Hydrocarbon potential in the North Eastern corner of Algeria, unravel by collaborative technology and digital transformation

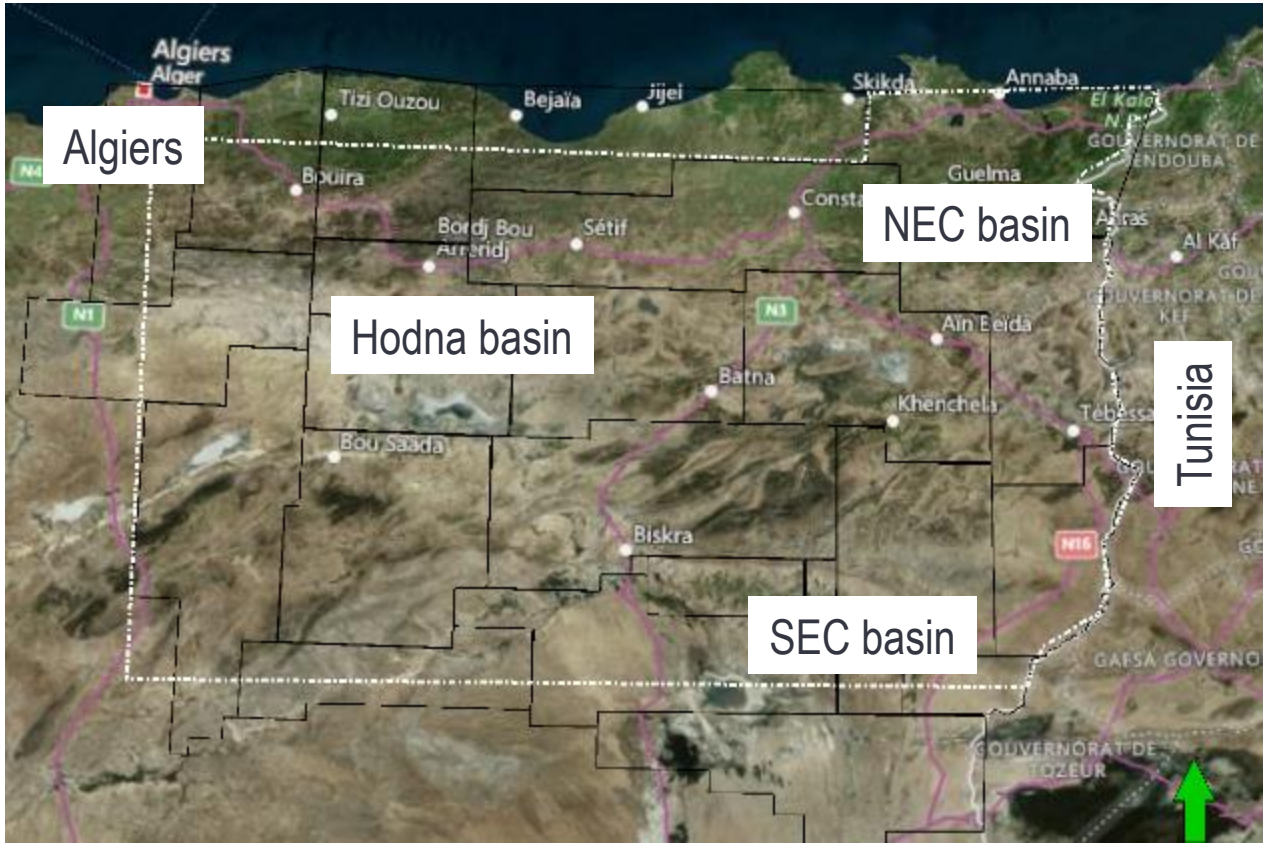
L. Adour[1], M. Djidjeli[1], O. Bouderbalah[1], N. el Hayat Allal[1], A. Dubois[2], N. Maache[2], M. Samy[2] and D. Bora[2]

1: ALNAFT

2: Schlumberger

Outlines

1. Introduction and technical challenges
2. Collaborative workflow and database
3. Hodna basin overview and prospectivity
4. SEC basin overview and prospectivity
5. NEC basin overview and prospectivity
6. Conclusions



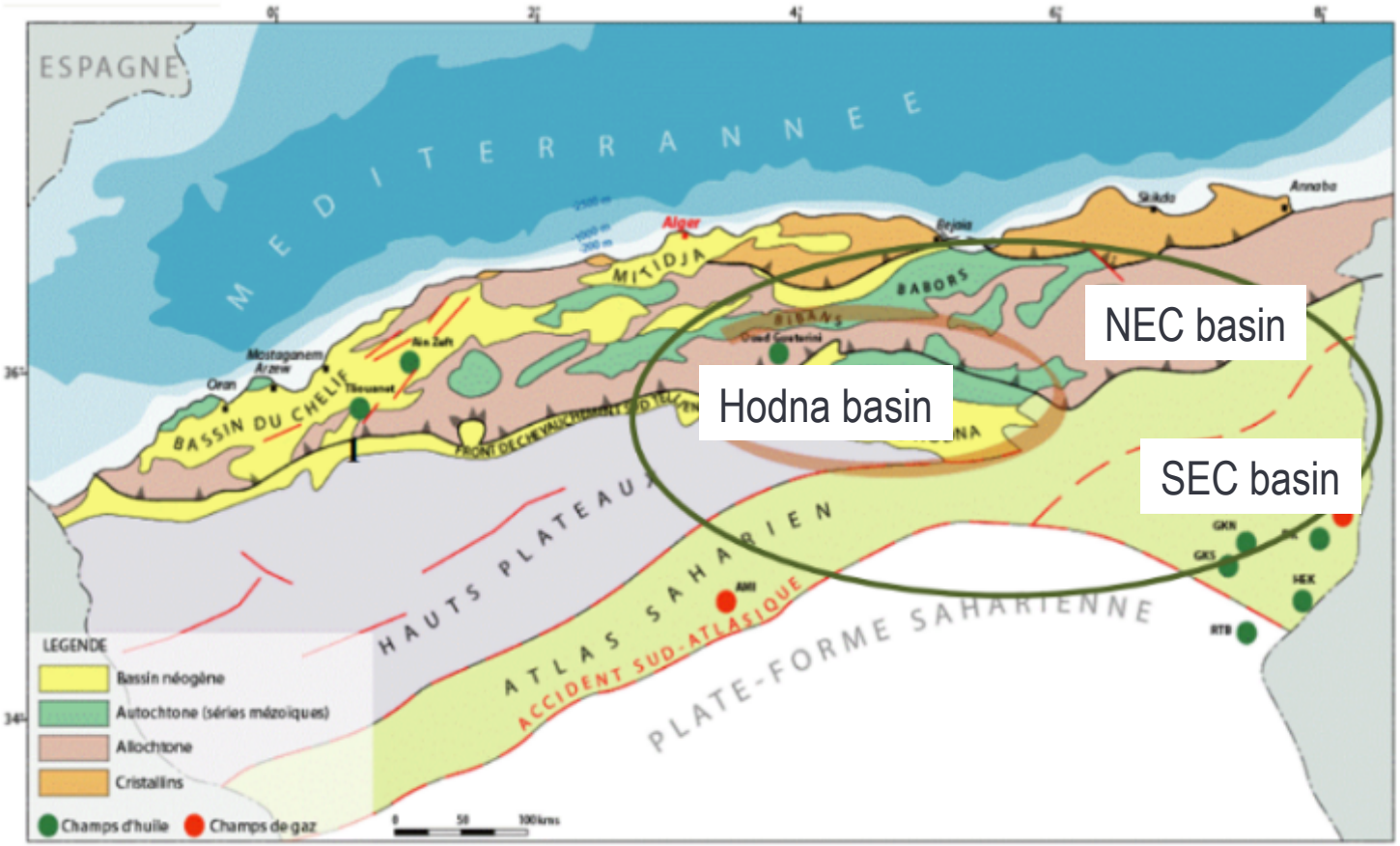
1. Introduction and technical challenges

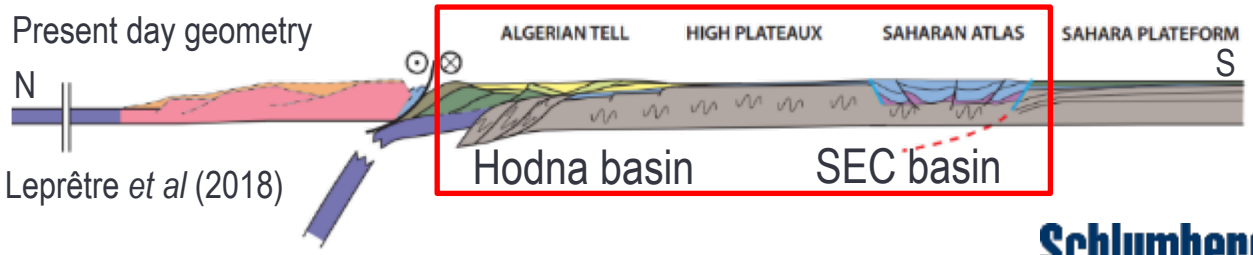
The study area is located North East of Algeria and spams over 240 000 km^2.

