DGS DHAHRAN GEOSCIENCE SOCIETY

THE OIL DROP

A DGS MAGAZINE | 2024 Edition



GEOSCIENCE IN THE ENERGY TRANSITION

BECOME A MEMBER!

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01

President Welcome Message

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President Welcome Message

DGS PRESIDENT WELCOME MESSAGE

On behalf of the Dhahran Geoscience Society, I am delighted to introduce you to this issue of the Oil Drop Magazine. As you delve into these pages, you will find insightful articles, groundbreaking studies, and updates on the diverse activities of our society and its members. Let this publication ignite inspiration, stimulate fresh perspectives, and remind us of the vital impact we have as geoscientists in shaping the future.

As a leading organization, the Dhahran Geoscience Society remains steadfast in its dedication to advancing geoscience research, nurturing collaborative relationships, and igniting professional growth. Our mission extends beyond supporting the technical growth of our members, as we are committed to making significant contributions to the wider energy and geoscience communities. With over 37 years of history, DGS continues to grow into a vibrant community fueled by intellectual curiosity, inventive spirit, and an unwavering commitment to excellence, coalescing to shape the future through shared knowledge and insights.

In a rapidly evolving industry, the challenges we face are vast—but so are the opportunities. From embracing digital transformation and artificial intelligence in exploration and production to addressing the intricacies of sustainable resource development, the geosciences have never been more dynamic or critical. At DGS, we are committed to empowering our members with the essential knowledge, resources, and connections to excel in this thrilling landscape.

Throughout this year, our society has focused on enriching engagement through technical workshops, professional meetings, and collaborative initiatives that connect professionals, academics, and students. These activities not only highlight cutting-edge developments but also emphasize the importance of lifelong learning and mentorship. I encourage you to embrace the opportunities offered by DGS across the three platforms: Professional Development, Technical Exchange, and Public Outreach.

Thank you for being part of this journey, and I look forward to your continued support and active participation in the Dhahran Geoscience Society. Together, let us forge ahead with purpose and determination to achieve new heights for our society.

FARES ABOUD

2024 DGS PRESIDENT





02

The 2024 Executive Committee

02

The 2024 Executive Committee

THE 2024 EXECUTIVE COMMITTEE



FARES ABOUD

2024 DGS PRESIDENT



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Young Professional Officer



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Social Media Office



EYAD HALAWANI
Treasurer



ABDULLAH ALQASEM
Academic Liaison Officer



ABDULMOHSIN ALARAIFI
Mentorship Program Officer



NABA AL HAMAD
Membership Officer



03

2024 DGS Volunteers

THANK YOU TO OUR 2024 CONTRIBUTING AUTHORS AND VOLUNTEERS

Contributing Authors



HARALD KARG
for his contribution ‘Understanding the Thermal Field of the Earth Crust: Relationship between Basement and Heat Flow in Eastern Arabia’



NICOLAS BOEHM
for his Summery of ‘DGS-KAUST Student Chapter‘



SAMAR ABU-SHAMMA
for her summary of ‘Vision 2030 – Crafting the Blueprint for a Sustainable Society’



LAMA AL-JUHANI
for her summary of ‘The Oil and Gas Industry Must Break the Paradigm of the Current Exploration Model’

ZAINAB ALMUBARAK
for her summary of ‘Integrated Geological Characterization of Vaca Muerta Unconventional Play’ and contribution ‘Green Heaven: A Journey through Oman’s Jebel Al-Akhdar’



TANYA ALAUDDIN
for her summary of ‘Mind the Gap: ‘The Role of Generative AI in Shaping the Future of Geoscience'

Volunteers

MOATH DOSSARY



SEMAT ABUSHAHEEN

MOHAMMED ALMULHIM

DANA ISMAIL

DANA ASSUDMI

04

Professional Development

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Professional Development

DGS SHINES BRIGHT AT IPTC 2024

From February 12-14, the Dhahran Geoscience Society (DGS) proudly represented itself at the International Petroleum Technology Conference (IPTC), drawing record-breaking crowds to its dynamic booth in the digital transformation zone.

A large number of attendees, comprising industry leaders, technical experts, young professionals, and university students, flocked to the DGS booth, eager to learn about its mission and objectives. Visitors' interactions were immense, sparking meaningful discussions and connections. Additionally, DGS's strong presence in IPTC served as a platform for collaboration with sister societies such as the American Association of Petroleum Geoscientists (AAPG), and the European Association of Geoscientists and Engineers (EAGE). The active engagement with the societies' representatives has set the stage for exciting future events and developments.

A major highlight of the event was the virtual geology session presented by Yaser Misrea, harnessing artificial intelligence to enhance geological interpretations. Drone-captured images of Tuwaiq Mountain revealed stunning lithological details, generating excitement among attendees. Technical exchange sessions proved equally popular, featuring insightful presentations on integrated reservoir modeling workflows, velocity model construction, and pseudo-average velocity kriging methods. Presenters seized the opportunity to showcase their work, expanding their audience reach.

GeoMentor, a novel speed mentoring initiative targeting young professionals and researchers, debuted successfully at IPTC. Over 45 expert mentors offered guidance across multiple scientific disciplines, forging valuable connections with aspiring minds.

Daily GeoTrivia contests were another highlight of DGS's participation, testing participants' knowledge on pivotal topics, including the Kingdom's geology and energy transition. Winners were recognized, further fueling enthusiasm and networking at the booth.

By delivering an unforgettable experience, DGS solidified its reputation as a hub for connection, knowledge-sharing, and professional development, attracting fresh attention from prospective members and volunteers alike.



04

Professional Development

MARCH DINNER MEETING

On the 4th of March 2024, DGS hosted a panel discussion and Dinner event centering on Vision 2030 and crafting the blueprint for a sustainable future. DGS president Fares Aboud opened the event with a short speech and introduced the moderator, Dr. Abdulrahman Al-Shuhail, Chief Technologist of Saudi Aramco's Geophysics Technology Division. The discussion commenced with the two panelists: the CEO of the National Center for Environmental Compliance Engineer Ali Bin Saeed Al-Ghamdi and Dr. Richard Bush, Chief Environmental Officer of NEOM.

Much of the discussion revolved around NEOM's embodiment of Vision 2030 by diversifying Saudi Arabia's economy. The plan is to make NEOM's 'The Line' the world's first truly sustainable city. This will be partly achieved by designing the city to emphasize walkability. The city will be dense, occupying an extremely small footprint of 36 square kilometers. Cars will not be utilized or needed, as every service required will be within a ten-minute walk. In addition to the prohibition of single-use plastics, Dr. Bush highlighted his strategy of diverting 98% of waste from landfills. Many of these initiatives will serve as benchmarks for sustainable practices across the rest of the country and on an international level.

Ali Al-Ghamdi discussed his strategy as the CEO of the National Center for Environmental Compliance, where he works with various industries on reducing greenhouse gas emissions and noise pollution, as well as increasing green areas and biodiversity in the Kingdom. He underscored their mission to protect Saudi Arabia's rich marine environment, coastline, as well as soil and air quality. The National Center for Environmental Compliance is currently engaged in building infrastructure to continually monitor activities that impact the environment.

The panel discussion touched upon the synergy between sustainability and technological innovation, highlighting the role this synergy plays in facilitating Vision 2030. For example, artificial intelligence and big data will enable NEOM to measure the efficiency of our use and employment of resources, as well as predict the consequences of our impact on the environment. The digital transformation is also playing an important role in enabling the National Center for Environmental Compliance to ensure industries are complying with their duties and obligations to preserve the environment. Dr. Bush discussed how NEOM plans to utilize biotechnology and environmental technology to increase the quality and longevity of the lives of the future residents of the city.

The panelists discussed some challenges encountered when implementing environmental sustainability initiatives in NEOM and elsewhere. One of these challenges is building a culture of awareness. NEOM is tackling this challenge by modelling sustainable values to the communities in the region. Dr. Bush shared NEOM's commitment to engaging with local communities in building new useful skillsets. This is manifesting in many ways, such as offering young talented individuals the opportunity to study abroad and become the next generation of experts. NEOM will also operate under separate laws, regulation and authorities, making it easier to integrate sustainability across all these authorities and laws, including the tourism, finance and sporting sectors.

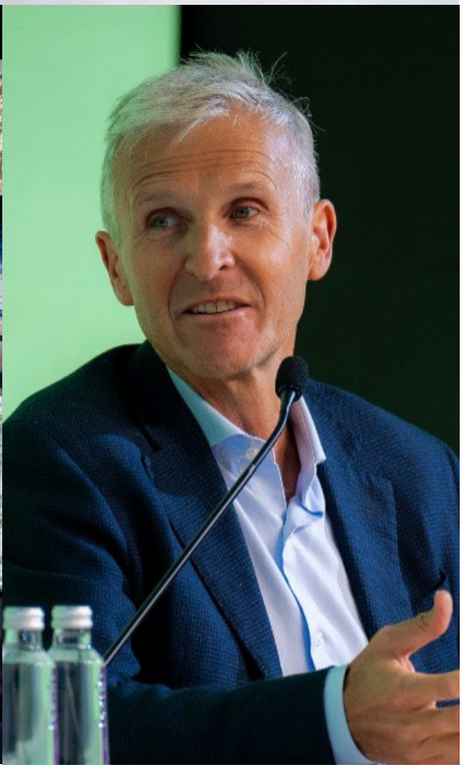
The discussion ended on a positive note, in which Dr. Bush advocated for Saudi Arabia to take an uncompromising position on becoming the leaders of environmental sustainability. Ali Al-Ghamdi encouraged both youth and leaders in the Kingdom to be proud of what we have achieved so far, and he highlighted that we as a nation have what it takes to be role models in environmental sustainability.

Written by: Samar Abu-Shamma, Geologist – Saudi Aramco









04

Professional Development

Digitalization in Geosciences Symposium (GEO 4.0):

A TRANSFORMATIVE GATHERING

The Digitalization in Geosciences Symposium (GEO 4.0) marked a significant milestone in advancing digital transformation within the geosciences industry. Organized by Saudi Aramco Exploration, chaired by Sa'id Al-Hajri (Saudi Aramco), and proudly hosted by the Dhahran Geoscience Society (DGS) alongside partner societies AAPG, EAGE, and SEG, this pioneering event took place from October 21 to 24, 2024.

With over 350 industry professionals from 22 countries and 40 companies, the symposium provided a collaborative platform for geoscientists, data scientists, and industry leaders to discuss cutting-edge digital solutions. The curated technical program, consisting of 127 presentations, aligned with the Exploration Digital Transformation Strategy, addressing critical topics such as AI-driven geoscience applications, data standardization, real-time decision-making, and remote monitoring.

The event commenced with an innovative Hackathon, exploring the capabilities of GenAI and Co-Pilot systems in geosciences. The opening keynote was delivered by Dr. Muhammad Al-Saggaf, President of KFUPM, emphasizing the importance of fostering new talent to drive digital transformation. A high-level panel discussion, moderated by Laila Al Hmoud (Saudi Aramco) and Olfa Zened (SLB), explored the challenges and opportunities of digitalization, featuring insights from industry leaders representing Saudi Aramco, SLB, TGS, and Viridien.

A key highlight of the symposium was the Young Professionals Forum, which addressed the adoption of AI in geoscience workflows. The discussion underscored the contrast between perspectives of early-career geoscientists and seasoned professionals, shedding light on the evolving nature of the industry.

The symposium was further enhanced by the GEO 4.0 Gala Dinner, where DGS was recognized for its sponsorship and support. Attendees celebrated achievements, networked, and honored the hard work of committee members. A special highlight was KFUPM's victory in the Hackathon, showcasing the remarkable talent emerging from the region.

With strong participation and invaluable discussions, GEO 4.0 was a resounding success, solidifying its role as a catalyst for digital innovation in geosciences. As the industry continues to embrace digital transformation, DGS remains committed to fostering collaboration and knowledge-sharing to drive the future of geoscience technology.











ORGANIZERS

HOSTS **PARTNERS**

PETRONAS ARMA DGS DHAHRAN SEG SOCIETY OF EXPLORATION GEOPHYSICISTS SPE Society of Petroleum Engineers AAPG EAGE SRMEG MOGSC

DGS Participation in IGS

DGS CONTRIBUTES TO THE SUCCESS OF INTERNATIONAL GEOMECHANICS CONFERENCE (IGS 2024)

The International Geomechanics Conference is a cornerstone of collaboration between Dhahran Geoscience Society (DGS), American Rock Mechanics Association (ARMA), and Society of Exploration Geophysicists (SEG), fostering cooperation for many years.

