

# Hydrocarbon Prospectivity in Mesozoic and Early Cenozoic Rift Basins in Central/Northern Kenya\*

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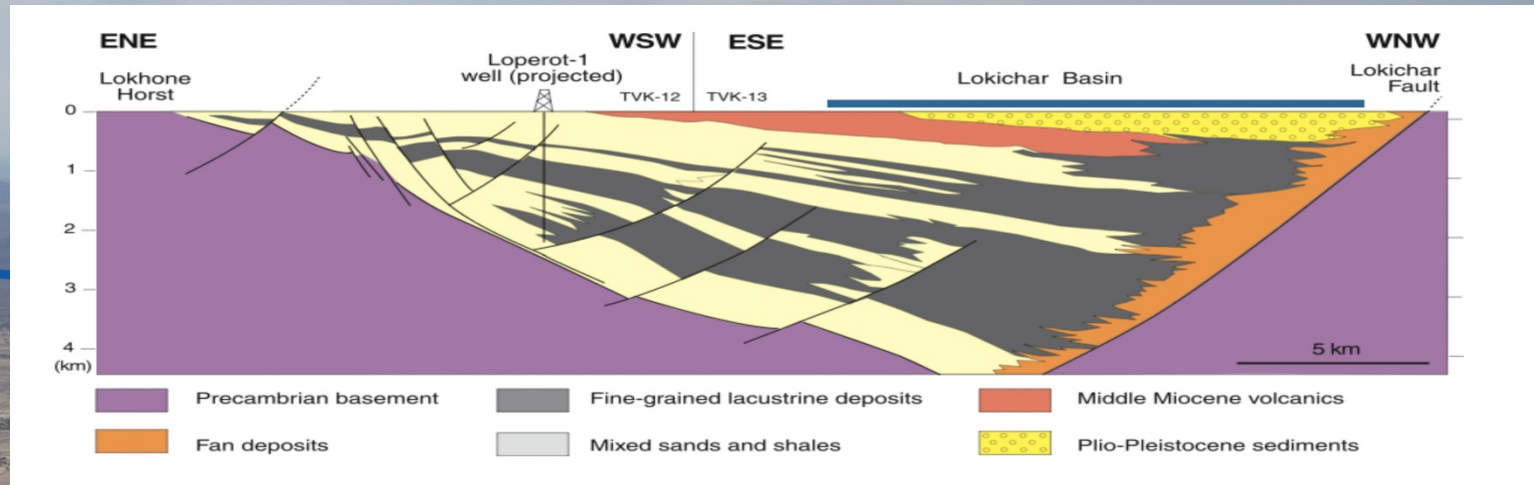
## Abstract

Because they offer the oldest and longest-lived sedimentary basins of the Cenozoic East African Rift System (EARS) and because they are a crossover area between rifts of Cretaceous and Cenozoic age, the Northern and Central Kenya rifts, (NKR) and (CKR), respectively, or NCKR collectively, are among the most important areas for hydrocarbon prospecting in the EARS (Figure 1).

The NKR, or Turkana Depression, consists of strings of N-S oriented half-grabens, the oldest known basins being of Paleogene-middle Miocene age. Crossing at the north end of the NKR are the NW-oriented Anza-Sudanese rifts that both are Cretaceous to Paleogene. The CKR shows two N-S half-grabens, the Baringo Basin (Paleogene-Present) and the Kerio Basin (Paleogene-upper Miocene). All basins are filled by up to 8-km thick sediments/volcanics of Cretaceous-Neogene age.

New studies have focused on reservoir/source rock quality and structural link between reservoir/source rock/seal. Both questions relate to the sequence of deformation events between the Anza-Sudanese (Cretaceous-Paleogene deformation) and Kenya (Neogene-Recent) rifts. Geophysical/field geology results confirm continuity in terms of deformation events between the Anza-Sudanese and NK rifts. In terms of hydrocarbon prospect, arkosic sandstones in CKR/NKR (or NCKR) demonstrate a good reservoir quality, with porosity up to 25 %. Strong changes in terms of diagenetic alteration relate to deformation events (burial/uplift) or change in sediment source. High quality source rocks relate to freshwater lake environments under tropical climate. Such environments have been identified during Paleogene in the NKR and lower Neogene in the CKR and are suspected in basins of the same age that have not yet been prospected. Relations between reservoir/source rock/seal are connected to Neogene deformation and have been investigated by magnetotelluric methods and high-resolution seismic stratigraphy.

