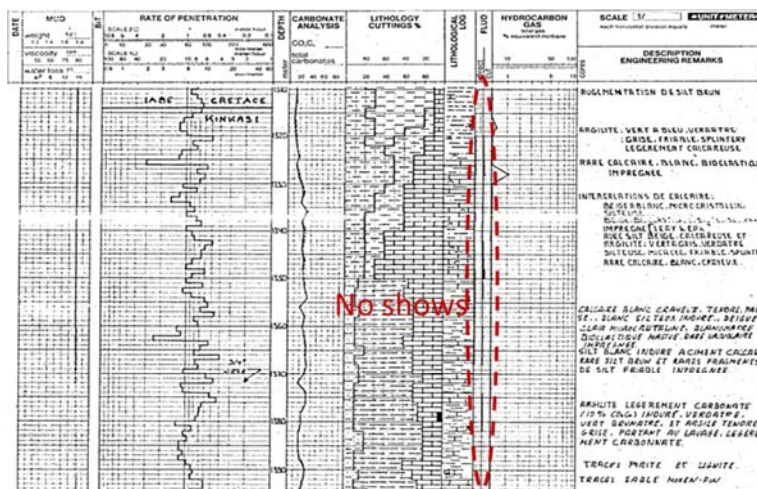


Figure 18. TS-02 Upper Cenomanian Litholog.



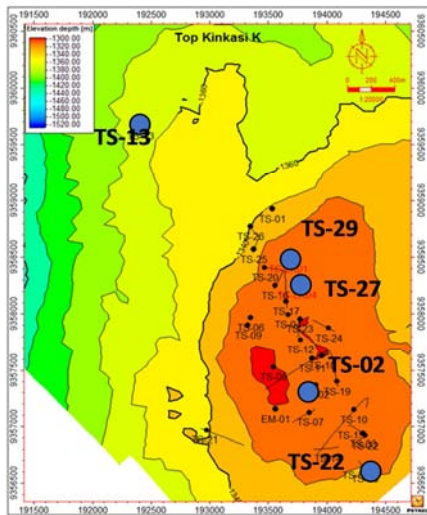


Figure 19. TS-02 Localisation.

#### 4.4. Chemical Analysis on Tshiende Upper Cenomanian Oil

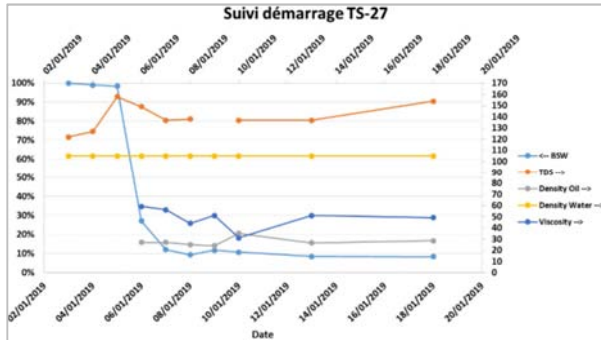


Figure 20. Chemical oil properties on UC TS-27 production.

Close monitoring has been done and is still ongoing on TS-27 oil chemical properties (Figure 19). For now, the UC oil seems to be heavier than the one produced in the LK7 or Pinda (28 API average instead of 33API for the other oils).

Measurement are ongoing to know on TS-02 the API of the oil. For the moment, the API measured is 34°API. It means that TS-02 is only producing LK7 oil currently, which

proves that the Upper Cenomanian is not properly activated, and need to be stimulated with frac. After the fracking operation, a density evolution study will be led to determine the UC/LK allocation.

#### 4.5. Index de productivité de la formation

Table 2. PI computation for different PIP values.

Date	PIP	BSW	FBHP	DP	LIQUID	PI
22/01/2019	170	9	222.2348	1587.765	69.01	0.043
21/01/2019	175	8	227.0205	1582.979	54.02	0.034
20/01/2019	235	9	287.2348	1522.765	53.96	0.035
19/01/2019		7.8	51.97769	1758.022	54.01	0.031
18/01/2019	206	8	258.0205	1551.979	51.96	0.033
17/01/2019	106	9.1	158.2562	1651.744	47.97	0.029
16/01/2019	103	11.9	155.8562	1654.144	60.04	0.036
15/01/2019	93	13	146.0919	1663.908	57.01	0.034
14/01/2019	101	9	153.2348	1656.765	79.01	0.048
13/01/2019	100	11.7	152.8133	1657.187	66.02	0.040
12/01/2019	155	8.5	207.1277	1602.872	72.02	0.045
11/01/2019	129	11.3	181.7276	1628.272	93.01	0.057
10/01/2019	96	10.7	148.5991	1661.401	86	0.050
09/01/2019	120	11.7	172.8133	1637.187	81.99	0.050
08/01/2019	190	9.3	242.2991	1567.701	67.03	0.043
07/01/2019	47	12.1	99.89904	1710.101	96.02	0.056

The formation productivity index is estimated at 0.042bbl/psi, even after stimulation. This low value explains the small UC production of the formation despite an important drawdown apply to the formation by the 6E2000 pcp pump.

#### 4.6. Way Forward

Following the development, the Upper Cenomanian on Tshiende through these four workovers, other wells are already candidates for future development.

TS-26 is an example. This well is an LK7 development well, with good oil shows in LK7. The well is currently waiting for an heavy workover in order to remove a stuck frac paker, but when this well will be available again, it is possible to perforate the UC (showing medium oil shows (Figure 21)) and produce in commingled both LK7 and UC reservoirs.

