AL HAJAR

31ST EDITION | AUGUST 2021

GSO unveils its New Logo

Sedimentological Characteristics of the Upper Jurassic to Lower Cretaceous Bau Limestone and Pedawan Formations, East Malaysia.

Dr. Alan Heward in the Interview of this Issue

How Remote Sensing Can Be a Variable Tool in Geo-Sciences and Climate Change Studies?

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ABOUT GSO

The Geological Society of Oman GSO was established in April 2001 as a vocational non profitable organizations which aims to advance the geological science in Oman, the development of its members and to promote Oman's unique geological heritage.

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BY THE EDITOR

Dear readers,

We are back this time, and we are bringing something new, that is likely to find a new soul in the Geological Society of Oman. After twenty years from the establishment of the GSO, the Society has launched the new logo, which was designed to find harmony and homogeneity between the Omani geology and the general geological concepts.

Internationally, the Department of Earth Sciences at Sultan Qaboos University participated in the Imperial Barrel Award (IBA) Competition, and they won second place worldwide in this annual competition in the USA. Congratulations on this achievement!

The Al Hajar Magazine and its team is working forward to provide a hearty and convenient meal to our dear readers through our publications, so we also welcome your contributions and suggestions to the magazine.

Yousuf Al Darai

Al Hajar Magazine Editor

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ON THE COVER	*Photo By : Afifa Al Hashim (A photo from Wadi Ta'ab)* *Instagram: @TheDabdoob*

THE SULTAN QABOOS UNIVERSITY TEAM ACHIEVED THE SECOND PLACE IN THE IBA COMPETITION GLOBALLY

IMPERIAL BARREL AWARD

AAPG Imperial Barrel Award
A Joint Program of AAPG and the AAPG Foundation

Imperial barrel award (IBA) is an annual geoscience competition organized by AAPG. IBA was initially an MSc course unit in the Imperial College London. However, AAPG adopted the program in 2007 as an annual prospective basin evaluation competition between universities worldwide. Since then, graduate geoscience departments have participated in IBA to win funds for their departments and international recognition for scoring one of the first three places. The program consists of two phases. In the first stage, universities compete on a regional scale. The winning teams from the first stage qualify for the finals to compete against 12 universities, 6 of which from the USA sections and the remaining from the rest of the world regions.

Technically, the IBA runs for an intensive eight-week period during the global stage in which the teams analyze a dataset of various aspects (geology, geophysics, petrophysics, petroleum engineer, etc.) comprising all nature of hydrocarbon field in its exploration phase. This is followed by teams delivering their results in a 25-minute presentation in front of an industry-expert judges panel. The winning team qualifies for the finals based on the technical broadness of multi-discipline integration, quality, clarity, and teamwork organization of the presentation. In addition, students get the chance to work with industry cutting-edge commercial and open-source software packages with mentoring from industry -leading professionals.

The Middle East region started participating in 2010 with mainly undergraduate students. Over the region, Sultan Qaboos University teams secured the first place in most of the competitions they participated in and was the only university from the Middle East region that participated in all IBA competitions from 2010.

Internationally, in 2011 the SQU team gained experience and won 3rd place internationally with a group of undergraduate students competing against postgraduate students from well-recognized universities worldwide. In 2013, the SQU team won again 3rd place internationally. In 2021, the SQU team proved their talents and raised the bar to a higher level by winning 2nd place internationally. The team demonstrated extraordinary professionalism analyzing the dataset rigorously and critically, delivering outstanding prospectivity evaluation of the field under investigation. Despite the difficulty of holding physical meetings due to the COVID19 pandemic, the team expressed great harmony and made everyone proud of this achievement.

The table below summerizes various achievements accomplished by SQU teams in this competitive and prestigious program. The list reflects the high caliber and quality of the undergraduate program at the SQU Earth Science department.

The Earth Science department, led by Dr. Talal Al Hosni is a great advocate and supporter of such programs, which enriches students' experience and prepares them for career life. He also encourages students to be proactive and exploit every possible opportunity to build their skills to be better geoscientists.

YEAR	ACHIEVEMENT
2010	2nd place winner in the Middle East
2011	3rd place winner globally
2013	3rd place winner globally
2014	1st place winner in the Middle East
2015	2nd place winner in the Middle East
2016, 2017, 2018, 2019	1st place winner in the Middle East
2019	Teamwork excellence award winner globally
2020	2nd place winner in the Middle East
2021	2nd place winner globally

At the end, GSO would like to take this opportunity to congratulate all SQU IBA teams from 2011 to present who contributed to this historical record of the university and the Sultanate. Well done to SQU IBA 2021 members namely, Salma Al Rahbi, Thuraiya Al Harthi, Said Al Farsi, Marwa Al Hadhrami and Iman Al Fazari and their faculty advisors Dr. Mohammed Farfour and Dr. Khalil Al Hooti. GSO wishes you a successful career after graduation. Hopefully, in the coming years, SQU builds up upon your experience and aims for the championship.

The Details of GSO New Logo

الجمعية الجيولوجية العمانية
Geological Society of Oman

Design by :
Yasir Abdullah
Al Hasni

CONCEPT

The colors represent the different Geological Time Era's

- CENOZOIC
- MESOZOIC
- PALEOZOIC
- PRECAMBRIAN

The letter "GSO" is an abbreviation of Geological Society of Oman and "Since 2001" is the year of establishing society

The small circles in the logo are symbols that present Oman Geology as hidden gems.

The disarrangement appearance of GSO letters is indicative of the different topography of the Sultanate of Oman.

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Geological Society of Oman الجمعية الجيولوجية العمانية

Sedimentological Characteristics of the Upper Jurassic to Lower Cretaceous Bau Limestone and Pedawan Formations, East Malaysia.

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INTRODUCTION

The Northwest Borneo is divided into three geotectonic zones which are the Miri, Sibu, and the Kuching Zone (Haile, 1974; Hutchison, 2005). Recent research revealed that the Kuching Zone is part of a convergent margin of Sundaland and is comprises of Paleozoic to Mesozoic successions in the south which are overlain by undeformed Upper Cretaceous to Cenozoic sediments in the north (Breitfeld et al., 2017, 2018). In recent years, geological and geochronological investigations of the Cretaceous successions of the Kuching zone has been undertaken by Breitfeld et al., (2017, 2018) and Breitfeld and Hall, (2018). The Uppermost Cretaceous to Eocene sedimentary successions of the Kuching zone has been investigated by Breitfeld at al. (2018). However, the sedimentological characteristics of the Upper Jurassic to lower Cretaceous successions of the Kuching zone is limited (Soon, 1992).

In this article we briefly describe the lithofacies and the petrographic characteristics of the Bau limestone and the Pedawan Formations exposed in and around the Bau town.

The Bau limestone and the Pedawan Formations constitutes the Upper Jurassic to Lower Cretaceous successions of the Kuching Zone (Fig. 1A-B). In this article we briefly describe the lithofacies and the petrographic characteristics of the Bau limestone and the Pedawan Formations exposed in and around the Bau town. We also infer the provenance characteristics of the Pedawan Formation.

GEOLOGICAL BACKGROUND

The Pedawan Formation conformably overlies and locally interfingers with the Upper Jurassic to Lower Cretaceous Bau Limestone (Wilford and Kho, 1965). Wilford and Kho (1965) subdivided the Pedawan Formation into the Lower (Upper Jurassic to Lower Cretaceous), Middle (Aptian to Cenomanian), and Upper (Turonian to Maastrichtian) members based on the lithological characteristics and fossil content. The Pedawan Formation is unconformably overlain by the fluvio-deltaic Kayan Sandstone (Upper Cretaceous to Oligocene).

Youngest zircon populations from the volcaniclastic rocks of the topmost Pedawan Formation indicate continuation of volcanic activity until c. 86 million years (Breitfeld et al., 2018).

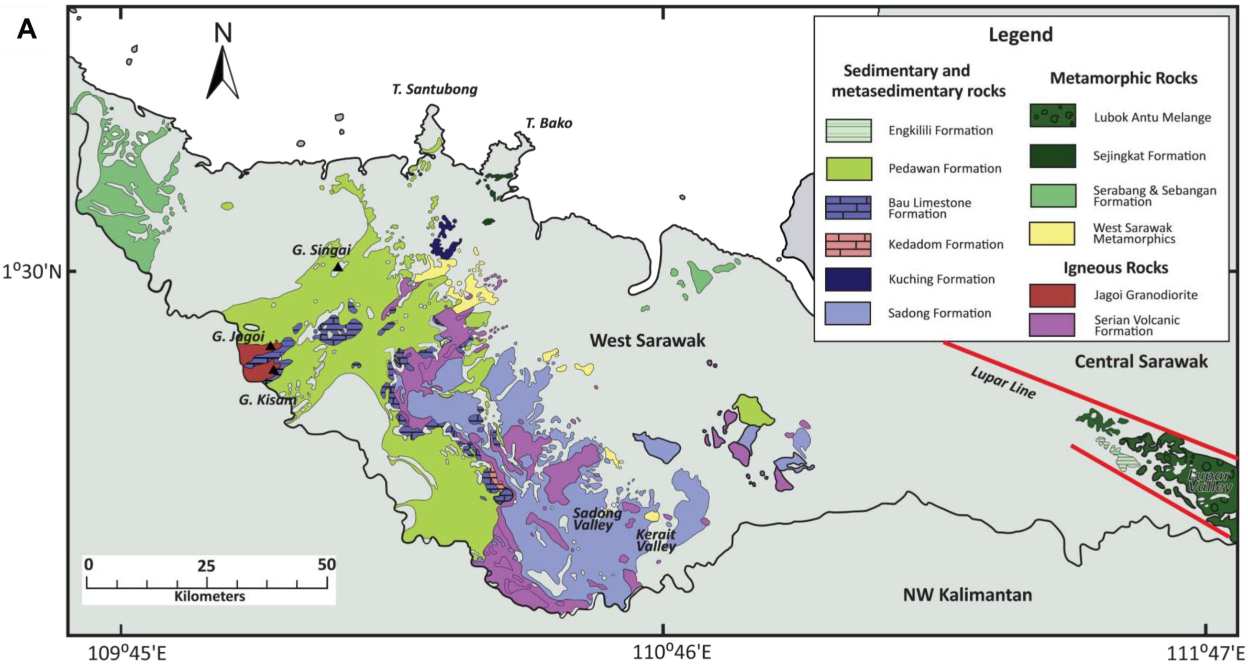
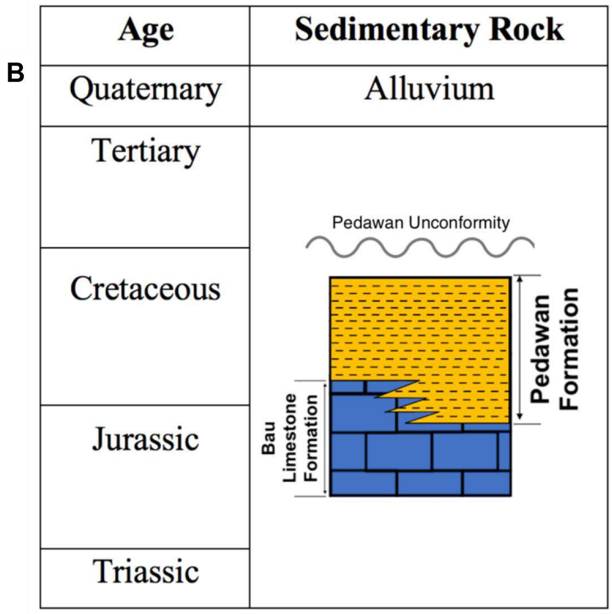


