

## **Conference Programme and Book of Abstracts of Presentations**

**at the**

**ACMED 1<sup>ST</sup> International Conference on Solid Minerals Research, Technology and Policy**

**(ACMED 1<sup>ST</sup> COSMIRTEP 2023)**

**Theme: Solid Minerals and Energy Transitions: Global Trends, Technology Disruptions, Prospects and Opportunities**

**AUST, Km 10 Airport Road, Galadimawa, Abuja, Nigeria**

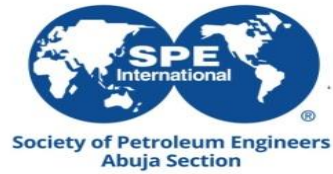
**November 29 – 30, 2023**

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#### **Goodwill Message by the Chief Host, Professor A. P. Onwualu, FAS, Acting President, African University of Science and Technology (AUST), Abuja, Nigeria**

Nigeria as a country has been grappling with development challenges since after independence 63 years ago. The country started off well after independence in 1960. At that time, the political structure revolved around the regional governments. Each of the regions thrived on revenue generation through agriculture. Over the years, oil was discovered and somehow, agriculture was neglected because of our new found wealth – oil and gas. Today we have seen a near collapse of every infrastructure in Nigerian economy, mostly caused by dwindling revenue from oil, leading to inability to build and maintain other infrastructure. Government at all levels have come to realize that revenue generation through diversification is the way to go. Solid minerals have been identified as the new economic sector that can drive economic development by providing avenues for revenue generation. The sector is however inundated with challenges, basically bordering on poor access to investments, technology and skills for driving the sector. The sector, like many other economic sectors require interventions towards removing these constraints. I believe various stakeholders are currently working on different aspects of the challenge.

As a university, our role is to provide knowledge required to solve these problems so that the solid minerals sector can be moved from the current situation where the sector is dominated by resource poor artisanal and small-scale miners to a situation of prosperity

driven by technology enabled commercial mining, mineral development and value addition. This led to the establishment of the African Centre for Mineral Exploration and Development (ACMED) aimed at developing and harnessing technology towards developing the minerals sector. The first major outing of ACMED is this conference. I must congratulate the Center Leader, Dr Morgan Leo Akpan for putting this conference together. My expectation is that the conference will come up with solutions that can change the value chain of mining and minerals sector in such a way that the sector can begin to contribute significantly to the revenue base of the country in a sustainable manner.

I therefore welcome everybody to the conference and believe that with the caliber of participants I see here, sustainable solutions can be found for the solid mineral sector. This cannot come at an auspicious time than now when there are new governments at the state and federal levels in Nigeria.

Thank you.

Prof. Azikwe Peter Onwualu, FAS.

**Rationale by the Conference Chair, Dr Morgan Leo Akpan, Resident Faculty, Department of Petroleum and Energy Resources Engineering, Centre Leader, ACMED, African University of Science and Technology (AUST), Abuja, Nigeria**

According to the International Energy Agency (IEA), the average amount of minerals required for a new unit of power generation has increased by more than 50% over the years due to the rise in the share of renewable energy sources in the global energy mix. From this singular indicator, it is evident that the demand for minerals needed to manufacture and sustain power generation systems in order to achieve the global agenda on energy transition will continue to rise. Given that the low emission energy and transportation systems are more mineral intensive than their fossil fuel counterparts, the energy transition window provides a great opportunity for the solid minerals subsector. Further, as the world population continues to grow, the infrastructure needed to meet the demands for transportation, housing, clean water, sanitation, etc will continue to increase the need for solid minerals. While lithium presently enjoys the fastest growth rate in terms of demand, it is projected that the global demand for mineral resources required to satisfy technological and industrial applications by 2040 will be dominated by graphite, copper, and nickel. Nigeria is endowed with significant mineral resources, but most of these resources remain untapped. In a report published by the African Development Bank (AfDB) in 2019, it was stated that the mining sector in Nigeria accounted for only 0.5% of the GDP and a paltry 0.3% of employment. These numbers are far cry from what they should be, going by the enormous solid mineral resources that the country is endowed with. Recent records have it that the Ministry of Mines and Steel Development (MMSD) in Nigeria has identified more than 40 unexploited solid minerals in commercial

quantity across the country. It is estimated that Africa accounts for about 30% of all global mineral reserves. But due to the emphasis on the export of raw materials in the continent, the region is yet to derive full benefits from these natural endowments as evident in the low foreign exchange earnings from the subsector across the continent as well as lower employment levels in the sector compared to other resource-rich countries in North America, Europe, Asia, and Australia. Indeed, solid minerals are gradually becoming a “resource curse”, with dire health and environmental consequences as seen in DR Congo and other countries in the region. Using Nigeria as a reference, among the issues impeding sub-Saharan Africa region’s aspiration of using solid mineral resources to diversify its economy include lack of indigenous capacity, inadequate policy and analytical systems, lack of equipment, infrastructural deficit, security threats, etc. Industrialized countries that have good governance and socioeconomic base to deliver goods and services to their citizens usually place strong emphasis on tertiary education, research, technology diffusion, and the appropriate policy mix that encourage innovation. This is the route that African countries must take in order to turn around the socioeconomic fortunes of the continent.

ACMED 1<sup>ST</sup> COSMIRTEP 2023 provides a platform to articulate research results, policy options, and socioeconomic dynamics with which African countries can take informed decisions in the area of solid minerals and mining which is unanimously agreed to hold great potential for the continent in terms of job creation, income generation through foreign exchange, foreign direct investment, poverty reduction, among others. In line with one of our core mandates as a regional research-focused University which is to generate and disseminate knowledge and information which are critical for African renaissance and economic growth in the 21<sup>st</sup> century, this international conference is organized by the African Centre for Mineral Exploration and Development (ACMED), a research focused Centre established and domiciled in African University of Science and Technology (AUST), Abuja, Nigeria to engage stakeholders in the analysis of the challenges, prospects and opportunities in the solid mineral subsector across the continent. The challenges that confront Africa’s solid mineral subsector are also opportunities for the generation and enfranchisement of knowledge to address them. This conference presents an opportunity to network and harness the enormous knowledge base of Africans at home and in the diaspora with the ultimate goal of using solid mineral resources as one of the instruments for socioeconomic transformation of the continent. The issues raised in this rational informed the objectives of the Conference which are as follows:

- To identify, synthesize, and analyze the factors impeding sustainable and optimum utilization of solid mineral resources in Africa and proffer solutions to them
- To engage researchers/experts, policy makers, politicians, investors, innovators, and other stakeholders in the analysis of the challenges and opportunities presented by the solid mineral subsector under the global energy transition
- To provide a platform for stakeholders, including Africans in the diaspora, professional societies, public institutions, private sector, academic institutions, and students to identify deficiencies and opportunities, recommend solutions and initiate collaborative projects and programmes on sustainable and optimal utilization of solid minerals for the attainment of Sustainable Development Goals (SDGs) in the continent

- To provide an opportunity for research partnerships, bilateral cooperation, networking, business matching, signing of agreements and partnerships, etc among the stakeholders in the Sector

## **Profiles of Some Speakers**

### **Brief Profile Prof. Olugbenga Akindeji Okunlola**



#### **Keynote Speaker**

Professor Olugbenga Okunlola holds a PhD degree in Economic Geology of the University of Ibadan, Nigeria, where he is currently a full Professor and Head, Department of Geology. He has previously got a B.Sc. Geology of the University of Ilorin (1982) and a Masters of exploration Geology, Ahmadu Bello University, Zaria (1991). He obtained in addition, professional proficiency Certifications from the University of Oxford, England (2016) and The British Geological Surveys England.(2010)

He has 40 years' experience as a geoscientist that straddles the public service, industry and academia. He has served as a Special Adviser (Mineral Assessment) to the Director General of the Nigerian Geological Surveys Agency (NGSA) from 2006 to 2013. He currently chairs the Mining Road map Implementation Strategy Team (MIST). He is also the coordinator of the Solid Minerals, Mines and Steel Technical Working Group (TWG) for the development of the Federal Government Medium Term National Development plan (2021-2025). He is a former member of the board of Nigerian Extractive Industry Transparency Initiative (NEITI) a subset of the global EITI and chaired the Technical Committee of the board. He is also a member of the minerals sub group of the United Nations Economic

Commission for Europe (UNECE) expert working group for the development of the United Nations framework for minerals and Energy Resource systems (UNFC). A member of the African Union (AU) Expert working group for the development of the African Mineral Resources Classification and Pan African Resource and Reserve code AMREC-PARC and also a member of the African Union commission, expert working group on development of policy frame work for Artisanal Mining and Mineral Governance in Africa. He is a board member of the PANAFGEO, a collaborative training initiative of the European Union EUROGEOSURVEYS and the Organisation of African Geological surveys (OAGS)

He has handled numerous consultancy assignments for international and local agencies and companies including the African Development bank (AFDB) and the World Bank (MINDIVER PROJECT). He currently has about 106 publications to his credit in many reputable Journals, conference proceedings, book chapters and has successfully supervised 9 Ph.D dissertations and over 30 M.Sc. students thesis.

He is currently the President of the Geological Society of Africa, Past President of The Nigerian Mining and Geosciences Society, President of the Geoscience Information and Research in Africa Network (GIRAF) and Vice President for Africa, Association of Geoscientists for International Development (AGID).

He is a Fellow of the Geological Society of London, Fellow, African Scientific Institute, Fellow , Nigerian Mining and Geosciences Society (NMGS), Fellow, The Nigerian Society of Mining Engineers, Fellow, Nigerian Association of Engineering Geologists and the Environment, and Fellow of the Nigerian Association of Hydrogeologists. He is a member of the Society of Economic Geologists (SEG), Member, Geological Society of South Africa, Country councilor, International Association for Geoethics (IAGETH) and Council member, International Geoscience Educators Organisation (IGEO) amongst others.

He is happily married with children.

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## Profile of Professor Emeritus Omowumi Iledare



**Omowumi Iledare, *Ph.D.*, Professor Emeritus in Petroleum Economics, *Fellow NAEE, Snr. Fellow USAEE, Fellow NSE NIPetE, Fellow Energy Institute***  
**Lead Paper Presenter**

**Professor Emeritus Wumi Iledare (PEWI)** has over 40 years of technical, professional, and academic experience analyzing the geopolitics and economics of oil and gas industry and the global oil and gas economy. An expert in international petroleum economics and fiscal regimes analytics, Dr. Iledare, is the Executive Director, Emmanuel Egbogah Foundation for Petroleum and Energy Industry Economics and Policy Advocacy, Abuja, Nigeria. He served on the Nigeria National Assembly Technical Advisory Team to the Joint Committee on Petroleum Industry Reforms from 2015 - 2021. A Distinguished Fellow and the immediate Past President of Nigeria Association for Energy Economics (NAEE, 2015-2019), Iledare is a Senior Fellow and the 2008 President of the United States Association for Energy Economics (USAEE), the 2014 President of the International Association for Energy Economics (IAEE), and the Director, Society of Petroleum Engineers (SPE, Africa Region in 2019-2021. Iledare publishes, severally, on oil and gas economics, technology, and policy, ranking among the top 500 SCOPUS authors in Nigeria, 2014-2020. Iledare is a recipient of several professional awards including NAEE Lifetime Achievement Award, Outstanding SPE Africa Regional Award for his contributions to petroleum engineering in SPE Africa; and the prestigious Award for Outstanding Contribution to the International Association for Energy Economics (IAEE).

### **Profile of Prof Richard K Amankwah**



#### **Lead Paper Presenter**

Prof Richard K. Amankwah is a Professor of Minerals Engineering and Vice Chancellor of the University of Mines and Technology (UMaT), Tarkwa, Ghana. He holds a PhD in Biohydrometallurgy from Queens University, Kingston, Canada.

Richard is a Principal Consultant to the minerals industry, serves on the Governing Board of the Ghana Chamber of Mines (GCM) Tertiary Education Fund and is the Chairman, Adjudicating Committee of the Ghana Mining Industry Awards. He served as the Chairman of the Ministerial Committee to Review the Health and Safety Regime of Ghana's Mining Industry.

He was the Principal Investigator for the National Science Foundation (USA) project that sought to unravel the link between mining, land disturbance and the emergence of Buruli ulcer; the UNDP Project on building the capacity of artisanal and small-scale miners in eliminating mercury and innovative mercury-free processes; and the British Council project on mining, farming and economic development. He has also worked for the European Union and the World Bank, and was the Lead Country Researcher for the United Nation's Economic empowerment project on Women in Artisanal and Small-scale Mining.

Prof Amankwah is a Visiting Professor to the African University of Science and Technology, Abuja Nigeria, Jomo Kenyatta University of Agriculture and Technology and the International Institute for Water and Environmental Engineering, Ouagadougou, Burkina Faso. His research interests include gold beneficiation, biohydrometallurgy, environmental biotechnology, waste engineering, microwave

processing of minerals, geo-metallurgy, medical geology, and small-scale gold mining. He is a Fellow of the West Africa Institute of Mining and Metallurgy (WAIMM), and a member of six other professional bodies. Prof Amankwah was a mentor of Barrack Obama's Young African Leadership Initiative and he has been adjudged a "Lifetime Gold Legend" by Forbes Monaco

### **Brief on Engr Umar B. Bindir PhD**



Lead Paper Presenter

1. Engr Umar Buba Bindir (PhD), a Fulani man, was born in Yola Town, Adamawa State, Nigeria. He had his basic education in Yola Town and graduated from the High-Ranking Nigerian University of Maiduguri with a First-Class Honours Degree in Agricultural Technology in 1983.
2. He has a Masters and Doctorate Degrees from the prestigious Cranfield Institute of Technology (CIT), now Cranfield University in the United Kingdom (UK). He professionalized as an Agricultural Machinery Design and Development Engineer in 1987 and 1991 respectively.
3. Engr Bindir has numerous professional qualifications and awards including:
  - Chartered Engineer (CEng), UK;
  - COREN Registered in Nigeria
  - Fellow of the Nigerian Academy of Engineering;

- Fellow Nigerian Society of Engineers;
  - Fellow of the Nigerian Institution of Agricultural Engineers;
  - Fellow of the Solar Energy Society of Nigeria; and
  - National Productivity Order of Merit (NPOM) awardee.
4. Engr Bindir has earned several national and international awards, with a wide technical working experience in Nigeria, UK and Oceania.
  5. He has served in the Academia, worked in Industry, was a Director for many years in the main stream Nigerian Federal Civil Service. He was the immediate past Director General/CEO of the National Office for Technology Acquisition and Promotion (NOTAP), the main institution regulating and promoting Industrial Property and Technology Transfer in Nigeria from 2009 to 2015. Dr Bindir was also a Secretary to the Government of Adamawa State from 2015 to 2019.
  6. In 2020, he was appointed as the Director of Innovation and Research at the Air Force Institute of Technology, Kaduna.
  7. In 2020, he served as a Special Assistant to President Muhammadu Buhari on Social investment and was appointed as the National Coordinator of the National Social Investment Programme (NSIP) by the Honourable Minister, Federal Ministry of Humanitarian Affairs, Disaster Management and Social Development from 2020 till May 2023.
  8. Currently Engr Bindir serves as the Founder and Chairman of the Bindir Knowledge Centre (BKC) located in Yola Town Adamawa State. BKC is a Non-Governmental Organisation established to support children (in school and out of school) and youth, to acquire modern knowledge in both education and entrepreneurship.
  9. Engr Bindir is a thorough Technology Penetration Expert and an accomplished Engineer. His ingenuity and exquisite skills in ideas generation and innovative Project Development and Implementation easily stands him out in all his places of primary assignment.
  10. As the then Director General/CEO of NOTAP, he was the driving force behind the National Policies and Strategies aimed to link academia and industry. He is still the champion on the strategy to develop Science and Technology Parks and Clusters in Nigeria.
  11. Engr Bindir's passion mainly lies in solving poverty challenges through the deployment of technology-based capacity and empowerment know-how. He believes that Nigeria will ultimately industrialize through timely acquisition and deployment of relevant technologies and innovations into its economy.
  12. This Technocrat is one of the longest serving yearly invited lecturers at the National Institute of Policy and Strategic Studies (NIPSS) Kuru, the Nigerian Defence College (NDC), Armed Forces Command and Staff College (CSC), Jaji, etc spanning over 15 years. He is also a regular keynote speaker at COREN General Assemblies, NSE General Assemblies, Numerous University Convocation Lectures, CVC Conferences and many other academic and technical speeches Worldwide, including the World Science Forum (WSF), World Technopolis Association (WTA) and UNECA conferences.
  13. Engr Bindir is happily married to a very beautiful wife and they are blessed with two lovely children (a girl and a boy).

### **SAM AMADI – Citation**



Lead Paper Presenter

Dr Sam Amadi, a policy strategist and law and governance expert, is the Director of Abuja School of Social and Political Thoughts and a Visiting Professor at the Emerald Energy Institute at the University of Port Harcourt. He is the Chair of the Development Law Group of the Nigerian Bar Association’s Section on Public Interest Law and Development (SPIDEL), which he as a founding council member. He was Associate Professor and head of Department of International Law and Jurisprudence at Baze University, Abuja until June 2021. He was a Visiting Research Fellow at the Nigerian Institute of Advanced Legal Studies from 2016-2018. Between 2010-2015, he was Chairman and CEO of the Nigerian Electricity Regulatory Commission (NERC). He has been editor of journals and held lecturing and advisory positions in universities, government institutions and international organizations. Amadi has been a member of several boards including, UN’s Advisory Council of Global Electricity Initiative, Section on Public Interest and Development Law of the Nigerian Bar Association, Center for Law and Social Action (CLASA), and Maldova Foundation, a Washington-based policy Think Tank. He is the Chair of Board of Trustee of Albino Association of Nigeria and Civil Liberties Organization, Abuja Branch. He has been chairman of some Senate technical committees including, Senate Technical Committee on review of Nigeria’s Transport Sector Bill and Senate Technical Committee on review of Nigeria Competition and Consumer Protection Commission Bill. He was a member of the Presidential Committee on Reform Processes in the Public Service in Nigeria and was a consultant and member of the Ministerial Committee on ‘Bloody Oil’ constituted by the Minister of Foreign Affairs in 2009. In 2020, he was a visiting lecturer on Energy Policy and Regulation at the Emerald Energy Institute for Petroleum, Energy Economics, Policy and Strategy, University of Port Harcourt for MSC and PhD students.