# HYDROCARBON PROSPECTIVITY IN MESOZOIC AND EARLY CENOZOIC RIFT BASINS IN CENTRAL / NORTHERN KENYA



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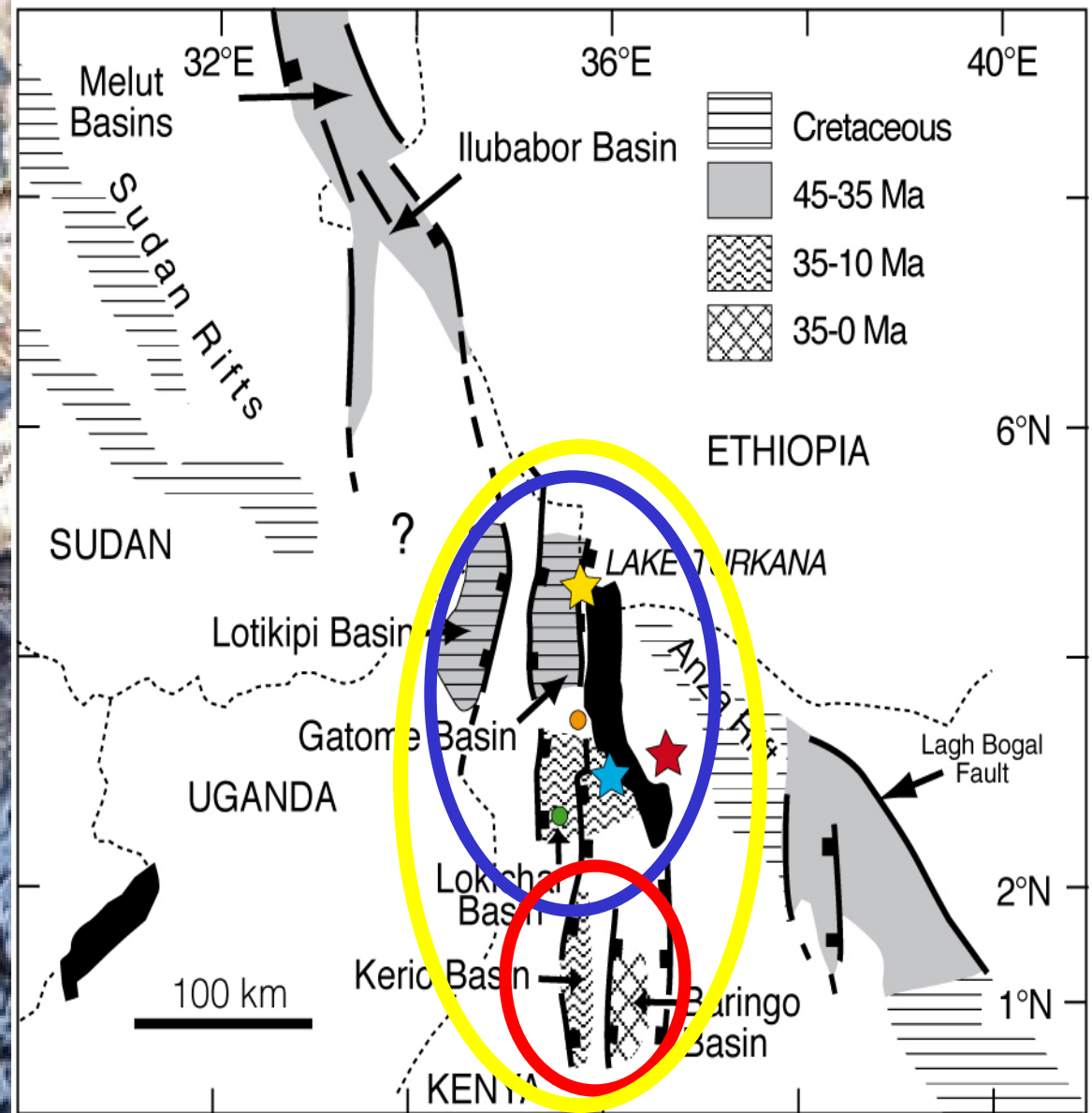