The 2024 conference, held in Kuala Lumpur, Malaysia from February 18-20, 2024, was warmly hosted by Petronas. The conference theme focused on "The Role of Geomechanics for Sustainability and Energy Efficiency", providing a premier platform for exchanging geomechanics knowledge and expertise.

A notable aspect of the conference was the great collaboration effort between ten professional societies, including ARMA, DGS, SEG, SPE, AAPG, SPWLA, CSRME, EAGE, MOGSC, and SRMEG. This collaborative approach contributed significantly to the conference's success, thanks to the leadership of these prominent organizations.

The conference attracted a diverse group of participants, representing 105 global organizations across 34 countries, resulting in a comprehensive technical program. The conference was kicked off with a training program titled "Training with Fellows", featuring renowned experts, Maurice Dusseault (University of Waterloo), Laura Pyrak-Nolte (Purdue University), and Derek Elsworth (Pennsylvania State University).

The technical program encompassed a broad range of topics, including CCUS, Petroleum, Mining, Geothermal, Hydrogen, Geotechnics, Environmental and Deep Space (a newly introduced topic). With 465 abstracts, 205 presentations, and 42 sessions, the conference provided a rich exchange of ideas and research findings.

One of the highlights of the conference was the Presidents' Panel, where the presidents of the partner societies shared their insights on the roles of their respective organizations in the new era of sustainability. They discussed ways to maintain relevance and address the challenges faced by their societies.

Looking forward, the 2025 conference will be hosted by Saudi Aramco in Khobar, Saudi Arabia from November 17-20, 2025. The conference committee aims to build upon the successes of previous events, further promoting collaboration and growth within the geomechanics community.







05

Technical Exchange



Virtual Lecture Recap:

"GEOTHERMAL ENERGY IN SAUDI ARABIA —REALLY?"

The Dhahran Geoscience Society hosted Dr. Volker C. Vahrenkamp, a professor of Geology at KAUST & renowned expert in geothermal energy, on April 4th, 2024. With 28 years of experience in exploration and production, Prof. Vahrenkamp shed light on the viability of geothermal energy as a sustainable power source in Saudi Arabia.

The session, attended by 86 participants, began with a quote from His Royal Highness Prince Abdulaziz bin Salman Al-Saud, underscoring Saudi Arabia's commitment to renewable energy sources including solar, wind, and geothermal—in driving a circular carbon economy.
The session opened with a probing question to the audience: how many barrels of oil does Saudi Arabia consume internally? This internal consumption supports critical activities like transportation, electricity generation, and desalination—all of which geothermal energy could potentially help address.

The expert presenter emphasized that geothermal energy is an abundant, reliable, and multi-purpose resource. It holds immense promise for Saudi Arabia, particularly in applications like desalination, which is vital for the Kingdom. Globally, geothermal energy is gaining traction due to its long-term economic advantages, as evidenced by the Levelized Cost of Energy (LCOE) evaluation matrix shared during the session.

The fundamentals of geothermal energy, including its heat sources and various applications, were explained. The lecture highlighted the two main methods of utilizing geothermal heat—with or without heat pumps—and showcased its relevance to regional geology in Saudi Arabia. The Kingdom's complex geological structure influences geothermal opportunities, particularly the heat ranges required for different applications.

While acknowledging the substantial geothermal potential in Saudi Arabia, Prof. Vahrenkamp noted the imperative to quantify and assess these resources. Notable players in the Kingdom are spearheading efforts to advance geothermal capabilities, including Saudi Aramco, NEOM, Saudi Geological Survey (SGS), King Abdullah University of Science and Technology (KAUST), Taqa Geothermal, and Eden Geopower.

A particular highlight of the lecture was the KAUST Geothermal Exploration Pilot (K-GEP), which focuses on advancing subsurface and geothermal drilling technologies. The guest lecturer highlighted the program's objectives which include geothermal reservoir monitoring, cascaded energy extraction (combining hybrid solar and geothermal systems), membrane-based mineral extraction, and carbon capture and storage (CCS).

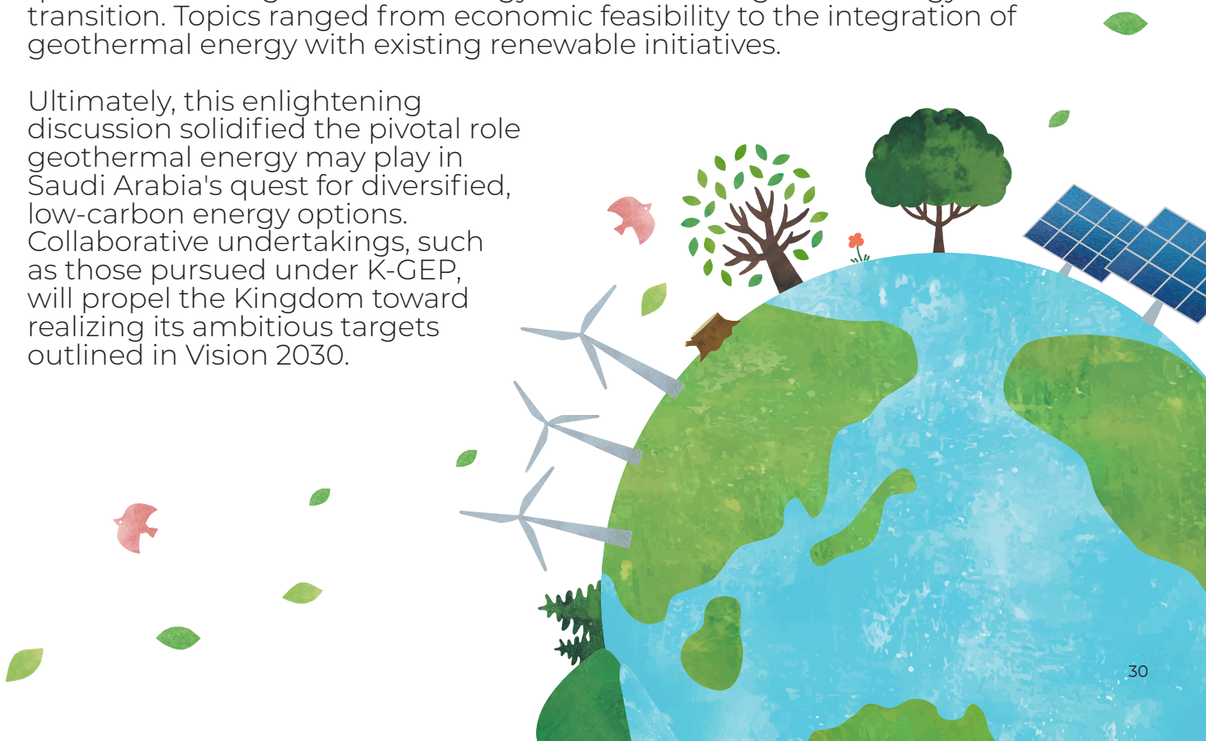
Prof. Vahrenkamp outlined four stages involved in the pilot project:

1. Data collection and monitoring, including seismic, fiber optics, and water samples
2. Heat-reservoir characterization and simulation
3. Geothermal system implementation
4. Long term monitoring and research observatory

The presenter offered a comparative look at global geothermal developments, underscoring the need for Saudi Arabia to build expertise and resources to match international standards. As the country continues to explore its geothermal potential, key challenges include addressing geological complexities and ensuring the technology is cost-effective over time.

The session concluded with a lively Q&A, where participants posed questions about geothermal energy's role in the Kingdom's energy transition. Topics ranged from economic feasibility to the integration of geothermal energy with existing renewable initiatives.

Ultimately, this enlightening discussion solidified the pivotal role geothermal energy may play in Saudi Arabia's quest for diversified, low-carbon energy options. Collaborative undertakings, such as those pursued under K-GEP, will propel the Kingdom toward realizing its ambitious targets outlined in Vision 2030.



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Technical Exchange

SPWLA-DGS Workshop:

ADVANCES IN GEOTHERMAL ENERGY EXPLORATION AND DEVELOPMENT

The SPWLA Saudi Arabia Chapter and the Dhahran Geoscience Society successfully hosted the 14th Topical Workshop, titled Advances in Geothermal Energy Exploration and Development, at the Kempinski Hotel Al Khobar from April 30 to May 1, 2024. Sponsored by TAQA GEOTHERMAL, the event brought together industry experts, academics, and professionals to explore cutting-edge advancements in geothermal energy and its growing role in the global shift toward sustainable energy solutions.

Pre-Event Training: Laying the Foundation

Before the main workshop commenced, a special pre-event training session was conducted at Dhahran Techno Valley. Esteemed professors from King Fahd University of Petroleum & Minerals (KFUPM) and industry experts from TAQA Geothermal led sessions covering geothermal energy fundamentals, exploration techniques, and project development strategies. The session provided participants with essential knowledge, setting the stage for in-depth discussions during the workshop.

Day 1: Exploration and Reservoir Characterization

The first official day of the workshop opened with speeches from TAQA GEOTHERMAL CEO Meshary Al-Ayed, Aramco's Reservoir Description Manager Nedhal Al-Musharfi, and SPWLA President-Elect Robert Gales. Following their remarks, keynote speaker Hjálmar Eysteinsson (TAQA) delivered insights on geophysical methods in geothermal prospecting, focusing on resistivity studies and Magnetotelluric soundings.

The sessions that followed were dedicated to geothermal exploration and reservoir characterization. Presentations covered diverse topics, including:

- Geothermal Energy Resources in the Riyadh Region (Dr. Abdulrhman Hussain Alghamdi, KACST)
- Low-Enthalpy Salt Geothermal System Exploration (Manaf Alqatari, Saudi Aramco)
- Geothermal Systems of Hot Springs (Hassan Baioumy, TAQA)
- Well Placement Strategies for Economic Returns (Prof. Ruud Weijermars, KFUPM)

The afternoon sessions delved into geothermal project formation evaluation, presented by Robert Gales (Halliburton), and concluded with a panel discussion that engaged participants in a thought-provoking exchange of ideas on geothermal advancements.

Day 2: Project Development and Production

The second day shifted focus to geothermal project development and production. Industry leaders from SLB, Baker Hughes, AdrillTech, IGNIS H2 Energy, and Weatherford shared insights on reducing uncertainties in geothermal projects, geothermal play fairway analysis, reservoir management strategies, and drilling advancements in challenging rock formations.

Key presentations included:

- Geophysical Data-Driven Solutions for Geothermal Success (Alessandra Battaglini, SLB)
- Geothermal Play Fairway Analysis: A Texas/Gulf Coast Case Study (Trever McKen & Rik Doll, Baker Hughes)
- Maintaining Cooled BHAs in Geothermal Wells (William Pettitt & Kevin McCarthy, AdrillTech)
- Advancements in Drilling Across Abrasive Rocks (Salih Burak Birinci & Sinem Kaymak, TAQA)

The day concluded with an engaging panel discussion and a closing session summarizing key takeaways from the two-day event.

Key Takeaways and Future Outlook

The workshop underscored the immense potential of geothermal energy within the Kingdom of Saudi Arabia and beyond. Participants engaged in vibrant discussions on leveraging cutting-edge technologies, optimizing exploration techniques, and enhancing geothermal project efficiency.

TAQA GEOTHERMAL, SPWLA, and DGS expressed their gratitude to all speakers, participants, and organizers for making the workshop a resounding success. The collaborative efforts highlighted the importance of continued research and innovation in the geothermal sector, paving the way for a more sustainable energy future.



05

Technical Exchange

May Session:

MEET THE EXPERT

On May 6th of 2024, DGS hosted Dr. Taury Smith for the year's first Meet the Expert session. Dr. Smith is a specialist in carbonates and mixed-carbonates systems and sequence stratigraphy. He is a holder of the esteemed AAPG Bulletin best paper award along with co-author Graham Davies. Over the past 11 years, Dr. Smith has been a global consultant for the oil and gas industry on both carbonates and organic rich shale reservoirs. The title of his talk was 'Integrated Geological Characterization of Vaca Muerta Unconventional Play, Neuquen Basin in Argentina'.

After the master of ceremony Moath Dossary opened the event, Dr. Smith started with some basic knowledge about unconventional plays, and the Neuquen Basin in Argentina. The organic-rich source rock Vaca Muerta deposited in Late Jurassic/Early Cretaceous. It is one of the biggest unconventional plays outside the United States, and it produces light oil, condensate and dry gas. The structure of the play starts with a regional unconformity and a flat (layer-cake) organic shale, followed by platform carbonate buildups and sandstones prograding from Southeast to Northwest.