It encompassed three basins: Hodna basin, North East Constantine (NEC) basin, South East Constantine (SEC) basin and the Atlas Range.

The area was last structured during Paleogene and Neogene uplifts, as the land masses of Europe and Africa collided.

It's a long and narrow range separating the Mediterranean coastline from the Saharan platform.



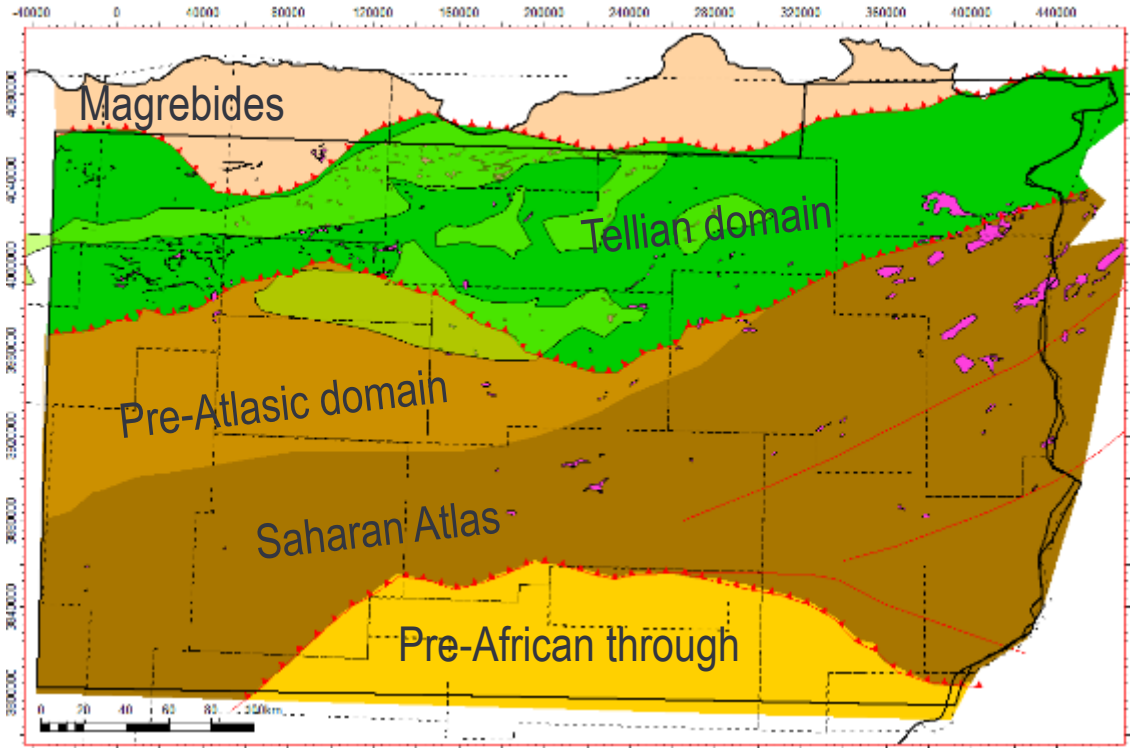


Leprêtre *et al* (2018)

1. Introduction and technical challenges

The study area presents four different structural domains:

- ❑ The Pre-African through to the South
- ❑ The Atlas domain, consisting of the Saharan Atlas and the Pre-Atlasic domains. It consists in inverted foreland Mesozoic series.
- ❑ The Tellian domain – allochtone and autochtone
- ❑ The Magrebides- Kabyle crystaline allochthone



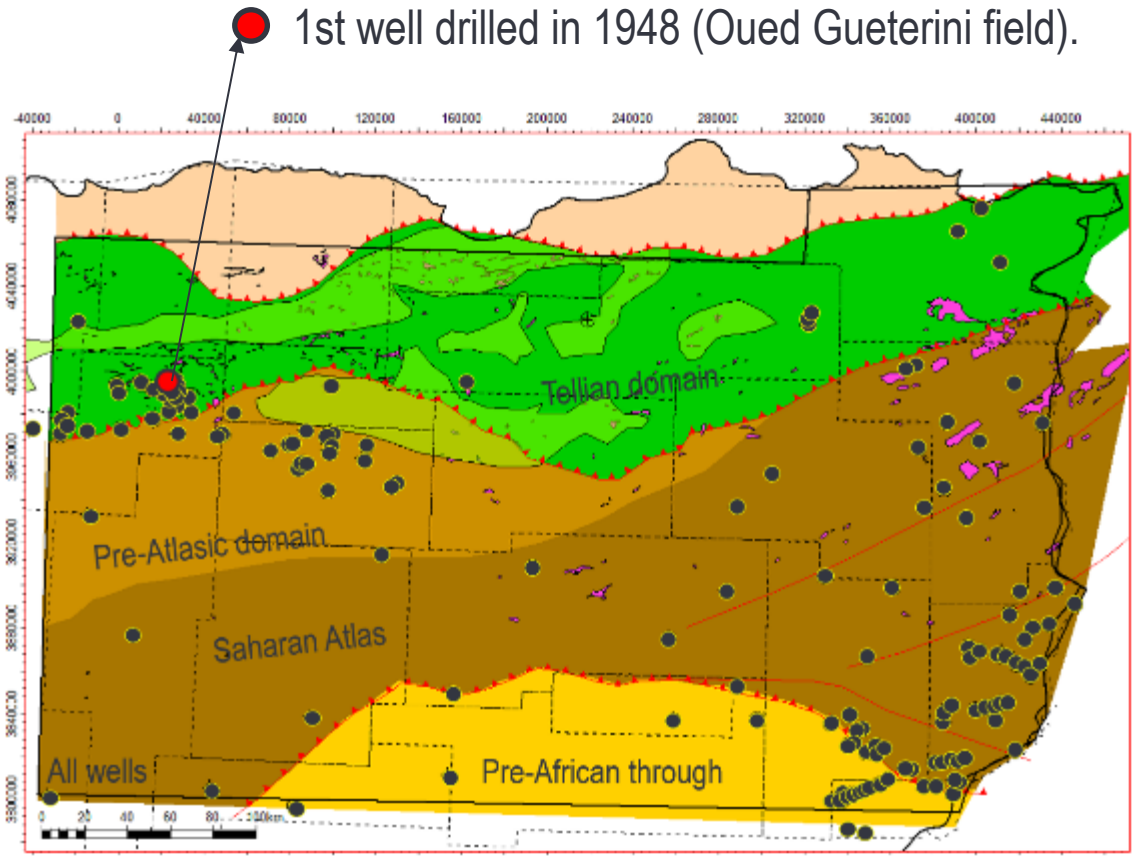
1. Introduction and technical challenges

The very first well in Algeria was drilled in the Atlas: Oued Gueterini in 1948.

Since then, over 150 wells were drilled with few discoveries being made. This is explained by the structural and sedimentological complexity of this area.

Now, this part of Algeria presents many traps, several reservoirs and source rock levels and discoveries should be made there.

