



**NATIONAL CENTER FOR PETROLEUM RESEARCH AND DEVELOPMENT, ENERGY COMMISSION OF NIGERIA, ABUBAKAR TAFAWA BALEWA UNIVERSITY, BAUCHI**

**PROCEEDINGS OF THE NATIONAL WORKSHOP ON PETROLEUM RESEARCH ACTIVITIES IN NIGERIA'S INLAND BASINS**



*20th December, 2021  
Chartwell Hotels & Suites, Adjacent 33 Artillery Brigade  
Barracks, Opposite FCMB, Jos Road, Bauchi Nigeria*



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**Petroleum Exploration and Environmental Controls in the  
Nigerian Context: Implications for Sustainable Oil & Gas  
Exploration in Nigeria**

**20<sup>th</sup> December, 2021  
Bauchi, Nigeria**



Proceedings of the National Workshop on Petroleum Research Activities in Nigeria's Inland Basins. "Petroleum Exploration and Environmental Controls in the Nigerian Context: Implications for Sustainable Oil & Gas Exploration In Nigeria"

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Prof. Abdulazeez M. Ahmad, Vice-Chancellor, A.T.B.U., Bauchi, Nigeria.

### II. Special Remarks by the Chief Host

Prof. Eli Jidere Bala, Director General/CEO, Energy Commission of Nigeria.

### III. Chairman's Opening Remarks

Dr. Ogbonnaya Onuh, Hon. Minister, Federal Ministry of Science, Technology and Innovation.

### III. Goodwill Messages

- Prof. Muhammad Bello, MD/CEO, Nigerian Galaxy Backbone Limited, Abuja
- Prof. Aliyu Jauro, DG/CEO, National Environmental Standards and Regulations Enforcement Agency, Abuja
- Senator Salisu Matori, Dan Masanin Bauchi, Bauchi Emirate Council, Bauchi State.

### IV. Vote of Thanks

Dr. Bappah Adamu Umar, Ag. Director, National Centre for Petroleum Research & Development (NCPRD), Bauchi

## WORKSHOP PAPERS:

### I. Carbon Capture and Storage Technology: A Feasible Option for a Sustainable Oil and Gas Exploration in Nigeria

Dr. Bappah Adamu Umar, Ag. Director, National Centre for Petroleum Research & Development, Bauchi, Bauchi State.

### II. Sedimentology & Stratigraphy of the Bima Group of the Gongola Sub-Basin, Northern Benue Trough, NE Nigeria: Implications for Lower Cretaceous Petroleum System in the Nigerian Inland Frontier Basins.

Dr. Bukar Shettima, Department of Geology, University of Maiduguri, Borno State.

### III. Possible Distributions and Maturation of Hydrocarbons in the Chad Basin, Northeast Nigeria.

Dr. Sani Ali, Department of Physics, Abubakar Tafawa Balewa University, Bauchi State.

### IV. Palynology of the Late Cretaceous Sediments at Jauro Jauto, Gombe, Northern Benue Trough, NE Nigeria.

Abdulkarim Haruna Aliyu, National Centre for Petroleum Research and Development, Bauchi State.

### V. The Future of Oil and Gas in the Nigerian Economy.

Prof. Abubakar Sadiq Maigari, Department of Applied Geology, Abubakar Tafawa Balewa University, Bauchi, Bauchi State.

### VI. Cost Effective, Environment Friendly Frontier Exploration for Nigeria's Inland Basins.

Dr. Isah Aliyu Goro, Department of Geology, Federal University of Technology, Minna, Niger State.