Figure 1: (A) Geological map of the Pedawan Formation and its bounding Formations in and around Bau, east Malaysia (modified after Breitfeld et al, 2018). (B) Stratigraphic position of the Bau limestone and Pedawan formations (after Soon, 1992).



LITHOFACIES

The Bau Limestone Formation is made of conglomerate, sandstones and limestones. The Bau limestone is the uppermost member of the Bau Limestone Formation (Soon, 1992). It is a white to grey colored fossiliferous limestone with oolite (Fig. 3A -B) and intraclasts. The limestone is generally massive with poor bedding and pure. Soon (1992) has subdivided the Bau limestone in four categories: massive, poorly bedded, nodular and brecciated limestones. The Bau limestone contains a few sandstone beds, indicating intermittent break in carbonate sedimentation (Soon, 1992). The lithological characters and fossil content of the Bau limestone suggest that it was deposited in a warm, shallow marine tropical to sub-tropical sea and represent a reef (*skeletal limestone deposits formed by organisms*, see Soon, 1992).

The Pedawan Formation is characterized by alternating beds of dark grey shale and fine-grained sandstone (Fig. 2A).

At places, the Pedawan Formation is partly intercalated with the Bau limestone Formation (Soon, 1992). However, in the study area, no intercalation with conglomerate and limestone has been observed. A few blocks of limestone have been observed within the shale facies of the Pedawan Formation. The Pedawan Formation conformably overlies the Bau Limestone and is in turn, unconformably overlain by the Kayan sandstone.

The Pedawan sandstones and siltstones are interbedded with the shales and these interbedded lithological associations are laterally persistent (Fig. 2A). The base of the sandstone beds often bears sole marks (Flute casts) (Fig. 2B). The sandstones sharply overlie the shale units with erosional contacts and have a variety of small scale primary sedimentary structures like laminations, strongly asymmetric ripples and ripple cross-laminations, graded beds and penecontemporaneously deformed beds (Fig. 2C).

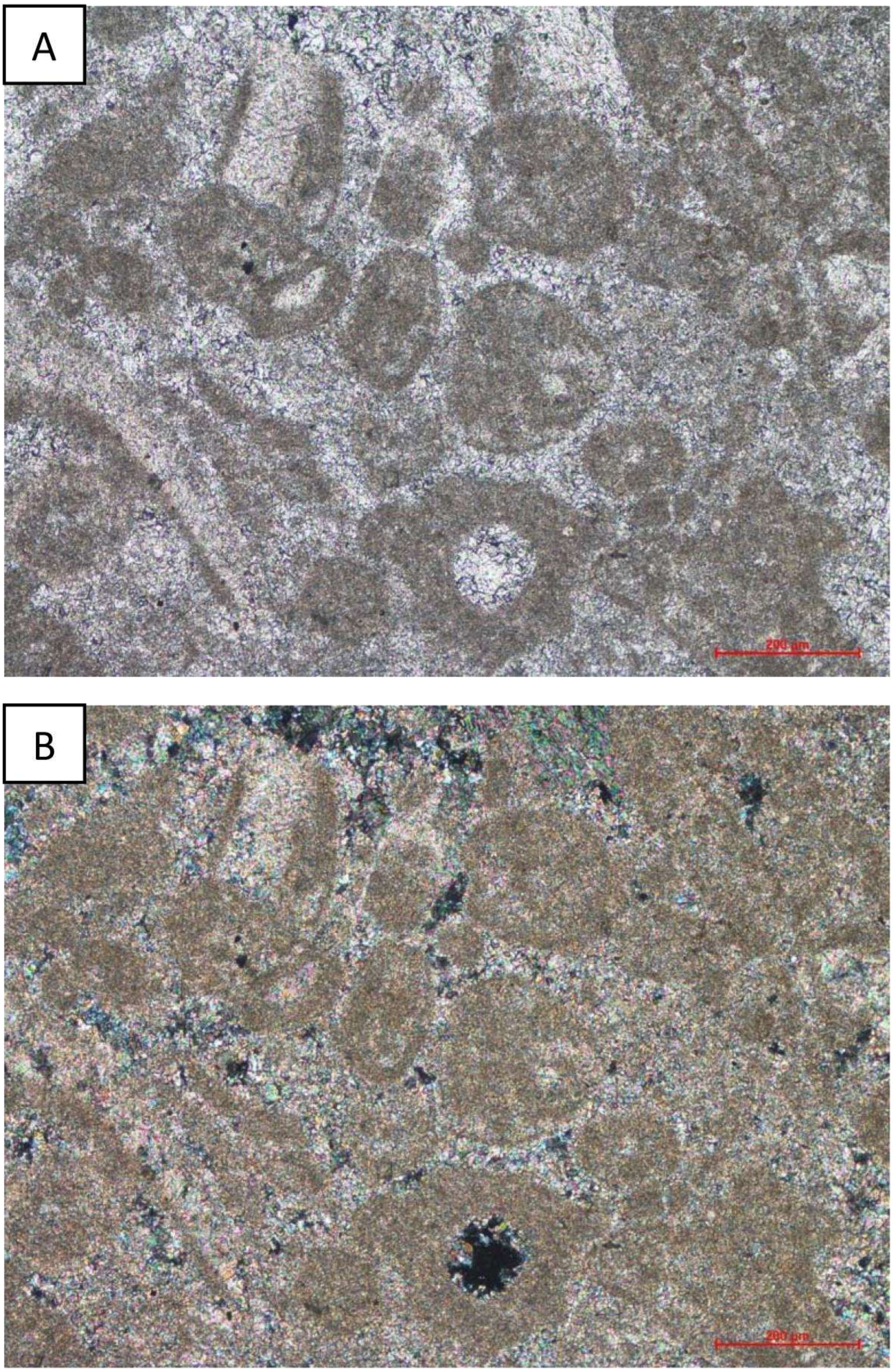


Figure 3: Photomicrographs of Bau limestone: (A) under plane polarized light and (B) between cross-polars; note ooids with concentric ring; in some ooids, the nucleus is made of micrite, indicating intragranular porosity (see Boogs, 2009; Tan et al., 2012).

A

B

C

Figure 2: Pedawan Formation: (A) Laterally persistent sandstone-shale alternation, Bau, Kuching. (B) Flute casts within Pedawan sandstone, Bau, near Kuching (hammer length 42 cm). (C) Complex penecontemporaneous folding with oppositely facing closure (hammer length 42 cm).

The persistent sandstone-shale banding, erosional lower contact of the normally graded sandstone beds with flute cast, in combination with strongly asymmetric ripples, parallel laminated bedding and massive beds indicate that the Pedawan Formation represents turbidite deposit (cf. Kuenen and Migliorini, 1950; Bouma, 1962; Stow and Shanmugam, 1980; Stow et al., 1996; Stow, 2005; Pickering and Hiscott, 2016; Stow and Smillie, 2020).

PETROGRAPHY

The Bau limestone is allochem dominated; the spherical ooids (Fig. 3A-B) are the most abundant allochemical components. In addition to ooids, there are a few fossil fragments (bioclasts) and intraclasts. The oolites have micritic fragments at the center (nucleus; Fig. 3A-B; see Tan et al., 2012, their fig. 3d). Most of the ooids have single nucleus (Boggs, 2009). Concentric structures around the nucleus has been observed. At places, micritic fragments form the nucleus (cf. Boggs, 2009, his figs. 9.7-8). None of the ooids have radial fabric.

The spherical ooids are indicative of agitated water condition during their formation and lack of ooids with radial fabric (form in quiet water condition) support shallow agitated environmental condition, probably in a shallow carbonate platform (Boggs, 2009).

The presence of micritic material within the oolite suggest intragranular porosity and indicates uplift that favors short period exposure during marine regressions (Tan et al., 2012). The microcrystalline calcite (micrite) is the orthochemical component of the Bau Limestone. The rock thus can be named as Oosparite following the classification scheme recommended by Folk (1959).

The Pedawan sandstones are compositionally as well as texturally highly immature. Proportion of lithic fragments is much higher compared to the feldspars (Fig. 4A-B).