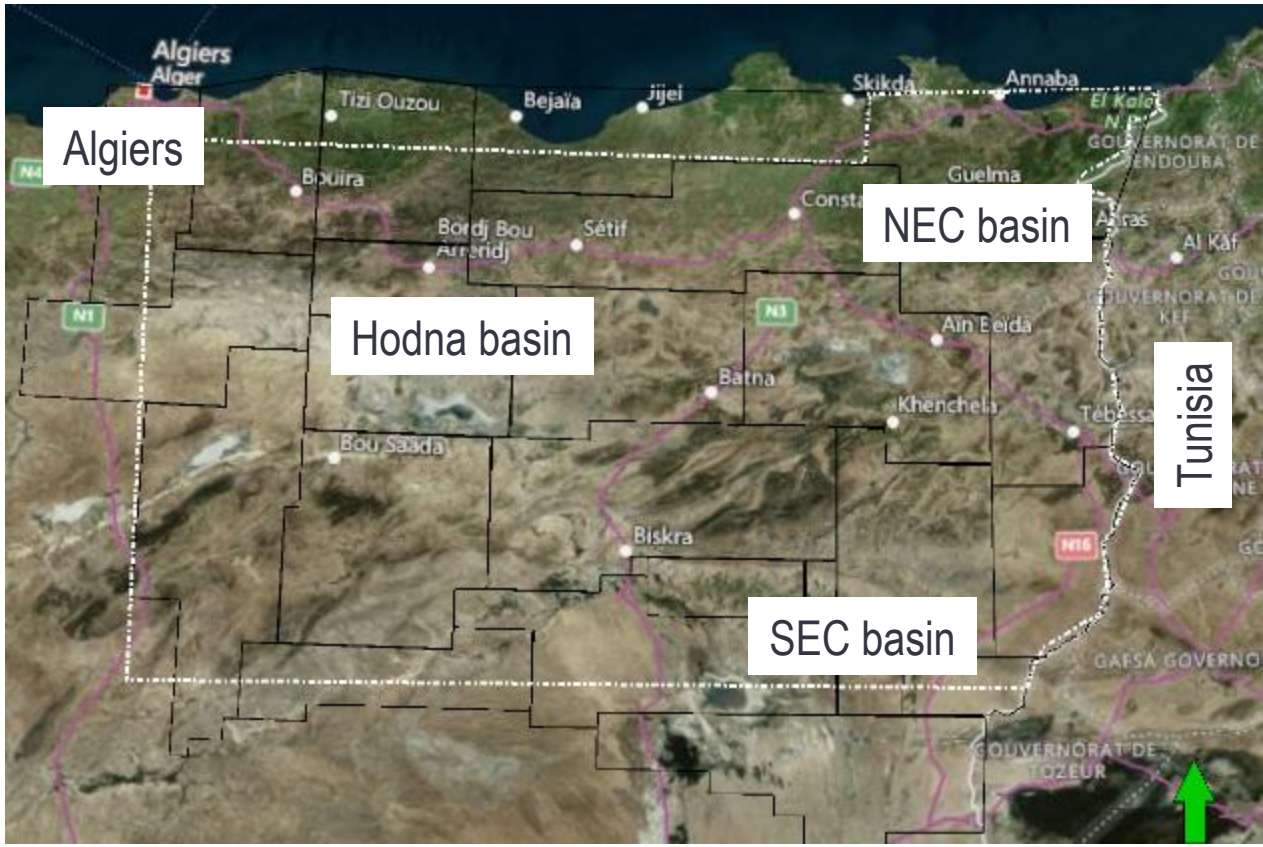
So, in 2018, it was decided to evaluate its hydrocarbon potential by making use of the latest technologies to tackle the structural, sedimentological and basin modeling challenges.



1. Introduction and technical challenges

The technical challenges, in this project, came from:

- ❑ The size of the study area: over 1/10th of Algeria and spamming on 2 UTM zones,
- ❑ Three standalone basins: Hodna, North East and South East Constantine basins,
- ❑ Structural and sedimentological complexity,
- ❑ Poor data-coverage in some part of the study area (less than one well for 1000 km^2),
- ❑ Discrepancy in data quality: data acquired from 1948 until today, in different formats….
- ❑ Over 66 GB of data to be screened, digitized, loaded and analyzed.

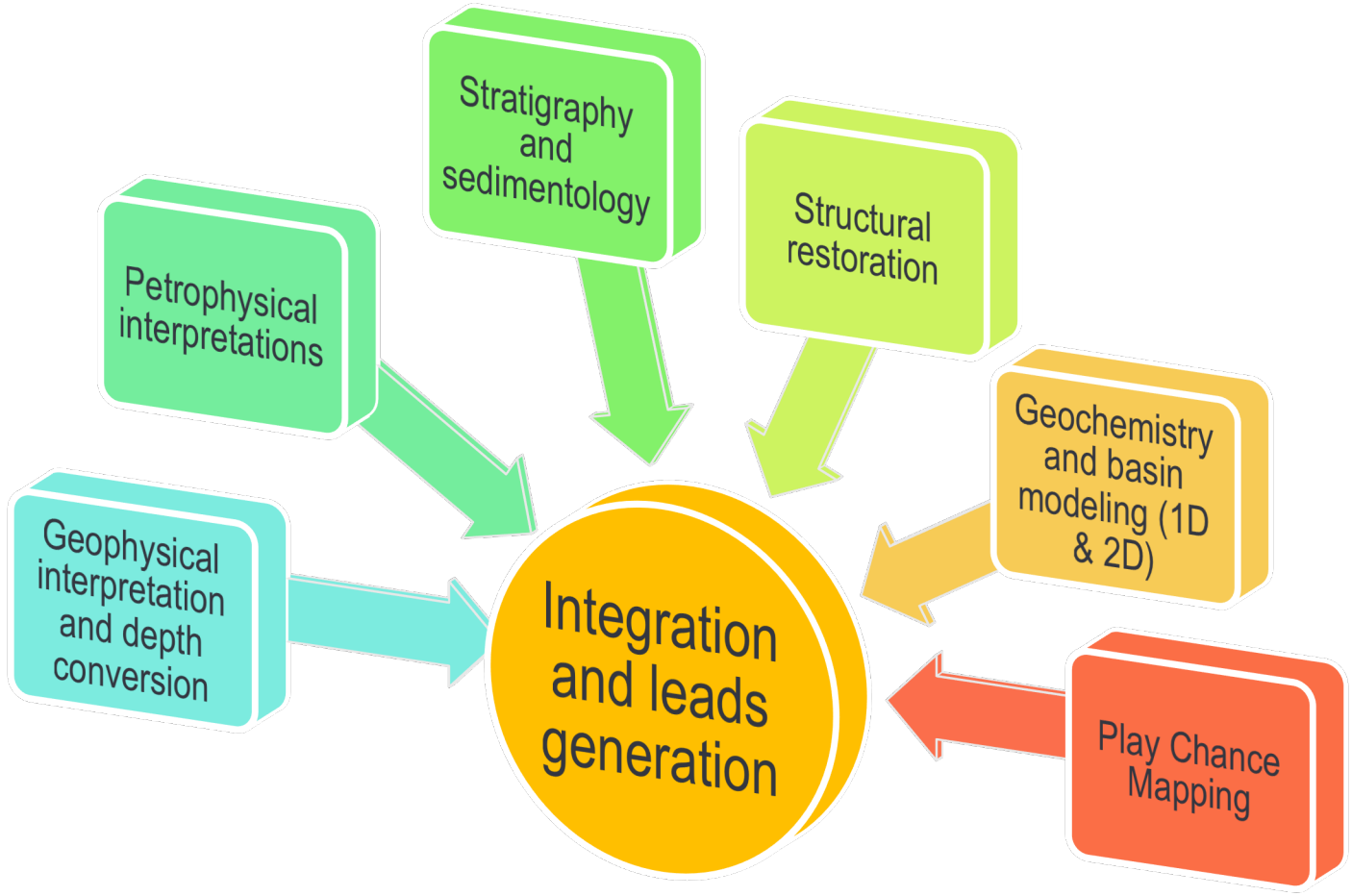


2. Collaborative workflow and database

To overcome those challenges, an integrated team of experts was brought together and a collaborative workflow established.

This workflow was implemented on SLB platforms, with Studio as the collaborative environment.

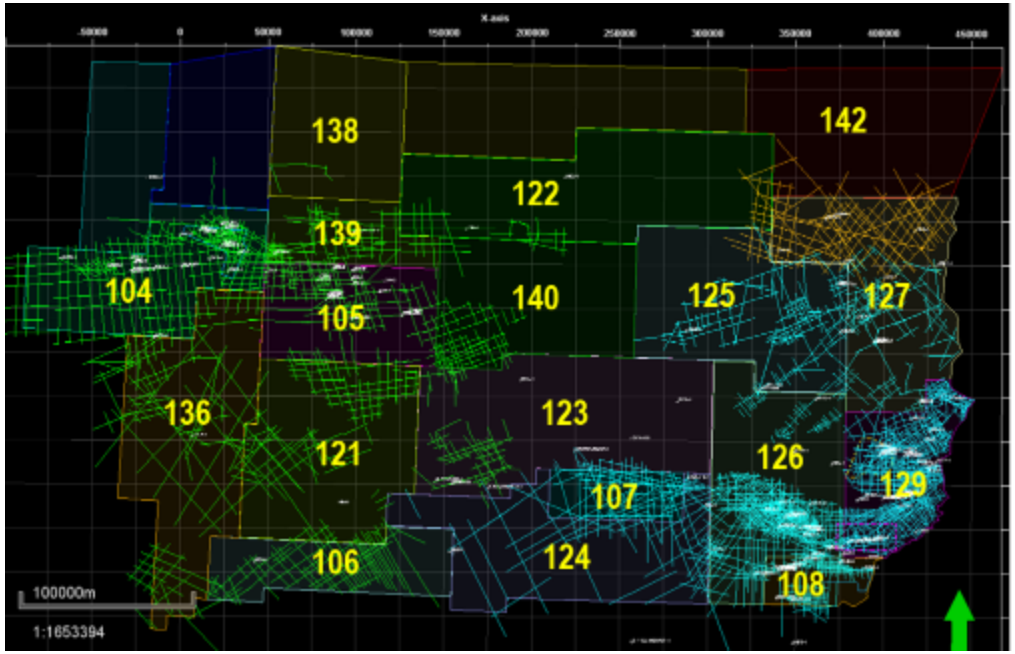
This collaborative work allowed to capture the prospectivity in the three basins, prospectivity that will be presented in the following slides.