**The Northern Kenya Rift  
(also known as the  
Turkana Depression)**

**&**

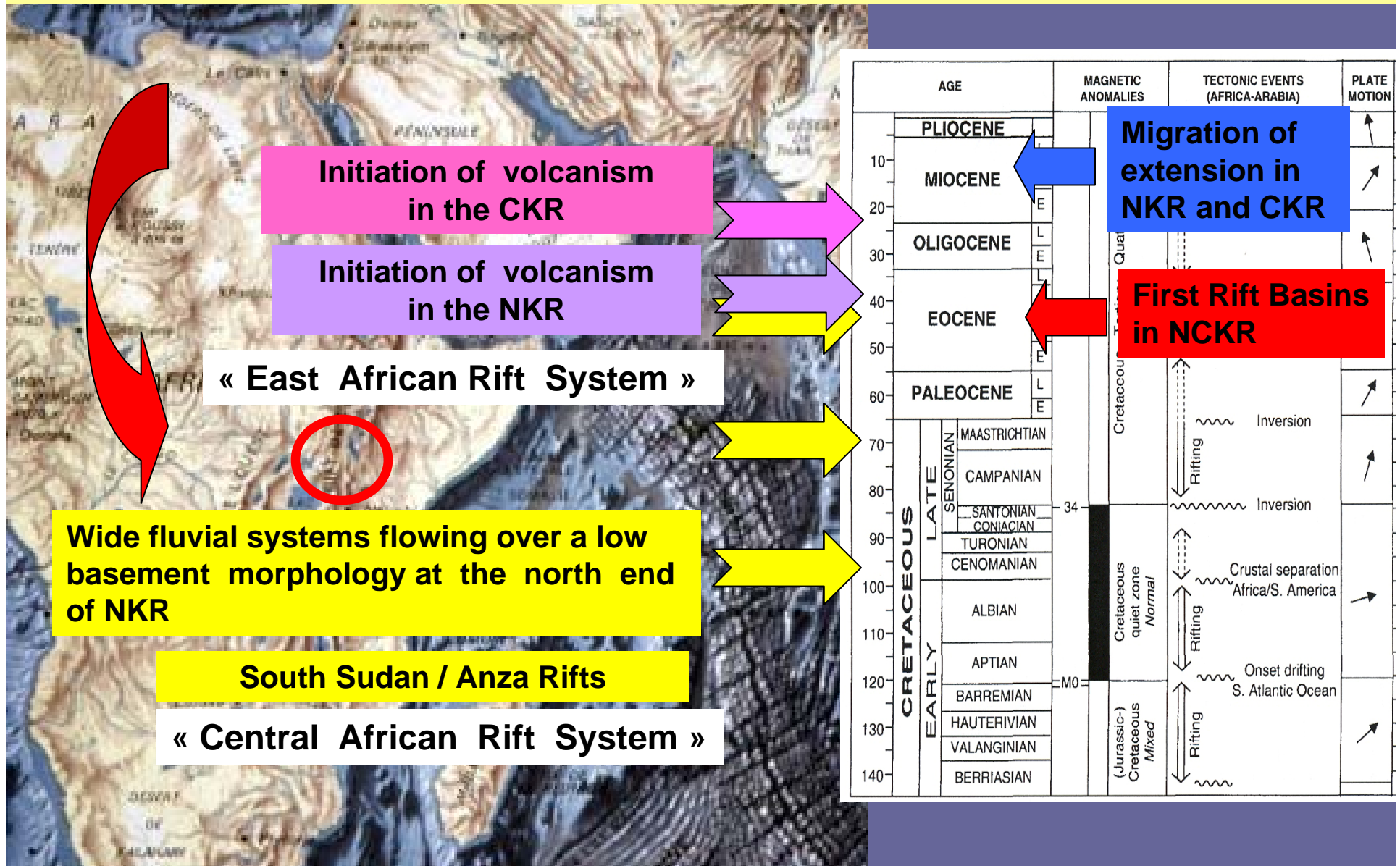
**The Central Kenya Rift**

**NCKR: A major segment  
of the East African Rift  
System**



**A tectonically complex structure that offers a suite of sedimentary basins interpreted as the oldest and longest-lived basins of the EARS**

A long and complex structural history is stored in the NCKR...  
with more than **10 km** of sediments and volcanics accumulated  
since **CENOMANIAN**...





*Major border fault*

*Lake Baringo*

*Deep fault-bounded trough*

*Complex basin flank*

*Alluvial plain*

## 6 major deep fault-bounded troughs

4 basins have been identified below modern alluvial plain morphologies:

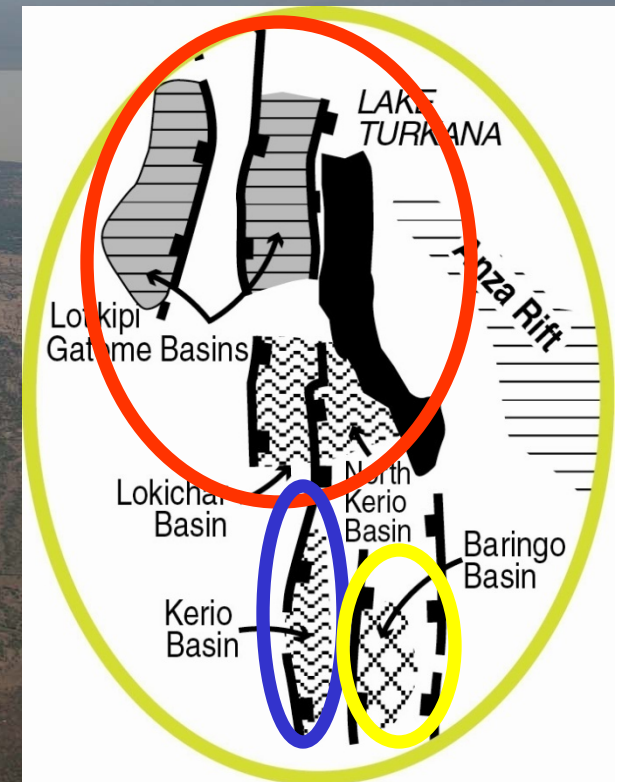
- The Lotikipi and Gatome Basins
- The Lokichar and North Kerio Basins

The 2 other basins show today a typical rift-basin morphology, but geophysical investigations have demonstrated the existence of deep buried troughs:

- The Kerio Basin
- The Baringo Basin

Organized in 3 groups:

- 1) Cretaceous (?) - Paleogene to Lower - Middle Miocene
- 2) Paleogene to Middle Miocene
- 3) Paleogene to Pleistocene



# **Petroleum Prospectivity in the NCKR Basins How to Evaluate their Hydrocarbon Potential ?**

## **Some Geological Keys to the Exploration Potential**

### **SOURCE ROCKS**

- ❑ **Existence of extensive lacustrine environments in subsiding troughs**

**Accumulation of thick sequences of organic oil-prone mudstones and shales:**

**Climate conditions, suboxic environments**

### **RESERVOIRS**

- ❑ **Existence of widespread alluvial and fluvial environments providing attractive reservoirs:**

**Petrography and cement mineralogy**

### **SEALS**

- ❑ **Deposition of lacustrine and floodplain mudstone intervals that can provide seals**
- ❑ **Volcanism at different scales of space, different time periods and different stages of basin evolution**