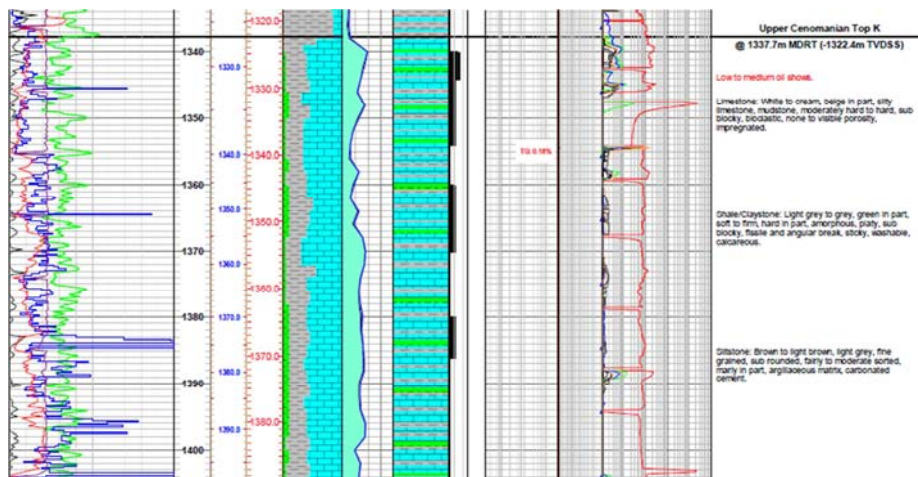


Figure 21. TS-26 UC Litholog.

Same remarks can be done on the TS-28. TS-28 is plugged and abandoned, but a project to side-track the well is understudy. If this well is done, and assuming a similar Litholog than the parent well (Figure 22), perforation can be proposed in the Upper Cenomanian.

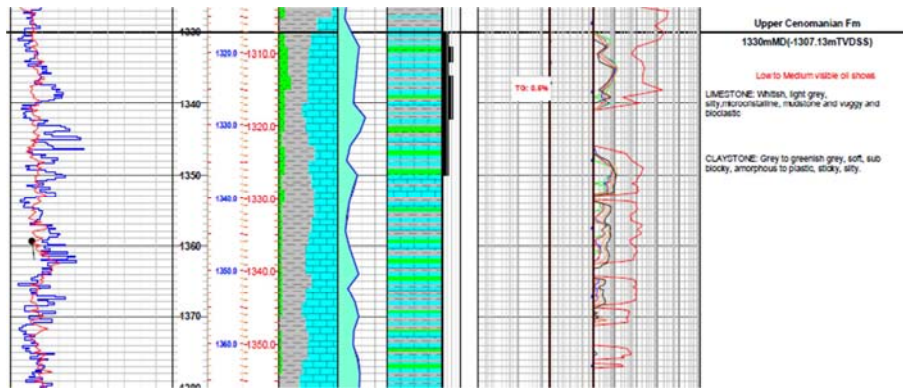


Figure 22. TS-28 parent well UC Litholog.

Other well, currently producing, are candidates for perforation.

The criteria to choose the wells are:

1. Good oil shows
2. Medium to low oil production to not risk any important well lost

The well candidates are TS-19, TS-16 and TS-23.

Below is the oil shows seen in the Tshiende wells (Figure 23).

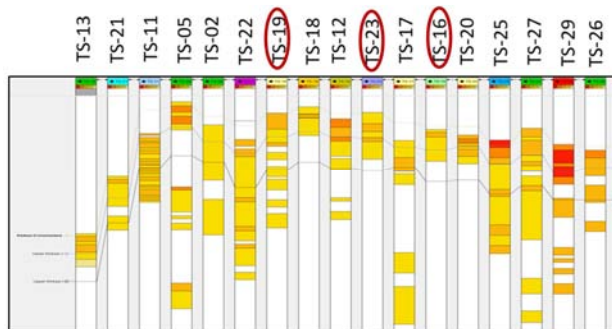


Figure 23. Oil shows on Tshiende.

## 5. Conclusion and Suggestions

To close, the Tshiende deposit has been operated by Perenco-Rep since the year 2000, including a STOOIP estimate of 64MMstb for all three reservoirs.

However, this year, TS-27 this proved possible to produce to the higher Cenomanian. This success will unlock the reserves and the daily production of this reservoir.

Therefore, we can confirm that the Cenomanian reservoir's production contribution is possible while re-evaluating the development potential of the whole Cenomanian, by placing new wells and the possibilities of reconversion.

After an extensive review of the Tshiende well potential for Upper Cenomanian production, a development plan is proposed.

Four workovers are put forward to develop the Upper Cenomanian potential:

Table 3. Development plan is proposed.

	Action	Interval	Frac Size	Total Proppant	Proppant type	ODT Stand off
TS-29	Perf +Frac	1336-1356m MDRT	4,5klbs/m	90,000 lbs	Carbolite	47m
TS-22	Perf +Frac	1320-1335m MDRT	6klbs/m	90,000 lbs	Carbolite	64m
TS-02	Frac	1321-1366m MDRT	2klbs/m	90,000 lbs	Carbolite	24m
TS-13	Refrac	1382-1391m MDRT	2,5kbs/m	22,500 lbs	Carbolite	7m

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