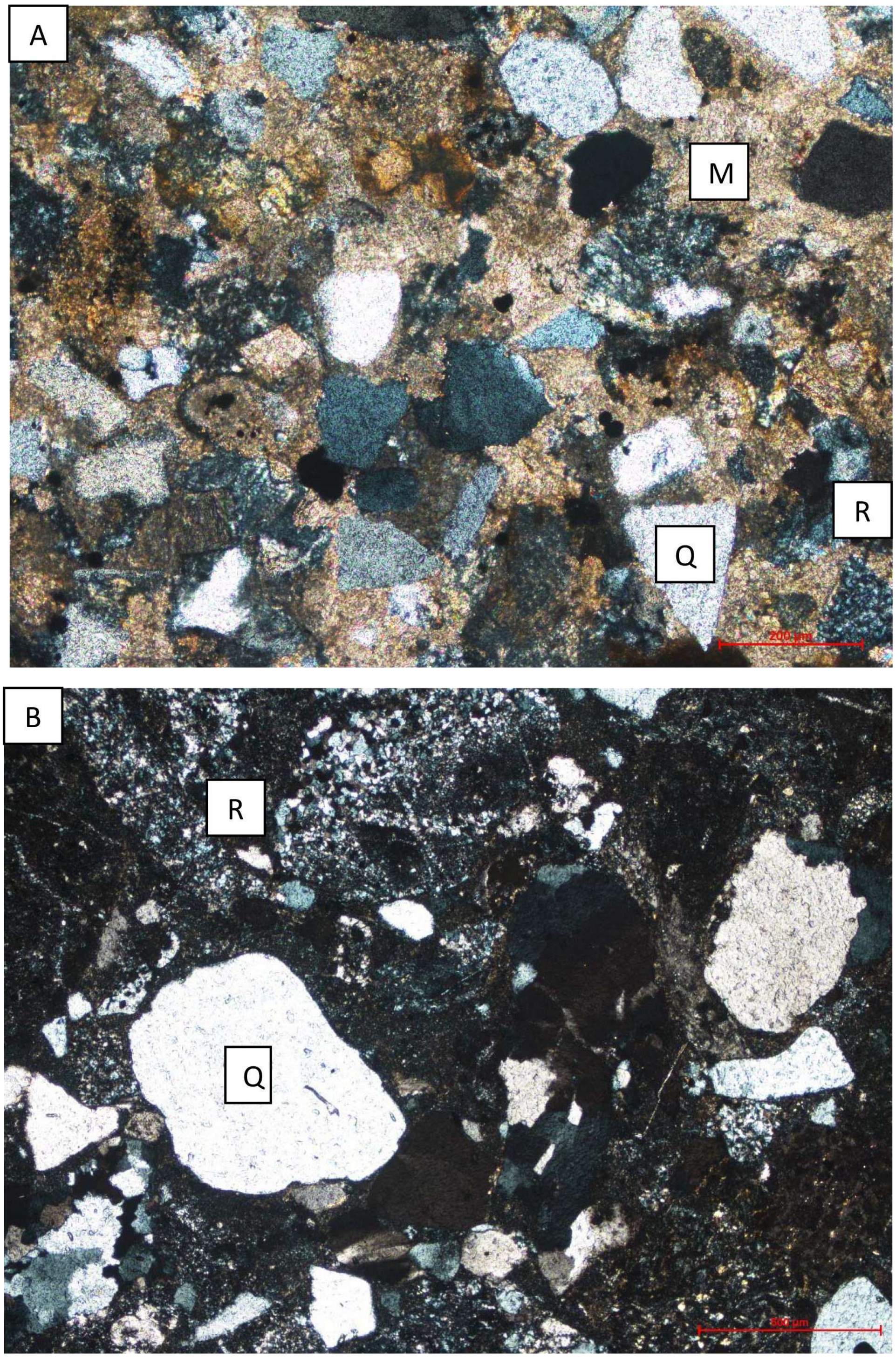


Figure 4: Photomicrographs of Pedawan sandstone: (A) Matrix (M) supported texturally immature sandstone with highly angular quartz grains (Q) and sub-rounded rock fragments (R). (B) Very poorly sorted quartz (Q) and rock fragments (R); note predominance of rock fragments. In general, the feldspar content of these sandstones are low (see text for details).

The persistent sandstone-shale banding, erosional lower contact of the normally graded sandstone beds with flute cast, in combination with strongly asymmetric ripples, parallel laminated bedding and massive beds indicate that the Pedawan Formation represents turbidite deposit .

The sandstones are very poorly sorted with matrix content around 18-20%. Felsic volcanic rocks, siltstone, mudstone and sandstone fragments have been observed. Proportion of feldspar is low; both alkali and plagioclase feldspar have been observed. Although most of the framework grains are angular to subangular,some rounded to well-rounded framework grains have also been noted. Quartz grains are mostly angular to subangular and shows sutured grain contact which indicate compaction. Micas are either absent or very rare in these sandstones. Many quartz grains exhibit undulatory extinction and indicate deformation. However, volcanic quartz are not uncommon (see Breitfeld et al., 2018).

Compositionally, the Pedawan sandstones are lithic wacke (Pettijohn, 1975; Fig. 5A). In the Quartz-Feldspar-Lithic fragment plot of Dickinson (1985), the Pedwan sandstones plot in the recycled orogen field (Fig. 5B). In the discriminant plot of Weltj (2006), the Pedawan sandstones fall in the field of recycled orogen. As pointed out by Dickinson (1985), orogenic recycling occurs in subduction complexes and fold thrust belts. As pointed out by Breitfeld et al (2018), the Pedawan Formation represents fore arc deposit. Thus the discriminant plot of the Pedawan sandstone supports the subduction zone setting.

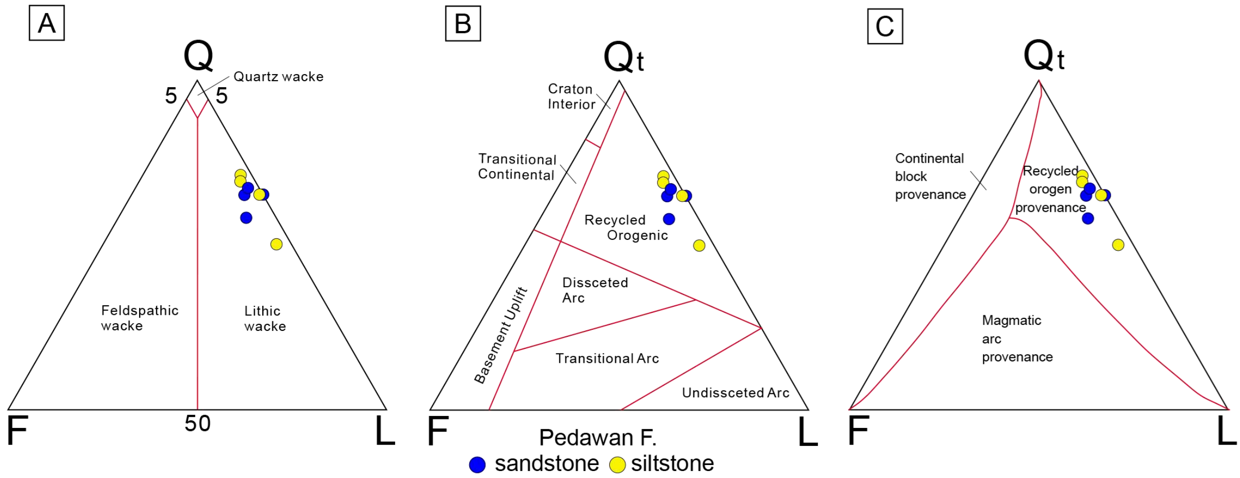


Figure 5: (A) Plot of Pedawan sandstones and siltstones; compositionally, these are lithic wacke (Pettijohn, 1975). (B) Discriminant plot of the Pedawan clastics in Dickinson (1985) diagram; the samples plot in the Recycled Orogen field. (C) Discriminant plot of the same samples in Weltj (2006) diagram. The samples plot in the Recycled orogenic provenance.

FUTURE RESEARCH DIRECTION

We present preliminary sedimentological data from the Bau limestone and Pedawan Formations. As we pointed out, the lower part of the Bau limestone Formation is made of siliciclastics and no sedimentological facies analysis of these siliciclastics has been undertaken so far. Although there is a general consensus that the Pedawan Formation represents deep sea turbidites formed in an arc setting (Breitfeld et al., 2018), high resolution ssedimentary facies analysis of the Pedawan Formation is yet to be done. Although Breitfeld et al (2018) have presented high quality geochronological data, the sediment geochemistry and the provenance study of the Jurassic -Cretaceous successions of Northwestern Borneo is limited.

