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Keynote Speaker 1: Unlocking the Future Energy Potential Through the Understanding of the Geology

The subsurface and surface geological settings of Oman have vividly offered, for decades, great understanding of the earth processes and the evolution of the global and regional petroleum systems. Today, as the globe unavoidably requires to harvest in sustainable clean energy, Oman's geology yet becomes the center of focus in offering major solution to unleash the future energy solutions for the country and the region.

Dr Mohamed Al-Kindi is an experienced Chief Executive Officer with a demonstrated history of working in the oil and energy industry, and mining sector. Skilled in Petroleum, Product Optimization, Petrophysics, Petroleum Economics, and Reservoir Engineering, as well as mining-block evaluations. Strong business development professional with a PhD in Philosophy focused on Geology - Structural Geology from University of Leeds. He gained his BSc in Physics and Geology in 2003 from Aberdeen University, UK and his PhD in Structural Geology in 2006 from University of Leeds, UK.

Keynote Speaker 2: Bioleaching of Cu, Ni, Co, Mo, Au, U and Zn from ores and black shales: Past, present and future

The role of acidophilic iron- and sulfur-oxidizing autotrophs is well established in the bioleaching of sulfide ores and black shales for the commercial-scale extraction of Cu, Ni, Co, Zn, U and Au by heap, dump, in-situ and stope-leach operations in the mining industry. The acidophilic iron and sulfuroxidizing mesophiles (Acidithiobacillus ferrooxidans, Acidithiobacillus thiooxidans, Acidithiobacillus ferrivorans, A. ferridurans, A. ferriphilus, A. ferrianus, A. sulfuriphilus, Leptospirillum spp.,) and moderate thermophiles (Acidithiobacillus caldus, Acidimicrobium and Sulfobacillus spp.) as well as mesophilic and thermophilic archaea (Ferroplasma, Sulfolobus, Acidianus, Metallosphaera spp.) and many others including iron-oxidizing heterotrophs play an important role in bioleaching of sulfide ores and black shales (Wang et. al., 2018; Yi et. al., 2021; Rawlings 2005). These bacteria are habitats of sulfur springs, hot water springs, bioleaching environment, acid mine drainage and tailings dams, which are capable of oxidizing pyrite (FeS_2), metal sulfides, sulfur (S0) and reduced inorganic sulfur compounds (thiosulfate, polythionates) to produce sulfuric acid (H_2SO_4) and/ or soluble metal sulfates ($CuSO_4$, $NiSO_4$, $CoSO_4$, $VOSO_4$, $MoSO_4$ and $ZnSO_4$) during bioleaching process. Gold (Au) is liberated from the pyrite or arsenopyrite matrix during bioleaching process and remains in the ore leached residue. Biologically generated sulfuric acid acts as a leaching agent (lixiviant), while ferric sulfate ($Fe_2(SO_4)_3$) as a powerful oxidant which oxidizes metals sulfide minerals and metals contained are then leached by sulfuric acid formed during bioleaching process. In fact, bioleaching process is an indirect acid leaching process, in which sulfuric acid is generated from the bacterial oxidation of pyrite or metal sulfide by the metabolic activity of Fe and S oxidizing acidophiles. The bioleaching reactions involve pH values in the approximate range of pH 1.5-3.5 as the low pH facilitates proton attack on the minerals and alleviates the precipitation of metals in the leach solution. Soluble metals from the acidic bioleach solution by ion-exchange resins/ solvent extraction to separate and recover to produce metals concentrate as metals end-products (Bhatti, 2015; Tuovinen and Bhatti 1999). The Sultanate of Oman has potential ore deposits of Cu-sulfide, Au and Zn-Pb as well as black shale beds of the Rus formation in northern Oman. Bioleaching process can be applied to virgin sulfide ore deposits, mine overburdens, mine wastes and black shales to extract valuable metals at one-third to one-fifth cost of the conventional hydrometallurgical process. Acid leaching process can be established to extract Ni, Co and Mn from the Ophiolite Ni-laterites, Oman Mountains (Al-Khirbash, 2015). In addition, beneficiation studies for light REEs present in the Crabonatite of Semail and Masirah Ophiolite in Oman (Sobhi, 2015) can be carried out to produce REEs concentrate using shaking table, magnetic separator and froth flotation techniques.

Dr. Tariq Bhatti did his Ph.D. in Chemistry with specialization in Mineral Biotechnology (Mineral Bioprocessing of ores) from the Institute of Chemistry, University of Punjab (Lahore, Pakistan). He got predoctoral USAID Fellowship in the field of Mineral Biotechnology at the Department of Microbiology, Ohio State University, Columbus, during 1991-1993. He also got postdoctoral fellowships at the Tampere University (Finland) and Umeå University (Sweden) in the field of mineral bioprocessing during 2009 and 2010. Dr. Bhatti has over 40 years of research and teaching experience in the domains of mineral processing, bioprocessing, and applied and analytical chemistry. He has served the Pakistan Atomic Energy Commission (PAEC), the Balochistan Copper Gold Project (BCGP), and the Jordan Atomic Energy Commission (JAEC) and engaged in teaching and applied research projects related to hydrometallurgy and biohydrometallurgy of ores. He also served as a full-time and adjunct faculty member (associate professor or professor) at the Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad (a prestigious, highly ranked degree awarding institute of PAEC) during 2003–2014. He is one of the faculty members who initiated the MSc degree program on Minerals Resource Engineering in 2015 for mining engineers and geologists at PIEAS. He has published over 50 national and international publications, two book chapters, and one review article. Dr. Bhatti's research interests include mineral bioprocessing of ores and black shales (mineral biotechnology), sulfide mineral oxidation biogeochemistry, chemical extraction of lithium from pegmatite rocks and brines, fermentation (organic acid production by fungi), biosorption of heavy and toxic metals by fungal biomass, environmental bioremediation, and metal nanoparticle biosynthesis.