# Applying these Geological Keys to:

## The Cretaceous (?) - Paleogene to Lower - Middle Miocene Group of sedimentary basins in the northwest part of NKR

### □ The Lotikipi Basin:

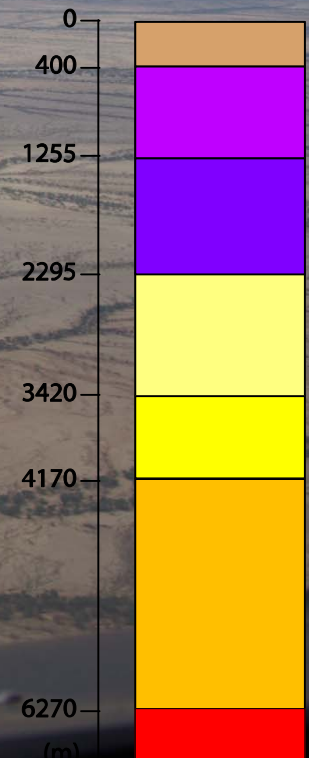
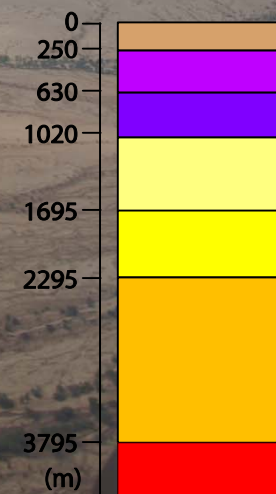
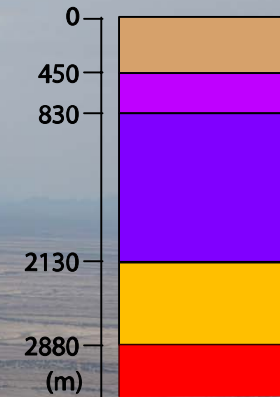
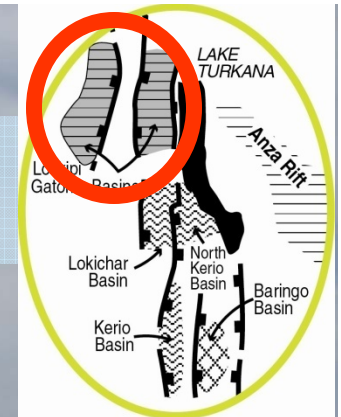
Only imaged by the AMOCO TVK-4 seismic line  
Infill from Top to Bottom formed by:

- 1) Miocene to Recent sediments, unknown facies
- 2) **Volcanics of the Turkana Formation**  
(2.5 km thick, 39-25 Ma)
- 3) **Sediments (possibly the Lapur Formation ?)**  
700 m thick
- 4) **Basement (Precambrian)**

### □ The Gatome Basin:

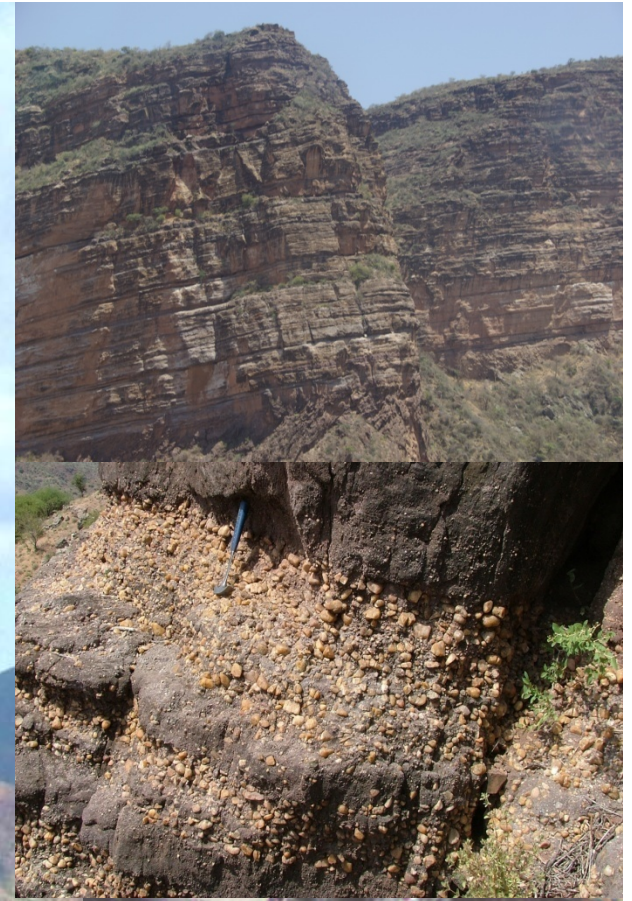
Imaged by the AMOCO TVK-7 seismic line  
Infill from Top to Bottom formed by:

- 1) Volcaniclastic sediments ? post lower Miocene
- 2) **Volcanics of the Turkana Formation**
- 3) **Sediments ? 4 to 6 km thick ?**
- 4) **Basement (Precambrian)**



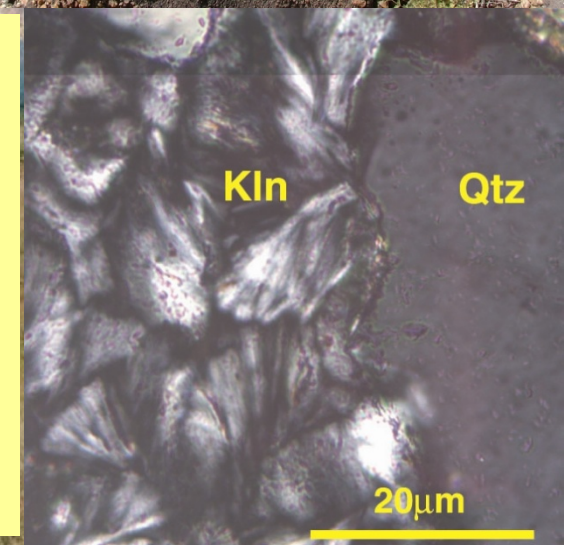
## The Lotikipi / Gatome Basins:

➤ *in terms of RESERVOIRS*



Coarse- to medium / fine-grained arkoses, 600 m thick  
Braided stream environment, wide lateral extension  
Cretaceous (?) to late Eocene age,  
Possible equivalent to the NUBIAN SANDSTONE (?)  
Porosity: 15–20 %  
Cements: calcite, kaolin, hematite