Studio Petrel Techlog

2. Collaborative workflow and database

Over 66 GB of data were screened, cleaned, digitized, loaded in Petrel or Techlog and this consolidated input database was then pushed and stored in Studio, the Schlumberger collaborative platform allowing different disciplines to work together on the same database and to share their interpretations.



Geophysics	Petrophysics	Geology	Geochemistry
▪ 150,000 km^2 covered by seismic, ▪ 18 blocks, ▪ 118 x 2D surveys, around 4000 lines, around 50 000km of 2D seismic, ▪ 4 x 3D surveys,	▪ 132 wells with raw logs ▪ But only 84 wells with enough logs for evaluation	▪ Over 200 wells ▪ Over 300 reports ▪ 127 wells having cores	▪ TOC for 70 wells ▪ RockEval results for more than 50 wells. ▪ Biomarkers in 10 wells

3. Hodna basin overview and prospectivity

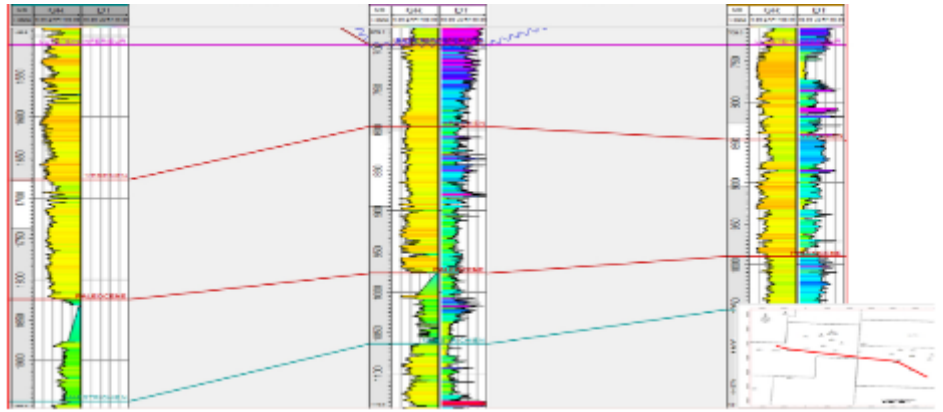
The stratigraphic succession recognized in the Hodna basin includes the series from the Triassic to the Neogene.

The complex tectonic history of the basin has affected this stratigraphic succession, which has been subdivided into autochtonous and allochtonous formations that have been thrusted from the North to the South.

Key reservoir levels are:

- Miocene (sandstone)
- Oligocene (sandstone)
- Eocene / Ypresian (Limestone)
- Turonian (Limestone)

Hodna			
	Periode	Etages	Formations
	IV		
	Pliocene		
Allochtone & Autochtone	Miocene	Miocene Inf-Sup: M3	c b a
		Miocene inf : M2 ou M2'	M2b M2a: "Serie Marno-greseuse" Allo et Autochtone
		Miocene inf : M1	
	Oligocene		Oligocene Continental
	Eocene	Lutetien	Serie Lagunaire Serie Calcaire
		Ypresien	Ypresien I Ypresien II
	Paleocene		
	Senonien		
Autochtone	Turonien		
	Cenomanien		
	Albien		
	Aptien		
	Barremien-Neocomien		
	Berriasien		
	Portlandien-Kimmeridjien		
	Oxfordien-Callovien		
	Dogger		
	Lias		
	Trias Lagunaire		
	Trias Detritique		

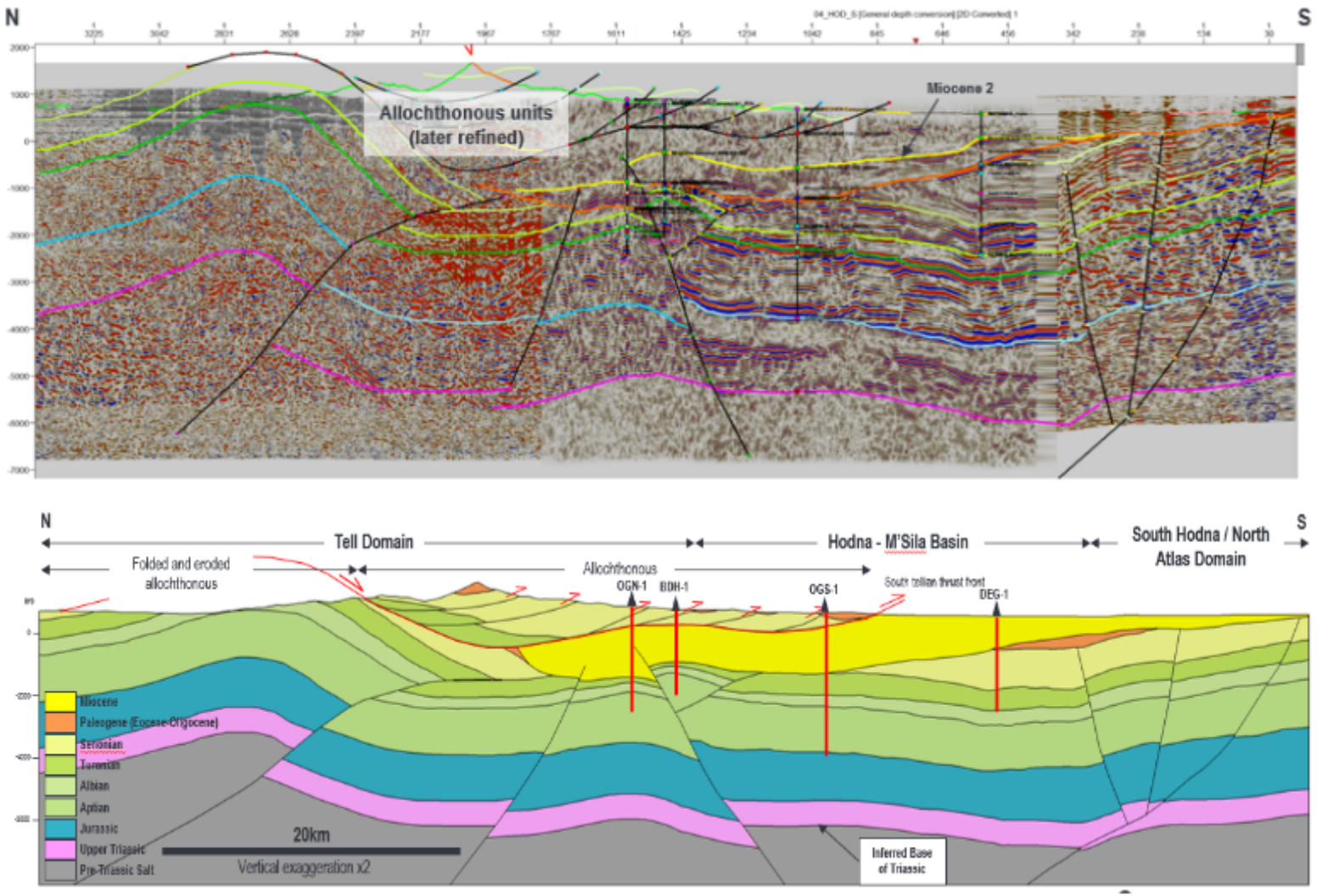


Ypresian correlation in Hodna basin

3. Hodna basin overview and prospectivity

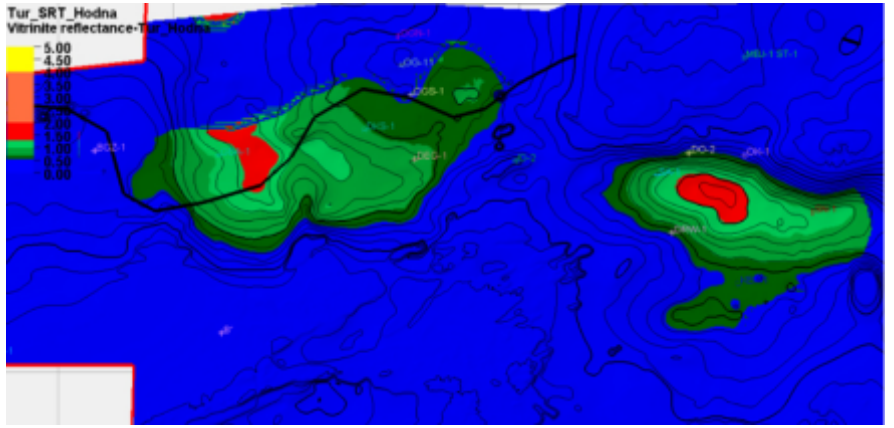
The Hodna basin displays the following structural units (from North to South):

- Tell domain characterize by an E-W-trending Anticline.
- The Allochthonous Tell Domain characterized by south-verging imbricated thrust-related folds.
- Hodna/M'Sila Basin - Miocene Depocenter.
- Atlas Domain with outcropping autochthon units.