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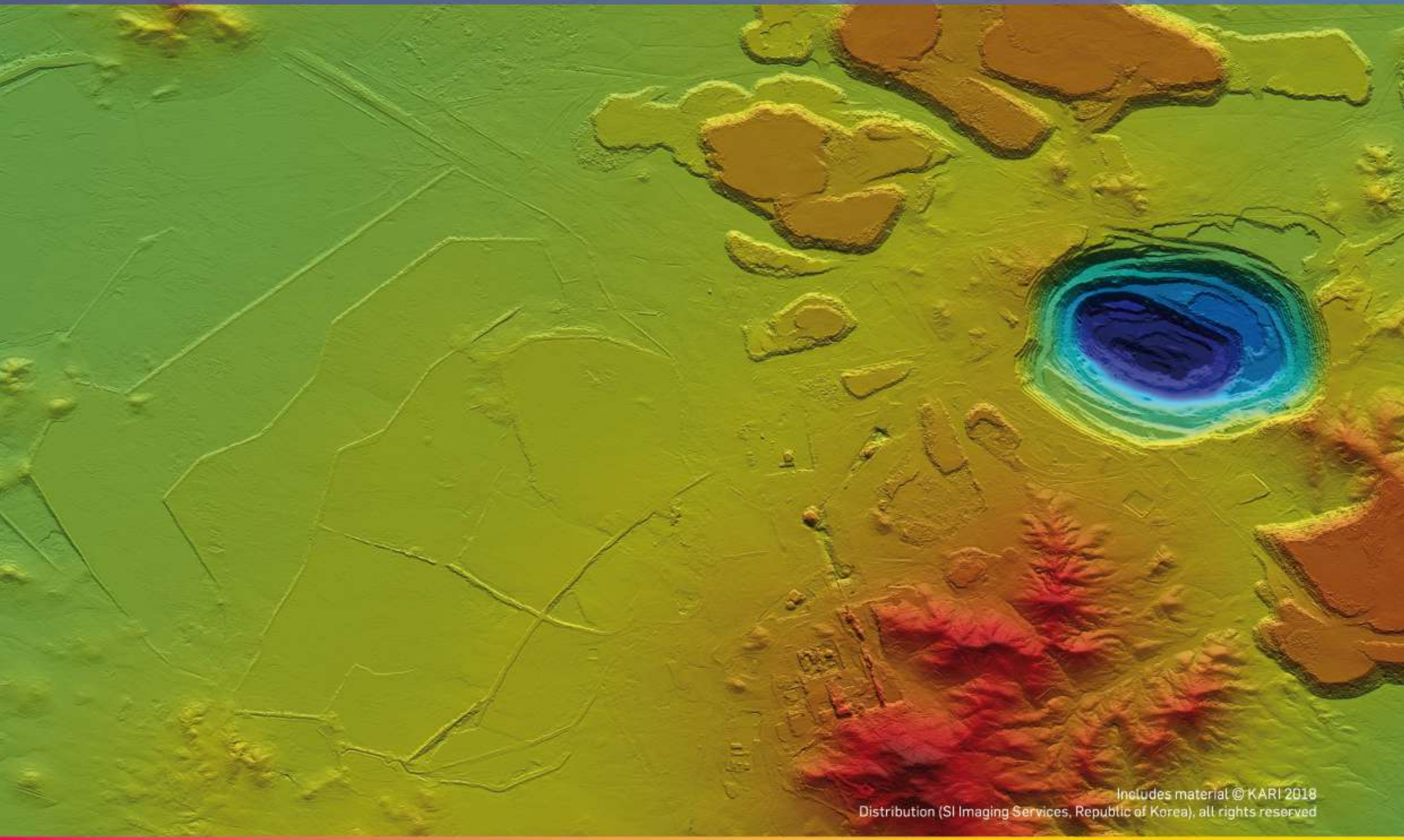
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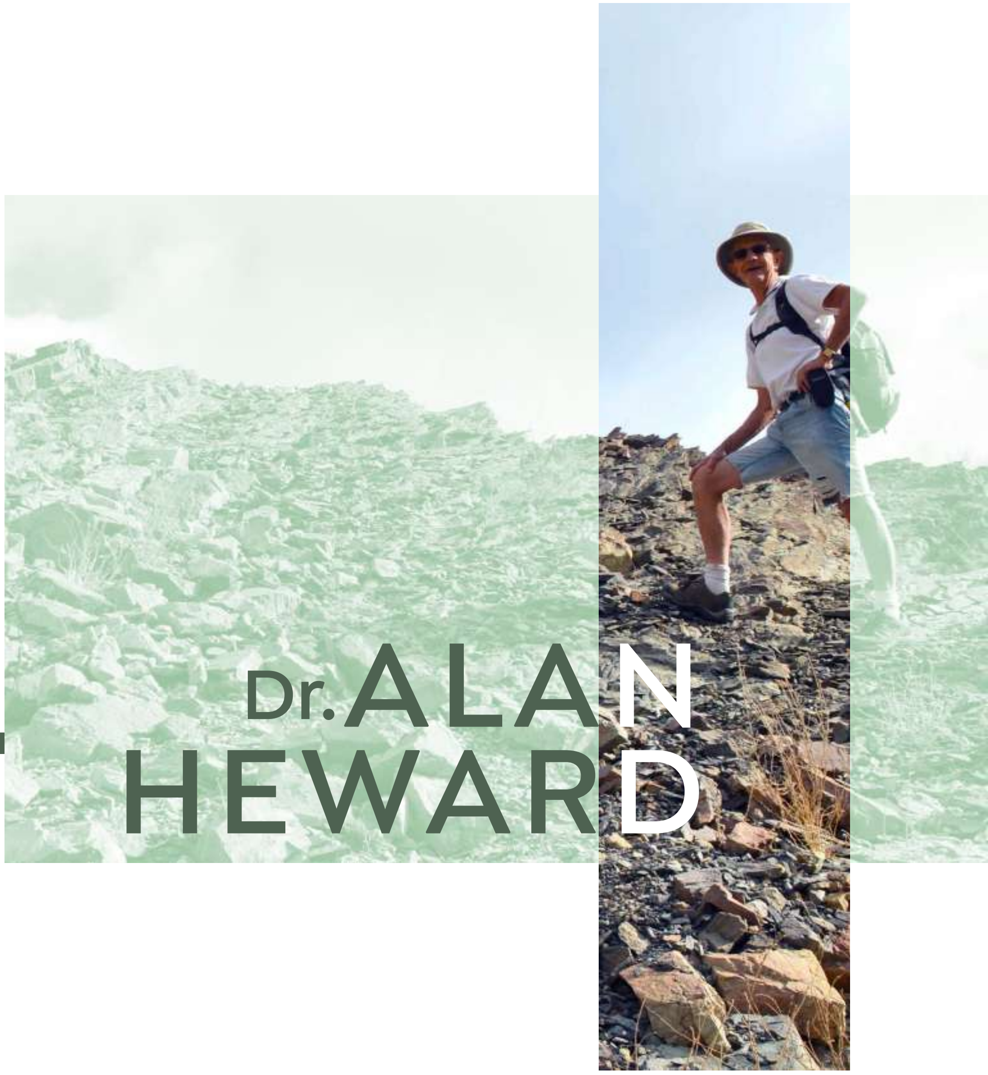
INTERVIEW OF THIS ISSUE

In this corner of Al-Hajar magazine, we are happy to speak with one of the geologists who continued to support and contribute to the geology of Oman for many years. Dr. Alan Heward, an honorary member of the Geological Society of Oman, has delivered numerous lectures and fieldtrips to the members of the society. He has been a great support to the projects conducted by the society and many of its members over the years.

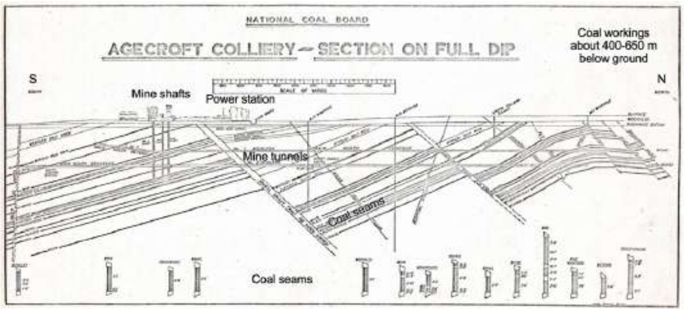
Dr. Alan Heward, an honorary member of the Geological Society of Oman



Dr. ALAN HEWARD

01 *Dr. Heward, why did you decide to study geology? And what topics of geology interest you most?* My interest in geology stemmed from collecting fossils in Wales when I was a child. I also developed an interest in physical geography (geomorphology) from family holidays in Pembrokeshire and the Lake District. Fortunately, I went to a secondary school where I could take geology, geography and chemistry at A level. Annual field trips to the Forest of Dean fed my interest in geology, as did 7 months working in a coal mine between school and university, and attending geology evening classes at Manchester University and Wigan Technical College and the field trips that went with them.

Agecroft colliery in Pendlebury, Manchester, was a deep coal mine, one of 9 working in the Lancashire region of the U.K. in the late 1960s. I was assigned to Agecroft as it had a mine geologist who also assisted other pits in the area when they ran into geological problems. This experience led to my interest in coal-bearing sequences and the Carboniferous in general. My normal job, when not accompanying the geologist, was as an apprentice surveyor. When we weren't 'down-pit' levelling or surveying, we were in the office updating mine plans and calculating surveys. The draughting skills I learned proved useful at university and in later life.



When I finished university, I was most interested in clastic sedimentology. I had to rapidly build on my carbonate sedimentology to be able to teach it. With time my interests have broadened and my recent work has been more about oil and gas fields, palaeontology and the history of exploration in Oman and the Middle East.

02 *We are keen to know more about your study, career, and research past?* I studied geology at King's College, London, and undertook my Ph.D. in sedimentology at Oxford University under the supervision of Harold Reading. Harold was in the forefront of clastic sedimentology research in the U.K. at the time. My doctoral study was on Late Carboniferous coal-bearing sediments in the Cantabrian Mountains of Northern Spain, supported by a Shell studentship. Subsequently, I spent 4 years lecturing at Durham University, worked for Shell, Lasmo, PDO and Petrogas, and had 5 years consulting. I learned a great deal from each of these phases of my career and the access to subsurface data and the experts I have had in industry, academia and museums. I supervised three Ph.D. students when at Durham, one worked on Permian aeolian sediments, another on Carboniferous ganisters (silica-rich sandstones or palaeosols) and the third on the Durham coal measures, then extensively exposed in opencast coal mines.

03 *What are the skills that are most important for a position geology?* Interest rather than skill and a liking for fieldwork and investigation. Working in the subsurface you may be looking at seismic or well data that nobody else has ever seen. Frequently the data is incomplete and you need to be able to make reasonable conclusions on what you have. Common sense is often required. An ability to finalise, document and present work within deadlines is important. Being able to work with others and other disciplines, and not be cowered or daunted by them. Some of their data is great for helping you understand the rocks.

