

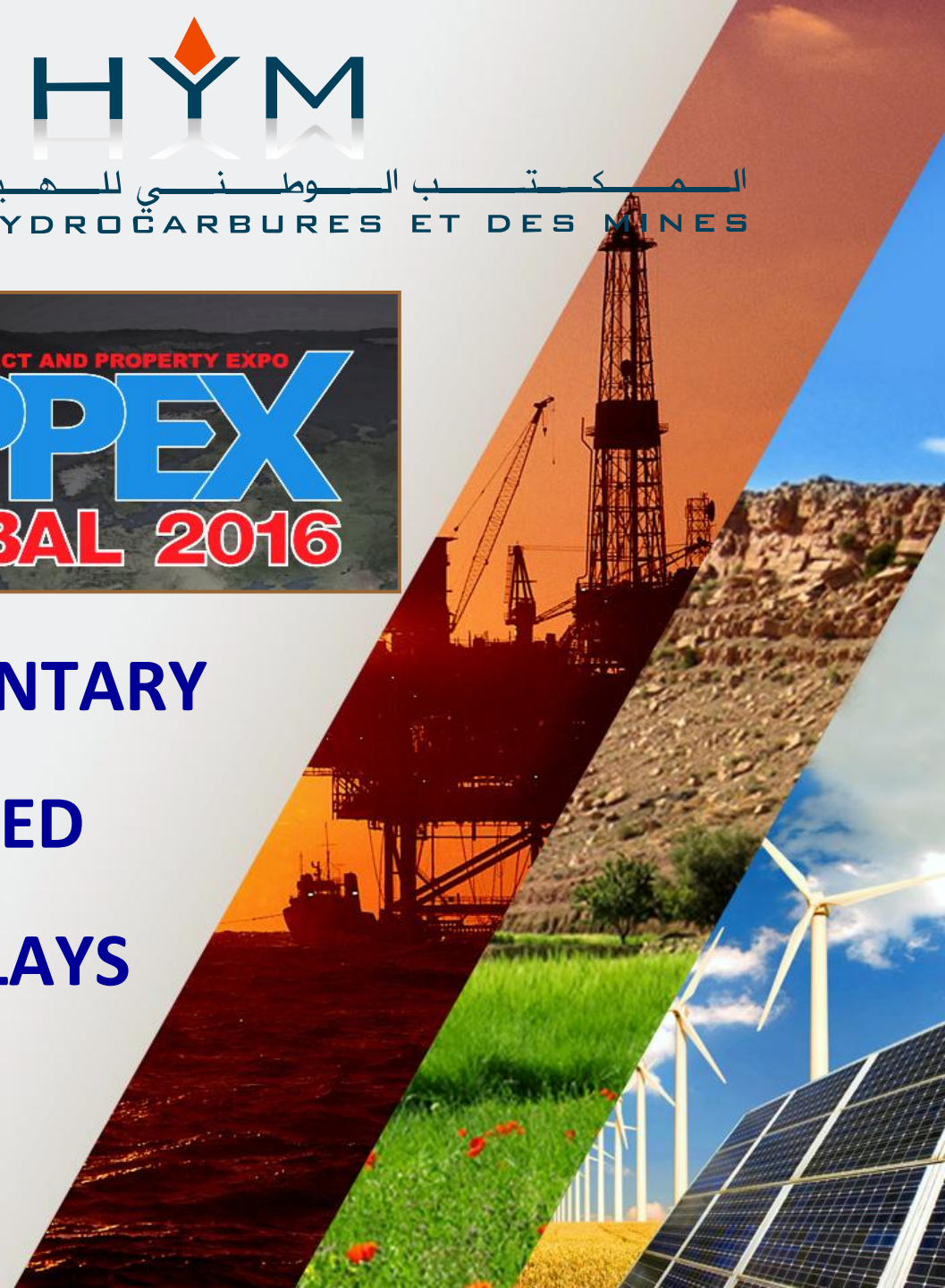


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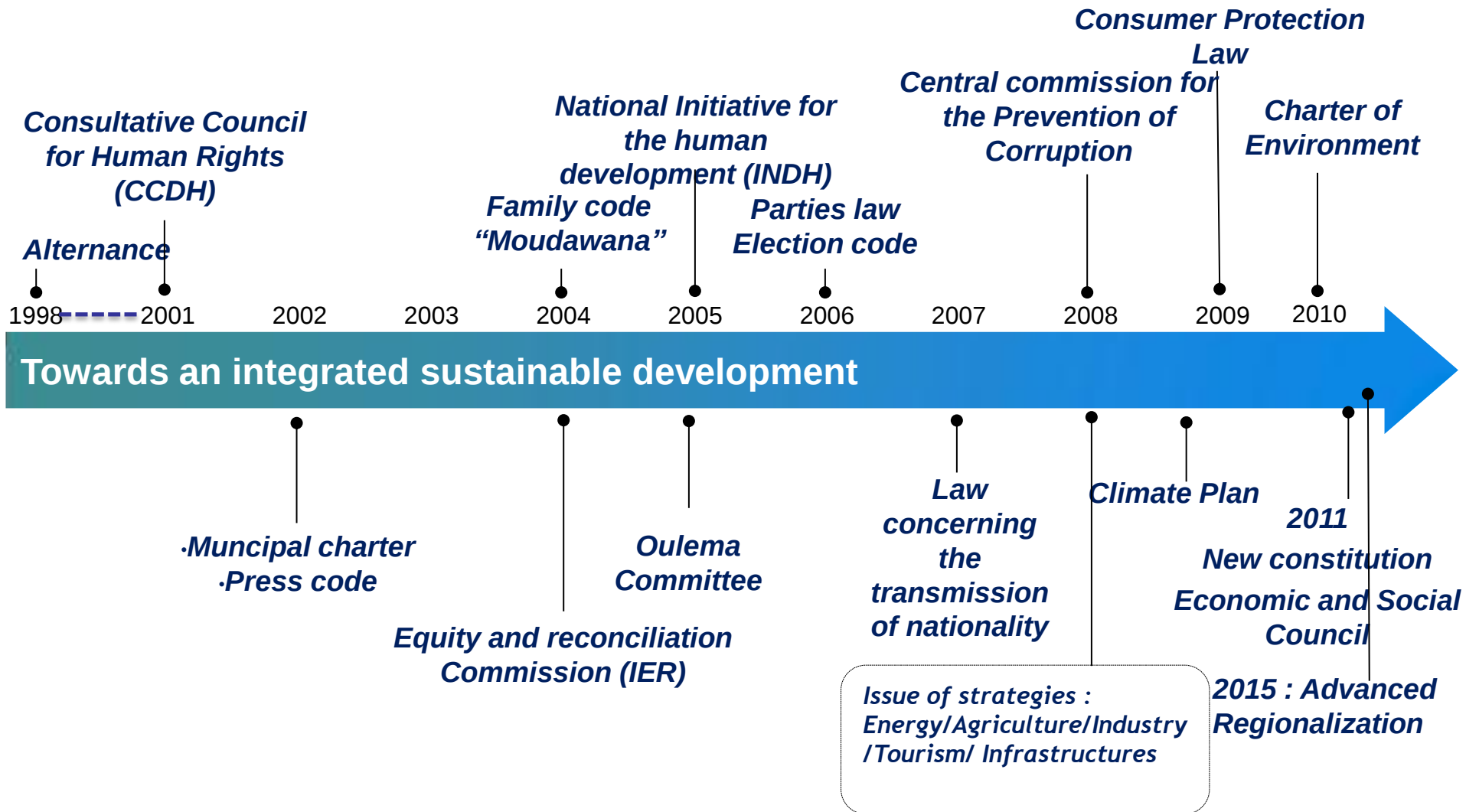


MOROCCAN SEDIMENTARY BASINS: IDENTIFIED HYDROCARBON PLAYS

A. BENARCHID, A. AIT SALEM



MOROCCO: AN INTEGRATED DEVELOPMENT

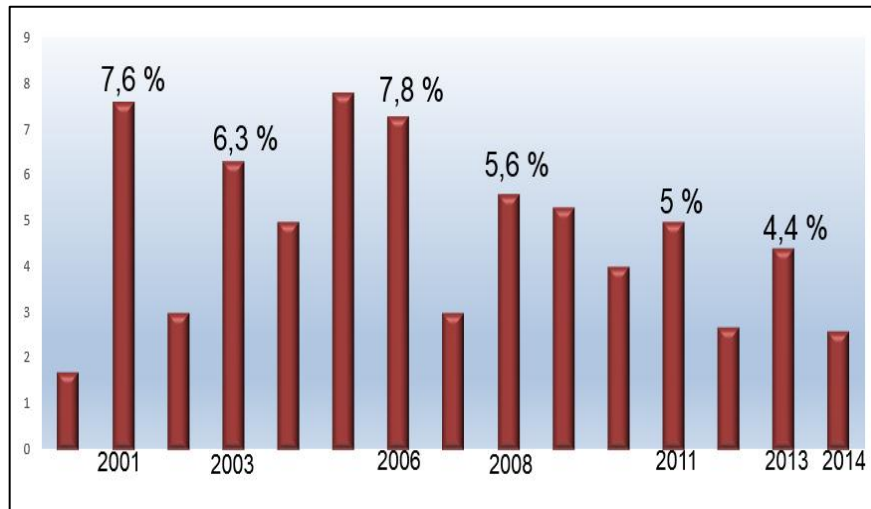


THE ENERGY SECTOR

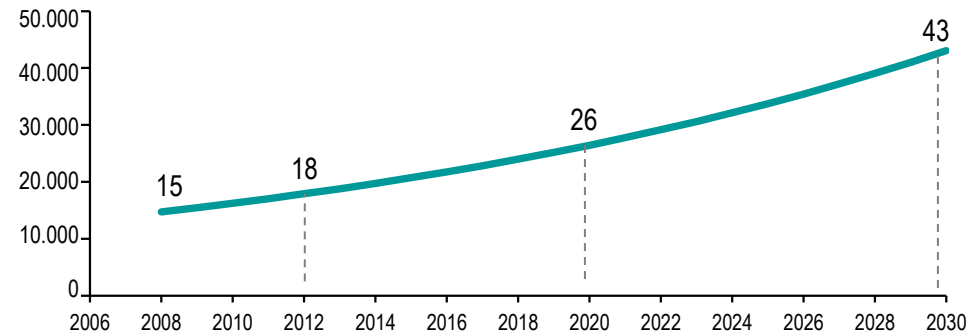
Morocco's demand in:

- **Primary energy : X2 BY 2020 AND X3 BY 2030**
- **Electricity: X2 BY 2020 AND X4 BY 2030**