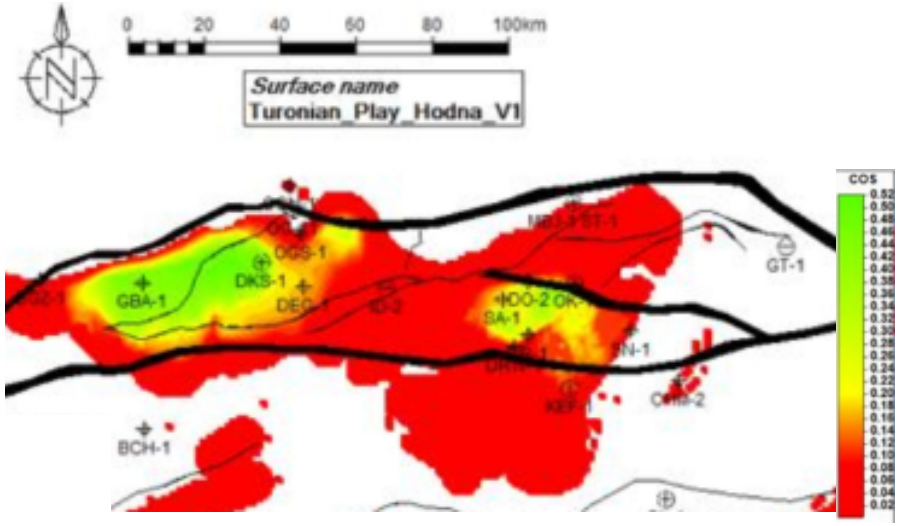


3. Hodna basin overview and prospectivity

- 11 x 1D PSM were carried out as well as 2D PSM on 4 transects crossing the basin,
- The Turonian source rock is the best source rock in Hodna basin,
- Source rocks in Eocene (Ypresian) has low maturity and corresponding low transformation ratio.
- Cenomanian: Modelled result shows transformation ratio varying from 35% to 60% in Hodna area and generation trend is more favorable towards foredeep due to reducing impact of Eocene inversion.
- Albian: Modelled results show up to 70% transformation ratio in Hodna



Modeled Lower Turonian maturity in Hodna basin



Total COS for Turonian

3. Hodna basin overview and prospectivity

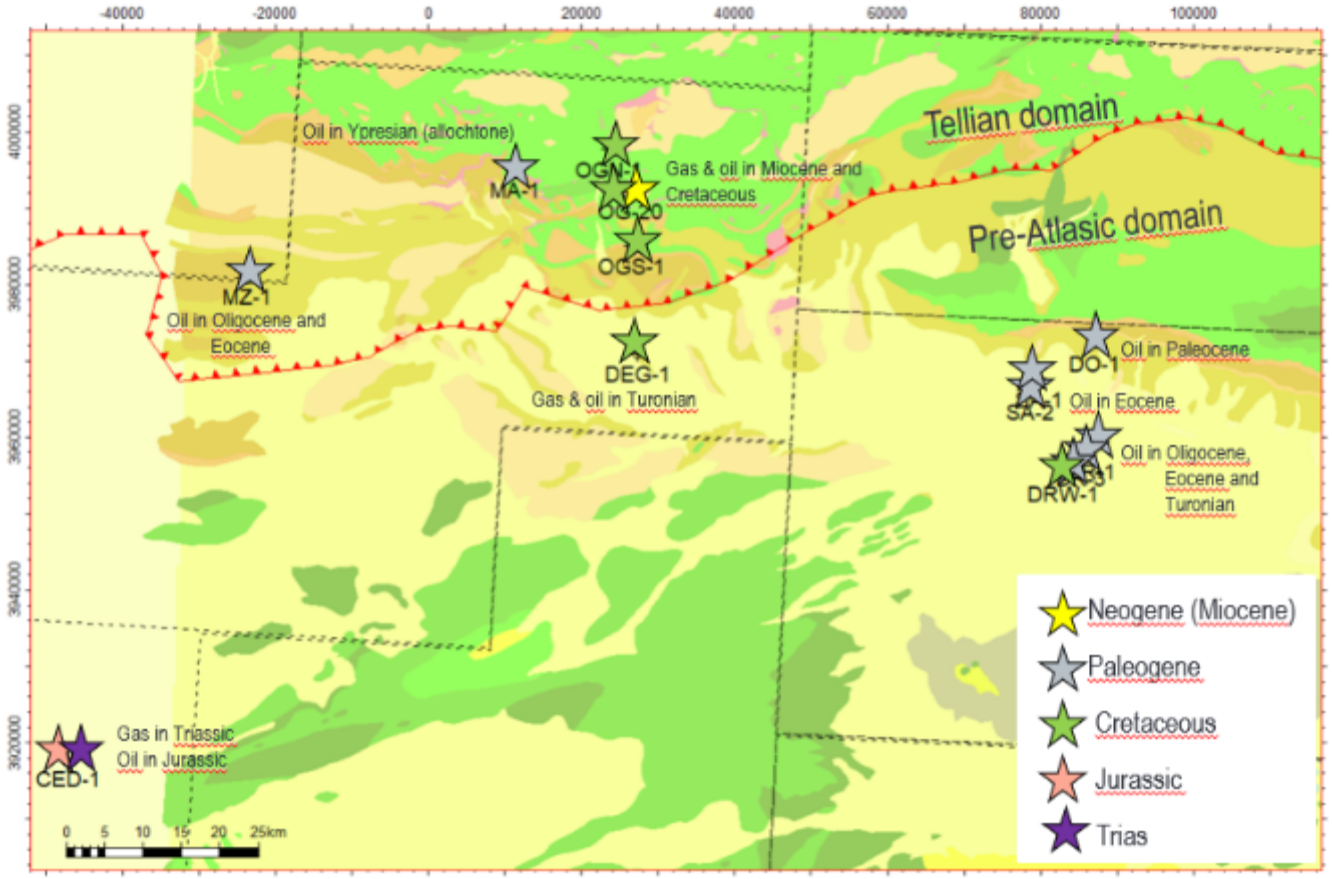
In the Hodna basin, reservoirs are mostly in Paleogene units on the Pre-Atlasic domain and Cretaceous units in the Tellian domain.

Now, oil and gas shows were reported in the Trias, Jurassic and Miocene.

Turonian, Cenomanian and Albian source rocks are also present and mature.

An Ypresian source rock may be matured under the North Atlasic fault.

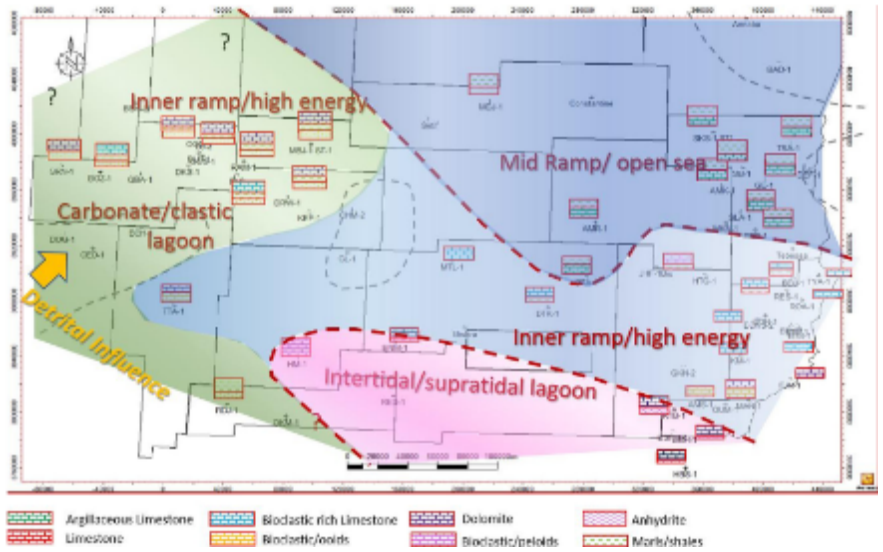
There's also a possibility of remigration of preexisting accumulation during Eocene inversion.



