AL HAJAR

Geological Society of Oman
Quarterly Newsletter

Geo Arabia 2004
Special Edition

Second Edition March 2004

President's message

On behalf of the Executive Committee of the Geological Society of Oman, I am pleased to introduce to you this special edition of **AL HAJAR** (GSO quarterly newsletter) which is published to coincide with the convening of the 6th Middle East Geoscience Conference and Exhibition (Geo2004). On this occasion, I would like to thank the editorial committee, various authors, and sponsors for making this edition a success.

Since the society's inception on the 15th of April 2001, GSO has managed to gain recognition not only locally but also regionally and internationally. We were able to do that by strictly adhering to the most important objective for which the society was formed; to act as a platform through which information and technology related to the science of geology is disseminated. GSO has also managed to gain the trust and confidence of sponsors by consistently delivering informative and educational programmes. From the start, the society had set a vision for itself of becoming one of the premier scientific societies in the region. GSO started early on that road when it participated in Geo2002. Since then, the society's involvement in regional and international conferences has grown. Our involvements in Geo2004 and the upcoming Muscat IAS meeting in 2005 are good examples of that (see relevant sections in this newsletter). Moreover, the launch of **AL HAJAR** newsletter in January 2004 represents another positive step in the direction of achieving that vision.

For further growth in the coming years, GSO has to maintain the enthusiasm of its membership body. In addition, further opportunities of cooperation between the society and other regional and international geoscience organisations need to be identified and pursued. For that growth to be sustainable, GSO needs to diversify its sponsorship base and increase the contributions from its membership body. The society, therefore, counts on your support.

Hisham A. Al-Siyabi
GSO President

Welcome from the Editor

AL HAJAR launch in January 2004 was a success and GSO aims at establishing **AL HAJAR** as a leading geoscience newsletter in Oman and Internationally. GSO would, therefore, like to sincerely thank all the parties involved in the production of the **AL HAJAR** for their support and encouragement.

This issue of **AL HAJAR** is a special publication for GeoArabia 2004, and GSO aims at expanding on the topics presented to cover a much wider and more international audience. The topics covered in this issue may be divided into the following main topics:

Exploration opportunities in Oman: We are proud to introduce the first contribution on a series of articles outlining hydrocarbons exploration opportunities in Oman which is provided by Saleh Al-Anboori from the Ministry of Oil and Gas. The articles will be describing the exploration opportunities in the different blocks within the Sultanate. In this issue this is complemented by one of the operating companies (Encana) view on the exploration opportunities in Oman provided by Glen Mah. Hydrocarbons do not comprise the only occurrence worth exploring for in Oman as the **minerals wealth** in Oman Mountains constitutes an exceptionally prospective investment. This is highlighted by an article from Salim Al-Busaidi from the Ministry of Commerce & Industry.

Earthquake hazards in Oman is on of the scientific articles in this issue and is presented by Ali Al-Lazki from Sultan Qaboos University. The seismicity of Oman is exploited in relation to the surrounding regions of the gulf and in particular the southeastern margin of Arabia. The other science article is provided by Joachim Amthor, a geologist from Petroleum Development Oman and is titled " **The Precambrian-Cambrian Boundary in Oman**". New dating techniques applied to South Oman subsurface data are supporting a mass extinction and faunal turnover at the Precambrian-Cambrian boundary. To spicy up our audiences taste, some intriguing **fossils** that were found in the Al Khalata Formation are presented by Alan and Franci Heward.

A **show case article on GSO** and its activities is presented to provide background information on the society and its interests. Some of the GSO activities are then highlighted in two categories: **reviews on GSO activities** in collaboration with other organisations and societies such as **GeoArabia** and **IAS** and reviews on the organized monthly talks and fieldtrips. Of importance is the **ladies only field trip** on the geology of the Muscat area, which proved to be very popular and enlightening. A set of two talks and a field trip on the "**Snowball Earth**" hypothesis also proved to be exciting and many geoscientists enjoyed the educational discussions between Paul Hoffman and Philip Allan hosted by the GSO during January 2004. These intense topics are diluted with a profile on the father of Oman geology and GSO's honorary member "**Ken Glenne**" who delights us with an account of his life and carrier development. Ken is currently in the process of writing a new book "The desert of Southeast Arabia" which he promised to provide a short review for one of the next issues of **AL HAJAR**.

I would finally like to thank the contributors for their enthusiasm and dedication to make this a truly special publication and hope this spirit will last for the many coming issues of **AL HAJAR**.

Nadia Al-Abry
Acting GSO Editor

What's inside

- Exploration Opportunities in Oman P 3
- Exploration Opportunities in Oman: An Operator`s Perspective P 4
- The Minerals treasure in Oman ; Future for Investment P 6
- Earthquake Hazard in Oman & the southeastern margins of Arabia? P 8
- The Precambrian-Cambrian Boundary in Oman P 9
- GSO: A major leap for the geological community P12
- Snowballs in Oman? P16

AL HAJAR
Geological Society of Oman
Quarterly Newsletter

Membership has its Benefits

Welcome to the Geological Society of Oman "GeoArabia 2004" newsletter. Why are we doing this? Well we are a relatively new society established with the aim of promoting Earth sciences to youth, graduates and industry professionals alike, and to act as a forum for geo-scientists in the region for networking, exchanging ideas, information and news within the "Geo" Community. This year we have launched our society newsletter **"AL HAJAR"** to meet these aspirations.

Oman is a country rich in geological treasures, from the Hajar Mountains a short distance from Muscat to the Huqf in Central Oman. Oil and gas reserves are found in formations as diverse in age as they are in lithology, from the Cretaceous to the Pre Cambrian, from carbonates to marine and aeolian clastics. Many of these formations are reservoirs in other areas in the Gulf region. Fortunately for us most of the subsurface geology is spectacularly developed in outcrops throughout the country and is readily accessible for field trips.

The society plans to publish the newsletter on a quarterly basis and will present articles on Oman geology, surface and subsurface, present industry news from the region and organize a number of field excursions each year to sites of geological interest. The society aims to arrange and facilitate courses, technical workshops and meetings in the future, such as the IAS conference being held in early 2005.

Membership opens the door to Oman's riches and will have benefits not only for those in Oman, but for all the geo-community working in and around the Gulf region. As a member you will receive **AL HAJAR** on a quarterly basis and will be made aware of the society activities through regular emails. As a GSO member you will be connected to what is happening in the magnificent Oman "geologically".

By: John Willoughby
John.Willoughby@pdo.co.om

ENCANA™

Encana Corporation is one of the worlds leading independent oil and natural gas companies and North America's largest natural gas producer and gas storage operator. EnCana has four key North American growth platforms: Western Canada, offshore Canada's East Coast, the U.S. Rocky Mountains and the Gulf of Mexico. In addition, EnCana has two key high potential international growth platforms: Ecuador where we are a major private sector oil producer and the U.K. central North Sea, where EnCana operates the Buzzard Oil Field; one of the largest oil discoveries in the U.K. in the past 25 years. EnCana also conducts high impact exploration in many other international locations including the Middle East.

EnCana in the Middle East is an active operator in Oman, Qatar, and Yemen, and holds a 50% non operated interest in Block 5 in Bahrain. In February 2003 EnCana was awarded a 100% interest and operator ship of Blocks 3 and 4 in the Sultanate of Oman. These Blocks encompass approximately 39,000 Km2. EnCana's seismic acquisition program is underway and EnCana will drill three wells during the first three year exploration period. EnCana also hold a 100% interest in Block 2 in Qatar covering 11,000 Km2. EnCana is currently seeking a partner to par ticipate in the second exploration period in Block 2. EnCana also operates Block 47 in the Republic of Yemen. Block 47 covers over 7,000 Km2 and EnCana currently holds a 52.5% interest.

By: Duncan Nightingale
duncan.nightingale@encana.com

Exploration opportunities in Oman

Exploration opportunities in Oman are geologically and geographically diverse. Hydrocarbon producing areas extend from offshore Musandam Peninsula (Block 40) in the extreme Northern part of Oman to the Marmul area (Block 6) in the South of Oman (figure. 1).