Dr. Amadi is a peace and conflict management and justice sector professional. He has delivered commissioned papers for Nigeria's Institute of Peace and Conflict Resolution and has engaged on conflict mitigation programs for the United State Agency for International Development (USAID). The program focused on restive states in Northern Nigerian and Niger Delta states and reviewed the implementation of early warning signals and conflicts mitigation strategies. As a consultant he developed toolkits for needs assessment and evaluation of interventions, and advised on policy interventions for coexistence and social harmony.

Dr Amadi has engaged with various international organizations such as USAID, OPEC and AU. In 2007 and 2008, he was a member, Nigerian Delegation to the Commonwealth and Heads of Government Summit (CHOGM) in Uganda and the Organization of Petroleum Exporting Countries (OPEC) in Saudi Arabia. He has been Consultant for Open Society Initiative of West Africa on Migration, Globalization, and Human Rights in 2008. He was a Fellow at the Carr Center for Human Rights Policy, Kennedy School of Government, Harvard. He has authored books and articles in both local and leading international journals. He presently coordinates the Abuja School of Social and Political Thoughts and Chief Ideas Officer of the Logosphere Advisory, a public sector policy and strategy consulting firm in Abuja. He holds a research doctorate degree (SJD) in Law from the Harvard University, Cambridge, Massachusetts (2004), a Master of Public Administration (MPA), (2003) and a master's in law (LL.M (2001), from the same institution. He has an LL.B., from the University of Calabar, in 1992. He was called to the Nigerian Bar in 1993 after passing from the Nigerian Law School. In April 2021, he was appointed member of the Law Reform Committee. A standing committee of the Nigerian Bar Association (NBA).

# **ACMED 1<sup>ST</sup> INTERNATIONAL CONFERENCE ON SOLID MINERALS RESEARCH, TECHNOLOGY AND POLICY (ACMED 1<sup>ST</sup> COSMIRTEP 2023)**

Theme: Solid Minerals and Energy Transitions: Global Trends, Technology Disruptions, Challenges and Opportunities

November 29 – 30, 2023

Venue: African University of Science and Technology (AUST), Km 10 Airport Road, Galadimawa, Abuja, Nigeria

## **Schedule of Conference Programme**

### **Day 0**

10: 00 am

12:00 pm

### **Tuesday, November 28, 2023**

Registration Opens

Reception at AUST and Hotels

### **Opening Ceremony**

### **Day 1**

8:00 am

9:00 am

9:05 am

9:10 am

9:25 am Goodwill Messages

### **Wednesday, November 29, 2023**

Registration Continues

Scene Setting by the Conference Chair, Dr Morgan Leo Akpan

National Anthem of the Federal Republic of Nigeria

Welcome Address by the Chief Host, Professor Peter Azikiwe Onwualu, FAS, President, African University of Science and Technology (AUST), Abuja, Nigeria

- Governors
- Ministers
- Commissioners
- Association of African Universities (AAU)
- Representative of Physically Challenged Persons
- African Natural Resources Development Centre (ANRDC), African Development Bank (AfDB)
- African Minerals Development Centre (AMDC), African Union
- World Bank
- Economic Community of West African States (ECOWAS)
- The German Federal Ministry of Economic Cooperation and Development (GIZ)

- United Nations Development Programme (UNDP)
- Global Rights
- Multilateral Organizations
- Ambassadors/High Commissioners

10:00 am

Sponsors/Partners Remarks

- Sokoto State Government
  - NNPC
  - TotalEnergies
  - Nigerian Custom Service
  - Nigerian Content Development and Monitoring Board (NCDMB)
  - African Minerals Development Centre (AMDC), African Union
  - Raw Materials Research and Development Council (RMRDC)
  - Society of Petroleum Engineers (SPE)
  - Nigerian Midstream Downstream Petroleum Regulatory Authority (NMDPRA)
  - Nigerian Upstream Petroleum Regulatory Commission (NUPRC)
  - Ministry of Mines and Steel Development (MMSD)
  - Seplat Energy PLC
  - Nigerian Agip Oil Company Limited
  - Nigerian Extractive Industry Transparency Initiative (NEITI)
  - Nigeria Mining Cadastre Office, Nigeria
  - United Nations Development Programme (UNDP)
- Rapporteur: Dr Prisca Nneka Onuoha and Ms Njoku Chinwendu

**Plenary**

10:30 am

Keynote Address by Professor Olugbenga Okunlola, President, Geological Society of Africa  
 Title: Solid Minerals and Energy Transitions: Global Trends, Technology Disruptions, Challenges and Opportunities

- Chair: Professor Peter Azikiwe Onwualu, FAS, President, African University of Science and Technology (AUST), Abuja, Nigeria



Co-Chairs: (1) Professor Grace Ofori-Sarpong, Dean, Postgraduate School, University of Mines, Tarkwa, Ghana (2) Dr Vanessa Ushie, Acting Director, African Natural Resources Development Centre, African Development Bank (AfDB) Headquarters, Cote D'Ivoire (3) Professor Hycienth Aboh, Former President, Nigerian Institute of Physics (NIP) (4) Professor Prince Ishaku Abner, Adjunct Professor, University of Abuja; Coordinator, Oil, Gas and Energy Unit, University of Abuja Business School, University of Abuja, Nigeria (5) Dr Aaron Auduson, Associate Professor of Geophysics/Head, Dept of Geology, Federal University of Lokoja, Kogi State, Nigeria

- Rapporteur: Ms Biodun Bukky Ogundipe and Mr Metu Godwin

Wrap Up by the Chair

11:00 am

Tea Break/Photo Session/Visit to Exhibition Booths

11:30 am

Lead Paper I by Dr Umar Bindir, Former National Coordinator, Nigerian Social Investment Programme (NSIP), Federal Republic of Nigeria

Title: Solid Minerals Research, Technology and Innovation: Exploring the Policy Benefits for Nigeria

- Chair: Professor Abu Mallam Former Dean, Faculty of Science, University of Abuja, Nigeria
- Co-Chair(s): (1) Professor Shadrach Jatau, Former President, Nigerian Mining and Geosciences Society (NMGS) (2) Dr Marit Kitaw, Interim Director, African Minerals Development Centre (AMDC), African Union, Addis Ababa, Ethiopia (3) Dr Tunde Adekola, World Bank Country Office, Azokoro, Abuja, Nigeria (4) Dr Chukwuemeka Uwanaka, Head, Department of Business Administration and Public Policy, African University of Science and Technology (AUST), Abuja, Nigeria (5) Ms Emily Offodile, Special Assistant to the Honourable Minister of Solid Minerals on Community Engagement, Federal Republic of Nigeria

- Rapporteur: Ms Bashar Raheemat

Wrap Up by the Chair

12:00 pm:

Panel Discussion and Interactions with the Participants

Topic: The Role of the Legislature in Solid Mineral Governance in Nigeria

- Chair: Professor Nasir Naeem, Special Assistant, Technical to the Honourable Minister of Steel, Federal Republic of Nigeria
- Co-Chair: Professor Joseph Olakunle Coker, President, Nigerian Institute of Physics (NIP)

Panelists/Discussants

- Mr Tunde Adeyemi, Nigerian Geological Survey Agency (NGSA), Nigeria
- Ambassador Chibuzor Okeke, National Assembly Consultant, Nigeria
- Dr Chukwuemeka Uwanaka, Head, Department of Business Administration and Public Policy, African University of Science and Technology, Abuja, Nigeria

- Rapporteur: Engr Adamu Hassan Abubakar

Wrap Up by the Chair  
12:30 pm

Lead Paper II by Professor Richard Amankwah, Vice Chancellor, University of Mines, Tarkwa Ghana; Member, International Advisory Board (IAB), African Centre for Mineral Exploration And Development (ACMED)

Title: From Poverty Alleviation Activity to a Wealth Creation Business Venture

- Chair: Professor Hycienth Aboh, Former President, Nigerian Institute of Physics (NIP)
- Co-Chair: (1) Mr Ezekwem Ejah, Capacity Development Department, Nigerian Content Division, TotalEnergies, Nigeria (2) Dr Ayuba Salihu, Nile University, Nigeria
- Rapporteur: Dr Odette Ngasoh and Ms Jamila Ado Wailare

Wrap Up by the Chair

1:00 pm

Lunch Break/Visit to Exhibition Booths

2:00 pm – 3:30 pm

Technical Session as Scheduled

3:30 pm – 4:00 pm

Coffee Break

4:00 pm - 4:30 pm

Reports by Technical Session Chairs

- Chair: Dr Jude Ejepu, Federal University of Technology (FUT), Minna, Niger State  
Co-Chair(s): (1) Ms Miranda Ikfi, Mining and Geology Engineer, National Mining Corporation,

Siege Social B.P. Yaounde, Cameroon; (2) Dr Bosco Okolo-obi, Resident Faculty, School of General Studies, African University of Science and Technology, Abuja, Nigeria (3) Ms Diamante Kafuti, Kibali Deputy Exploration Manager, Barrick Gold Corporation, DR Congo

- Rapporteur: Ms Omotola Medubi

Wrap Up by the Chair  
End of Day 1 Proceedings

**Exhibitors:** NNPCL ACMED Raw Materials Research & Development Council (RMRDC) Ministry Mines and Steel Development (MMSD) Nigerian Content Development and Monitoring Board (NCDMB) Nigerian Custom Service

## Day 2

**Thursday, November 30, 2023**

8:00 am

Scene Setting by the Conference Chair/Chair, LOC, Dr Morgan Leo Akpan

8:00 am

National Anthem of the Federal Republic of Nigeria

8:15 am

Lead Paper III by Dr Sam Amadi, Director, Abuja School of Political Thoughts and Chair, Centre for Public Policy and Research

Title: Complexities of Global Transition: A Nigerian Perspective

- Chair: Madam Gertrude Ngabirano, Independent Consultant and Former Executive Secretary, East African Science and Technology Commission (EASTECO)
- Co-Chairs: (1) Professor Sunday Nwaubani, Head, Department of Civil Engineering, African University of Science and Technology (AUST), Abuja, Nigeria (2) Dr Usman Bello, Head, Department of Pure and Applied Mathematics, Chair, Senate Ceremonials Committee, African University of Science and Technology (AUST), Abuja, Nigeria (3) Dr Muiyiwa Odele, Team Lead, United Nations Development Programme (UNDP), Abuja, Nigeria
- Rapporteur: Ms Salome Hosea and Mr Metu Godwin

Wrap Up by the Chair

8:45 am

Panel Discussion and Interactions with the Participants

Topic: Mineral Characterization, Classification, and Grading for Different Applications

- Chair: Dr Mohammed Lawal Buga, FICCON, FIPAN, MD/CEO, Nuzlak Laboratories and Former Director, Industrial Chemicals and Minerals, Raw Materials Research and Development Council (RMRDC), Federal Republic of Nigeria
- Co-Chair: Mr Tim Eldon Tufoin, Geologist and Managing Director, Timadix Geomin Consult Nigeria, Tanzania, and Cameroon
- Panelists/Discussants
- Dr Nandom Abu, Director, Minerals and Materials Development Department, Raw Materials Research and Development Council (RMRDC), Federal Republic of Nigeria
- Dr Sallim Salaam, Project Coordinator, Mineral Sector Support for Economic Diversification Project (MinDiver), Federal Republic of Nigeria
- Dr Emeka Flemin Okengwu, International Consultant/Development Expert
- Mr Patrick Odiegwu, MD/CEO, Polyguard Investment Nigeria Limited
- Dr Abdulkhakeem Bello, Director of Academic Planning, African University of Science and Technology (AUST), Abuja, Nigeria
- Dr Vitalis Anye, Head, Department of Materials Science and Engineering, African University of Science and Technology (AUST), Abuja, Nigeria
- Dr Manasseh Tukura, Retired Director, Nigerian Geological Survey Agency (NGSA)
- Rapporteurs: Ms Bernice Abraham/Engr Adamu Hassan Abubakar

Wrap Up by the Chair

9:15 am:

Lead Paper IV by Professor Wunmi Iledare, Former Director, Society of Petroleum Engineers (SPE), Africa Region

Title: The Inevitability of Petroleum in the Emerging Energy Landscape

- Chair: Engineer Salahuddeen M. Tahir, Head, Assets and Investment Services, NNPC Gas and Power Investment; Chairman, Society of Petroleum Engineers (SPE), Nigeria Council
- Co-Chairs: (1) Professor Prince Ishaku Abner, Adjunct Professor, University of Abuja; Coordinator, Oil, Gas and Energy Unit, University of Abuja Business School, University of Abuja, Nigeria (2) Dr Alpheus Igbokoyi, Head, Department of Petroleum and Energy Resources Engineering, African University of Science and Technology (AUST), Abuja, Nigeria (3) Dr Omolora Victoria Oyelade, Department of Physics, Bingham University,

Nasarawa State, Nigeria (4) Mr Olaniyi J. Olatomiwa, Research, Technology and Innovation (RTI) Department, NNPC Limited Headquarters, Abuja, Nigeria

- Rapporteur: Mr Metu Godwin

Wrap Up by the Chair

10:00 am

Tea Break/Visit to Exhibition Booths

10:30

Special Lecture

Title: Emerging Technologies and Techniques in Solid Mineral Development

- Lecturer: Dr Emeka Flemin Okengwu, International Consultant/Development Expert
- Chair: Dr Vitalis Anye, Head, Department of Materials Science and Engineering, African University of Science and Technology (AUST), Abuja, Nigeria
- Co-Chairs, (1) Engr (Dr) Amina Danmadami, Nigerian Midstream Downstream Petroleum Regulatory Authority (NMDPRA) Headquarters, Abuja, Nigeria (2) Dr Dauda Garuba, Independent Researcher and Development Practitioner
  
- Rapporteurs: Ms Ese Esele and Ohaeri Tochi Keriana

Wrap Up by the Chair

11:00 am– 1:00 pm

Technical Sessions as Scheduled

1:00 pm – 2:00 pm

Lunch Break/Visit to Exhibition Booths

2:00 pm – 2:30 pm

Reports by Technical Session Chairs

- Chair: Dr Jude Steven Ejepu, Federal University of Technology (FUT), Minna, Nigeria
- Co-Chair: Dr Grace Kehinde Samuel, National Agency for Science and Engineering Infrastructure, (NASeni), Abuja, Nigeria
  
- Rapporteur: Dr Prisca Nneka Onuoha

Wrap Up by the Chair

2:30 pm– 2:45 pm

Evaluation and Planning for Next Conference

- Facilitators (1) Madam Gertrude Ngabirano, Independent Consultant and Former Executive Secretary, East African Science and Technology Commission (EASTECO) (2)

Dr Omolara Victoria Oyelade, Department of Physics, Bingham University, Nasarawa State, Nigeria (3) Dr Grace Kehinde Samuel, National Agency for Science and Engineering Infrastructure, (NASENI), Abuja, Nigeria (4) Mr Ezekwem Ejah, Total Energies, Lagos, Nigeria (5) Mr Ibrahim Ibrahim, RTI Department, NNPC Limited, Abuja, Nigeria

2:45 pm – 3:00 pm

Questions and Comments/Presentation of Gifts

3:00 pm – 3:30 pm

Communique

3:30 pm – 3:35 pm

Vote of Thanks by Dr Muhammed Abubakar Haruna, Focal Person, Mineral Economics and Policy, African Centre for Mineral Exploration and Development (ACMED)

3:35 PM – 3:50 pm

Closing Remarks by the Chief Host, Professor Peter Azikiwe Onwualu, FAS, President, African University of Science and Technology (AUST), Abuja, Nigeria

**6:30 PM: CONFERENCE DINNER & AWARD NIGHT**  
(Formal Attire)

### Schedule of Technical Session Leadership

Coordinator: Mr Emmanuel Chizor Okwunwanne, Programmes Coordinator, Mathematics Institute and Students Recruitment, African University of Science and Technology (AUST), Abuja, Nigeria

S/N/Code	Technical Session	Panelists	Rapporteur(s)	Date	Time	Venue
1	Solid Minerals and the Global Energy Transition	Dr Ikechukwu Stanley Okafor (Chair) Dr Morgan Leo Akpan Dr Ayuba Salihu Dr Dahiru Sani Dr Omolola Victoria	Engr Adamu Hassan Abubakar	29-11-2023	2:00 pm – 3:30 pm	AUSTInspire
2	Mainstreaming Gender in Solid Mineral Development	Prof Gace Ofori-Sarpong (Chair) Dr Grace Kehinde Samuel Dr Odette Ngasoh Ms Omotola Medubi Engr Faithlyn Nwadishi, JP	Dr Odette Ngasoh	29-11-2023	2:00 pm – 3:30 pm	NNPC Hall
3	The Impacts of Solid Mineral Exploration and Exploitation on the Physical Environment	Prof Sunday Nwaubani (Chair) Dr Dauda Garuba Dr Morgan Leo Akpan Ms Emily Offodile Mr Kolawole Banwo	Ms Bashir Raheemat	29-11-2023	2:00 pm – 3:30 pm	Board Room II
4	State of the Art Technologies for Solid Mineral Exploration, Processing & Utilization	Dr Jude Ejepu (Chair) Dr Godwin Amobi Alo Dr M. L. Buga Dr Abdulhakeem Bello Ms Lumun Amanda Feese Dr Usman Abdulmalik Dr Vitalis Anye	Ms Bernice Abraham	29-11-2023	2:00 pm – 3:30 pm	PTDF Hall
5	Environmental Monitoring & Policy Development for the Mining Sector	Dr Muhammed Abubakar Haruna (Chair) Dr Alpheus Igbokoyi Dr Ifeyinwa Ijeoma Obianyo Mr Auta Jonathan	Mr Metu Godwin and Ms Blessing Iweha	29-11-2023	2:00 pm – 3:30 pm	ICT Building
6	Making Artisanal & Small-scale Mining (ASM) More	Prof Richard Amankwah (Chair) Dr Jude Ejepu	Dr Prisca Nneka Onuoha and Ms	29-11-2023	2:00 pm – 3:30 pm	Zenith Hall

	Efficient, Safe, and Sustainable	Dr Bosco Okolo-obi Ms Diamante Kafuti Dr Lemchi Wala Ms Bukky Abiodun Mr Habibu Wushishi	Jamila Ado Wailare			
7	Contaminated Site Remediation Techniques for Mining Sites	Dr Vitalis Anye (Chair) Dr Alpheus Igbokoyi Prof Sunday Nwaubani Dr Abdulhakeem Bello Dr Dauda Garuba Ms Miranda Ikfi	Ms Ese Esele and Ohaeri Tochi Keriana	30-11-2023	11:30 pm – 1:00 pm	Board Room II
8	Licensing, Entrepreneurship, and Business Opportunities	Dr Muhammed Abubakar Haruna (Chair) Dr Emeka Uwanaka Dr Vitalis Anye Ms Bukky Abiodun	Mr Adewale Oluwatobi Festus	30-11-2023	11:30 pm – 1:00 pm	Zenith Hall
9	Sustainability, Corporate Investment, and Social Responsibility	Ms Gertrude Ngabirano (Chair) Dr Alpheus Igbokoyi Mr Ahmed Aliyu	Ms Biodun Bukky Ogundipe	30-11-2023	11:30 pm – 1:00 pm	PTDF Hall
10	Emerging Technologies and Techniques in Solid Mineral Development	Dr Nandom Abu (Chair) Dr Morgan Leo Akpan Dr Abdulhakeem Bello Dr Vitalis Anye Dr Emeka Uwanaka	Ms Bernice Abraham and Ms Jamila Ado Wailare	30-11-2023	11:30 pm – 1:00 pm	Board Room II
11	Solid Minerals and the Oil and Gas Industry	Mr Ezekwem Ejah (Chair) Dr Ikechukwu Stanley Okafor Mr Mudi Abubakar Dr Ayuba Salihu Engr (Dr) Benjamin Ileh Attah Engr Oghenerume Ogholo	Ms Salome Hosea and Mr Oko Ukie Emmanuel	30-11-2023	11:30 pm – 1:00 pm	AUSTInspire

### Special Events/Programmes (Optional)

City Tour (Those interested Contact Saheed Adewale on +2348067954955 for details).