4. SEC basin overview and prospectivity

The stratigraphic succession recognized in the SEC includes the series that were crossed mainly from Jurassic to Tertiary. As in the Hodna Basin, the various tectonic events that have occurred in this basin are reflected in the series of Mesozoic.

Key reservoir levels are Cretaceous.



Paleogeography of the Albian carbonates

SEC				
Periode	Etages	Sous-Etages	Formations	Horizons
Quaternaire				
Pliocene			Ferkane	
Miocene			Gres de Djerid	Hz Asfar
Discordance				
Eocene	Lutetien		Souar	
			Djebs	
	Ypresien		Metlaoui	
Paleocene			El Haria	
Cretace	Senonien	Maestrichien	Abiod	
		Campanian Sup		
		Campanian Inf	Aleg Superieur	
		Santonien		
		Coniacien	Aleg Inferieur	Douleb
	Turonien			Ras Toumb
	Cenomanien		Zebbag	
	Albien	Dolomitique (Vraconien)	Zebbag Calcaire	
			Orbata	
	Aptien		Sidi-Aich/Bou Nedma	
	Barremien		Boudinar/Meloussi	
	Neocomien		Sidi Kralif	
	Malm			
	Dogger			
	Lias	Calcaire		
		Dolomitique		
Trias		Argilo-greseux		

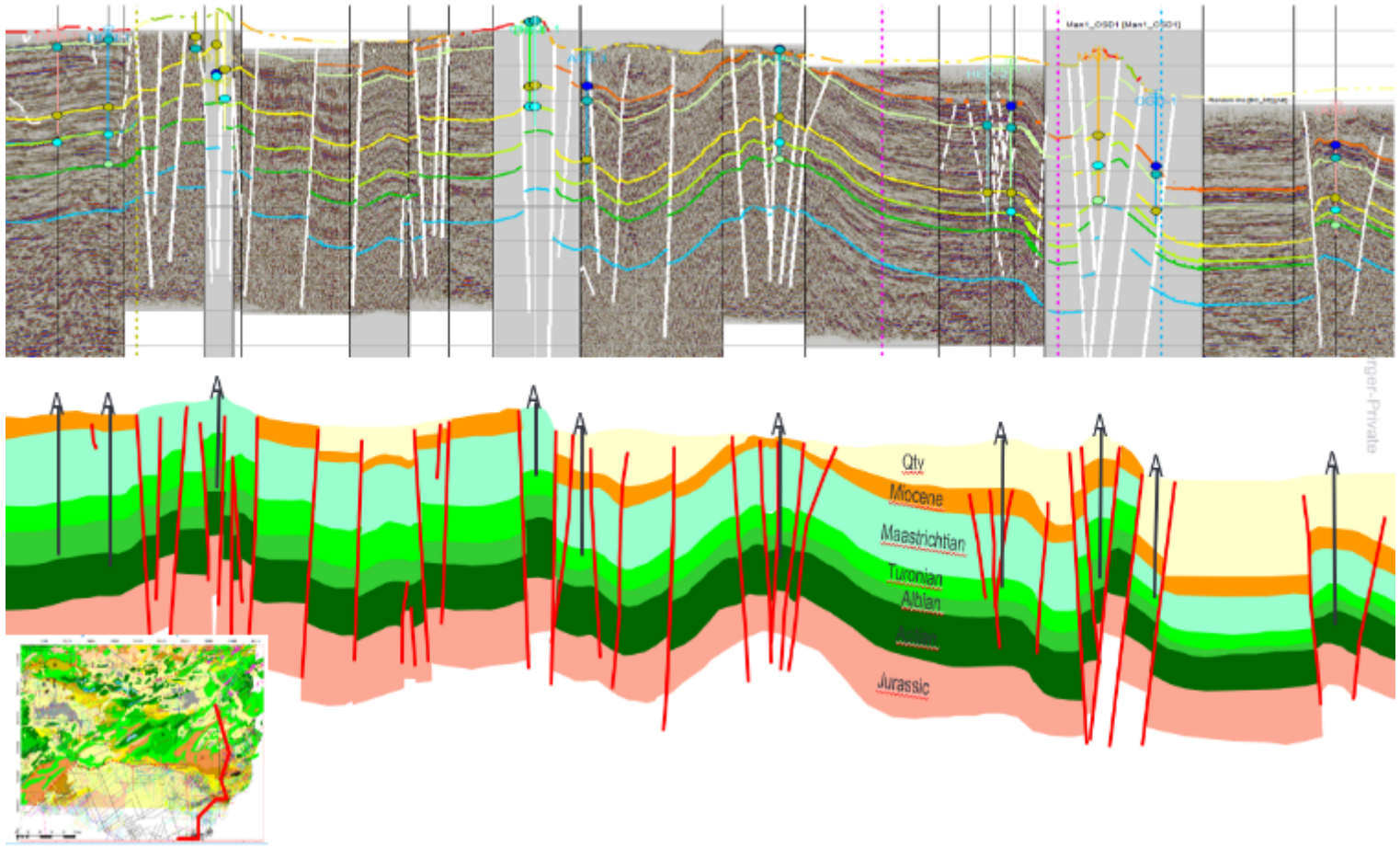
4. SEC basin overview and prospectivity

The SEC basin lays between the Atlas to the North and the Melrhir Through to the South.

Traps there formed after the tectonic inversion between the Middle Eocene and the Oligocene, which developed intense fracturing accompanied by NE-SW folding.

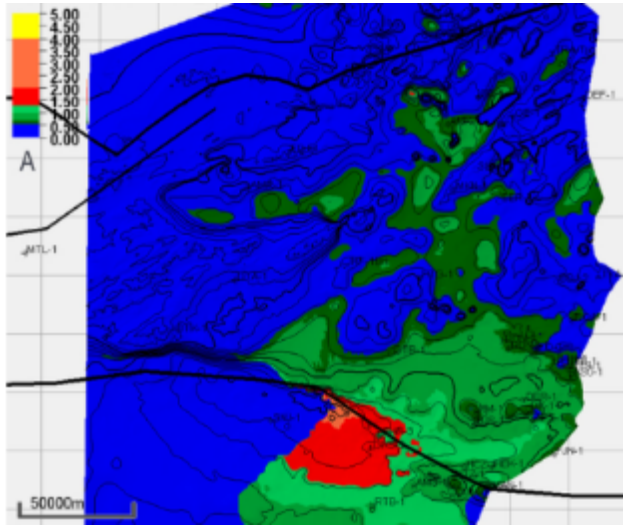
These tectonic events reactivated deep faults and were followed by an overall uplift accompanied by the rise of Triassic evaporites along longitudinal faults.

Traps are structural to mixed types. Their axial directions are NE-SW, and their meridian sides are straighter than the northern sides. They are often affected by normal or reverse faults with varying throws and directions.

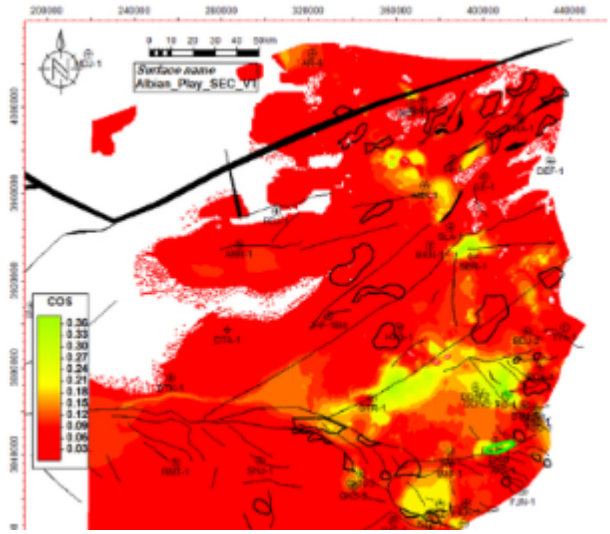


4. SEC basin overview and prospectivity

- 7 x 1D PSM were carried out as well as 2D PSM on 2 transects crossing the basin,
- The Early Turonian and late Albian (Vraconian) source rocks are the best in the SEC basin,
- Paleotemperature trend exhibit wider distribution than Hodna
- Source rocks in Eocene (Ypresian) has low maturity and corresponding low transformation ratio.
- Turonian: Modelled result shows transformation ratio up to 70% in SEC. Modelled results shows hydrocarbon generation has favorable conditions due to limited impact of post Eocene inversion on generation
- Albian: Modelled results show up to 40-100% in SEC area. Transformation and generation is favorable.



