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[AV]Discovering Oil in Uganda: Opening the East African Rift Play*

Bob Cassie[1], Charles Sheen[2], and Paul Burden[3]

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*Adapted from oral presentation given at the Discovery Thinking Forum, AAPG International Conference and Exhibition, Melbourne, Australia, September 13-16, 2015.

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Key Points

In the late 1990s the Lake Albert region was largely unexplored and of little interest to the petroleum industry. However, several factors made this area attractive to Hardman Resources and their joint venture partner, Energy Africa (both later acquired by Tullow Oil):

- Attractive geology with signs of an active oil source, reservoir and seal;
- Successful rift basin analogs existed elsewhere;
- As there was little interest from other companies, it was possible to acquire a large exploration area with high equity and reasonable terms (including the exploration commitments).

However, the basin was remote, and the development economics were unclear.

Regional gravity and magnetic data suggested the basin contained up to 6000 m of sedimentary section. Multiple seeps had been identified around the basin, and analysis of the best known seeps indicated the presence of a lacustrine algal source and a mixed terrestrial and lacustrine source. The distribution of seeps suggested a widespread, mature source, and/or good migration. A comparison to other rift basins suggested a number of trapping styles, including tilted fault blocks in pre- and syn-rift sections and drape over fault blocks, could be expected.

Executing an exploration program in this remote area, with little access to services and support, was challenging. In 2003, an initial 1589 km seismic survey was recorded across the whole lake by Hardman, in co-operation with the University of Syracuse, using a converted fishing boat and a small acquisition system. This provided a very cost effective overview of the basin and identified a number of leads. Subsequently, an onshore and transition zone seismic survey was acquired to define prospects for drilling.

All the identified prospects shared a common risk, seal against basement faults. The largest prospect would have required a deviated well drilled from shore, through a major fault to a bottomhole location in the lake – a high risk option for an initial well in a remote area. The joint venture, therefore, decided to test the play concept with simple vertical, onshore wells and drilled both the Mputa and Waraga prospects.

The success of the initial wells demonstrated the potential of the basin and subsequent exploration has discovered 1.7 billion barrels of oil in 17 fields. More than 80 exploration and appraisal wells have been drilled with a 90% exploration success rate.

Lessons learned include:

- Be prepared to do something different (in terms of the areas to explore and how to do it);
- "Cautious optimism" is useful (don't talk yourself out of a project too early!);
- Sometimes it can be easier to execute a program than you might first think – particularly if you are prepared to do something different.

References Cited

Cloke, I., 2011, Building an East African asset base: Presentation, East Africa Energy Week Conference, Nairobi, Kenya, May 16-18, 2011.

Harris, N., J.W. Pallister, and J.M. Brown, 1956, Oil in Uganda: Memoir IX, Geological Survey and Mines Department, Entebbe, Uganda, 33p.

Wayland, E.J., 1925, Petroleum in Uganda: Memoir 1, Geological Survey of Uganda, 61p.

Discovering Oil In Uganda

Opening the East African Rift Play

Bob Cassie
Chas Sheen
Paul Burden

Presentation outline

1. The East African Rift & Albertine Graben
2. Why explore Lake Albert?
3. The seismic surveys – finding the targets
4. Mputa & Waraga – proving the basin
5. Building on success
6. Concluding remarks

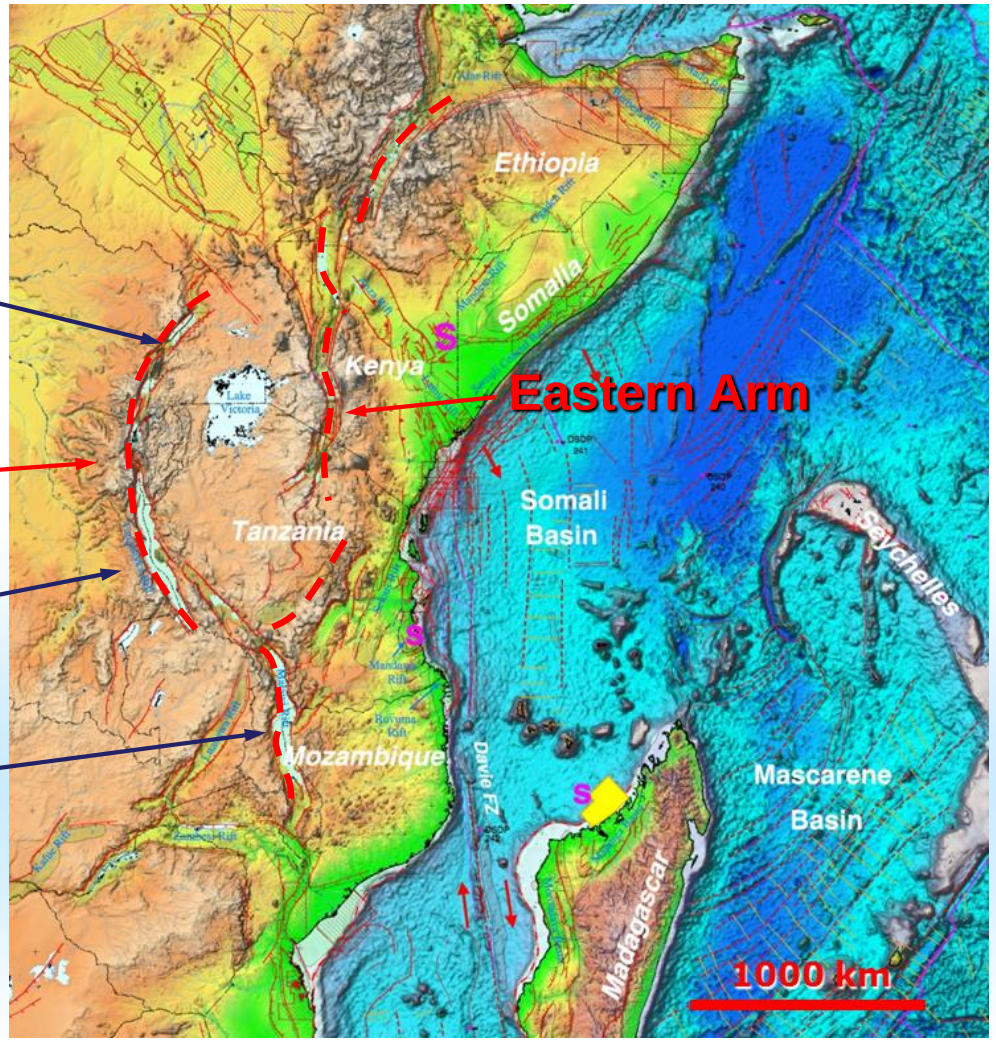
East African Rift

Lake Albert
~60 m WD

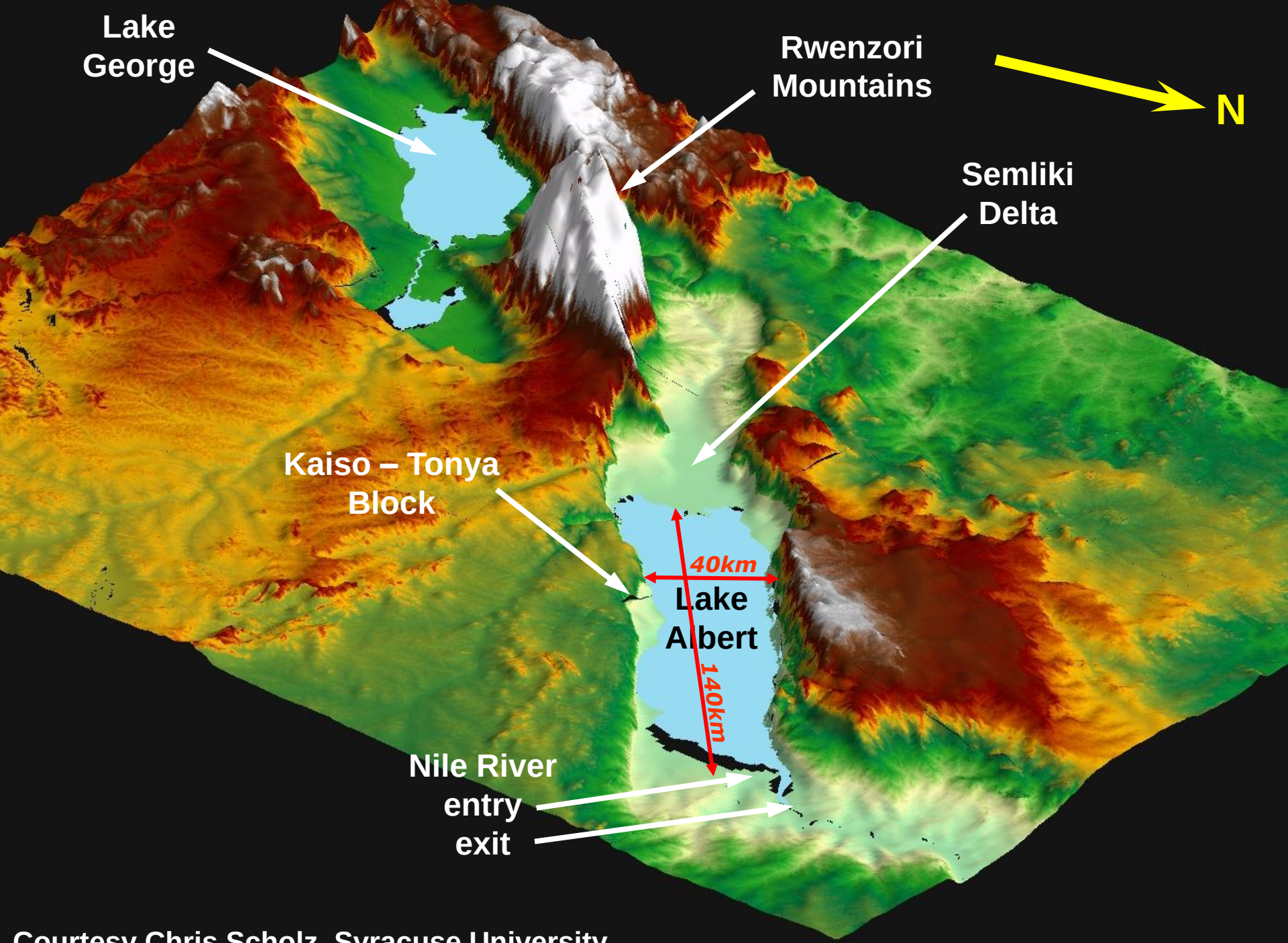
Western Arm

Lake Tanganyika
~~1,400 m WD

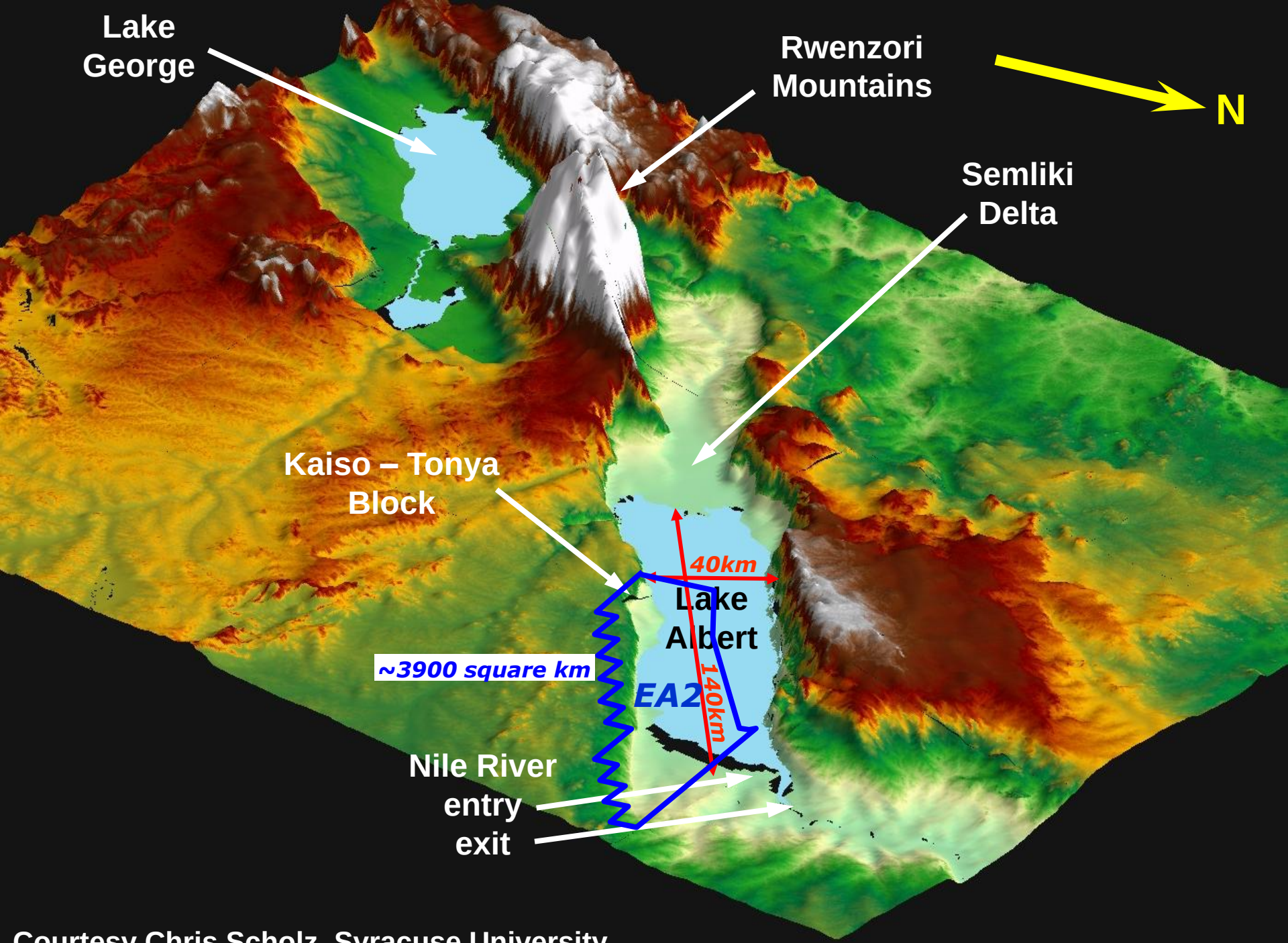
Lake Malawi
~700 m WD



Presenter's notes: Lake Depths are mainly deep; Lake Albert is shallow, with lots of sediment fill.



Courtesy Chris Scholz, Syracuse University



Courtesy Chris Scholz, Syracuse University

Why Lake Albert?

Why Lake Albert?