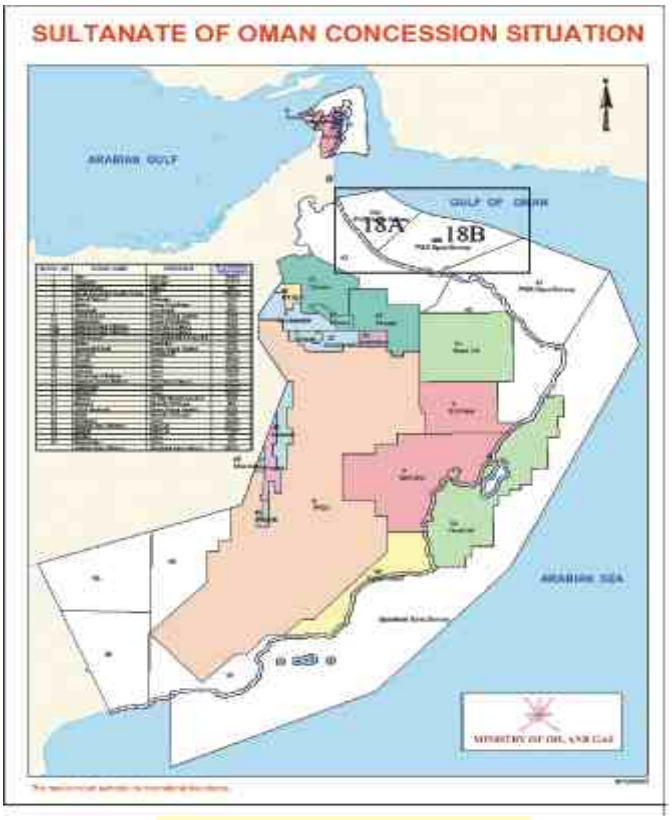

Figure.1: Oman Concession Map

The variety of proven exploration plays combined with the high exploration success record demonstrates Oman's prospectivity and potential. The four fundamental elements of working petroleum systems; charge, seal, reservoir and trap are found in rocks ranging in age from Precambrian to Tertiary. Prolific hydrocarbon charge has been generated from proven source rocks mainly in Upper Precambrian, Cambro-Ordovician and Lower Cretaceous strata. Additional scope exists for Upper Cretaceous and Lower Tertiary petroleum systems to be developed in North Oman (sub-thrust) and offshore in thick depocentres. Sealing lithologies are well-developed at all stratigraphic levels, and the presence of significant hydrocarbon (both oil and gas) columns indicates that these seals are effective. Producing reservoirs include Precambrian carbonates (Nafun and Ara Groups), Cambro-Ordovician sandstones (Haima Supergroup), Carboniferous sandstones (Ghariff and Al Khlata Formations) and Cretaceous carbonates (Shuaiba and Natih Formations). Potential but largely unproven reservoirs include the Precambrian sandstones of the Abu Mahara Group, Upper Cretaceous turbidites (Aruma Group) and Tertiary clastics and carbonates (Fars Group).

TECHNICAL REVIEW OF THE OPEN BLOCKS

Several international oil companies were granted oil and gas rights under Exploration and Production Sharing Agreements (EPSA). The current number of companies operating under EPSA in the Sultanate is 8 companies under 11 agreement covering 14 blocks. A series of open block reviews will be presented in the Al-Hajar. For this issue, Block 18 in the North of Oman will be presented.

Block 18

Block 18 occupies 18,267 Km2 and is located offshore in Gulf of Oman in the northern part of the Sohar Basin (figure - 1). Until 2001 the block was covered by 3,000 km of 2D seismic. As part of speculative seismic survey and reprocessing project by PGS, additional 2,451 km of 2D was acquired on the Block. Based on the out come of this project the Block is divided into two Blocks, Block 18 A (7,920Km2) and Block 18 B (1,352 Km2).

Two wells were drilled in block 18, the first being Batinah Marine A-1 drilled in 1968 by Wintershall Consortium , targeting a large structure in the Tertiary and pre- Tertiary layers. It encountered approximately 300 m (gross) of Masstrichtian lithic sandstone. Later detailed seismic interpretation showed that the well was not on structure.

Wintershall Consortium drilled the second well Batinah Marine B-1 in 1971 and the well encountered approximately 600 m (gross) of Eocene carbonates. Good gas and oil shows (occasionally up to C4) in the Upper and Lower Masstrichtian and the Cretaceous were noted while drilling. One well, Barka – 1, which was reported to have good gas and oil shows within the Eocene, was drilled by AMOCO in 1985 in the nearby onshore Block 43.

MAIN PLAY CONCEPTS (figure. 2)

Source Rocks - Eocene Rusayl Formation and Maastrichtian

Traps - Stratigraphic / Rotated fault blocks / Toe -thrust

Reservoirs - Maastrichtian sandstones / Eocene Carbonates / Miocene Sandstones /Miocene – Pleistocene turbidities

Seal - Deep water Shales / Marl / Gas hydrate

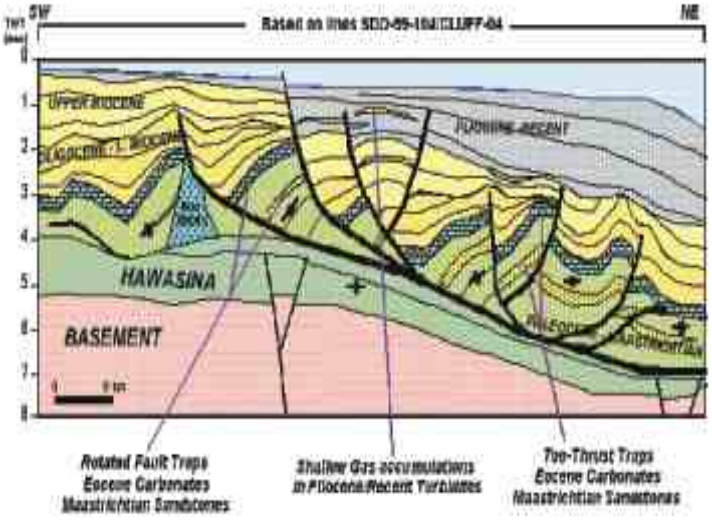

Figure. 2: Play concepts in blocks 18&41

By: Saleh Al-Anboori
s.alanboori@mog.gov.om

AL HAJAR
Geological Society of Oman
Quarterly Newsletter

Exploration Opportunities in Oman: An Operator's Perspective

EnCana is a relatively new company with respect to exploration in the Middle East. Formed in March of 2002 by the merge of two Canadian oil and gas companies, Pan Canadian Energy and Alberta Energy Company, EnCana is one of the largest (market capitalization ~ US $20 Billion) independent oil and gas companies in North America. At the time of the merge EnCana's only Middle East acreage were onshore Block 47 and Block 60 in Yemen, acquired by Pan Canadian during 2001. Since then, EnCana has aggressively expanded its exploration commitments in other Middle East countries such as Bahrain (2002), Qatar (2002) and Oman (2003), (Figure.1). Today, EnCana is one of the largest net working exploration landholders in the Middle East.

Figure 1. EnCana Middle East land holding

EnCana is the operator (100% W.I.) of the Afar Block 3 and Ghunaim Block 4 onshore of east-central Oman. EnCana completed internal technical and commercial evaluations, followed with a bid submission and successful EPSA negotiation in 2002 that culminated in the award within one year, after EnCana began expressing an interest in bidding on the two blocks. The Exploration Production Sharing Contract (EPSA) for these two blocks was ratified by Sultanate decree on April 16, 2003.

EnCana had identified Oman as a country that met requirements as part of a Middle East business strategy for exploration opportunity. Some key factors for Oman exploration opportunity are summarized as:

- Availability of large acreage blocks that have favourable hydrocarbon fundamentals for significant oil and gas discoveries;
- Established legal, fiscal, regulatory, tax environment that is transparent, open and stable;
- Modern petroleum infrastructure that offers an opportunity for low cost development and operation;
- Politically one of the most stable and secure countries in the region;
- A niche competitor environment, one in which the majors and super majors are not pursuing.