Dr. Smith examined 20 wells including a 1000 m Vaca Muerta reservoir interval. He demonstrated the utilization of emerging technologies and geoscience tools in establishing Vaca Muerta's depositional environment, sedimentology, sequence stratigraphy and pore system characterization. For instance, ion milling in SEM analysis and seismic data were instrumental in determining basin structure and well correlations. Additionally, cuttings and thin sections were used to build a stratigraphic column and a 2-D facies model.

Providing critical details, Dr. Smith explained the different facies of Vaca Muerta, starting from the basin and moving up to the shallow intervals while demonstrating variations in TOC values, fossils and minerals. For example, the reservoir's silty organic-rich mudstone (the kitchen) has the highest TOC values reaching up to 12%. Additionally, other organic-rich intervals (above the kitchen) have 7-8% TOC. Dr. Smith illustrated the process of hydrocarbon generation and differentiated between kerogen and bitumen in SEM images. He also introduced the term 'marine snow', which explains the process of organic matter (kerogen) sinking through the water column to the sea floor.

Following that, Dr. Smith used SEM images to compare between two wells, one in the oil window, and another in the dry gas window. Vaca Muerta in the dry gas well had larger organic pores due to light hydrocarbon generation. Other pore types such as detrital and diagenetic pores were observed, and an estimation of relative pore abundance was demonstrated. Capitalizing on the aforementioned technologies and innovative techniques, Dr. Smith identified the characteristics of the best reservoirs and established two super sequences with two major anhydrites in the unconventional play.

Towards the end of the talk, Dr. Smith emphasized the application of ion milling in imaging micro-porosity of both unconventional and carbonate reservoirs, and he addressed several insightful questions from the audience.

Written by: Zainab Almubarak, Geologist – Saudi Aramco



05
Technical Exchange

July Session:

MEET THE EXPERT



On July 1st, DGS's "Meet the Expert Series" featured Dr. Cleveland Jones, drawing an audience of approximately 100 attendees, including seasoned geologists, geophysicists, students, and young professionals. Dr. Jones, a renowned researcher and consultant in the oil and gas industry, delivered an engaging virtual presentation emphasizing the critical role of adopting and implementing new technologies in the field.

Dr. Jones emphasized the need to integrate emerging technologies to overcome the limitations of traditional exploration methods, highlighting the Stress Field Detection (SFD) method as a groundbreaking innovation. SFD, a passive technology, provides a more efficient approach to identify accumulations in the subsurface.

At a more technical level, SFD operates as a mesoscopic-scale transducer that detects fine spatial variations in the gravitational potential energy (GPE). The method has demonstrated a high likelihood of discoveries, enabling exploration in areas previously overlooked due to the constraints of conventional geophysical techniques.

Comparing SFD with established methods like seismic imaging, Dr. Jones underscored its unique advantages, particularly in relation to Environmental, Social, and Governance (ESG) considerations. With zero direct environmental footprint, SFD minimizes disruptions to ecosystems and nearby communities, making it especially valuable in sensitive environments such as the Amazon rainforest.

In closing, Dr. Jones advocated for the widespread adoption of SFD as a preferred geophysical technique and encouraged integrating multiple survey methodologies to enhance pre-drilling confidence. When asked about SFD's feasibility in radioactive and geothermal settings, he affirmed its adaptability and cross-disciplinary relevance.

Beyond showcasing technological advancement, Dr. Jones' talk aligned with DGS's mission to enhance technical expertise and promote sustainable exploration practices. His insights into SFD technology demonstrated how embracing innovation can drive both technical excellence and environmental responsibility in the oil and gas industry.

Written by: Lama Al-Juhani, Geophysicist - Saudi Aramco



05

Technical Exchange

UNIVERSITY STUDENTS COMPETE IN THE SEG|DGS MIDDLE EAST CHALLENGE BOWL

The SEG|DGS Middle East Challenge Bowl Competition brought together some of the brightest university students in the region for an exciting test of their geoscience knowledge. Organized by the Society of Exploration Geophysicists (SEG) in collaboration with the Dhahran Geoscience Society (DGS), the virtual event saw five teams from universities across the Middle East and North Africa for a chance to represent the region at the SEG Challenge Bowl Finals on August 27 during IMAGE.

A Test of Knowledge and Speed

The Challenge Bowl is an international competition designed to assess students' technical knowledge in geosciences. Teams of two players competed in a fast-paced quiz format, answering questions spanning geology, geophysics, and earth sciences. The contest consisted of multiple rounds with increasing difficulty, testing both accuracy and quick thinking.

Each difficulty featured three rounds:

- **Round 1:** Open questions with decreasing points over time.
- **Round 2:** Category-based questions covering various geophysical disciplines.
- **Round 3:** Short, high-intensity rapid-fire questions with penalties for incorrect answers.

As teams progressed through the rounds, scores were reset, and lower-scoring teams were eliminated, culminating in a high-stakes final round where the top teams competed for victory.

Meet the Competitors

The competition featured teams from prestigious universities across the region, including:

- **Khalifa University (UAE)** – Omar Abdulrahman Abdulla Aleter Aldhanhani & Arwa Hussam Aldin Lutfi
- **King Abdullah University of Science and Technology (KSA)** – Dea Vallerie Oemaiya & Muhammad Iqbal Khatami
- **King Fahd University of Petroleum and Minerals (KSA)** – Ahmed Nagy Abdelqawi & Fauzan Oriyomi Akomolafe
- **Tanta University (Egypt)** – Eman Salah Badr & Rawan Hany
- **University of Boumerdès (Algeria)** – Ines Zerkouk & Abderrahmane Bahloul

These talented students demonstrated their depth of knowledge, teamwork, and quick decision-making throughout the competition.

Esteemed Host and Industry Support

The competition was honored to have Peter M. Duncan as its host. Dr. Duncan, a distinguished geophysicist and entrepreneur, originally initiated the SEG Challenge Bowl program in 2006. His leadership and contributions to the geophysical industry have been widely recognized, and his presence added greatly to the event.

The contest was made possible through the support of the Dhahran Geoscience Society (DGS), which not only co-hosted the event but also sponsored exciting rewards for the winning team. DGS continues to play a vital role in fostering technical knowledge and professional development in the geoscience community.

A Rewarding Experience and Future Opportunities

Beyond the thrill of competition, the event provided a valuable learning experience for all participants. Engaging with challenging questions and competing against peers from different institutions helped sharpen their technical and analytical skills. The victorious KAUST team earned the prestigious opportunity to represent the region in the SEG Challenge Bowl Finals, where they competed against top teams from around the world.

Looking Ahead

The SEG|DGS Middle East Challenge Bowl was a resounding success, highlighting the talent and potential of the next generation of geoscientists. As the competition concluded, organizers expressed their appreciation for all participants, the dedicated efforts of the organizing teams, and the continued support of SEG and DGS in advancing geoscience education.

Congratulations to KAUST for their dedication and outstanding performance, and best of luck to all participants in their future endeavors!



September Session:

MEET THE EXPERT



On September 3rd 2024, the Dhahran Geoscience Society had the pleasure of hosting Dr. Ardi Koeshidayatullah, professor at KFUPM, to discuss the role of generative AI in shaping the future of Geosciences during DGS's Mind the Gap luncheon. He began his talk by highlighting the evolution of Generative AI (GenAI) at extremely fast rates, which started back in 2010 with Google's introduction of an autocomplete feature. He then reiterated that deep learning is revolutionizing data analysis in geosciences, in a way that complements traditional methods.

Dr. Koeshidayatullah emphasized the distinction between Artificial Intelligence (AI), Traditional Machine Learning, and Generative AI, clarifying that AI enables computers to mimic human cognition, whereas Traditional Machine Learning involves prediction-based decision-making from existing datasets. GenAI, however, generates novel data samples resembling those found in training sets.

Dr. Koeshidayatullah explored the vast potential of GenAI in Geosciences, highlighting its capacity to operate under Supervised, Unsupervised, and Self-Supervised regimes. He explained the concept of Generative Modelling, showcasing its ability to capture crucial features of real-world images through Latent Space representations.

Following a brief overview of this rapidly expanding field, Dr. Koeshidayatullah posed three pivotal questions to spark reflection: Are we justified in our excitement about GenAI? Can it add substantial value to our work? And what are the limits of its applicability?

Through examples drawn from his own research, Dr. Koeshidayatullah illustrated the practical utility of GenAI in Geosciences. His real-time petrography model of carbonate sedimentology, capable of identifying lithologies with remarkable accuracy, served as a striking illustration of GenAI's promise. Although less precise than expert geologists, the model offered unparalleled speed.

Furthermore, Koeshidayatullah showcased the effectiveness of Generative Adversarial Networks (GANs) in overcoming data scarcity and specialist knowledge gaps. By synthesizing labelled data, GANs alleviate tedious manual annotation processes. Examples included Pore and Grain Segmentation, Carbonate Thin Section Descriptions, Seismic Volume Completion, and Automated Core Mineralogy Analysis.

As Dr. Koeshidayatullah concluded his enlightening presentation, he cautioned against uncritical adoption of GenAI methods, stressing the imperative of balanced usage to avoid compromising scientific rigor. To bridge the divide between Industry and Academia ('Mind the Gap'), he advocated for closer collaboration and access to extensive, openly accessible datasets.

Written by: Tanya Alauddin, Geologist - Saudi Aramco





On October 13th, an engaging luncheon event was held featuring a keynote lecture by Dougal Jerram, a distinguished geologist from DougalEARTH Ltd. and a research professor at the university of Oslo. Hosted by DGS, the event brought together geologists, industry professionals, and researchers to explore the fascinating world of volcanic geology, with a particular focus on the Arabian Shield.

An Insightful Presentation on Volcanic Systems

Professor Jerram's talk, titled A Journey into the World of Hot Rocks, provided a deep dive into the geological significance of large igneous provinces and volcanic rifted margins. He highlighted key volcanic formations worldwide, such as the Paraná-Etendeka province, the North Atlantic Igneous Province, and the Ethiopian-Yemen hotspot, before shifting focus to the unique volcanic history of the Arabian Shield.

One of the key themes of his presentation was the potential applications of volcanic and basement rocks in various geological and energy-related fields. He discussed how these formations could be explored for geothermal energy, carbon capture and storage (CCS), and even hydrocarbon reservoirs. He emphasized the need to better understand the subsurface volcanic systems, especially in the Red Sea region, where active volcanism continues to shape the landscape.

The Arabian Shield's Geological Importance

Professor Jerram shed light on the Arabian Shield's complex volcanic history, noting that the region's geological formations offer a unique opportunity to study the interaction between older basement rocks and younger volcanic deposits. He explored fundamental questions regarding the temporal and spatial relationships of volcanic formations, the varying geophysical properties of different volcanic facies, and their role in subsurface fluid dynamics.

One of the fascinating aspects of his talk was the discussion on volcanic heterogeneity and how variations in rock density, porosity, and structure impact their behavior as reservoirs. Through examples from Ethiopia, Namibia, and Scotland, he illustrated how new technologies such as 3D modeling, LiDAR scanning, and drone-based geological mapping are revolutionizing the way geologists study volcanic terrains.

Applications in Geothermal and Carbon Sequestration

A key takeaway from the presentation was the immense potential of the Arabian Shield for sustainable energy solutions. The Kingdom of Saudi Arabia, with its diverse geological framework, presents an ideal landscape for exploring geothermal energy resources. Professor Jerram discussed the role of volcanic rocks in hosting geothermal reservoirs and the significance of faulted basement rocks in enhancing permeability for fluid movement.

Additionally, he addressed the relevance of volcanic formations in CCS, emphasizing how lava-hosted reservoirs could serve as ideal locations for carbon storage. By integrating geophysical data with outcrop studies, researchers can build robust models to evaluate the feasibility of carbon sequestration projects.

Advanced Geological Techniques and Future Directions

The talk also touched upon the advances in geophysical imaging and core sample analysis that are enhancing our understanding of subsurface volcanic structures. Professor Jerram showcased studies where integrated methodologies—such as borehole geophysics, seismic imaging, and drone photogrammetry—were used to quantify fractures and understand reservoir dynamics.

One of the most exciting developments he highlighted was the use of high-resolution 3D models to simulate volcanic reservoirs. He demonstrated how researchers have been able to create detailed digital reconstructions of volcanic outcrops, allowing for better predictions of subsurface characteristics.

Closing Remarks

In conclusion, Professor Jerram reiterated the importance of continued research and collaboration in the field of volcanic geology. He encouraged industry and academic partnerships to further explore the potential of the Arabian Shield's volcanic resources, emphasizing that the region holds untapped opportunities for geothermal energy, carbon sequestration, and reservoir exploration.