- **Attractive geology**
  - **signs of an active, oil source**
  - **reservoir, seal likely**
  - **rift basin analogs**
- **Good position available**
  - **not competing with bigger players**
  - **large block, high equity**

...but remote & economics unclear

Hardman & Uganda

1997 – signed PSA over Exploration Area 2

1998 – oil price crash, relinquished PSA

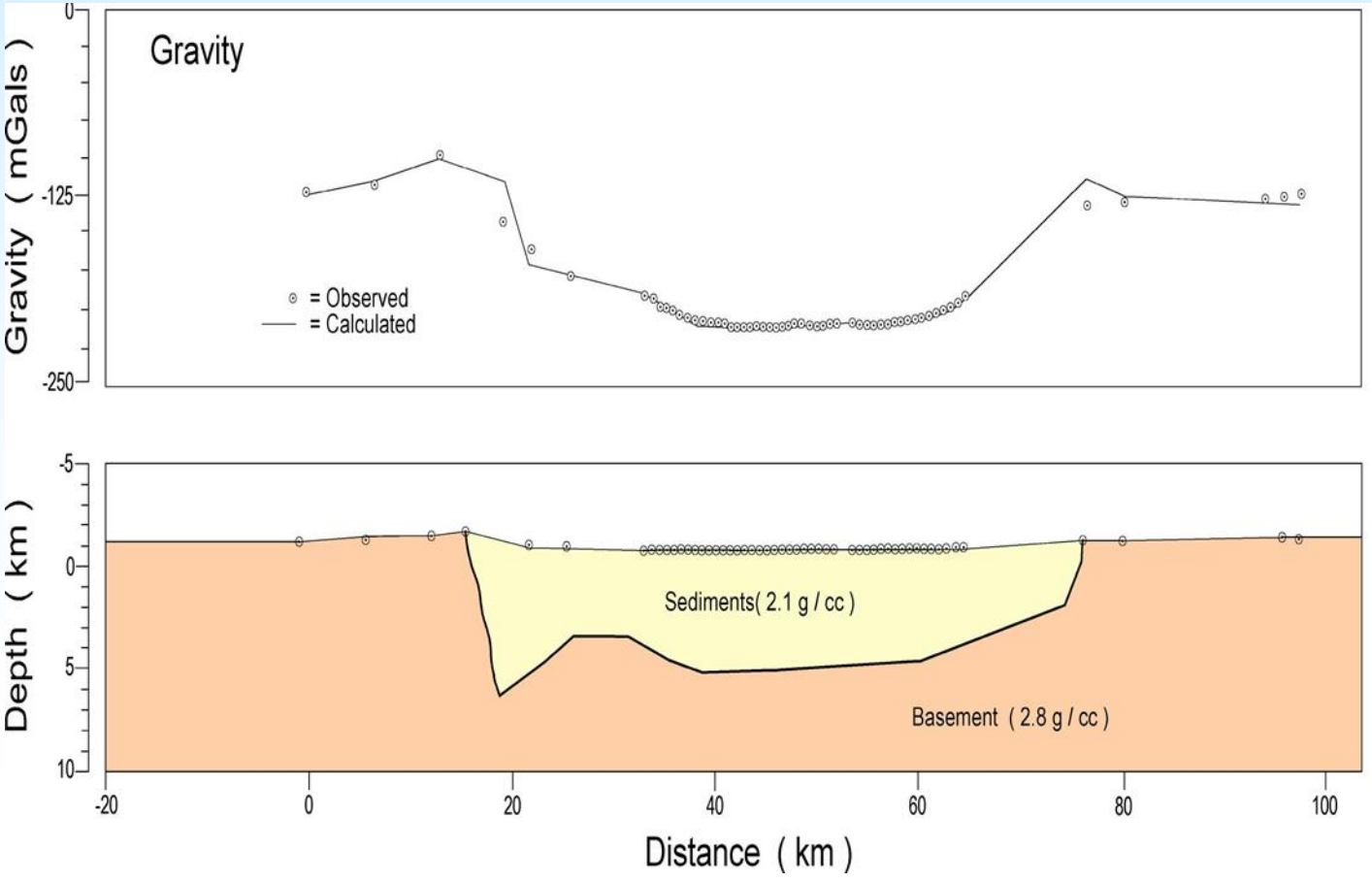
2001 – Mauritania farmout and drilling success, now funded

"Uganda's too good to leave behind, let's go for it"

Late 2001 – Hardman and Energy Africa sign new PSA

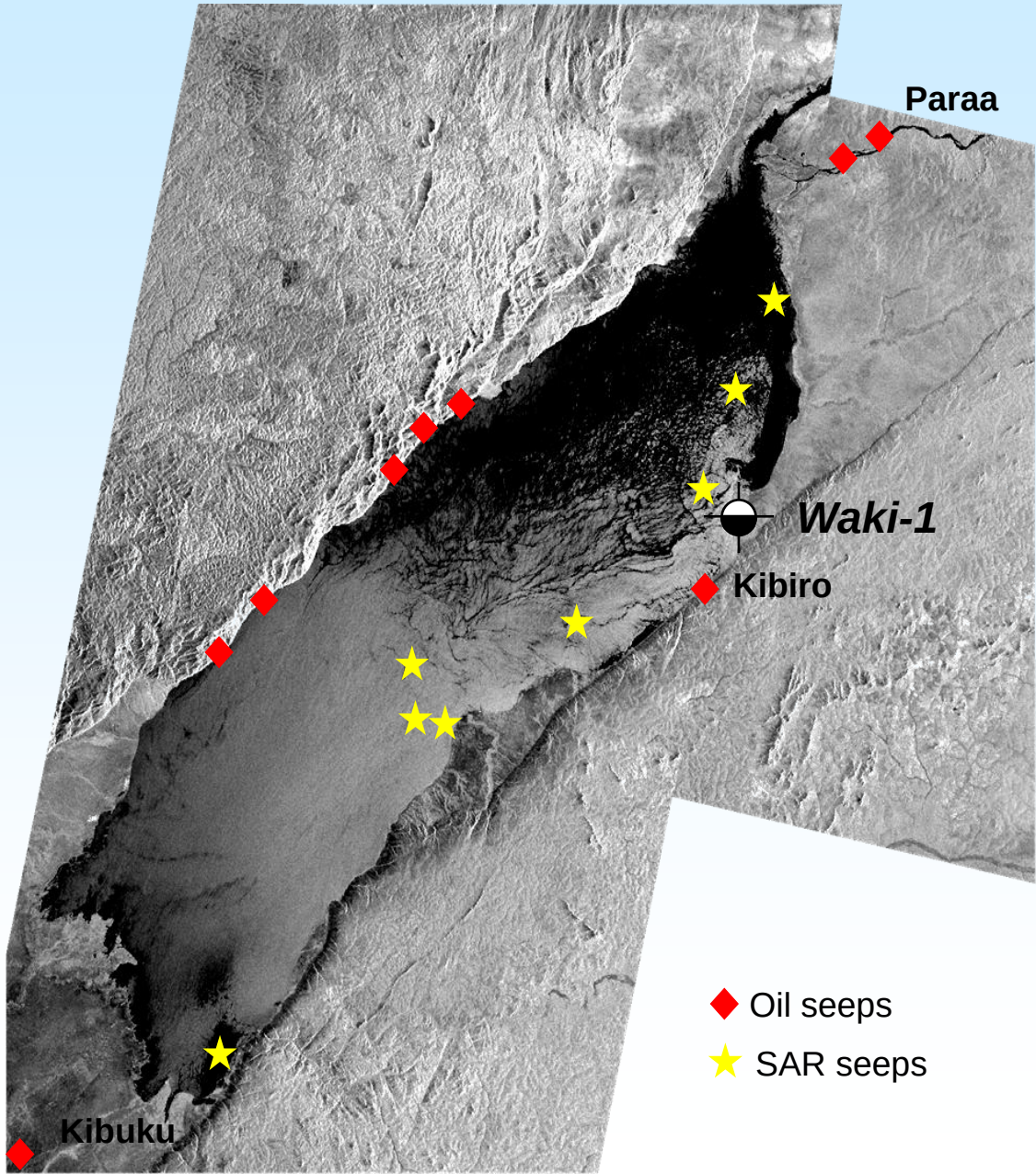
Gravity and magnetic data

- 5,000 to 6,000 m of predicted section
- Sufficient depth of burial for generation
- Northern & southern sub-basins – separated by a possible “transfer zone”



Oil Seeps

- Wayland (1925) survey
  - 52 oil seeps identified around Lake Albert
- Kibiro seep
  - Very rich, Type I lacustrine algal source
- Paraa & Kibuku seeps
  - Mixed terrestrial & lacustrine source
- SAR survey identified “low confidence” seeps in lake



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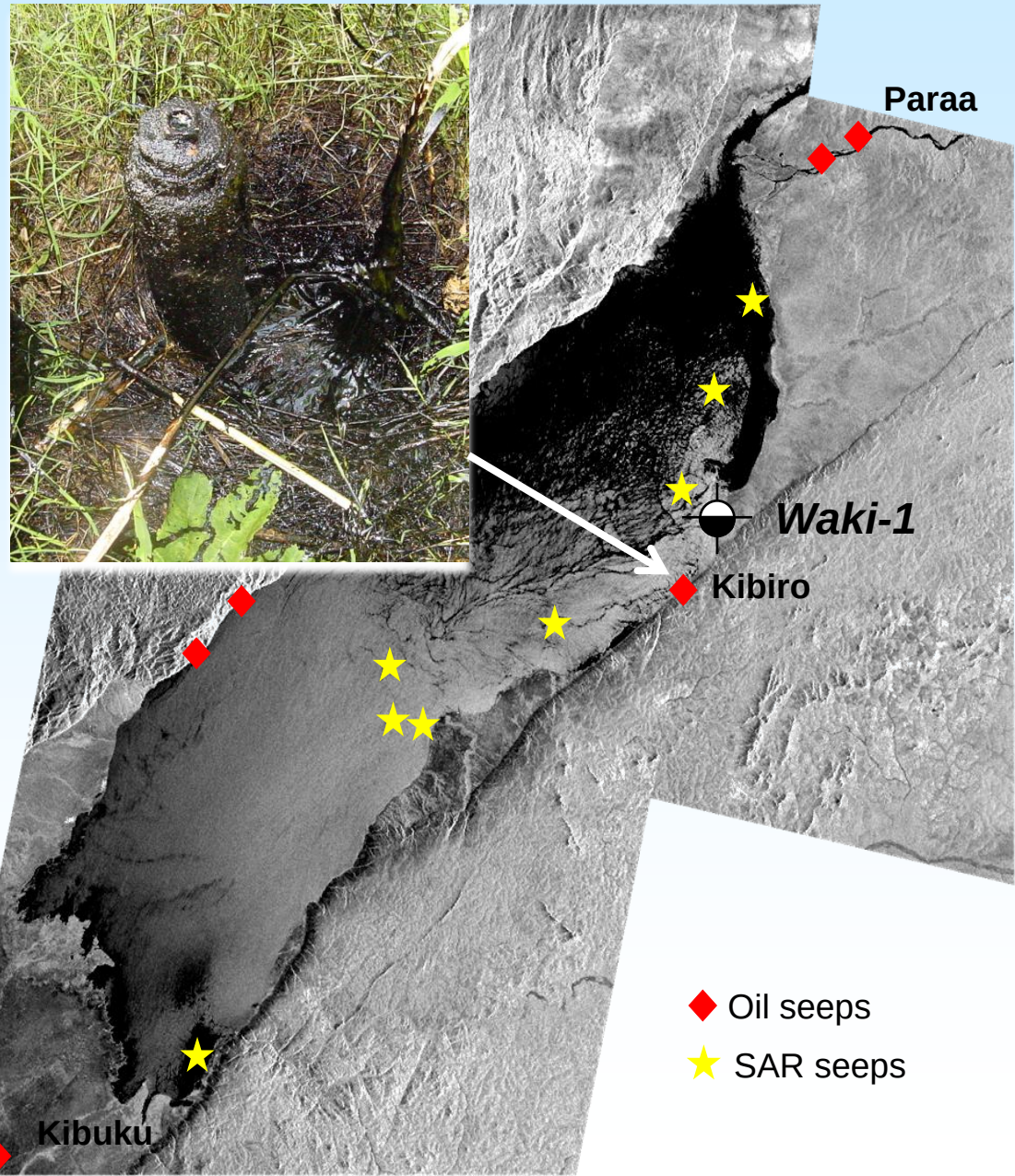
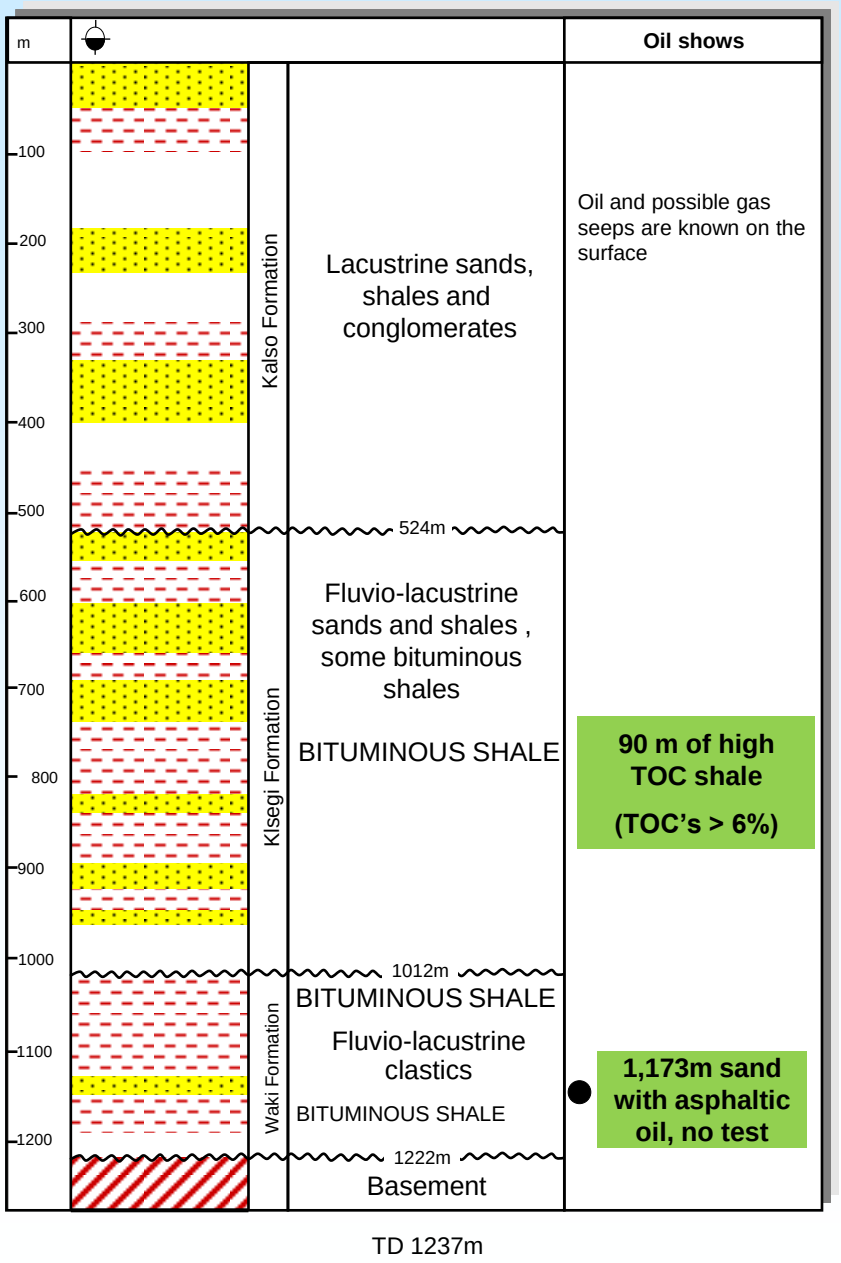
- ***Suggests widespread, mature source and/or good migration***



Waki-1

- 1938, first well in East Africa
- Close to basin-bounding fault
- TD 1237 m, gneissic basement
- Interbedded sands & shales
- “oil shales” with associated shows from 760 m to1175 m
- “Asphaltic oil” at 1173m, no test
- 6-7% TOC and extractable hydrocarbons in 90 m “oil shale” from 760 m (Harris, 1956)



Trapping Potential

Gravity & magnetic interpretation

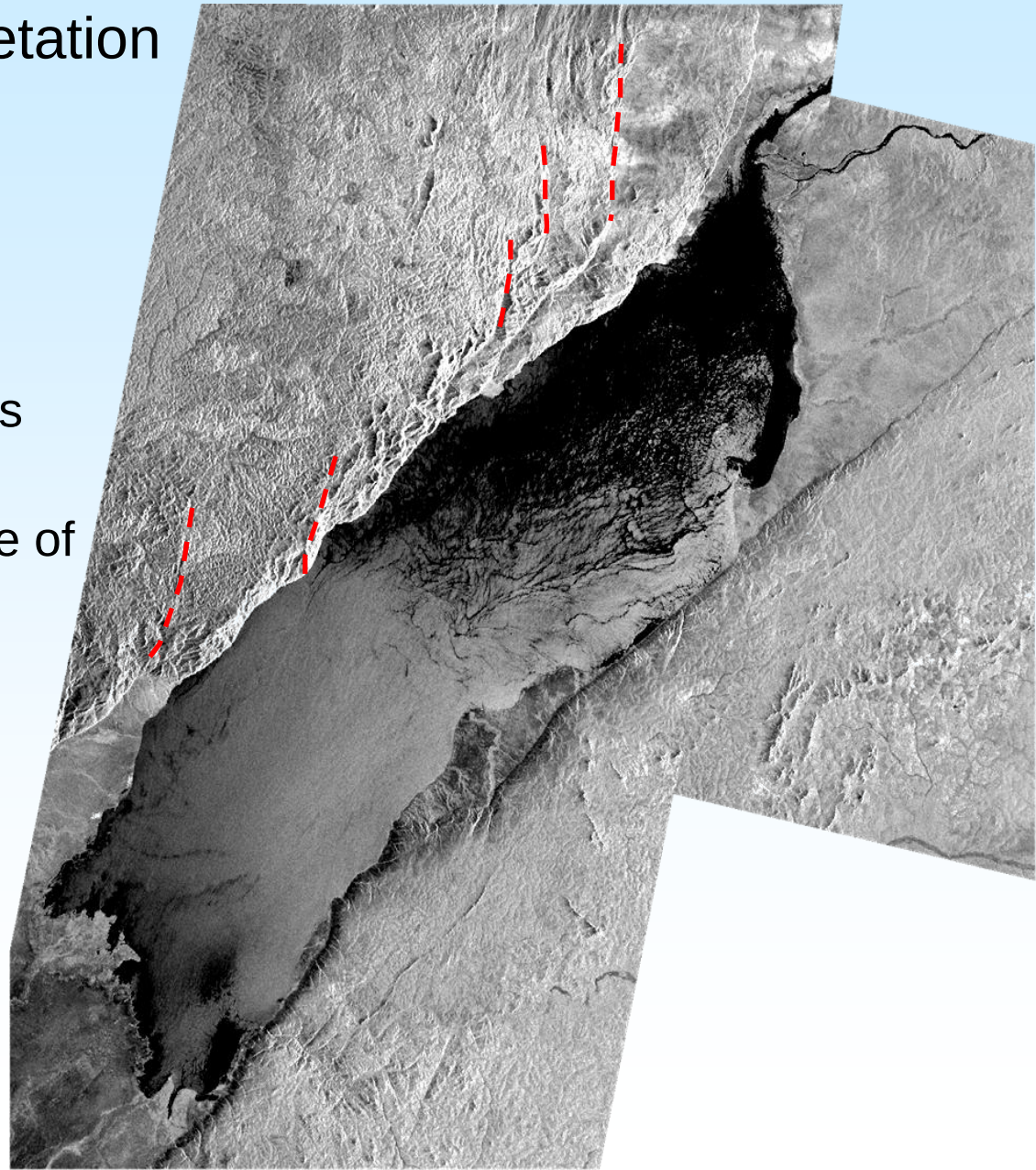
- Large faults
- Intra-basin highs

Regional tectonics

- Basement fault patterns
- Earthquake focal solutions suggest strike-slip motion
- Rwenzori uplift – evidence of compression?