These factors are recognized by all foreign E&P companies operating in Oman and create the initial attraction to exploration opportunities.

Oman exploration opportunity – Initial perspectives of a foreign E&P company

The upstream petroleum business in Oman is dominated by PDO. PDO operates Block 6 which contains almost all of Oman's oil and gas producing reserves (95%). Industry perceptions are that Block 6 contains most of the oil and gas prone basins, with the peripheral blocks available to others having minor potential.

Analysis of discovered field reserves cumulative over time (creaming histories) demonstrates that the traditional Cretaceous and Permian plays are mature (Figure 2). PDO (Naylor et al., 2001) acknowledge that future hydrocarbon reserve addition of significant volumes must come from new play types that are now being found in deeper Paleozoic traps.

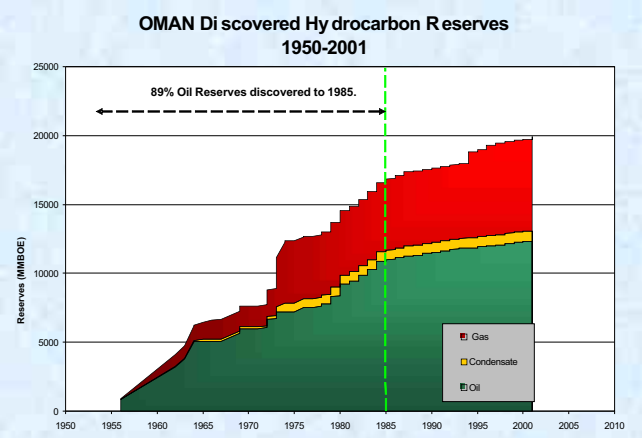

Figure 2. Oman Cumulative Reserve Growth (Data Source: IHS Energy)

Most of the operators in Oman believe under-explored new play trends exist on their acreage. Access to geological and geophysical data from the Ministry of Oil and Gas (MOG) was imperative for EnCana to quickly establish exploration knowledge and determine the potential for new exploration opportunities in the available open blocks. Greater accessibility to data will benefit operators and improve opportunities for exploration success.

The prosperity of the oil and gas business has created the tremendous infrastructure in Oman that is favorable to operators such as EnCana:

Stable fiscal, regulatory, legal and governance systems.

- Petroleum infrastructure including pipelines, export facilities and vibrant service sector.
- Industrialization creating a regional demand for gas supply.
- The result of these conditions allows companies to measure operating risks and ability to manage business with confidence.

Block 3 & 4 exploration opportunities EnCana perspective

EnCana's entry into Oman began with a MOG data-room review in early 2002. Of the 11 open blocks reviewed only the Afar Block 3 demonstrated the presence of an active petroleum system with the discovery of non-commercial oil reserves at Farha-1.

Access to more detailed information culminated in a technical and commercial evaluation. EnCana has identified potential for new oil play trends related to subtle traps and deep gas-condensate structures for Block 3 and Block 4. These constitute:

- **Huqf Arch Flank** :
Light oil in Paleozoic sandstone stratigraphic traps, sourced from proven Infracambrian source rock.

- **Ghaba Salt Basin** :
Deep gas/condensate in Paleozoic reservoirs trapped by faulted or salt related structures. Kauther and Khazzan gas-condensate discoveries are recent examples.

These play trends reside on the eastern side of the Ghaba Salt basin along the northwest flank of the Huqf Arch. The majority of the identified play trends are contained within Blocks 3 and 4 which, if drilling tests are successful, will allow efficient commercial development of the trend and justify the long-term commitment of EnCana to Oman.

In Oman most open blocks cover large areas and offer the capability to acquire entire geological trends. Maersk/Phillips (previous operators of Block 36 & 38) and Novus (current operators of Block 15, 31 & 47) are other operators that have utilized this strategy. Capturing an entire play trend offers an operator the opportunity to confirm the geological elements of the play trend, create an exploration prospect portfolio and drill the best opportunities. Again, if successful, these large tracts will justify a long-term commitment to the country, to the benefit of both the operator and the government.

During 2004 EnCana will incorporate reprocessed seismic data and new 2D seismic data in an interpretation focused on prospect mapping. Geological studies will identify the potential for local oil source kitchens proximal to mapped prospects. Plans to drill exploration wells in late 2004 are being considered.

Future opportunities in Oman

Operators of exploration blocks want to establish and grow a successful oil and gas business in Oman. Few have had success in the shadow of PDO's dominant position.

There must be some truth to the perception that exploration blocks outside of PDO Block 6 lack the presence of commercial accumulations of oil and gas. No operator will deny that the exploration opportunities on their respective blocks are highly risky and likely to fail. Will the failures of previous operators also be the fate of current and future competitors?

The situation that is evolving today is unlike the past. Block 6 geological basins are mature. Oil production from PDO fields is in decline (Figure 3). Efforts to arrest this decline are part of future PDO chalanges but will lead to spending more resources on production maintenance (D'Souza, 2003). PDO's target is to regain daily oil production levels of 800,000 by 2007 but will be challenged to grow significantly beyond this.

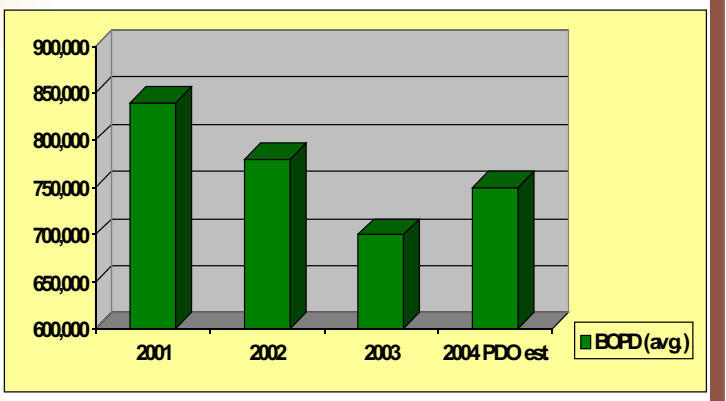

Figure 3. PDO daily oil production history (Source: Oman Economic Review & IHS Energy)

The MOG must consider methods to create more exploration and production opportunities for current operators and new entrants. In other mature hydrocarbon regions (e.g., UK North Sea and U.S Gulf of Mexico) open competition has prolonged the survival of exploration and production activities. However these mature regions usually have governments that play a role in facilitating and regulating oil and gas activities including adjustments to royalty, tax and regulatory requirements that enhance exploration incentives.

Change is constant and often unpredictable. Progressive change within Oman has created a modern, vibrant and stable country with a vision to maintain growth and retain its position of regional influence.

EnCana plans to be successful in Oman and will seek opportunities for participation in the continued success of the oil and gas business in Oman.

By: Glen Mah
Technical: Glen.Mah@encana.com
Operational : Duncan.nightingale@encana.com

References

D'Souza N., 2003. Can he deliver ?. Oman Economic Review, January 2003 p 24-29.

Naylor, M.A. and L.Y. Spring, 2001. Exploration strategy development and performance management: a portfolio-based approach. GeoArabia, Vol. 6, No. 4, p 553-570.

AL HAJAR
Geological Society of Oman
Quarterly Newsletter

The Minerals treasure in Oman; Future for Investment

Introduction

The Sultanate of Oman is traditionally known for mining copper ores since 3000 BC. Several localities of the remaining slogs have been found in different places in the Oman Mountains, particularly in the Sohar region at al-Asil ancient mine (Figure.1). Other places such as Samail and Samad were also very active in mining.

These mines were exploited for copper sold mainly to the Sumerian empire. During the Islamic era vast expansions of many of the smelter sites in the Oman Mountains was experienced. After that time the mining industry in Oman continued to decline until the 20th century, when modern mines were started at the sites of al-Asil, Arja and Bayda near Sohar in January 1983. The development of these mines with a capacity of 3000 tones per day ensured production of about 14,000 tones per year of cathode copper for more than 10 years.