Keynote Speaker 3: Natural hydrogen exploration – State of knowledge and focus on the Intra-cratonic systems

Hydrogen directly coming from the Earth could represent an alternative source of decarbonized hydrogen and potentially provide the opportunity to rapidly scale up green hydrogen production for domestic use and export. Hydrogen can be naturally produced by various processes in the subsurface. We first propose to review the generation processes and elements of the hydrogen system though known case studies and focus on the intra-cratonic hydrogen occurrences that are not directly related to a mid-oceanic ridge system type. In this type of environment, the hydrogen is proposed to be mostly coming from water which is separated from oxygen by diagenetic process or by radiolysis. Since hydrogen is the most abundant element of the solar system, the degassing of large reserves of deep seated H2 from the mantle or the Earth's core have been also proposed. The most well-known process is the oxidation reaction between water and ferrous sediments resulting in their transformation to the ferric state through the release of H2. This process is the best candidate to explain high hydrogen flux measured above intra-cratonic surface depressions all over the worlds, such as in Brazil, Mali, United-States and Russia. We will here provide an overview of natural hydrogen exploration in the world as well as the real rush toward natural Hydrogen exploration that is happening in Australia. In February 2021 the state of South Australia opened the doors to Hydrogen Exploration and as soon as September 2021 all the exploration licences have been applied to! Given that natural hydrogen exploration is quickly scaling up and has a potential to support energy transition for Australia and the global market, we need to unlock the natural hydrogen system with the best science, and we need to undertake a multidisciplinary approach, involving expertise from minerals, petroleum, groundwater systems and biology.

Dr Emanuelle Frery is a senior research scientist leading a research team at the CSIRO, the Australian Science institute. Her expertise is in natural geogenic hydrogen exploration. Her team focus on multidimensional modelling with an expertise in structural geology applied to comprehensive assessments of energy production impact on the groundwater systems and the environment. Dr. Frery is passionate about fluid and gas circulation along natural faults and the impact of those circulations on the seismic cycle. She works with a multi-scale approach, from fieldwork to laboratory analyses and to numerical modelling. She acquired a worldwide academic expertise in this field with a PhD thesis on the circulation recorded in the well-known red sandstone of the Colorado Plateau and her implication in the IODP research. Before joining CSIRO, she worked in the oil and gas industry as a seismic interpreter and a petroleum system analyst.

Keynote Speaker 4: Hydrogen: Decarbonization Lever and Future Energy Vector

Blue and Green hydrogen are not competing, but rather complementary energy carries that are expected to unlock new levers to decarbonize hard to electrify industrial and demotic energy and chemical feedstock applications. In country rich with renewables and geological energy resources, the prospect of hydrogen as a future energy carrier will shape the future energy industry in Oman. Addressing the challenges to enable fast upscaling of hydrogen production in Oman to enable global hydrogen trade will unlock opportunities in the full hydrogen value chain.

Dr. Khalil Al Hanashi is the Coordinator of Oman's National Hydrogen Alliance (Hy-FLY) under the Ministry of Energy and Minerals. He also holds the role of senior energy renewal divisor in Petroleum Development Oman (PDO) where he focuses on supporting new energy trends and projects through collaboration and partnerships. He comes from energy and technology management background. Dr. Khalil holds a Ph.D. in sustainable energy technology from the Energy Technology Research Institute in the University of Nottingham, UK. He graduated from the University of Newcastle upon Tyne in the UK with M.Sc. in applied process control and holds B.Eng. in systems and control engineering from the University of Sheffield, UK.

He has more than 17 years of experience in the Energy sector. Started his career working with oil and gas operations and engineering in PDO before taking the role of corporate technology advisor in the corporate planning directorate of PDO. He also worked as business development and oil and gas research manager in EJAAD, the industry-academia-government collaboration platform for applied industrial research.

Dr. Khalil contributed to various energy transition strategies, projects and studies including Oman's National Hydrogen Economy, Oman national energy master plan and PDO strategy refresh. Dr. Khalil guest lectures in local academic institutes and co-supervises students in academia for final year project and mentor students doing their year in industry or graduate placement.

Keynote Speaker 5: From gas to stone Carbon Capture and Storage: where are we?