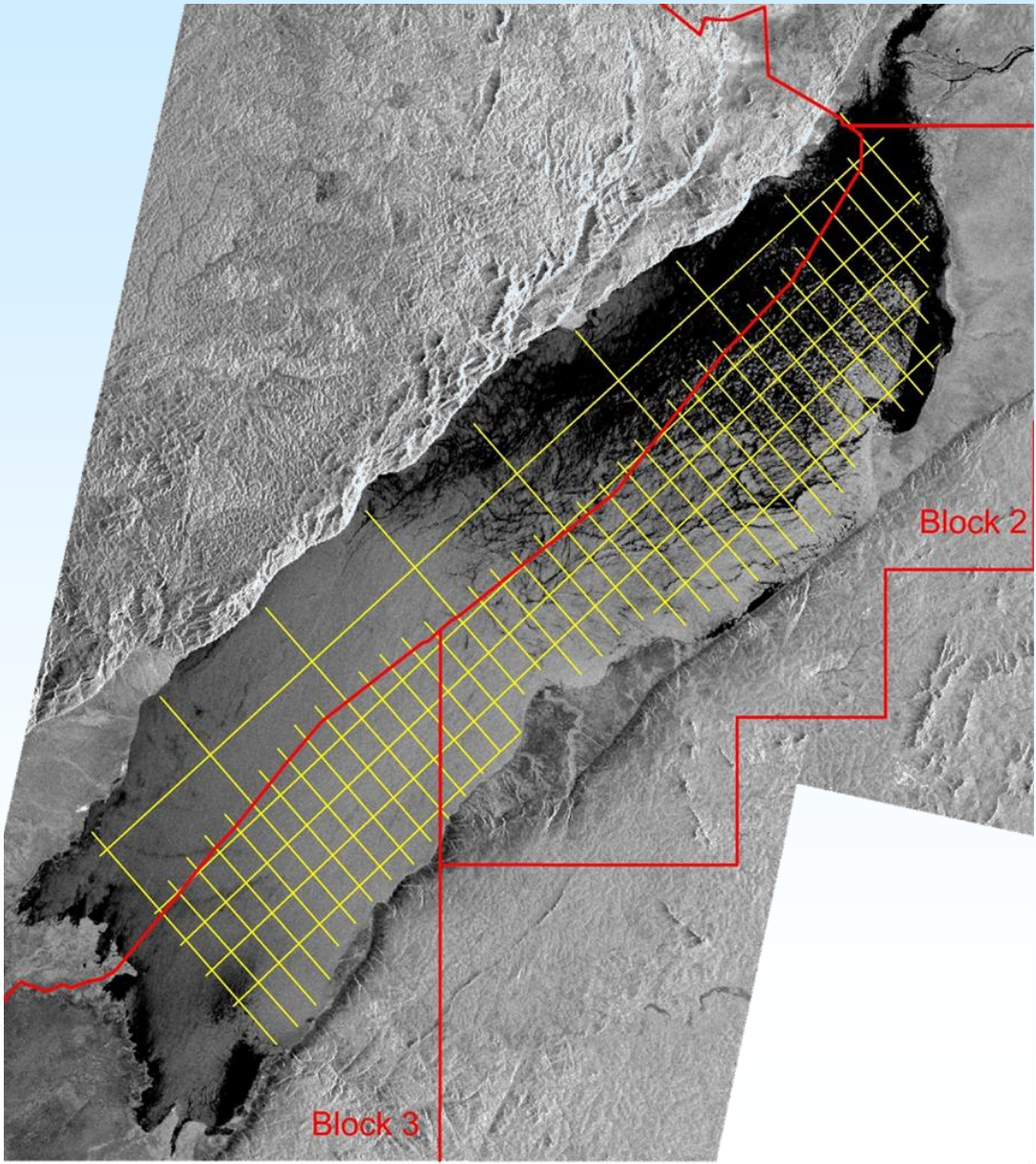
Analogy to other rift basins

- Tilted fault blocks in pre- & syn-rift section?
- Major faults stepping into basin?
- Drape over fault blocks?



Proposed Lake Albert Seismic

- Basin–wide survey
- 1,500 km, 5x3km grid
  - Possible infill for prospect definition
  - Joint program with EA3
  - Extensions into DRC
- Conventional operation too expensive
- Acquired with Syracuse University research team



RV Kilindi

- RV Kilindi - purpose built for lake research
- Modular, easy to transport in containers
- Required equipment upgrades for “industry” survey

RV Kilindi

Additional equipment too heavy for vessel!

Plan B

Fishing vessel transported overland from Lake Victoria

Plan B

Plan B

Victoria III

- **1200 m, 48 group solid streamer**
- **120 cu in, 2,000 psi airgun source**
- **24 fold, 25 m SP, 5 sec records**

Lake Albert Seismic Survey

1,589 km acquired

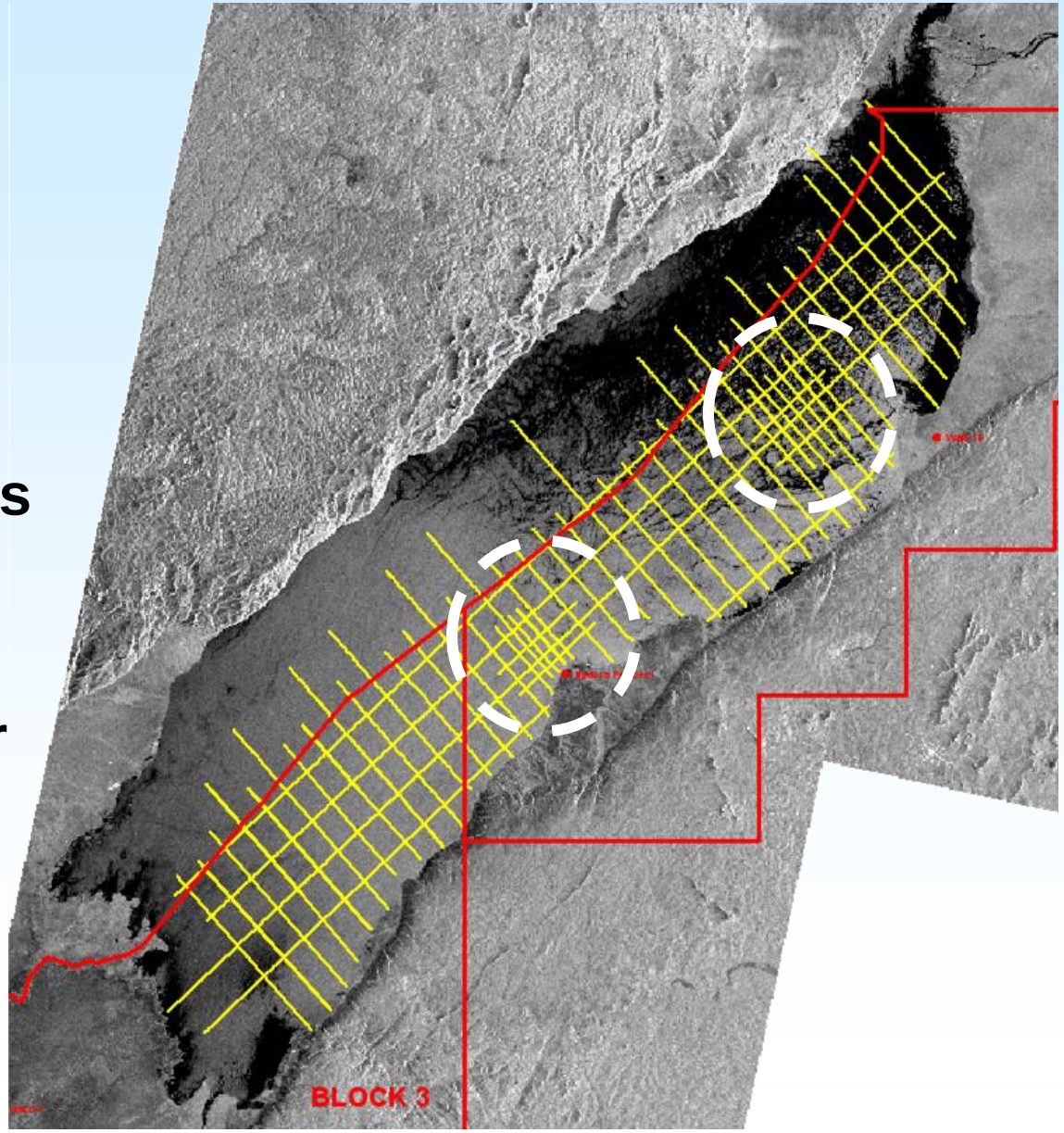
79 days total

57 days recording

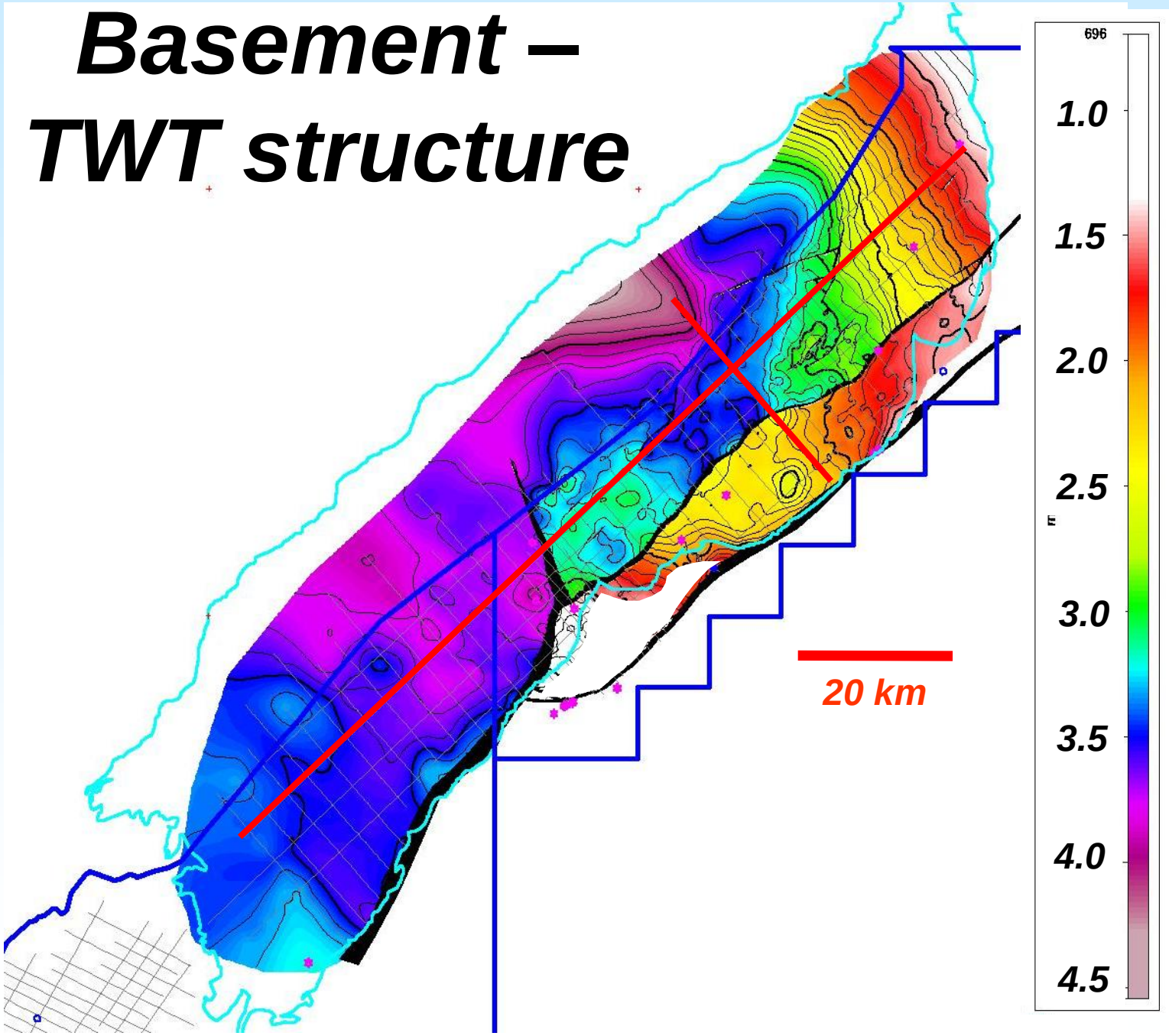
~$2,000 per km

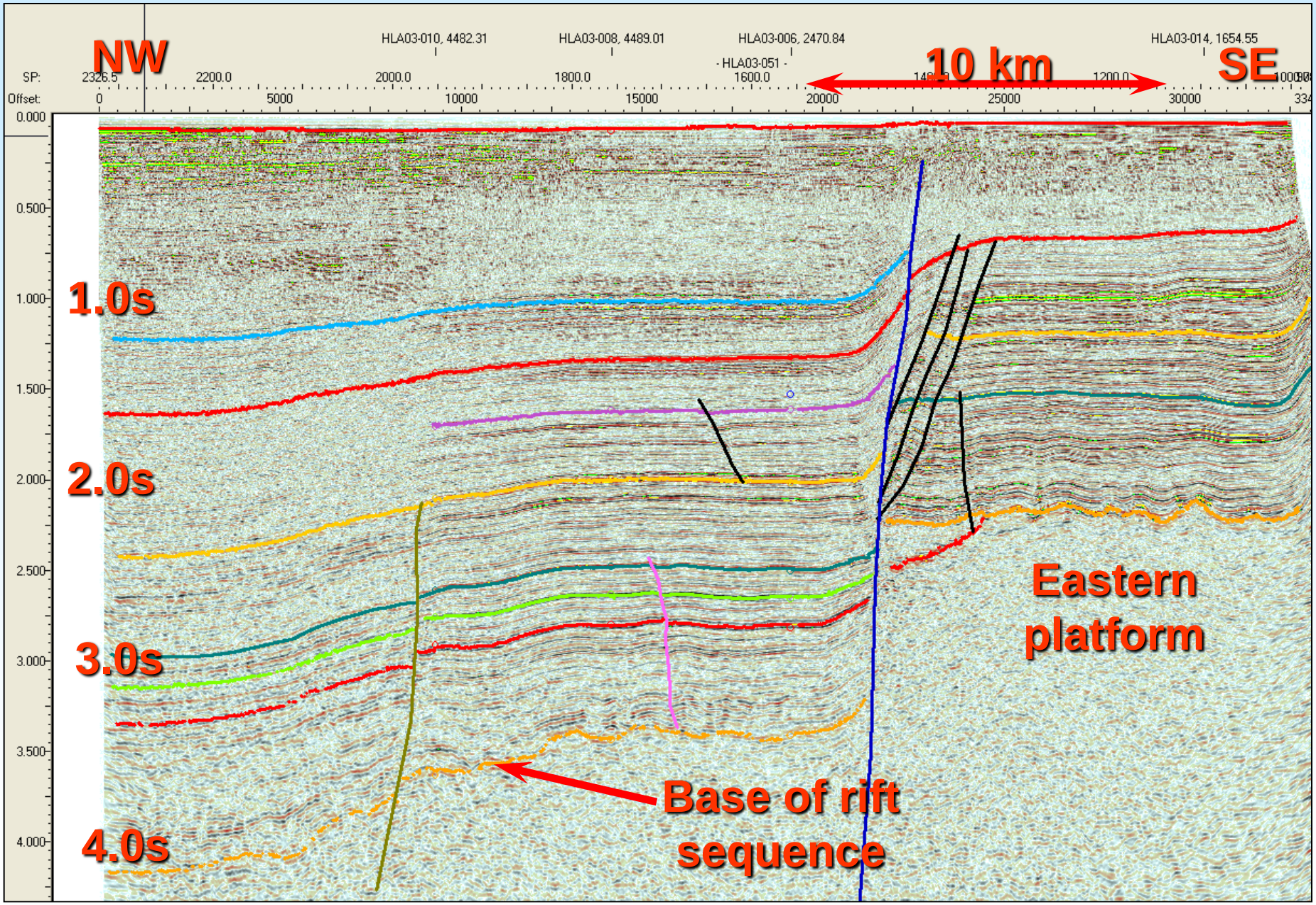
Dropped some DRC lines – security issues