Figure.1: Ancient mine at al-Asil, near Sohar

Geological Infrastructure

Since 1974 when the ministry of Petroleum and Minerals was created, the first task for the Directorate General of Minerals was to build up the necessary geological database for future developments in minerals exploration and mining industry.Other strategical plans such as exploration and detailed geological mapping were also implemented.

These resulted in geological maps at a scale of 1:250,000 and for the first time 1:1,000,000 maps covering the entire Sultanate being produced. In addition several maps of the Oman Mountains at a scale of 1:100,000 were produced and 2 sheets of 1:500,000 metallurgical maps covering the entire country and showing the minerals localities for both metallic and non-metallic commodities were accomplished. The Directorate also focuses on the high potential mineralized zones in the northern Oman Mountains and therefore carried out detailed mapping at 1:25,000 and 1:50,000 scales. This work revealed new discoveries of copper, silver and gold prospects.

Minerals Occurences & Revenues

Modern exploration techniques such as ground and airborne geophysics, drilling, remote sensing imagery, combined with expertise in metallogenic models enable better understanding and efficiency in minerals exploration. For the past twenty years a number of specialized international companies in geology and mineral exploration were given the opportunity to work in Oman. These include companies such as Prospection Ltd, OMCO, BGR, BRGM, Bishimetal, Hunting, Robertson Research and JICA, which all contributed to the establishment of a mineral inventory of Oman. In addition, a number of studies and researches and detailed mapping have provided a better understanding of the geology, geotectonic and metallogenic evolution in Oman.

Currently the Sultanate hosts many economical mineral deposits (Table. 1). In the north of Oman, Al-Ghazain (about 15Mt, Figure. 2) and Al-Raki (16Mt) areas have the largest potential mines for future mining which can supply the local market with electrical copper, gold and silver associates for at least 20 years.

Oman mining Co. also has started to mine the 2.6Mt of gold ore at Yanqil area, which will last for 5 years producing 500kg of pure gold per year. As a result of the governmental support and encouragement, National Mining Co. (a local Omani Company) has been granted a concession area at Shinas for gold and copper exploration. The company discovered 3.5Mt of massive sulfides at 2-3% Cu, and 1 g/t of gold at Shinas and Hatta prospects. These two deposits are potentially economic due to them being easily minable and occur at shallow depths.

Mineral Deposit	Location	Estimated Reserves (Mt)
Gold, Silver and copper ores	Northern Oman	>35
Chromite	Northern Oman	>2
phosphate	Al-Halaniyat	>2
Coal	Al-Kamil	122
Manganese	Sur	1
Gypsum	Dhufar	1,000
Kaolin	Houshi	7
Silica sand	Hiama	10
Quartzite	Qarayat	10
Marble	Northern Oman	150
Limestone	Various locations	>300
Dolomite	Qurayat, Dhufar	>100
clays	Various locations	>100
Attapulgite	Al-Shawaimiah	300
Industrial salt	Bar Al-Hakman	>200
Laterite	Ibra	100
Microgranite	Ja'alan	>100
Aggregate	Various locations	1000

Table. 1: Summary of selected mineral occurrences and reserves.

Source: Directorate General of Minerals, Ministry of Commerce and Industry, 2004

Chromite is also found in Oman in many locations, recognized within dunite and harzborgite at the top of the mantle and cumulate sequences of the Ophiolite. Oman Chromites Co. produced about 30,000 tonnes in 2002 of chromite products and exported to international markets. There are more than 200 chromite bodies which have been documented by the Directorate General of

Minerals; most of which have high potential and economic value. However, many chromite deposits have not yet been explored in detail and still need comprehensive studies. The total known reserves of chromite ores in Oman are estimated at 2 million tonnes.

Figure. 2: Al-Ghazaian copper and gold ore prospect.

A number of the sedimentary successions in the Sultanate indicate potential economic value. The Hawasina exotic Formations are widely spread in Oman Mounties and are mined for ornamental stones and marble. Currently there are more than 7 marble queries producing more than 135,000 tonnes per year of good quality marble slabs.

The Omani marble is sold locally and internationally with a growing demand in international markets. Armor stones and building materials are also widely produced in Oman for the local and regional markets. During 2002, the sultanate produced about 2.2 million tonnes from these materials. Cement based raw materials such as gypsum, laterite and limestone are also mined from different areas for local and regional cement manufacturing.

Lead, zinc, and silver are discovered in the late Proterozic to Cambrian dolomite and dolomitized base of the late Permian carbonate platform in the Saih Hatat region. Coal beds with 122 million tonnes of proven reserves have been found in the Tertiary sedimentary cover near Al-Kamil area. A number of economical deposits such as silica ores, kaolin, gypsum, attupolgite, dolomite, clays, quartzite, ornamental stone and many others are largely available in the Sultanate and most of them have been briefly to extensively evaluated (see Table. 1).

The ministry of Commerce and Industry represented by Directorate General of Minerals encourage the private sector to invest in the mining industry. The recent mining law (issued by the royal decree on March 2003) facilitates this by reducing the cost of mining as follows:

- The Royalty on all minerals (metallics & non-metallic) revenues has been fixed at 5%.
- Tax exemptions for all machinaries used in mining and plants.

By: Salim Al-Busaid
d.gs@mocioman.gov.om

References:

Al-Busaidi, S., Qidwai, H., Kawamura, K., Zachria, C., 1996. Industrial Rocks and Minerals Survey: A'Sharqiyah Area. Directorate General of Minerals, Ministry of Petroleum and Minerals, Sultanate of Oman (unpublished).

Bechennec, F., Le Metour, J., Wyns, R., Beurrier, M., 1991. Geological map of the Sultanate of Oman. NF 40-8, 1:1000,000. Explanatory Notes, and Map. Directorate General of Minerals, Ministry of Petroleum and Minerals, Muscat, Sultanate of Oman.

Le Metour, J., Michel, J.C., Bechennec, F., Platel, J.P., Rojer, J., 1995. Geology and mineral wealth of the Sultanate of Oman. Directorate General of Minerals, Ministry of Petroleum and Minerals, Muscat, Sultanate of Oman.

Pasquet, J. F., 1995. M.P.M. Geological Documents. Industrial Rocks and Minerals Deposits in the Sultanate of Oman, Al-Azri H. (ed). Directorate General of Minerals, Ministry of Petroleum and Minerals.

AL HAJAR
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Earthquake Hazard in Oman and the southeastern margin of Arabia?

Earthquakes are one of the most catastrophic events that, in seconds, leave behind thousands in death tolls not to mention the millions to billion of currency lose in damage of human structures. It is considered that plate motion and their interaction with each other is the prime cause for earthquakes. The earthquakes [magnitude 6.9] that hit Bam, December, 2003, Iran, left a death toll of ~41,000 humans and lose in buildings, infrastructure, and heritage (Zoback, 2004). If we are to assess earthquake hazard in Oman we ought to first define where Oman is located relative to active plate boundaries and how these plate boundaries influence seismicity within Oman would. Noteworthy, earthquakes do not only occur along plate boundaries, but do occur within individual plates, where they are termed as intra-plate earthquakes.
However, these earthquakes are considered to occur less frequently compared to those along plate boundaries. The earthquake [magnitude 7.6] that occurred in Bhuj, India, on January 26, 2001 and killed ~20,000 and injured more than 100,000 is considered an intra-plate earthquake as it occurred away from the plate boundary. This is also the case for the Bam, Iran earthquake.

Oman is located in the southeast corner of the Arabian Plate. The Gulf of Aden and the Red Sea divergent plate boundaries represent the south and the southwest bounds of the Arabian plate. Oceanic lithosphere is being created along these boundaries as the Arabian plate moves northwards away from the African plate. The Dead Sea Fault System (left lateral) represents the northwestern boundary of the Arabian plate, where Arabia moves northwards relative to the African plate.