Unlocking the Rich Volcanic History and
Arabian Shield
Prof Dougal A. Jerram
DougalEARTH ltd.
NJORD Centre,
niversity of Oslo
ts from; Alan Bischoff, Alessio
Galland & Károly Németh
colleagues over the years with
rs cited during the talk




DGS




Reserved

DGS-KAUST Student Chapter:

A REMARKABLE START IN 2024

The DGS-KAUST Student Chapter has had an extraordinary first year since its establishment in June 2024. With a mission to promote geosciences among students and foster connections between academia and industry, the chapter has quickly become a dynamic hub for learning, collaboration, and fun.

The chapter was founded under the leadership of five dedicated officers: President Nicolas Boehm, Vice-President Wesam Abu Laila, Treasurer Jordania Zerpa, Outreach Officer Sebastian Patino, and Social Officer Hassan Alsaihati. Supporting their efforts is faculty sponsor Prof. Frans van Buchem. Together, the team set the foundation for what has become a thriving community of geoscience enthusiasts.

Engaging the KAUST Community

The chapter introduced itself to the broader KAUST student body during the Student Expo on August 21, 2024. This event marked a significant milestone, as the chapter gained substantial interest and grew to 50 active members. Students from diverse academic backgrounds joined, united by a shared passion for geosciences.

Workshops, Hackathons, and Industry Engagement

DGS_KAUST chapter participated in impactful events thus far. On June 27, 2024, members attended a one-day workshop on Carbon Capture and Storage (CCS) in Al Khobar, hosted by the DGS and led by Dr. Phil Ringrose. This workshop provided invaluable insights into CCS technologies and their critical role in addressing climate change, reinforcing the chapter's commitment to staying at the forefront of industry advancements.

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Thought Leadership and Industry Insights

The chapter organized a highly anticipated talk by Dr. Gerard Massonnat of Total Energies on October 16, 2024. Co-hosted with SPE and ARMA, the event delved into the future of geoscience professionals, addressing emerging industry trends and challenges. Dr. Massonnat's insights were met with enthusiasm and sparked meaningful discussions among attendees.

Exploring Cutting-Edge Research

The chapter's biggest event to date took place on November 10, with a visit to the Aramco Research Center. This immersive experience featured presentations on Aramco's upstream research and upcoming Hackathon at KAUST in January 2025, and an exclusive tour of the facility's state-of-the-art labs. With nearly 40 participants, the event highlighted the chapter's ability to organize impactful and inclusive activities.

Blending Fun and Knowledge

November 19 was a day of diverse experiences, beginning with a snorkeling trip to coral reefs led by carbonate specialist Prof. Volker Vahrenkamp. The morning adventure allowed participants to connect with the natural beauty of the marine environment while learning about its geological significance.

Later that day, the chapter co-hosted a talk with the SPWLA student chapter, featuring Dr. Mark Ma from Saudi Aramco. Dr. Ma presented on petrophysics fundamentals and recent advancements in the field, offering students valuable insights into this critical area of geoscience.

Looking Ahead

In just six months, the DGS-KAUST Student Chapter has established itself as a cornerstone of the geoscience community at KAUST. Through diverse events and collaborations, the chapter has successfully bridged the gap between students, academics, and industry professionals.

Looking forward, the chapter plans on building on this momentum with even more ambitious plans for the future. An exciting field trip is already in the works for February 2025, promising a hands-on learning experience that will further enrich our members' geoscience journey. With a growing membership and a commitment to excellence, the DGS-KAUST Student Chapter is poised to inspire and empower the next generation of geoscientists.

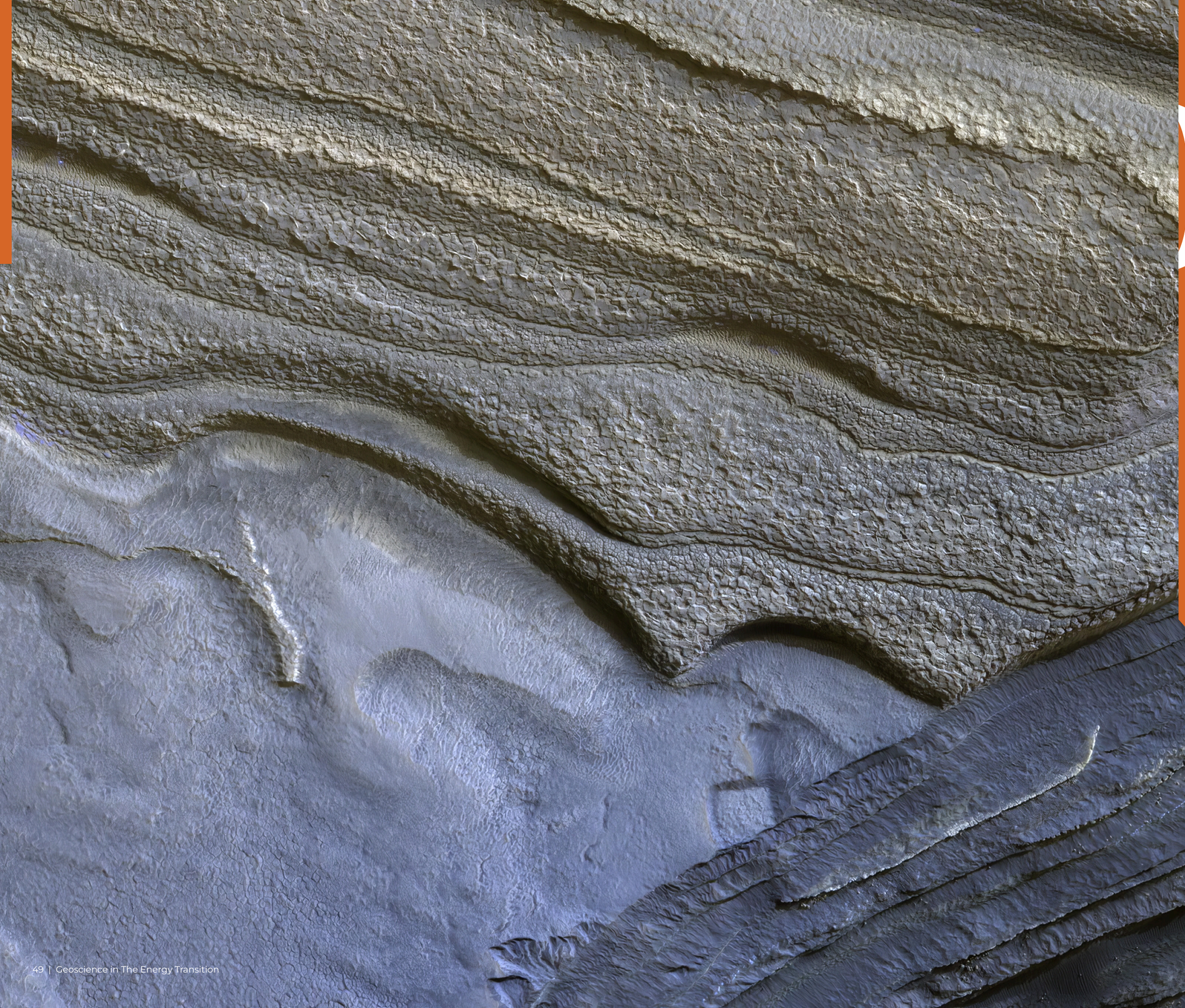
Written by: Nicolas Boehm, PhD Student - KAUST

05
Technical Exchange









06

Public
Outreach

06
Public Outreach

DGS AND BENAA CHARITY ASSOCIATION JOIN FORCES FOR THE RAMADAN FOOD DRIVE

On March 10, 2024, the Dhahran Geoscience Society (DGS), in collaboration with the Benaa Charity Association for Orphans Care, organized a Ramadan Basket Food Drive to support underprivileged families in Khobar and Dammam. This initiative provided essential food supplies to help families in need during the holy month of Ramadan, ensuring they had the necessary resources to observe the month with comfort.

DGS remains dedicated to giving back to the community, fostering a spirit of generosity, and supporting charitable initiatives that create a lasting impact. Through this campaign, DGS aimed to amplify its contributions to local charities and strengthen its role in social responsibility, leaving behind a meaningful legacy for future generations



DGS SPREADS JOY WITH EID HOSPITAL VISIT AND GIFT DISTRIBUTION

As part of its commitment to community engagement, the Dhahran Geoscience Society (DGS) visited a local hospital to distribute Eid gifts to patients, bringing smiles and warmth to those in need. The initiative aimed to spread joy, uplift spirits, and share the festive spirit of Eid, ensuring that patients felt remembered and cared for during the celebration.

Through this heartfelt gesture, DGS reaffirmed its dedication to compassion, kindness, and social responsibility, making a positive impact on the community.



06
Public Outreach

DGS ORGANIZES SUCCESSFUL BLOOD DONATION CAMPAIGN IN COLLABORATION WITH SAUDI ARAMCO AND JOHNS HOPKINS HEALTH CARE

The Dhahran Geoscience Society (DGS), in collaboration with Saudi Aramco's Corporate Citizenship and Johns Hopkins Dhahran Health Care, organized a blood donation campaign to support local hospitals and patients in need. The initiative was a resounding success, with generous donors stepping forward to contribute to this life-saving cause.

Through this campaign, DGS reinforced its commitment to social responsibility and community well-being, making a tangible difference in the lives of those in need.

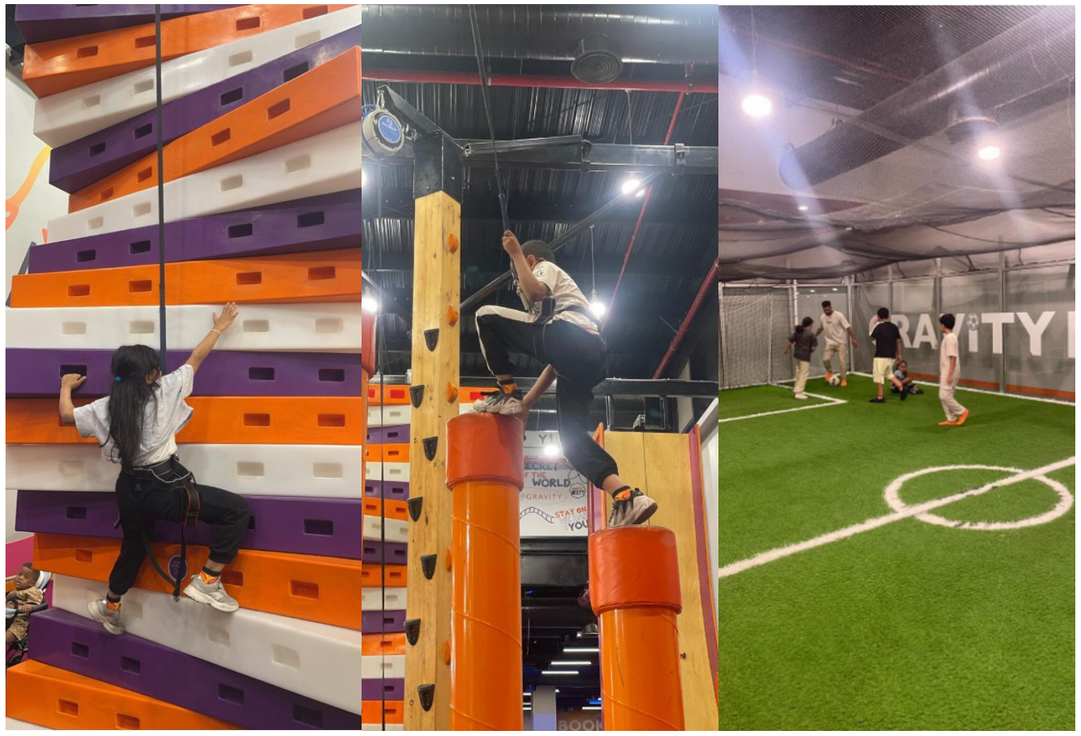




06
Public Outreach

DGS ORGANIZES A FUN-FILLED DAY FOR BENAA CHILDREN AT GRAVITY TRAMPOLINE PARKS

The Dhahran Geoscience Society (DGS)'s Public Relations team organized a heartwarming visit to Gravity Trampoline Parks, where they hosted a group of children from Benaa -a charitable association dedicated to orphan care in Saudi Arabia's Eastern Province. The event was a joyful celebration, providing the children with a day full of laughter, energy, and unforgettable moments. The kids participated in a variety of engaging activities, including soccer and dynamic trampoline games that fostered a sense of excitement and camaraderie. Through their thoughtful initiative, the DGS team not only created an enjoyable experience but also received heartfelt recognition from the Benaa Association for their outstanding efforts. The event allowed the children to celebrate their achievements while marking the start of a fun-filled summer vacation. By supporting such meaningful causes, DGS continues to demonstrate its deep commitment to social responsibility and enhancing the quality of life in the community. This initiative highlights the organization's dedication to giving back and fostering a stronger connection with the local society, leaving a lasting impact on the children, their families, and all those involved. The smiles and gratitude exchanged at Gravity Trampoline Parks will surely remain a cherished memory for all.