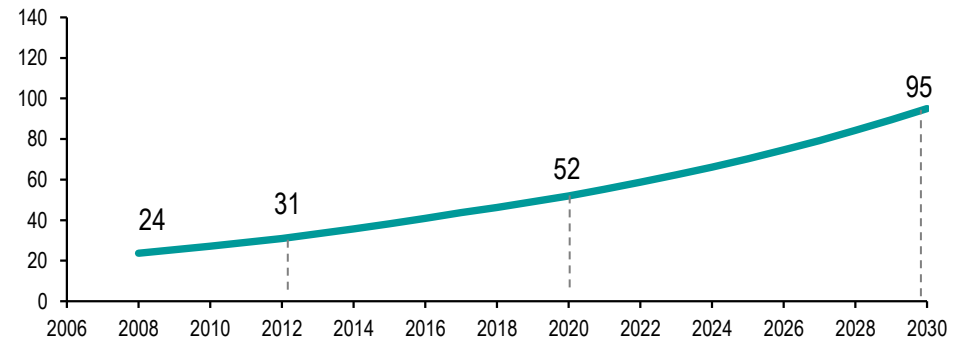
GDP GROWTH : 5%/ YEAR



CONSUMPTION IN MILLIONS TEP

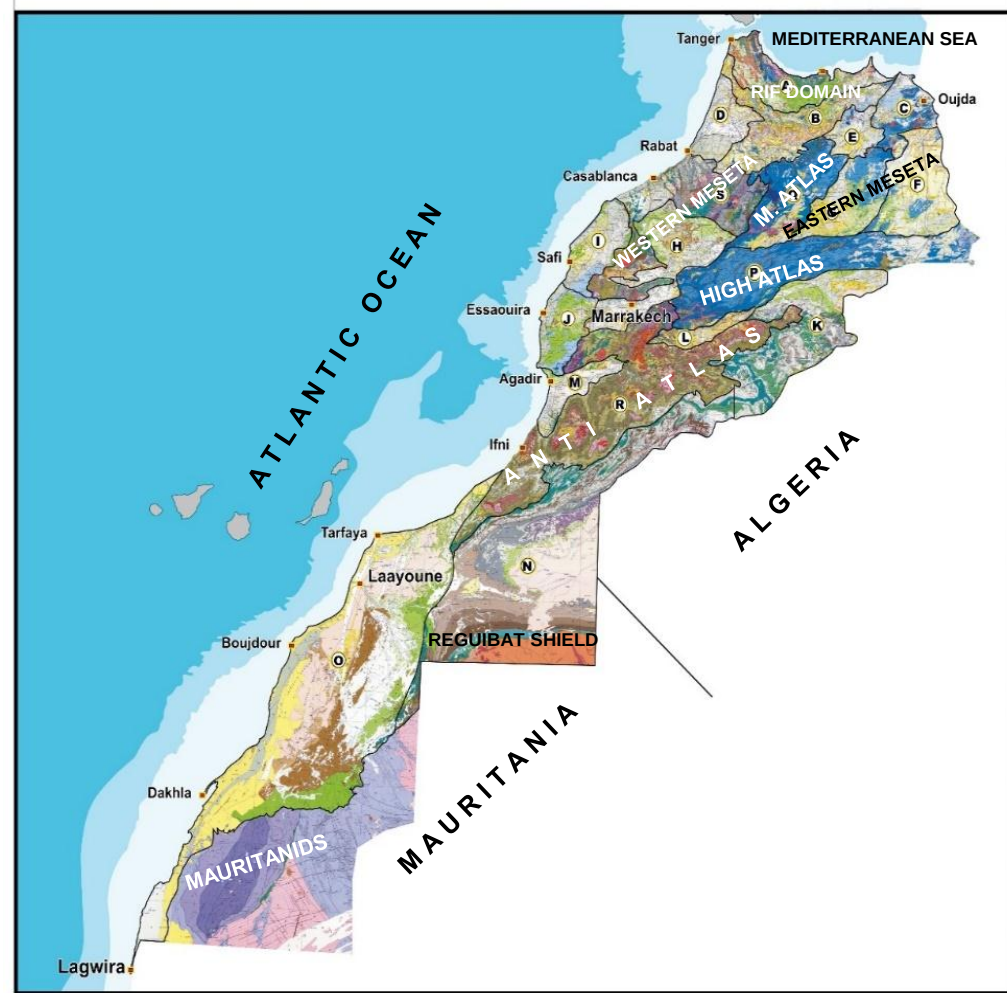


CONSUMPTION IN TWH

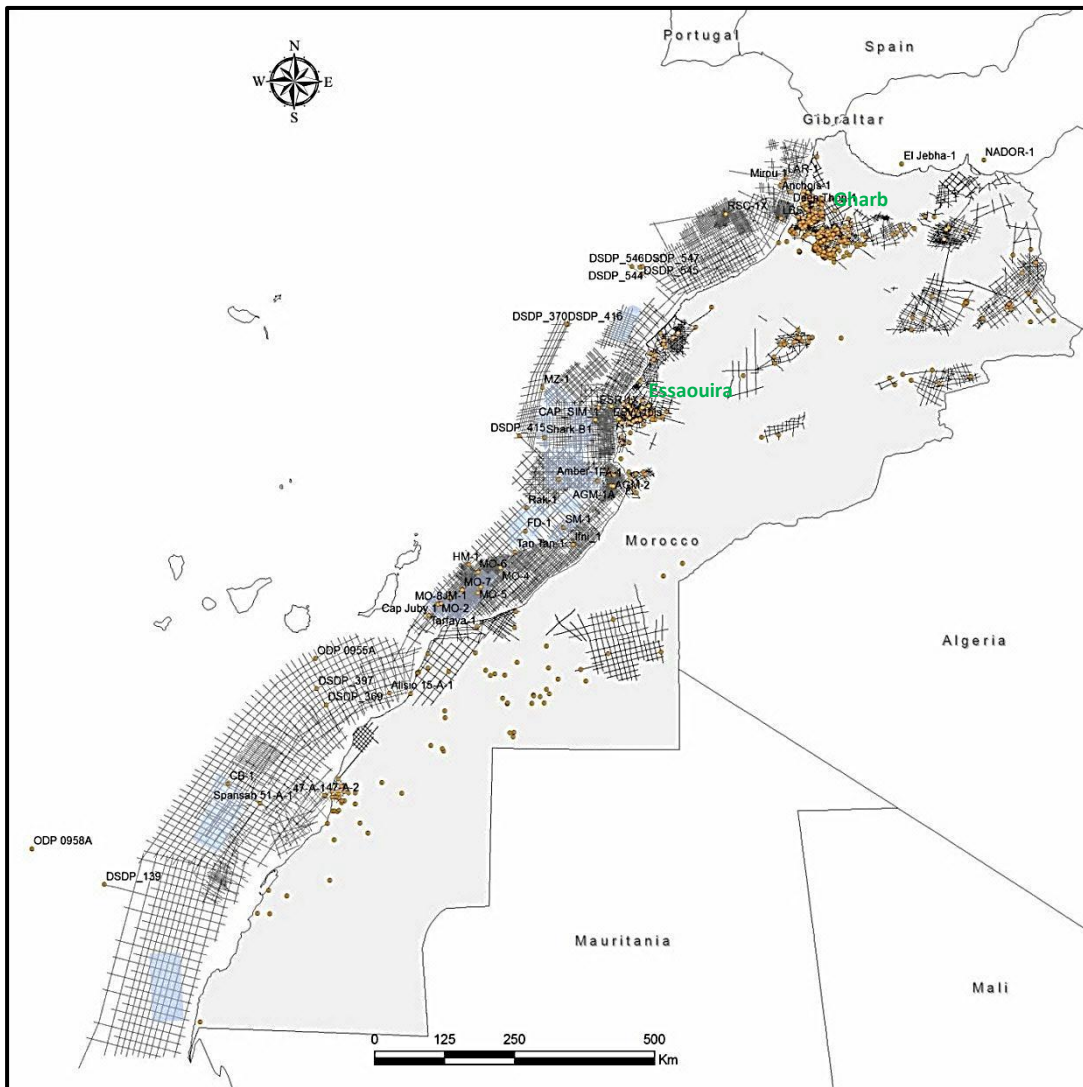


MOROCCAN SEDIMENTARY BASINS

- **Large sedimentary basins of several geological and structural types** : Total surface area : **918 237Km²**.
 - **A very extended offshore domain**: **3 000 km** coast line on the Atlantic and **500 km** on the Mediterranean sea.
- Total surface: 300 000 Km² (to 4 000 m bathymetry), consisting of Mesozoic and Cenozoic sedimentary basins.**
- **A various onshore sedimentary basins**: Objectives ranging from Precambrian to Neogene



EXPLORATION SNAPSHOT : OFFSHORE & ONSHORE



SEISMIC & WELLS DATABASE

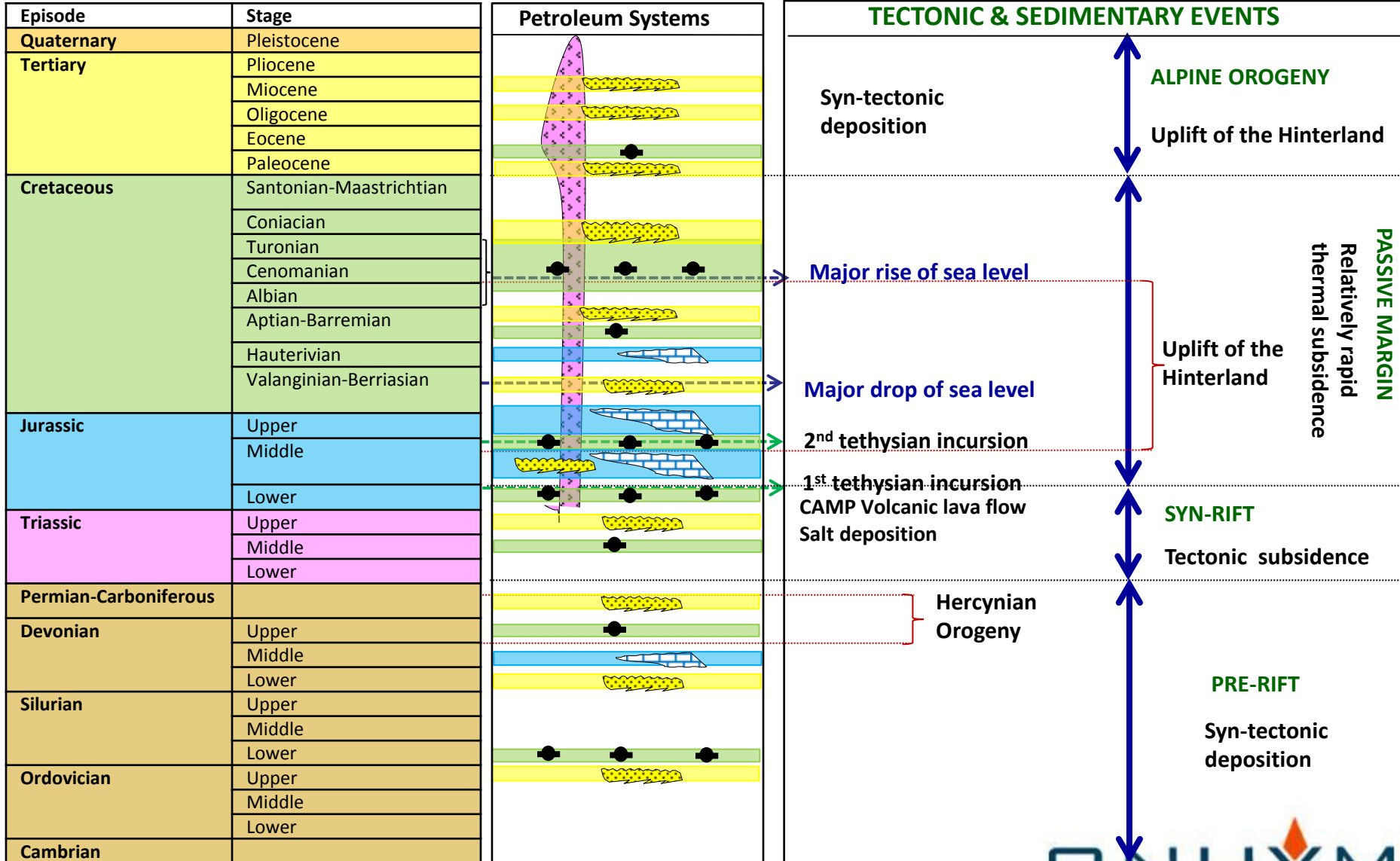
Seismic (2000-2015) :

- 2D Seismic: 88 934Km
- 3D Seismic: 49 331Km²

Exploratory Wells:

- 43 wells offshore (41 in the Atlantic & 2 in the Mediterranean)
- 293 wells Onshore