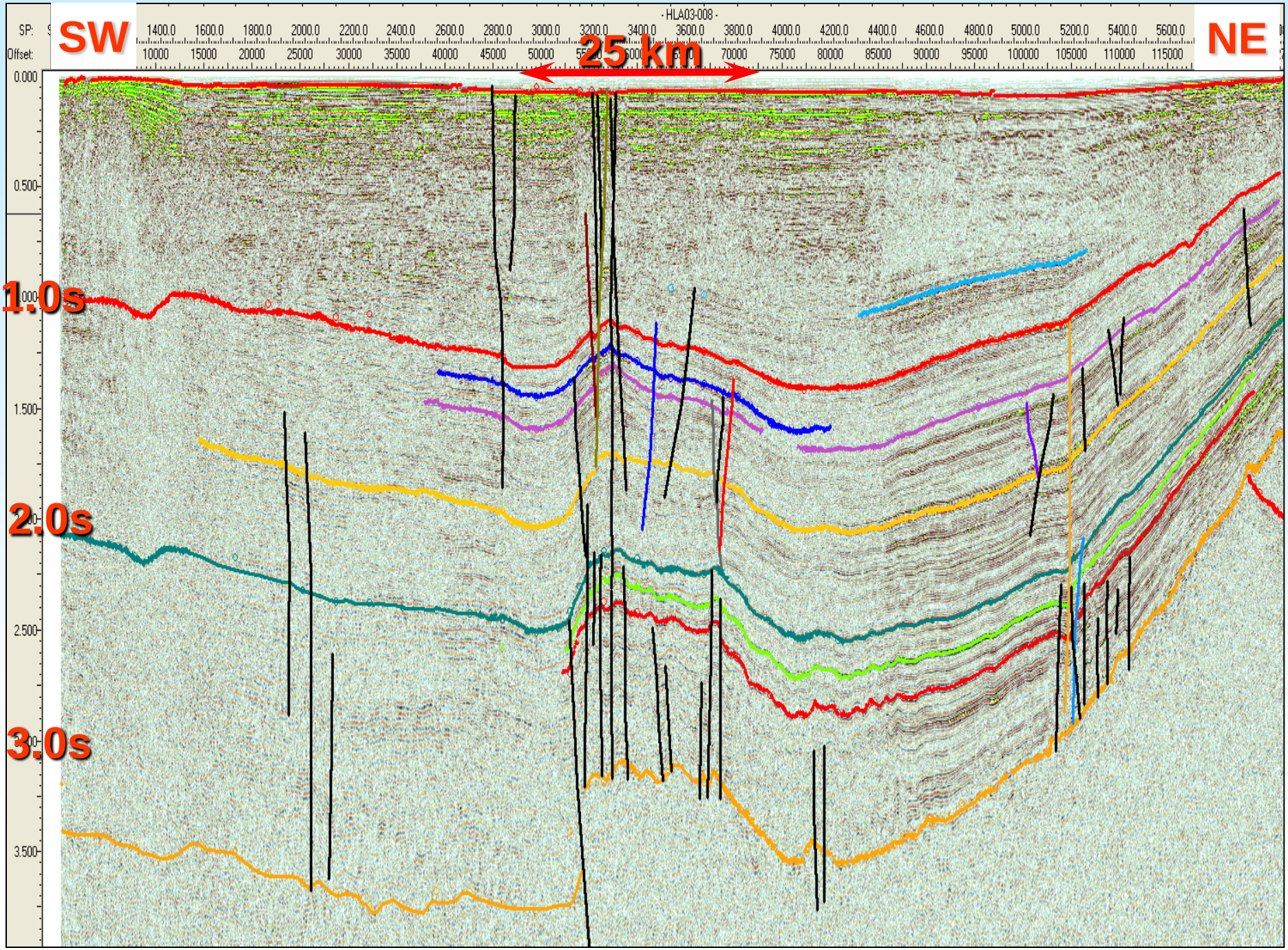
Infill grids acquired over possible prospects



Basement – TWT structure

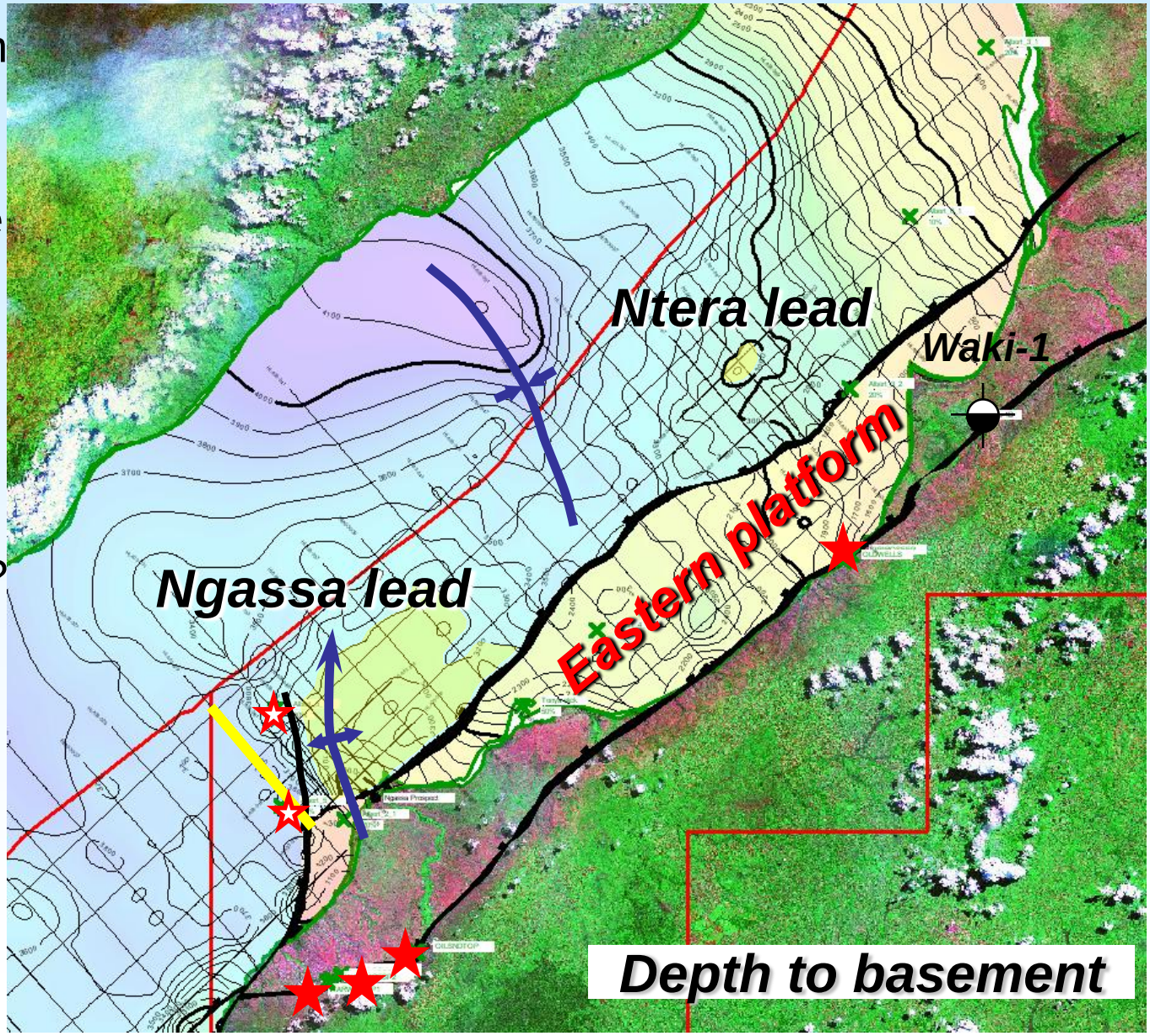



NW
SE
10 km
HLA03-010, 4482.31
HLA03-008, 4489.01
HLA03-006, 2470.84
- HLA03-051 -
HLA03-014, 1654.55
SP:
Offset:
1.0s
2.0s
3.0s
4.0s
Eastern platform
Base of rift sequence


SW
NE
25 km
- HLA03-008 -
SP:
Offset:
1400.0 1600.0 1800.0 2000.0 2200.0 2400.0 2600.0 2800.0 3000.0 3200.0 3400.0 3600.0 3800.0 4000.0 4200.0 4400.0 4600.0 4800.0 5000.0 5200.0 5400.0 5600.0
10000 15000 20000 25000 30000 35000 40000 45000 50000 70000 75000 80000 85000 90000 95000 100000 105000 110000 115000
0.000
0.500
1.000
1.500
2.500
3.500
1.0s
2.0s
3.0s

Ngassa Lead

- Large downthrown closure against basement fault
- Shallow amplitude anomalies
- SAR seeps
- Drill deviated from onshore?
- Does the trend continue onshore?
- More seeps found onshore
- **Acquire TZ and onshore data**



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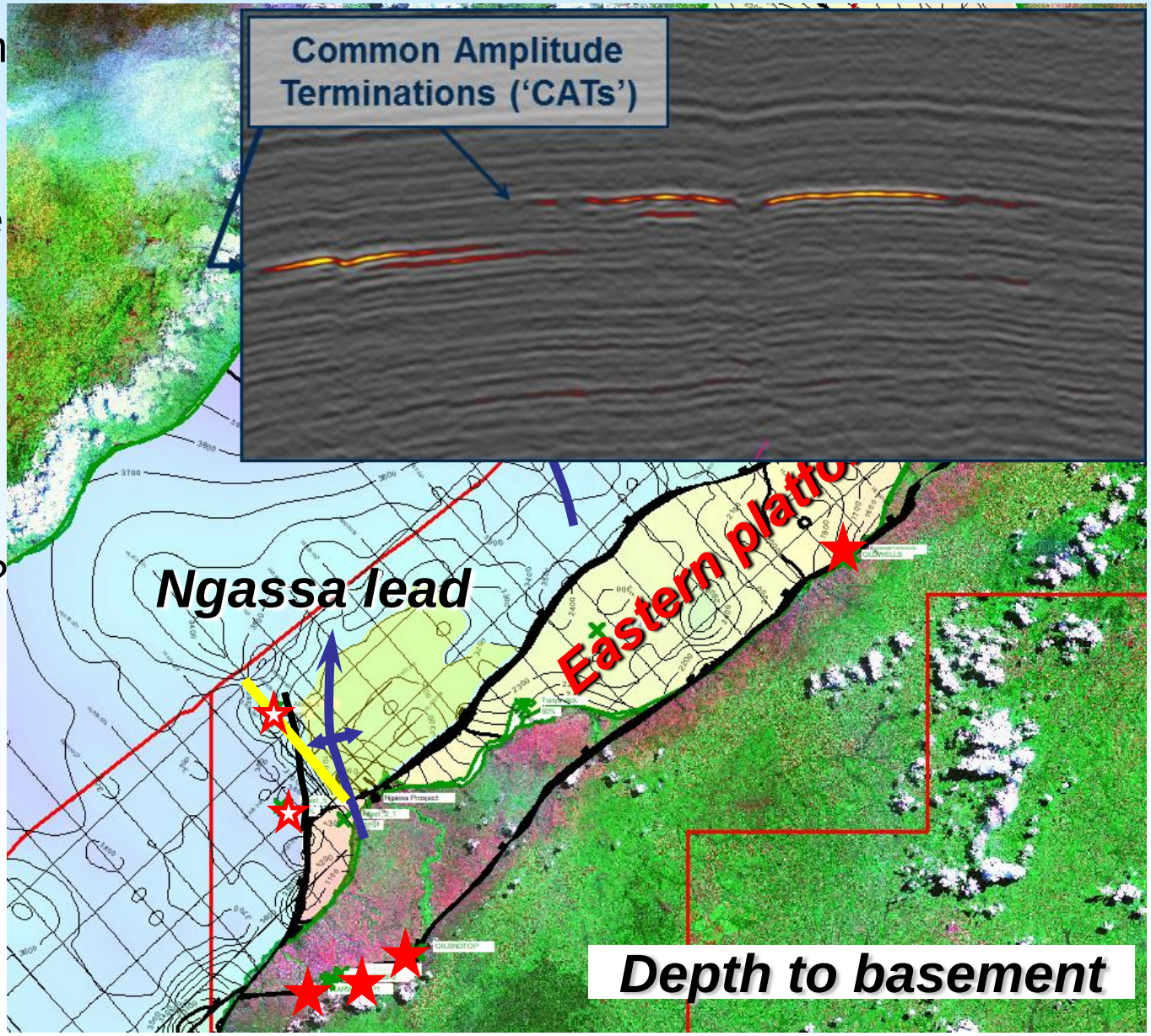


2005 Kaiso-Tonya Seismic Survey

Acquisition Issues

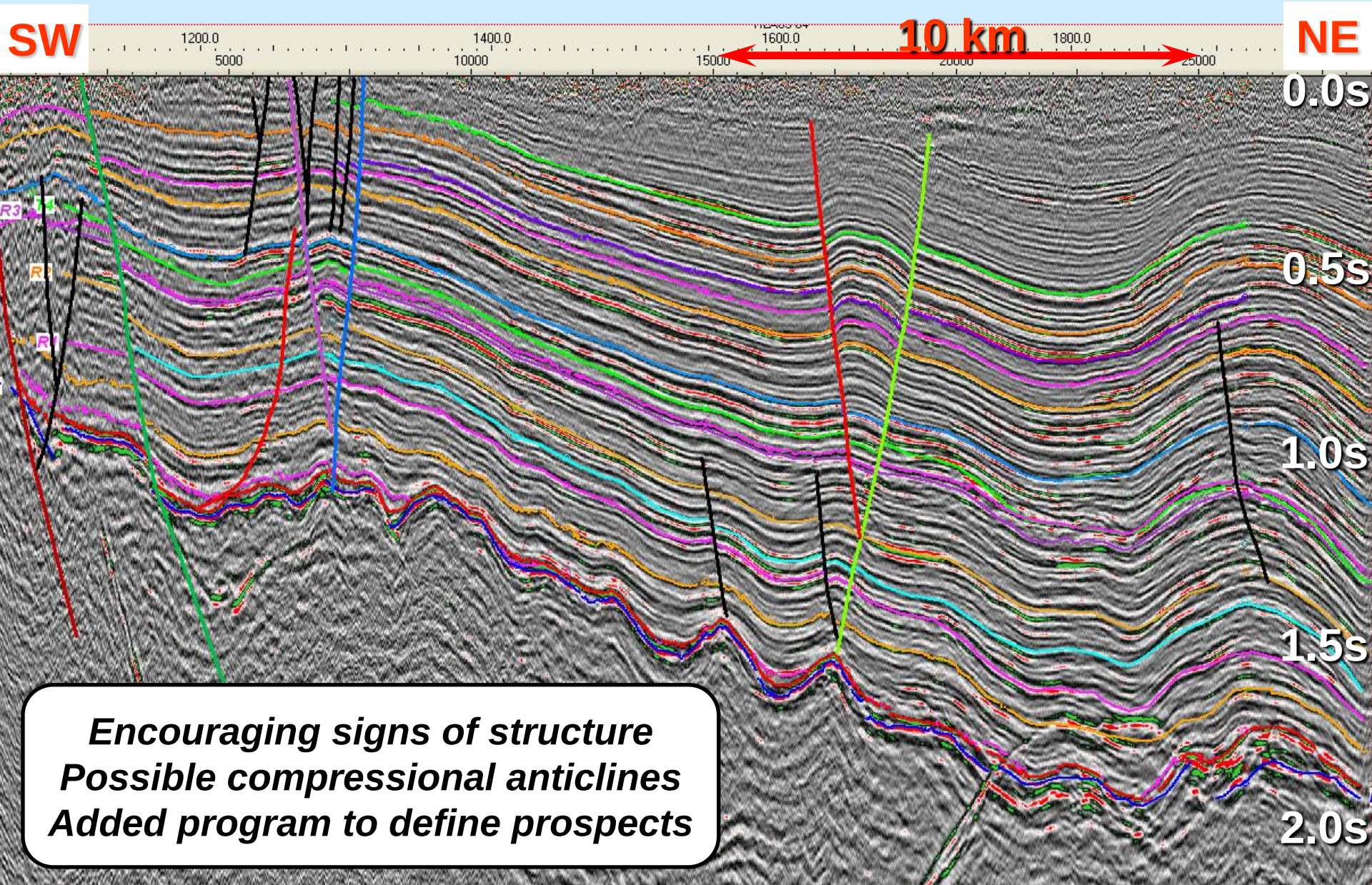
- Upgrade road access
- Communications
- In-field processing
- Support vessels
- Explosive handling