04 *From your perspective, what are the issues facing people working in geological projects?* Understanding the purpose and scope of the project, the timescale available for it, and staying focussed. A great deal of time and effort is often spent obtaining and QC'ing data and reports. Build on previous studies, don't ignore them and know when to ask for help and advice if you run into aspects or interfaces you don't understand. You may feel you are a good geologist, but some of your predecessors may have been better, working with a subset of the data and the tools of the time. They also possibly had a broader understanding of other fields in Oman or analogues elsewhere in the world than you do.

05 *Which of your scientific publications you feel most proud of? And why? And is there a publication or a research topic that you wanted to make for a long time, but still haven't had time to do so?* I don't have a favourite. I get a sense of satisfaction when each one is completed and published. Each paper is a challenge and you are never quite sure how they will turn out.

One feels almost a duty to publish, to capture material of scientific interest for others. I have never had a problem publishing subsurface data, with permission from the relevant authorities and oil companies.

It is amazing how chance occurrences can lead to research interests that go on for years. Work on the Amdeh Formation stemmed from a fieldtrip in 2004 that was in part to financially support a PDO contractor.

Sampling from that trip, led to contacts with Giles Miller and Richard Fortey at the Natural History Museum in London and later work with them on conodont and trilobite faunas from the Amdeh, Rann and Qarari Formations that continues to this day.

I have several articles in the pipeline or in my mind, trying to document material I have worked on, collected or had access to that is not yet in the public domain (e.g. The Umm as Samim and the Fars sequence that outcrops a few metres beneath it). More ideas for publications come along every year.

06 *What do you like most about the geology of Oman?* Its variety and that there is much still to be discovered that is totally new to the region or to science when in the hands of experts. Often I have just collected material or sent pictures to experts who know when they are something different or new.

It has been a real privelige to discover locations in Oman that have clearly never been collected before.

Deeper-water trilobites and graptolites not previously known from outcrop in Oman, from the Middle Ordovician Amdeh 5, SE of Al Habubiyah. The rocks here are of greenschist/blueschist metamorphic grade and yet still the fossils survive.

In the subsurface of South Oman, I always enjoyed the challenge of making a prognosis for a well and it coming-in as planned, or learning from it when it didn't. With the number of wells drilled in Oman one receives abundant feedback. And more feedback still when the well comes onto production.

I also benefitted immensely from working with expert palynologists in the U.K. and Oman who can tell you the age and depositional environment from microfossils. Their biostratigraphic framework is key to working on the Al Khlata and Amdeh Formations in Oman and, for example, the slump blocks of the Brent field in the U.K. Having promising-looking samples processed for palynology even threw up some interesting results when working on the largely 'barren' Permian desert Rotliegend sediments in the U.K.

Remopleurid trilobite — Cyclopygid trilobite — Tuning fork graptolite

07 Which of your contributions to the Geological Society of Oman you value the most?

I have enjoyed contributing to the Geological Society of Oman and have always felt I want to give something back to the country and its geoscientists. I particularly liked the opportunity to mix with people from different companies and institutions on GSO fieldtrips and to learn more about the geology of Oman from enthusiasts in their own fields or areas.

If I had to choose one contribution above all others, it would have to be the 50th Anniversary field trip of the spudding-in of Fahud-1. It was a unique and memorable occasion in January 2006. 36 participants camped on the south side of the Fahud structure near the old Iraq Petroleum Company camp site and airstrip. Quentin's presentation of his father Mike's photographs, Don Sheridan's explanations, Peter Walmsley's cine-film of drilling operations and James Morris' description of Sultan Said's visit to the Fahud rig and camp kept us entertained in the evening. A cold shamal wind blew overnight and the next day was brilliant sunshine as we visited various locations in the Fahud field. The trip culminated with a late Omani lunch in Nizwa with the sons of Aziz Al Luwehi who had worked with the Iraq Petroleum Company field geologists (Al Hajar- 8th edition, March 2006, p. 2-5; GSO Field Guide No. 16).

GSO field trip in January 2006. Don Sheridan, one of the IPC field geologists involved in plane-table mapping the Fahud structure in the autumn of 1954, cutting the celebration cake in PDO core shed before we headed off to the field.

08 *You have mentioned many times that the geology of Oman offer countless opportunities for MSc and PhD research studies that could contribute tremendously to our understanding of the evolution of Oman and the region. Could you please name some of these opportunities?* Off-hand it is difficult to name topics, but when you are involved in a certain formation or area you realise how little is known about it. Often the detailed field mapping and geology of Oman has not been done. There several mapping projects and questions to resolve in the Amdeh Fm in Saih Hatat, for example, and in the subsurface, many opportunities exist… for instance, the origins of porosity and permeability in the ooidal dolomite 'drain' reservoir of the Haushi Limestone in the Sahmah field, Block 7, or the sedimentology and petrology of the mixed carbonate-clastic Haushi Limestone, surface and subsurface across Oman.

Often, a supervisor (or a student) should have a general idea of a topic and then let the student explore and work out a project within that. One that interests and develops their skills and experience. Students should never be afraid to ask for help, or to seek to use more advanced equipment at other universities or institutions that can help them in their studies. The documentation skills you learn writing-up a masters or doctoral thesis stand you in good stead for your future career.

09 *What abilities or personal qualities do you believe contribute most to the success in the geoscientific life?* Interest, hard work, an ability to step outside your comfort zone and work with others, the ability to finalise work and to document it. Breakthroughs often happen when you 'play' with data, collaborate with others across disciplines, or take a risk and try something new. In the Nimr area, in early 1990s, we were given ample opportunity and every encouragement to experiment with horizontal wells by my boss at the time, Samir Al Kharusi. As long as, I should add, we met our production targets and were able to generate more reserves. Documenting is a great skill to have, to record personal or official minutes of meetings. Presenting work, giving lectures and leading field trips are other skills to develop, as are, in due course, managing people and contractors.

10 What special advice do you have for a student seeking to qualify for a position in the geo-sciences field? For some, it is easy to step into your first job, having been sponsored by a company or university for further studies. For others, it is more difficult. For the latter, don't be dis-heartened, stick at it, join a contractor or service company and consider doing an additional qualification. Eventually an opportunity will come along, or something different that interests. A geoscience training is often a good entry qualification to other professions, in the U.K. at least. There is no substitute though for hard work and field experience. What else can you do to differentiate yourself on a CV so you get an interview? doing some independent study, completing something adventurous, volunteering etc. The main thing though is to find a job that interests you and you enjoy doing. Then work is a pleasure that you also get paid for! When you get your first job, don't expect to be a manager in a year or two, unless you are an entrepreneur and you have set up a successful start-up company. As you move up the ladder, you will spend more and more time doing non-geological things, some of which can also be interesting, like dealing with people, authorities, partners, stakeholders, budgets, contracts and HSE.

We are so glad to talk with you Dr. Alan Heward. Thank you very much for giving us some of your time and your experiences. We hope the best of luck to you in your future research topics.

WADI TA’AB

A natural haven that captivates the senses

Coordinate: Lat: 22°54'1.75"N Long: 59°11'12.56"E

Wadi Ta’ab is located in the Qurayyat state in the Ta’ab Village, about 160 km away from Muscat, below the Selmah Plateau, where the Majlis al Jinn Cave is located. The dominant lithology at this Wadi is gray to white marly or micritic limestone with chert nodules.

How Remote Sensing Can Be A Variable Tool In Geo-Sciences and Climate Change Studies?

By: Jasem Albanai (GIS and Remote Sensing Analyst)

Remote sensing is defined as a science that extracts information about the Earth's surface, including land and water, through reflected or emitted electromagnetic radiation from the Earth's surface, at a distance or without direct contact. This is mostly via satellites designated to monitor and study the Earth, or airplanes that may contain a pilot, as used in the past, or without pilot ("drones"), which are more prevalent these days.

To simplify this definition, we can start with the sun, which is the source of electromagnetic radiation on Earth. The sun is constantly emitting electromagnetic radiation of different wavelengths. These rays differ in their physical properties, they may be short in wavelength and high-energy, or long and relatively low -energy. These rays reach Earth after a journey that takes about eight minutes from the sun.

The rays begin to interact with the Earth's atmosphere; some are subjected to dispersion, absorption, and reflection, while the atmosphere allows the passage of some of these rays to reach the Earth's surface. The rays interact with the surface of the Earth, where some of them are subject to direct reflection and are of high-energy, while others are absorbed by the surface and are relatively low-energy. The appearance of the surface – in remote sensing terms – differs according to its interaction with the sun's rays. Some surfaces appear to reflect a portion of the sun's rays intensively, while others strongly absorb rays, where energy is reduced and released later in the form of heat loss. All of these reactions are captured through the sensors devoted to the Earth's observation; these sensors detect and monitor these rays.

Scientists divide electromagnetic radiation from the sun into several sections according to its physical properties.

One such division is according to "wavelength", where several categories are used, including: gamma, x-ray, ultraviolet, visible “light”, infrared, microwave, and radio. These rays are all present in nature, but the human eye can detect only a small part of the spectrum. Only this range is called a visible band. The visible band is a mixture of colors ranging from blue to red, passing through green. All the colors in nature, according to what the human eye can see, are a mixture of these three colors, and thus the human eye can see nature only by mixing them [1].

Satellites need a certain number of days (Landsat 8 needs 16 days, for example) to orbit the Earth and capture a specific area again. This is a unique feature of airborne imaging that can be used in crises and emergencies. Besides, aerial imagery is characterized by its relative non-exposure to the effects of the atmosphere, such as clouds and dust particles, as they are at relatively low altitude. This means that the appearance of clouds in the images is avoided, unlike with space imagery.

The rays interact with the surface of the Earth, where some of them are subject to direct reflection and are of high-energy, while others are absorbed by the surface and are relatively low-energy.