**Potentially excellent reservoir**



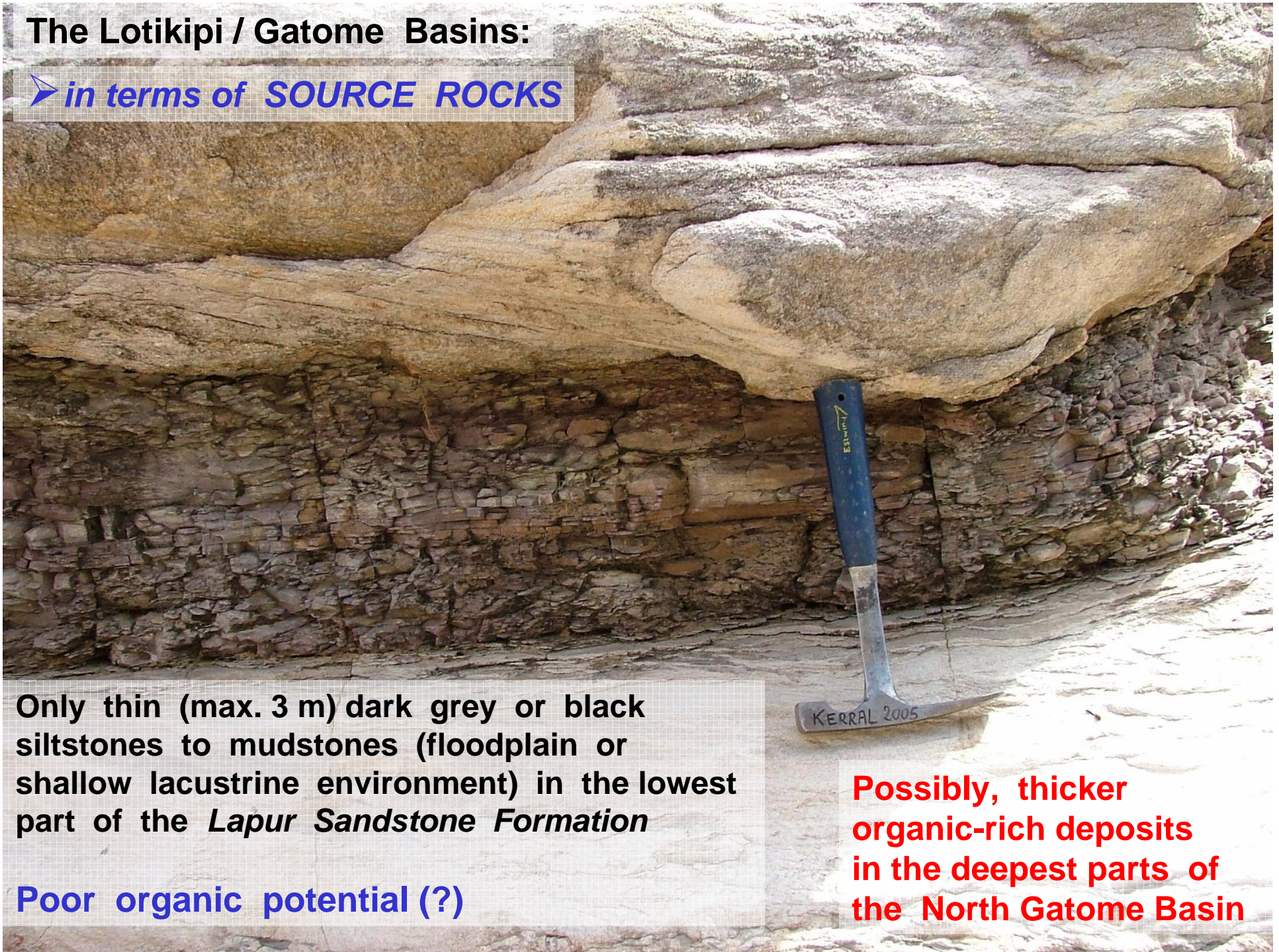
## The Lotikipi / Gatome Basins:

➤ in terms of **SOURCE ROCKS**

Only thin (max. 3 m) dark grey or black siltstones to mudstones (floodplain or shallow lacustrine environment) in the lowest part of the *Lapur Sandstone Formation*

Poor organic potential (?)

Possibly, thicker organic-rich deposits in the deepest parts of the North Gatome Basin