Local Issues

- Fishing communities
- Wildlife reserve
- Grazing

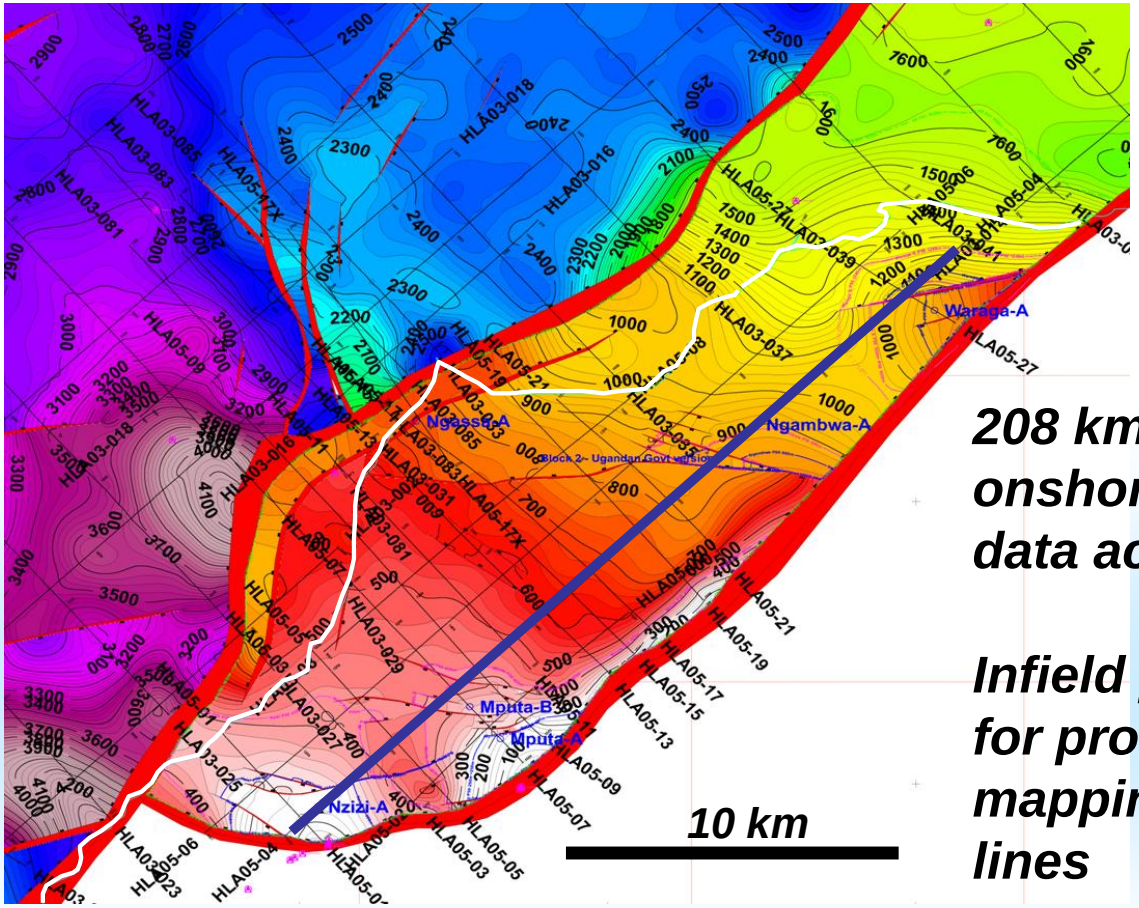
Presenter's notes: Remote and very poor fishing communities; impact of road was positive.

First line, Kaiso-Tonya area



Encouraging signs of structure
Possible compressional anticlines
Added program to define prospects

Basement map, Post-survey

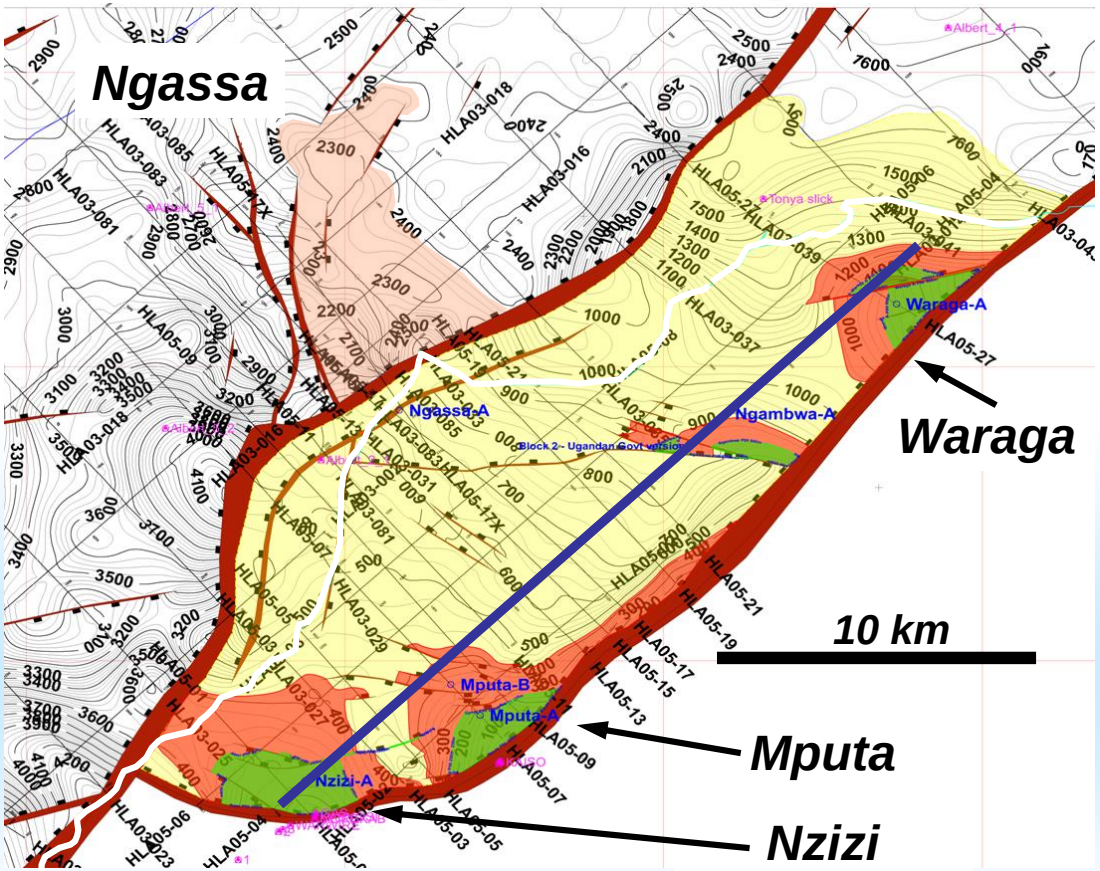


208 km of TZ and onshore seismic data acquired

Infield processing for prospect mapping & infill lines

Presenter's notes: cost of seismic: $11,000 per km.

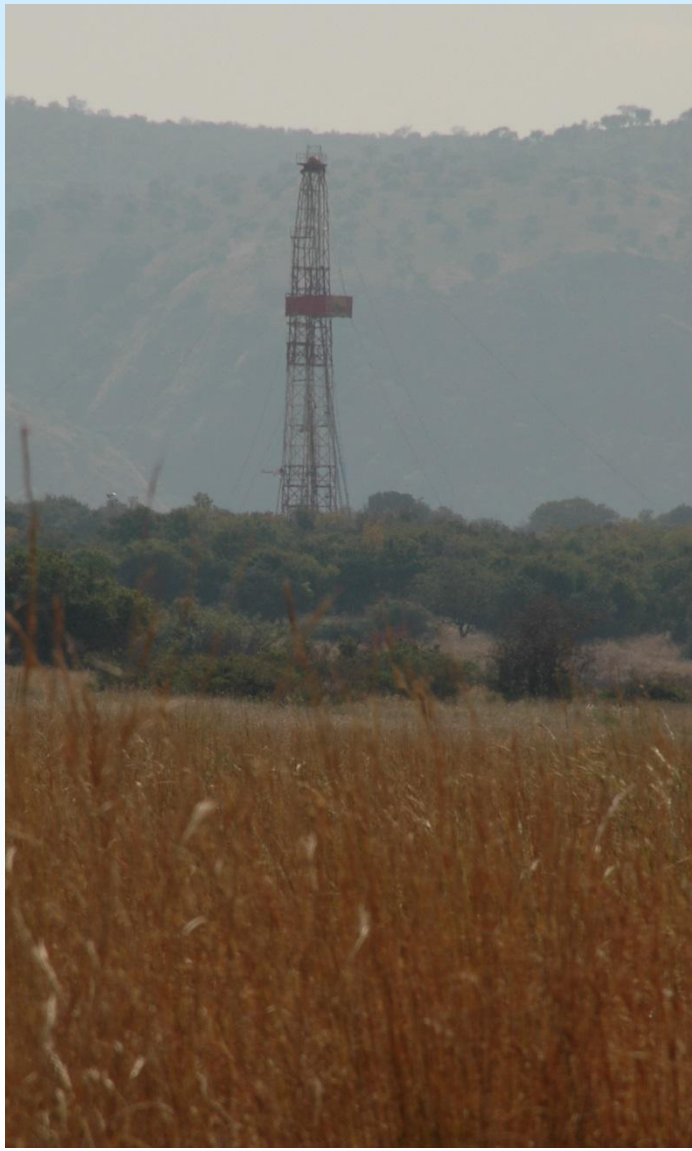
Prospects – pre-drill



Presenter's notes: Upside cases: Mputa and Nzizi merge; absolute upside – whole block closes.

Drilling target selection

- All prospects shared a common risk
  – seal against basement faults
- **Mputa**
  – Highest point on block with seeps updip
  – Complex fault pattern
  – Best chance of charge but is it breached?
- **Waraga**
  – Simpler structure but limited control
  – No seeps - migration & charge risk?
- **Ngassa**
  – Biggest prospect but offshore
  – Technically challenging, expensive, long reach well across major fault
- **Test concept & prove the basin with simple vertical wells**
- **Drill both Mputa & Waraga**