Tour of RMRDC Resource Centre, Raw Materials Research and Development Council (RMRDC) Headquarters, Maitama, Abuja  
(Those interested Contact Dr Muhammed Abubakar Haruna on +2348033059623 for details).



## Technical Sessions

### Technical Session 1: Solid Minerals and the Global Energy Transition

#### **Solid Minerals Development and the Global Energy Transition: Scoping the Unveiling Challenges and Opportunities for Nigeria**

Akpan Morgan L<sup>1</sup>; Steven Jude E<sup>2</sup>; and Odele M<sup>3</sup>.

<sup>1</sup>African University of Science and Technology (AUST), Abuja, Nigeria

<sup>2</sup>Federal University of Technology (FUT), Minna, Niger State, Nigeria

<sup>3</sup>United Nations Development Programme, UNDP

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Based on the recent report by the International Energy Agency (IEA), the average amount of solid minerals required for a new unit of power generation has increased by more than 50% over the past two decades due to the rise in the share of renewable energy sources in the global energy mix. Given that the low emission energy and transportation systems are more mineral intensive than their fossil fuel counterparts, the energy transition window provides a great opportunity for the solid minerals subsector in Nigeria. From these indicators, it is evident that the demand for solid minerals needed to manufacture and sustain power generation infrastructure and other systems in order to achieve the global agenda on energy transition will continue to rise. The objective of this study is to analyze the challenges confronting the development of solid minerals sector in Nigeria within the contexts of the global energy transition vis-à-vis the agenda towards net-zero milestone. The methods used in this research included desk review of case studies and previous works on the subject, as well as the analysis of relevant data. The paper identified some challenges confronting the development of Nigeria's solid minerals sector. These included insufficient legal/regulatory framework, lack of indigenous capacity, lack of synergy among stakeholders, and security threats. The recommendations offered in this study centred on the remedies for the identified challenges as well as the need for public education to sensitize and also create awareness on the subject among the people.

Keywords: International Energy Agency; solid minerals; renewable energy; Nigeria; energy transition; net zero

#### **Advances In Clay-Reinforced Polymer Nanocomposites for Sustainable Zinc-air Battery Applications**

Ojinma N<sup>1</sup>

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The search for sustainable energy alternatives and advent in nanotechnology has led to the utilization of naturally occurring minerals in the fabrication of energy conversion and storage devices such as zinc air batteries. Evidently, the array of research on mineral -based polymer nanocomposite electrolytes are on the increase. Specifically, the use of clay and clay nanocomposites have gained wide attention due to their intrinsic properties and well-known advantages such as high availability, extreme surface areas, porous structure, improved strength, excellent heat absorption, barrier characteristics and other electrochemical properties. However, a major problem associated with clay- based nanocomposites zinc -air batteries is the lack of efficient technical and economic routes toward their commercialization. This review is focused on recent trend on clay nanocomposites as suitable reinforcements for solid polymer electrolytes in zinc-air batteries. The various synthetic routes, modification techniques, mechanical and electrochemical properties of clay nanocomposites electrolytes are highlighted. Further, future perspective with respect to the role of government in policy and policy implementation for the exploration and exploitation of clay and clay -derived minerals are succinctly summarized. This will provide up-to date information for researchers, industrialists as well as government agencies on the importance of naturally occurring minerals in transitioning present energy sector to a sustainable development.

Keywords: Sustainable energy; nanotechnology; storage devices; electrolytes; electrochemical properties; nano composites

### **Role of Natural Gas in Energy Transition in Nigeria**

Oruwari Humphrey<sup>1</sup>

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<sup>1</sup>Nigerian National Petroleum Corporation Limited (NNPCL)/Nile University, Abuja, Nigeria

Nigeria is endowed with abundant natural gas; Nigeria's proven gas reserve is placed at 209.5 trillion cubic feet. The natural gas sector holds significant potential role. Natural gas is a strategic asset and a transition fuel that will foster sustainable development in Nigeria. The study investigated the role of natural gas in the energy transition in Nigeria. Despite abundant natural gas reserves in Nigeria, the role of natural gas in the country's energy transition has been minimal. The main problems with the efficient utilization of natural gas in the energy transition in Nigeria are inadequate funding and limited domestic gas penetration. Using a literature review and case studies of natural gas projects to illustrate how natural gas can contribute to sustainable development. The study findings revealed that while natural gas can play a vital role in addressing emission impacts, helping to decarbonizes the energy industry, and mitigating climate change, the key challenges to a low-carbon gas future in Nigeria are inadequate infrastructure, gas flaring, inadequate funding, and

limited gas penetration for domestic use. The study concluded and recommended that the government should provide an enabling environment that will boost investors confidence, such as adequate security, the right legal and regulatory framework, the development of the gas market in the supply chain, and strengthening other gas development structures.

Keywords: Nigeria; natural gas; transition fuel; energy transition; sustainable development; climate change

### **Biodiesel Production from Desert Dates (*BalaniteAegyptiaca*) Seed Oil using Calcium Oxide Obtained from River Snail Shell as Catalyst**

Alabi Wasiu<sup>1</sup>

<sup>1</sup>NASENI/Nile University, Abuja, Nigeria  
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Petroleum is presently the most dominant source of global energy supply and the consumption of it is on the increase due to economic increase, globalization and human population. Also, petroleum derived products' prices are not stable and the combustion of this fuels are greatly contributing to environmental pollution. Biodiesel is a renewable, biodegradable less pollutant emitting, non-toxic, more environmentally-friendly fuel and reduces greenhouse gas emission. This study was carried out for the production of biodiesel using heterogeneous/homogenous based catalyst; this catalyst has been considered in view of ease of catalyst separation from the mixture and low energy consumption. Calcium oxide was synthesized from river snail shells through calcinations method at 800 °C for 4 hours in a muffle furnace and used as catalyst for the production of biodiesel from desert date seed oil. The chemical composition of the calcined river snail shell catalyst was determined by XRF (X-ray fluorescence) techniques. Desert date seed oil had an acid value of 3.92mgKOH/g and density of 0.243g/cm<sup>3</sup> which was transesterified into biodiesel using Electromagnetic stirrer device. Methanol was introduced with CaO into the reaction vessel containing the desert date seed oil. The Central Composite Design method was achieved at varied temperature of 50-60 °C and the catalyst concentration between 0.5-2.0wt% at constant reaction time of 1 hour 30 minutes after which the mixture was allowed to settle and the methyl ester was separated from the mixture. The characterization of Desert Date seed oil methyl ester showed that the biodiesel had a flash point 65°C, pour point of -4°C, cloud point of 2°C, acid value of 3.92mgKOH/g and density of 0.87g/cm<sup>3</sup> and these values are all within the range as specified by ASTM (American Society for Testing and Materials and EN (European) standards for biodiesel. The FTIR analyses also revealed that Desert Date seed oil contains much oil content that makes it suitable raw materials for biodiesel production. The maximum response yield of biodiesel was 90% at the

temperature of 60°C and catalyst concentration of 0.5 wt%. This work further shows that derived catalyst obtained from river snail shell can be used as catalyst to produce biodiesel through transesterification process.

Keywords: Petroleum; energy; globalization; environmental pollution; renewable; greenhouse gas

### **Collaboration as a Development Support Strategy for Marginal Oil Field Development in Nigeria**

Oruwari Humphrey<sup>1</sup>

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In 2018, the Nigerian Government launched the Marginal Field Bid Round, offering 57 marginal oil fields to local and international investors to increase the participation of indigenous companies in the upstream sector of the oil and gas industry in order to increase production, and generate revenue for the government. The purpose of the study is to examine collaboration as one of the success strategies for marginal oil field development in Niger Delta. Collaboration is working together to achieve a common goal. It involved separate companies working towards shared or common goal, collaboration can often be an important source of competitive advantages. It helps in pooling of resources to make capital available for marginal oil field operation. This study adopted a literature review and multiple case studies of AFREN Plc, Frontier oil limited and Universal Energy limited in the development of Okoro, Setu field, and Qua Iboe field to highlight the role of collaboration in the development of marginal oil field. The method adopted was qualitative method using literature review and multiple case study to highlight the role of collaboration in the development of marginal oil field. The findings showed that the successful development of marginal oil fields is possible through joint cooperation among the stakeholders of the oil and gas industry. Collaboration in terms of infrastructure sharing, knowledge sharing, and strategic partnership improve the performance of marginal oil field development. The overall result revealed that collaboration in form of strategic alliance and partnership is a driver or development support strategy for marginal oil field development. This research study recommends creation of an enabling environment for investment, for example the political environment, community challenge and security for marginal field investment in Niger Delta. The government should ensure that there is stable macroeconomic policy and efficient legal system that allows for contract to be enforced and support access to channels to arbitration.

Keywords: Nigerian Government; oil and gas industry; collaboration; Niger Delta; marginal oil field; enabling environment

## **Carbon-Based Nanomaterial for Lithium-Ion Battery Anode: A Case Study of Graphene**

Bernice Ngwi Abraham<sup>1</sup>

Department of Materials Science and Engineering

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Recently carbon and its derivatives have been found to be the best anode materials for LIBs. Many attempts have been made to enhance the functionality and durability of Lithium ion batteries (LiBs), because their potentials. In this review we consider various forms of graphene explored as anode materials for the fabrication of Lithium ion batteries. Researches have demonstrated that graphene and its composites can be used as anode materials for LiB's to dramatically improve the operational stability, enabling the development of significantly more potent, long-lasting LIBs.

Keywords: graphene structure, graphene synthesis, LIBs, composite, anode.

### **Solid Mineral and Global Energy Transition**

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Globally, the development of adequate technology to achieve low Carbon emission targets in Energy Systems is on the front burner. Much emphasis is laid on the use of Solid Minerals considered as vitamins to the Energy Transitions Chain. The critical nature and characteristics of some solid minerals have made them indispensable to the future energy equation in the world. Chief among the Minerals vital for Transition from Fossil Fuel to Low Carbon Energy system is the Rare Earth Elements (REE). Rare Earth Elements (15 Lanthanites, Scandium and Ytterium) are common components of clean energy technology such as Wind Turbine and Electric Vehicles and Super Permanent Magnets. Rare Earth Metals availability has become a common issue in planning transition from fossil fuel energy to low carbon energy. The past decade has seen several countries establish critical Solid Mineral lists including those critical to the development of low Carbon Energy. This article focuses on the relationship between Rare Earth Elements and the Energy Transition, while discussing demand and supply of these Critical Minerals in the Energy Transition Process. We investigate the challenges regarding current and future supply of REE from African Continent. The stakes and challenges are numerous especially on Demand and Supply. A new reserve for REE has just been discovered in Akwa Ibom State (Nigeria). This will seriously challenge the Chinese quasi-monopoly of the International REM Market Supply. Other issues are in connection with the absence of equivalent substitutes, the low cycling rates or even the environmental damage linked to the process of extraction and production. In the face of

these we propose concrete recommendations and policies in order to meet the ecological challenges of the energy transition and to ensure a reliable future supply.

Keywords: Solid minerals, rare earth elements, wind turbines, electric vehicles, Akwa Ibom, China, environment.

Technical Session 2: Mainstreaming Gender in Solid Mineral Development

### **The Consequences of Mechanized Sand Mining on Women in Lagos**

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For many decades, manual sand mining has been a traditional occupation in Rabaka community in Ikorodu. Skilled male divers fill buckets with sand from the bottom of the lagoon, while the women stockpile this sand for sale to truck drivers, earning about a thousand naira per day (less than US\$2) unless they are canoe owners. This traditional method of sand mining sustained livelihoods for decades by balancing sand harvesting with produce from the environment. However, the arrival of foreign men in the region and the use of powerful mechanized dredgers and tractors has rapidly pushed the manual sand miners out of business. This exploratory study revealed enormous consequences for the communities, particularly the women lost out on this source of livelihood without a viable alternative and have resorted harvesting mangroves for sale as firewood; collecting and selling plastic bottles from the lagoon; and unregulated fishing. Fishers' livelihoods are further threatened by mechanized sand mining: noise pollution and habitat destruction reduce their catch, while dredging machinery destroys fishing nets, sparking conflicts between the fishers and miners. For the men of Rabaka, difficulty to find alternative employment on the mechanized platforms was experienced since the workforce is primarily composed of foreigners or men from other neighbouring communities. This paper revealed that while monitoring and control of the mechanized dredging operations are needed and still lagging, efforts should be made to develop sustainable livelihood pathways for the women affected.

### **Women Participation in Fisheries Activities as Means of Livelihood in Doma Local Government Area of Nasarawa State**

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The study was conducted to determine women participation in fisheries activities as a means of livelihood in Doma Local Government area of Nasarawa State, Nigeria. A total of sixty (60) women involved in fisheries activities were selected through purposive sampling technique in the study area. Primary data were collected through the use of structured questionnaire and personal interview of the respondents. Simple descriptive statistics was used to analyze the data. Results of the study showed that 33.3% of the respondents were within the active productive age of between 31 and 40 years. Majorities (63.3%) of the respondents were married, and about (40%) had 6-10 years' experience in fisheries activities. Result indicated that majority (33.35) of the respondents were engaged in smoked fish marketing while 26.7% were involved in fresh fish marketing. The result further revealed that majority of the respondents do not spend a kobo on transport, firewood, repair and maintenance, fuel, processed fish, purchase of fresh fish, fishing equipment, fridge, cooler, drums, bowls and rent on land and shops respectively. The major constraints faced by women in fisheries activities in the study area were lack of credit facilities, poor transportation, lack of extension contact and lack of storage facilities. It can be concluded that women play predominant and significant role in the post-harvest sector of the fish production in Doma Local Government Area of Nasarawa State. Therefore, the study recommended that Women in the fisheries should be developed through extension training programs and skill acquisition, provision of credit facilities to improve their businesses, improve transport facilities, health and education services to improve their participation in development programs and government should institute development programs for rural women.

Keywords: Doma, livelihood, women participation, respondents and fisheries activities.

### **Gender and Intersectionality Gaps in Natural Resource Management and Benefit-sharing: the Case of Women in the Solid Minerals Sector in Nigeria**

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There is a global recognition of the marginalized conditions of the female gender in nearly all facets of life. Despite various efforts through policies and programmes to redress this challenge, women have remained under-represented in the global scale of access to opportunities and better conditions of life. This include attaining parity with their male counterparts in natural resource extraction, revenue management and benefit-sharing. A gendered scan of the natural resource environment reveals a far less representation and influence of women compared to their male counterparts. While the petroleum sector has proved the worst drained in view of their insignificant number, woman's comparative greater visibility in the mining sector has been largely limited to artisanal and small-scale participation. Worse still, women voices are daily drowned in mining community development project negotiations owing to unprogressive traditional/cultural practices which foreclosed them from sitting with men in meetings. This has pushed many women to the margins of survival and under-development in many resource-bearing communities. This paper seeks to examine the marginalization of women in natural resource (mis)management and benefit-sharing against the backdrop of gender intersectionality discourse with specific focus on the Nigerian mining sector. The paper will attempt to find answers to such questions as: What are the underlying



gender intersectionality issues in natural resource extraction and management? Where are the structural gaps? How have the gaps affected women's interest and participation in the Nigerian mining sector governance and operations? Within the purview of the Sustainable Development Goals (SDGs) slogan of "Leave no One Behind" and the call for gender parity, how should men retool into becoming the instruments for increased women participation in the Nigerian mining sector? Where are the entry points for them to do so? What other steps should be taken to enhance the push for gender parity across the mining value chain in Nigeria?

### **Gender Dimensions of Artisanal and Small-Scale Mining (ASM) of Barite Ores in Nasarawa State, Nigeria**

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The role of male and female miners and the impact of Artisanal and Small Scale Mining (ASM) of barites in Nigeria on environment and safety were determined through a field survey using a structured questionnaire and Focused Group Discussion. Results show that barite miners consist of 52% male and 48% female. Men (100%) are mostly involved in blasting, digging and cracking while women (100%) are involved in cleaning, washing and transfer of excavated barite to designated locations for stacking. The gender challenges identified include: unsafe work environment and poor remuneration for women; inadequate enforcement of mining laws and regulation, poor access to finance, disparity in access to safety gears, degraded environment and devastation of agricultural land. Recommendations towards achieving gender parity sustainable production of barites for the oil industry are proposed to include: modification and implementation of existing ASM policy to emphasize gender mainstreaming, support programs for gender parity for the sector, formalization of activities of ASM and creation and support for women cooperative miners.