GEOLOGICAL SNAPSHOT & PETROLEUM SYSTEMS

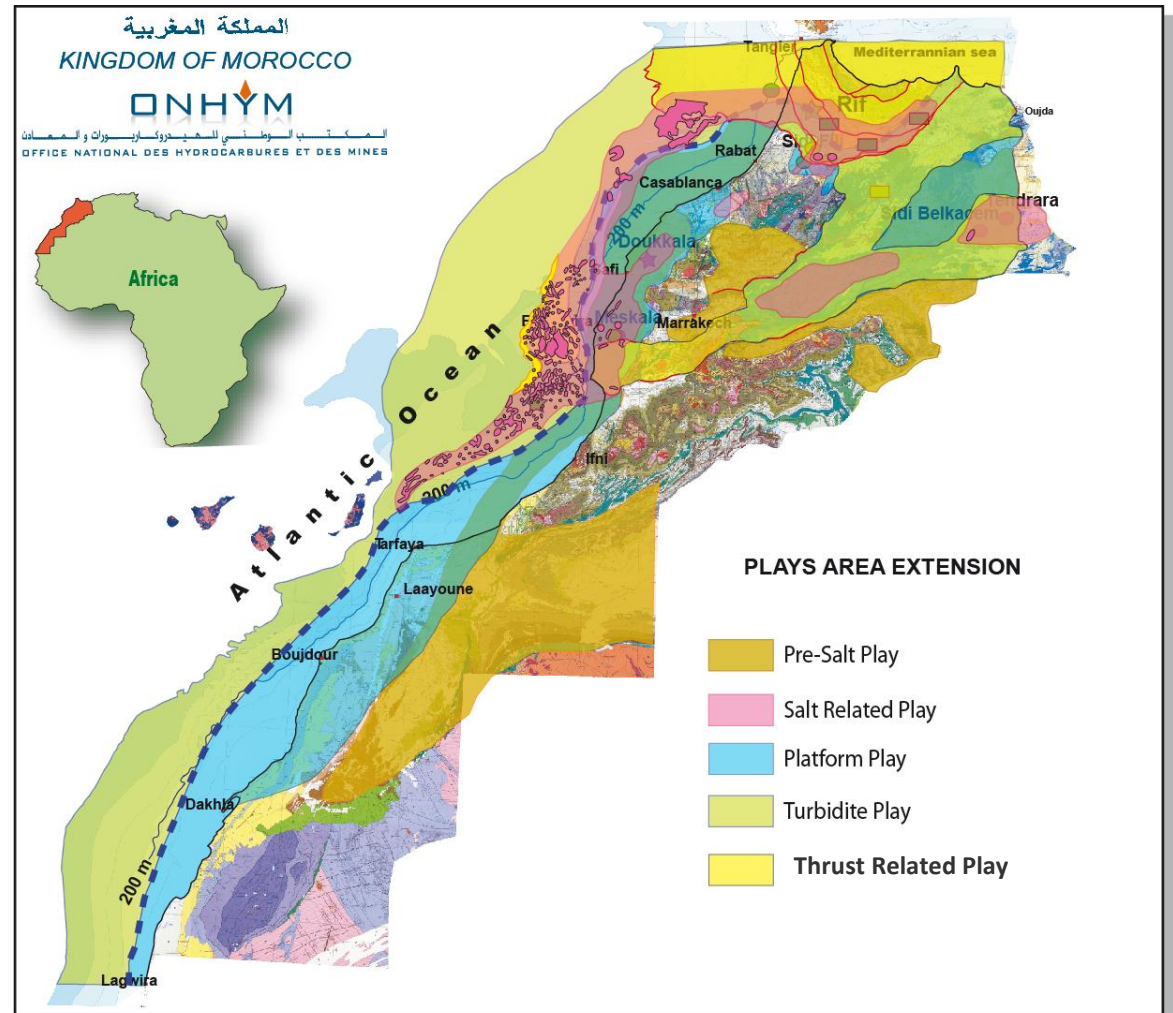


HYDROCARBON PLAYS

■ Identification of different plays widely extending in space and geological time:

- Pre-Salt Play
- Salt Related Play
- Platform Play
- Turbidite Play
- Thrust Related Play

■ The presence of these plays has been proven by the exploration works undertaken and the limited hydrocarbon discoveries made so far.





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HYDROCARBON PLAYS :

PRE-SALT PLAY

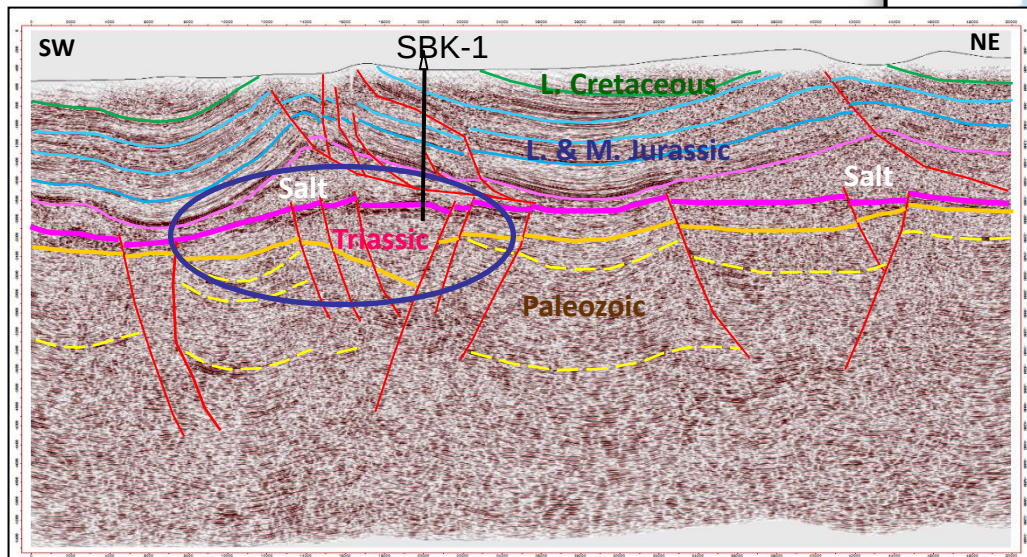
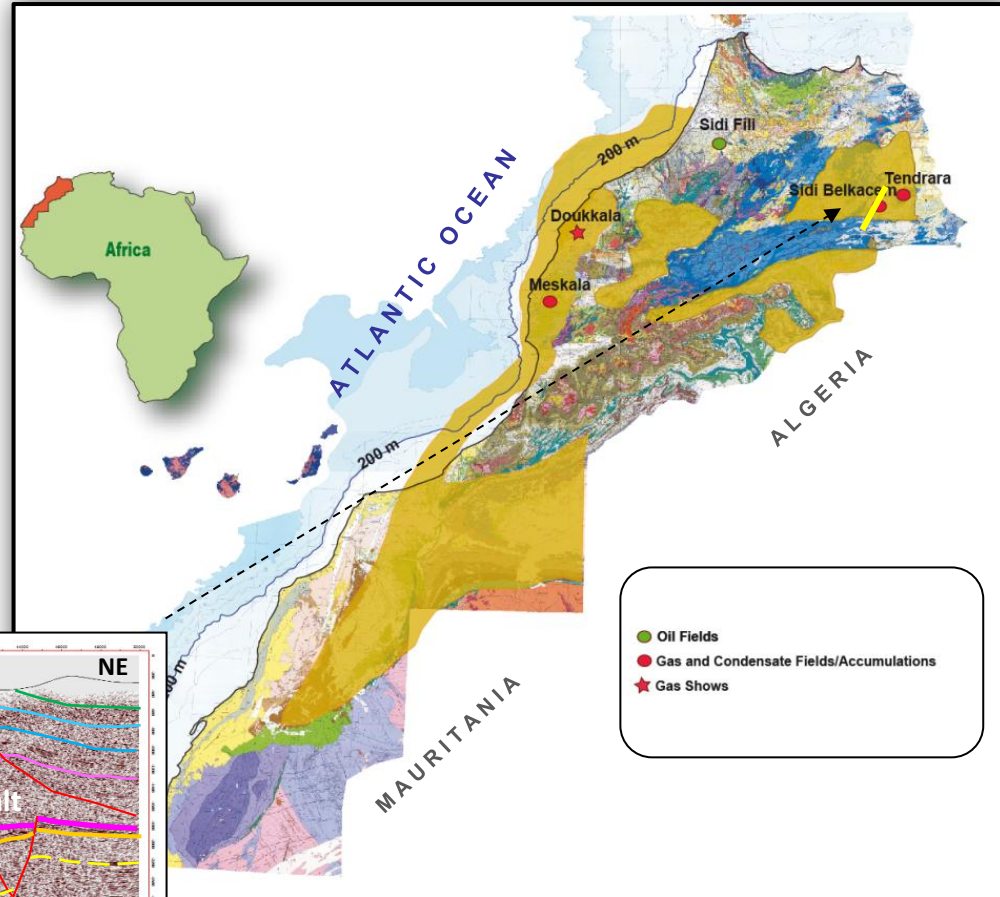


PRE-SALT PLAY: EXTENSION & OBJECTIVES

Paleozoic and Triassic objectives

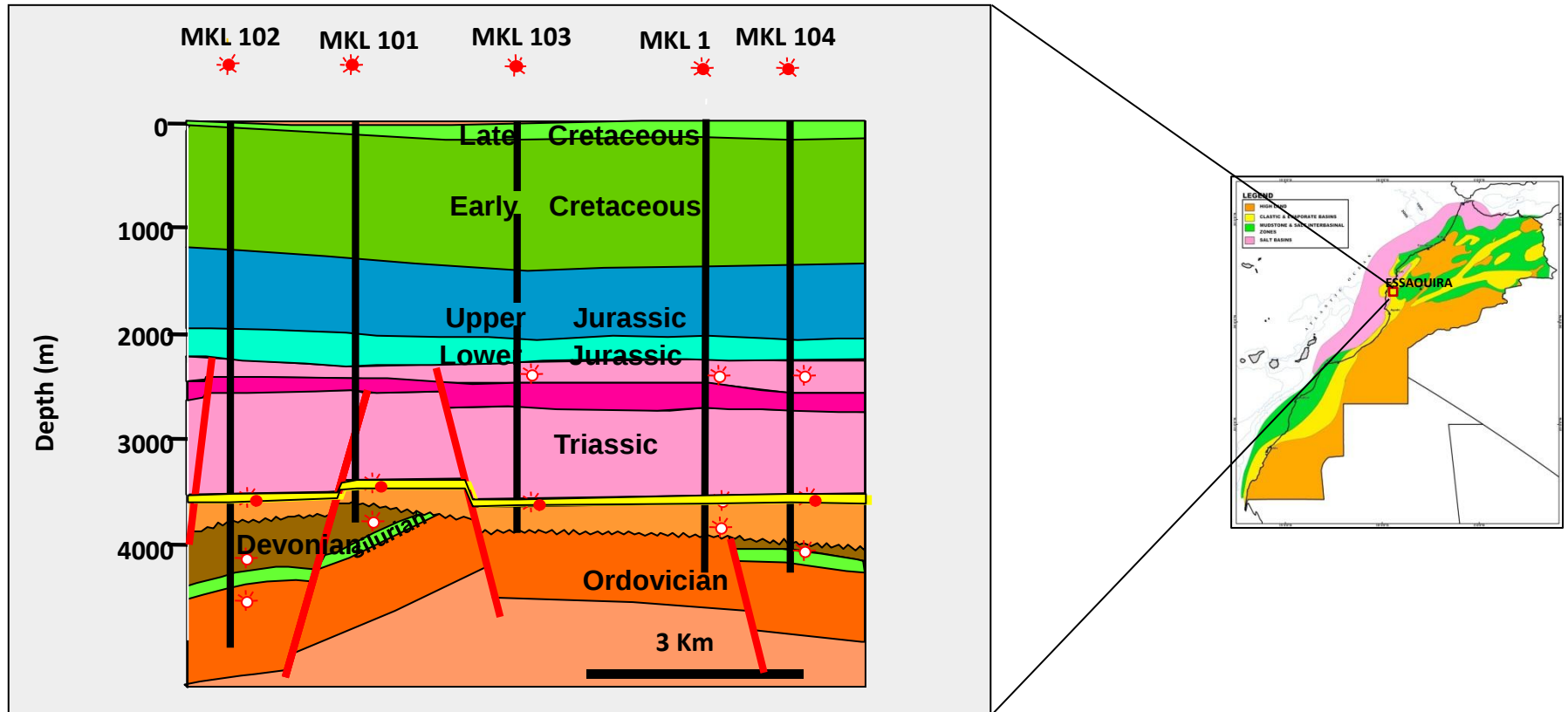
Petroleum Systems:

- **Source Rock** : Silurian hot shale, Frasnian shale & possible Triassic lacustrine
- **Migration**: Vertical through faults & lateral
- **Reservoir** : Ordovician sandstones, Devonian carbonates and Triassic sandstones (TAGI)
- **Seal**: Palaeozoic interbedded shale & marls and Triassic & Liassic interbedded shale & salt
- **Trap**: Hercynian structures, Faulted tilted blocks and accommodation anticlines