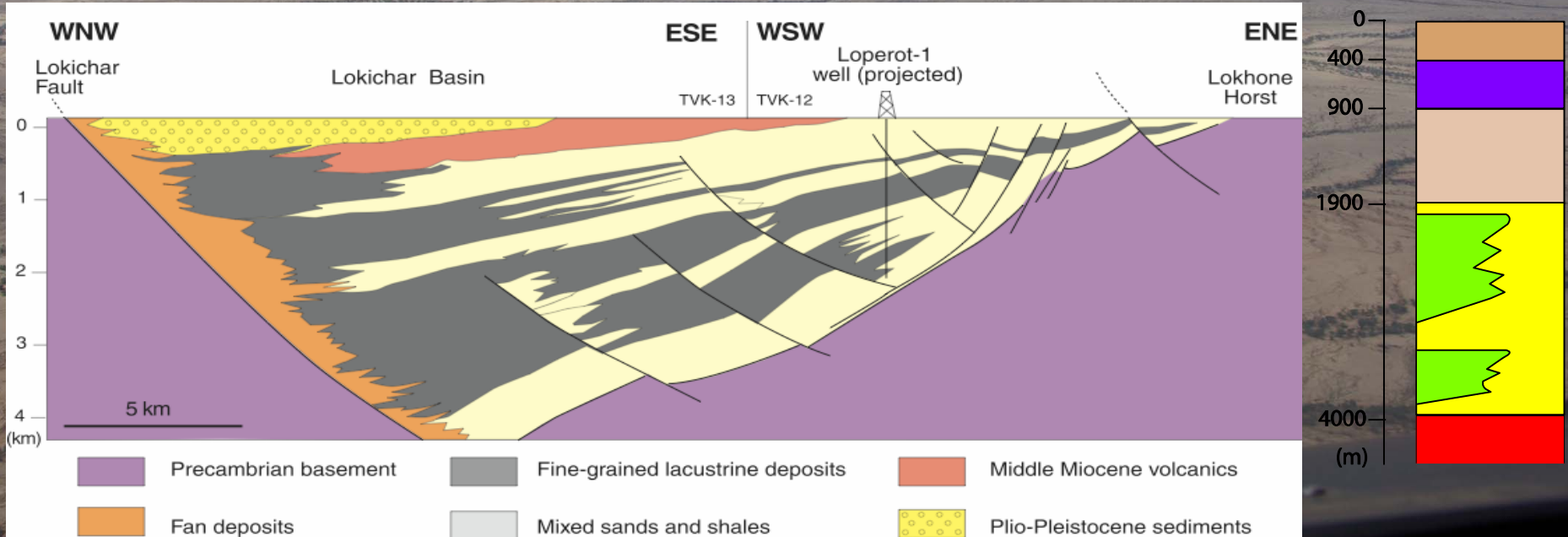
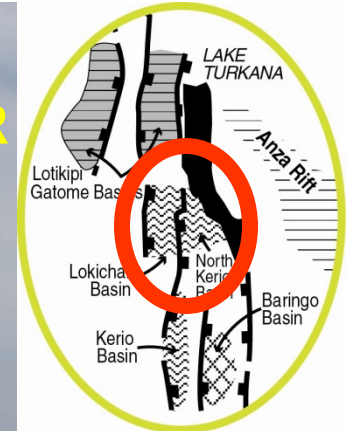


# The Cretaceous (?) - Paleogene to Lower - Middle Miocene Group of sedimentary basins in the southern part of NKR

## □ The Lokichar / North Kerio Basins: Imaged by numerous AMOCO seismic lines

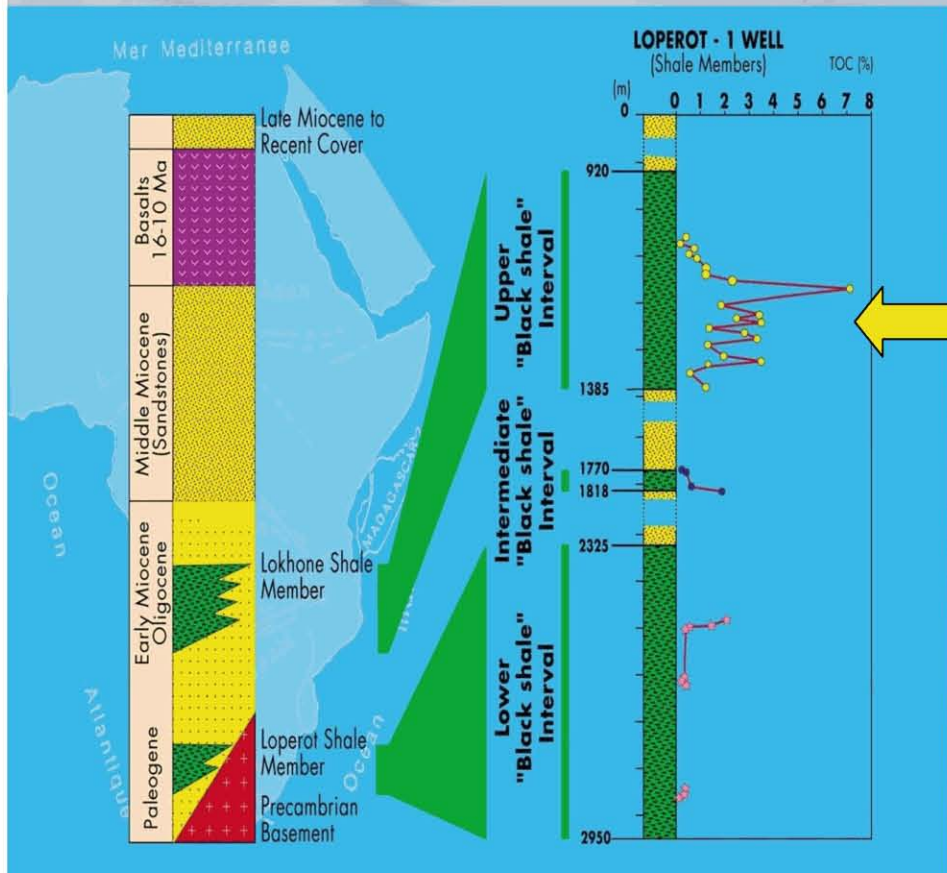
Infill from Top to Bottom formed by:

- 1) Post- Middle Miocene to Recent sediments, fluvial facies
- 2) **Middle Miocene volcanics (12-10 Ma)**
- 3) **Sediments of fluvial and lacustrine facies (> 4 km thick)**  
**Cretaceous (?) or Eocene to Oligocene- middle Miocene**
- 4) **Precambrian basement**



# The Lokichar / North Kerio Basins:

➤ *in terms of SOURCE ROCKS*



✓ Climate conditions



✓ Extensive freshwater lacustrine environment in a subsiding trough

✓ Accumulation of thick sequences of oil-prone shales in suboxic environment: Deposition of the Lokone and Loperot Shales (TOC 1- 17 %)