**Keywords:** Gender mainstreaming, barite, Artisanal and Small Scale Mining (ASM), women miner, mineral value chain.

### **Factors Influencing Career Progression of Female Physical Metallurgists in the Steel Foundry Industry in Ekurhuleni, Gauteng (South Africa)**

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The steel industry is one of the largest sectors in South African manufacturing. For companies in this sector to be competitive and successful; skills such as physical metallurgy are essential. Engineering in South Africa is characterized by a shortage of females. As such, in line with the employment equity; companies including foundries, have a mandate of not only employing but upskilling female technicians/technologists and engineers. The paper discusses questions relating to the progression of professional females working in the foundry industry as metallurgists and recommends strategies which foundries can adapt as retention and developmental plans. Failure to address this subject will entail susceptibility of the foundry industry to lose its qualified professionals due to lack of growth and diversity. Qualitative research method approach, identified as the third methodological movement or paradigm was adopted as it included online surveys with qualified metallurgists employed in the steel foundry industry, and structured virtual interviews with technical and hiring managers working with physical metallurgists. Main factors contributing to career progression of female physical metallurgists in the steel foundry industry will be discussed. In addition to that, retention strategies will be provided as reference for the industry.

**Keywords:** career progression; physical metallurgists; steel foundry industry, Ekurhuleni (South Africa)

### **Mainstreaming Gender in the Nigeria Solid Mineral Sector: Ebonyi and Edo State**

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**Introduction:** Gender inequality within Nigeria's solid mineral sector is stark, particularly evident in the under representation of women. This study delves into the gender biases that persist within the sector, focusing on Ebonyi and Edo states.

**Objectives:** This study aims to understand the challenges and prospects for women in the solid mineral sector in Ebonyi and Edo states, identifying policy gaps and suggesting ways to promote gender inclusion.

**Methodology:** Employing a mixed-methods approach, this research involved data collection from relevant stakeholders utilizing desk review, key informant interviews (KII) and focus group discussions (FGDs) to gather qualitative insights. A total of 160 respondents (78% female, 22% male) participated.

**Findings:** Research findings reveal significant policy gaps contributing to gender disparities in the solid mineral sector. Upon examination of key regulations, including the 2007 Mineral Act and Mineral and Mining Regulation (2011), it becomes evident that

an absence of gender-specific guidelines is a prominent issue. Furthermore, a distressing underrepresentation of women (3%) in decision-making positions, in contrast to men (97%), highlights a stark inequality. Within this context, the patriarchal framework inadvertently perpetuates unconscious biases, impacting funding opportunities for women-led businesses and fostering an environment conducive to sexual violence. In addition, the sector's struggle with in effective enforcement of environmental regulations, attributed to security and funding challenges, results in abandoned mine sites that pose specific challenges for women.

**Conclusion:** Gender inequality remains prevalent within the solid mineral sector in Ebonyi and Edo states, addressing these disparities requires comprehensive policy reforms and effective implementation.

**Keywords:** gender, inequality, solid mineral sector, policy gaps, gender inclusivity.

### **Mainstreaming Gender in Solid Mineral Development: An Overview**

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Gender mainstreaming in the field of solid mineral development is a critical yet often overlooked aspect of sustainable resource management. This paper presents an overview of the challenges militating against effective mainstreaming of gender in solid mineral development. It also prescribes measures and approaches that can be used to engender social justice and equity for women in the mining sector. According to the report published by the International Labour Organization (ILO), the extractive industries which include mining and the quarry have over the years been dominated by the male workforce. The report also revealed worrisome gender bias against women in terms of access to finance, access to equipment, access to technology, inadequate institutional support and services. Research has also shown that women in the mining sector often experience fear of low job safety, less opportunity for promotion, greater difficulty balancing work with household responsibilities, their competence and exposure. Data that were generated through survey and questionnaires, interviews and case study are presented. It was found out that just about 15% of the work force in the mining and quarry

sector were females. The consideration of gender in the development of solid mineral resources is critical for achieving sustainable and inclusive economic growth. Some results have shown some positive outcome such as increase representation of women managements while others have highlighted challenges in policy implementation.

Keywords: International Labour Organization; extractive industries; gender bias; solid mineral; sustainable; mainstreaming; social justice

**Technical Session 3: The Impacts of Solid Mineral Exploration and Exploitation on the Physical Environment**

**Contribution to the Lithochemical and Environmental Study of the Land Located Towards the South-west of the Shasha River, Masisi territory, North Kivu Province in the Democratic Republic of Congo: An Approach to Assess the Influence of Climate Variation on the Geology of the Environment**

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This work related to the lithochemical and environmental aspect of the land located towards the southwest of the Shasha River in the territory of Masisi in DR Congo, was done in 2021 and follows questions related to the existence of possible mineralization in the said environment compared to its direct surroundings whose mineralization has already been reported in particular thanks to artisanal mining. Geographical and climatic considerations show that the environment is located in a context with tropical climate and mountain climate influenced by altitude and an average monthly temperature ranging from 16 ° to 21 ° C whose manifestations are observed on the soil and vegetation. On a clay-sandy, soil grows a grassy savannah whose anthropogenic activities are considerably modified. The geology of the environment is similar to that of Kivu linked to the history and evolution of the African plate and consists of metamorphic formations attributed to the Precambrian and intersected by a post-orogenic granitic intrusion. The work of the field surveys carried out in 2021, was done according to the routes and the samples duly selected were analyzed by spectrometry.

Keywords: lithochemical ; environmental ; mineralization ; artisanal mining ; climate ; metamorphic

**Impact of Solid Mineral Exploration and Exploitation on the Physical Environment**

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Solid mineral exploration and exploitation is currently being promoted as a strategy to diversify the Nigerian economy. Mineral developmental stages which are exploration, mining and processing can lead to different types of environmental damage to the physical environment comprising the biosphere, atmosphere, and hydrosphere. The land has been badly dented with scars of mining activity. Some abandoned mine pits are filled up with water, surrounded by heap of overburden and mine tailings which cause increase in radiation exposure, landscape defacement and destruction of land leading to land erosion among other problems pose danger to man and animals. The water and air are also not left without pollution resulting in poor air quality, disruption of biodiversity, ozone layer depletion, destruction of aquatic animals. The environmental damage has in turn resulted in waste of arable land, as well as negative impact on economic crops and trees which impact negatively on food security. This paper identifies and discusses the extent of the problem, the impacts, their consequences and strategies for mitigating existing problems and how to prevent future occurrence of such negative impacts. Adoption and implementation of the strategies will ensure minimum negative impact of solid mineral exploration and exploitation on physical environment in Nigeria.

Keywords: Green mining, pollution, mineral development, environmental hazards.

### **The Impacts of Mining: Gaining Geospatial Insights from the Coburn Mineral Sands Project in Western Australia**

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The global demand for Heavy Mineral Sands such as Zircon, Ilmenite, Rutile, and Rare Earth Metals (REEs) negatively impacts environment. Open-pit mining being the most devastating method is associated with the rapid loss of vegetation cover, soil, rocks, water, and other natural-occurring matter as humans attempt to gain access to mineral-bearing ores, and to process recovered materials. It is therefore of utmost importance to diligently monitor areas where this type of mining is carried out, as this is imperative to understand the extent to which the environment is degraded as a result of the mining-induced activities. This continuous monitoring and thorough assessment of mining operations is often valuable in holding mining entities accountable with a view to promote effective ecological restoration efforts and ultimately minimize the impacts of mining-related activities on the environment, humans and other species. In this study, we aim to use Landsat multispectral remote sensing data to assess and classify the extent to which mineral sands exploitation

by operators of the Coburn Mineral Sands Project in the state of Western Australia is negatively impacting the environment. This study will make use of Landsat images spanning 24yrs, from 1999 to 2004 to implement change detection by conducting time series analysis as well as spectral calculation of Soil-adjusted Vegetation Index (SAVI) to determine vegetation loss and soil exposure.

Keywords: remote sensing, environmental degradation, change detection, time-series analysis, vegetation loss.

### **Assessment of Baryte Ore Mining – Based Contamination, Associated Health Consequences and Environmental Remediation**

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Mining activities endanger human lives through the uncontrolled release of toxic heavy metals. These metals are major causes of widespread mineral poisoning in Northern Nigeria, and severe health risks in children and adults living within the mining community. Whenever solid minerals are extracted or mined, the mines or large pits are created and abandoned. The pits usually contain leftovers of minerals that may be leached in the presence of water into the soil or transported by water into the rivers and other waterways. These heavy metals can also get into the environment as fine-size particles (dust) and contaminate the air. The ingestion of the toxic metals in drinking water, plants, soil and air through the mouth, nose, skin by humans and animals may cause moderate to extreme health risks. Baryte ores like other non-carcinogenic ores are associated with some heavy and light metals that are mostly carcinogens. Heavy metals in baryte ores may include cadmium (Cd), lead (Pb), iron (Fe). In addition to the carcinogenic metals, some non-

carcinogenic heavy metals are associated with baryte ore. Although non-carcinogenic, they become harmful at concentrations above the allowable limits stipulated by the national and international bodies responsible for health and environmental safety. This paper assesses the extent of heavy metal contaminations and estimates the toxicity levels of heavy metals in mining sites and within the mining community to identify and classify short-time and long-time health risks. It estimates the levels of heavy metal exposure to humans either by oral ingestion or diffusion through the skin, and compares the concentrations of the metals with the standards provided by the national and global health and environmental regulatory organisations. The paper also characterises and analyses potential human health risks in water samples and tailings from baryte mines and in drinking water based on the outcome of the comparative risk analysis. Water samples and tailings collected from different mines in three mining sites are analysed using the Inductively coupled plasma mass spectroscopy (ICP-MS). Results show that the concentrations of barium (Ba) and Pb are above the national and global health and environmental standards. Index of geo-accumulation (Igeo) and contamination factor (CF) for Fe, Pb, and Ba reveal that the samples are moderately to extremely polluted, and highly contaminated. The non-carcinogenic risk for Ba is 87% and 99% for Pb. The chronic daily intake for these metals confirmed that possible consequences of long-time exposure is imminent and the maximally exposed individuals (MEI) to toxic heavy metals in drinking water and air are residents of the mining sites < miners < children. Although the current carcinogenic health hazard is insignificant due to low Cd concentration, some precautionary measures should be taken to prevent non-carcinogenic risks of Ba, Pb and Fe, and long-time exposure to Cu and Zn. It is expected that uncensored exploration of baryte ores may cause potential toxic metal poisoning over a long period. Frequent analysis of water, soil, plant and air within the baryte mining sites, and direct medical examination of humans will help to checkmate chronic intake of heavy metals and ensure strict adherence to national and global mining and environmental standards.

Keywords: Mining; heavy metals; baryte ores; health; environmental; contaminated, cadmium toxicity, barium contamination

### **Impact of Heavy Metals on the Environment and Human Health: A Comparative Analysis of Two Mining Communities in Niger State, Nigeria.**

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Unregulated mining of precious metals has led to pollution in the environment and food chain, as well as outbreaks of poisoning in affected communities. However, there is limited evidence on the effect of heavy metals on the environment and health of communities

in north-central Nigeria. This study investigated the comparative presence and concentration of some heavy metals, namely, arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), nickel (Ni), lead (Pb) and zinc (Zn) in various samples collected from water sources, soils, staple food cultivars, and blood samples of inhabitants around Kataeregi and Kurebe mining communities in Niger State, Nigeria. The samples were collected using standard methods and digested using a tri-acid mixture and concentration of heavy metals was determined using Atomic Absorption Spectrometry (AAS). The analysis revealed the water and soil samples only showed exceeding levels in As, 0.017 mg/L; Hg, 0.014 mg/L; Pb, 0.004 mg/L; and As, 37.2 mg/kg, Cd, 6.7 mg/kg, and Hg, 1.1 mg/kg, respectively, in Kataeregi; and Cd, 0.023 mg/L; Hg, 0.012; and Hg, 0.315 mg/kg, respectively, in Kurebe. Heavy metal concentrations in staple food cultivars consumed at both mining sites were found to be within the permissible levels set by the WHO/FAO, except for As (1.72:1.82 mg/kg), Cd (0.41:0.09 mg/kg), Ni (0.41 mg/kg) and Hg (0.71 mg/kg) in cereals and vegetables from Kataeregi, and As (1.56 mg/kg), Hg (2.09 mg/kg), in legumes and Cd (0.43 mg/kg) in tubers from Kurebe. Also, significant elevations in the blood Pb, 11.2 µg/L; Hg, 11.1 µg/L; urea, 8.43 mmol/L and creatinine, 1.61 mg/dL and a decreased mean hemoglobin (Hb) concentration (67.1%, 9.8±2.3 g/dL, P<0.05) was observed in samples from Kataeregi. Attributing the compromised renal functioning and hematologic impairment to the accumulation of toxic heavy metals, as evident in the clinical manifestation of inhabitants in both mining sites. Alternative safe drinking water sources, continuously monitoring, sensitization and assessment on the potential health risks and profiles are highly advocated for in this community; additionally, nanobioremediation approaches are needed to clean up polluted farmlands and waters to reduce heavy metal contamination in the food chain and the associated health risks.

Keywords: heavy metals; mining; outbreak; poisoning; staple food cultivars; nanobioremediation

### **Comparative Assessment of Heavy Metals in Soils, Drinking Water Sources and Food Cultivars in Galadima-koko and Leshigbe Mining Communities in Niger State, North-Central Nigeria**

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The presence of heavy metals in the environment represents a global public health issue because of their bioaccumulation, nondegradability, they contaminate the food chain and subsequently affect human metabolomics. The current study aimed to determine the concentrations of heavy metals (As, Cd, Cr,Co, Cu, Fe, Hg, Ni, Pb and Zn) in two hundred and thirty samples from water sources, soils and staple food crops in two mining communities (Leshigbe-Borgu and Galadima-Shiroro) in Niger state, North-central Nigeria using Atomic Absorption Spectrophotometer (AAS).The extent of heavy metal in soils and waters from the two study areas ranged from very severe pollution to excessive pollution and slight contamination to severe pollutions respectively. The heavy metals also showed similar distribution pattern in vegetables, legumes and cereals food cultivars from both sites posing significant health risks. Thus, it is recommending the need for regular monitoring of farm lands and drinking water sources from risk prone mining areas to detect early heavy metals toxicity for prompt interventions.

Keywords: heavy metals; food chain; metabolomics; pollution; food cultivars

### **Assessing the Environmental Impact of Mining Activities on Groundwater Systems within Akiri and Environs, Nasarawa State, North-central Nigeria**

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The impact of mining activities on groundwater systems in Akiri, North-central, Nigeria was investigated. Geological mapping of the area was conducted with Twenty (20) water samples collected and analyzed for major ions and heavy metals using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). Hydrogeochemical characteristics of the groundwaters were evaluated by means of physico-chemical analysis. High concentrations of dissolved constituents were noted to have occurred through the oxidation of metallic sulfides (Pyrites, arsenopyrites, chalcopyrite) and acid dissolution of the silicate rocks (e.g. feldspars, micas,) producing high concentrations of Al, Ca, Mg, Na and K.The recorded averaged values for the major ions: calcium, magnesium, sodium, potassium, Sulphate, chloride, bi-carbonate, lead, arsenic, chromium, cadmium, barium and copper were compared to standards of World Health Organization (WHO, 2011), United States Environmental Protection Agency (USEPA, 2018) and Nigerian Standard for Drinking Water Quality (NSDWQ, 2007). The intake of these heavy metals through drinking water poses problems because they are toxic at low levels



and are known carcinogens. Graphical plots (Piper, Durov and Schoeller diagram) of ionic concentrations in the groundwater were used to characterize water facies and identify processes responsible for the ionic assemblage. Dominance of cations and anions in water samples is in the order:  $\text{Na} > \text{Ca} > \text{Mg} > \text{K}$ ; while that of the anions is in the order:  $\text{HCO}_3 > \text{SO}_4 > \text{Cl}$ . Groundwater in Akiri and environs is seen to be characterized by five water types:  $\text{Na} + \text{K} + \text{SO}_4$  Type,  $\text{Ca} + \text{Mg} + \text{HCO}_3$  Type,  $\text{Na} + \text{K} + \text{HCO}_3$  Type, Mixed Type and  $\text{Ca} + \text{Mg} + \text{ClSO}_4$  Type. The environmental impact of mining activities on groundwater in Akiri and environs is therefore, noted to be significant.

Keywords: Environmental Impact, Mining Activities, Groundwater, Carcinogens.

### **Mitigating Barium Contamination in Mining Effluents for Enhanced Environmental Sustainability and Public Health: a Density Functional Theory (dft) Computation**

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The need to promote environmental sustainability in the management of mining operations in our communities is raising serious concerns due to the health risks that its often-exposed residents of such communities face and their public health. A case in point is the mining of the barite mineral, which often finds valuable application in the formulation of drilling mud for regulating the weight of mud in oil and gas well drilling. However, the poor management of its mining wastes and effluents could potentially contaminate the community's water bodies, including surface and groundwater. Water with barium content could expose public health to the danger of promoting metabolic problems, neurological disorders, cardiovascular issues, and kidney diseases. Therefore, it's essential to adhere to water quality standards and regulations to ensure that barium levels and other contaminants in drinking water remain within safe limits. To better promote the health and safety of the environment, our study explores the potential of employing adsorbent fragment models with varying functional groups to gain insight into their capability to facilitate the removal of barium from mining effluents or wastewater

containing dissolved barium. Several functional groups, such as acetaldehyde (CHO), carbonyl (CO), nitrile (CN), carboxylate (COO), alcohol (COH), and carboxylic acid (COOH), were explored. Using density functional theory (DFT), we computationally investigated the capacity of these functional groups to influence the barium removal process, employing the B3LYP functional and 6-31G\* basis set. Findings from our study show that compounds containing carbonyl and carboxylate functional groups were more promising for attracting the barium component, which would contribute immensely to the removal of barium from the water due to their stronger interaction and affinity for barium relative to other functional groups, which were weaker. Our study, therefore, predicts that biomass-based adsorbents activated with carbonyl and carboxylate functional groups would favorably adsorb barium from mining effluents or wastewater, promoting better environmental sustainability and the safety of aquatic animals and residents in such communities.