The continental crust of Arabia collides with Eurasia along the Bitlis and the Zagros suture zones in the north and the northeast bounds of the Arabian plate. Mountain belts in eastern Anatolia and the Zagros are evidence/result of Arabia's ongoing collision with Eurasia. Further south of the Zagros, the boundary zone changes along the Makran Subduction Zone, where the remnant ocean basin of Oman is currently being consumed beneath Eurasia. Finally in the southeast, the Owen and Murray TFZ (Transform Fault Zone) represents the easternmost boundary of the Arabian plate with the Indian plate.

At present time the Arabian plate moves at a rate of ~2cm per year relative to a stable Eurasia (McClusky et al., 2000). In geological time scale, how did Arabia plate develop to its present day shape/position? In the past, in the Cretaceous, an important event occurred that lead to the consumption (subduction as well as obduction) of the Neo-Tethyan Ocean along the north & northeast boundaries of "Afro-Arabia". As this convergence continued, the initial split of the Arabian plate occurred in phases beginning in Late Eocene and Early Pliocene (e.g. Hempton, 1987), where Arabia is considered born and separate from “mother” Africa. Further separation of Arabia from Africa along the Dead Sea Fault occurred in the Mio-Pliocene times that lead to increased northward motion of Arabia relative to Africa (e.g. McKenzie, 1972).

Now! How does Arabia's plate motion affect the seismicity in Oman, particularly? Earthquakes that occur along plate boundaries or within, pose a possible threat to cities that fall within a few hundred kilometers radius. At present, seismic events recorded by the Earthquake Monitoring Center (EMC) at Sultan Qaboos University, are observed to dominate nearby plate boundaries of Arabia along the southern Zagros fold & thrust belts, the Makran Subduction Zone, the Owen and Murray TFZ, and the Gulf of Aden. Relatively, minor seismic activity is observed to occur within the southeastern margin of Arabia, which remains the subject for further investigations! Seismic activity is also observed along the more distant plate boundaries such as the northern Zagros and Bitlis suture zones, the Red Sea, and the Dead Sea Fault System.

On the one hand, determination of an earthquake hazard is primarily associated with the frequency of recorded earthquakes and their magnitudes along plate boundaries or a fault zone. While on the other hand, events that have occurred in the pre-instrumentation period serve to expand the longer term earthquake recurrence estimates, but with lesser certainty in both temporal and spatial distribution. These historical records serve to quantify historic-prehistoric seismic hazard of earthquakes that may have affected a particular region in the past.

Instrumentally recorded moderate to large magnitude earthquakes along the southeastern Arabian margin are few! Some of those are: the Dhammar earthquake [magnitude 5.7], Yemen, occurred December 13, 1982, which left ~3,000 dead; Alkamil earthquake [magnitude 5.1] occurred on March 3rd, 1971 recorded by the USGS catalogues, but was not reported to be felt by locals in Oman (possible location error!); and recently two earthquakes [magnitude 4.5 & 5.1], occurred in Masafi on March 10 & 11, 2002, Fujairah, UAE.

Historic records in Oman indicate an earthquake to have possibly occurred in the old city of Qalhat. The old city of Qalhat ruins in Oman is a possible historical site that could have been devastated by an earthquake. The Qalhat earthquake is postulated to have occurred in the last quarter of the fifteenth century (Dickson, 1982). It is yet to be determined the mechanism at which a whole city such as Qalhat has been swallowed by the sea! or could by a major Tsunami.

Although, at present, no damage is reported on existing structures, such as 100 to 200 years old castles as a result of an earthquake in Oman, earthquake hazard remains possible in Oman (Qamaruddin & Al Harthi, 2000). Earthquake hazard assessment is not complete until a thorough study on the present day seismicity has been conducted and evaluated, investigation on historical earthquake records, and detailed studies on recent deformation (neotectonic) of the region being accomplished. The reason being is that earthquake recurrence cycle may differ and may vary from yearly, decadal, to hundreds and even thousands of year's cycle, such as the Bam earthquake, where the 2000 years-old-citadel just got

By: Ali I. Al-Lazki
lazki@squ.edu.om

References:

Dickson, P.A., 1986. Preliminary Assessment of the earthquake Hazard in the Sultanate of Oman. Consultancy Mission Report for the Ministry of Communication and the United Nations Development Programme (UNDP).

Hempton, M.R., 1987. Constraints on Arabian plate motion and extensional history of the Red Sea, Tectonics, 6, 687-705.

McClusky, S., Balassanian, S., Barka, A., Demir, C., Ergintav, S., Georgiev, I., Gurkan, O., Hamburger, M., Hurst, K., Kahle, H.,

Kastens, K., Kekelidze, G., King, R., Kotzev, V., Lenk, O., Mahmoud, S., Mishin, A., Nadariya, M., Ouzounis, A., Paradissis, D., 2000. Global positioning system constraints on plate kinematics and dynamics in the eastern Mediterranean and Caucasus, Journal of Geophysical Research, 105, 5695-5719.

Qamaruddin, M.& Al-Harthi, A.S., 2000. Earthquake response of a historical castle, Science and Technology Journal, Sultan Qaboos University, 5, 25-34.

Zoback M., 2004. Why must earthquakes be this devastating? Washingtonpost.com, January 4, B05.

The Precambrian-Cambrian Boundary in Oman

The Precambrian-Cambrian boundary is one of the most important intervals in the history of life, because it encompasses the appearance and diversification of metazoans. In the history of metazoan evolution the most significant episodes of radiation often have been preceded by equally impressive extinction events. Extinction has been suggested to predate the largest of these radiation events; the so-called 'Cambrian explosion' (e.g. Seilacher, 1984; Brasier, 1989; Knoll and Carroll, 1999). However, supporting evidence for extinction has been challenged. New biostratiographic, carbon isotope, and Uranium-Lead (U-PB) zircon geochronologic data from the subsurface of South Oman now strengthen hypotheses invoking mass extinction and faunal turnover at the Precambrian-Cambrian boundary (Amthor *et al.,* 2003).

In South Oman, slabs of oil-filled carbonate rocks of the Ara Group are entrapped in salt domes at depths of 3 to 5km (Figure. 1). These rocks, known as 'carbonate stringers', constitute important hydrocarbon reservoirs and are known for quite some time to be amongst the oldest oil-producing rocks in the world.

Biostratigraphy

Paleontological data suggest that the carbonate stringers cycles (A1- A6) are formed close to the Precambrian-Cambrian boundary. Subsurface cores contain abundant evidence for body fossils, most commonly Cloudina (Conway-Morris et al., 1990; Grant, 1990) and Namacalathus (Grotzinger *et al.,* 2000) (Figure. 2). Both body fossils occur in or associated with thrombolite reefs of the A1 to A3 sequence. Although there are several cores with thrombolite occurrence in the A4 and A5 sequences, no body fossils have been observed at these stratigraphic levels.

Carbon Isotope Chemostratigraphy

Carbonates of the A4 cycle are characterised by a marked negative carbon isotope excursion (Figure 1). This sharp negative anomaly associated with the A4 carbonates is interpreted as being correlative with an excursion of nearly identical magnitude that is observed globally near the Precambrian-Cambrian boundary (e.g., Knoll and Carroll, 1999). The global extent of this anomaly has been confirmed through direct age dating.

Geochronology

Thin volcanic ash beds are present in several wells at stratigraphic levels of strategic importance. An ash bed (sample BB-5) occurs within basal strata of the A4 carbonate unit (Figure 1), which contains the abrupt excursion in ?13C, interpreted as the Precambrian-Cambrian boundary. Thus, its age provides an accurate estimate for the onset of this globally significant biogeochemical event. Furthermore, because the body fosslis Cloudina and Namacalathus are restricted to strata beneath the ash bed, within A1–A3 carbonate units, its age provides a direct constraint on the age for the upper range limit for these fossils.

A second, stratigraphically older ash bed (sample MKZ-11) occurs below the top of the A3 carbonate (Figure 1). Core facies indicate deposition of the ash within a large thrombolite reef; Cloudina fossils are abundant below and above the ash bed within the reef facies.