PRE-SALT PLAY: DISCOVERIES

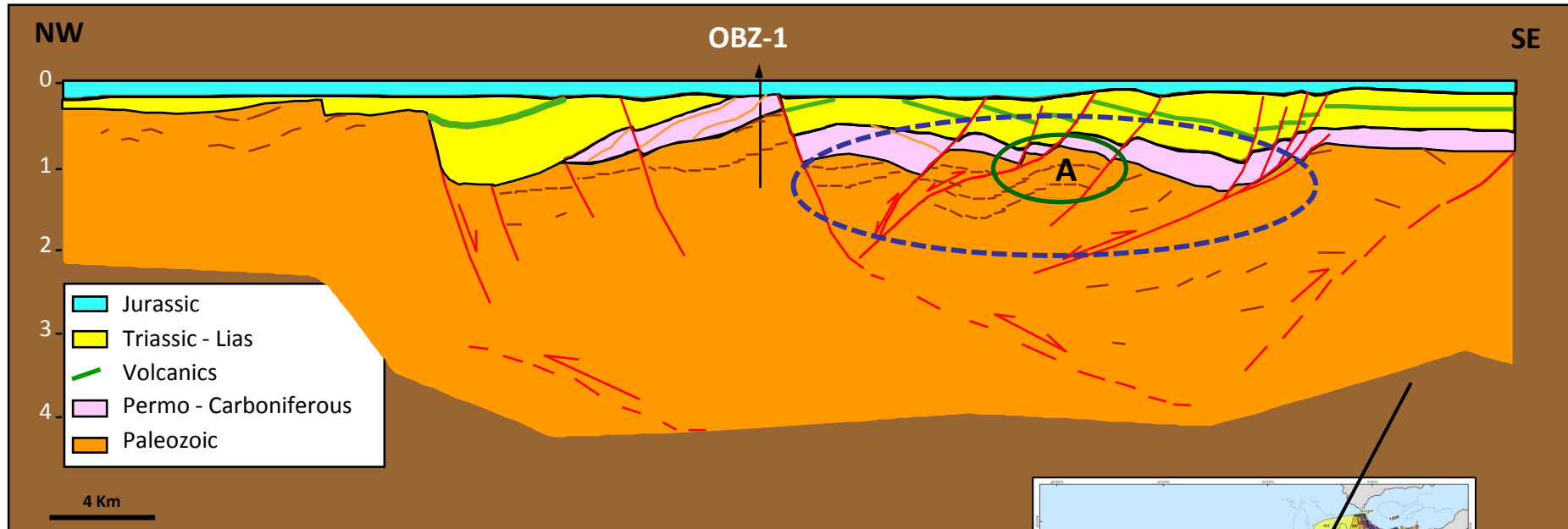
Example of Meskala field-Essaouira Basin



- Discovered in 1980
- Gas and condensate field
- 1 exploration well
- 9 appraisal & development wells and 4 producing wells

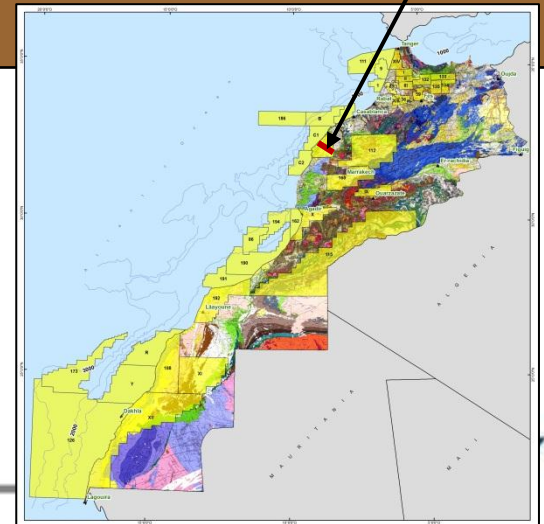
PRE-SALT PLAY: REMAINING PROSPECTIVITY

Onshore Doukkala basin



Remaining Prospectivity:

- Triassic sandstones in accommodation anticlines created by rift normal faults with opposite vergence
- Paleozoic carbonates and sandstones in hanging wall anticlines associated with reverse faults (A)





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HYDROCARBON PLAYS : SALT RELATED PLAY

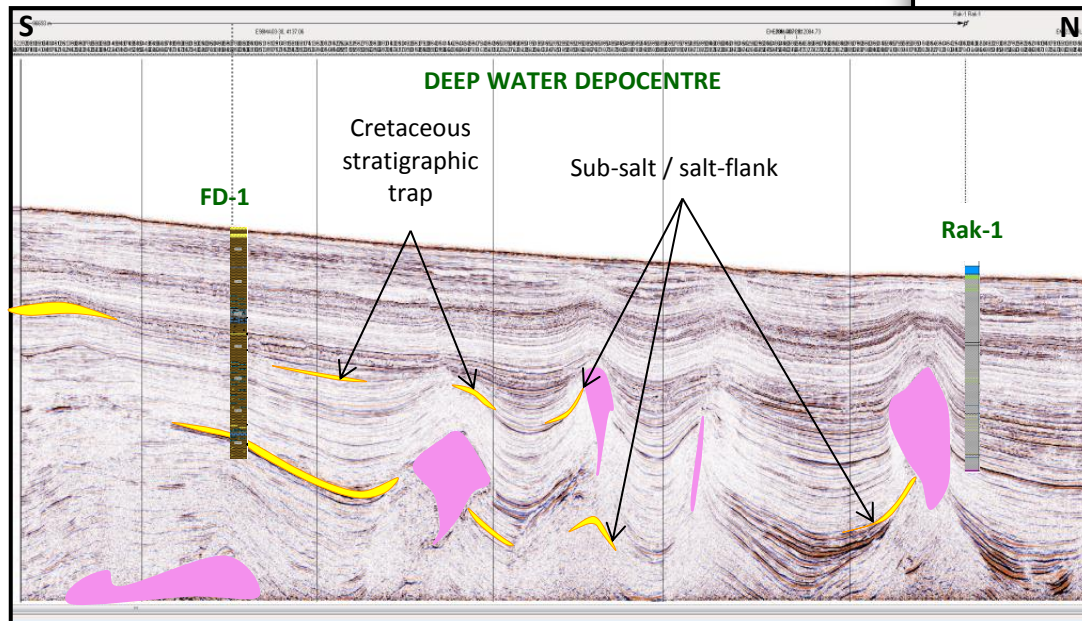
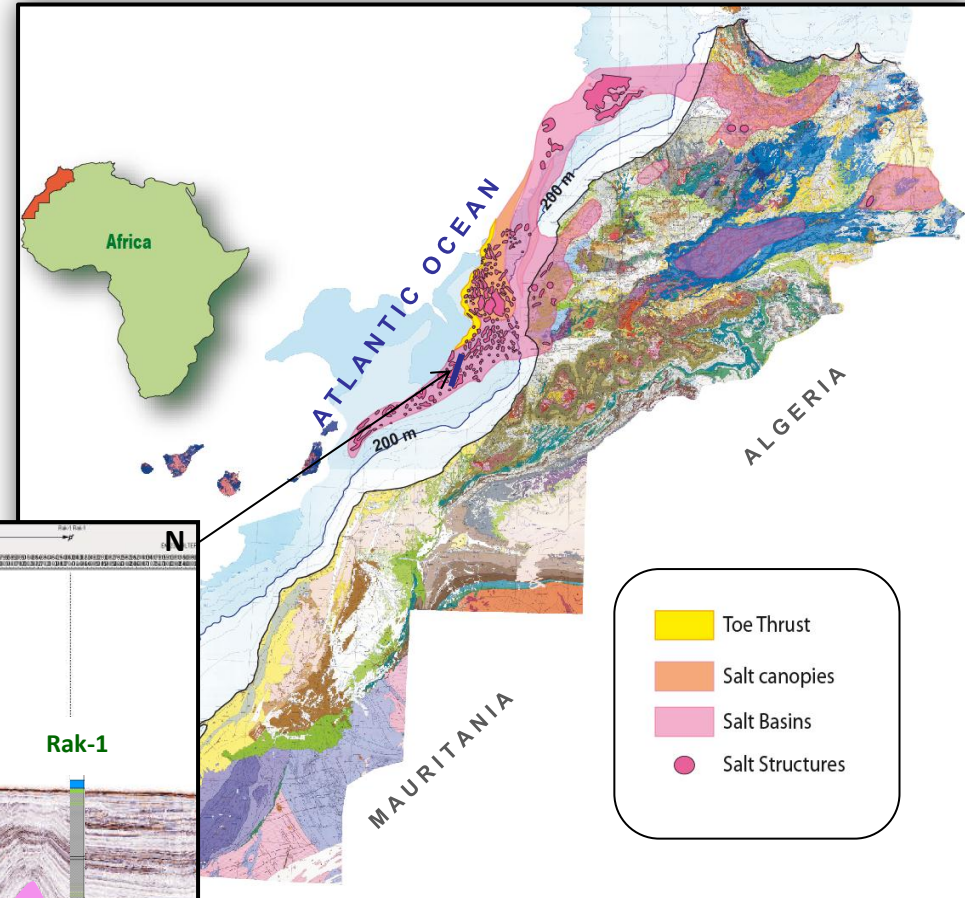


SALT RELATED PLAY: EXTENSION & OBJECTIVES

Mesozoic and Cenozoic objectives

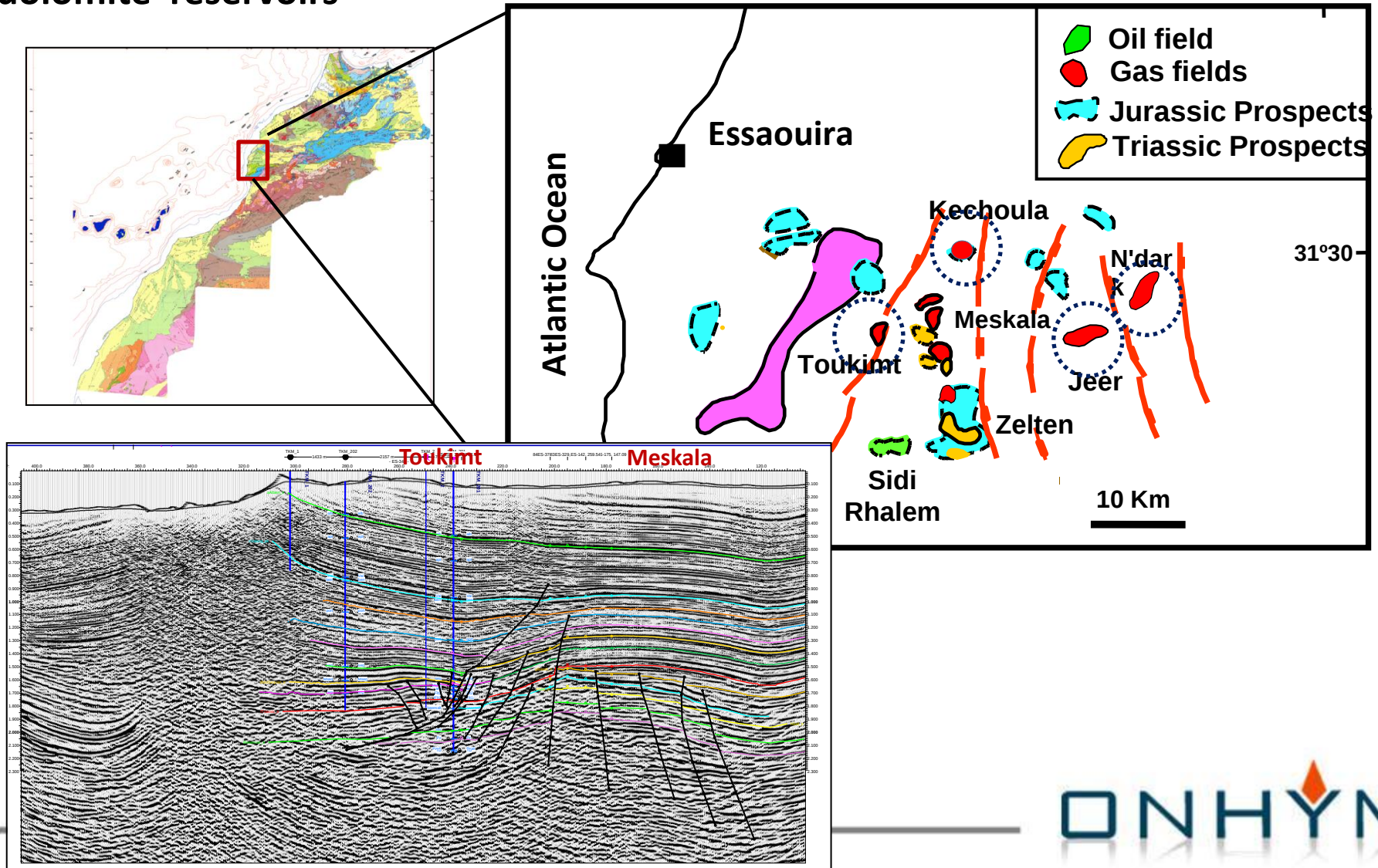
Petroleum Systems:

- **Source Rock** : Jurassic and Cretaceous shale & carbonates
- **Migration**: Vertical through salt welds
- **Reservoir** : Jurassic carbonates & clastics, Cretaceous & Tertiary clastics
- **Seal**: allochthonous salt, interbedded shale & marls (Jurassic and Cretaceous)
- **Trap**: combined (salt related structures)



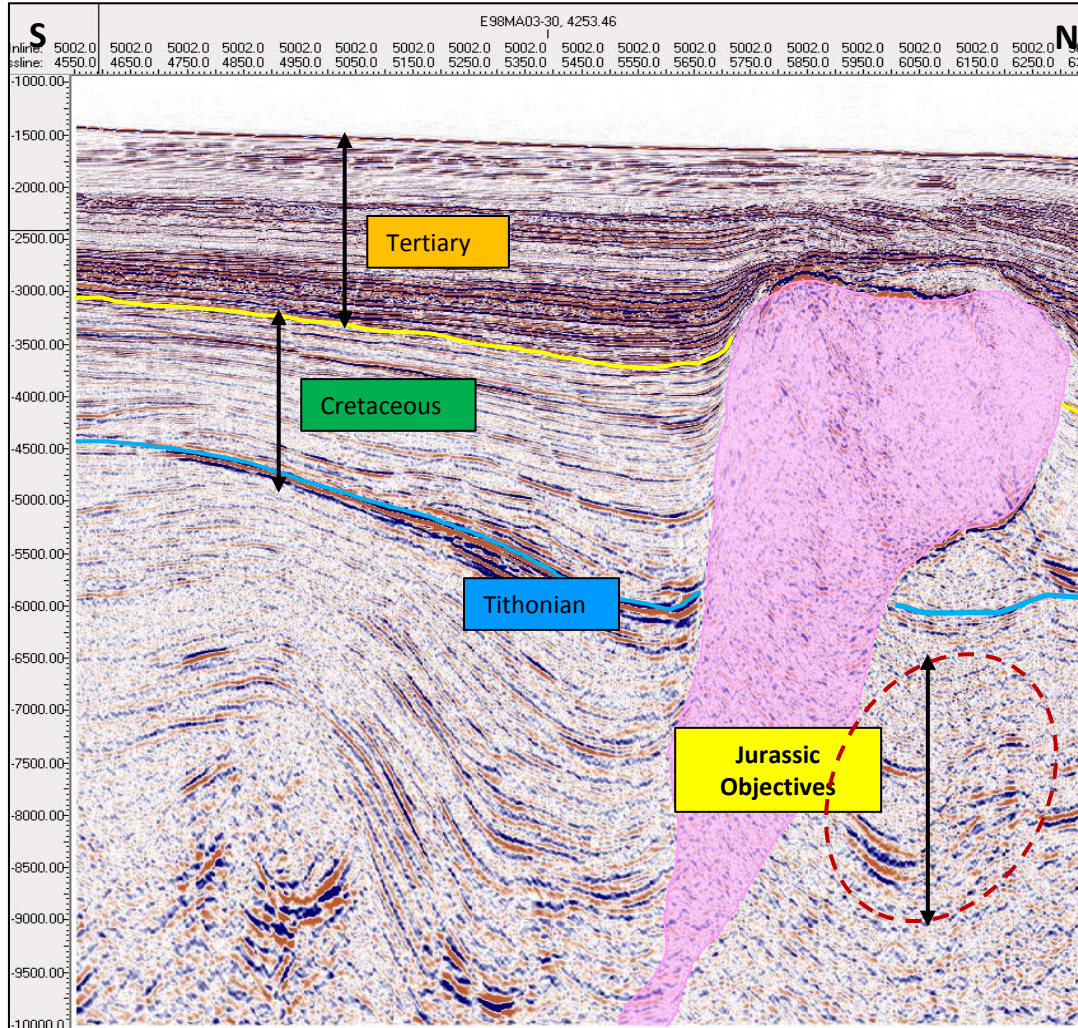
PRE-SALT PLAY: DISCOVERIES

Essaouira Basin: Producing fields of gas and condensate from Upper Jurassic dolomite reservoirs



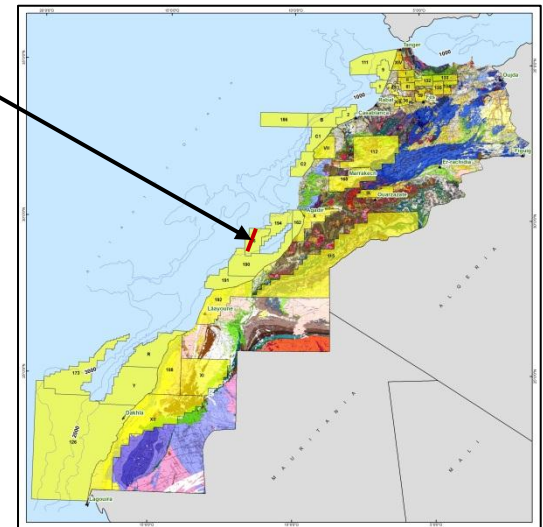
SALT RELATED PLAY: REMAINING PROSPECTIVITY

Example of Sub-salt play (Foum Draa Offshore)



Sub-salt objectives:

- Lower Cretaceous and Jurassic clastics and carbonates below the salt





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HYDROCARBON PLAYS : PLATFORM PLAY

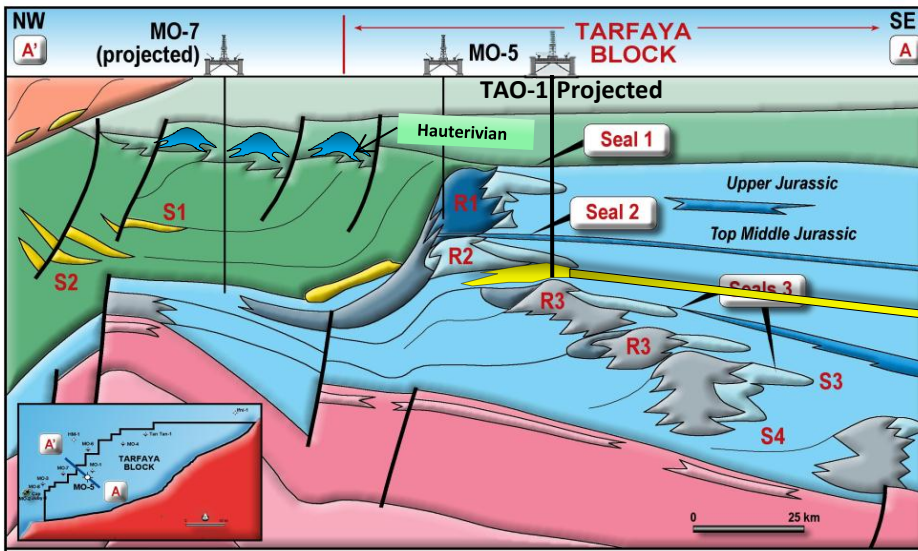
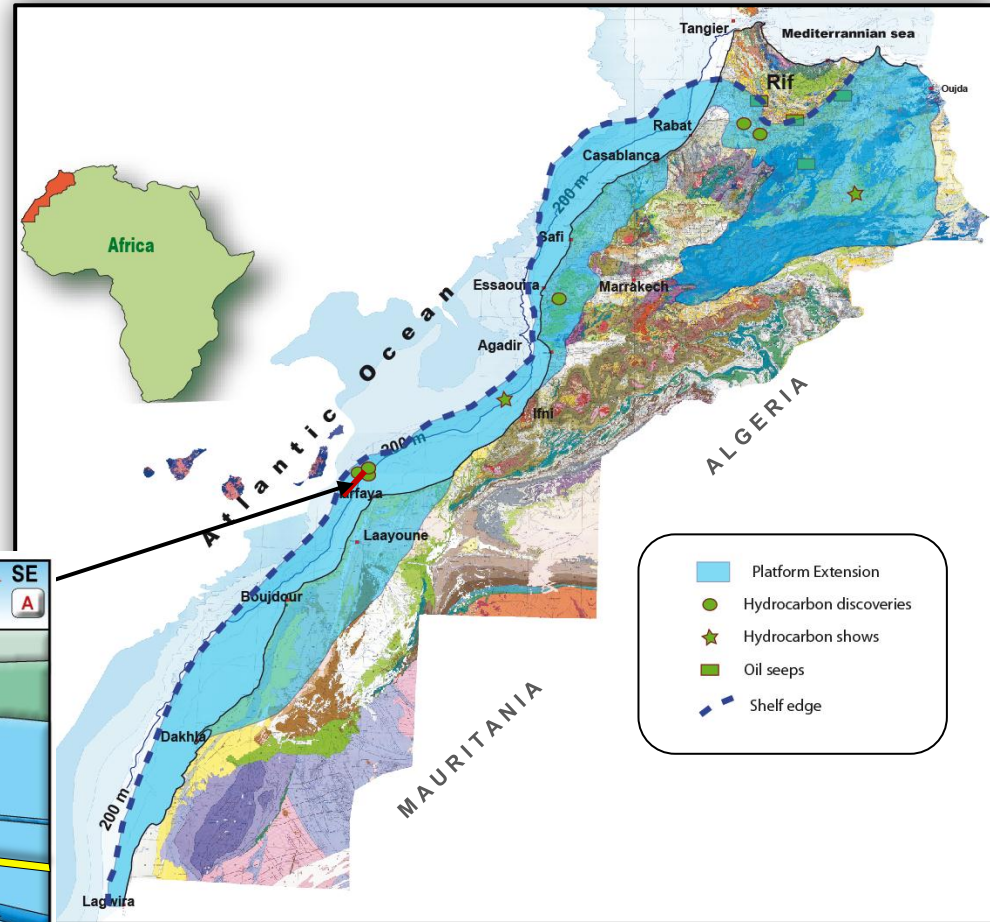


PLATFORM PLAY: EXTENSION & OBJECTIVES

Jurassic and Lower Cretaceous objectives

Petroleum Systems:

- **Source Rock** : Callovian and Toarcian marls & shale
- **Migration**: Vertical short pathway
- **Reservoir** : Shelfal Jurassic carbonates, sand-oolite shoals & prograding delta and Hauterivian reefs
- **Seal**: Cretaceous & intra-Liassic shale and Callovian MFS
- **Trap**: combined