Keywords: Mining; barium; water pollution; public health; effluent treatment; adsorption

Technical Session 4: State of the Art Technologies for Solid Mineral Exploration, Processing & Utilization

### **Magnetic and Remote Sensing in the Evaluation of Hydrocarbon Prospect in Parts of Lower Benue Trough**

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The study was meant to investigate for indications of hydrocarbon prospect using remote sensing and aeromagnetic data in parts of Lower Benue Trough. With the objective of evaluating structures and lithology that could have direct bearing to hydrocarbon formation. Oasis Montaj, Surfer 13, Arc GIS and Rockworld software were used for qualitative and quantitative interpretations. Results from remote sensing data revealed that lineament distributions, density and orientations vary across the study area. The escarpment (Agwu, Awka, Enugu, Nsukka, Udi and Ukehe) areas, have high prevalence of lineaments than the lowlands/valleys, suggesting a structurally deformed area. The magnetic data revealed low magnetic anomalies were delineated in Adani, Enugu-Ezike, Nsukka, Awka, Awgu, Enugu and Nkalagu while magnetic highs were delineated in Eha Amufu, Okposi, Igumale, Udi and Ukehe, indicating sedimentary and uplifted basement areas, respectively. Sediment thickness varies from < 2000m in Enugu, Udi, Ukehe, Eha-Emufu and Igumale and > 2000m in Adani, Enugu-Ezike, AwkaAwgu, Okposi and Nkalagu areas. Remote sensing and magnetic lineament analysis show that NE-SW and NNE-SSW were the predominant lineament orientations, with minor occurrences in the NW-SE, E-W and N-S lineament orientations. Surface and subsurface lineaments correlate mostly within the escarpment zones (Enugu, Udi, Agwu and Awka), indicating the connectivity of these lineament structures and act as conduits for the upward propagation of hydrocarbon in the overlying sedimentary cover. While Adani, Nsukka, Ukehe, Enugu-Ezike and Nkalagu areas, with poor surface and subsurface lineament correlation suggests that the surface lineaments were not structurally connected to the subsurface structures and therefore, unfavourable

for hydrocarbon formation but could be good prospect for mineral deposits and groundwater. Comparison of areas of high lineaments connectivity with areas of large sedimentary thickness (> 2000m), low magnetic intensities and geologic map, indicates that Awka and Awgu areas were the most probable hydrocarbon prospect areas.

Keywords: Remote sensing, hydrocarbon, aeromagnetic, lower Benue Trough, and hydrocarbon indicators.

### **Structural Deformation to Magnetic Basement Rocks and Hydrothermal Altered Zone, an indication to Gold Mineralisation within Zuru-Yauri Schist Belt, North Central Nigeria**

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This paper presents a summary of the research carried out within the southern terminal of Auna Schist belt, an area enclosed by latitude 10.00<sup>0</sup> to 10.30<sup>0</sup> and longitude 4.00<sup>0</sup> to 5.00<sup>0</sup> using Aero-magnetic and Aero-radiometric data. The structural deformation to the basement rocks interpreted as faults, fractures, dykes, joints and geological boundaries were delineated. From the radiometric data, regions that has suffered hydrothermal alterations due to potassium enrichment and Thorium depreciation were mapped and interpreted as regions of orogenic gold mineralization. Nine major fault lines were identified and some subsistent fracture lines denoted as F1--- F9 and f's. A major fault labelled F9 trending NE-SW, cut the study area into two runs diagonally for about 70 km. Regions of hydrothermal alteration were evaluated from K/Th ratio, K-deviation and F-parameter. Combination of these grid results obtained from the three methods stated above was used to build a ternary map, where K/Th is red, k-deviation is blue and F-Parameter as green. Analysis and interpretation of the ternary image indicate that regions where high K/Th values (0.3 – 0.5) %/ppm, high k-deviation values (7.3 – 60.6) and high F-Parameter values (0.8 – 1.3) appears as white on the color aggregate, an indication of high hydrothermal altered zone. Area with grey color indicating moderately altered zone. Regions that appears as dark color indicate low values of K/Th, K-deviation and F-Parameter this occurs within the sedimentary formation of Bida Basin sand stone, located at the Northern end and South Eastern corner of the study area. A comprehensive analysis of these results delineated region of hydrothermal altered zones in white and grey color that coincides with areas within the faulted and fractured basement. Delineated structures from the magnetic data that coincide with regions of potassium altered hydrothermal zones are marked as regions of orogenic gold mineralization haloes. These regions are within Luma Tungan-Dangaje and New Busa. Ferin Ruwa, Gwagwade. Kinke, Kadovillages.

Keywords: Hydrothermal zones, F-Parameter, K-deviation, Zuru-Yauri Schist belt

## **Delineating the Regional Gold Mineral Veins within Wawa (Sheet 128) and Kubil (Sheet 159) Niger State, Nigeria, North Central Nigeria**

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Aeromagnetic data subjected to various filtering method: Analytical Signal, First Vertical Derivatives(FVD) and Center for Exploration Targeting (CET). was used to delineate the geological structures that could serve as host to gold within Wawa (Sheet 128) and Kubil (Sheet 159) Niger State, Nigeria. The area is bounded by Latitude 4°00' and 4°30'E' to Longitude 9°30' and 10°30'N. The total magnetic intensity map comprises of both positive and negative anomalies with magnetic values within the study area ranges from -66.589 nT to 129.237 nT. The result of the FVD and CET revealed magnetic lineaments in SW-NE direction that could serve as gold veins around latitude 9°50' to 10°10'N within Yangari, Lasun Sarabe, Wawa Malete town down to Doro across river Yakumosin. The major lineament are mapped as F1 to F7 on the first vertical derivatives.

**Key words:** Aeromagnetic data, Wawa sheet, Kubil sheet, analytical signal. first vertical derivative, Center for Exploration Targeting, geological structures, gold veins

## **Reconnaissance Study of Gold Mineralization in North-Central Nigeria: An Integrated Remote Sensing and Aerogeophysical Approach**

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This study employs remotely sensed data and aerogeophysical datasets as a reconnaissance tool to select optimal sites for potential economic gold mineralization in 1:100,000 Zungeru Sheet 163, North-Central Nigeria. The aim of this research is to understand the structural setting, map lithologic contacts, and identify hydrothermally altered zones. To achieve this goal, spatial suitability analysis was conducted using Oasis Montaj, ENVI, and ArcGIS Pro software. Selected bands of the Landsat 8 OLI image were subjected to feature-oriented principal component analysis (Crosta approach) to map hydroxyl and iron oxide alterations. Regional topographic lineaments were mapped using SRTM DEM and Landsat 8 OLI images. The aeromagnetic data was processed into first vertical, tilt, total horizontal, and analytic signal grids. The aeroradiometric data was also processed into ratio and ternary radiometric maps to aid in the interpretation process. Results show that hydroxyl and iron oxide alterations dominate hydrothermal alterations in the study area. Topographic lineaments were linked with fracture zones, drainage channels, and other geomorphological features. Aeromagnetic

signatures showed complex anomalies that appear to be related to structures like faults, folds, and fractures. Broad, low-gradient features likely represent deep-seated bodies, whereas sharp and high-gradient responses are more likely to be related to near-surface features. Strong indicators of hydrothermal alteration zones are characterised by high K/eTh ratio values and are found to have a strong correlation with igneous intrusives. Ternary maps aided in the characterization of lithologies in the area, and five mineral prospective zones have been identified (Very Low, Low, Moderate, High, and Very High). The spatial distribution of mineral potential indicates that the integration of different thematic maps accounts for high prospects in areas with very high to very high zones.

Keywords: Remote Sensing, Aeromagnetic data, Lineaments, Gold mineralization, Suitability mapping

### **Effect of High Concentration of eth and eu within Part of North Central Nigeria on Geothermal Parameters**

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The study deployed aeromagnetic data to estimate geothermal potential and radiometric concentration data to evaluate the radiogenic heat in parts of Kaduna state, central Nigeria. The study area which has been noted for relative high concentration of Potassium (K), Uranium (eU) and Thorium (eU) within Nigeria is bounded by latitude 10°00' to 10°30' and longitude 7°30' to 8°30', an area of 6,050 km<sup>2</sup>. The modified Curie depth method was employed in evaluating the Curie depth, geothermal gradient and heat flow. The region is found to have its shallow Curie point depth of 8.43 km below Wugana. The heat flow of the study area has values ranging from 81.9 mW/m<sup>2</sup> to 171.9 mW/m<sup>2</sup> with an average value of 167.8 mW/m<sup>2</sup>. The geothermal gradients range from 32.76 to 68.8 degrees Celsius per kilometre, with an average of 67.16 degrees Celsius per kilometre. Results of radionuclide concentrations revealed that the northern central regions extending down to the central part of the study area recorded medium to high values of radiogenic heat flow in the range of 3.85 to 4.5 μW/m<sup>3</sup>. Correlating the result of geothermal potential with radiogenic heat production reveals that regions of low Curie point depth correspond to regions of medium to high radiogenic heat production. Hence, the regions of significant geothermal potential are the mid-northern and mid-western areas such as Wugana, New Kwasan, and down to Ron village. The geology consist of rocks such as Pophyritic Granite Biotite granite, medium-to-coarse grained Younger Basalt, and granite gneiss, these in-situ basement rocks has undergone structural deformation and weathering which account for high concentration of radionuclide which exhibit radioactivity and consequently generate heat at the subsurface.

Keywords: Curie depth, geothermal gradient, heat flow, aero magnetic and radiometric data

## **Interpretation of Aeromagnetic Data to Assess Structures and Solid Mineral Potentials of Kataregi and its Environ, Niger State, Nigeria**

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The mineralisation potential of Kataregi and its environs have been investigated using aeromagnetic data. Aeromagnetic data acquired from Nigeria Geological Survey Agency was interpreted using Euler deconvolution and First vertical derivatives of the processed magnetic anomaly map over the area. Enhancement of the magnetic anomalies observed from the interpreted magnetic anomaly map involved the use of derivative filters. The 3-DEuler deconvolution locate and estimate the depth to various anomalous bodies with depth to source body between 30 m and 428.5 m. The FVD anomaly map reveals the oval and linear shapes anomalies with values between -5.78 to 0.34 nT/m, the ASA amplitude map reveals wide range of values between 0.03 to 0.76 nT/m, the TDR map showed variations in anomalies with values ranging from -0.06 to 1.42 rad/m. The unveiled subsurface structural features are responsible for hosting mineralised deposits. The study area is dissected by a NE-SW and E-W trending lineaments. The highlighted lineament represents the short wavelength magnetic anomalies which cut across the migmatite gneiss and amphibolites schist of the study area. The depths obtained from these structures ranging from 38.0 to 428.5 m. The depth was estimated using a window size of 2550 m width and a maximum depth tolerance of 14%. The processed images revealed lineaments trending majorly in NE-SW directions diagnostic of primary structures of potential targets for mineralisation in the area. Generally, these suggested that these lineaments reflect real continuous fault/fractures in depth.

**Keywords:** Airborne magnetic data, fractures, folds, faults and lineaments

### **Mineralization and Geochemical Investigation of Tin Deposit around Maigemu Village, Jos East LGA, North Central Nigeria.**

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Principally, Tin exists in Nigeria as tin oxide (SnO<sub>2</sub>) called cassiterite or tinstone, which is the chief ore of tin. It is widespread metal and the earth's crust contains about 0.0002-0.0008 per cent or 2 to 8 grams per tonne of rocks. The primary deposit is considered workable if they contain up to a minimum of about 0.3-0.5 per cent tin (3-5 kg to a tonne of ore). In assessing the mineralization potential of the research area, a preliminary geological and geochemical investigation was carried out with emphasis on the mineralization pattern and the local geology, as well as taken into consideration the location, accessibility and topography. The area of investigation is typical of both the basement complex of Nigeria and the Mesozoic younger granite ring complexes which intruded the previous and covers over 80% of the study area. Basically, there are two lithological (Migmatite gneiss and biotite granite) exposures encountered in the course of the mapping exercise outcropping both within the river channel, the low-land and upland. A total of 18 soil samples and panned concentrates were taken from the accessible area with an average of 500m spacing between each profile and each sampling point. Geochemical analysis reveals that tin concentration ranges from 7ppm to 1112 ppm with a mean value of 142.89 ppm and a background value of 53ppm. The threshold value being 159 ppm, indicates that there are three (3) isolated anomalous tin values. Comparing the background value (53 ppm) with the crustal abundance (2.2 ppm), the concentration is relatively high and this is traceable to placer tin deposit from the younger granite series.

**Key words:** Tin, Cassiterite, niobium, mineralization, Geochemistry

### **Gravity Concentration of Baryte-based Middling Particles using Home-Built Laboratory-Scale Mineral Jig**

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Middling particles arise from cleaning mineral concentrates or recovery of tailing during processing and constitutes one of the major technological failures of ore enrichment. These particles are usually 70% - 80% of the total mass of ores and exist in the form of unliberated minerals. For baryte ores, middling are composite particles containing baryte still locked with one or more non-baryte minerals. In addition to baryte ores, middling particles may be associated with other mineral ores whenever the percentage rejection of undesired minerals are low due to low or poor liberation of minerals within the ores, surface and interfacial attachment or adsorption of undesired minerals on the surfaces of desired minerals. Middling reduces the sharpness of mineral separation, results in the predominance of mixing over segregation during the separation stage and has a negative consequence on separation efficiency in general. Whenever middling particles are observed in mineral concentrate, the quality of the concentrate is significantly low and requires re-grinding of the concentrate at an additional cost. Current effort geared towards reducing the quantity of middling requires the classification, screening, re-grinding and reprocessing of the concentrate or ores. Wet mineral particles are decanted, separated from water, dried and further grinded to improve the mineral liberation and increase % liberation of minerals within the ore. The wet solid particles may also be treated to modify the mineral surfaces and interfaces to improve mineral separation. These processes attract additional costs and are huge enough to cause complete bankruptcy and total collapse of the processing plants. This paper presents the use of indigenously fabricated laboratory-built mineral jig to process fine particles of complex ores containing baryte, iron, lead and more than five (5) other minerals as impurities in the ores. The designed mineral jig was used to process 20 grams of baryte in each process cycle at varying processing conditions. There are ~ 88% BaSO<sub>4</sub> in the jig concentrate at the end of a single process in baryte jigging. Quartz and hematite in baryte ores are reduced from ~ 6.0-6.7% to 4.8-5.94% and from ~ 1.0-1.25 to ~1.1. Results also show that at varying jig frequency, jig amplitude and water velocity, the optimum baryte yield of ~98 % baryte was recorded. The recovery



of baryte is  $\geq 74\%$  for all particle sizes ( $< 250 \mu\text{m}$ ) and increases from  $\sim 90\%$  to  $\sim 99\%$  as the jig frequency increases from 115 rpm to 153 rpm. The specific gravity, separation efficiency, optimum jiggling conditions and % rejection of impurity are determined or measured and the implications of the results discussed extensively. The percentage of mineral recovery is comparable with the industrial output. However, the percentage rejection of non-baryte minerals is low and more of the undesired minerals are retained within the jig concentrate. The baryte separation efficiency and percent rejection of non-baryte minerals can be improved by optimising the mineral jiggling conditions to ensure the mineral jig design and processed baryte meet industrial standards, and perform better than existing or imported mineral jig for gravity concentration of baryte mineral.

Keywords: Mineral concentrates; tailings; ore; baryte; separation efficiency

### **Preliminary Geological and Geoelectrical Prospecting for Manganese Ore Within Tashan-kade, Teginia Neighbourhood in North-central Nigeria**

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Manganese is presently in critical global demand. Yet the manganese ore deposit around Tashan-Kade has remained hitherto unreported and unevaluated. This study attempts to reconnoiter its spatial extent and subsurface thickness by surface lithologic mapping and 2D geoelectrical prospecting. Lithologic identification of the rocks was conducted using texture and Mafic Colour Index. Streak colour, hardness level on Mohr Hardness Scale, lustre and effervescence with hydrogen peroxide solution are the criteria employed in identifying the manganese ore body. The 2D geoelectrical survey was conducted with ABEM Terrameter (SAS 4000), following the Wenner Alpha geometry. The geoelectrical data comprised electrical resistivity (ER) and induced polarization (IP) measurements. The data was processed and interpreted using RES2DINV software. Migmatitic schist, amphibolite, granite and manganese body are the

outcropping units found. The manganese body is schistose and gives a sooty residue, thus indicating it is pyrolusite. The 2D inverse ER and IP modelled sections respectively reveal ER values lower than 100  $\Omega\text{m}$  and IP values lower than 2 ms, where the manganese body outcrops as continuous sheet-like bodies. ER and IP values are respectively close to 300  $\Omega\text{m}$  and 10 ms in the vicinity of disseminated rubbles of the deposit. A minimum surface spatial extent of 540,000  $\text{m}^2$  of the deposit was delineated between latitudes N10°8'10" to N10°9'00" and longitudes E 6°11' 45" to E 6°12' 00". Its estimated mean subsurface thickness is 8 m. This gives a conservative minimum volume of 4,320,000  $\text{m}^3$  for manganese ore body within the coordinates it is delineated.

Keywords: Manganese ore, Reconnoiter, Lithologic mapping, 2D geoelectrical survey, Pyrolusite

### **Geological, Aeromagnetic, and 2D –Resistivity Delineation of Panda Marble Deposits Within Muro Schist Belt, Northern Nigeria**

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Nigerian economy will suffer when the world eventually implements paradigm shift from petroleum as primary energy source. Increased industrial utilization of her solid mineral deposits will reduce the consequences. Marble deposits exist within the Muro Schist Belt. Delineation and reserve estimation of the deposits are part of requirements for attracting development investors. Such critical investment – related investigations have hitherto not been conducted for the deposits. This study conducted the investigations by geological mapping on 1:12,500 scale, delineating lateral and vertical extent of the deposits from Katawa Sheet 228 aeromagnetic data, 2D- resistivity sections and cored hole data. Aeromagnetic grid of Katawa Sheet 228 was obtained from Geological Survey Agency of Nigeria and transformed to the equator. Its georeferenced magnetic intensity map was produced, and first and second derivative magnetic maps were generated using Oasis Montaj. 2D resistivity sections were produced for six traverses laid out using Wenner Array, using RES2DINV software. The 2D resistivity sections were lithologically calibrated using core data and lithologic sections obtained from quarry pits. The surface area of the marble deposits was obtained from produced geological map, using Global Mapper Software. The specific gravity of marble samples was determined. The conservative reserve was estimated by multiplying marble area extent with its thickness and specific gravity. The marble has  $2.3137 \times 10^7 \text{ m}^2$  area extent, 2.71 specific gravity and 24.25 m average thickness. Its conservative reserve estimate

is  $1.52 \times 10^6$  tons. This reserve is adequate for utilizing the deposit to manufacture fertilizers, poultry feeds and modular cement companies.