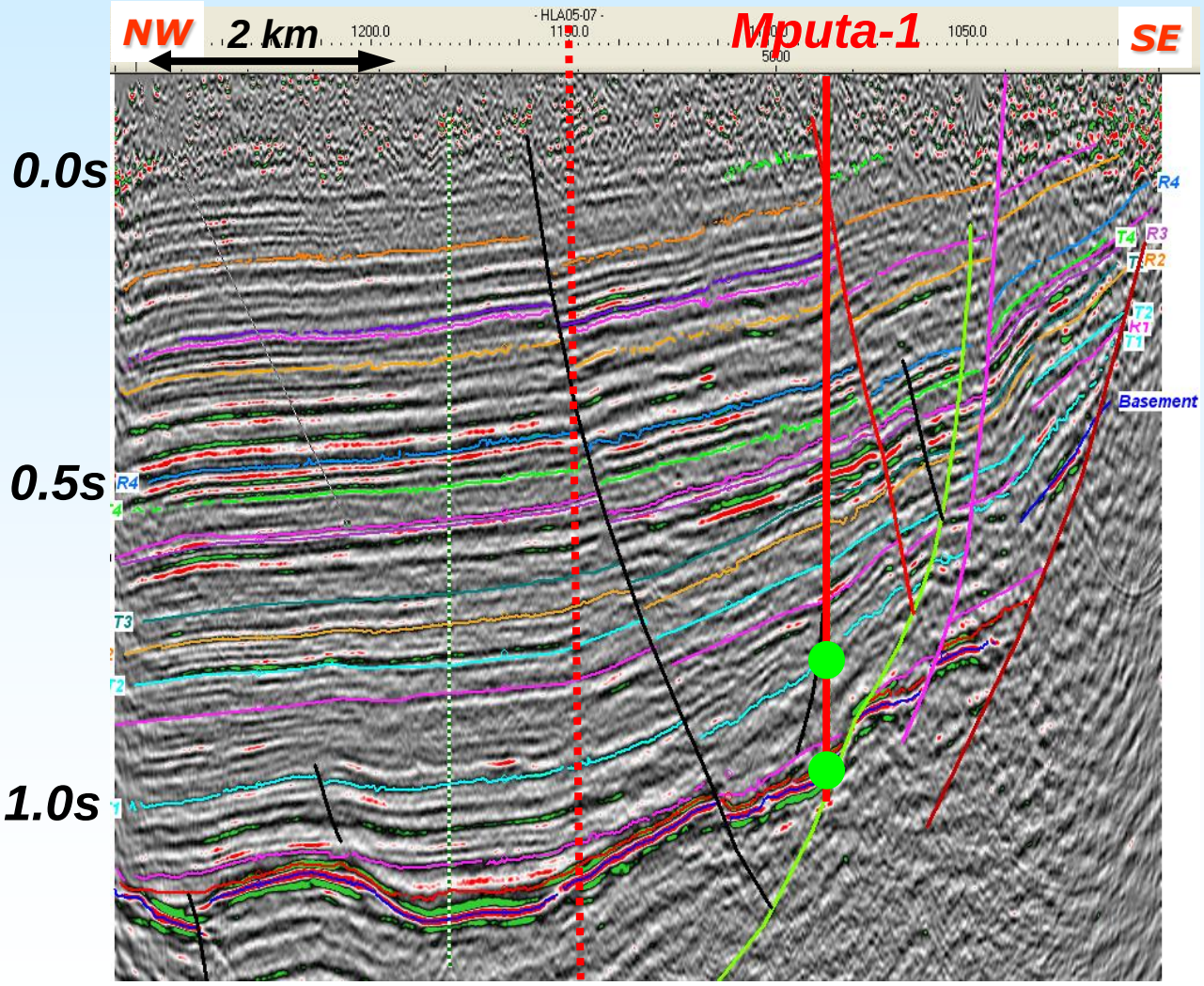


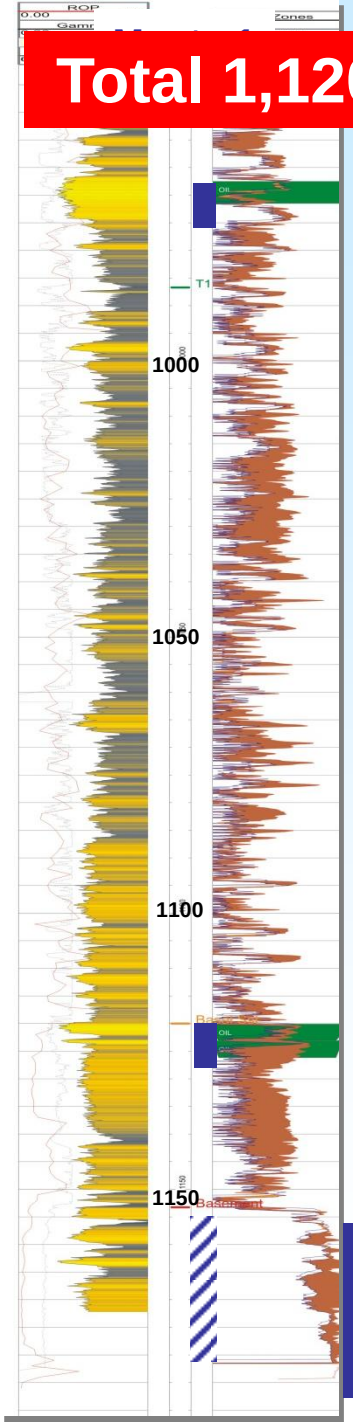
First, build a road

Mputa-1

Spud – December 2005

Testing – August 2006





Total 1,120 bopd

4.4m net pay

DST 3
820 bopd
(5/8” choke)
33⁰ API

Oil shows throughout interval

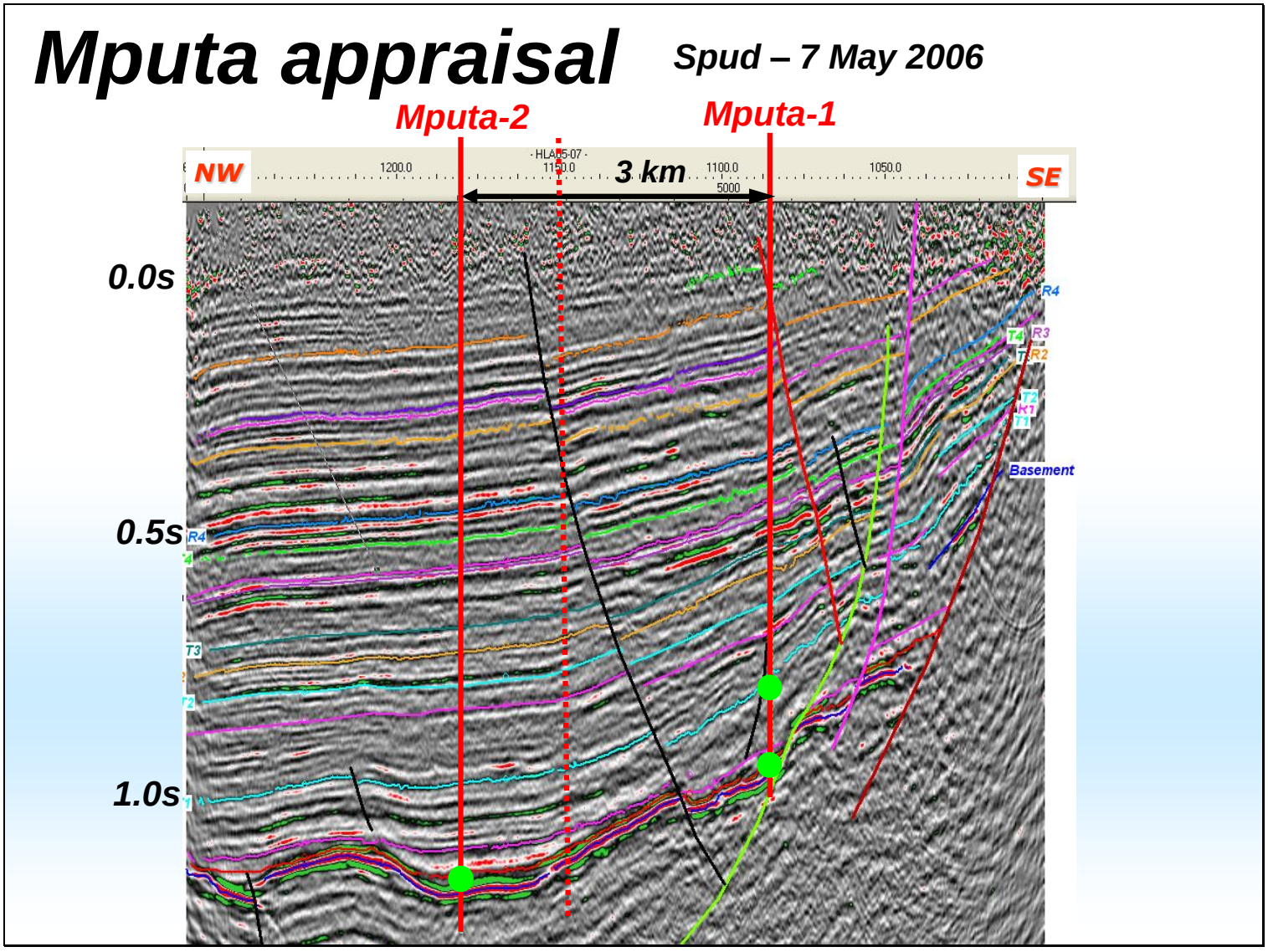
DST 2
300 bopd
(1/2” choke)
32⁰ API

2.3m net pay

DST 1
Minor oil recovered from fractures

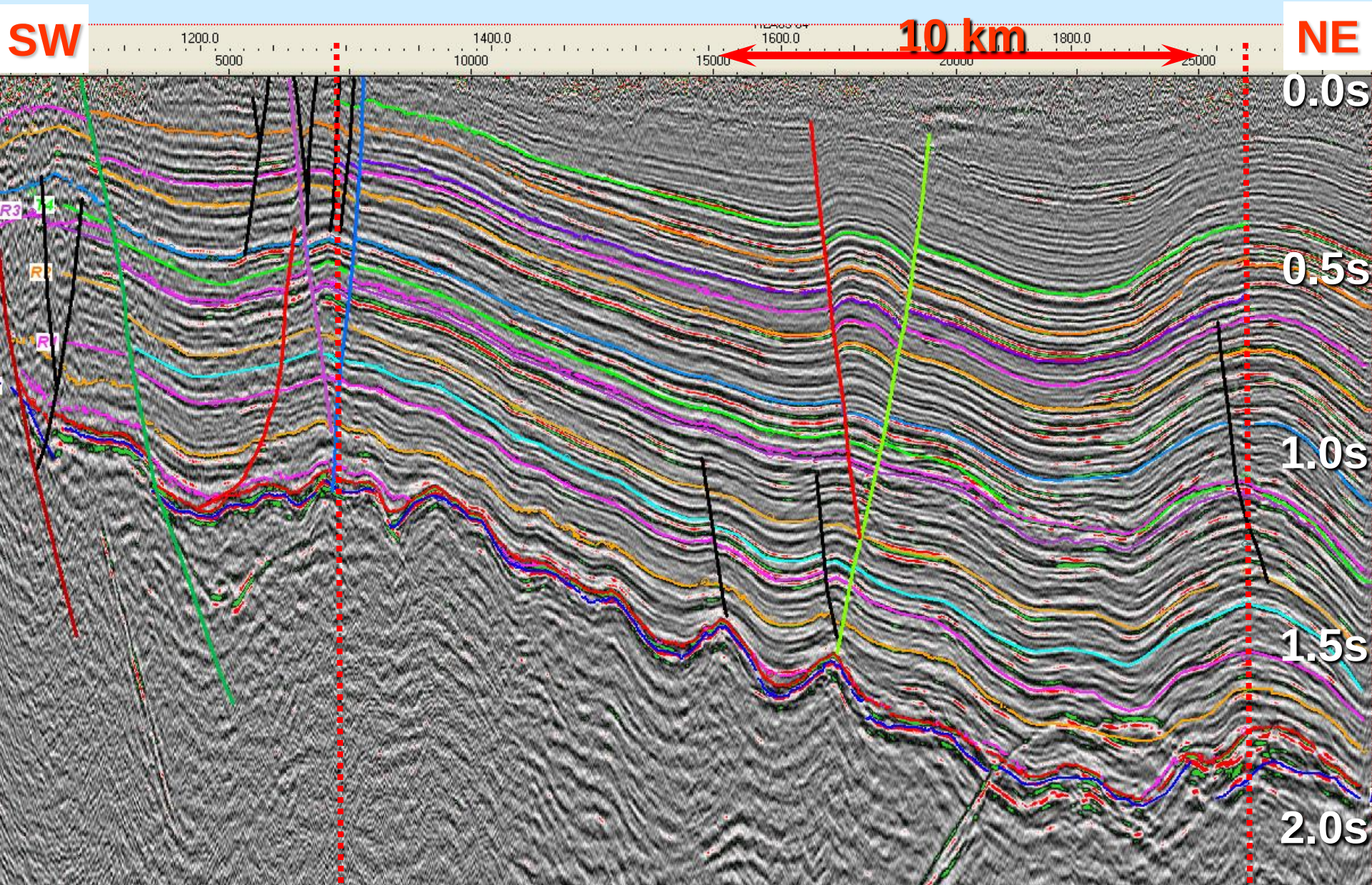
Mputa appraisal

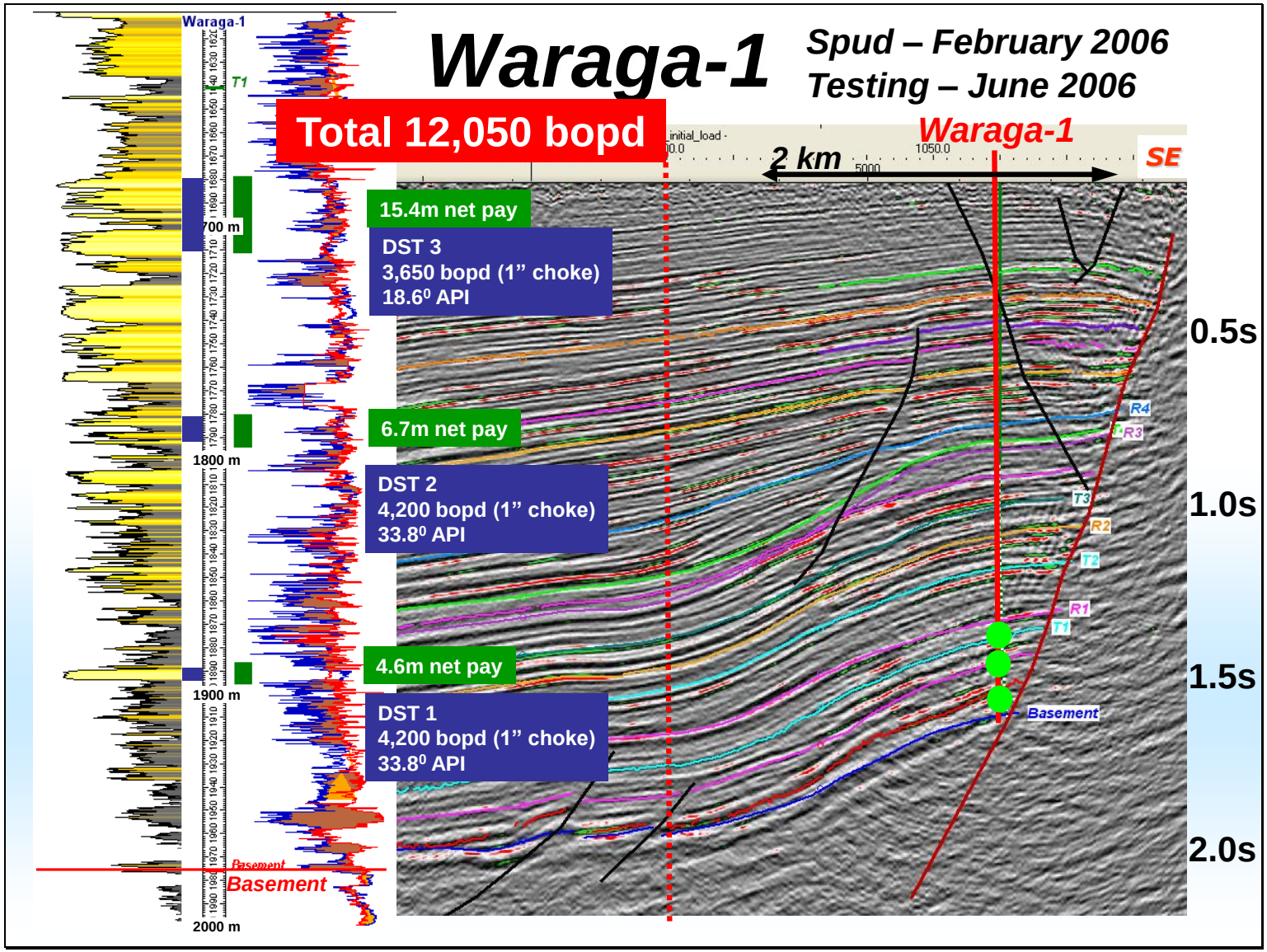
Spud – 7 May 2006



Presenter's notes: Aggressive downdip step-out, looking for reservoir "thicks" in basement lows, with long columns to support upside cases.

Mputa - Waraga





Presenter's notes: Discovery deeper in section than prognosed; very sandy in shallower section, a poor seal? The best seal is seemingly in the deepest section, more lacustrine shales, which are better for trap. Average porosity – mid to high 20's.

Tullow acquires Hardman

A$1.47 billion (US$1.1 b) offer in September 2006.

Transaction completed January 2007

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MARKETS MONEY PORTFOLIO QUOTES SMALL BUSINE

Tullow Oil wraps up Hardman with $1.47bn bid

John Phaceas, Perth
September 26, 2006
Page 1 of 2 | Single page

A A

Other related coverage

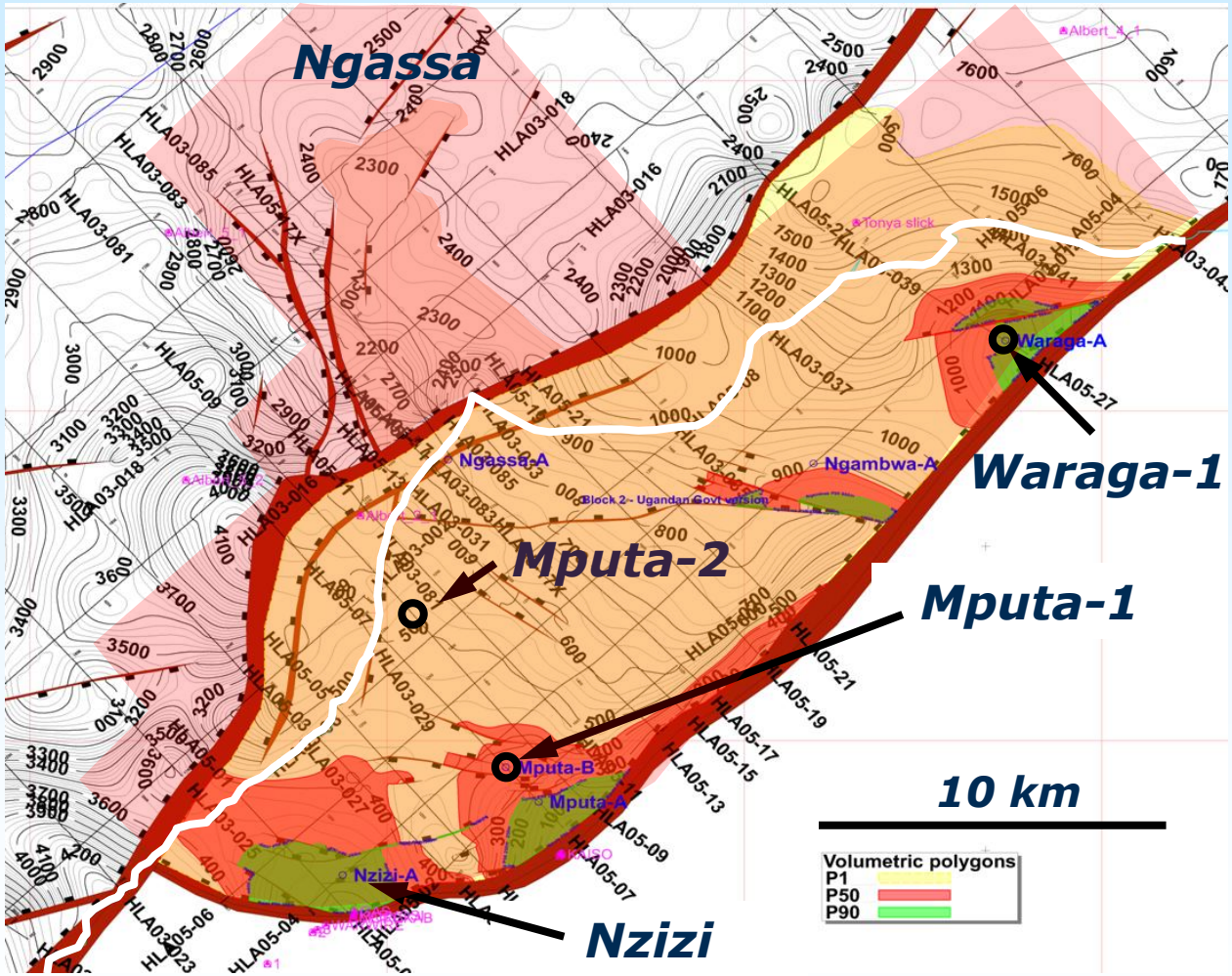
- Takeover bid sees Hardman shares soar

PERTH oil producer Hardman Resources has unveiled a friendly $1.47 billion takeover offer from Irish rival Tullow Oil.

London-listed Tullow, Hardman's 50:50 partner in its promising Ugandan oil project on Lake Albert, yesterday offered $2.02 per Hardman share after negotiating with Hardman executives over the weekend.

The offer means another home-grown resources company is poised to fall into foreign hands because of [illegible]stralian investors' distaste for assets in the developing world.