## PHOTO GALLERY

## COMMUNIQUE



## **COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO**



### **Cost effective, environment friendly, frontier exploration for Nigeria's inland basins**

**Dr Isah Aliyu Goro**

Department of Geology  
Federal University of Technology, Minna

Presented at the National Workshop on Petroleum Research Activities in  
Nigeria's Inland Basins on December 20<sup>th</sup> 2021 at Chartwell Hotel, Bauchi

## Objectives

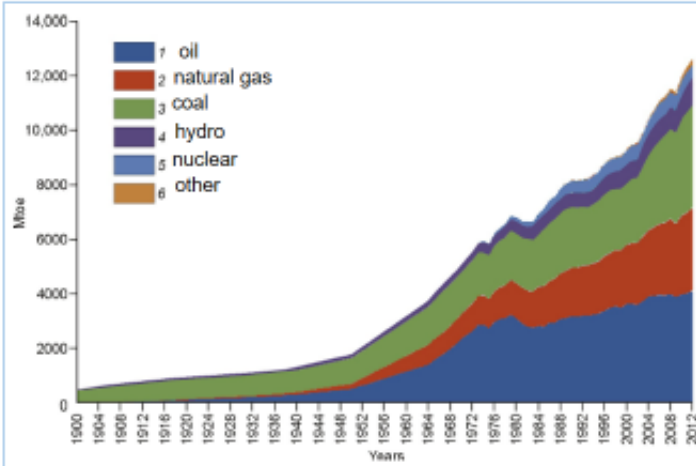
- Justification for HC exploration in the inland basins
- Highlight conventional model for HC exploration and its drawbacks
- Discuss some cheap, environmentally friendly frontier exploration tools suitable for the inland basins of Nigeria



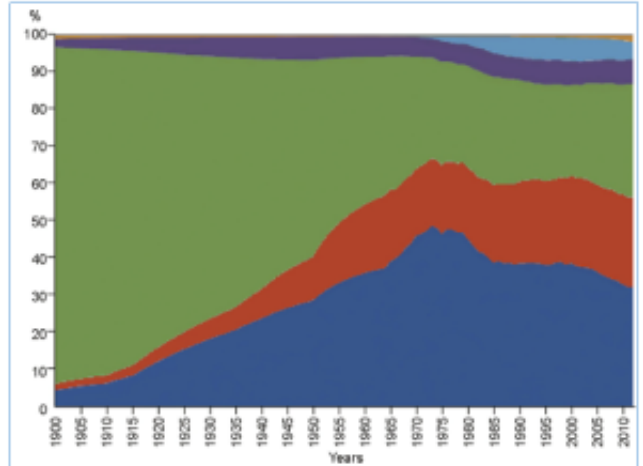
**COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO**

**Justification for HC exploration in the inland basins**

- Analysis of the global energy trends



Global production of energy sources in 1900–2012.

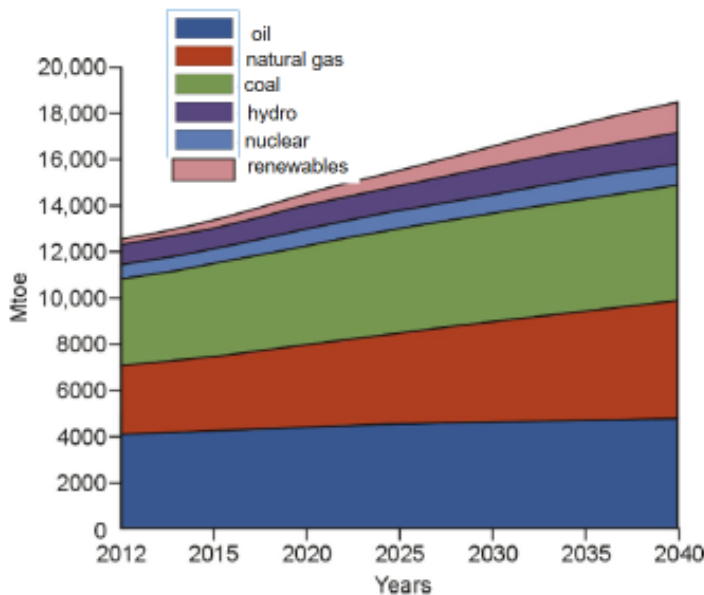


Shares of energy sources in the global energy mix in 1900–2012.