Keywords: Industrial utilization, Solid mineral deposits, Panda marble deposits, Aeromagnetic map, 2-D resistivity section, Wenner array, Conservative reserve estimate

### **Self-Organizing Maps for Semi-automated Geologic Mapping Using Multidimensional Remote Sensing and Geophysical Datasets in the Paiko Sheet 185, North-Central Nigeria**

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This research introduces a novel approach to semiautomated geologic mapping in the Paiko Sheet 185, North-Central Nigeria, by optimizing the integration of remote sensing and airborne geophysical datasets. We employ the Self-Organizing Map (SOM) method to overcome challenges associated with interpreting complex multidimensional datasets for semi-automated regional geologic mapping. The significance of this study lies in its cost-effective solution for mineral exploration, achieved through the innovative application of the SOM method in combination with remote sensing and geophysical data integration. By doing so, we address critical industry challenges and demonstrate the practical effectiveness of our approach. Our research primarily centers on utilizing the SOM method for interpreting multidimensional geophysical data, distinguishing distinct geophysical signatures linked to various lithologies and geologic processes. Additionally, we emphasize the importance of data selection, processing, and the integration of optical remote sensing data with other geophysical datasets. This approach enables the discrimination of rock types and the analysis of processes relating to gold and associated mineralization in the region. Key findings from this research highlight the successful application of the SOM method in identifying and mapping geologic units. Moreover, it enhances subtle geophysical signatures extracted from multiple data sources, thereby improving our understanding of the geological characteristics and processes within the study area. Our results underscore the effectiveness of applying the SOM method for integrated analysis of remote sensing and geophysical data. This effectiveness not only enhances geological feature comprehension but also streamlines semiautomated mapping processes. These findings have broader implications, suggesting that regions with geological complexities can benefit from adopting SOM as a valuable tool for optimizing mineral exploration and geologic mapping while simultaneously reducing manual efforts and costs. This research targets a wide

audience, including researchers in the field of geology and mineral exploration, government agencies involved in geology and mineral exploration-related activities, private sector stakeholders, and other interested parties.

Keywords: Mineral Potential Mapping (MPM), Self-Organizing Map (SOM), Geologic Mapping, Geophysical Signatures.

### **The Gaps in Mineral Processing Research in Nigeria: A Case Study of Barite Processing**

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Scientific research is all about asking and answering the right question. Many research questions are asked based on the research problem while others are tailored to confirm the tentative or expected solutions. In both situations, the gaps may be referred to the ‘problem’ and the ‘expected outcomes’. Identifying gaps in mineral processing research in Nigeria and Africa is becoming much necessary as there are several problems begging for solutions. Some of these problems have been recommended and addressed in the literature. However, the solutions proffered do not seem to answer the research questions either partially or entirely. In some instances, the right questions were not asked and as such, the answer to a ‘wrong’ question turns out to be mere experimental results without any substantial application and implication to the identified scientific problems. Mineral processing is a surface- and site-specific occurrence and should be taken

as such. It encompasses research on the materials, properties, process and application. Current mineral processing research is mostly driven by the interest on the process and application of the minerals without very keen emphasis on research targeted at unravelling the fundamentals or basic understanding of the materials and their properties. Results from such process- and application-based research have not contributed very significantly to the understanding of the mineral surface properties and development of mineral resources of Nigeria owing to the kind of research questions the authors are looking to answer. This paper reviews mineral processing research in Nigeria and Africa. It examines the baryte research processes and studies the mineral properties. As opposed to following-the-set of procedures contained in the published articles, emphasis was given to the understanding and gaining of insight into the factors that control and underpinned the liberation, separation and recovery processes of desired and undesired minerals contained in rock-forming minerals or ores. A desk-study method and topical discussion approach were combined in the review to present baryte crystal surfaces, the quality of baryte deposits in Nigeria and the relevance of the atomistic study of baryte surfaces. Several gaps related to the materials- and property-based research are identified and extensive discussion on the fundamentals of specific gravity measurement, liberation size assessment, processing efficiency, and the contributions of the minerals properties to the applications. Some emerging areas of mineral processing research are also examined and recommended for industrial and technological development of baryte mineral and other minerals. The gleanings from the basis of the experimental and computational studies on barite mineral surfaces is fundamental to the understanding of the mineral properties and process and optimization of mineral processing conditions. The knowledge gained if applied, is valuable to mineral processors, mineral processing industries and critical for local processing of baryte ores in Nigeria for oil drilling applications and other industrial purposes.

Keywords: Scientific problem, mineral processing research, research gaps, research question, barite processing, application

### **Petrography and Geochemistry of Gold Mineralization in Roguwa, Nasarawa State, North Central Nigeria**

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A detailed geologic mapping, petrographic description and the geochemistry of the rocks were carried out to determine their textures and mineral composition, and major, trace and Rare-Earth Elements (REE) concentrations. The study area is located in Roguwa, Karu local Government Area of Nasarawa state Nigeria, part of Keffi sheet 208° NW, it falls between latitude N08°51'00" and N08°53'30" and longitude E07°42'00" and E07°44'00" respectively covering an approximate surface area of 14.5Km<sup>2</sup>. A total of twenty-five (25) samples were collected for analysis, fourteen (14) were selected for thin sections and eleven (11) for geochemistry. Thin sections of samples were analysed using transmitted light microscope, while X-Ray Fluorescence method was used for geochemical analysis. Petrographic studies of rocks in the study area show that the area is composed of three lithologies which are pelitic schist, granite gneiss and pegmatites. From the thin section analysis, some major rock forming minerals such as plagioclase, quartz, biotite, muscovite, and microcline with accessory minerals like sericite, apatite, sphene, garnet and patches of opaque minerals were identified. From the geochemistry result, it was observed that the study area show element association of Cu-Pb-As in varying concentrations, this association is a common pathfinder to gold. The results from geochemistry also show that samples of schists surrounded with granitic intrusions have higher concentrations of gold than the gneisses. The study area can generally be regarded as having potential for gold mineralization and these rock types can be target during exploration.

**Keywords:** geologic, petrographic, geochemistry, mineralization, gold

### **Removal of Arsenic from Aqueous Solution using White Rot Fungi; *Trametes Versicolor* and *Phanerochaetechrysosporium***

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Heavy metal contaminants, commonly found in soils, sediments and water are generally produced through natural and industrial processes such as mining, refining and electroplating activities. One major pollutant from these industrial effluents is arsenic, a poisonous and carcinogenic chemical. However, efficient and cost-effective removal of arsenic (As<sup>3+</sup>) from wastewater remains a major challenge. This study explored the possible removal of arsenic from aqueous solution using the white rot fungi; *Trametes versicolor* and *Phanerochaetechrysosporium*. The effects of contact time (0-24 h), fungi biomass concentration (0.5-1 g) and initial As<sup>3+</sup> concentration (20-100 mg/L) were investigated. The results showed that arsenic removal from solution was greatly affected by the experimental conditions studied. Faster arsenic removals were observed for all experiments conducted with fungi biomass, with percentage arsenic removal reaching 92.3% and 84.6% for *T. versicolor* and *P. chrysosporium* respectively at 3 h using 20 mg/L initial arsenic

concentration. Langmuir and Freundlich isotherms were used to evaluate the data. The adsorption isotherm studies suggested that the biosorption of arsenic onto fungal biomass of *T. versicolor* and *P. chrysosporium* both followed the Langmuir isotherm model, with maximum arsenic capacities of 1.311 mg/g and 1.305 mg/g respectively. Overall, *T. versicolor* showed slightly better arsenic removal than *P. chrysosporium* under all studied conditions.

Keywords: Arsenic, trametes versicolor, phanerochaetechrysosporium, biosorption, langmuir isotherm

### **Enhancing the Adsorptive Properties of Activated Carbon: The Effect of Biologically Generated Ferric Sulphate**

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Activated carbon (AC) has been widely used for adsorption-based applications due to its high surface area, less cost and reusability. The hydrometallurgical gold extraction industry has activated carbon application as an integral part of its processing operations. However, surface remodification is required before reuse. Ferric-based compounds has been extensively proposed. This study explores the potential of utilising biologically generated ferric sulphate from the Biooxidation process effluents in treating AC for gold adsorption applications. Batch experiments were conducted with varying concentration of bio-generated ferric sulphate (9-15 g/L), temperature (25-75 °C) and time (2-7 hrs) at the pretreatment stage. Gold adsorption studies followed the pre-treatment process. Results indicated about 9-11% increased gold adsorption when AC was pretreated with biogenic ferric sulphate as compared to untreated AC with adsorption rate respectively estimated to be about 0.57 and 0.36 using the Calgon's model. Again, increasing the ferric iron concentration and pretreatment time had a positive correlation with increase in adsorption rate of AC while pretreatment temperatures of 25 °C and 75 °C gave equally high results as compared to the untreated AC. Modelling the gold adsorption after treatment using the Langmuir and Freundlich adsorption isotherms indicated a best fit for the Langmuir isotherm. Kinetic modelling also indicated pseudo second order model fitting. Overall, biogenic ferric sulphate for AC treatment shows a promising route to increase the adsorptive properties of AC for gold adsorption while projecting an alternate use for BIOX effluent generated during the BIOX pretreatment process.

Keywords: Activated carbon, biogenic ferric sulphate, freundlich adsorption isotherms, adsorption, langmuir isotherm

### **Enhancing Lithium Extraction from Lithium Ore (Spodumene) Using Biogenic Ferric Sulphate**

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Lithium is a crucial element used in the nuclear, medicinal, ceramic, and battery industries. The demand for lithium is projected to increase exponentially by 2030 due to the popularity of electric vehicles and portable electronic devices. The highest concentration of lithium is found in pegmatite, which is the prime source of the mineral. Developing new or enhancing existing processes to extract lithium from pegmatite can drastically lower the production cost of lithium. In this work, the biogenic ferric sulphate solution was used as a leaching agent and the effects of parameters such as ferric sulphate concentration and pulp density on the leaching of the lithium were studied. Batch experiments were carried out at varying biogenic ferric sulphate concentrations of 5, 10, 15 and 20 g/L and solid to pulp densities of 10%, 20%, 30% and 40%. XRD characterization indicated that the ore contained predominantly quartz, albite and spodumene (17.3%). Results from batch experiments showed that an increase in the concentration of ferric sulphate caused an increase in lithium extraction with the optimum of 45.6% lithium recovered. Furthermore, lithium extraction increased with increasing pulp density but dropped beyond 30% pulp density. Overall, biologically generated ferric sulphate can be a promising means of extracting lithium from spodumene ore.

Keywords: Lithium, biogenic, ferric sulphate, spodumene, pegmatite.

### **ICP\_AES/MS Geochemistry and Petrogenesis of Gold Bearing Wonaka Schist Belt; Implication for the Control of Gold Mineralization in Nigeria**

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Precambrian supracrustal schist belts believed to host gold in Nigeria occur predominant in western half of the country, consisting of low to medium grade deformed metasediments and metavolcanics intruded by Pan-African granitoids. However, recent exploration and studies indicated anomalous gold occurrence in Central and Eastern parts, in which case Mesozoic anorogenic granitoids and Precambrian Pan-African migmatites dominate respectively. The aim of this research is to study the petrogenetic attributes of Wonaka schist belt and discuss them in the light of gold mineralisation, so that the geologic control for gold in Nigeria would be indicated. This, was achieved via ICP-AES/MS (Inductively Coupled Plasma Atomic Emission Spectroscopy/Mass Spectrometry) trace and ultra-trace elements geochemical analysis. Over 3000 artisanal and small scale gold miners were engaged in the Wonaka schist belt, but geochemical result obtained did not show any gold value beyond 5 ppb, implying gold occurrence as independent of lithology and all



local structures. Elemental ratios in La/Sc, La/Cr, La/Co, Th/Sc and Th/Co are critical of provenance, though the metapelites exhibits the characteristics of a mixed source compositionally, pillow basalts contributed greatly to sediments source. Th/Sc ratio is approximately '1', indicating Wonaka geochemical terrain provenance as Old Upper Continental Crust (OUCC) affected by intracrustal differentiation. The Wonaka metasediments were comparable to Early Proterozoic shales. Trace elements spider diagram shows a systematic trend indicating Wonaka rocks as co-genetic. No systematic relationship is observed between the lithology and the gold. It is concluded that the gold is controlled mainly by regional structures, rechannelled and hosted in associated rocks by radiant localized structures.

Keywords: ICP-AES/MS geochemistry, petrogenesis, gold mineralization, Wonaka Schist Belt.

### **Bioleaching of Cobalt from Spent Lithium-Ion Batteries using Acidophilic Bacteria Consortium**

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Due to the rising demand for corresponding critical metals and mounting concern over the environmental effects of solid waste management, recycling of valuable metals from spent lithium-ion batteries (LIBs) has received a lot of attention recently. These used LIBs are a secondary source of metals, especially cobalt (Co) that may be recovered and reused in a variety of ways to lessen environmental dangers and increase the sustainable supply of Co. This research investigated the bioleaching of Co from spent LIBs using bacteria consortium of acidophiles at different solid/liquid ratios. Specifically, research on bacteria consortium growth properties was conducted in both mixed culture and during the period of a two-stage bioleaching procedure. After 11 days of bioleaching experiments employing consortia of extremely acidophilic bacteria gave a cobalt recovery rate of 90% at a pulp density of 10 g/L. Co extraction was affected by pulp density and it was found to decrease at high pulp densities. Structural and surface morphological investigations by XRD and SEM/EDS of the spent LIB powder before and after bioleaching confirmed the efficiency of the bacterial activity in mobilizing the Co from the discarded LIBs. Also, results comparing bioleaching to chemical leaching demonstrated that bacteria consortium can improve Co leaching from Spent LIBs. The findings of this study imply that using bioleaching to recover a considerable amount of cobalt metal from used LIB could be an environmentally friendly method.

Keywords: Cobalt; Bioleaching; Spent Lithium-ion batteries; Bacteria; Recycling

## **Climate Change and Its Implications for the Mining Sector: A Case Study of Nigeria**

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The Nigerian mining sector is one of the sectors that are critical to Nigeria's Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC) which seeks to grow Nigeria's economy at 5% annually, while also making the country more resilient to the impacts of climate change. Based on the 2050 Long-Term Vision for Nigeria, the impacts of climate change can threaten the country's quest to diversify its economy through the mining sector. The impacts of climate change are already manifesting across Nigeria in the form of extreme weather events such as rising sea level, floods, and storm surges in the southern part of Nigeria to deforestation, dipping groundwater level, and retreating Lake Chad in the northern part of the country. Presently, there is a gap in knowledge in terms of the current and anticipated impacts of climate change on mining operations across the various geological and environmental zones in Nigeria. The objective of this paper is to present and also analyze the potential impacts of climate change on the mining sector in Nigeria, drawing on available historical/contemporary data and technical information. It also articulates the prevailing and projected impacts of climate change on mining activities across the country, leveraging relevant scientific results and projections. The research methods used in this study included review of relevant case studies and publications as well as analysis of relevant data obtained from previous works on the subject. Aside identifying poor utilization of scientific contributions and impacts in the formulation of policies aimed at tackling the impacts of climate change on mining operations in Nigeria, the study also identified the need for proactive measures necessary to preempt the impacts of climate change on vulnerable mining sites in the country. The findings and recommendations of this study, among them being the need to leverage scientific outcomes in the formulation of policies on mining governance in Nigeria, will help in sanitizing the Nigerian mining sector, particularly in the areas of mitigation and adaptation to climate change. Furthermore, this study will also help in promoting sustainable mining practices in Nigeria.

Key words: United Nations; climate change; Nigeria; mining sector; weather; sustainable mining

## **Implication of Carbon Pricing in the Mining Sector: Overview of the Nigerian Oil and Gas Industry**

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Mining activities globally has been associated with the emission of carbon and other greenhouse gases. Activities within the sector which have contributed immensely to the national GDP have not only been marred by the incessant pollution of the atmosphere, but has also been affected by climate change impact. This paper explores the approaches and implication of a vital mitigation action and environmental policy “Carbon Pricing” which is considered as one of the most efficient tools recommended for the mitigation of emissions in the oil and gas industry. This paper considers the peculiarity of the oil and gas industry in the mining sector, its environmental footprint and economic role. It explores international treaties and national policies, such as the Paris Agreement, the Nationally Determined Contribution (NDC Report) and the Petroleum Industry Act (PIA) and their implication in the implementation of Carbon Pricing Initiative in the Nigeria oil and gas industry. Particularly, this paper documents the recent national efforts within the industry concerted around the Carbon Pricing Initiative, which are indeed perquisite to the success of implementing this initiative in the sector. The paper showcases the oil and gas industry taking the lead in the development of sustainable environmental policies such as the adoption of the Carbon Pricing Initiative, and puts forward evidences that can be emulated and replicated in other industries within the mining sector.

Keywords: Mining; emission; climate change; mitigation; oil and gas; carbon pricing

Technical Session 6: Making Artisanal & Small-scale Mining (ASM) More Efficient, Safe, and Sustainable

### **Making Artisanal and Small-scale Mining (ASM) More Efficient, Safe and Sustainable**

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Artisanal and small-scale mining (ASM) plays a crucial role in the global mineral supply chain, providing livelihoods for millions of individuals in resource-rich regions. However, ASM operations often face significant challenges that hinder their efficiency, safety, and sustainability. This abstract explores the key obstacles faced by ASM practitioners and highlights the opportunities for improving their practices. The lack of access to modern technology and equipment limits the efficiency of ASM operations. The introduction and adoption of efficient and environmentally friendly technologies, such as mercury-free ore processing methods and improved extraction

techniques, can increase productivity while minimizing environmental impacts. Safety is a major concern in ASM, often characterized by the absence of proper training, inadequate mine planning, and limited enforcement of safety regulations. Implementing comprehensive training programs, promoting the use of protective equipment, and strengthening regulatory frameworks can significantly improve the safety conditions for ASM miners. The sustainability of ASM activities is closely tied to the responsible management of natural resources and the mitigation of social and environmental impacts. Encouraging formalization, promoting responsible mining practices, and enhancing stakeholder involvement can help ensure the long-term viability and sustainability of ASM operations. This abstract serves as a starting point for further research and exploration of strategies and initiatives aimed at making artisanal and small-scale mining more efficient, safe, and sustainable.