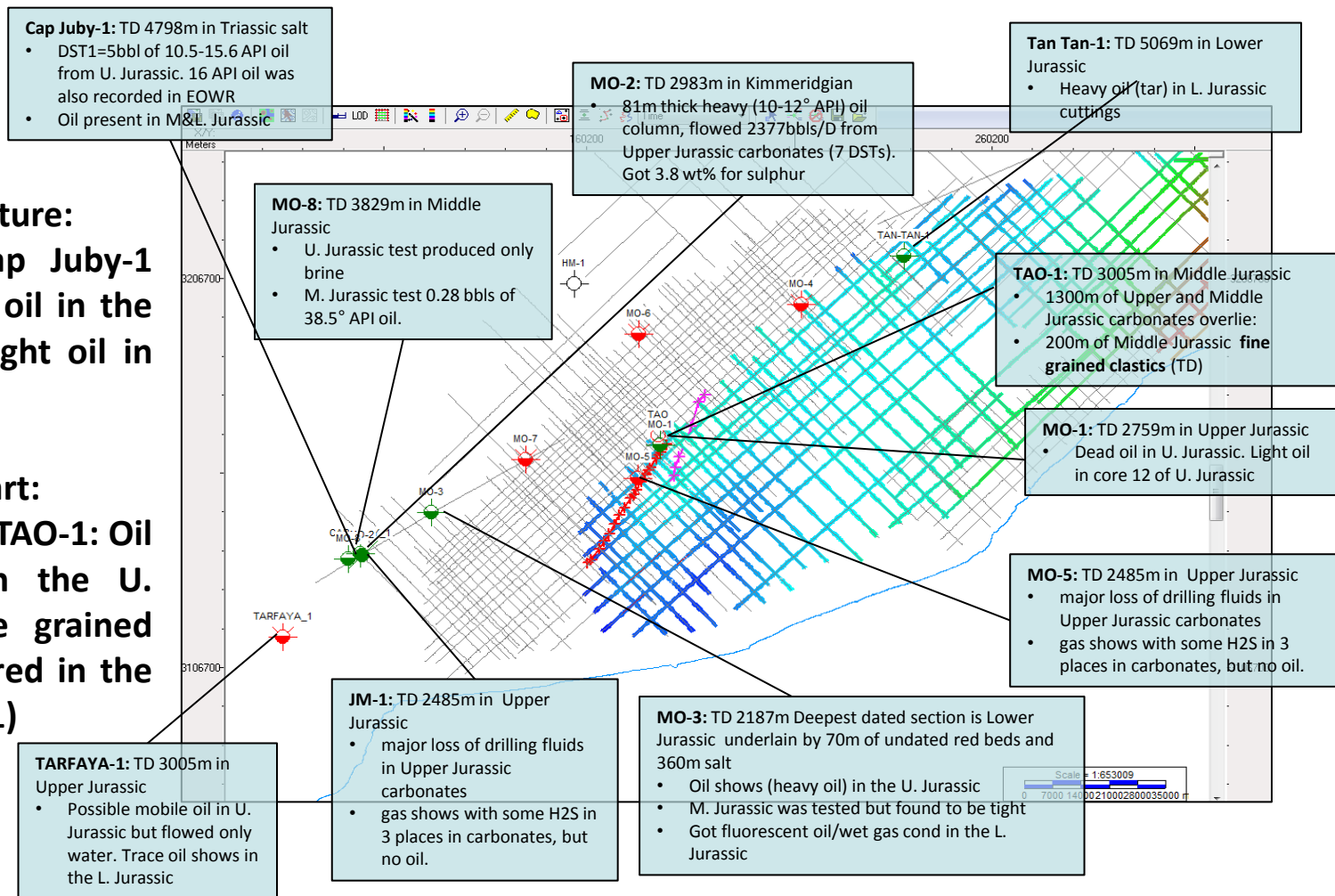


PLATFORM CARBONATE PLAY: DISCOVERIES

SUMMARY:

■ **Cap Juby structure:**
MO-8, MO-2, Cap Juby-1 and JM-1: Heavy oil in the U. Jurassic and light oil in the M. Jurassic.

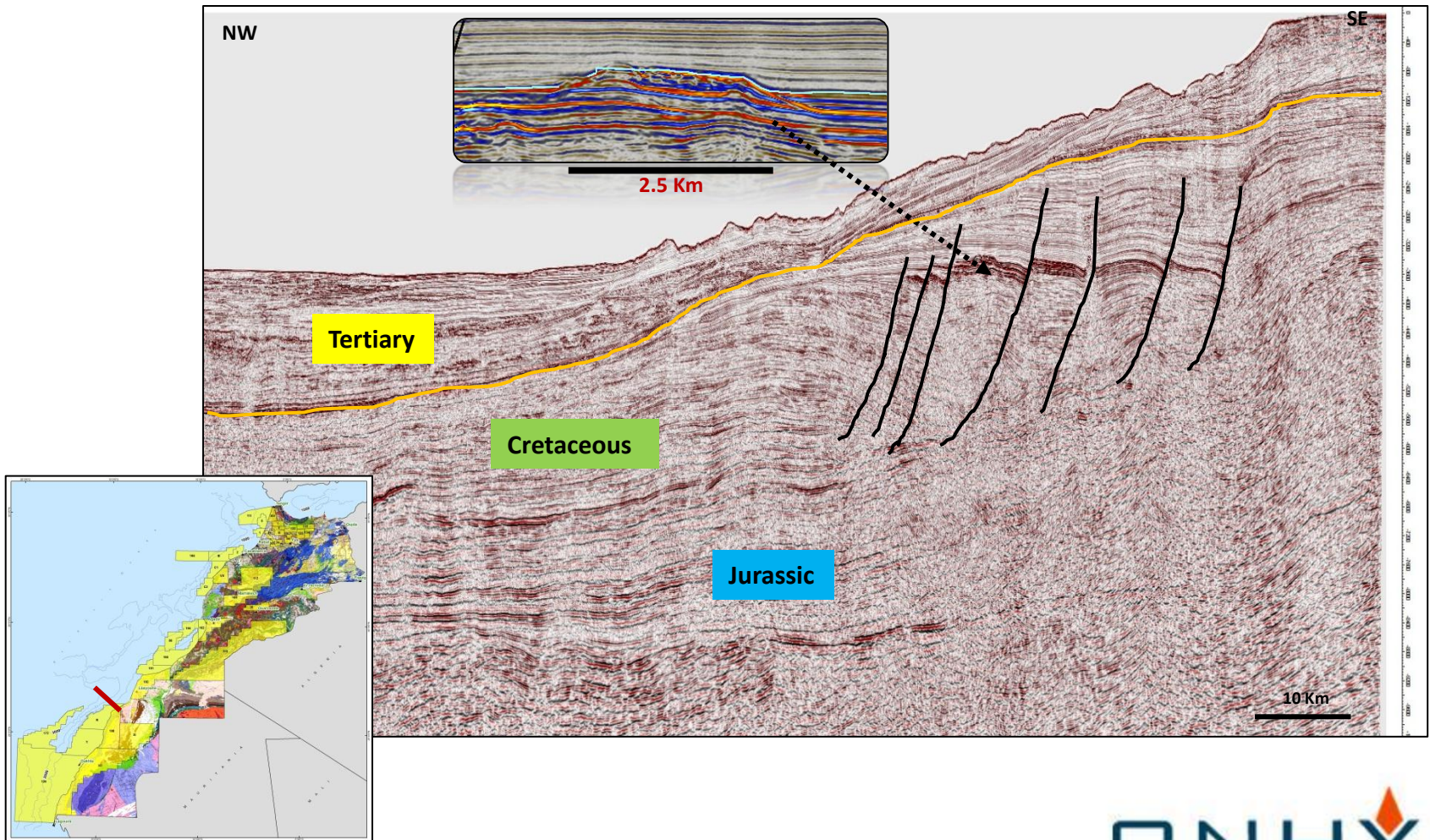
■ **The Eastern part:**
MO-5, MO-1 and TAO-1: Oil & gas shows in the U. Jurassic and fine grained clastics encountered in the M. Jurassic (TAO-1)



PLATFORM CARBONATE PLAY: REMAINING PROSPECTIVITY

Example of Hauterivian reef build up (Boujdour Offshore)

Covering an area of 75 Km²





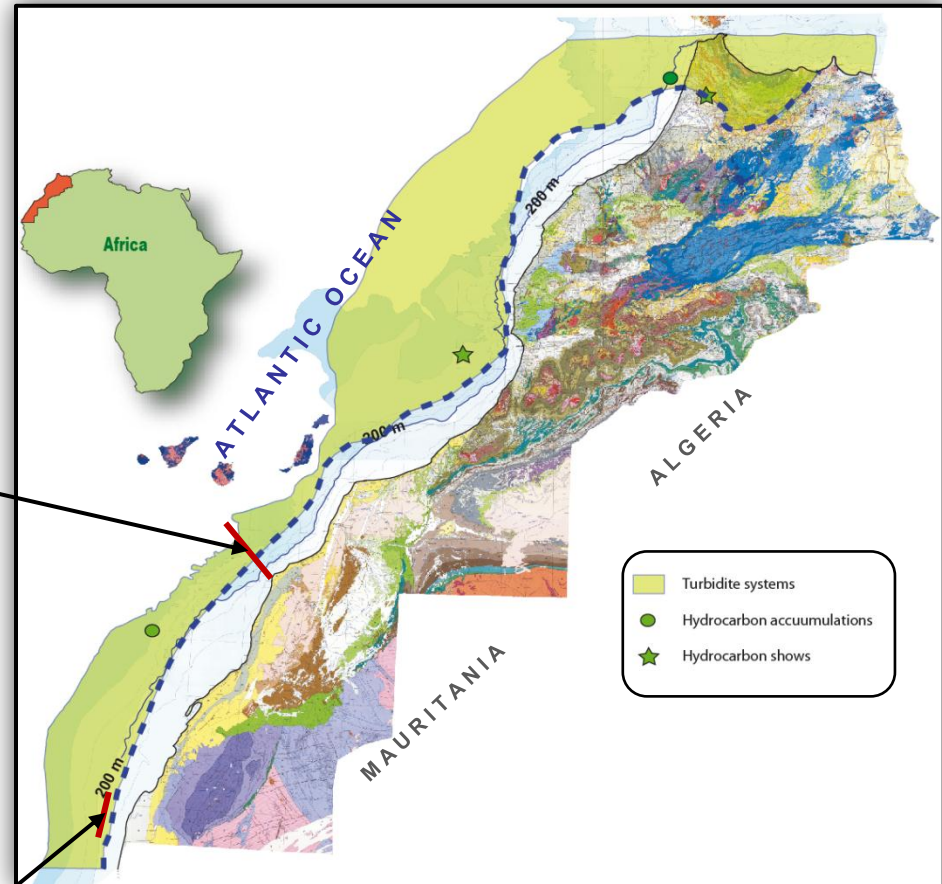
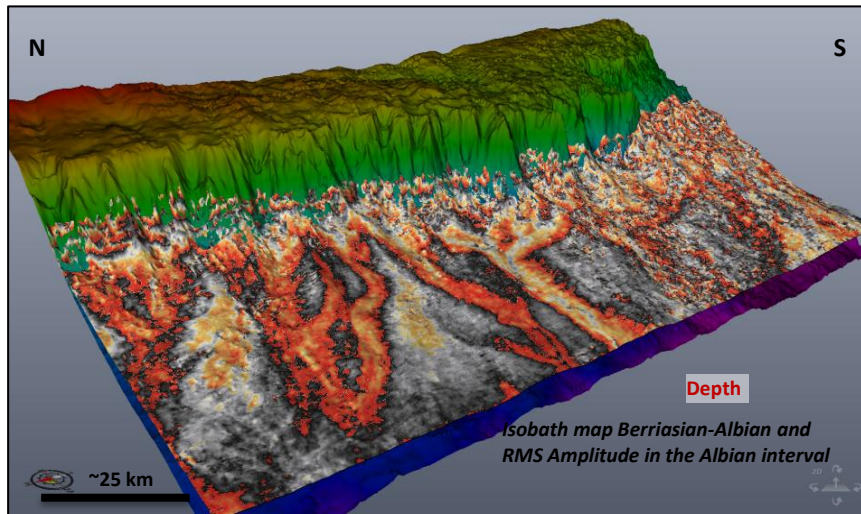
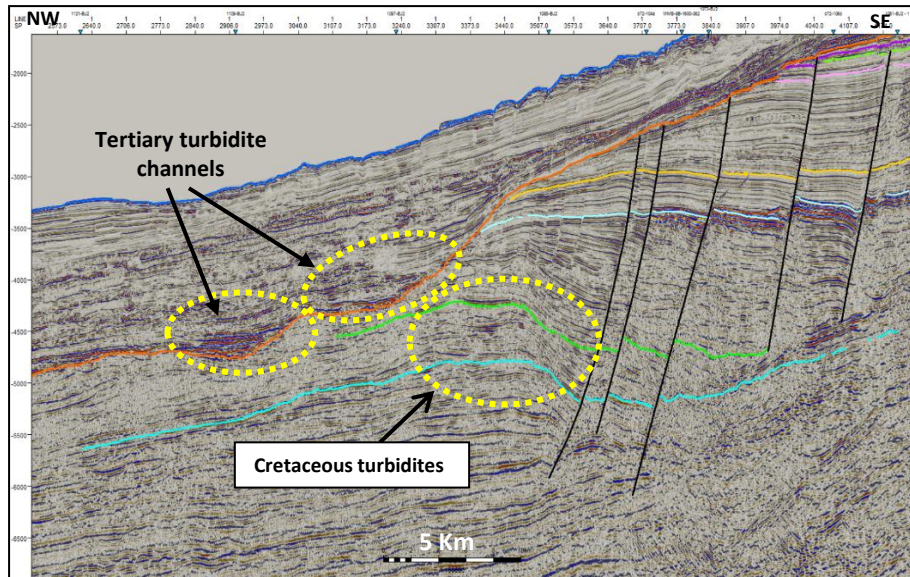
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HYDROCARBON PLAYS : TURBIDITE PLAY