(Kontorovich et al, 2014)

**Justification for HC exploration in the inland basins**

- Analysis of the global energy trends



- Key driving forces

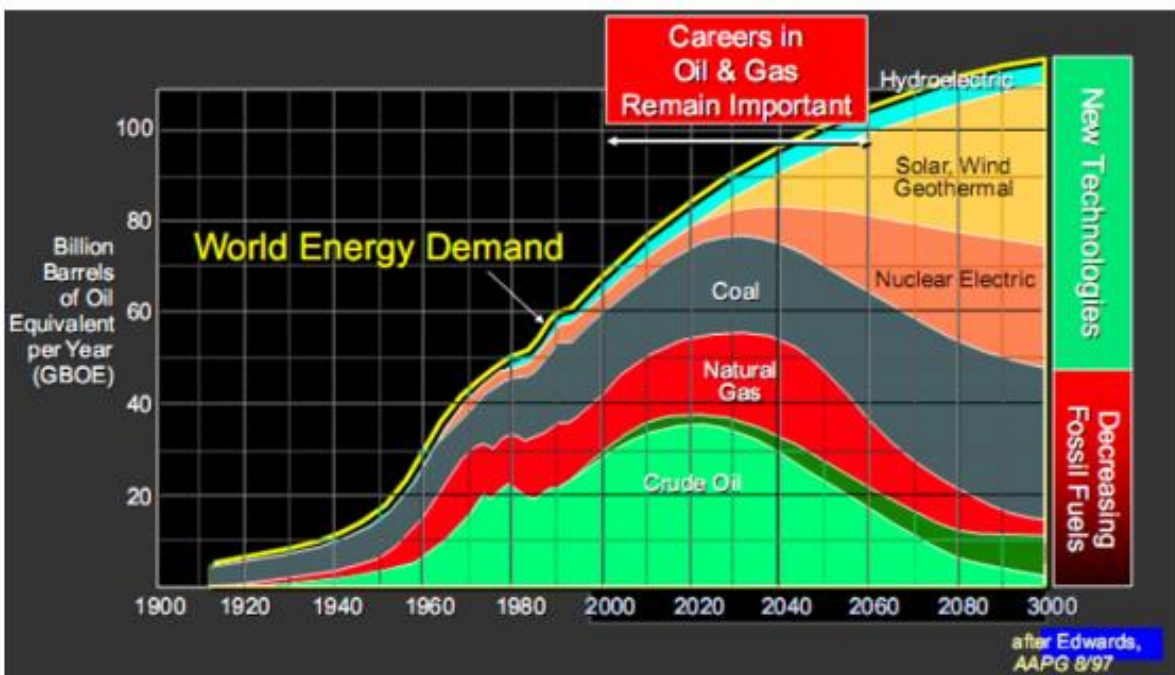
1. The rapid growth in the world's population
2. Economic boost and an upsurge in energy consumption in the developing world
3. The continued growth in world energy consumption

Forecast of global energy production by the main types of energy sources (2012–2040). (Kontorovich et al, 2014)



## COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO

### Justification for HC exploration in the inland basins



### Justification for HC exploration in the inland basins

#### Local perspective

- The population of Nigeria is expected to grow to about half a billion in 30 years
- The need to grow the reserve for export as well as for local/domestic use
- About \$400 million would be spent annually to fund exploration of oil and gas in the frontier basins under the new Petroleum Industry Act (PIA)
- The PIA also encourages more local content development and participation



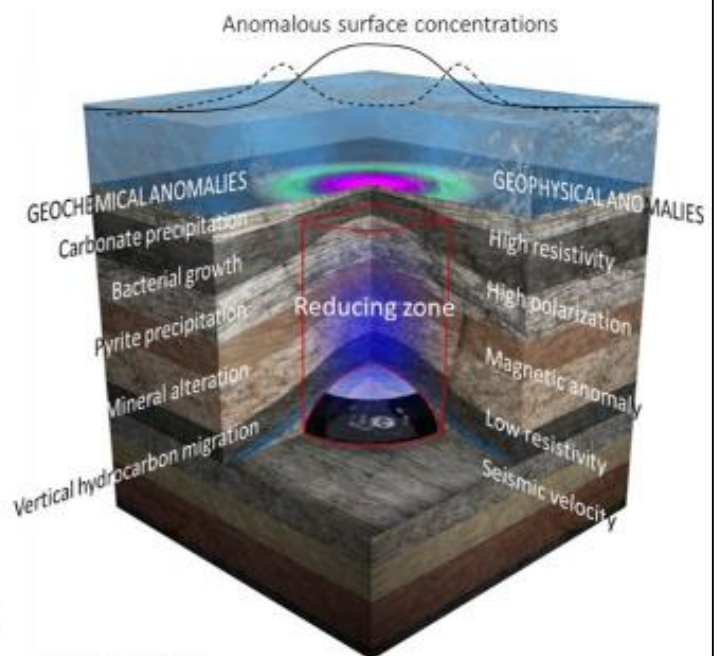
## COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO

### Conventional exploration workflow in the oil industry

- **Basin focus** – Regional context leading to an understanding of the working petroleum system(s). – outcrop, seismic, core, wireline log, etc
- **Play focus** - play comprises a seal and reservoir combination coupled to a mature source rock
- **Prospect focus** - For a prospect the explorer is trying to assess risks at a specific location - seismic data
- Drill first well
- This may take several years or decades to achieve and costs a lot of fortune because of reliability on seismic and well datasets
- This has resulted in so many unexplored and underexplored basins globally (e.g. Cleveland, 2018)
- Apart from the large expenses associated with seismic data acquisition, they also pose serious environmental concerns

### Cost effective environment friendly HC exploration tools

- These are tools that can be used for basin evaluation to identify “sweet spots” for hydrocarbon accumulation for further evaluation
- Instead of finding traps (seismic), these techniques find hydrocarbons
- This may be direct hydrocarbon indicators such as seepages or effects of seepages in near surface environment
- These techniques have the advantage of detecting hydrocarbons directly thereby reducing risk since they can effectively indicate areas without hydrocarbon potential







## COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO

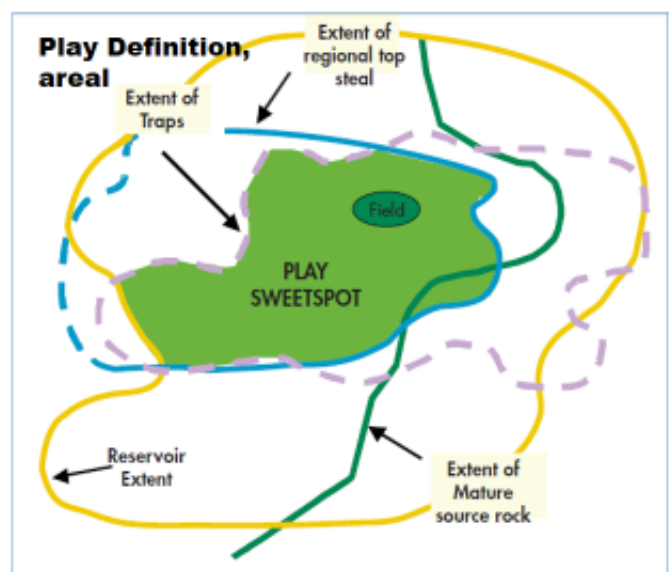
### Cost effective environment friendly HC exploration tools

- **They work on the premise that:**
  - Almost all oil and gas accumulations leak and the leakage is predominantly vertical
    - Therefore the phenomenon of seepage almost always occur above subsurface accumulations (even evaporite seals leak, e.g. Patton and Manwaring (1984))
  - They can identify and map HC-induced alteration
  - They are able to show whether the HC accumulation is oil or gas
- **Other advantages include:**
  - Cost effectiveness
  - Minimal environmental impact
  - High chances of discovery - Analysis have shown that prospects with an associated hydrocarbon anomaly are 4-6 times more likely to result in a commercial discovery than prospects without such an anomaly
- **The following techniques will be briefly discussed**
  1. Outcrop evaluation integrated with shallow well data
  2. Real time Soil gas analysis
  3. Radiometric analysis
  4. Magnetotelluric method