Keywords: Sustainability, Safety, Efficiency, Artisanal & Small-scale Mining.

### **The Mine Site Assessment Tool as a Capacity Building Instrument: A Case Study of Mining Communities in Ghana**

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**Background:** In undertaking their operations, artisanal and small-scale mining companies are required to incorporate a social inclusion policy in their work. In this case, concerns of gender, youth, and persons with a disability must feature prominently in their operations. Conceptualizing and operationalization of these issues are sometimes problematic as local communities, mining companies and regulators have different perspectives and expectations on addressing critical issues mining communities face.

**Method:** The Mine Site Assessment Tool (MSAT) was formulated to assist in generating information across the broader spectrum of issues that define company-community relationships. It addresses a range of economic, environmental, social and governance issues. In this case, the tool was applied at Manso Aponapon, Adansi Kenya Osino, Ayanfuri, Tarkwa, Akwatia and Tongo through community dialogues with women, youth, people with disability and relevant stakeholders. The community dialogues were followed with stakeholder meetings between the communities and regulatory bodies such as the Minerals Commission and the Environmental Protection Agency.

**Findings:** Through limited external assistance in the form of capacity-building and modest financial support, community members were able to use constructive, evidence-based engagement methods to seek an improvement in companies' environmental, economic, governance and social management and disclosures.

**Conclusion:** Findings from the project has shown that the MSAT can be used to build the capacity of the marginalized in mining affected communities to voice out. A focus on the MSAT can enable and build the confidence of mining communities to drive the engagement process with regulatory bodies, mining companies and government.

### **Wear Resistance and Fracture Toughness Behaviour of Baryte Mining Tools: A Review**

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The quality of materials used to fabricate mining tools are tested in service on their resistance to wear and fracture. Metal tools are mostly used by artisanal miners and mineral processing industries for mineral mining and processing in Nigeria and Africa. The activities of artisanal miners in Nigeria constitutes ~ 90% of the entire mining activities. These miners depend solely on indigenous metal workers (commonly called Blacksmiths) for mining tools made from iron-based metals or steels. Baryte mineral is relatively soft but surrounded with highly abrasive, tough and hard rocks. Due to the hardness of host rocks such as sandstone (quartz) and other minerals with a hardness higher than steels, the mining tools wear, and the edges are blunt after a few months of application. The industrial-scale mining of baryte in Nigeria has also been unsuccessful due to tools wear and high cost of repair. Thus, the need to source materials with better wear resistance, reasonably high toughness, strength and a balance of critical material properties for mining purposes. This paper presents

a critical review of the wear resistance and fracture toughness of barite mining tools. It assesses current limitations to metal tools used in baryte mining and failure of tools in service due to material deficiency, and proposes cost effective and indigenous solutions for improving wear and fracture toughness of tools. The paper also identifies factors underpinning the physical metallurgy of wear behaviour of baryte mining tools to optimise the overall mechanical properties in service. A desk - method study and topical issue-based discussion approaches were adopted in this review. Research articles were sourced using keywords. Literature was gathered and reviewed, observations and research gaps were identified, analysed and discussed to reflect major material properties and technologies required for improving the quality of metal tools. Although the review is limited to the technical (material manufacturing, selection, and structure) and economic (tool cost) assessments, the secondary data show that metal tools wear and have low fracture toughness due to material and process deficiency. Certain hard metal tools with excellent properties are identified. The properties of the tools can be improved by core hardening and toughening using nano-sized tough ceramics, plant-based sources and bio-synthesized cyanide for the pack-carburizing and nitriding processes. It is critical to explore the qualities of low – carbon steel and cast iron by using technologies to reduce carbon content in cheap high – carbon steels or supplementing nitrogen (N). While other cost-effective methods of hardening steel using agricultural and domestic wastes (cassava leaves, potato sprouts, and bamboo shoots) are better alternatives, it is necessary to note that meeting the needs of artisanal miners for mining and cutting tools requires the introduction and adoption of laboratory-based techniques to solve real societal problems which is imperative for indigenous development.

Keywords: Mining tools; wear; baryte; host rocks; metallurgy; emerging techniques

### **Leveraging Technology to Strengthen Sustainability in Artisanal and Small-scale Mining (ASM)**

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Artisanal and Small-Scale Mining (ASM) plays a pivotal role in global mineral supply chains and provides livelihoods to millions. However, its operation often faces multifaceted challenges, ranging from illegality, human rights violations, gender-based violence, child labor, poor working conditions, limited market access, and exploitative market structures. All these challenges have negatively impacted the sustainability of the ASM sector across many countries. The ASM stakeholders are working continuously to confront the obstacles in the sector and there is a consensus that the limitations are rooted in the traditional mining practices. To address these bottlenecks, our research seeks to investigate how the ASM sector can leverage advanced technology in its operations. We propose integrating advanced yet affordable technology to improve mining practices in the ASM with an emphasis on improving mining methods, access to the market, and enhancing transparency in the sector. The research utilizes a qualitative methodology to undertake academic and industry literature analysis and interviews with stakeholders across the ASM sector. The research utilized gemstone mining in Kenya which is predominantly under the ASM category. It was found that the sector has lagged in leveraging the use of disruptive technologies across its operations from exploration to marketing of its minerals. However, it was evident that sector players were willing to utilize these advanced technologies and new approaches to ensure the sustainability of the sector. In conclusion, the ASM sector sustainability is at significant risk hence an immediate call to action among the stakeholders is a necessity. The sector should leverage advanced technology such as digitalization in mining methods, online and digital marketing, and blockchain technology to enhance traceability and transparency. Through leveraging disruptive technologies, the sector's sustainability will be assured.

Keywords: ASM, blockchain technology, digitalization, sustainability, cleaner energies

### **Making Artisanal and Small-scale Mining of Sandstone More Effective, Safe, and Sustainable: A Case Study of Sandstone Mining in the Eastern Part of Imo State, Nigeria**

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Artisanal and small-scale mining (ASM) of sandstone is a significant economic activity in the eastern part of Imo State, Nigeria. However, it often faces challenges related to inefficiency, safety hazards, and unsustainable practices. This study aims to explore ways to enhance the effectiveness, safety, and sustainability of sandstone mining in the region. The research adopts a case study approach, focusing specifically on sandstone mining in the eastern part of Imo State, Nigeria. Primary data was collected through site visits, interviews, and surveys of sandstone miners, local communities, and relevant stakeholders. Secondary data, including government reports and scholarly articles, were also utilized. The study identifies several factors contributing to the ineffectiveness of sandstone mining, such as limited technical skills, inadequate equipment, and a lack of formalized mining practices. These challenges not only

hinder productivity but also result in unsafe working conditions and environmental degradation. To improve effectiveness, the study proposes the implementation of technical training programs for sandstone miners, which would enhance their knowledge of mining techniques, safety precautions, and environmental conservation practices. Furthermore, providing access to modern mining equipment and tools would facilitate more efficient and productive operations. In terms of safety, the research recommends the establishment of safety regulations and standards in sandstone mining. In terms of sustainability, the study emphasizes the importance of adopting environmentally friendly practices in sandstone mining. Moreover, the study highlights the significance of engaging local communities and involving them in decision-making processes. By implementing the proposed measures, sandstone mining in the eastern part of Imo State, Nigeria, can become more effective, safe, and sustainable. The findings of this study can serve as a guide for policy-makers, mining companies, and local communities in improving ASM practices in the sandstone mining sector, leading to long-term socio-economic development while minimizing environmental impact.

Keywords: Sandstone; Nigeria; safety hazards; sustainability; environmental degradation; ASM practices.

### **Green Mining as a Strategy for Fostering Environmental Sustainability in Artisanal and Small Scale-mining in Nigeria: Concepts, Challenges and Opportunities**

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With the discovery of different mineral deposits in Nigeria including lithium in commercial quantities, economic mining activities have significantly increased in the sector. Nigeria's economy has grown significantly as a result of mining activities, which is also creating jobs and providing alternative means of livelihood for people while providing raw materials for industries. Traditional mining methods, however, frequently cause serious environmental degradation, such as habitat destruction, soil erosion, water pollution, and deforestation which in turn impact negatively on food security, economic growth, healthcare and livelihoods. To reduce the environmental concerns connected with mining in Nigeria, this paper examines the concept of "green mining". It explores the tenets of green mining, challenges of adoption and offers suggestions for applying eco-friendly techniques in solid minerals development in Nigeria. Green mining technologies and practices offer superior performance with respect to energy efficiency, greenhouse gas emissions and the use of chemicals

Keywords: Green mining, mines, hazards, techniques, minerals

Technical Session 7: Contaminated Site Remediation Techniques for Mining Sites



## Small Businesses and Entrepreneurial Opportunities in Nigeria's Mining Sector

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The study will investigate the feasible entrepreneurial opportunities available to artisanal and small scale mining businesses in Nigeria, going by the licensing and regulatory provisions as contained in the Nigerian Mining and Minerals Act (NMMA) 2007, and the N5 billion Nigerian Artisanal and Small-Scale Miners Financing Support Fund (NASSMFSF) 2017, which among other reasons, aims to boost the participation of artisans and small scale miners that constitute over 80 percent of industry operators, as well as enhance formal participation in the sector. The specific objectives will be to: to ascertain the comprehension level of artisanal and small mining companies with the provisions of NMMA and NASSMFSF; to determine the absorption/access level of NASSMFSF among artisanal and small mining companies; to determine the level of institutional support available to artisanal and small mining companies from institutional MSME development organisations; and recommend feasible business policy approaches that enhances the performance of artisanal and small mining companies in Nigeria. The provisional study method was mixed, with focus group discussions among 200 respondents comprising sectoral representatives from, using the Taro Yamane formulae. Structured questionnaires for quantitative data were subsequently administered to elicit further data based on previous findings, with statistical analysis done using Microsoft Excel. Provisional findings shows that artisanal and small mining companies still under perform in regulation compliance- though this cannot be divorced from the overall literacy level in the country. This may also explain further findings that include relatively low absorption/access to NASSMFSF among artisanal and small mining companies, while institutional MSME development organisations such as SMEDAN, DBN and academic institutions, do not have very visible support for artisanal and small mining companies. Enhancing the literacy level of the country, alongside artisanal and small mining companies; and increased provision of trainings plus non-financial support by institutional MSME development organisations, will enhance the entrepreneurial performance of artisanal and small mining companies in Nigeria.

Keywords: Business performance, regulatory compliance, legal literacy, MSME development

Technical Session 9: Sustainability, Corporate Investment, and Social Responsibility

**Framework for the Development of a National Policy on Critical Minerals in Nigeria**

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The increasing global demand for critical minerals underscores the need for a well-defined and strategic National Policy that covers their exploration, exploitation, beneficiation, and sustainable management. Nigeria, which is rich in mineral resources, has the potential to become a significant player in the global critical minerals supply chain. However, Nigeria's solid minerals sector currently faces several challenges, including inadequate geological data, inconsistent regulatory practices, environmental degradation, and limited community involvement. These gaps in the existing policy framework have hindered responsible and sustainable mineral extraction. This paper presents a policy framework that addresses these gaps and challenges in Nigeria's current approach to critical minerals management. The framework aims to enhance Nigeria's global position in the resource security landscape by focusing on three pillars: Resource Identification and Assessment, Sustainable Extraction, and Global Collaboration. It emphasizes key principles such as Responsible Mining Practices, Adherence to International Standards, Environmental Protection, Social Engagement, Manpower Development, and Consistent Regulatory Efficiency. This study employed a rigorous policy analysis approach, drawing upon extensive data sources such as the Nigeria Minerals and Mining Act 2007, Nigeria Minerals and Mining Regulation 2011, international best practices, and consultations with experts from the mining industry, government officials, and local communities. This comprehensive policy framework overhaul has the potential to rejuvenate Nigeria's mineral sector by attracting increased investments, promoting responsible practices, and enhancing overall sustainability. The framework serves as a blueprint for comprehensive policy development, positioning Nigeria as a responsible player that benefits both its citizens and the global community in the era of green technologies and sustainable Critical minerals.

Keywords: Nigeria, policy framework, sustainable mining, resource assessment, global collaboration, development

Technical Session 10: Emerging Technologies and Techniques in Solid Mineral Development

**The Impact of Emerging Technologies and Techniques in the Nigerian Solid Minerals Sector: A Cost - Benefit Analysis**

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As global population increases, the scale and impacts of mining has increased exponentially and there are a number of emerging trends when considering the future of the sector. Therefore, countries are transcending to modern forms of technology to achieve scale economies, decarbonization, mine health and safety and environmental sustainability through leveraging on Automation, Big Data Analytics, Digital Innovations, and Artificial Intelligence amongst others. The totality of these innovations have human, social and economic impacts which can have negative and/or positive effects on the principle of shared value. These complex interdependencies are reshaping the industry on a global scale and for Nigeria to leverage on her mining sector and expand to regional and global value chains there is need to scale up linkage creation, value addition and resource-based industrialization through research, technology and innovation. While abundant literature exists on the emergence of technologies in the solid minerals sector in general, this study, using a desktop and library based analytical review, finds a dearth of research on cost-benefit analysis of emerging technologies on the Nigerian mining landscape to essentially drive law and policy. Taking this into consideration will not only ensure that technological disruptions will be a win-win for communities and stakeholders to drive growth and global competitiveness for the sector, but also ensure that Nigerian mining laws and policies are reformed to adapt to these trends and interdependencies.

Key Words: Mining, technology, Sustainable Development Goals, shared value, resource based industrialization, value A addition, linkage, AFCFTA, mining law and policy

### **Machine Learning Innovations for Improving Mineral Recovery and Processing: A Comprehensive Review**

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Traditional mineral processing and recovery methods, while effective, often experience resource inefficiencies and consumption challenges. To overcome these limitations, cutting-edge technologies, including Machine learning (ML), emerged as a paradigm shift in the mineral processing and recovery sector, offering predictive insights, data analysis, and real-time monitoring capabilities. Machine learning algorithms, such as Artificial Neural Networks (ANN), Support Vector Machines (SVM), Random Forests (RF), and reinforcement learning, among others, triggered this paradigm and are applied extensively to optimize mineral recovery processes. This review article explores real-world examples and case studies to unveil the transformative potential of machine learning in mineral

processing and recovery. This review unveils that machine learning algorithms are extensively utilized in enhanced ore sorting and classification, predictive modeling for process optimization, real-time process control and fault diagnosis, and automated mineral identification in the mineral resource recovery and processing sector. Among these applications, predictive modeling for process optimization and enhanced ore sorting and classification stand out, with ANN being the most frequently employed algorithm. These algorithms are particularly prevalent in optimizing the leaching processes for industrial and metallic minerals. While challenges persist, such as limited data availability, non-normally distributed and non-linear data, and varying data dimensions and rates, the advantages of employing machine learning are undeniable. These advantages include enhanced operational efficiency, waste reduction, increased recovery rates, real-time monitoring, cost-effectiveness, time efficiency, and reduced energy consumption. By bridging traditional methods with modern solutions, this article aspires to catalyze further research and dialogue and promote the widespread adoption of machine learning, fostering more efficient and sustainable practices in mineral processing and recovery.

**Keywords:** Mineral Recovery; Mineral Processing; Machine Learning; Artificial Intelligence; Conventional Mineral Processing.

### **Emerging Technology Application in Artisanal Processing of Coal and Sandstone: A Case Study Nokubonga**

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Artisanal processing in the metallurgical industry is considered as a process that relies on personal skills of an individual to mine and process valuable minerals and metals using basic tools (such as a hammer and a chisel). Artisanal processing is regarded as a source of social and economic development in rural areas and is often conducted by the local communities with an aim to sustain themselves. Sandstone and coal deposits that is explored by artisans are classified as above the surface and below the surface. Artisanal mining and processing of the above the surface sandstone (dimension stone) is characterized by the use of a hammer and a chisel to mine them, thereafter, cut into shape and polished for specified usage and does not necessitate concentration and extraction from an ore. The below surface sandstones are mined using a tractor-loader-backhoe (TLB) and then processed. In contrast to this, coal is scavenged from illegal mines and transported on foot or by bicycles to depots run by the artisanal miners. Over the years, academicians have been inspired to

create sustainability tools to monitor, control, and enhance the environmental impacts of products and processes as a result of the realization that these artisanal activities have detrimental effects on the environment and human health. This paper reports recent developments on the emerging technology application in artisanal processing of coal and sandstone with an aim of identifying potential solutions leading to the creation of a formalized, healthy, and safe artisanal mining that can operate optimally and in a sustainable manner while contributing to the economy through job creation. The paper discusses the findings from the use of single mode microwave cavity to cut sandstone and to recover the resins from coal while the evolution in the technology development process will shed light to associated risks, threats and opportunities.

Keywords: Artisanal mining and processing, coal, sandstone, sustainability, technology applications

### **Quality Assured Characteristics of Middle Group Chromitite Materials for their Possible Sustained Optimized Beneficiation**

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High grade chromite lower group seam (LG6) material is becoming expensive to mine due to the depth required to access the orebody, this has compelled the chrome mining industry to look for alternative mining and processing methods and ores mineralogical quality to mine at economically viable costs. Middle groups chromitite rich MG3 and MG4 materials found in the Bushveld igneous complex of South Africa, being upper, offer an alternative mining method because they are mined by open-cast methods which are cheaper and safer to operate. The sustainability of the chrome mining operations requires processing low-grade materials, the processing of previously dumped tailings materials from the platinum group metals concentration as well as from the previous chromite extraction. Mineral deposits vary in terms of grade, mineralogy ( $\text{Fe}^{2+}/\text{Fe}^{3+}$  ratio and Fe/Cr ratio), and mineral textures. The variability of the mineralogical content of the used chromite bearing material has a direct influence on the overall metallurgical performance and the smelter ferrochrome yield. A sustained geological study and an articulated beneficiation process development of the middle group chromitite materials (MG3 and MG4) have not yet been conducted. This paper discusses the assurance of quality of the medium group

chromitite materials mineralogical characteristics for a sustained optimised beneficiation. The outcomes from the above development would contribute to the extension of the chrome operations in the Bushveld complex.

Keywords: MG3, MG4, mineralogical, sustained beneficiation.