GEOSCIENCE SCHOOL VISITS: EMPOWERING THE FEMALE COMMUNITY

In a concerted effort to promote geoscience education and inspire the next generation of female scientists, DGS conducted four impactful high school visits. These visits aimed to educate students on essential geoscience concepts while fostering a connection between young women and the field of geoscience.

During each visit, our team of enthusiastic geoscience professionals engaged students through interactive presentations and hands-on activities. The curriculum was carefully designed to make complex concepts accessible and relatable, ensuring that students grasp the fundamental principles of geology, paleontology, and environmental science. This was done through:

1. **Interactive Learning:** Each session featured engaging demonstrations, allowing students to explore topics such as rock types, fossil formation, and the importance of geological resources. These activities sparked curiosity and encouraged active participation.
2. **Empowering Female Students:** A significant emphasis of our visits was to connect geoscience to the female community. Our team included female geoscientists who shared their personal journeys, highlighting the diverse career paths available in the field. This representation aimed to inspire young girls to consider careers in geoscience and related disciplines.
3. **Real-World Applications:** We discussed how geoscience plays a crucial role in addressing global challenges, including climate change, natural resource management, and environmental conservation. By illustrating the relevance of geoscience to everyday life, we aimed to foster a sense of responsibility and interest in future studies.
4. **Q&A Sessions:** Each visit concluded with an open forum where students could ask questions and engage in discussions with our professionals. This interactive component allowed students to seek advice and gain insights into pursuing their interests in geoscience.



06

Public Outreach

ROCKY ROAD: A COLLABORATIVE JOURNEY WITH ITHRA

In November and December 2024, DGS proudly collaborated with Ithra to present the "Rocky Road" event, an engaging educational experience that highlighted the fascinating world of geoscience. Over the course of two months, our team of dedicated geoscience professionals led visitors on an immersive journey through a series of interactive stops, each designed to unveil the complexities of our planet's geological history.

The event featured a variety of informative sessions, each focusing on critical aspects of geoscience including:

1. **Petroleum Systems:** Our experts guided visitors through the intricacies of petroleum systems, explaining the processes that lead to the formation of hydrocarbons. Interactive displays and models illustrated how geological formations contribute to petroleum reserves, fostering discussions on energy resources and sustainability.
2. **Rock Types:** Participants explored the diversity of rock types, learning to identify igneous, sedimentary, and metamorphic rocks. Hands-on activities allowed visitors to examine samples and understand the formation processes, while expert-led discussions highlighted the significance of these rocks in understanding Earth's history.
3. **Fossils and Paleontology:** A dedicated session on fossils captivated attendees as they discovered how these ancient remnants provide insights into past life forms and environments. Our geoscience professionals discussed key fossil finds and their implications for understanding evolution and Earth's climatic changes.
4. **Geological History:** Taking a step back in time, visitors were immersed in the geological history of the region. Through engaging presentations, they learned about significant geological events, including plate tectonics and mass extinctions, and how these events shaped the Earth's surface.

The Rocky Road event was a resounding success, attracting a diverse audience eager to learn about the geological sciences. Our collaboration with Ithra enabled us to foster a deeper understanding of Earth's processes, encouraging curiosity and appreciation for the natural world. We extend our gratitude to all participants and look forward to future collaborations that continue to inspire and educate.





07

Reader Contributions

07

Reader Contributions

Understanding the Thermal Field of the Earth Crust:

RELATIONSHIP BETWEEN BASEMENT AND HEAT FLOW IN EASTERN ARABIA

Harald Karg, Saudi Aramco Unconventional Resources Exploration Division

Introduction

The understanding of the thermal field of the earth crust is key to successful mapping of hydrocarbon and geothermal energy resources. Composition and thermal structure of the lithosphere provide the controls on subsidence and geometry of evolving sedimentary basins and are of crucial importance for the understanding of its thermal evolution (e.g., Artemieva and Mooney 2001; Jaupart et al. 2016).

Published data on the thermal state of the eastern Arabian Platform are scarce (e.g. Gettings and Showail, 1982), suggesting low heat flow at the eastern flank of the Arabian Shield. This work was stimulated by an initial observation of a systematic eastward thermal gradient increase perpendicular to the orientation of the inherited basement structural grain and Proterozoic terrane assembly, suggesting that the present thermal field is a blue-print of the underlying basement substrate (Fig. 1).



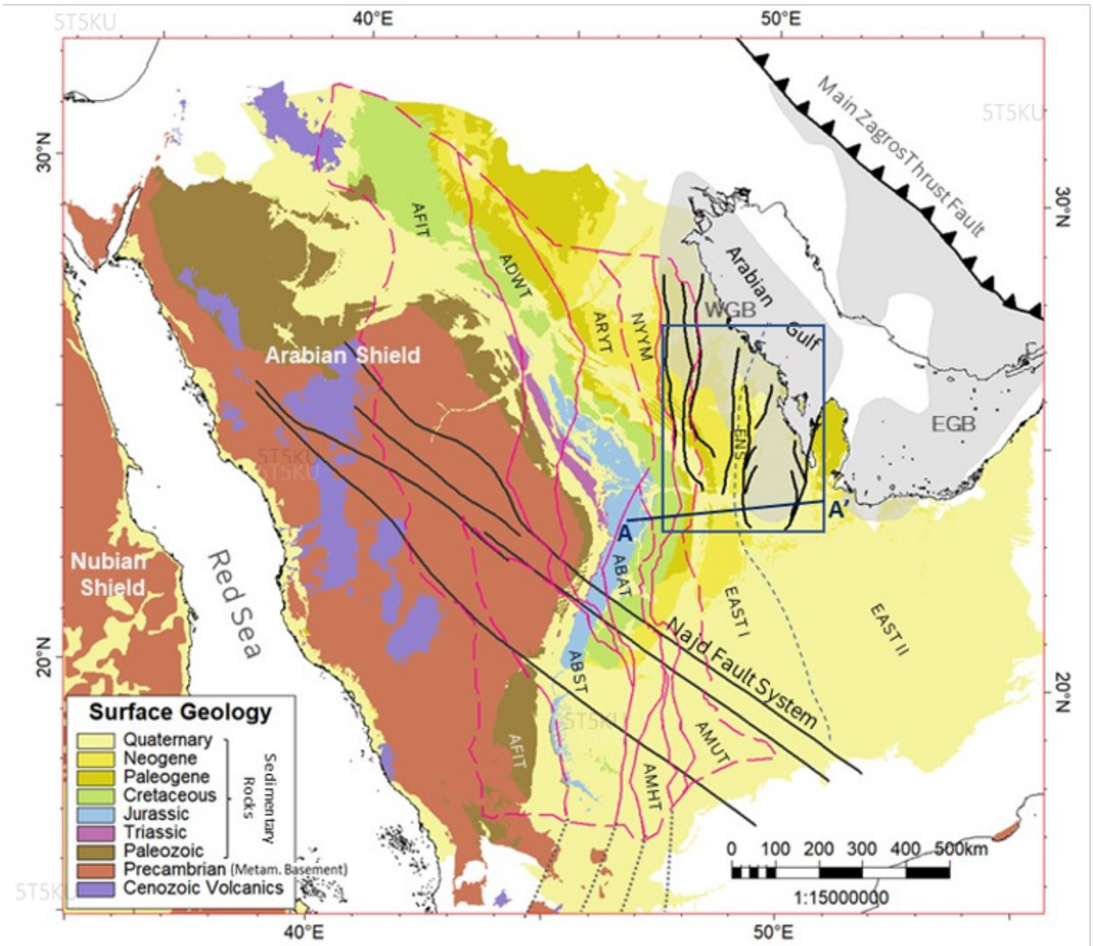
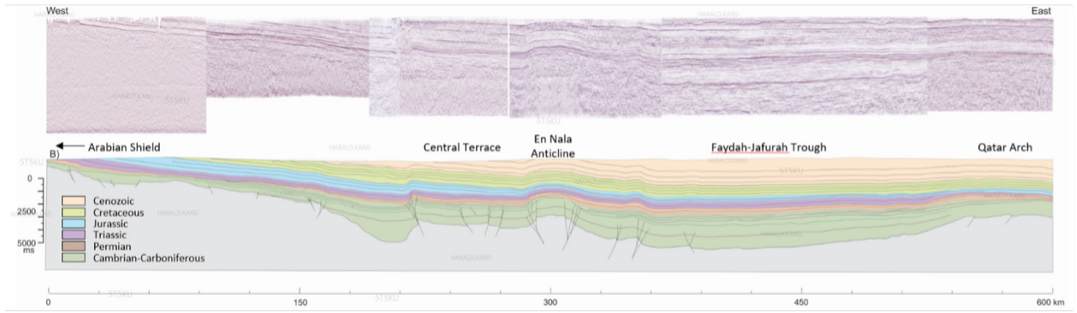


Fig. 1. Surface geological map of Saudi Arabia and adjacent areas, basement terrane boundaries after Ahmed et al. (2019) and proprietary information. Grey shading: Phanerozoic basins with >7000 m sediment accumulation (see text). WGB: Western Gulf Basin system, EGB: Eastern Gulf Basin system. EAST I/II: Eastern Arabian sub-terranes I and II, AMUT: Al Mukalla Arc Terrane, NYYM: Nuayyim Terrane, AMHT: Al Mahfid Terrane, ABAT: Al Bayda Arc Terrane, ARYT: Ar Rayn Terrane, ABST: Abas Terrane, ADWT: Ad Dawadimi Terrane, AFIT: Afif Terrane, ENS: En Nala Suture (Ghawar). Rectangle: study area outline. Solid lines within rectangle: seismically mapped basement faults.



New regional seismic interpretation (Fig. 2) as well as a reinterpretation of gravimetric and magnetic data reveal a significant complexity of inherited basement structure. This study focuses on the question of the influence of crustal heat source distribution, crust and lithosphere thickness, and Moho topography

Fig. 2. Cross section of the study area at lithospheric scale. a) Uninterpreted 2D reflection seismic line 600 km in length running from West (left) to East (right), location shown on Fig. 1. The data is time migrated and displayed here with a vertical exaggeration (VE) of approximately 10 (vertical range is 5.75 sec. two-way travel time). b) Interpretation of (a) and main tectonic units.

on the past and present thermal field. The area under study is part of the easternmost Arabian Platform, and extends from the Dibdibah Trough, the Khurais-Burgan lineament, and the En Nala axis in the west, to the Qatar Arch in the east.

Temperature Data Base

We present 663 new bottom-hole temperature measurements from a total of 237 wells intersecting Ordovician to Neogene age sedimentary rocks. Overall, corrected temperatures range from 35 to 188°C and cover a depth interval between 500 m to 5700 m (Fig. 3). Temperature data in general show a linear increase with depth, indicating an undisturbed and equilibrated, conductive thermal regime.