## The value of outcrop data

### Outcrop evaluation integrated with shallow well data

- Outcrop sequence stratigraphy (how much do we know about our basins) can we compare with the north sea basin where almost all data sets are available for most Fms
- Biostratigraphy/palynology (source rock maturity studies based on spore colour index e.t.c.)
- Programmed exploration using universities near basins
- Outcrop structural analysis (teams to provide criteria for documentation of structural data of both local and regional scale) – satellite images inclusive
- Program can be devised by NCPRD/NNPC and targets for 1, 2, 3 years can be made with little funds (both UG and PG students can be used)

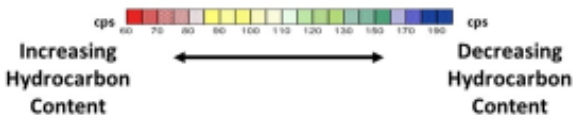
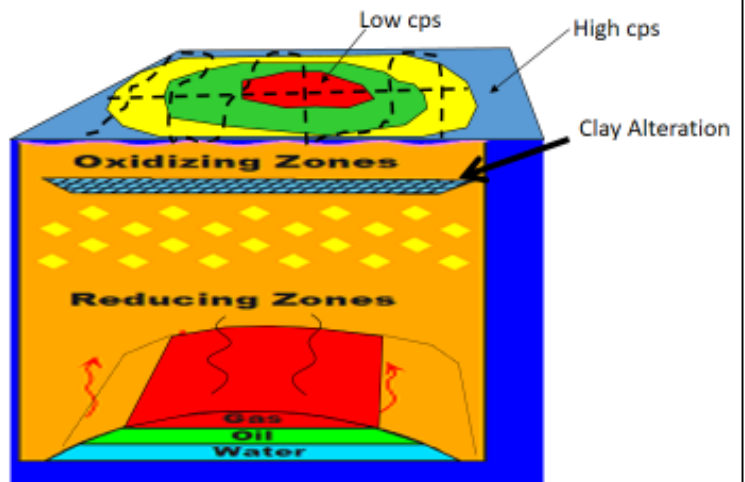




## COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO

### Radiometric surveys

- Provide cost effective means of early identification of high potential areas in a basin using gamma ray counts
- Based on:
  - Measuring Gamma Rays at the surface
  - Equipment indirectly measures hydrocarbons that have seeped and have been trapped in soil above HC accumulations
  - All seepage phenomena result in a measurable negative radioactive anomaly (very low gamma ray counts)



### Radiometric surveys


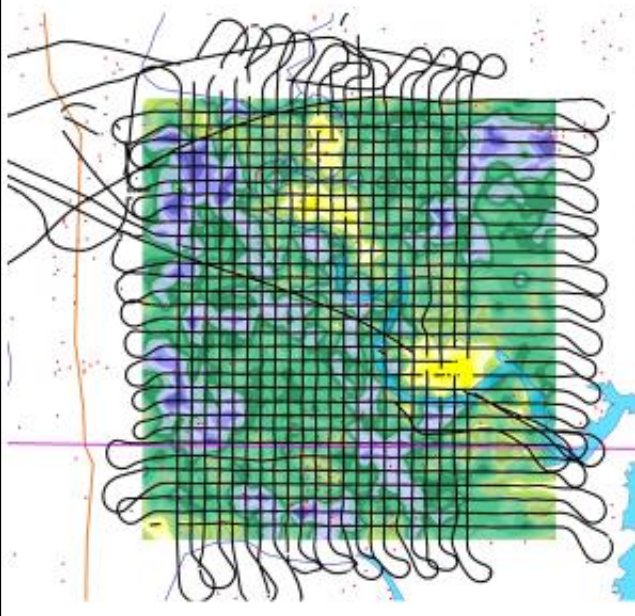
- Portable equipment hung at the back
- Does not require much crew members
- The survey could either be land based or aerial based






# COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO

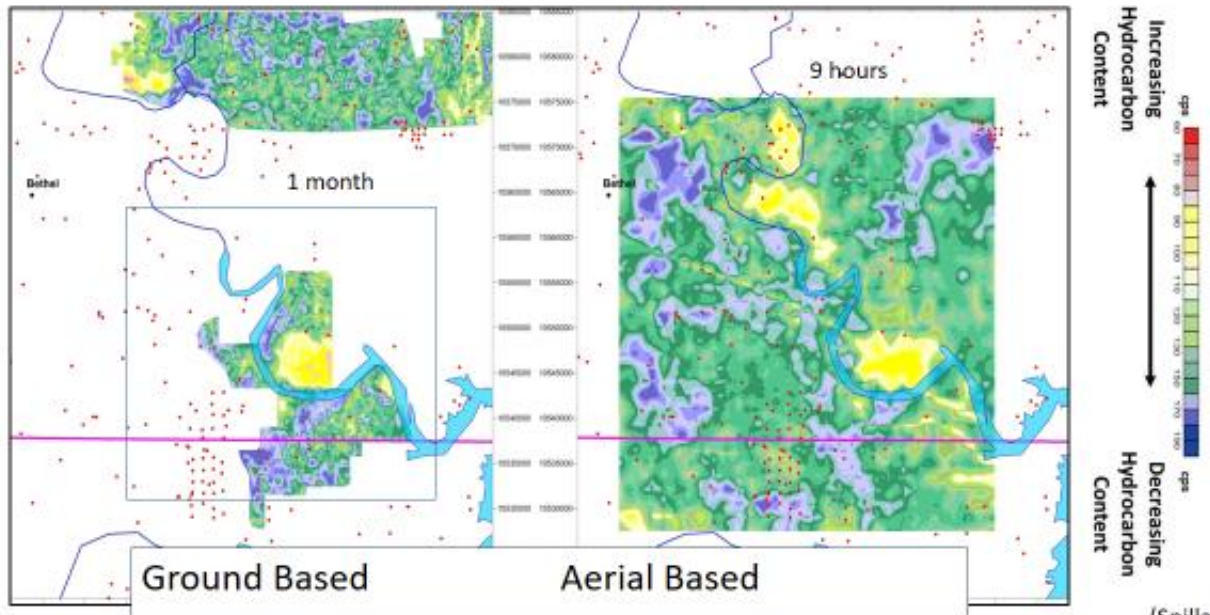
**Aerial example**



- Pilot conducting radiometric survey



## Comparison between land and aerial survey results



1 month

9 hours

Ground Based

Aerial Based

Increasing Hydrocarbon Content

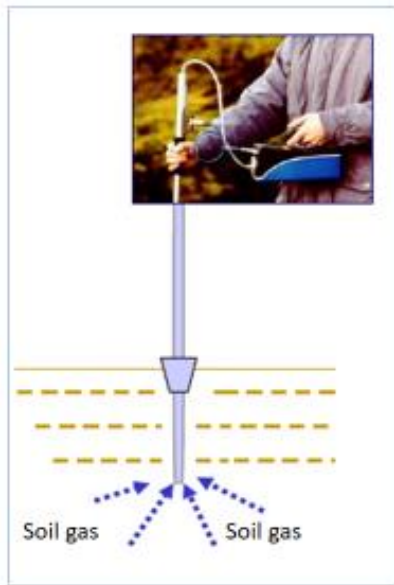
Decreasing Hydrocarbon Content

(Spillar, 2019)

## COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO

### Real time soil gas analysis

- Uses Hand Held ECOPRO gas analyser
- Soil gas is drawn into the probe and continuously analysed in the instrument
- Used to detect HC composition and whether oil or gas
- Detection of C1-C4 generally suggests subsurface gas accumulation



### Magnetotelluric survey

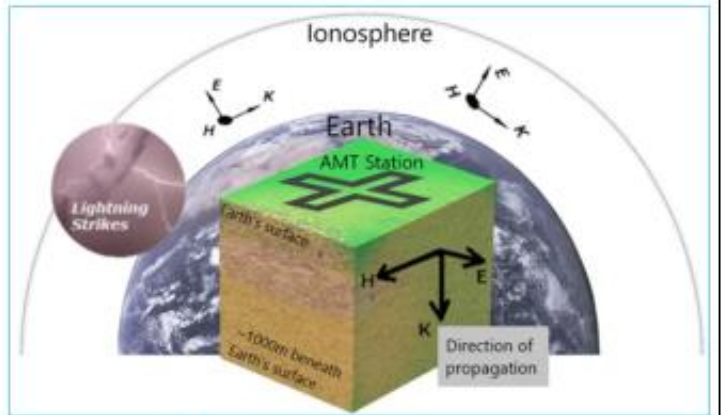
- Relatively cheap geophysical method for determining depth to HC zone with basin wide coverage
- Magnetotellurics (MT) uses natural time variations of the Earth's magnetic and electric fields to measure the electrical resistivity of the sub-surface
- The main factors affecting the resistivity are the lithology and pore fluid as well as pressure and temperature



## COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO

### Simple site set-up

- Greater depth of investigation than other geophysical methods
- Highly portable equipment that can be moved to site by hand



Schematic of MT theory, showing the magnetic source fields and geometry of the measured fields E (electric) and H (magnetic).



### Site set up

- Equipment include both electrical and magnetic sensors
- Orienting and leveling of magnetic conduction coil
- Running of field computer for real time data analysis
- Very few crew members

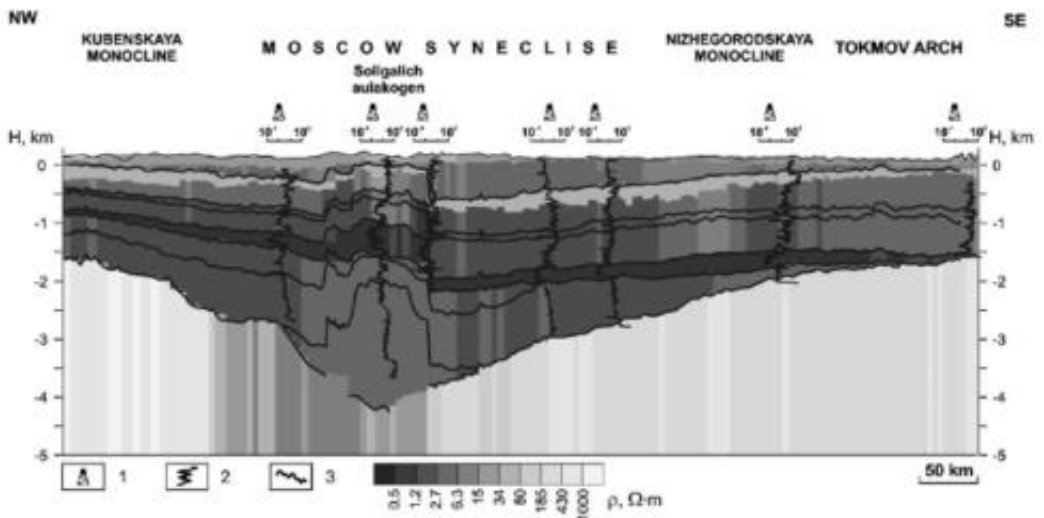




## COST EFFECTIVE, ENVIRONMENT FRIENDLY FRONTIER EXPLORATION FOR NIGERIA'S INLAND BASINS – DR ISAH ALIYU GORO

### Magnetotelluric survey

- Low resistivity around 2km depth indicates
  1. high porosity interval
  2. High permeability
  3. Low or zero hydrocarbon saturations
  4. Probably brine water



Resistivity cross section of the Moscow syncline (Russia)  
1 – Boreholes, 2 – electrical logging results, 3 – seismic boundaries (Bubno, et al., 2007)

### Conclusions

- Oil and gas will dominate the world energy supplies in the next few decades
- Nigeria needs to increase its existing reserves for local use to meet the need of growing population and for export
- The costs associated with the conventional model for HC exploration in frontier basins has led to many unexplored basins
- It was also shown that
  - Radiometric surveys detect HC induced alterations
  - Real time soil survey detect HC concentration and composition
  - Magnetotelluric surveys determine depth to HC bearing zone
- Detailed outcrop evaluation integrated with Radiometric, Soil geochemical and Magnetotelluric surveys can provide cheap, environmentally friendly alternative tools for early identification of HC sweet spots in the inland basins of Nigeria

# Thank you