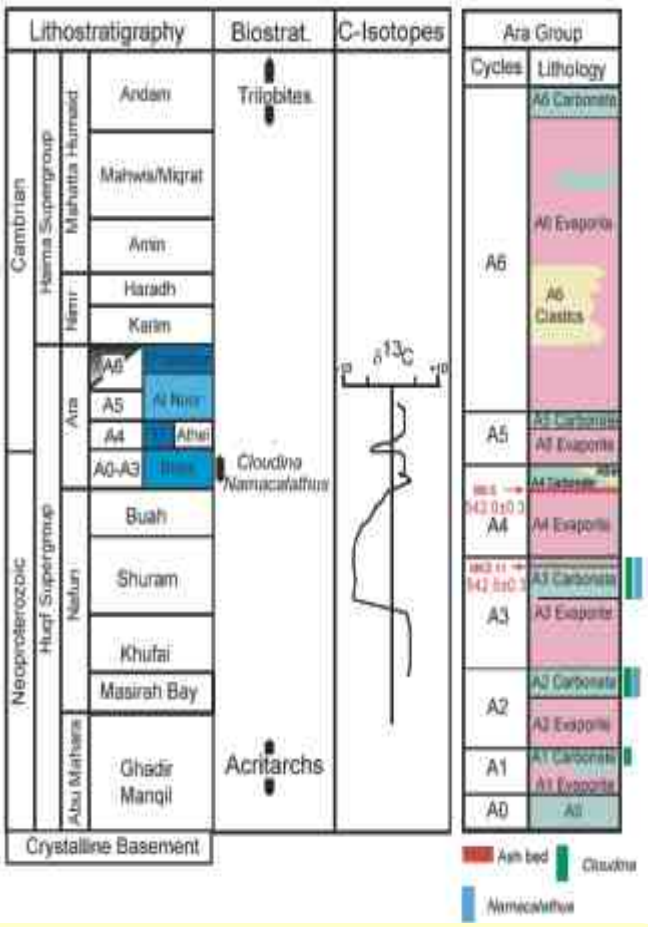

Figure 1 : Stratigraphy of Huqf Supergroup (Amthor *et al.,* 2003). Right hand column shows internal Ara Group Stratigraphic subdivisions. Each cycle consists of a lower evaporite ± 0.6 Ma., shown in the red). Terminal proterozoic Cloudina and Namacalathus are present int he A2 and A3 carbonates , but absent above the A4 carbonate , thus making the PCB at the base of the A4 carbonate for fur ther discussions see Al Husseini *et. al,* 2003.

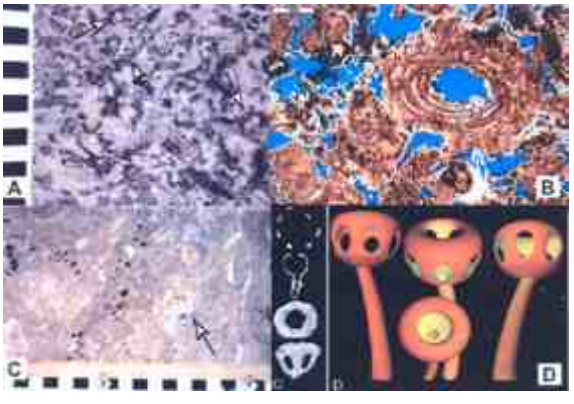

Figure. 2.A) Cloudina fossils (arrows) in A3C thrombolite buildup . B) thin section photomicrograph of Cloudina fossils . C) Probable Namacalathus fosils (arrow) in A3C thrombolite buildup.D) Illustration of digital reconstructions of Namacalathus fossils (Grotzinger *et al*.,2000)

Extinction at the Precambrian-Cambrian Boundary?

In addition, probable Namacalathus fossils occur below the ash bed. Zircon grains from BB-5 (17 samples) and MKZ-11 (12 samples) were used to determine the U-Pb ages of the two volcanic ash intervals. The age of the A4 Carbonate was estimated at 542.0 ± 0.6 Ma, and the A3 Carbonate at 542.6 ± 0.3 Ma (Amthor *et al*., 2003).

Biostratigraphic, carbon isotope, and U-Pb zircon geochronological data from the Ara Group of Oman indicate an abrupt last appearance of Cloudina and Namacalathus coincident with a large-magnitude, but short-lived negative excursion in the carbon isotope composition of seawater that is globally coincident with the Precambrian-Cambrian boundary.

U-Pb zircon age data from an intercalated ash bed directly define this negative excursion to be at 542 ± 0.3 Ma, consistent with previous age constraints from Siberia and Namibia. Combined with the global biostratigraphic record, these new data from Oman strengthen hypotheses invoking mass extinction and faunal turnover at the Precambrian-Cambrian boundary.

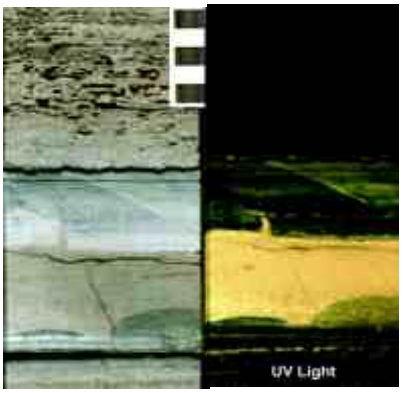

Figure 3 : The MKZ -11 ash bed in core under normal white light (left) and under UV light (right).

By: Joachim Amthor
Joachim.Amthor@pdo.co.om

References:

Al-Husseini, M., Amthor, J., Grotzinger, J., and Mattner, J., 2003, Arabian Plate Precambrian-Cambrian Boundary interpreted in Oman's Ara Group: GeoArabia, v. 8, p. 578-580.

Amthor, J. E., Grotzinger, J. P., Schröder, S. Bowring, S. A., Ramezani, J., Martin, M.W., and Matter, A. 2003, Extinction of Cloudina and Namacalathus at the Precambrian-Cambrian boundary in Oman: Geology, v. 31, p. 431-434.

Brasier, M.D., 1989, On mass extinctions and faunal turnover near the end of the Precambrian, in Donovan, S.K., ed., Mass extinctions, processes, and evidence: New York, Columbia University Press, p. 73–88.

Conway Morris, S. C.; Mattes, B. W. & Menge, C., 1990, The early skeletal organism Cloudina: new occurrences from Oman and possibly China: American Journal of Science, v. 290A, p. 245-260.

Grant, S. W. F., 1990, Shell structure and distribution of Cloudina, a potential index fossil for the terminal Proterozoic: American Journal of Science, v. 290A, p. 261-294.

Grotzinger, J.P., Bowring, B.Z., Saylor, B.Z., and Kaufman, A.J., 1995, Biostratigraphic and geochronologic constraints on early animal evolution: Science, v. 270, p. 598–604.

Knoll, A.H., and Carroll, S.B., 1999, Early animal evolution: Emerging views from comparative biology and geology: Science, v. 284, p. 2129–2137.

Seilacher, A., 1984, Late Precambrian and Early Cambrian metazoa: Preservational or real extinctions?, in Holland, H.D., and Trendall, A.F., ed., Patterns of change in Earth evolution: Berlin, Springer-Verlag, p. 159–168.

"Enigmatica" from the Al Khlata?

We spent part of Eid at Al Khlata following up the chance discovery of a pitch (bitumen) clast in a diamictite by a visiting student. Unfortunately, in several hours of searching, we found no more.

However, we did visit some other Al Khlata outcrops and at one we went up a small side wadi. All of a sudden the wadi floor was strewn with blocks showing all sorts of delicate sole marks (Dzulynski and Walton would have been in their element), burrows, unusual rosette-shaped iron concretions and strange bifurcating crack fills.

The interval concerned is a centimetre-bedded lake deposit above the basal diamictite and overlain by a complex of diamicts, sands and gravels. It may record interglacial conditions. The sediments were probably organic-rich at the time of deposition and then oxidised and reddened secondarily. Any ideas as to what any of the features illustrated are or might imply will be most welcome.