Carbon Capture (Utilization) and Storage (CCUS) has been investigated over the last 20+ years to attempt to reduce the anthropic carbon imprint, yet very few large scale CO_2 storages exist in the world. After a brief overview of the landscape of current and in-coming large scale CO_2 storage, the three most recent new paths of technologies for carbon storage will be presented: (i) Direct Air Carbon Capture (DACC); (ii) Gas or supercritical CO_2 injection in depleted gas reservoirs; (iii) Carbon mineralization in volcanic reservoirs. Discussions around pros and cons from each technology will be developed from lab scale to field scale and lessons learned from successful CCUS projects. What remains to be done to maximize success will conclude the talk.

Dr. Lionel Esteban is principal petrophysicist at CSIRO (Perth, WA) since 2009. He holds a BSc and MSc in geophysics and a PhD in petrophysics and simulation of radioactive fluids dynamics in shale barriers for the French agency of nuclear waste management (ANDRA) from the University of Toulouse and Institut de Physique du

Globe of Strasbourg (France). He develops and tests petrophysical experimental laboratory approaches and integrate them to logs analysis to characterize and understand the physical properties responses of unconventional and conventional reservoirs at different scales using a wide spectrum of petrophysical tools including by instance: X-ray imaging, electrical, nuclear magnetic resonance, mechanical, and core flooding under (or not) HP/HT. His current research focuses on rock physical properties, fluid dynamics and fluid-rock interactions in shales (seal to gas) and conventional reservoir rocks for hydrocarbon, CO_2 and hydrogen gas storage.

Keynote Speaker 6: Geothermal Energy: A Little-Known Defense in the Fight Against Global Warming

- As the tangible impacts of climate change become impossible to ignore, we are realizing the need to switch to clean sources of energy to power our daily lives.
- The world needs to invest in sustainable, safe, cost-effective, and reliable solutions to the changing and growing global energy demands.
- Geothermal Energy is a sustainable and renewable energy source that is still largely untapped. As an environmentally friendly resource it has the potential to meet heating, cooling and electricity demands for the future.
- Geothermal energy is green and plentiful, and it can be used for generating electricity or heating and cooling buildings. Its potential has been recognized for a long time, the utilizable geothermal energy potential in several parts of the world is far greater than the current utilization and geothermal has an important role to play within the energy systems of many countries
- Geothermal provides a reliable source of energy as compared to other renewable resources such as wind and solar power While much of the focus is on wind and solar, there are other forms of renewable energy that have the potential to make significant contribution in achieving a more sustainable future. One of the most promising is geothermal energy Not only is it a proven solution, but it also has some inherent advantages that may surprise people unfamiliar with this sector.
- The largest single disadvantage of geothermal energy is that it is location specific.

Geothermal plants need to be built in places where the energy is accessible, which means that some areas are not able to exploit this resource. On the other hand, many industries that needs electricity is started to establish close to energy sources.

- There are promising areas, based on elevated thermal gradients and potentially conductive geology, for hosting a geothermal resource in existing hydrocarbon fields in Oman.
- Geothermal power is a reliable and renewable energy source that is local by its nature and offers baseload power generation. Exploring the countries geothermal potential by leveraging its extensive oil and gas expertise in oil and gas countries as Oman, subsurface datasets, and technology access can be one of the paths to success.

Locally gained experiences with the deployment of skills from oil and gas into geothermal is very applicable and helpful covering similar domain expertise such as geology, reservoir engineering and drilling experiences Exploring the country's geothermal potential by leveraging its extensive oil and gas expertise, subsurface datasets, and technology access can be one of the paths to success.

Dr Azzan Al Yaarubi, Technical Manager, OPG Schlumberger

Mr Tevfik Kaya, BDM Geothermal & CCS, MENA, Schlumberger

Keynote Speaker 7: Energy Transition-The Underground Storage of Hydrogen

Rising global atmospheric carbon emissions and changing climatic patterns across the globe is a major concern. The 2016 Paris agreement mandate to limit the further temperature increase of 1.5 ˚C requires number of initiatives under the mainstream theme of Energy Transition. This talk reviews the scientific and technological opportunities of achieving the net-zero targets via the pipeline transport and underground storage of hydrogen with the associated benefits of development of industrial hubs. The talk will focus on the Net Zero Technologies mainly around blue hydrogen production, transport and their utilization via geological storage evolving around the storage mechanisms involving the brine-rock interactions, hydro-thermo-geo-chemical-dynamic effects and the caprock seal-integrity issues.

Dr Prashant Jadhawar is Academician (Lecturer/Assistant Professor), University of Aberdeen, Scotland, UK. Dr Prashant Jadhawar is an engineering professional with 20 years of experience in academia and petroleum industry in UK, Germany, Australia, and India. Over the years he has led numerous projects including the enhanced oil and gas recovery and pipeline flow assurance. His expertise also includes gas (H_2, CO_2, natural gas) transportation, subsurface storage in the geoformations (depleted hydrocarbon reservoirs and aquifers), through the means of laboratory experimentation and numerical simulation tools. Currently he is leading project/s to develop the means of transportation and injection of hydrogen (H_2), CO_2 and natural gas in the subsurface in porous media and its seasonal reutilization.

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