Maturity of Late Albian



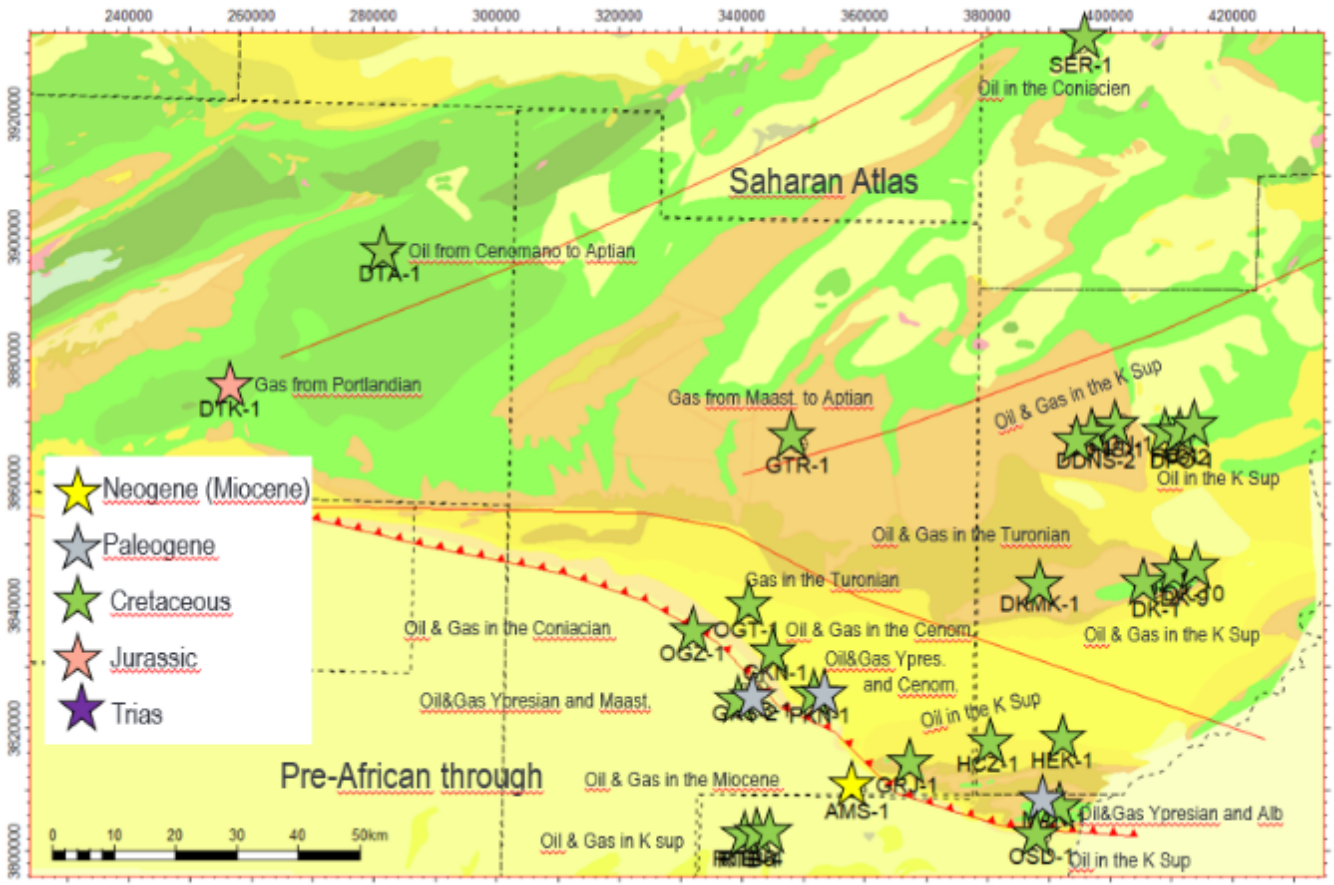
Late Albian COS

4. SEC basin overview and prospectivity

In the SEC basin, reservoirs are mainly Cretaceous with oil and gas shows reported from Jurassic, Paleogene and Neogene units.

Traps are mostly structural.

And the source rocks are Turonian, Cenomanian and Albian.



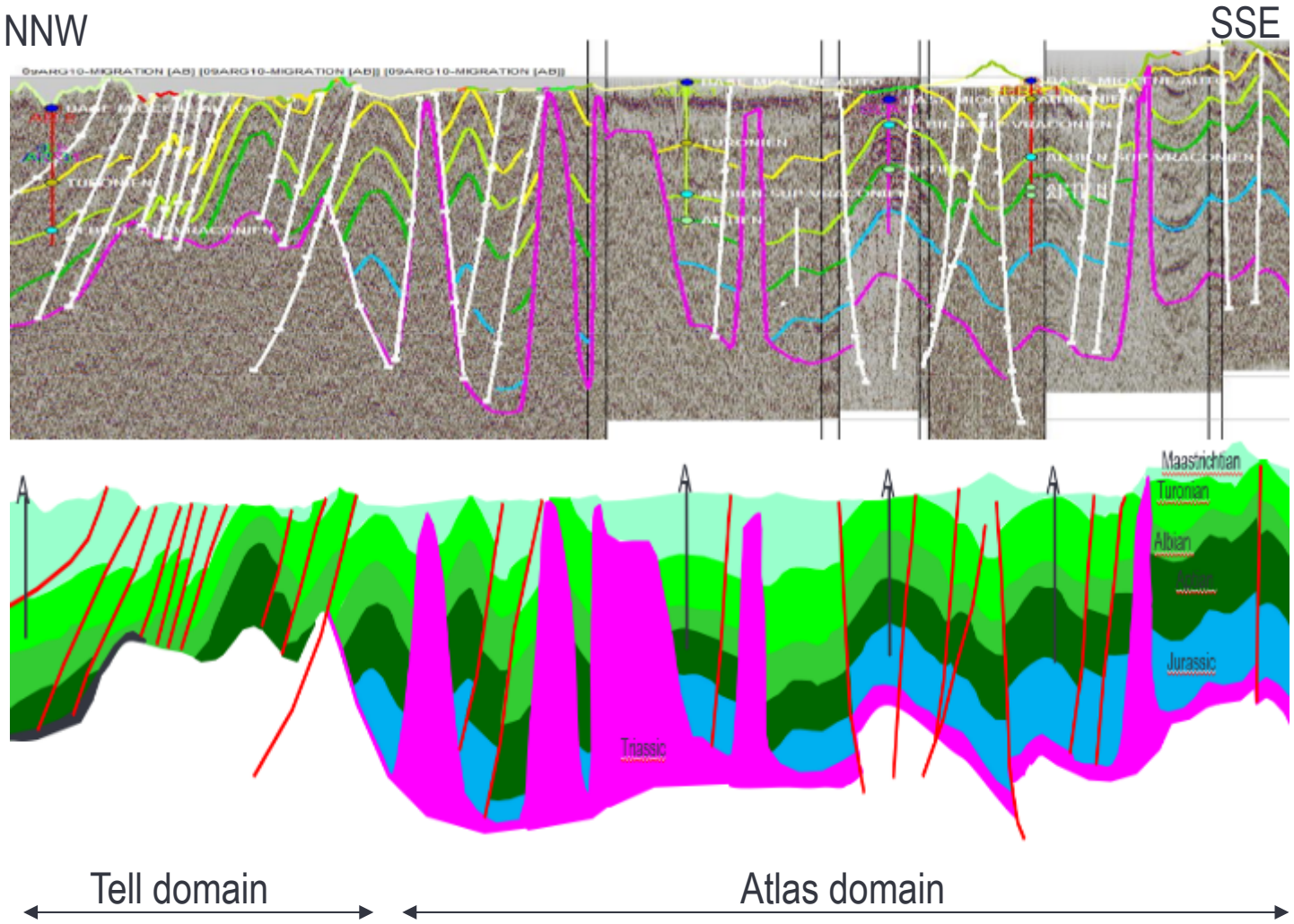
5. NEC basin overview and prospectivity

The NEC basin stratigraphy is similar to SEC and Hodna basins.

Two structural domains are expressed in this basin:

- The Tell domain to the North with imbricated south-vergent thrust systems with a thin-skinned structural style (Triassic detachment)
- The Atlas Domain to the South whith a change in the structural style from E-W to NE-SW, diapirs and thick Paleogene units.

No Play Chance Mapping analysis has been done in this basin as no source rock was intersected. Now two positive tests are indicating a working petroleum system there.