PLATFORM PLAY: EXTENSION & OBJECTIVES

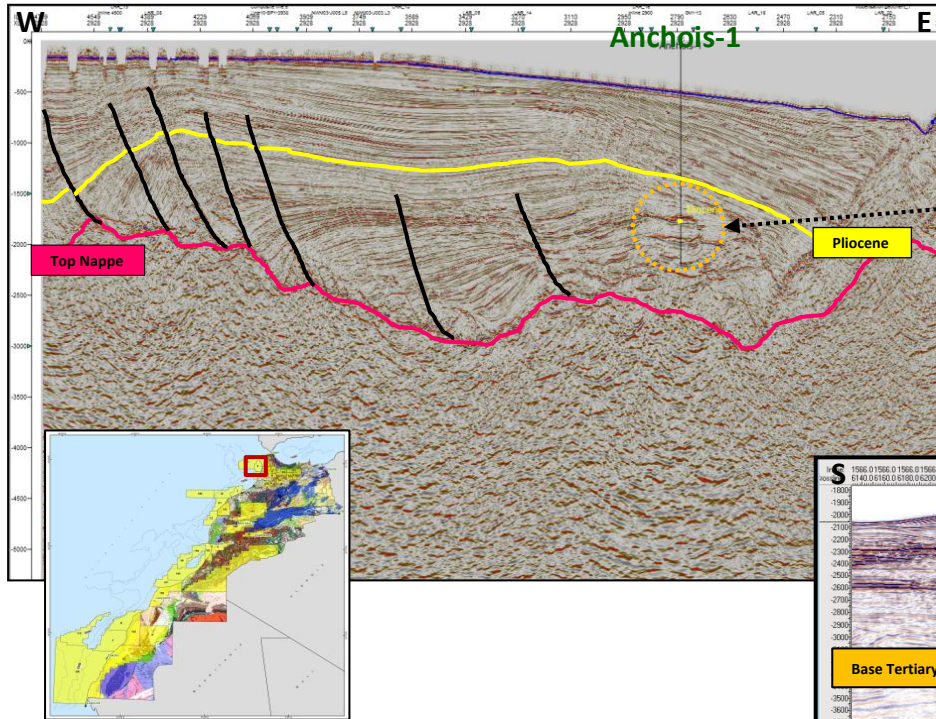
Tertiary and Cretaceous objectives



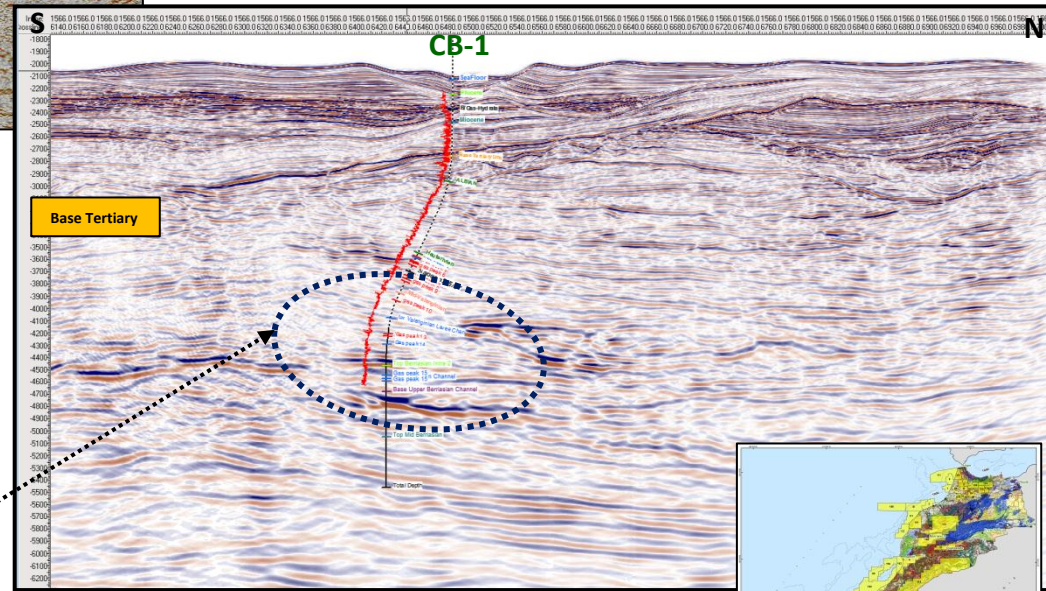
Petroleum Systems:

- **Source Rock** : Jurassic & Cretaceous carbonates & shale
- **Migration**: Vertical short pathway
- **Reservoir** : Tertiary and Cretaceous turbidite sandstones
- **Seal**: interbedded shale & marls (Cretaceous and Tertiary)
- **Trap**: combined

TURBIDITE PLAY: DISCOVERIES



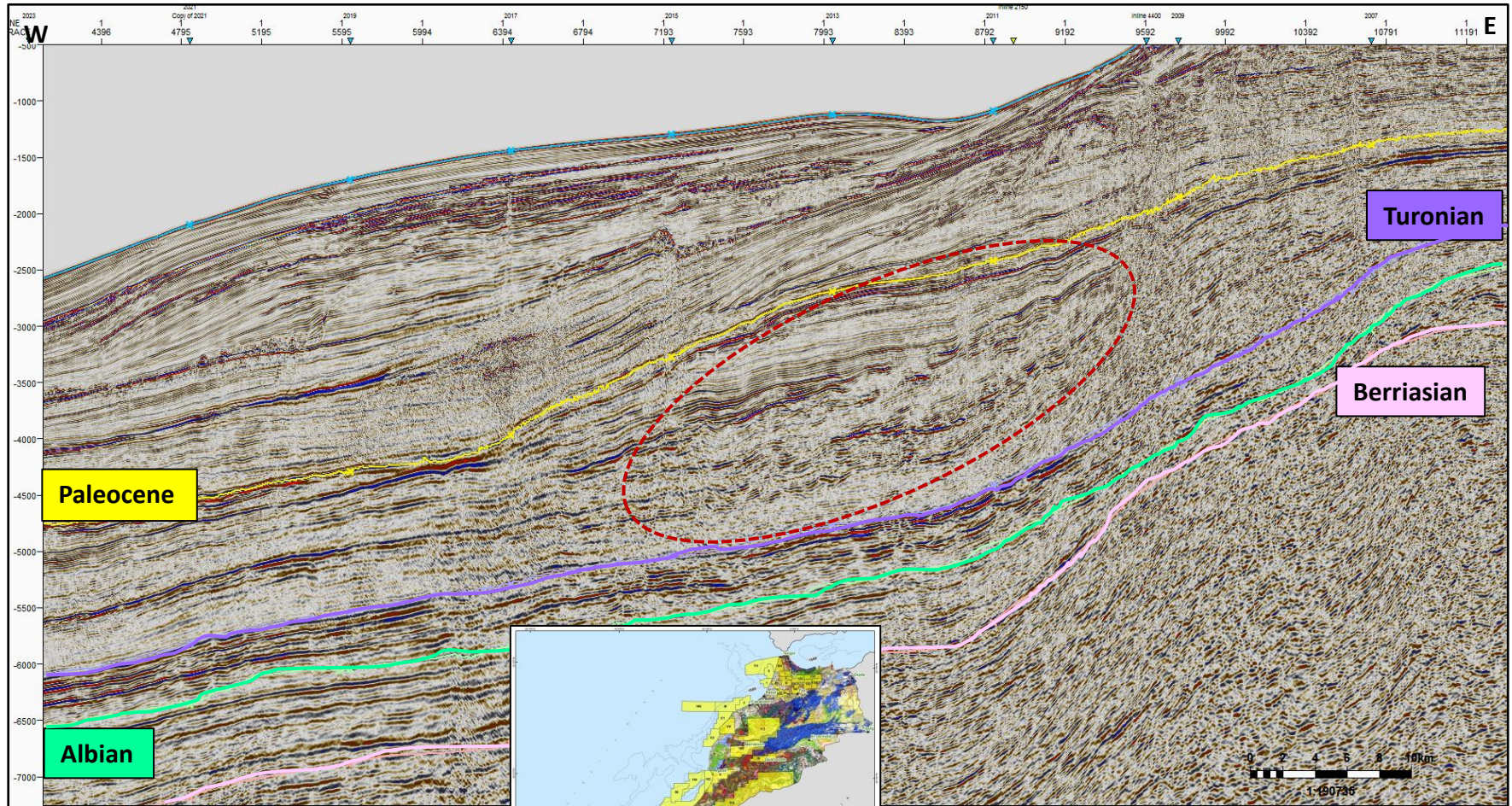
- TD : Upper Miocene (2332 m TVDSS) / 388m water depth
- Thermogenic gas discovery at Lower Pliocene turbidites (2 sand levels)



- TD : Tithonian (5462 m TVDSS) / 2131m water depth
- Valanginian Slope Fan and Berriasian Channel have thermogenic gas
- Hydrocarbons are uppermost oil to gas condensate maturity

TURBIDITE PLAY: REMAINING PROSPECTIVITY

Example of Upper Cretaceous slope fan turbidites (Dakhla Offshore)





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HYDROCARBON PLAYS : THRUST RELATED PLAY

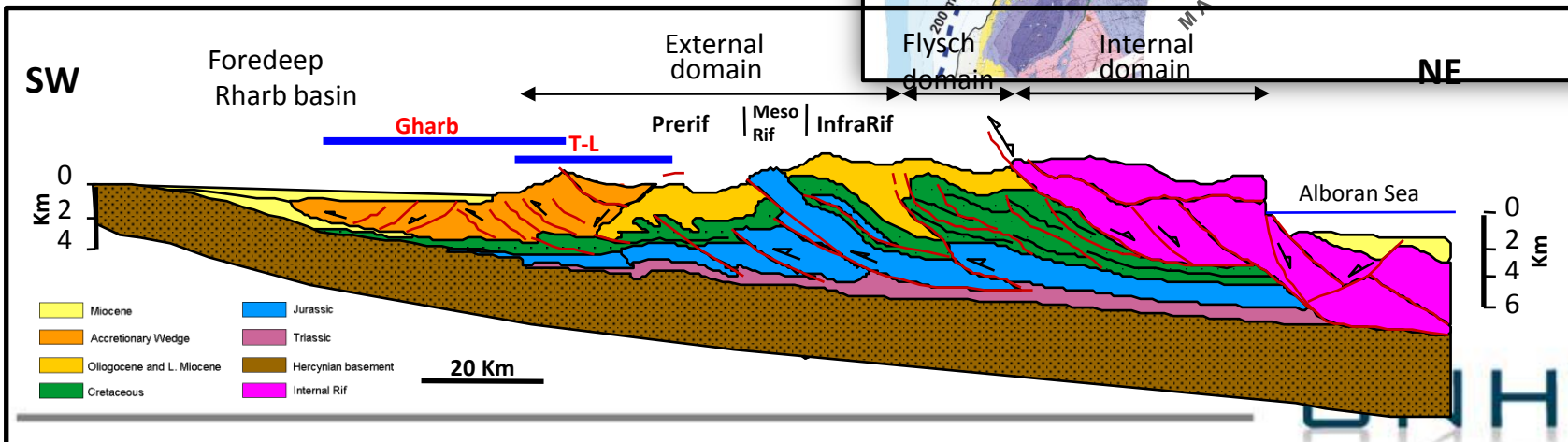
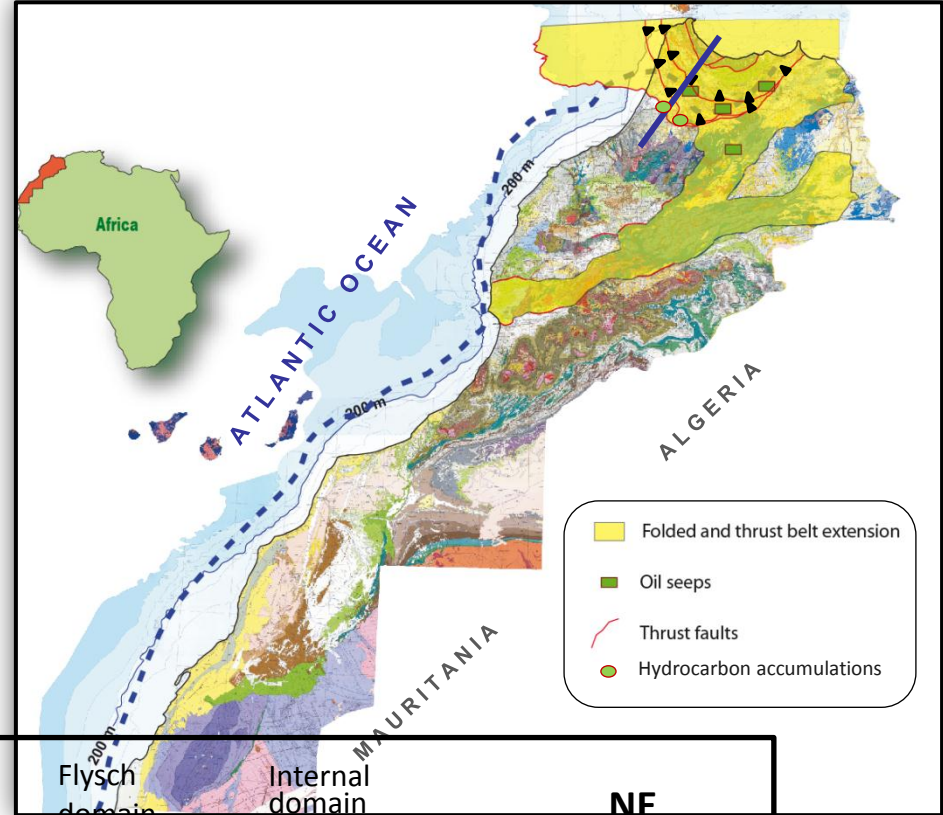