By: Alan & Felicity Heward
alan.heward@pdo.co.om

Bifurcating crack-fills, roots or burrows? Note the vertical burrow openings on the larger slab.

Parallel-sinuous current scours, frondescent marks or a deposit-feeding trace fossil? Other burrows, or is the large cylinder a root cast?

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"GSO: A major leap for the geological community"

Introduction

The Geological Society of Oman was founded by a Ministerial decision in April 2001, to resolve the need to provide a platform for knowledge sharing and exchange of ideas to the growing numbers of Omani geologists. Our vision is to become one of the premier geological societies in the region by actively sharing Oman's unique and diverse geological heritage with the rest of the scientific community.

The Geological Society of Oman has successfully completed its second year and we are currently towards the end of our third year (2003-2004). Since April 2001, GSO has steadily grown in size with a total of 270 members attracted to join the society till January 2004. The enrolling members represent a spectrum of geoscientists from a wide and diverse background and affiliations. The members range from amateur geologists through academia students and professors to energy companies staff and managers (Figure. 1). The majority of members are of the active category followed by associate members then junior and student members. In addition, three individuals were awarded honorary membership since 2001. (Figure . 2)

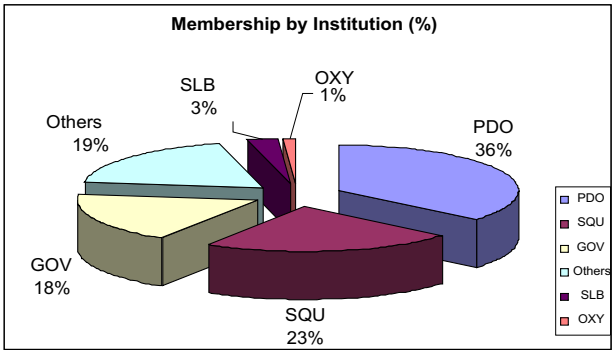


Figure. 2: GSO members differentiated by categories

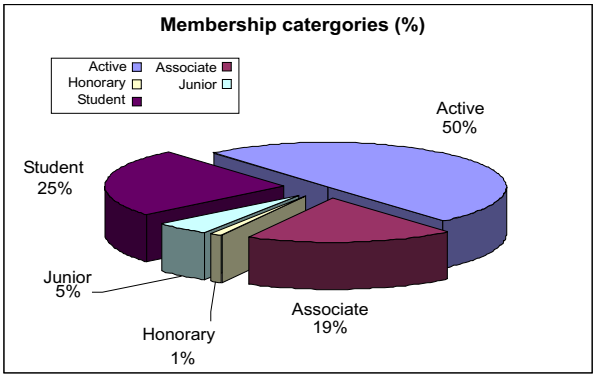


Figure. 1 : GSO members differentiated by affiliating institutions

Activities

GSO activities span a wide variety. These include monthly talks, field trips, teacher's workshops and annual exhibitions, which are run on regular basis supported by the growing numbers of attendees. Collaboration with international and renowned societies is one way to establish a distinguished presence in the geoscience field and therefore, international as well as local scientists are invited to conduct and participate in the activities of GSO. An example of this is the hosting of **Charles Kerans**, one of AAPG distinguished lecturers, by GSO to give a talk on the "Evolving Models of Middle Eastern Cretaceous Carbonate Reservoirs " in March 2002.

Furthermore, in accepting an invitation from the GSO, Robbie Gries, the president of the American Association of Petroleum Geologists (AAPG), visited the Sultanate (17th-21st of April, 2002) following the GeoArabia 2002 conference. Robbie's visit included an exposure to the diverse and spectacular geology of Oman through a field trip to Jabel Shams and presenting a talk that addressed the "Role of the geologist in meeting future energy demands".

Monthly Talks & Field Trips

Since its conception in 2001, GSO has steadily but surely flourished. This is reflected in the increase in the number of talks given and field trips conducted by the society (Figure. 3). In the first year, GSO arranged for six monthly talks and organised two fieldtrips. In 2002-2003, the monthly talks number had risen to 10 talks whilst five field trips were conducted. A total of twelve monthly talks and five fieldtrips, are scheduled for (2003-2004), of which many have already been presented. The talks covered a wide variety of topics and were presented by local scientists (SQU, PDO & MOG) as well as international visitors from the Netherlands, UK and USA.

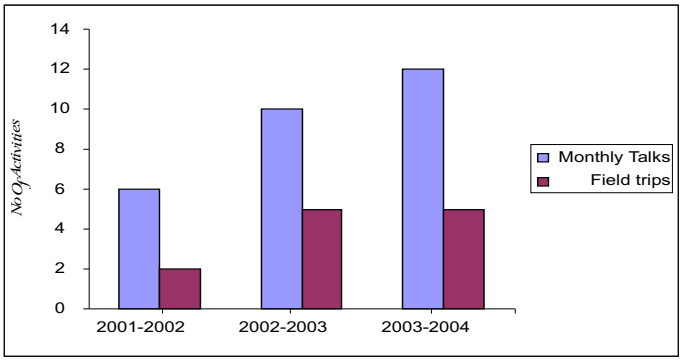


Figure. 3: Number of monthly talks and field trips conducted by GSO since 2001.

International Collaboration

Our plan for the reminder of this year (2003-2004) and coming years aims to expand on all our previous activities in addition to establishing and affirming a more international presence amongst the leading geoscience organizations. At the international level, GSO and for the first time is represented in the organizing committee of the 6th Middle East Geoscience Conference (GEO 2004). In addition to many of its members presenting in the conference, GSO is sponsoring a field trip "Early-Late Permian Gharif deposits of Oman at outcrop and in core" in Oman and a workshop "Shu'aiba Core Workshop" in Bahrain whose details are provided later on in the newsletter. Moreover, GSO together with the Joint Virtual Reality Centre for the Carbonate Studies and the Department of Earth Sciences at Sultan Qaboos University is organising the 24th IAS sedimentology conference. The conference will be held in Muscat in early 2005 and carries the theme "Scenic Sedimentology".

In its quest to develop links with other societies in the region, the Geological Society of Oman represented by Hisham Al-Siyabi, Mohamed Al Harthy and Zaher Al Musallami met with 33 members of the Dhahran Geoscience Society (DGS) during their visit to Oman as part of a fieldtrip that DGS was running which lasted from the 9th to the 14th of February 2003. GSO representatives visited the group on the 9th of February at the Bustan Palace Hotel. During the meeting Hisham Al-Siyabi and Mohamed Al Harthy gave two presentations to the group about the general geology and the petroleum geology of Oman, respectively. Opportunities for future cooperation between the two societies were also discussed.

GSO also joined ventures with the Society of Petroleum Engineers (SPE), Oman division, and co-organised a talk and a fieldtrip during March of 2003. Stephen Thomas the chairman of the Oman Petroleum Alliance (OPAL) delivered the talk, which was held on the 11th of March 2003. The title of the talk was "Building industry wide consensus to develop a world class oil and gas industry for Oman". The destination of the fieldtrip, which took place on the 27th of March 2003, was Wadi Meeh and Yiti. The trip was led by Henk Rebel and Omar Al Ja'aidi and focused on the structural geology of the area.

Another milestone for the society was achieved when GSO sponsored the running of the 2003 SEG/EAGE distinguished instructor short course here in Oman. The link between the GSO and European Association of Geoscientists and Engineers (EAGE) was first established during GSO's first participation at Geo2002. At that encounter, ways of cooperation between the two societies were discussed. The SEG/EAGE course, which was titled "Geostatistics for seismic data integration in earth models", was delivered by Dr. Olivier Dubrule. The course which was held on the 18th of October 2003 was attended by 40 participants including students from Sultan Qaboos University.