What distinguishes remote sensing is the ability of sensors carried on satellites or airplanes to sense only a specific part of the electromagnetic spectrum ("radiations"); that is, these sensors allow us to choose only a specific range, where we can see nature with red reflections only – or blue or green only. This is what the human eye cannot do.

The capabilities of the sensors are not only limited to seeing visible ranges separately, but they can also display electromagnetic bands that the human eye cannot sense at all, such as infrared and microwave radiation; this is of great importance for studying the natural environment and the Earth's surface, as these radiations provide us with new information about the surface of our planet, just as happens when a doctor shoots X-rays at a patient to see fractures in their bones, as these rays are characterized by penetration into human skin. Or as happens when the military wears a sensor that senses thermal infrared radiation at night; they can locate enemies through the radiation emitted by their bodies. The heat emitted by their bodies differs from the heat of the objects that surround them.

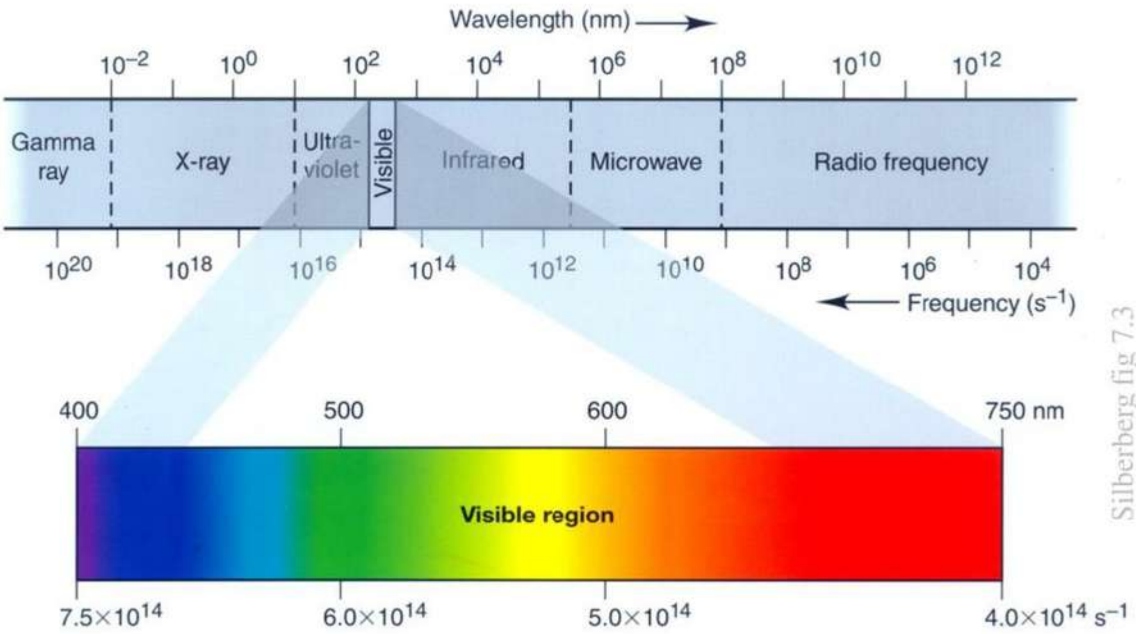


Figure 1: Electromagnetic radiation

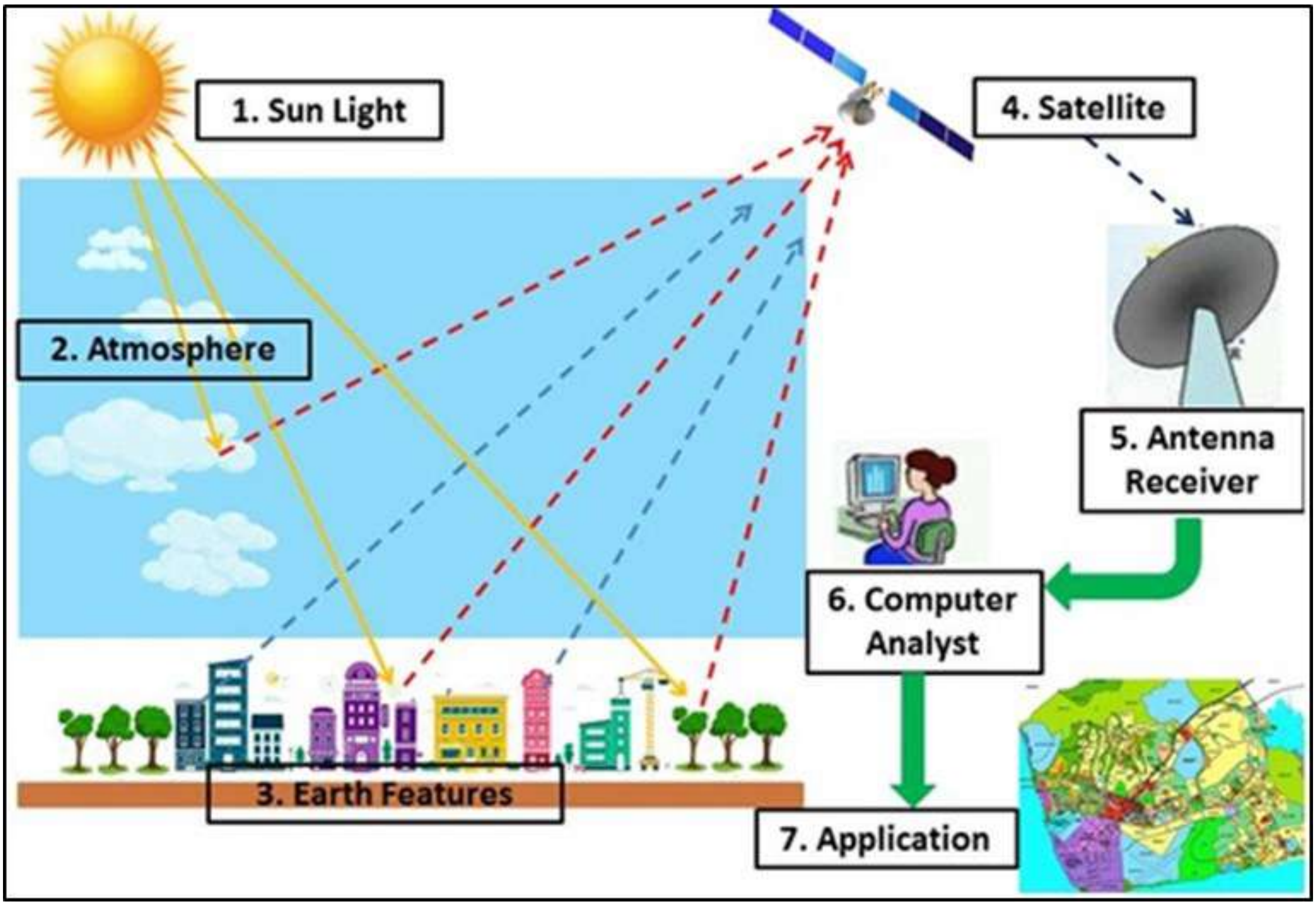


Figure 2: Remote sensing data extraction levels

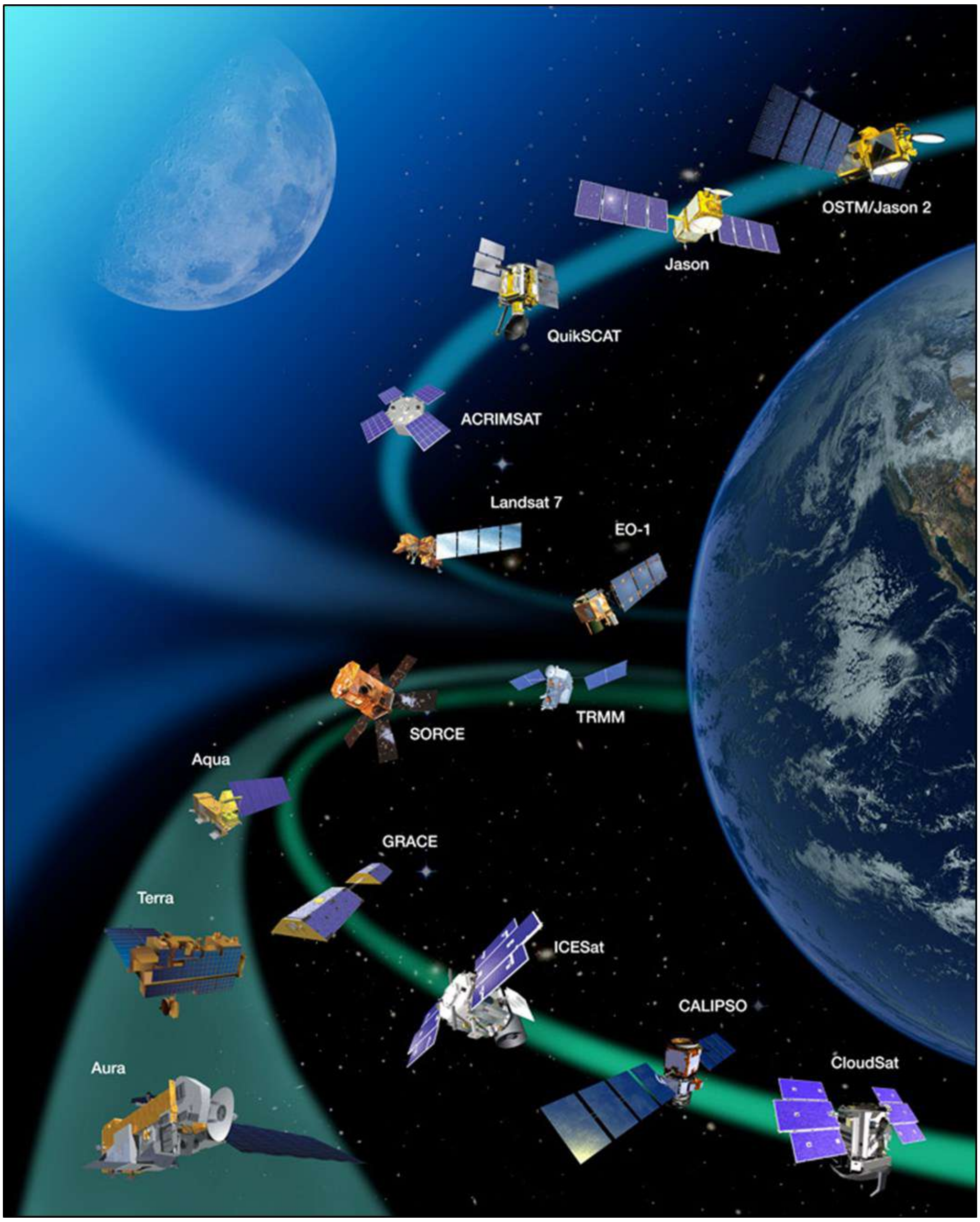


Figure 3: Satellites designated to observe the Earth placed in different orbits and at different heights, as determined by the goal of the satellite in the first place