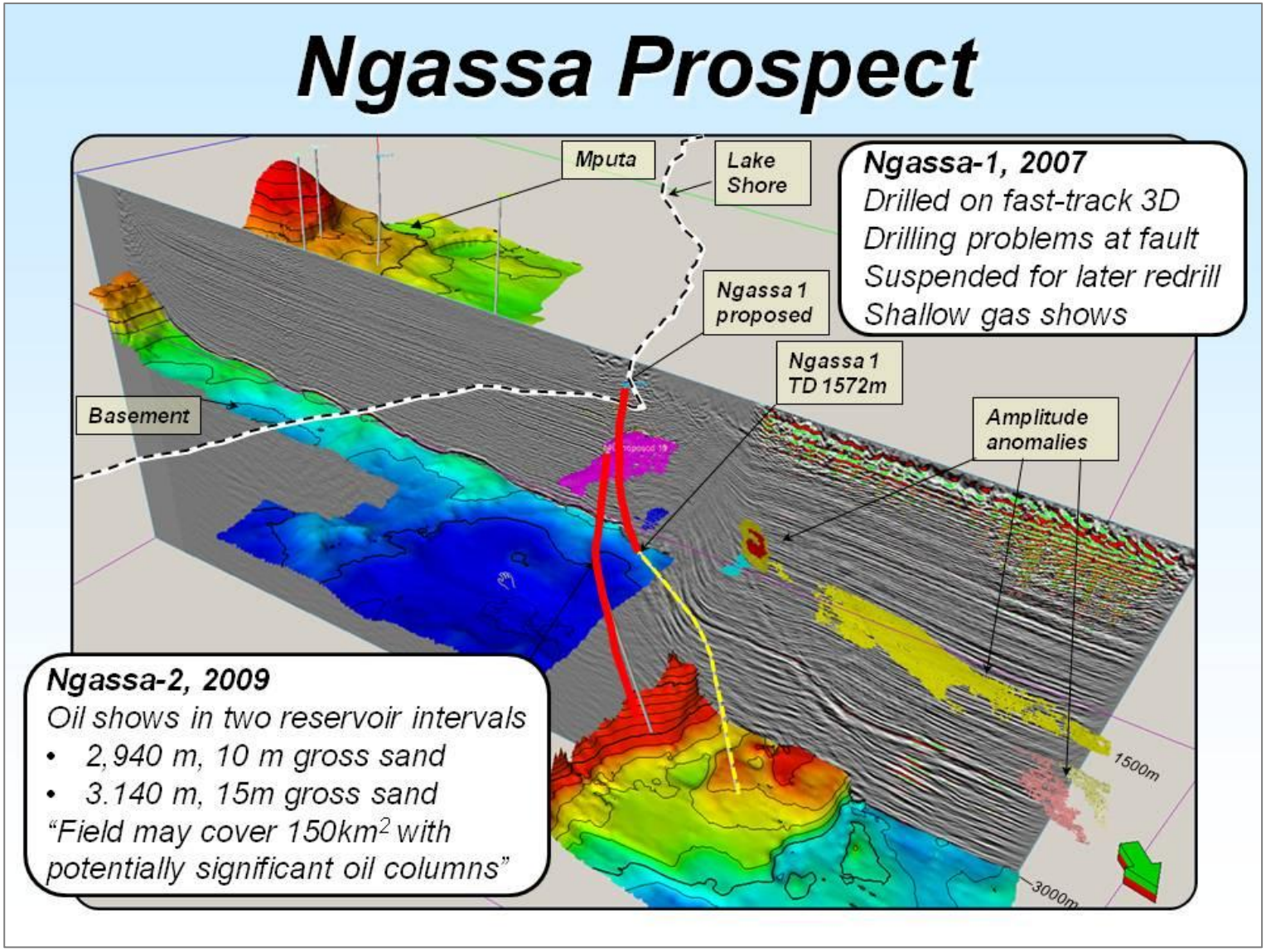
Kaiso-Tonya area, next steps



- **Exploration & appraisal success**
- Nzizi-1, Nzizi-2
- Mputa-3, Mputa-4

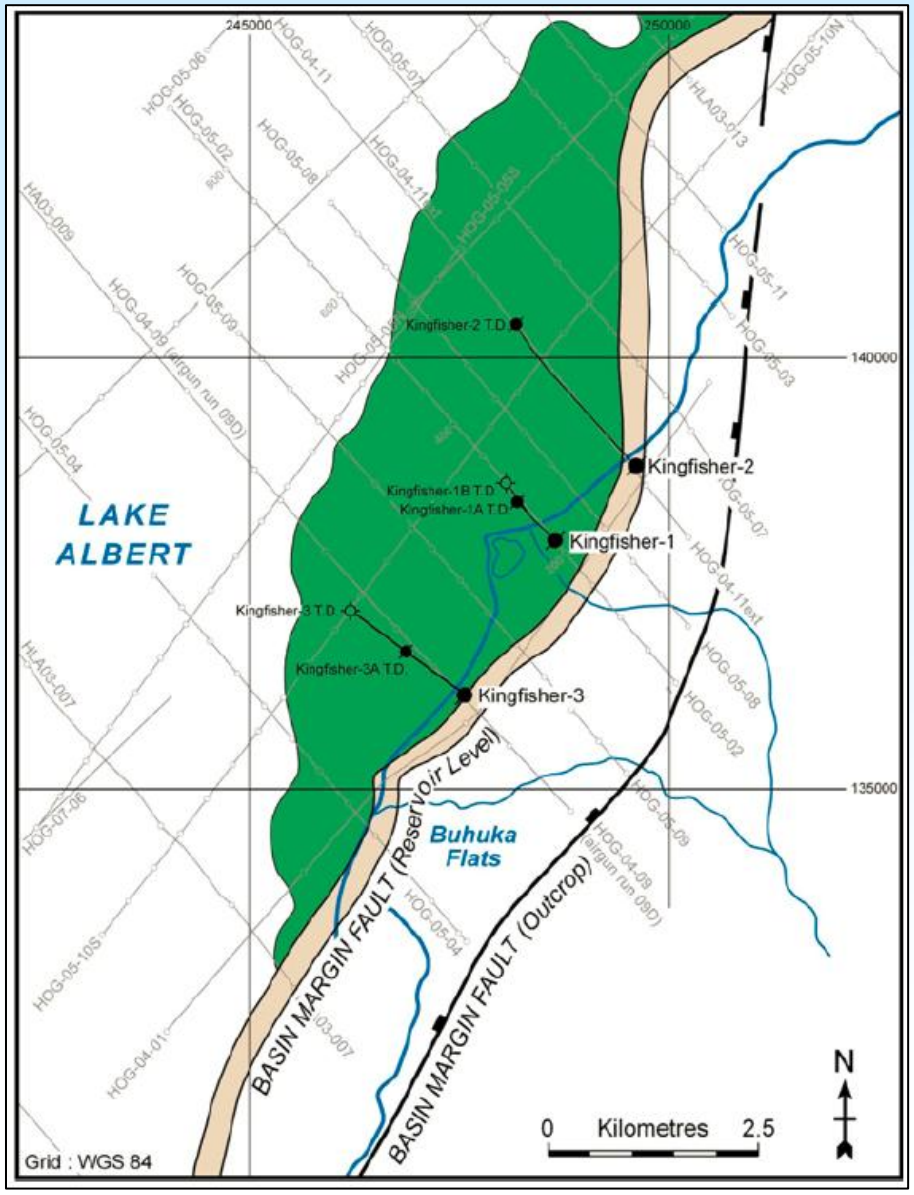
- **3D seismic**
- >500 km^2 3D
- Acquired from May ‘07-April ‘08

Ngassa Prospect



Presenter's notes: Tullow pre-drill comments : "Largest prospect in Uganda; 600 mmboe potential."

Kingfisher Field

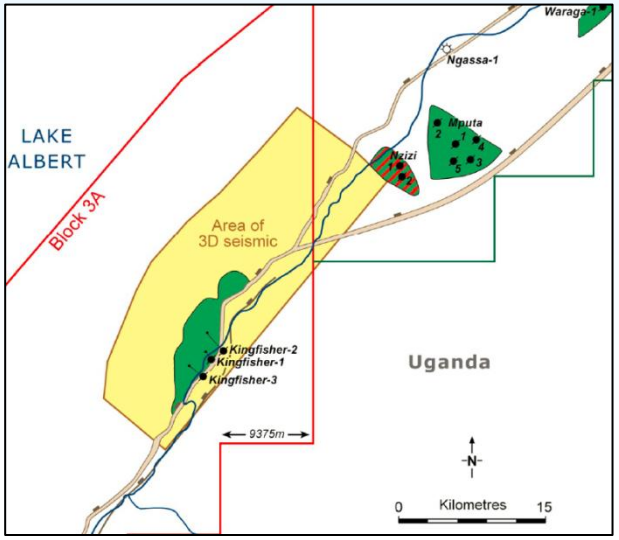


Resources ~ 200 MMBO

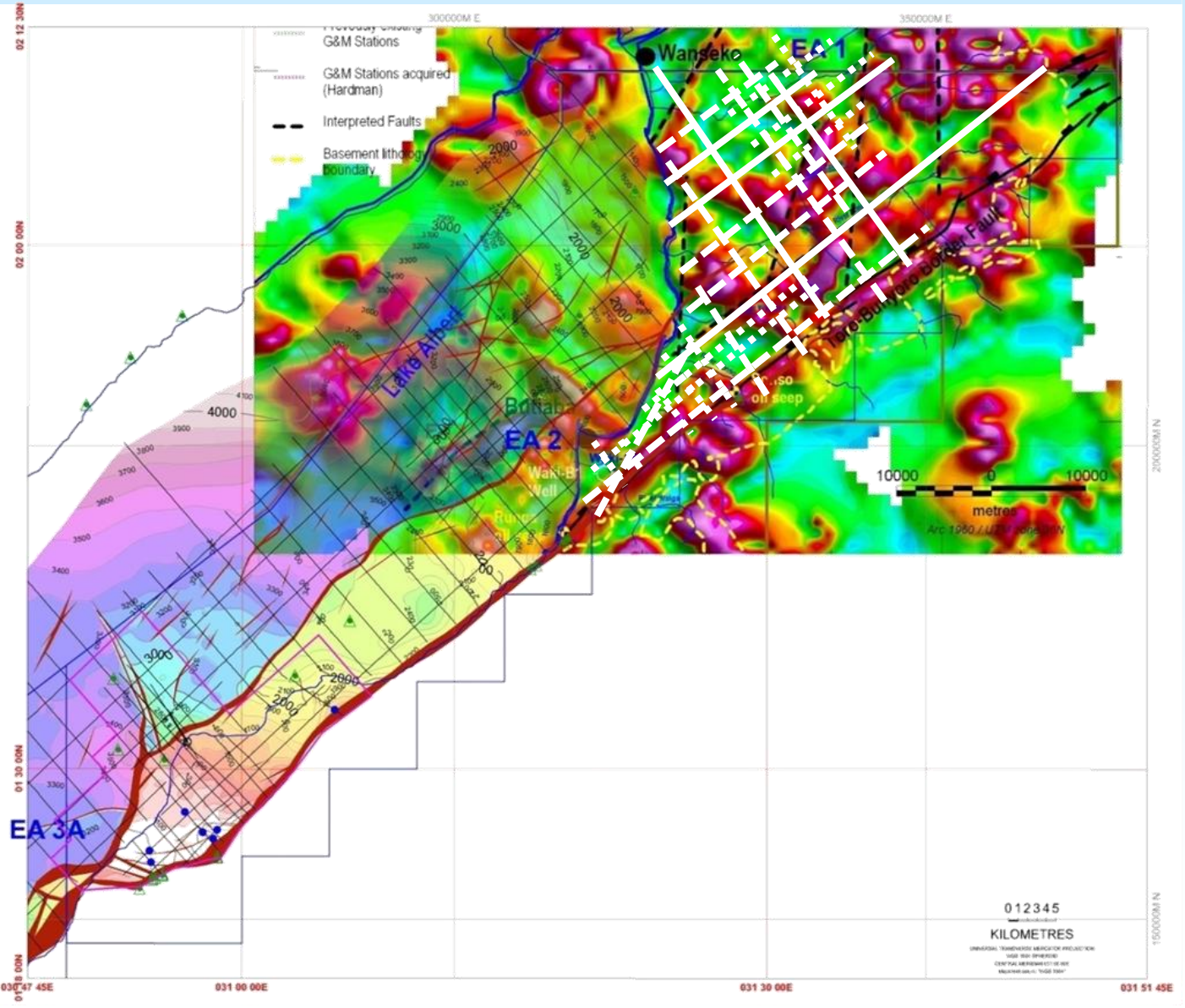
Kingfisher-1, 2006
Combined rate 13,983 bopd, 30-32 API

Kingfisher-2
Combined rate 14,364 bopd

Porosity 22-24%
Perm 100-10,000mD



Exploring the north



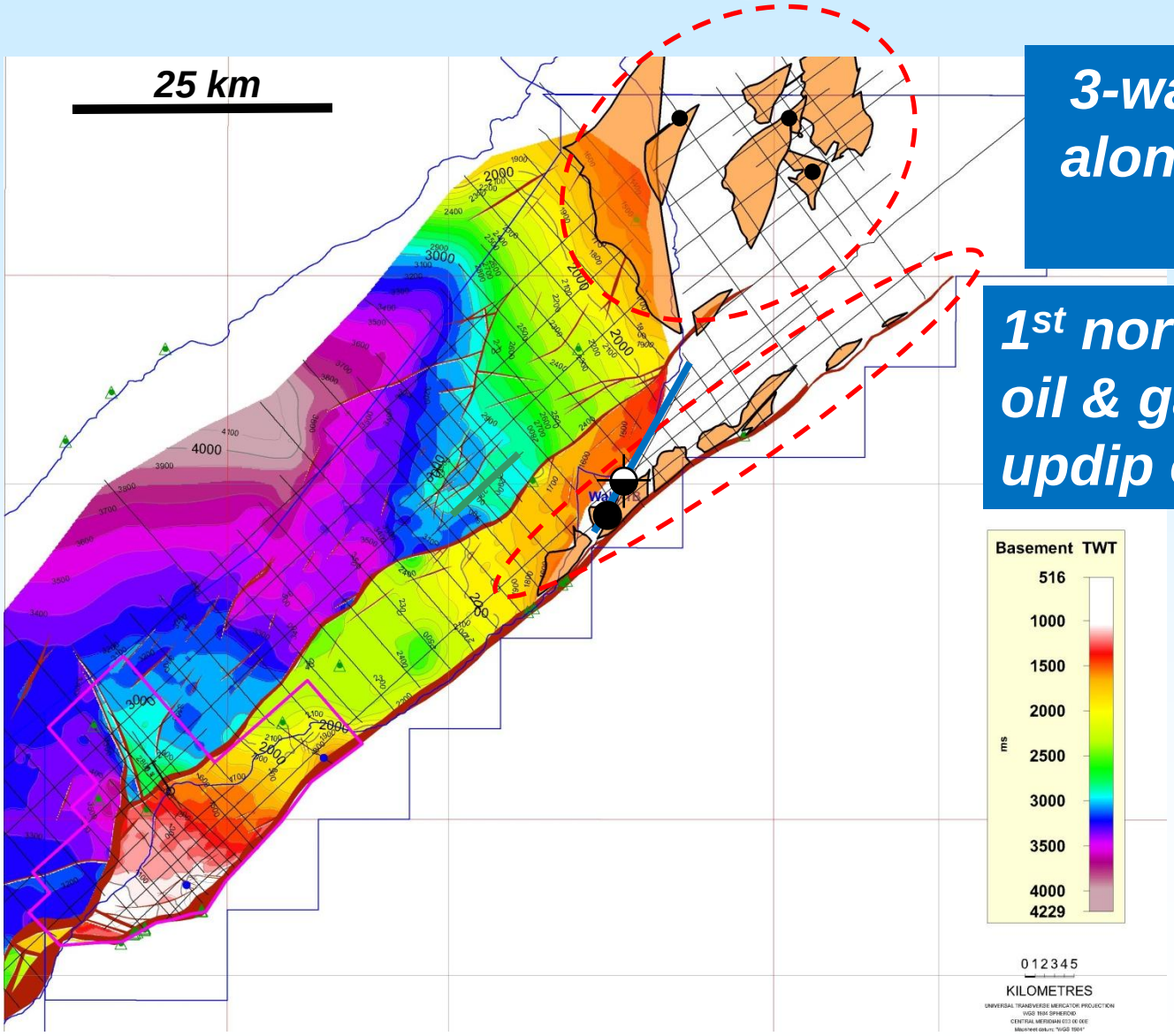
Gravity showed possible correlation with seismic in Kaiso-Tonya area

PEPD completed a gravity survey over northern area in late 2005/early 2006

The gravity survey was used to position Phase I Butiaba Seismic Survey 161km (Q4 2007)