**Good Source Rock Potential**



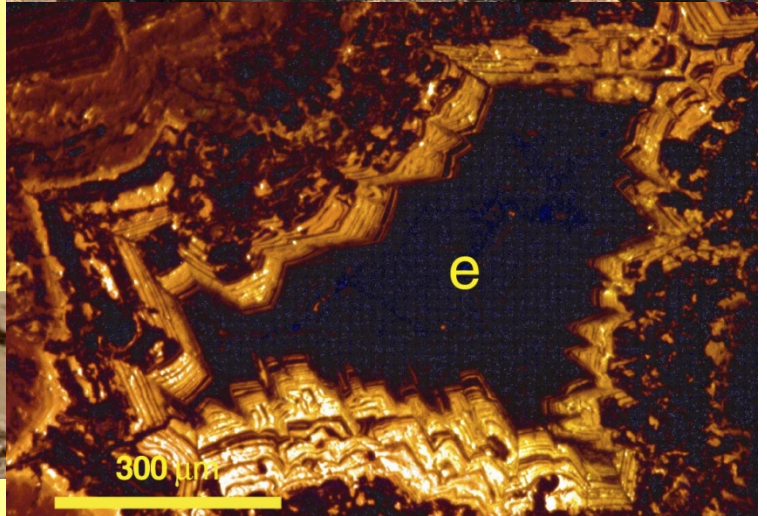
## The Lokichar / North Kerio Basins:

➤ *in terms of RESERVOIRS*

### The early basin fill:

Cretaceous (?) or Eocene to late Oligocene  
Coarse- to medium / fine-grained sandstones,  
basement-derived  
Porosity 10 - 20 %  
Cements: Calcite, kaolin

**Good reservoir potential**



### The upper part of the sedimentary infill:

Considerable volcanoclastic component due to intense volcanism  
to the south of the basin (23 Ma)  
Prone to diagenetic alteration: precipitation of analcite-calcite cement  
Porosity 1 - 15 %

**Not considered to be potential reservoir rocks**



# The Paleogene to Middle Miocene / Pleistocene Group of sedimentary basins in the CKR

## ❑ The Kerio Basin:

Imaged by one seismic line (NOCK) and gravity data

Infill: > 6 km of sediments and volcanics

Paleogene - Early Miocene sediments: arkosic sandstones (?)

Early – Middle Miocene volcanism

Mio-Pliocene sediments: fluvio-lacustrine facies

## ❑ The Baringo Basin:

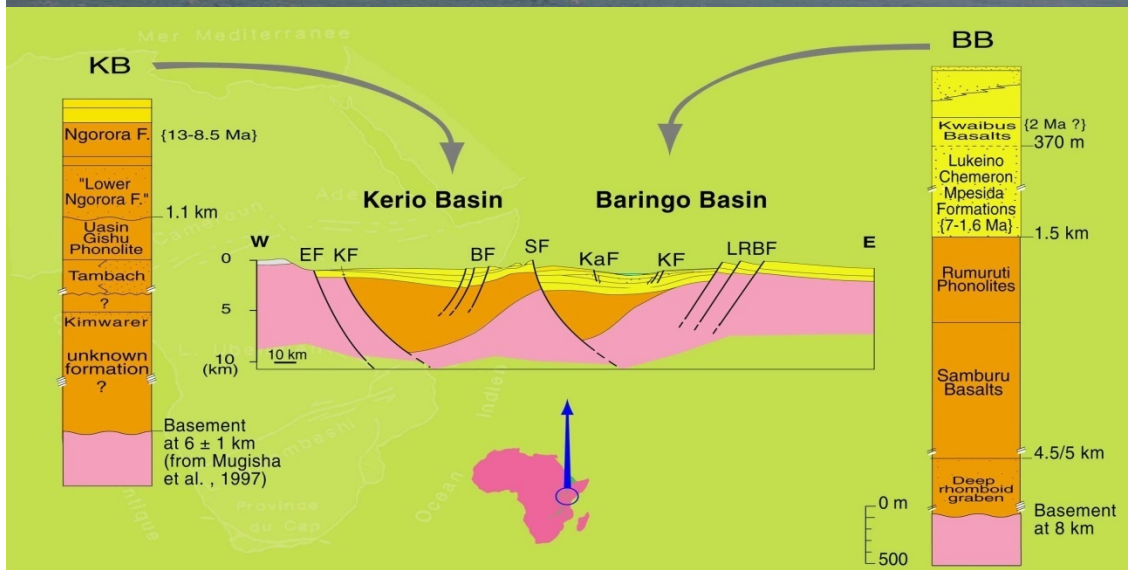
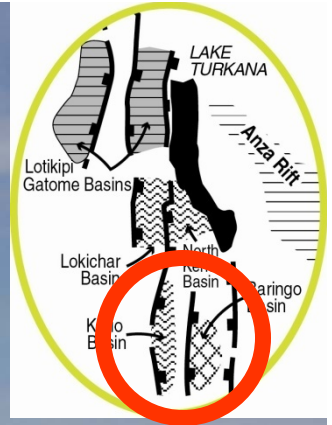
Imaged by magnetotelluric data

Infill: Precambrian basement at 8 km

Paleogene - Early Miocene sediments: arkosic sandstones (?)