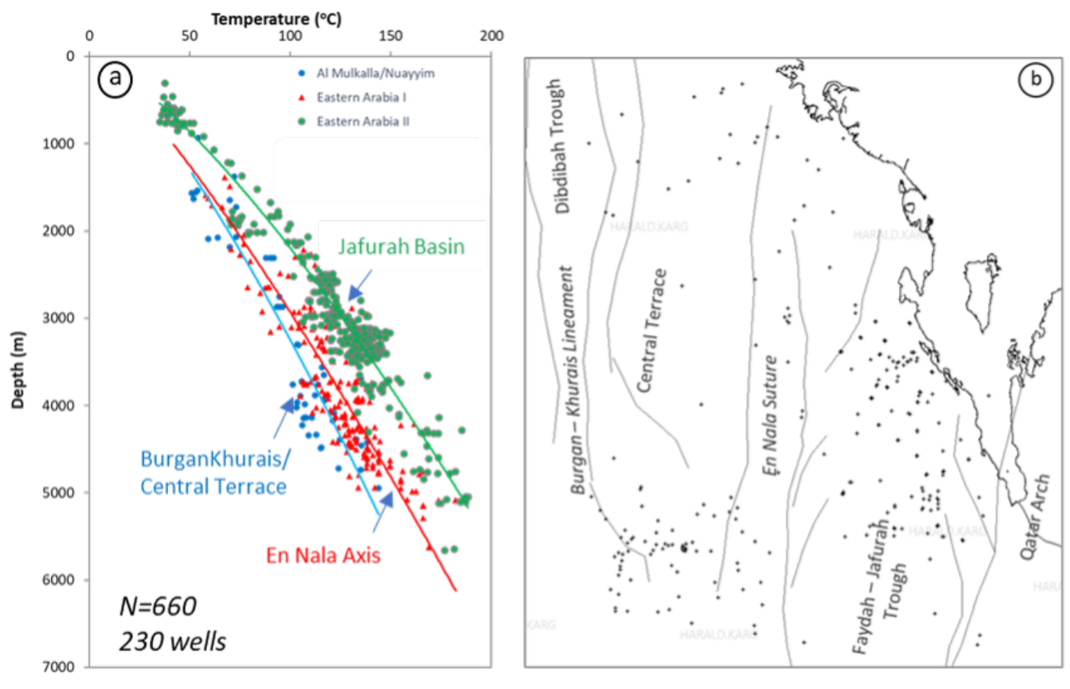


Fig. 3: Bottom-Hole Temperature data indicating increase of geothermal gradients from west to east.

The dataset clearly exhibits increasing thermal gradients from the Burgan-Khurais lineament and the Dibdibah trough in the west, the Central Terrace in the center and the FJT and the En Nala lineament in the east. No evidence exists of thermal anomalies caused by deep convective disturbances or any abrupt vertical changes in thermal conductivity.

Thermal Modeling Methodology and Parameters

A full 3-D finite element model has been development based on seismic depth markers and gravity-derived top-Basement structure. The thermal structure of the lithosphere can be approximated by the steady state solution of the thermal conductivity equation according to Fourier's Law of heat conduction:
$qz = -k\,\partial T/\partial z$,

where the heat flow qz is in mW/m2, and the geothermal gradient ∂T/∂z is in °C/km. k is the thermal conductivity, in W/m K. For each defined model layer (sediments, crustal layers), corresponding physical and thermal rock properties (Table 1 and 2) have been defined. Considering radiogenic heat sources decreasing exponentially within the crust, the equation for conductive and steady-state vertical heat transfer in its 3-D form is:
$\nabla\, 2\, T = (- A0 * e(-z/D)) / k$

with $\nabla = (\partial/\partial x; \partial/\partial y; \partial/\partial z)$; T = Temperature, °C; A = heat production, µW/m3; z = depth (km); k = thermal conductivity, W/m·K; D = the characteristic exponential heat decrement in km.

Model Layer	Rock Type/Lithology	Min. Thermal Conductivity W/mK	Max. Thermal Conductivity W/mK	mean Thermal Conductivity W/mK
Average Sediments (Jurassic and younger)	Carbonates (limestones, subordinary marls and dolomites)	2.9	3.2	3.0
Average Sediments (Cambrian to Triassic)	Sandstones (litharenites, arkosic sandstones, quartzites)	2.6	3.1	2.8
Average Upper Crust	Metamorphic rocks, granites, granodiorites, gabbros	2.0	2.9	2.5
Average Lower Crust	Pyroxen-rich, mafic granulites	2.5	2.9	2.7
Lithospheric Mantle	Spinel lherzolite	3.5	4.5	4.0

Table 1. Thermal Conductivity for sedimentary, crustal and mantle rocks used in this study. Values represent Thermal Conductivity at 20°C. For modeling, the temperature dependence of thermal conductivity has been considered.

Model Layer	Rock Type/Lithology	min RHP, µW/m³	max RHP, µW/m³	mean RHP, µW/m³
Average Sediments (Jurassic and younger)	Carbonates (limestones, subordinary marls and dolomites)			0.40
Average Sediments (Cambrian to Triassic)	Sandstones (litharenite, arkose, quartzite)+Shales	0.80	2.00*	Layer-dependent
Average Upper Crust	30% Metamorphic rocks + 70% tonalitic composition	0.95	3.3	1.10_{AMUT}-$2.50_{EAT\,I}$-$3.0_{EAT\,II}$**
Average Lower Crust	Pyroxen-rich, mafic granulites	0.06	0.50	0.28
Lithospheric Mantle	Spinel lherzolite	0.01	0.03	0.02

Table 2. Radiogenic Heat Production (RHP) for sedimentary, crustal and mantle rocks used in this study.

Thermal Modeling Results

Modeling results overall show a clear relationship between observed geothermal gradients, modelled heat flow, basement structure and the location of terrane boundaries. As perceived from the temperature-depth plot in Fig. 3, the modeled SHF (Fig. 4a) exhibits a significant increase from west to east and displays a geographical separation between two main thermal regimes, i.e., a cooler one (Fig. 4b), located west of the En Nala axis; and a hotter one (Fig. 4c) to the east, i.e., between the En Nala axis and the Qatar Arch. Overall, Surface Heat Flow values span from 44-72 mW/m2 (Fig. 4a), hence exhibiting a difference of 29 mW/m2 between its minimum in the west and the maximum in the east. The lowest mean SHF has been modeled west of the Burgan-Khurais lineament (47±2 mW/m2). Maximum SHF values of above 70 mW/m2 occur in the central Jafurah Basin. Average geothermal gradients from surface to top basement, accordingly, show an increase from west to east. In the Burgan–Khurais lineament, the Dibdibah Trough and the Central Terrace low to moderate gradients of 22°C/km, 27°C/km, and 25°C/km, respectively, are observed, whilst the higher thermal gradients around 35°C/km and 31°C/km exist in the FJT and along its western flank, respectively (Table 3).

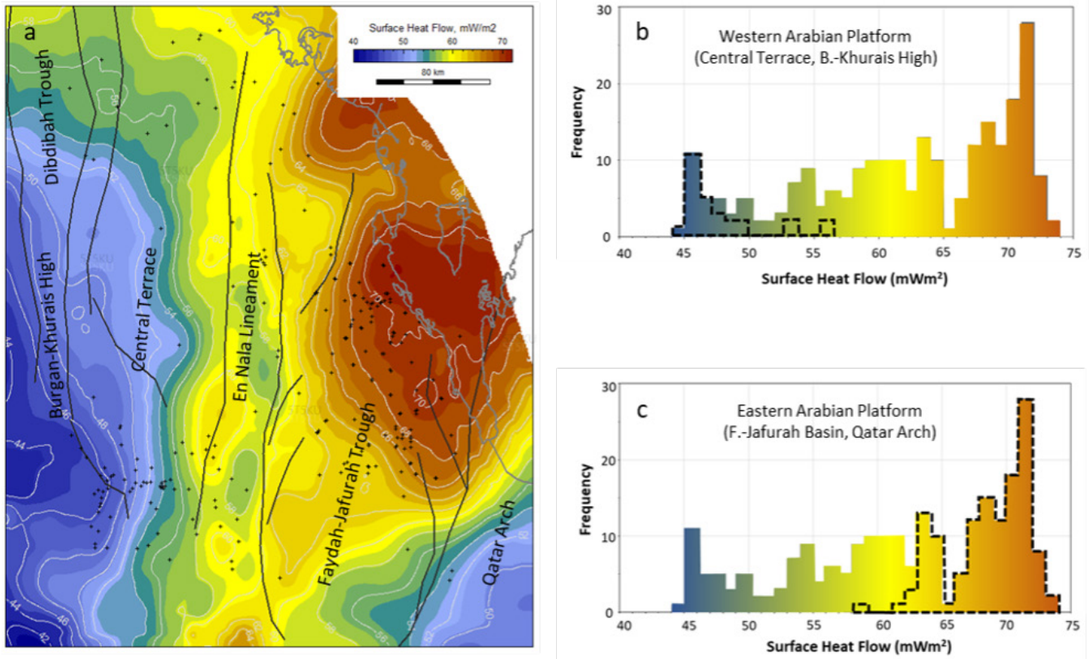


Fig. 4: Surface Heat Flow map (a) for Eastern Arabia with main tectonic elements and statistical heat flow distribution across the study area (colored b, c) determined from modeling of well clusters belonging to specific tectonic units. Dashed lines in b and c depict the modeled heat flow distribution west and east of the En Nala axis, showing a clear separation at a SHF of around 57 mW/m2.

The En Nala suture separates the geothermally hotter Eastern Arabian terranes from the cooler, western terrane province, comprising the Al Mukalla Arc, Nuayyim and Arabian Shield Terranes and the adjacent Arabian Shield (Fig. 1). At the same time, the westward decrease of surface heat flow also agrees with the findings of Gettings and Showail (1982) who determined 44 mW/m2 for the Ar Rayn Terrane and the Arabian Shield. Our model suggests a SHF of 47±2 mW/m2 for the Al Mukalla Arc and Nuayyim Terranes, located east-adjacent to the Ar Rayn Terrane, hence pointing towards an overall cooler thermal regime in the interior part of the Peninsula and on the eastern portion of the Arabian Shield.

Thermal modeling showed that regional variance in heat flow can chiefly be attributed to the effect of the radiogenic heat production within the sediments as well as within the upper crust. Sensitivity analysis of alternative thermal models described above has shown that a contrast from ~0.9 to ~3.0 µW/m3 in RHP within the upper crust between the eastern and western sector of the study area accounts for ~13 mW/m2 and the radiogenic heat derived from sediments accounts for another up to 15 mW/m2 of additional heat flux. Consequently, we can infer that the East Arabian terranes are likely built on more felsic, i.e., continental crust, as opposed to the back-arc, oceanic type crust that is associated with the western terranes and the Arabian Shield (Al-Husseini 2000; Stern & Johnson 2010; Johnson and Woldehaimanot 2013).

Tectonic Unit	Terrane	Avg. Geoth. Gradient, °C/km	Mean SHF ±SD, mW/m²	Modeled Temperature at Top Basement, °C	Crustal Thickness, km	# Wells	Source
Qatar Arch	E. Arabian II	26	53±1	191±1	38±1	3	this study
Central Faydah-Jafurah Trough	E. Arabian II	35	70±2	347±22	31±1	90	this study
Western Flank Faydah-Jafurah Trough	E. Arabian I	31	64±2	291±24	33±1	39	this study
En Nala Anticline	E. Arabian I	28	60±1	208±20	39±2	30	this study
Central Terrace	E. Arabian I	25	55±2	204±32	39±1	46	this study
Burgan-Khurais Anticline	Al Mulkalla/Nuayyim	22	47±2	157±18	40.3	19	this study
Dibdibah Trough	Al Mulkalla/Nuayyim	27	58±2	237±18	41±3	10	this study
Eastern Arabian Shield	Abas/Afifi/Ar Rayn		36-44		43±3		Gettings and Showail (1982), Al Damegh et al. (2005)

Table 3. Modeled geothermal gradients, mean SHF and mean crustal thickness of the principal tectonic units and their corresponding basement terranes identified in Eastern Arabia (Fig. 1).

07
Reader Contributions

Thermal Structure of Eastern Arabian Lithosphere: Discussion and Conclusions

This paper presents the first data-constrained heat flow model for Eastern Arabia and is based on an integrated analysis of gravimetric, magnetic, seismic and borehole temperature data. Surface heat flux at the top of the basement, i.e., after removing the effect of radiogenic heat production from the sediments, shows a systematic decrease from the eastern plate margin (72 mW/m2) towards its interior parts and the Arabian Shield (44 mW/m2), which we explain by variations in radiogenic heat production across basement terranes. The lithospheric radiogenic heat contribution to the total SHF accounts for 50-57%, and the Moho heat flux for 43-50%, accordingly. Matching borehole temperature data above the East Arabian sub-terranes requires the assumption of elevated RHP in the order of 3 µW/m3, compared to around 1 µW/m3 on the internal Arabian Platform, hinting towards a compositional gradient from more mafic to more felsic crust, on the central Arabian Platform and Arabian Shield and the eastern portion of the Peninsula, respectively. This is supported by deep wells intersecting rocks of granitoid composition east of the Arabian Shield. Phanerozoic heat flow evolution and basin formation are strongly coupled and directly related to endogenic process in the underlying lithosphere.

Eastern Arabian basins rest on well-differentiated, layered and thermally equilibrated lithosphere. Upper and lower crustal thickness are fairly homogeneous across the Arabian Plate and have likely been in that state throughout the Phanerozoic as chemical differentiation occurred prior to accretion.