Initial results led to two more seismic phases

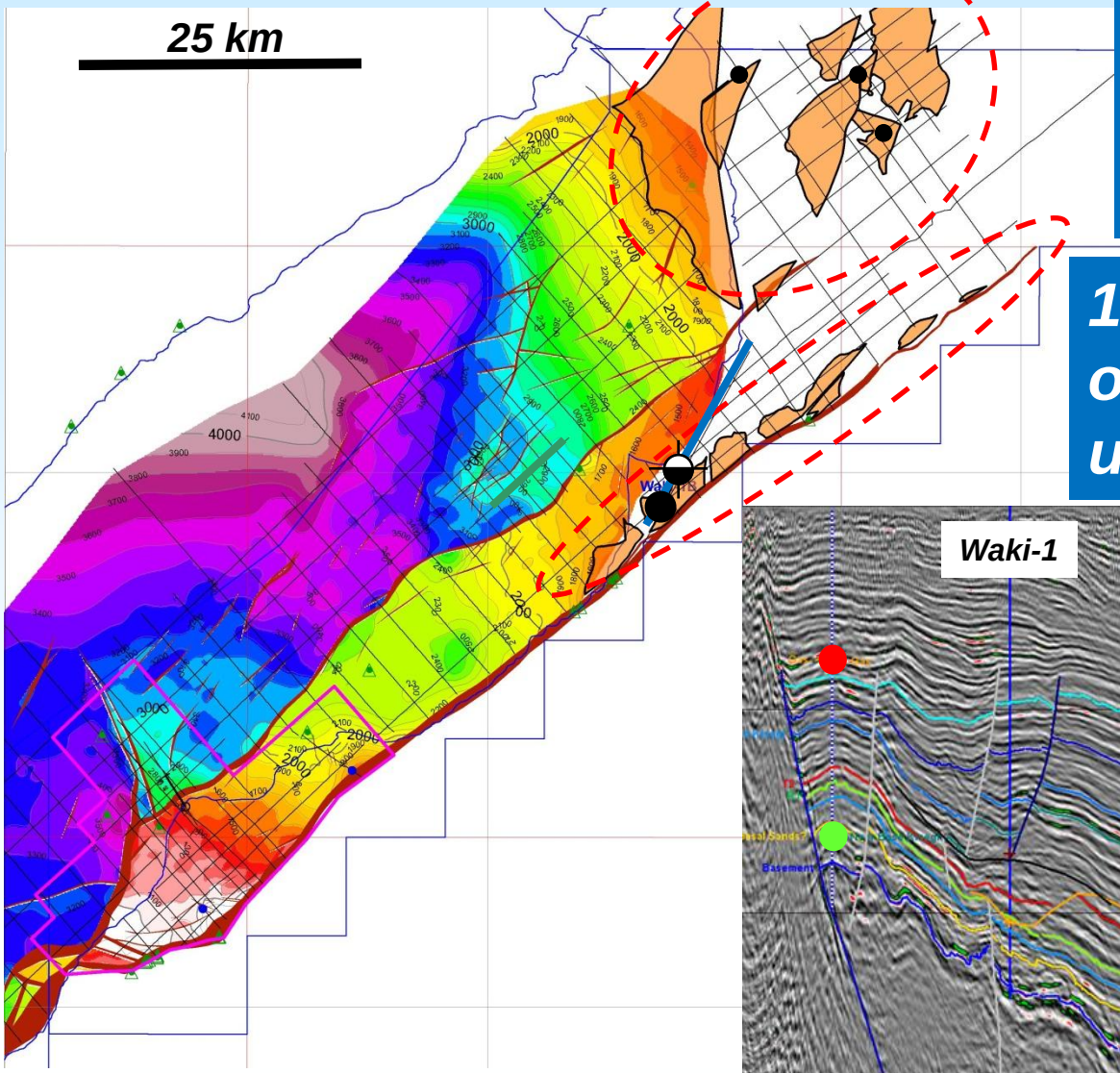
2008 drilling – a new play



3-way dip closures along the bounding fault

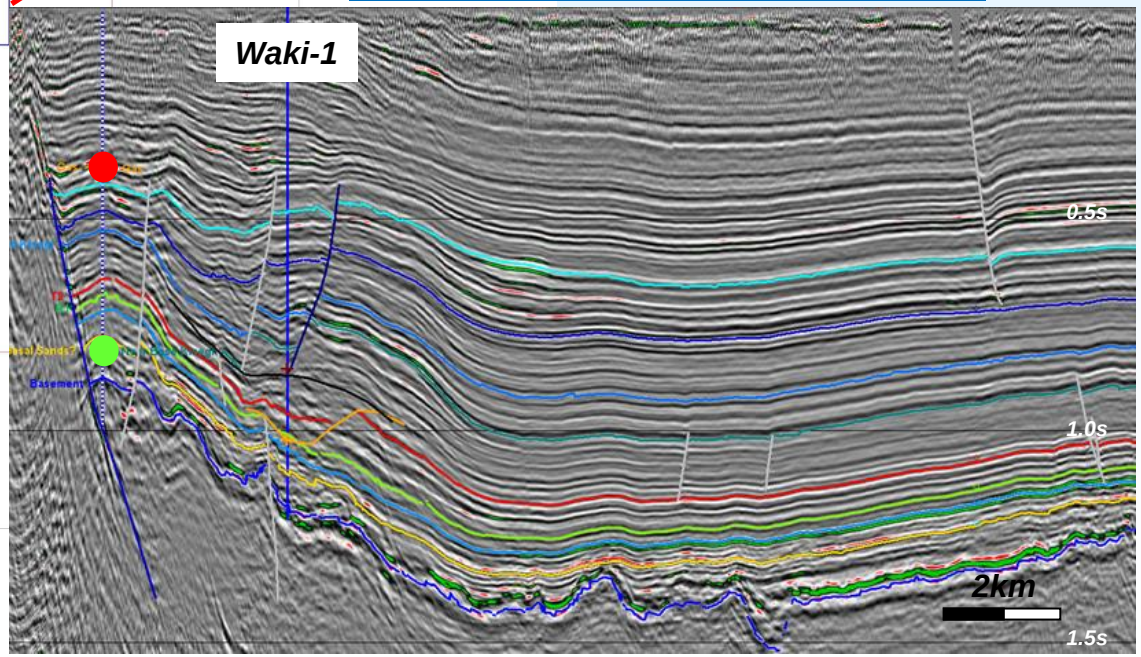
1st northern well – oil & gas discovery updip of Waki-1

2008 drilling – a new play

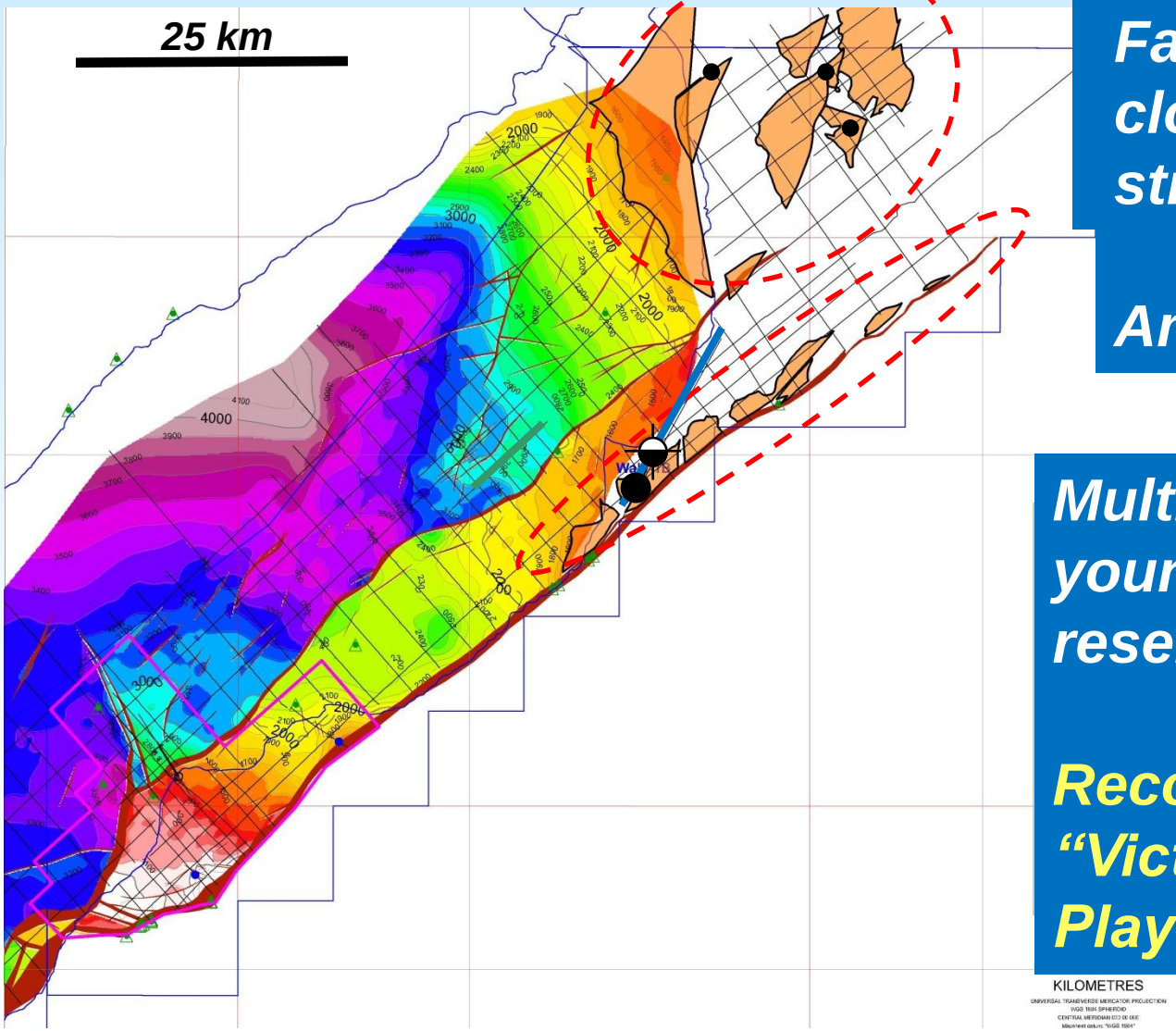


3-way dip closures along the bounding fault

1st northern well – oil & gas discovery updip of Waki-1



2008 drilling – a new play



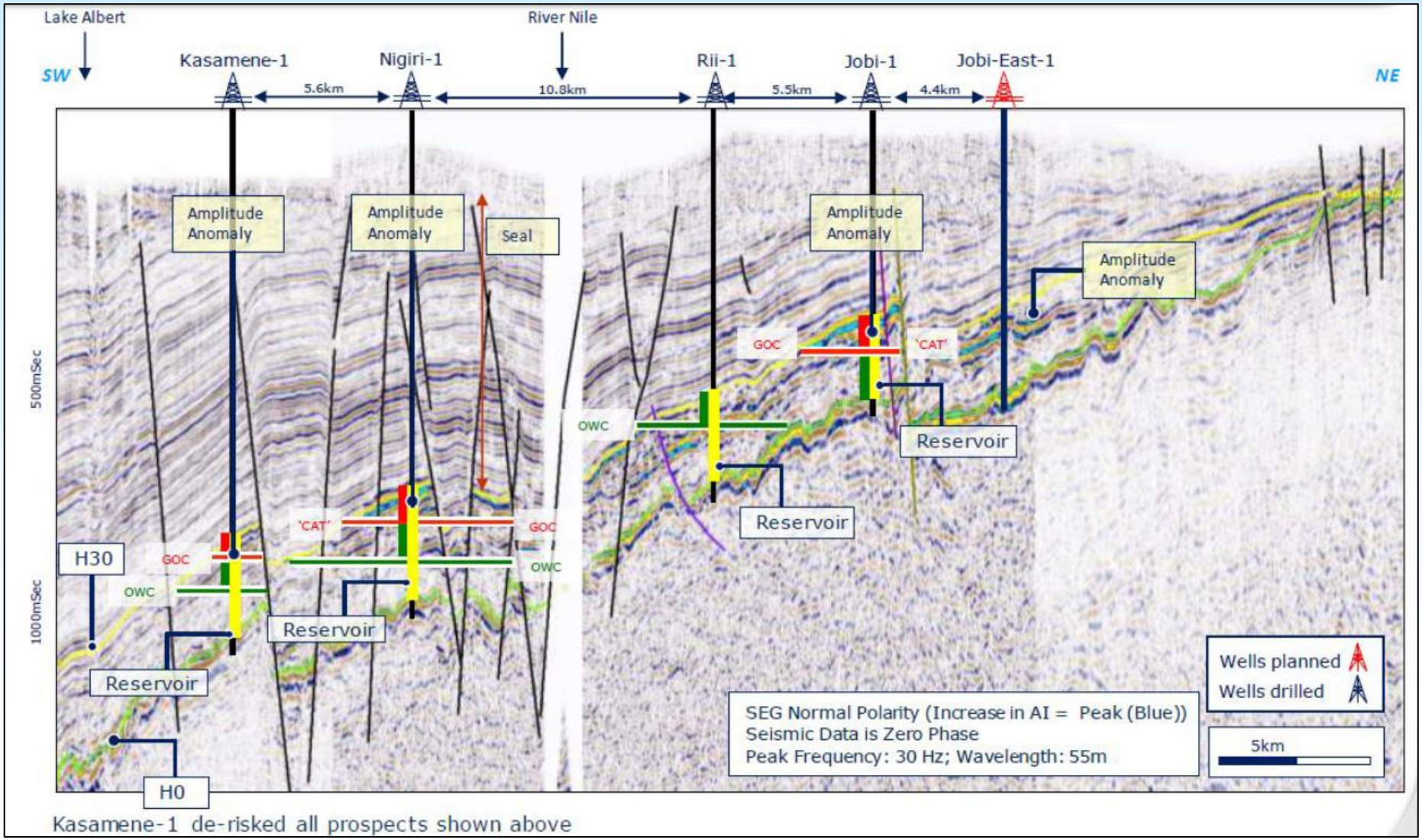
Fault controlled closures counter to strong regional dip

Amplitude anomalies

Multiple discoveries in younger, Pliocene reservoirs

Recognition of the "Victoria Nile Delta Play"

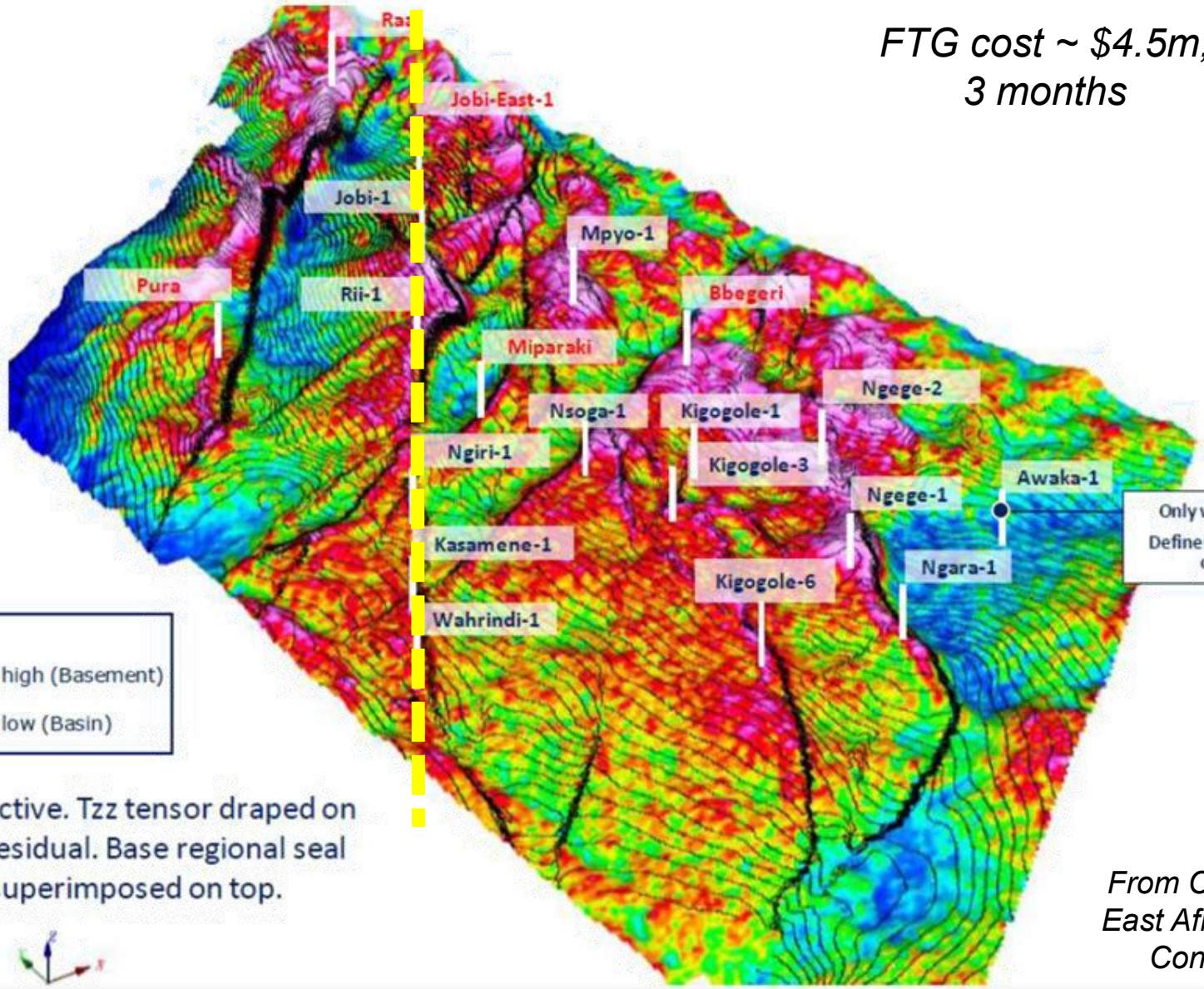
Northern area seismic line



From Cloke, 2011 East Africa Energy Conference

Victoria Nile – FTG & seismic

FTG cost ~ $4.5m,
3 months



NE perspective. Tzz tensor draped on top of Tz residual. Base regional seal contours superimposed on top.

From Cloke, 2011
East Africa Energy Conference

Lake Albert today

- **1.7 billion barrels of oil discovered**
- **17 oil fields**
- **80+ exploration and appraisal wells**
- **90% exploration success rate**
- **Field Development Plans submitted – moving towards FID**

(Tullow announcements)

Looking back…..

- Be prepared to do something different
- “Cautious optimism” is useful
- Sometimes it’s easier than you think

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