Early – Middle Miocene volcanism

Mio-Plio-Pleistocene sediments: fluvio-lacustrine facies



## ❑ The Kerio / Baringo Basins:

### ➤ *in terms of RESERVOIRS*

Very few outcrops illustrate the early history (Paleogene - Miocene) of the Kerio and Baringo Basins

Only 2 clastic formations are identified in the Kerio Basin, outcropping along the Elgeyo Border Fault:

#### ➤ The **Kimwarer Sandstone Formation**

(undated, possibly Paleogene ?), fluvial facies (?), arkosic-type

#### ➤ The **Tambach Formation**

(16 - 14.5 Ma), arkosic-type with minor volcanic clasts

Thick deposits of similar facies have been detected at depth in the Kerio Basin as well as in the Baringo Basin:

#### ➤ The **Kamego Formation** (possibly Paleogene)

Potential good reservoirs: Kimwarer, Kamego, similar to the Lapur or Lokichar facies



Kimwarer Sandstones

## ❑ The Kerio / Baringo Basins:

➤ *in terms of SOURCE ROCKS*

From Early - Middle Miocene

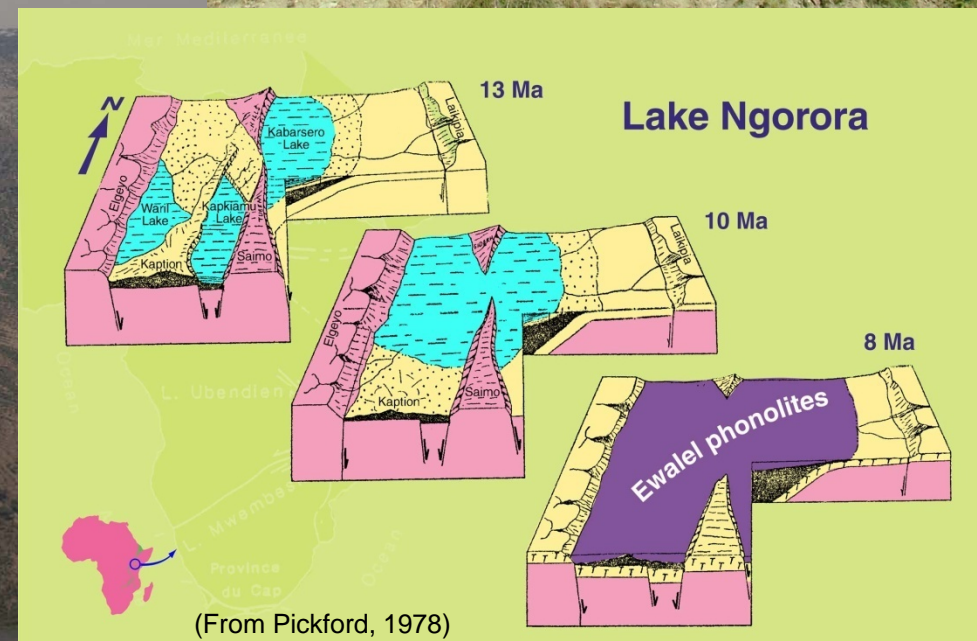
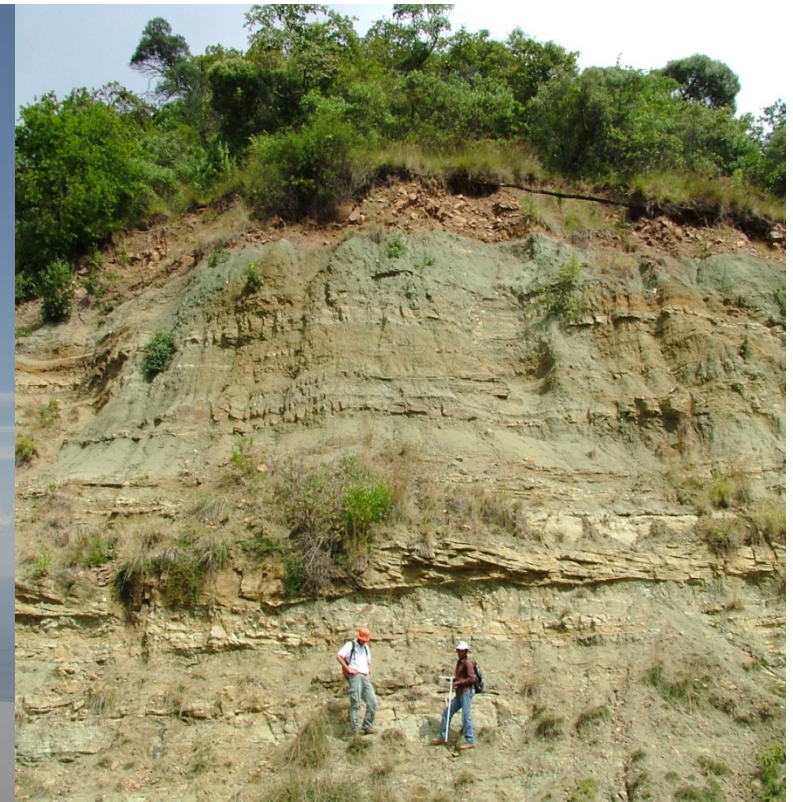
### ✓ Climate conditions

Open humid woodland and semi-deciduous forest environments alternate in this region during this period  
Similar to the Lokichar Basin conditions

✓ Lacustrine environments  
in the Kerio and Baringo Basins:  
Lake Tambach (16 - 14.5 Ma)  
**Lake(s) Ngorora (13 - 8.5 Ma)**

Deposition of the « **Poi Shales** »  
( $> 4\%$  TOC) in saline, alkaline lake(s) subjected to rapid lake level changes

different from Lake Lokichar ?



# Conclusions

## Petroleum Prospectivity in the NCKR Basins

### N° 1 - The Lokichar / North Kerio Basins \*

- ☐ Good quality source rocks
- ☐ Good reservoir rocks

### N° 2 - The Kerio / Baringo Basins \*

- ☐ Good quality source rocks, BUT associated to small lake basins
- ☐ Possible good reservoir rocks at depth ?

### N° 2 ex - The Gatome / North Gatome Basin

- ☐ Question on source rocks ?
- ☐ Good reservoir rocks

### N° 3 - The Lotikipi Basin

- ☐ Major question on source rocks ?
- ☐ Good reservoir rocks

*Thank you*  
*Merci*



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