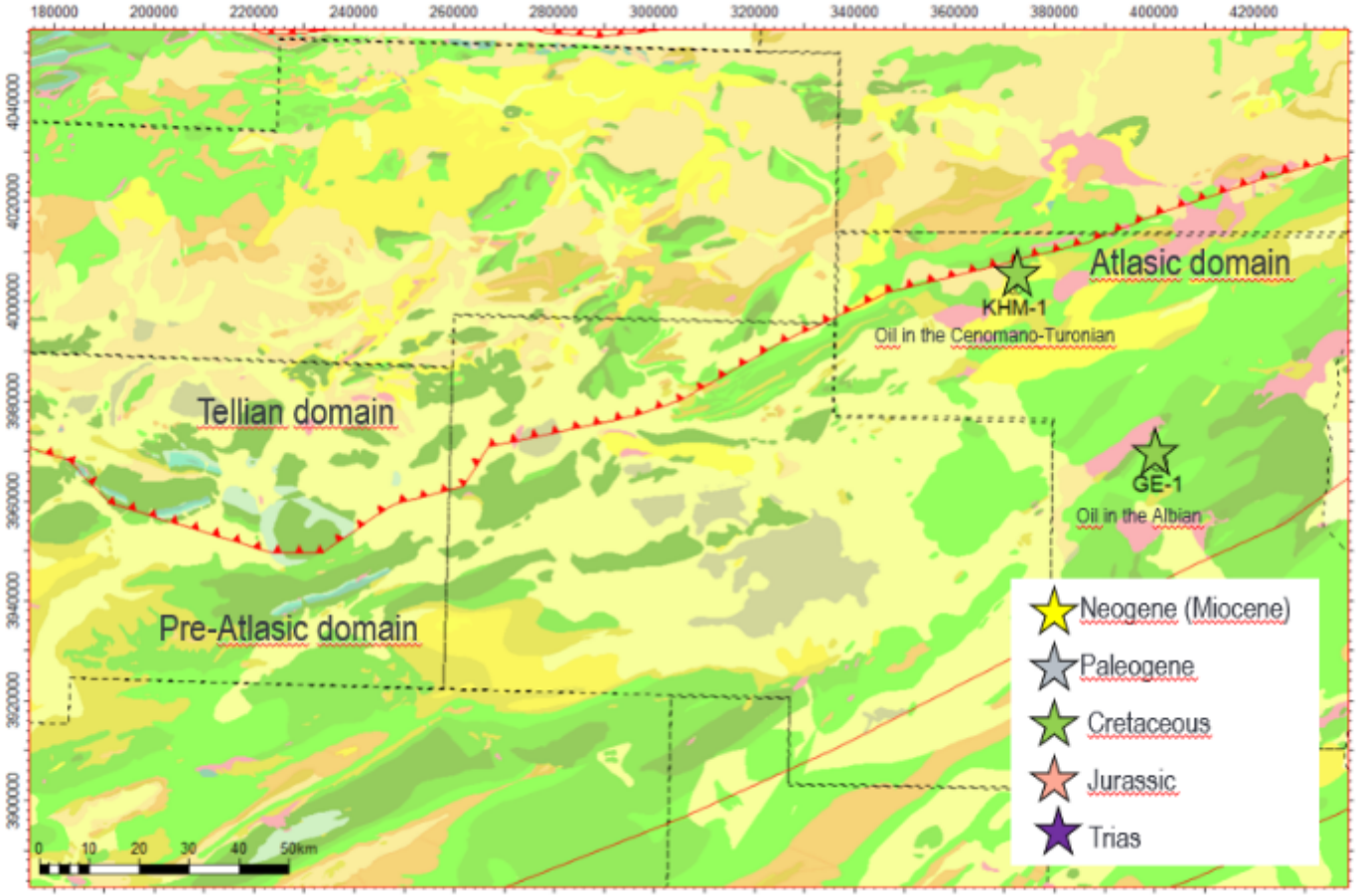
5. NEC basin overview and prospectivity

In the NEC basin, reservoirs are mainly Cretaceous.

Triassic salt remobilization impacted the deposition of reservoirs and created stratigraphic and structural traps.

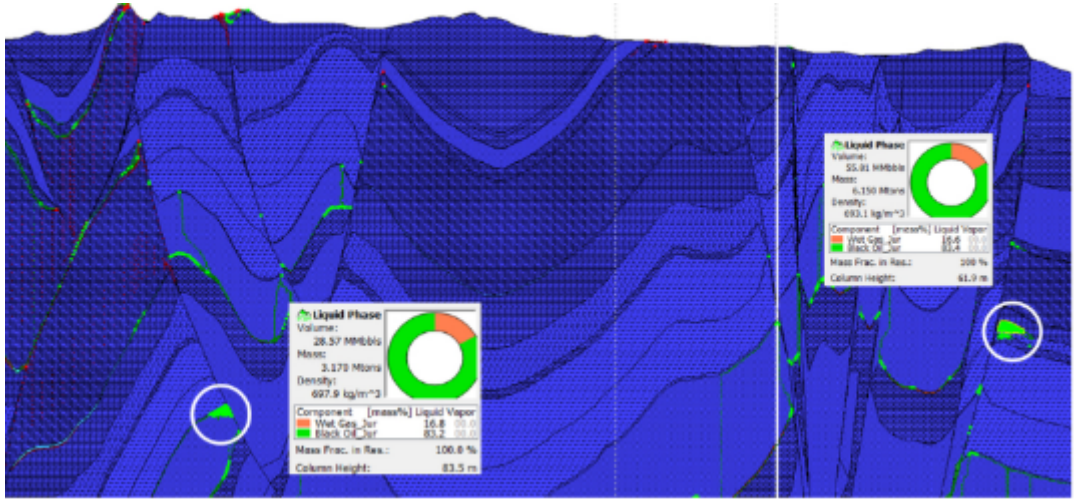
There're few wells in this basin and none has intersected a source rock.

Now two wells had positive oil tests, proving the existence of a working petroleum system model.

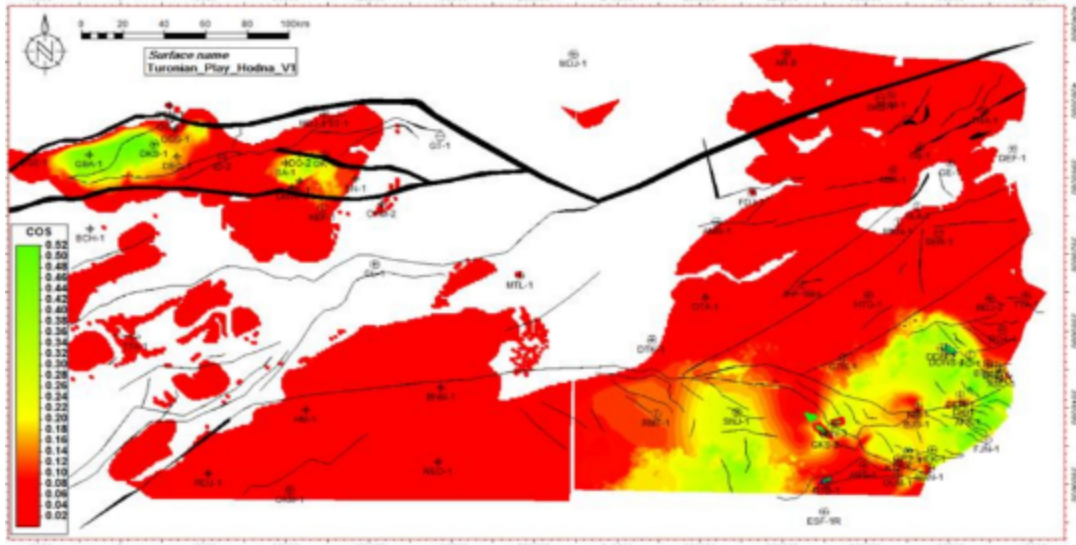


6. Conclusions

- The collaborative work followed in this project allowed to capture the prospectivity in Hodna, South East and North East Constantine basins. It's implementation on Petrel, Techlog and Studio was key for the project success.
- Among the three studied basins, the SEC basin is the most promising with new discoveries to be made in the Cretaceous.
- Prospectivity in Hodna basin is constrained by the restricted kitchen area. Now, this basin has a potential for new discoveries.



2D PSM



Turonian COS

6. Thanks

We would like to thank ALNAFT and Schlumberger teams that worked on the project:

ALNAFT team:

L. Adour,
M. Djidjeli,
O. Bouderbalah,
N. el Hayat Allal,
Y. Mokrani,
A. Dalil,
M. Guellati,
Y. Maksene,
A. Dahleb,
A. Razkallah,
J. Djellouli,
A. Debaili,
H. Habani

Schlumberger team:

A. Dubois,
M. Samy,
N. Maache,
D. Bora,
C. Darous,
T. Joppen,
M.A.M. Perez,
A. Haddouche,
G. Forrest,
O. Boumaiel,
F. Amraoui,
F. Zeghbib,
K. Kecili,
S. Alem,
R. Boudissa,
M. Dalachi,
S. Mehay,
K. Peters,
Y. Sahar,
M. Tchambaz,
R. Davies