THRUST RELATED PLAY: EXTENSION & OBJECTIVES

Jurassic, Cretaceous & Tertiary objectives

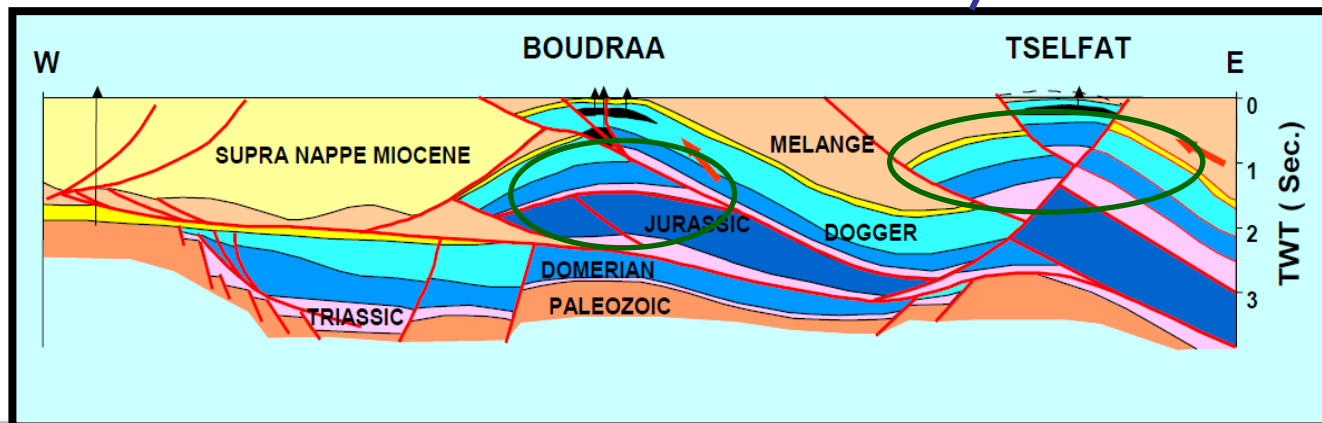
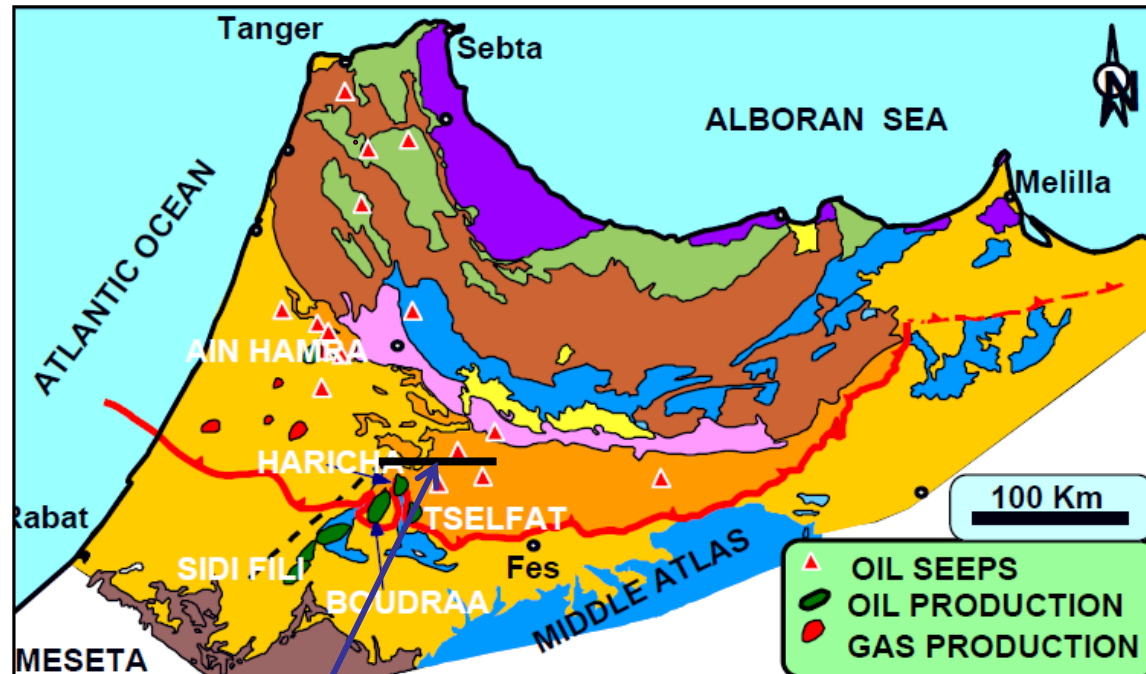
Petroleum Systems:

- **Source Rock** : Jurassic and Cretaceous shale & carbonates
- **Migration**: Vertical pathway through thrust faults
- **Reservoir** : Jurassic carbonates & silicoclastics and Cretaceous & Tertiary clastics
- **Seal**: interbedded shale & marls
- **Trap**: combined



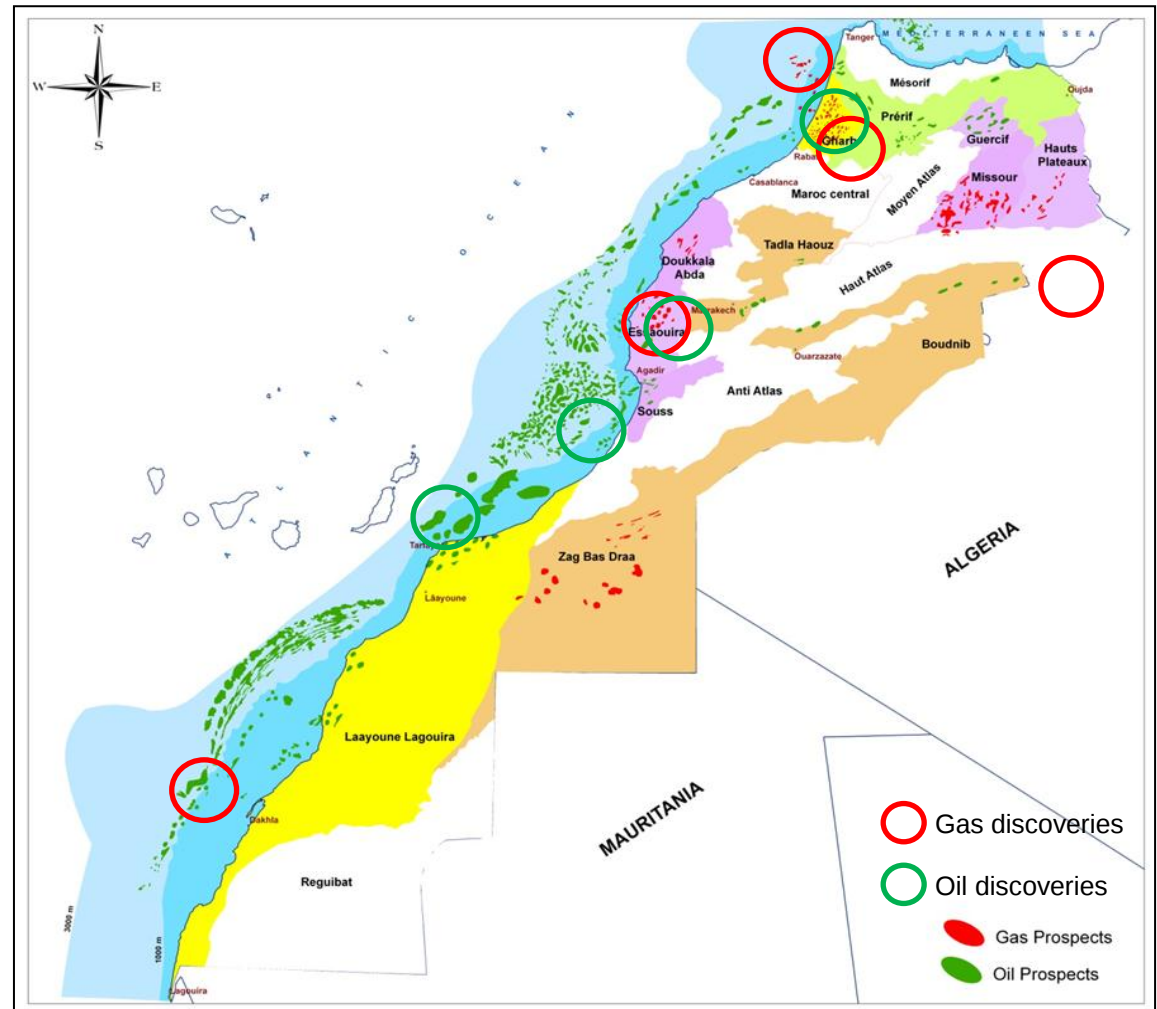
THRUST RELATED PLAY: DISCOVERIES & REMAINING PROSPECTIVITY

- Previous exploration tested successfully the upper thrust sheets. The hydrocarbon accumulations (Boudraa, Tselfat etc) are believed to have dismigrated from deeper sub-thrust structures
- **Sub-Thrust remaining prospectivity:**
 - Domerian platform limestone
 - Middle Jurassic sandstones (Haricha formation)



HYDROCARBON EXPLORATION: PROSPECTS & LEADS

- More than **800** prospects & leads have been identified in the different plays, onshore and offshore
- The prospects drilled so far showed some hydrocarbon accumulations and modest discoveries that have proven the identified plays
- Still considerable number of mature prospects deserves to be drilled.



CONCLUSIONS

- Moroccan geology is significantly favorable for oil and gas exploration and production : good evidences for the existence of viable petroleum systems ;
- Different plays were developed in the Moroccan sedimentary basins and have a wide stratigraphic and geographic extension;
- The identified plays are analogue to those identified in North Africa, Nova Scotia, West Africa and the Gulf of Mexico;
- The so far drilled wells have discovered modest local hydrocarbon to prove existence of working petroleum systems;

NEXT PHASE

- Upgrading of the existing leads (Additional seismic, special studies,.....) ;
- Continue testing the Mature prospects and the unexplored plays (ex. Sub-thrust and subsalt).





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