Heat flow and geology are intimately related. The endogenic mechanism of Phanerozoic basin formation is thermal subsidence of a formerly depleted and increasingly densifying mantle lithosphere, causing gradual deepening of the upper lithosphere boundary isotherm (=1300 °C, aka LAB: Lithosphere-Asthenosphere Boundary). Superimposed effects of thermal blanketing by sediments, the secular radiogenic decay, mostly within the crust, caused heat flow to decrease gently since accretion towards present day levels.

We thus postulate that heat flow evolution over time, i.e., since accretion of the Arabian Plate, is a function of both the composition of the basement substrate and the change of the LAB depth during post-collisional thermo-isostatic processes. The present-day surface heat flux, albeit lower than during initial crustal accretion, is largely equilibrated, but still carries the signal of an intrinsically heterogenous crustal composition. Since the Late Proterozoic, the crust in Eastern Arabia has been largely stable. Crustal stratification, characteristic for most of the Arabian Plate, is an expression of long-lasting differentiation processes, which by itself represents a necessary condition for crustal stability and thermal equilibrium.

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72% of this article comes from: Effect of Precambrian basement structure on heat flow distribution in Eastern Arabia Original Paper Published: 09 July 2024, Int J of Geosciences, Volume 113, pages 2327-2356, (2024)
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Reader Contributions

GREEN HEAVEN: A JOURNEY THROUGH OMAN'S JEBEL AL-AKHDAR

By Zainab Almubarak

On the early morning of April 19, 2024, with the golden sunlight greeting us, we set off for Jebel Al-Akhdar, which means “The Green Mountain” in Arabic. It is part of the Al Hajar mountain range, located 150 km from Muscat—a journey that took us approximately two and a half hours. A four-wheel drive was required as we ascended through serpentine roads, climbing breathtaking heights of 3,000 meters above sea level. My friend and I had booked the trip through a travel agency, and we were joined by two other female friends.

Our primary goal was to witness the blooming of the famous Damask roses and experience the harvesting process, which takes place from mid-March to the end of April. However, the road trip itself was a spectacular experience, offering breathtaking views of the region’s folded mountains. The area holds a rich geological history spanning hundreds of millions of years. Around 300 million years ago, during the late Paleozoic to early Mesozoic periods, the Al Hajar mountains began forming as part of the ancient Tethys Ocean. Later, during the Late Cretaceous Period, the Arabian and Eurasian tectonic plates collided, triggering intense tectonic activity and exposing oceanic crust onto the continental crust, forming the magnificent ophiolite sequences seen today. These ophiolites reveal layers of the Earth's interior, including peridotite, gabbro, and basaltic rocks. Over millions of years, continued uplift and erosion shaped Jebel Al-Akhdar into its present form.



Our first stop was Bait Asarh—meaning "House of Asarh"—a family-run rose water factory passed down through multiple generations. As we stepped into the factory, we were instantly enveloped in the floral, bright aroma of Damask roses, a scent both welcoming and calming. The local rose-pickers explained the traditional techniques used to extract pure rose water, employing ancient mud ovens known as Al-Duhjan. This method imparts a subtle smoky essence to the delicate liquid. The hosts warmly welcomed us with Omani coffee delicately infused with rose water.

Next, we visited the rose garden, where we learned the proper way to harvest the roses. The garden was filled with visitors, all captivated by the experience and eager to capture the moment amidst the vibrant pink blooms. The sight of giant baskets overflowing with freshly picked roses transformed the garden into a living canvas of color, joy, and tradition.



Our tour guide then took us to Anantara, a luxurious five-star resort perched atop Jebel Al-Akhdar. The resort's infinity pool, seemingly suspended above the dramatic valleys and cliffs of the Al Hajar mountains, was a breathtaking sight. Afterward, we headed to Birkat Al Mauz, meaning "Pool of Bananas," a historic village at the foothills of Jebel Al-Akhdar. We strolled beside lush banana plantations toward the traditional Falaj irrigation system, parts of which date back over 1,000 years. This remarkable system was designated a UNESCO World Heritage Site in 2006.

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We concluded our adventure with a meal at a traditional Omani restaurant, savoring local cuisine after a long day of exploring the mountains. This journey felt like traveling through time, from the ophiolite-covered mountains that tell a story of millions of years to the ancient agricultural traditions of Birkat Al Mauz, and finally, to the delicate art of harvesting and distilling rose water.

Our tour guide was both generous and enthusiastic, revealing hidden gems beyond our original itinerary. The experience was not only about the region's unique climate and landscape but also about discovering its profound geological and historical treasures.





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A Glimpse into DGS 2023

MEOS GEO SHOW



DGS made a significant impact at the MEOS GEO 2023 conference held in Bahrain, demonstrating its commitment to promoting geoscience in the region. The society's participation in the conference was marked by a series of successful activities and events.

One of the highlights of the conference was the visit of Saudi Aramco's Senior Vice President of Exploration Mr. Samer Al-Ashgar and members of Exploration Management, who showed support for the DGS team and encouraged them to continue their efforts. This visit added to the excitement and enthusiasm of the DGS team, highlighting the society's importance in the field of geoscience.

DGS and the Society of Exploration Geophysicists (SEG) co-hosted the SEG-DGS Challenge Bowl Competition, providing a platform for students in the region to showcase their talents and compete for a chance to participate in the SEG International Challenge Bowl at IMAGE 2023 conference in Houston, Texas later this year. This competition was a great opportunity for students to demonstrate their knowledge and skills in geoscience, while also promoting interest in the field among the younger generation.



The DGS booth offered visitors a chance to participate in a treasure hunt and live geo-trivia. These activities were well received, attracting participants from various international societies, universities, and companies. The booth also provided an opportunity for the DGS President and Executive Committee to showcase the society's mission and goals for 2023, encouraging visitors to join and become members of the society.

As a result of their successful participation, many visitors joined DGS as members of the society, expanding the Society's reach and impact. Overall, the DGS's participation in the MEOS GEO 2023 conference was a resounding success, reflecting the society's commitment to promoting geoscience in the region.



Dinner Meetings: March Dinner

WILL ACADEMIA MAKE THE LEAP?

by Dr. Muhammad Al-Saggaf

On March 14, 2023, DGS hosted the president of King Fahad University of Petroleum and Minerals (KFUPM), Dr. Muhammad Al-Saggaf, as a distinguished speaker for the DGS first 2023 dinner meeting. The event took place at the Grand Hyatt Hotel in Al Khobar and was attended by more than 300 people. Inspired by the fourth industrial revolution and its disruptive trends in numerous fields, including but not limited to digitization, big data, hydrogen mobility, and robotics, Dr. Al-Saggaf's presentation titled "Will Academia Make the Leap?" was intriguing, engaging, and inspiring. He shed light on the critical aspects of academia and explored their relationship to expanding local and global economies, developing technologies, and advancing human societies, he referred to three keys to "making the Leap."

While navigating the role of academia in making the leap, Dr. Al-Saggaf emphasized the tremendous efforts recently deployed in KFUPM to align with the expansion and creation of future sectors that meet increasing business and technology demands. Among such efforts are 14 newly introduced programs, 40 concentrations, and 35 new master's degree programs. Dr. Al-Saggaf explained how the design of each of those programs was meticulous and done with economic needs in mind.

One aspect of academia's role that Dr. Al-Saggaf shared was the relationship between the needed investment and talent. It was highlighted that both investment and talent are required to make the necessary transformations and that one cannot replace the other. Furthermore, the type of talent being developed in academic programs is equally important with economy-creating talent being the most needed for creating future sectors. The attitude of academic institutions towards technology was another critical factor that Dr. Al-Saggaf highlighted, explaining that academia should be "tech leaping"; in other words, academic institutions need to be constantly inventing and pioneering new technologies.

In addition to being the local academic hub for petroleum and other engineering disciplines, KFUPM has a newly aligned direction that maintains its legacy of graduating industry and business leaders, while simultaneously pushing the envelope to stay ahead of the curve. This is reflected in the University's intake of female students, which is among the highest in the world, and its competitive position in interdisciplinary programs besides engineering and sciences. Dr. Al-Saggaf left the audience with a resonating takeaway, i.e., "will academia make the leap? No, Academia will drive the leap."

Organized by the DGS Professional Development Committee, this successful gathering welcomed nearly 350 guests from several Saudi Aramco admin areas and departments, visitors from various sectors within the Kingdom, as well as current geosciences students of the College Preparatory Program (CPP). The event kicked off with a celebratory stand honoring our beloved country's first Flag Day, followed by opening remarks from DGS President Musab Al-Modrra. After that, Dr. Al-Saggaf walked the attendees through an incredibly enriching and engaging talk that explored KFUPM's strong position in unlocking local and global talent through the university's newly introduced and integrative graduate programs. The inspirational ideas shared by Dr. Al-Saggaf painted a clear picture of how academia is likely to not only take but drive the leap to expand economies, develop technologies, and advance human societies.



JUNE DINNER MEETING

On June 13th, a significant event unfolded under the auspices of DGS—a dinner gathering with a clear mission: to shine a spotlight on the pivotal contributions made by the Saudi Geological Survey in the context of Saudi Arabia's ambitious Vision 2030. Orchestrated with precision, the event was a platform for meaningful discussions.

Drawing a crowd of around 200 attendees, the evening took the form of an engaging panel discussion, masterfully guided by Dr. Mohammed Al Duhailan, the Director of the Exploration Resource Assessment Department. The panel was an assembly of luminaries, with Mr. Abdullah Al-Shamrani, CEO of the Saudi Geological Survey, Mr. Abdulrahman Alhawi, Vice President of Saudi Geological Survey for Initiatives and Strategic Projects; and, Dr. Abdullah Al-Nabhan, Senior Director of the Survey and Exploration Center at Saudi Geological Survey; sharing their insights.

The heart of the dialogue was dedicated to the Saudi Geological Survey's groundbreaking project—a comprehensive survey of the Arabian Shield to unearth substantial mineral deposits. This endeavor, acclaimed as the largest in the mining sector, is meticulously designed to fortify the third economic pillar of Saudi Arabia, as envisaged by Vision 2030.





Conversations spanned a wide spectrum, covering the indispensable role of the Saudi Geological Survey in realizing Vision 2030's objectives, the transformative influence of the initiative on specialized earth sciences, and the promising trajectory and aspirations shaping the realm of geology in Saudi Arabia.

The event was a convergence of minds aligned with a shared vision. The discussions transcended the surface, delving deep into the implications, opportunities, and challenges that come with steering a sector towards a brighter future. With the Saudi Geological Survey at the forefront of this discourse, the event highlighted the present efforts and offered a glimpse into the potential that lies ahead.

As the night unfolded, under the glow of shared perspectives and collaborative spirit, the dinner event cemented itself as a cornerstone in the ongoing narrative of Saudi Arabia's progressive journey. It underscored the significance of interdisciplinary collaboration and the pivotal role that organizations like DGS play in shaping the nation's trajectory. The gathering, illuminated by the insights of accomplished experts and visionaries, left a lasting impression—one that resonates far beyond the evening itself.

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A Glimpse into DGS 2023

OCTOBER DINNER MEETING

In October, the Dhahran Geosciences Society (DGS) hosted a professional meeting that left a lasting mark. The event featured a captivating presentation by Edward Wiarda, President of the European Association of Geoscientists and Engineers (EAGE). Wiarda's presentation, titled "Energy Transition: The Journey Ahead," explored key themes:

Obstacles and Solutions: Wiarda delved into the formidable challenges and barriers the energy industry faces in its transition to sustainable practices. He not only highlighted these hurdles but also offered potential solutions and strategies to navigate the path to sustainability. He emphasized the vast renewable energy resources in the Middle East, signaling the region's potential to become a global leader in sustainable energy practices.

Role of the New Generation: Central to Wiarda's talk was the crucial role that the younger generation plays in shaping the future of the energy sector. He emphasized the significance of young professionals in spearheading innovation, implementing sustainable practices, and steering the industry toward a more sustainable energy landscape.

Collaboration: Wiarda placed a spotlight on the importance of collaboration in addressing the intricate challenges within the energy sector. He emphasized the value of working closely with organizations like Aramco and other geoscience societies to foster knowledge sharing, stimulate innovation, and collectively advance the goals of the energy transition.





The event was a tremendous success, thanks to the concerted efforts of all attendees and the unwavering dedication of the Professional Development Committee. This gathering offered a valuable platform for professionals in the geosciences field to gain profound insights into the critical issues pertaining to energy transition and sustainability. Edward Wiarda's presentation shed light on the industry's challenges and opportunities, inspiring attendees to actively engage in shaping a more sustainable and innovative energy landscape for the future.