Satellites orbit the Earth at different heights, and thus differ in their coverage. Satellites also differ in their properties according to the purpose for which they were created. Some are devoted to providing accurate information about the Earth's surface by providing high-resolution images covering a small area of the Earth's surface, for engineering and planning purposes. We also find other low-resolution ones, but they cover a wide area, to know the pattern of geographical distribution, such as studying the difference in sea surface temperature or providing important information about the weather and climate conditions.

The satellites can also differ in the spectral bands that they display; some are devoted to studying plants, so they sense important spectral bands to extract information about vegetation; others, meanwhile, may be designed to study the soil, so we find different spectral characteristics according to the important spectra in soil studies. Thus, Earth today is covered by a network of satellites with different characteristics, such as spatial and spectral resolution. It is important to emphasize that the satellites are not imaging devices in themselves. They are objects that swim in space that can be used for any purpose. It is the sensors installed onboard that are responsible for imaging. Thus, these sensors render the satellite as a remote sensing satellite – or, indeed, otherwise.

Airplanes are like mechanisms for obtaining information about the Earth's surface. They also contain sensors with spatial resolution, "image resolution" and spectral resolution, which the sensor can sense from the different electromagnetic spectrum [2, 3]. However, the main differences between satellites and airplanes are coverage range, time zone, and atmospheric effects. Where airplanes cover relatively small areas because they are relatively close to the surface, unlike satellites, they give us high-resolution images over a limited space.

As for the timing, unlike the satellites, the researcher can choose the desired time for imaging. This is outside the human decision-making process with satellites; here, we are governed by the usual imaging time for the satellite, whereby different satellites differ in the time it takes them to orbit the Earth and return to imaging a specific region. As such, the satellite has a temporal resolution.

Remote sensing methods are used today in conjunction with modern spatial technologies, such as geographic information systems (GIS) and global positioning systems (GPS), to achieve spatial information integration between them. Satellite imagery, aerial photography and GPS outputs are entered into GIS to analyze and make use of all of them in the best possible way within one spatial environment. GIS is defined as the computer system that enters, displays, archives, manages, analyzes and exports spatial data and information. Considering that remote sensing methods provide us with data and information in a spatial nature, geographic information systems are the best environment to benefit from this data and information.

Through these systems, all major operations can be performed, which allows us to produce 2D and 3D maps with abundant spatial information from the Earth's surface.

Remote sensing has a unique importance in coastal studies, specifically those related to determining regional coastal differences. As coastal features differ in their properties, components and forms, this gives remote sensors the ability to distinguish these differences based on the different interactions of electromagnetic radiation bands with these different aspects. Thus, remote sensing represents one of the most important principles today in making maps and atlases. Moreover, the holistic view of satellite images – even in natural colors – allows us to recognize various phenomena, understand and see them with a bird's eye view. Remote sensing methods are used in studies related to earth sciences and climate change today. Previously, observations and simple descriptions were used to describe the changes occurring on the planet. Nowadays, scientific methods are applicable to change monitoring, such as using statistical analysis for field measurements.

Remote sensing has leapfrogged other methods to become the best way to detect changes. Due to the vast and continuous coverage of the planet, it has become possible to monitor spatial and temporal changes in a wider and more comprehensive manner. For example, remote sensing instruments are the best way today to monitor surface temperature (including that of sea water). Much of what we hear today about recent changes in surface temperature stems from satellite measurements. Monitoring this using remote sensing allows us to know the spatial differences due to the breadth of the area covered by satellite images, and the huge archive, covering a wide period of time, available from these means. Remote sensing applications extend to studying many aspects of climate change, such as sea level rise, where the radar images are used to measure the annual changes in sea levels. Remote sensing methods are also one of the main pillars underpinning a rapid response to natural disasters and extreme weather, many of which are believed to be issues related to climate change. This is especially true with the development of drone technology, which helps emergency teams assess damage and obtain information at the lowest time and material cost.

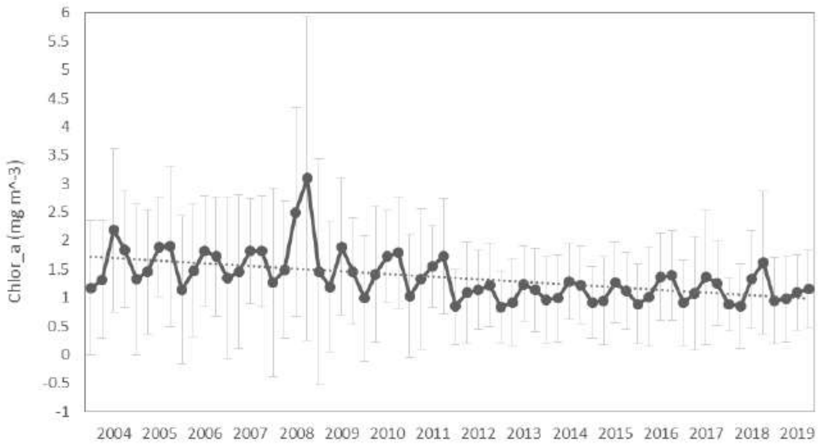


Figure 4: Example of a study of long changes: the temporal variation of near-surface chlorophyll-a in the waters of the Arabian Gulf (2004-2019) [4].

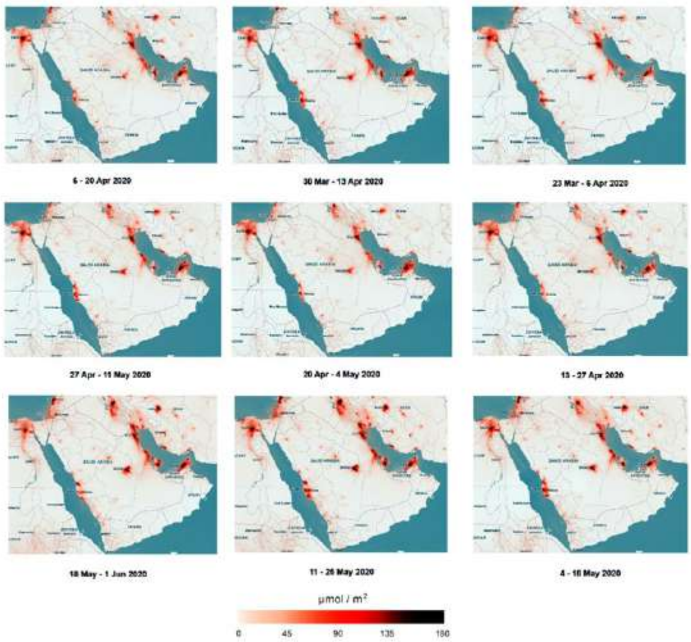


Figure 5: Example of a study of long changes: the spatial variation of No2 in the Arabian Peninsula [5].

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INTERNATIONAL NEWS

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MIDDLE EAST

IRAQ

Activity levels in Iraq, including the Kurdistan Region, have been significantly impacted by the COVID-19 outbreak, low oil prices and the OPEC+ production restriction agreement. Activity levels are expected to increase into the second half of 2021 as the various issues are resolved. Sinopec has been awarded a 49% interest in the Mansuriyah gas field development. The project will be operated by state-owned Midland Oil Company which holds the remaining 51%. Lukoil is expected to continue appraisal/development drilling at the Eridu field in Block 10, south Iraq, throughout 2021. Bashneft International will conduct 2D and 3D seismic surveys over the Salman field in Block 12, south Iraq, in 2021. Dhi Qar Oil Company is reportedly planning to drill additional new wells at the Subba field in 2021. The field has been shut in since October 2019 but production is expected to recommence in 2021.

TURKEY

Turkey's President Tayyip Erdoğan announced on 4 June 2021 that 135 BCM (around 4.8 Tcf) of natural gas reserves have been discovered from the Amasra 1 exploration well in the Turkiye Petrolleri A.O. (TPAO) operated B26, B27 deepwater offshore licence in the western Black Sea. The well, located at a water depth of nearly 2,000 m and around 40 km towards the northeast of Sakarya gas field (Tuna 1) was completed during mid-May 2021. TPAO termed the Amasra 1 discovery as the 'North Sakarya' field and reported that it would also be included in the Sakarya Field Development project. President Erdoğan also announced three new onshore oil discoveries in the country on 27 May 2021. Two discoveries, Akoba 1 and Yenişehir 1 (also reported as Larissa 1) are located in the Diyarbakır province towards the southeast of the country, whereas the third, Misinli 2, is in Kırklareli province towards the northwest of the country. All three discoveries were understood to be made by TPAO during May 2021.