### **Optimized Circularity of Diamonds Mine Tailings in Construction Industry : Case Study of Société Minière de Bakwanga, Mbuji-Mayi , Democratic Republic of Congo**

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Tailings and environmental management becomes very tricky when the two co-exist. The challenge faced by the Société Minière de Bakwanga (Miba) daily producing 20 000 carats of Diamonds to adequately manage their tailings is well known. This paper discusses the application of circular economy in the usage of diamonds tailings in the construction industry. Two types of concretes were produced : Foundation concretes for road construction and cement based concretes for different civil engineering applications. Each of the above concretes was characterised for its durability as they had to fulfil different materials performance requirements as related to their components composition and utilisation. The diamonds tailings contains numerous minerals like quartzs, ilmenite, clay, garnets, sandstones, diopsides and iron oxide. With a wear resistance ranging from 13 to 26, this aggregate presents a density of 2.34 with a higher absorption capacity of 12% requiring attention for cement based concretes because of the water/cement ratio requirement to be fulfilled. Results show that the 10000m<sup>3</sup> aggregates generated daily from the diamonds processing can be used to produce wear resistant concrete varying (from low to mid wear resistance). Soil foundation concretes exhibit a better base layer with a California Bearing Ration (CBR) exceeding 25.

Keywords: characterisation, tailings, diamonds and valorisation

### **Drill Core Exploration for Estimation of Limestone Resources in Effium Area Near Abakaliki, S/E Nigeria**

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Limestone is essential and a principal raw material including and for Portland cements manufacturing. During geological investigation and evaluation, the geology and geometry of its deposits is ascertained. Ideally the information expected should cover all the properties which are important in the resource's valuation. This directs and enhances the quarry design and the operational methods. Detailed surface reconnaissance geological mapping were complimented and probed with exploratory core-drilling using diamond impregnated bits on core recovery barrel appendaged on a GX-Y-1 rotary rig. Cored holes logging, recovered litho-core sample logging including strata-logging and correlation check-mated by subsequent attesting laboratory analysis of the litho-cored samples exercise were performed. Suitable software such as Mapsource, Rockworks 16 and excel were used at different times where and when needed in the course of this research. Lithologic units properties were imported into Rockworks 16 software environment and used to establish the limestone reserve estimates within the exploration lease area. The deposit estimate infers an economic viable resource.

Keywords: Core-drilling, limestone, litholog, Portland cement, reconnaissance, Rockworks 16, viable resource

### **Exploring and Reserve Estimation for Industrial Mineral Potential in Parts of Calabar Area (Ewen/Iwuru/Agbangana Axis) Southern Nigeria**

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For a developing nation, industrial rocks can be said to be very essential. Limestone and marble are one of the principal raw materials for industrial rocks such as cement manufacture. In Nigeria, Limestone occurs in the sedimentary environment of Benue Trough, Sokoto, Dahomey and Borno (Chad) basins. This Limestone forming environments (shallow coastal marine conditions) appears to have re-occurred several times in the geological history of the basins. The deposits of the Benue trough appear to contain the most economically

viable mineral resources including limestone in Nigeria. Nearly all the limestone deposits in the trough are used for industrial purposes such as cement. The Calabar Flank is one the main carbonate province in Nigerian Benue trough. Ibeto Cement Company obtained permit to explore the viability of limestone deposit in some parts of the Calabar flank area for the establishment of a Portland cement production plant. This research evaluated the presence and volumetric analysis of limestone occurrence recovered from core drilling holes in the area on Exploration Licenses (ELs) No. 17373 and part of No. 17374. Prior to subsurface core drilling investigation, surface reconnaissance survey was undertaken. Rockworks 16 software complimented with dilute Hydrochloric acid were used for this evaluation.

**Keywords:** Industrial rocks; Benue trough; mineral; Calabar flank; core drilling; Rockworks 16; exploration

### **Geology and Geochemistry of Ferberite – Bearing Quartzite in Zumba Area, North Central Nigeria**

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Tungsten minerals are ferberite ( $\text{FeWO}_4$ ), hubnerite ( $\text{MnWO}_4$ ) and wolframite [ $(\text{Fe}, \text{Mn}) \text{WO}_4$ ] which belongs to the wolframite group. The aim of this research was to evaluate the potential of the rocks to host tungsten. Tungsten Minerals have found use in the industries for the productions of alloys and armaments, carbides and wear resistant tools, welding electrodes, jewellerys, electrical appliances and heavy metal alloys. Field work revealed two main lithologies, which are schist and granite and has large quartzite intrusions which hosts the tungsten minerals. Petrographic studies revealed percentage of quartz of about 25 to 30% in schist, 65 to 70% in granite and 60 to 90% in quartzite, by visual estimation under the microscope. This indicates that the granite and the quartzite are quartz – rich. The schist is dominated by 50 to 55% biotite which indicates it is biotite - rich. X – ray diffraction pattern revealed four mineral phases; quartz ( $\text{SiO}_2$ ), ferberite ( $\text{FeWO}_4$ ), magnesite ( $\text{Mg}_2\text{CO}_3$ ) and columbite ( $\text{FeNb}_2\text{O}_6$ ). The concentration of trace elements in the quartzite shows  $W = 331371.85$  ppm against  $Cv$  of 1 ppm. In terms of mineralization in Zumba area  $W$  is highly mineralized in the quartzite. It is therefore recommended that, future studies include Scanning Electron Microscopy (SEM) studies to be able to decipher the structure and mineralogy of the ore.

**Keywords:** Tungsten, lithologies, industries, crustal abundance value ( $Cv$ ) and Zumba.



## **Integration of Ground Magnetic Method and Whole - Rock Analysis for Solid Mineral Exploration in a Part of Gwagwalada Area Council, Abuja, Nigeria**

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A ground magnetic survey provides detailed information on subsurface magnetic structures for mineral exploration. This method was carried out within 2.3km by 1.5km of Gwagwalada, Abuja, Nigeria bounded by longitude 7<sup>0</sup>5'20"E to 7<sup>0</sup>6'40"E and latitude 8<sup>0</sup>57'50"N to 8<sup>0</sup>58'40"N in the basement complex of north-central Nigeria. Twenty-five (25) profiles were established over the area at 100m interval. Data was obtained from the field using GSM-19 overhauster magnetometer at a time interval of 2s. It was corrected for Diurnal correction and analyzed using Oasis Montaj 8.4 software. The TMI value obtained from the field ranged from 33940.67 nT to a maximum value of 34056.67 nT, and was reduced to the equator. Application of the derivative filters delineated structures which trend NE – SW, E – W and NW – SE, analysis from analytic signal filter revealed that the area of study was characterized by varying anomalous magnetic amplitude also it picked up on the magnetic bodies' edges. The location and depth of the structure were determined using the modified dataset and the Euler deconvolution algorithm. Estimated depth of magnetic source body was about 16.88m to 74.99m. Rock samples picked during the field work were analyzed. Whole rock analysis using Induced coupled plasma-mass spectrometer (ICP-MS) revealed a large range of mineral oxides. The analysis showed that the area is rich in oxide of aluminum, iron, potassium, calcium and titanium. Samples with the highest silicate value such as quartz as regards to the analysis was generally low in other oxides such as Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O compared to other samples. This analysis provides vital information on the mineral deposit and structural setting of the study area for possible mineral exploitation.

Keywords: Ground magnetic, derivative filter, mineralization, analytic signal

Technical Session 11: Solid Minerals and the Oil and Gas Industry

### **Material Properties – Relationship of Baryte Mineral as a Weighting Agent in Drilling Mud and other Industrial Applications**

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The properties of drilling mud and other material multicomponent or compounds and their responses in service are mostly the direct contributions of the properties of each constituent. Drilling mud or other products that are formulated using baryte mineral showcase the potentials of baryte and its relevance in responding to material requirements in service. In the case of fluids, deformation may occur due to large variation in temperature and pressure. Whenever such happen, solids including baryte mineral are suspended, dispersed, and display different flow properties that contradict expected outcome. Although alternative materials such as surfactants have been developed to stabilise the colloids and control the fluid chemistry, respond to alter or normalise the effect of intermolecular forces and changes in atmospheric conditions, the contributions of baryte in the mud and in relationship with different material components are not thoroughly examined/assessed. Existing literature has limited the contribution of baryte mineral in drilling fluid – baryte is used solely to increase mud weight. However, beyond the reasonably high density of baryte, the mineral is relatively soft and contain some fractions of clay minerals and minerals of calcium, potassium, magnesium and sodium – which are minerals of soluble salts. These minerals add to the contribution of baryte minerals in drilling fluid and other industrial products far more than weight enhancement. This paper reviews the material properties of baryte mineral and its contributions in different applications. The paper examines the minerals chemistry and surface properties of baryte, assess their contribution (s) to the fluid chemistry and flow properties. Beyond its contribution to the weight of materials as products, the paper summarises the properties of baryte mineral with respect to the structure – composition – property relationship which largely controls the behaviour of baryte in service. It also reviews literature using combined desk study methods – topical or application-centred approaches. Scientific information is screened using keywords itemised in the paper. Drilling

fluids of different compositions and at varying quantities of baryte mineral – both as a weighting agent and an additive, were prepared and analysed. Results show that aside from the increase in the amount of solids in the baryte-based products due to the addition of baryte mineral, the flow property is altered. This suggests that the contribution of baryte chemistry to the properties of the products is not only based on the properties of baryte but also the accompanying minerals of water soluble salts. The additional contribution can sufficiently alter the water and fluid chemistry, and other limiting reactions aided by other multicomponent in the drilling fluid and other baryte-based products. The existing and existing – new knowledge of baryte mineral is useful and relevant, and may serve as a valuable piece of new knowledge that will encourage massive exploration and exploitation of baryte in Nigeria and its utilisation in several new applications, locally and globally.

Keywords: Properties; drilling mud; baryte; deformation; surfactants; weighting agent/materials, industrial applications

**Achieving Economic Prosperity Through the Implementation of PIA 2021 - The Clear and Distinct Roles of Nigerian Upstream Petroleum Regulatory Commission (NURPRC) and Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA)**

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The Petroleum Industry Act (PIA) 2021 was signed into law in August 2021 after over 20 years in the National Assembly. The Act has provisions that addresses all the perennial problems of the oil and gas industry in Nigeria such as host community development, focus on gas, proper decommissioning and abandonment, favourable fiscals regimes to attract investments, creation of distinct midstream and deepening of same in the light of energy transition, unbundling of composite licensing regimes, creation and expansion of opportunities for more businesses and jobs in the industry for Nigerians and investors, fostering of transparency and accountability in petroleum accounting, etc. The paper identified methods for achieving economic prosperity for Nigeria in the light of energy transition through the clear and distinct functions of the regulatory agencies, the inherent value-added propositions in the Act, opportunities for investments through the unbundled licensing system, entrenched transparency and accountability system for hydrocarbon accounting. The Paper will relate the various value additions in the Act that can be found valuable for the growth of solid minerals in the country.

Keywords: Petroleum Industry Act; National Assembly; oil and gas; energy transition; petroleum accounting; solid minerals.

### **Investigating the Impact of Salinity on Oil Recovery During Water flooding: An Experimental Approach**

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The oil and gas industry is constantly searching different methods to optimize oil recovery during water flooding. Two important factors which can significantly affect oil recovery is the salinity of the water injected and type core material studied from the formation. However, the impact of salinity on oil recovery during water flooding using core samples containing clay is not well understood. This paper investigated the impact of salinity on oil recovery carried out using two core samples obtained from shale rocks. The core sample labelled A was from Kogi state and core B was from Rivers state. Initially both core samples were dried in an oven at 88°C to cause natural fractures and connect the pore spaces then saturated with brine of 20g/l salinity and light crude oil of viscosity 3.35cp to simulate reservoir conditions within the core samples. The porosity of the samples was determined by liquid saturating method and the effective permeability was calculated using Darcy's law. Core flooding tests were conducted by injecting brine and varying the salinity levels at 10g/l to 50g/l to displace 20 ml of light crude oil originally saturated in each core sample. The results and analysis of the tests showed that the core sample B recovered more oil than sample A. The recovery factor efficiency of core A was 24%, 31.5%, 51%, 53% and 53.5% and the core sample B was 26%, 42%, 50.8%, 52.1%, 55%. The oil recoveries at breakthrough increased significantly with increasing salinity. The difference in oil recoveries among both core samples was observed at 30g/l of brine salinity were core B recovered 8.8% higher than core A. At 50g/l brine salinity, the oil recovery efficiency did not change for both core samples while changing the concentration of brine relative to the initial brine used. The findings of this study and the data retrieved shows the improvement of oil recovery factor increases as brine salinity increases which can be attributed to interfacial tension reduction and viscosity alteration.

Keywords: Salinity, oil recovery, brine, water flooding, core samples, EOR.

### **Development of an Environmentally Drilling Fluid Using Aloe Vera as an Additive**

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Drilling fluids additives significantly influence the success of drilling operations. Current drilling fluids demands and future difficulties have led researchers to develop environmentally friendly drilling fluids with less environmental impact. Aloe Vera, a natural plant with unique properties, offers a promising alternative to conventional drilling fluids. Calcium is the dominant composite element. Most of the elements present such as silicon, potassium, chlorine, and calcium are used as compounds such as Bio-derived and Modified Calcium Carbonate which is used for pH control, bridging, and plugging of permeable zones while drilling. This study was aimed at developing an environmentally friendly mud additive that uses aloe vera instead of a chemical ingredient. The experimental methodology involved the conversion of the aloe vera plant to a dry crisp form, followed by processing to obtain a suitable powder for incorporation into the drilling fluid. To examine the feasibility and performance of aloe vera addition for both water-based and oil-based mud systems, complete rheological experiments of different concentrations were done. This additive was used in conjunction with bentonite to create five representative drilling fluid compositions. Rheological properties and other related investigations were carried out at varying temperatures and assessed through standard laboratory tests. The experimental results were analysed to evaluate the feasibility of implementing eco-friendly drilling fluid. It was concluded that the amount of aloe vera concentration and temperature affects the rheological properties in both drilling mud as elevated temperatures have a thinning effect on oil-based mud making it less viscous and an increase in concentration causes a decline in yield point for both drilling fluids. This research contributes to the field of drilling fluid technology by demonstrating that aloe vera, an environmentally friendly alternative, can potentially replace toxic or chemical drilling additives, aligning with the industry's growing interest in sustainable practices.

Keywords: Drilling fluids; environmentally friendly; calcium; mud additive; aloe vera; viscous

### **An Experimental Study of Oilfields Scales Analysis and Dissolution using Acidizing Fluids**

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Formation damage reduces permeability of reservoirs thereby reducing well productivity. One of the methods that is used to remove formation damage is acidization. Oilfield scales are basically mineral scales that are formed during petroleum production and have the tendency to cause wellbore damage. Formation of oilfield scales result predominantly from over saturation of dissolved minerals in oil and gas produced water. In this study, scale samples have been analysed and identified using x-ray diffractometry. X-Ray diffractometry was used to identify minerals present in the wellbore scales. The X-Ray diffractometry results confirmed the presence of seventeen different minerals in the scales and these have been classified as carbonates, silicates and phosphates. Matrix acidizing fluids have also been designed and formulated to test the capability to dissolving the scales. 10% and 15% HCl (regular acids) as well as xylene were used on the scales to ascertain their dissolution capabilities. None of these three fluids was able to completely dissolve the sample scales because the mineralogical compositions revealed by XRD were mainly the HCl insoluble minerals such as Petalite, Xenotite, *etc.* Only 10% mineral composition of the scales identified were HCl soluble. The results of this study proves that, X-Ray Diffractometry must precede any action taken to remove/treat oilfield scales, especially when considering chemical dissolution. This will prevent wastage and save money and time.

Keywords: Permeability; reservoirs; acidization; mineral scales; X-ray diffractometry; oilfield scales

### **Investigating the Rheological and Filtration Properties of an Eco-Friendly Water Based Drilling Fluid Using Pozzolana Clay**

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Drilling fluids play a pivotal role in oil and gas production as they provide essential functions of carrying cutting, cooling, lubricating the bit and providing adequate wellbore stability. Among the drilling fluids, water based mud (WBM) is widely preferred due to its low cost, availability, cuttings removing capability and environmentally friendly nature as compared to oil based mud. However, the use of bentonite clay in the WBM drilling system poses an environmental risk when not properly disposed of. Bentonite contains titanium oxide (Ti<sub>2</sub>O) which can be harmful to soil and water bodies. Therefore, the main goal of this study is to examine the effect of reducing

the quantity of bentonite clay used as a base viscosifier in the formulation of the WBM system by substituting it with pozzolana clay. Pozzolana is a naturally occurring clay that is mainly made up of silica and alumina. In order to achieve this, drilling fluid blend samples consisting of a mixture of bentonite and pozzolana were designed. The composition of the mixture varies from 0% to 100% pozzolana. Their rheological and filtration characteristics were experimentally compared to the properties of bentonite WBM. Furthermore, the effect of carboxymethyl cellulose (CMC) at varying concentrations on the rheology and filtration loss of a WBM blend of 75 wt% pozzolana and 25 wt% bentonite was investigated. The experimental outcome revealed that the introduction of pozzolana reduced the plastic viscosity (PV) and yield point (YP) of the bentonite WBM from 43.2 cp and 86.4 lb/100ft<sup>2</sup> to 9.6 cp and 9.6 lb/100ft<sup>2</sup> respectively. Similarly, the gel strength of bentonite WBM decreases as the concentration of pozzolana in the WBM increases. It was also identified that the 100% pozzolana WBM (no bentonite added) failed to control filtration loss and had a thickness mudcake of 10 mm. However, with only 0.5 gm of CMC added to the blend of 75 % pozzolana 25 % bentonite WBM, the PV and YP obtained were similar to that of 100% bentonite WBM (43.2 cp and 86.4 lb/100ft<sup>2</sup>) while the filtration volumes lost were significantly less than the 100% bentonite WBM. The mudcake generated by the WBM blend of 75 % pozzolana 25 % bentonite with 0.5 g of CMC was 4 mm which was higher than the 2 mm observed for bentonite WBM. Therefore, a more efficient and environmentally friendly WBM can be formulated with a mixture of pozzolana and bentonite in the right proportion with the addition of CMC to control the water loss. The usage of pozzolana as part of the materials in the base fluid for WBM will provide jobs for the locals and generate revenue for the Government.

Keywords: Drilling fluids; oil and gas; environmentally friendly; bentonite clay; pozzolana clay; filtration characteristics