Much like previous events, this gathering highlighted the pivotal role organizations like DGS play in shaping Saudi Arabia's journey toward progress and sustainability. The event was illuminated by the wisdom and expertise of accomplished professionals and visionaries, creating a lasting impact that goes beyond the evening.

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A Glimpse into DGS 2023

Luncheon Meetings:

JUNE LUNCHEON

In June 2023, the Dhahran Geoscience Society (DGS) organized a technical event focused on Multidisciplinary Research Applications for Understanding the Geological Complexities of Unconventional Reservoirs. The gathering brought together industry experts, researchers, and students to discuss advancements in this critical field within the oil and gas sector.

The event featured a keynote presentation by Dr. Korhan Ayranci from King Fahd University of Petroleum and Minerals (KFUPM), a leading expert in unconventional reservoirs. Dr. Ayranci provided a comprehensive overview of the geological intricacies associated with these reservoirs, offering valuable insights into the challenges and opportunities they present.

Among the distinguished attendees were Samer Ashgar, Senior Vice President of Exploration, and Hafiz Shammery, Vice President of Exploration. Their presence underscored the significance of the topic and the industry's commitment to advancing research in unconventional reservoirs.

With an audience of 150 industry professionals, researchers, and students, the event fostered meaningful discussions and knowledge exchange. Attendees actively engaged with Dr. Ayranci's presentation, gaining a deeper understanding of the evolving landscape of unconventional reservoir exploration and development.

This successful event highlighted the importance of ongoing research and interdisciplinary collaboration in tackling the complexities of unconventional reservoirs. As the energy industry continues to adapt to new challenges, such initiatives play a crucial role in shaping the future of exploration and resource development.

SEPTEMBER LUNCHEON

On September 21st, DGS hosted Chief Operating Officer and Co-Founder of Reykjavik Geothermal, Gunnar Orn Gunnarsson. Mr. Gunnarsson holds over 40 years of experience in the manufacturing and energy industries and is a board member of several portfolio companies including some of the world's leading geothermal development projects. He is the former CEO of Iceland's venture capital fund, and a board member of many small and medium sized companies. Mr. Gunnarsson's talk, titled 'Geothermal Development at a Global Scale' took place at the Plaza Conference Center, where over 100 geoscience and engineering professionals gathered to listen to his great insights on global geothermal advancements, including case studies from Iceland, Turkey, and the United States.

The need for cleaner and more sustainable energy positions geothermal resources at the forefront of future exploration endeavors, motivated by this notion, Mr. Gunnarsson's presentation served as a high-level overview of key concepts related to project development phases, the advantages of geothermal energy, the surface development work needed prior to drilling wells, and a comparison between geothermal drilling and oil and gas drilling. The talk started with a brief description of geothermal energy and an illustration of where it is globally found based on geological setting. Following that, Mr. Gunnarsson emphasized the significance of geothermal energy by highlighting its advantages against the challenges faced by renewables, such as geothermal's low cost and its small geographic footprint. As for the essential groundwork required prior to drilling wells, geological, geochemical, and geophysical studies were emphasized as the main subjects of investigation that can set the stage for a successful geothermal well.

Mr. Gunnarsson's comparison between geothermal and oil and gas drilling demonstrated the opportunities that lie ahead with the similarities between the two leveraging transferable knowledge, and excitingly paving the way for a smooth energy transition. Applications of geothermal energy at different temperatures were showcased to bring diverse and multifaceted benefits to sustainability and a green future. Attendees had the opportunity to learn about the latest innovations in geothermal technology, such as enhanced geothermal systems and binary cycle power plants which are pushing the boundaries of geothermal energy production.

The case studies featured in the talk included some of the most notable geothermal success stories, which highlighted the potential of this green energy source in reducing carbon emissions, increasing energy security, and promoting sustainable development.

The event concluded with insightful questions from the audience that were met by enriching understandings stemming from Mr. Gunnarsson's vast experience and deep knowledge of the domain.



DGS IN NUMBERS

Igniting Interest: DGS and Social Media's Role in Fueling Gulf Area's Geoscience and Oil & Gas Industry Social media has emerged as a powerful tool to ignite interest and amplify engagement in specific industries. In this article, we explore the significance of social media, including LinkedIn, Instagram, and the social media channels of the Dhahran Geoscience Society (DGS), in fueling interest within the Gulf area's geoscience and oil & gas sector. DGS utilizes social media platforms such as LinkedIn and Instagram to enable focused outreach, connecting individuals in the Gulf area with a keen interest in geoscience and the oil & gas industry.

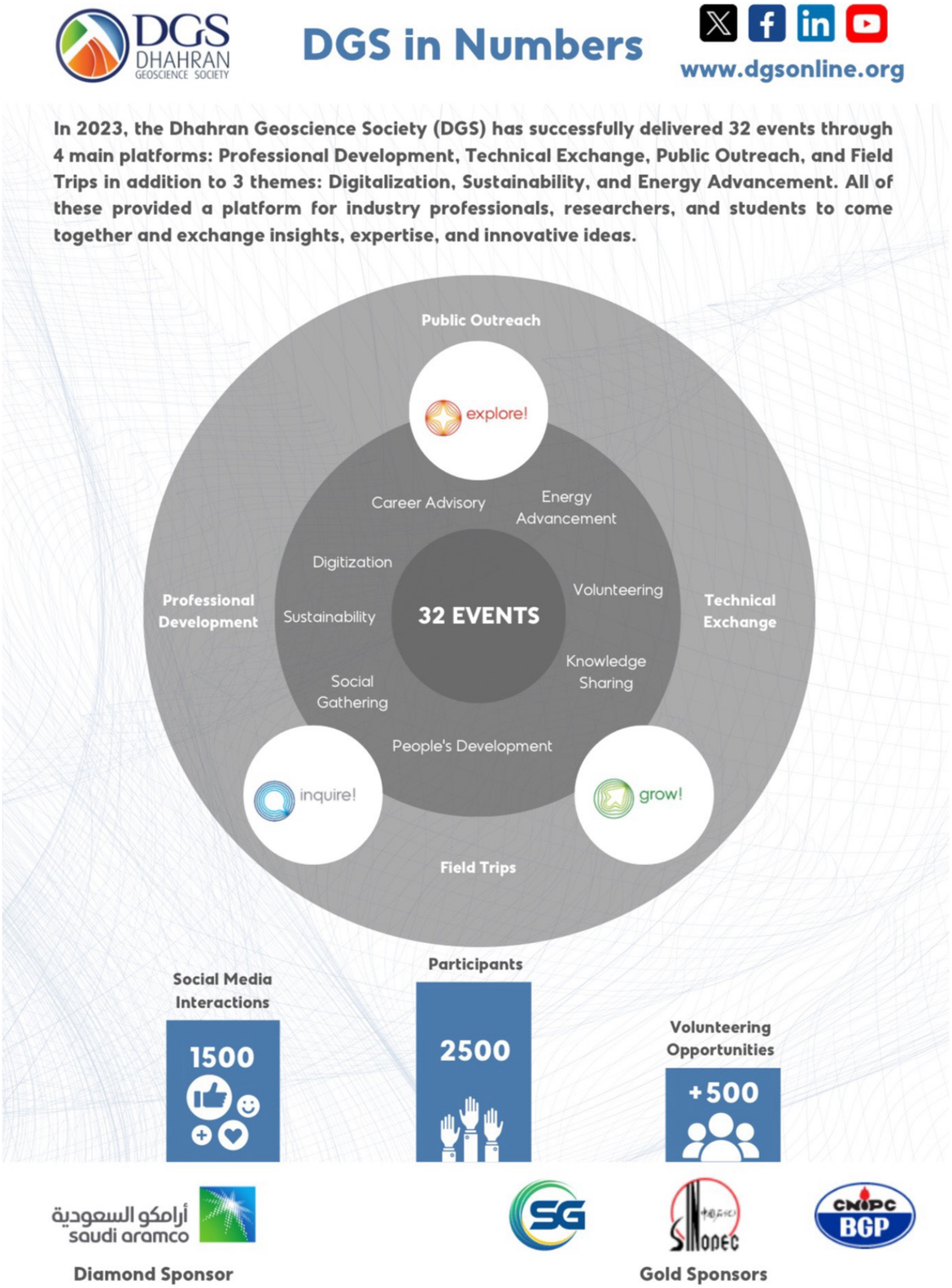
DGS's social media channels provide tailored content, networking opportunities, and updates specific to the region. Through its social media presence, DGS shares valuable insights, research findings, geoscience news, and technical articles related to the Gulf area's geology and oil & gas sector.

This facilitates the exchange of knowledge, promotes learning, and encourages collaboration among geoscience professionals, experts, and enthusiasts. DGS utilizes its social media platforms to promote and host virtual events, webinars, workshops, and conferences focused on geoscience and the oil & gas industry in the Gulf area.

These events bring together industry leaders, researchers, and professionals, providing a platform for sharing expertise, discussing advancements, and fostering professional growth. DGS's social media channels serve as a platform for highlighting conferences, internships, scholarships, and research positions within the geoscience and oil & gas sector in the Gulf area. These platforms help connect aspiring individuals with potential career prospects and educational avenues, contributing to the development of a skilled workforce.

Social media, including platforms such as LinkedIn, Instagram, and X are utilized by DGS as they play a vital role in fueling interest and engagement within the Gulf area's geoscience and oil & gas industry.

By leveraging targeted engagement, knowledge sharing, virtual events, and showcasing opportunities, DGS's social media presence empowers professionals, enthusiasts, and aspiring talent to thrive in this dynamic sector, fostering a vibrant geoscience community within the Gulf region.



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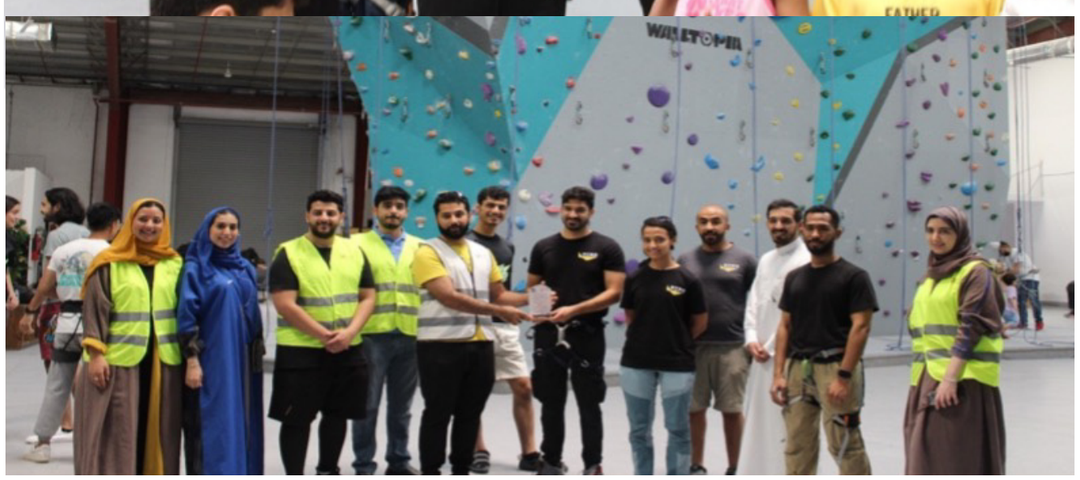
Rock Climbing

In a heartwarming display of compassion and community spirit, the Dhahran Geoscience Society (DGS) recently partnered with an orphanage organization and Dyno Indoor Climbing Center to create a memorable day for thirty-five children in need. It wasn't just about climbing walls—it was about helping these young hearts scale new heights of hope and possibility.

The highlight of the event was undoubtedly the radiant smiles on the children's faces. For them, it wasn't just a day of climbing; it was an opportunity to dream big and discover the endless potential life has to offer.

This special day symbolized hope, support, and a brighter future for these children. It stood as a testament to the profound impact of community, collaboration, and compassion, inspiring the children's dreams and aspirations.





PMU Student Visit to BGP

The Dhahran Geoscience Society (DGS) organized a successful event on May 4th, 2023, which involved a visit to the BGP Town base camp in Dhahran. The event was designed for engineering students from Prince Mohammad Bin Fahd University (PMU) and aimed to provide them with insights into seismic acquisition. During the visit, students had the opportunity to observe a live demonstration of seismic equipment, including the seismic vibrator and geophones.

The feedback from the students was overwhelmingly positive, highlighting the event's value in providing informative and engaging experiences. Such events play a crucial role in inspiring and educating the next generation of geoscientists while fostering a sense of community within the field.

DGS expressed its gratitude to BGP for hosting the event and for their contributions to the geoscience community.





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