SAUDIA ARABIA & QATAR

In April 2021, the United States Department of Energy (DOE) issued a joint statement of notification indicating that a "Net-Zero Producers Forum" was being established between the Energy Ministries of Canada, Norway, Qatar, Saudi Arabia and the US.

The COVID-19 pandemic led to a reduction in capital, operational and other expenditure by QP in Qatar. The North Field expansion projects remain a strategic priority, but secondary or tertiary oil recovery an imperative. IOC negotiations for participation in North Field East and North Field South expansion projects are edging closer to resolution.

The ongoing impact of the COVID-19 pandemic will extend a 25% reduction in CAPEX into 2021 in Saudi Arabia. Additional project delays, postponements and cancellations are envisaged. A proposal to expand maximum sustained capacity (MSC) to 13 MMbo/d is pending approval.

UAE

Projects are being delayed, renegotiated or shelved until the economic outlook improves and OPEC+ restrictions are lifted. Unawarded 2019 Abu Dhabi Bid Round blocks might yet be awarded during 2H 2021.

Production restrictions to ~70% installed capacity demonstrate ongoing disciplined management in a challenging environment. The UAE's dominant producer Abu Dhabi National Oil Company (ADNOC) has undertaken a strategic review of its commitments and started the year with a 30% CAPEX reduction against the 2021 plan. Exploratory programmes have been particularly vulnerable to delay since the onset of COVID-19 in 2020 but activity is now likely to pick up during 2H 2021.

YEMEN

Yemen is experiencing a humanitarian crisis brought about by armed conflict. Oil exports are generating essential foreign currency revenues.

Upstream operations are tentatively resuming, but there remain issues to be resolved. IOC development drilling activity resumed in 2021 following a six-year hiatus. All development drilling operations undertaken by international oil companies had been suspended during 1Q 2015 due to armed conflict and only resumed in 2021. National companies similarly suspended drilling activities due to security concerns, logistical and funding issues, but began to return to the field during 2018. OMV and Calvalley were amongst the first international companies to resume workover and production operations early in 2019, with Calvalley the first to mobilise a drilling rig to resume the development of the Hiswah oil field.

INDIAN SUB-CONTINENT

PAKISTAN

Six exploration licences were awarded during the first half of 2021 as an outcome of the onshore bid round, and a further nine licences are expected to be awarded to the successful bidders in the coming months. The bid round was launched from 9 October 2020 to 15 January 2021 offering a total of 20 onshore blocks, among which 15 blocks received successful bids. Among the total of 20 blocks offered under the bid round, seven are located in Indus Basin, six in Potwar Basin, four in Sulaiman Fold Belt, two are located in Pishin-Katawaz and one block in Balochistan Basin. The area of 12 blocks range between 2,100 to 2,500 sq km; four blocks between 1,000 to 2,000 sq km and four blocks below 1,000 sq km. Eni was looking to sell its exploration and production (E&P) assets in the country during 2020 and it was subsequently announced on 9 March 2021 that it had signed an agreement with Pakistan to Prime International Oil & Gas Company for selling all its E&P assets in the country. Prime International is a newly established company formed by the local Eni employees and Hub Power Company Ltd, an independent power company in Pakistan. It would comprise 50% shares of both - local Eni employees and Hub Power Company.

INDIA

Upstream activity has been affected by COVID-19, particularly the western offshore areas. This was further compounded with the arrival of Cyclone Tauktae; one barge capsized, two barges and several rigs went adrift. Exploration and development drilling for ONGC has been affected.

In terms of acreage offers, the Open Acreage Licensing Policy (OALP)-VI bid round involves plans to offer 10 blocks in six basins. The Discovered Small Fields Bid Round III launched on 10 June, offering 32 contracts comprising 75 discoveries, and ends on 31 August 2021. Oil India (OIL) & ONGC plan further Production Enhancement Contract offerings. Cairn Oil & Gas has spudded it's second and third exploration wells in newly awarded OALP blocks in India.

In company news, a virtual data room has opened for bidders concerning the Bharat Petroleum Corporation Ltd (BPCL) privatisation; stakes in Numaligarh Refinery Ltd (NRL) have been sold to OIL-EIL and the Assam Government acquired 100% stake in Bina refinery.

Reliance Industries Limited (RIL) has commenced gas production from the second KG-D6 deepwater project (Satellites Cluster), and Gujarat State Petroleum Corporation is offering opportunities to farm into five blocks.

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NORTH AFRICA

EGYPT

The Egyptian Government launched an International 2021 Bid Round for oil and gas exploration in 24 blocks. This new round includes twelve blocks in the Western Desert, three in the Gulf of Suez and nine in the Mediterranean Sea.

The calls for bids, which will close on 1 August 2021, are being issued by the Egyptian General Petroleum Corporation (EGPC) and the Egyptian Natural Gas Holding Company (EGAS).

In early July 2021, BP with partner Eni was drilling ahead of the new field wildcat Tiye 1 in the North Ras El Esh Offshore block while MOG Energy spudded Kamose Northwest 1 in the Kamose (Dev) block, both acreages being in the Nile Delta Basin.

LIBYA

The oil target of 1.6 MMbo/d set by the NOC could be close to being reached in end-2021 following the completion of ongoing projects and the extraordinary ability of the national company to perform under challenging circumstances. However, the strong need for maintenance works in the infrastructure and the lack of budget could prevent the achievement of the targets. The political resolution of the East-West conflict will be key to maintaining operations and increasing production, rather than matters relating to the pandemic and low oil demand. TotalEnergies is negotiating with Hess to acquire the company's 8.17% interest in the Waha concessions in the Sirte Basin. These concessions include 25 blocks and around 30 producing fields, including Gialo and Gialo North with a combined 4,600 MMbbl of recoverable oil reserves, and Defa with 2,850 MMbbl.

TUNISIA

Government instability reduces the attractiveness of the country; majors are leaving. Production operations are largely unaffected by COVID-19, and there remain high levels of petroleum rights activity. Exploration activity is at a low point; however, some recovery is expected moving into the second half of 2021.

Tunisian state company Etap is promoting the country's open blocks that are available to companies for direct negotiations. The Department of Energy of Tunisia indicates that the bids relating to prospection and/or exploration permit granting should be submitted to the General Manager of Energy with the name and address of the tender. Bid opening and bid evaluation will be done during the fourth week following the considered quarter.

ALGERIA

The energy minister has been replaced after only eight months. Production operations are largely unaffected by COVID-19, but the OPEC quota reduces production. The new hydrocarbon law is still not applicable one and a half years after it was passed; however, in the government session of 10 June 2021, four draft decrees of the ministry of energy and mines were discussed. These are reportedly the last four decrees that were outstanding to complete the hydrocarbon law. Once these four decrees are approved and published, the hydrocarbon law will become applicable.

In May 2021 Sinopec and Sonatrach signed a memorandum of understanding (MOU) to examine cooperation within oil and gas exploration and production in Algeria and internationally.

The companies will start discussions to renew the Zarzaitine production concession under the terms of the new hydrocarbon law. Sinopec is currently partnering with Sonatrach on the Zarzaitine oil field in the Illizi Basin of south-eastern Algeria.

MOROCCO

Predator Oil & Gas reported on 6 July 2021 that the MOU-1 well, the first exploratory well at Guercif Onshore permit in the Guercif Basin, found gas shows. The drilling of the well, spudded on 20 June, was planned to take up to 20 days with no other information before the wireline logs are evaluated. Predator considers that Moulouya is a low risk, play opening opportunity, situated only 9 km far from the Pedro Duran Farell pipeline (Maghreb). Moulouya prospects are part of the 7,300 sq km Guercif Onshore licence, located in the Guercif Basin.

MAURITANIA

There was little activity in Mauritania in 2020. Due to the oil price crash compounded by COVID-19, most E&P activities were delayed. In petroleum rights, TotalEnergies reduced its exposure to Mauritania by relinquishing the C-9 and C-18 blocks. The company also exited the C-7 block which was then awarded to Cairn.

Kosmos shelved plans to reduce its stake in the Mauritania and Senegal assets. In exploration, Shell completed 3D seismic surveys in blocks C-10 and C-19 and TotalEnergies completed 3D seismic surveys in blocks C-15 and C-31. No drilling took place. In field development, BP continued with the GTA development after adjusting the schedule to the COVID-19 pandemic. The GTA project is delayed by one year. Petronas interrupted the Chinguetti decommissioning work due to the COVID-19 pandemic and resumed operations in January 2021.

NIGER

Niger-Benin pipeline construction works have been suspended due to the COVID-19 outbreak. Savannah Energy Ltd (previously named Savannah Petroleum) is expected to resume drilling exploration wells in 2022, as reported by CEO Andrew Knott in late 2020. The British company intends to continue its exploration campaign after the R3 East Project goes into production, possibly in late 2021. Savannah made five discoveries out of five drilled wells in 2018.

CHAD

Glencore has stopped production at its fields until further notice due to the global crisis. As of June 2021, nothing new has come to light about the rumoured exit of Glencore from Chad. Two years ago, on 13 June 2019, it was reported by the press that Glencore intended to sell its Badila and Mangara fields in Chad.

Although the Swiss firm released no official statement, sources said several months before that the company was planning to divest its Chadian assets.

It is understood that Petroliam Nasional Berhad (Petronas) still intends to sell its assets in Chad (Chari licence) and Cameroon (Chad-Cameroon pipeline). On the other side, ExxonMobil which is the operator of both assets, is in discussion to sell them to Savannah Energy as announced on 3 June 2021. Delonex has also announced the sale of all its assets.

SOUTH SUDAN

The South Sudan 2021 bid round was officially opened by the South Sudan authorities on 23 June 2021. The government announced new seismic and reconfiguration of bidding blocks. It is understood that bids for the first tranche of the bid round (five blocks) are due by mid-August 2021. Virtual presentations of the five blocks of the first tranche were being held from late June onwards.

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