Other Activities

Amongst the activities the GSO takes pride in, is its continual involvement with the training of basic education teachers in the subject of geology. Last year, the GSO in collaboration with the Sultan Qaboos University, Petroleum Development of Oman and Ministry of Education had organized a 3 days workshop in geology. Twenty four teachers and supervisors from the various wilayat of the Sultanate of Oman attended the workshop, which included lectures, hands on practicals and field work. Going back to their schools, the teachers held their own geology practical sessions for the students using classic hand specimen collections gifted by the GSO. The workshop was highly commended by the teachers and the Ministry of Education and another workshop is planned for 2004.

For two years in a raw, GSO was able to put together a public exhibition to give the local community a flavour of Oman's fascinating and unique geology. The exhibit comprised of rock, fossil and mineral displays as well as aerial photographs and slide shows of the various geological features within the Sultanate. Many of the visitors were intrigued by the displays and it could confidently be said that awareness and curiosity of the geology of Oman was established.

To achieve our vision of becoming the premier geoscience society in the region, GSO has launched a quarterly newsletter in January 2004 called "**AL HAJAR**". The newsletter is intended to be crisp and light but still informative with a cutting edge. The newsletter incorporates technical, business and leisure geoscience topics. The first issue of **AL HAJAR** covered interesting topics and was received with much enthusiasm and support from the GSO members and other various parties and we are looking forward to establishing the newsletter as a platform of leading geoscience news and knowledge in Oman and internationally.

GSO is also working closely with the Department of Earth Sciences in the Sultan Qaboos University in order to further develop the students into mature geoscientis. To that objective the GSO sponsored the first SQU Geo-Group Newsletter in 2002.

From the outline above it is clear that GSO is established to deliver a message and it is taking on board the responsibility with pride, courage and commitment. Finally one may say: Although the establishment of the GSO was an important step for the Omani geologists, it is a much larger leap for the international geological community.

By: Nadia Al-Abry
Nadia.SN.Abry@pdo.co.om

GSO in GeoArabia 2004

From its establishment, the Geological Society of Oman has pursued the attainment of its goals and stated purpose through the continued running of field trips, technical presentations, publications and involvement in community affairs.

In the international arena, the GSO was involved in Geo2002 conference, which was held in Bahrain. The Geo2002 conference was a fantastic opportunity and provided a great platform for the introduction of GSO to the outside world. In GeoArabia 2004, GSO's contribution differs drastically. Not only will a significant number of its members be participating in either oral or poster presentations, the GSO is sponsoring a fieldtrip (Early-Late Permian Gharif deposits of Oman at outcrop and in core) and a workshop (Shu'aiba Core Workshop).

Moreover the GSO was involved in the organizing committee of the conference and a representative from GSO (Omar AL-Jaaidi) attended a meeting of a few days in Bahrain to help with setting up the conference program. The organising committee comprised a wide variety of associations such as national and international oil companies, academia, service industries and seven geoscience societies. This provided a very useful contact network for GSO and aided its interaction and involvement with the other organisations and societies. Of importance is the attendance of the GSO's representative of inauguaration of the Bahrain Geoscience Society during the visit.

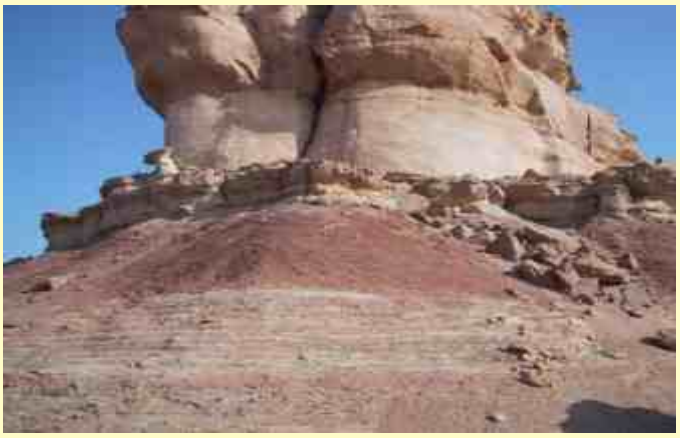
Continual interaction between Omar and the Geo2004 organizing committee was maintained whilst the details of the different events were being finalized. This allowed and facilitated the early cascading of information to GSO members. GSO will also be presented in the Geo2004 exhibition hall, where members of the society manning the booth will be happy to discuss the society's up coming activities and plans.

The Gharif Formation Field Trip

GSO's Geo2004 fieldtrip, which will run 2nd – 5th of March, will examine glacial pavements and deposits of the Al Khalata Formation, and shallow-marine and continental deposits of the overlying Gharif Formation. The Gharif Formation is devided into three sequences: lower Gharif (mixed clastic and carbonate sequence), Middle Gharif (a lagoonal and coastal plain deposit) and Upper Gharif (multi storey river channel-belt sands, mottled palaeosols and subaqueaous shales and sands deposits).

Al Khlata and Gharif sandstones form important reservoirs for oil in the South Oman and Ghaba Salt Basins west of the outcrops. Palynology is used extensively in correlating these reservoirs and provides important evidence of age, presence of unconformities, changing climate and depositional conditions.

The outcrops to be visited lie within the Arabian Oryx Sanctuary, a UNESCO World Heritage Site. A visit is planned to the Oryx Project Centre at Jaaluni. After visiting the outcrops in the northern Huqf area of Oman the participants will examine cores through the formation from nearby producing fields in the Petroleum Development of Oman core shed in Muscat.



Upper Gharif multi-storey channel-belt sandstones, paleosols and subaqueous shales/sands, north Huqf.

Middle Gharif calcrete-bearing paleosols and deformed subaqueous deposits, Bahja field, Central Oman.

The Shuaiba Workshop

The Shuaiba Formation contains some of the most prolific hydrocarbon reservoirs of the region mainly in a diverse spectrum of rudist build-ups, algal build-ups and biostromes, and subtidal shelf strata. Lateral and vertical facies variations and a complex diagenetic overprint combine to make these among the most heterogeneous and demanding for reservoir management.

This is the first time that cores will be on display from several Shuaiba reservoirs of the region. The purpose of this workshop is to examine these cores, allow comparison and differentiation, and to present these datasets within a regional context for the Shuaiba Formation. The workshop will be held for a day and a half starting on the 10th of March at the Bahrain International Convention Centre. Following regional overview individual topics will be introduced by short presentations followed by ample time for observation and discussion on the rocks.

By: Omar Al-Ja'aadi
aljaaidi@squ.edu.om

Scenic Sedimentology

IAS 2005
SCENIC SEDIMENTOLOGY
Muscat 10-13 January

For more details, visit the below link
gso.org.om

The Geological Society of Oman together with the Joint Virtual Reality Centre for Carbonate Studies (a Shell and SQU joint venture) and the Department of Earth Sciences at Sultan Qaboos University (SQU) will organize an IAS sponsored Sedimentology conference early in 2005. The 24th IAS meeting of sedimentology conference will be held at Sultan Qaboos University, in Muscat (Oman) under the theme of "scenic sedimentology".

The technical themes that will be covered in the Muscat Sedimentology Conference include: Neoproterozoic climate change; Glacial Deposits (Precambrian and Permo-Carboniferous in particular); Microbial deposits (Precambrian, Permian-Trias, Cretaceous); Carbonate platform systems (Precambrian and Cretaceous in particular); and modern and ancient aeolian systems.

The fieldtrip programme is set to cover almost the entire stratigraphic column exposed in the magnificent outcrops of the Oman Mountains, the Huqf and those near Salalah in the southern part of the country. The planned fieldtrips will look at Permian to Cretaceous Tethyan continental slope and abyssal plain deposits, PreCambrian deposits (clastics, carbonates and glacial deposits), Permo-Carboniferous glacial deposits, Mesozoic (in particular Cretaceous) platform carbonates, the Permian-Triassic boundary, Post-obduction Tertiary limestones, recent and modern carbonate-evaporite systems in Bar al Hiqman peninsular, and modern dune systems in al Wahiba and Rub al Khali. In addition, a fieldtrip is also planned to look at the Upper Cretaceous oceanic crust.

By: HishamAl Siyabi
Hisham.Siyabi@pdo.co.om

Eleven ladies exploring Majestic Muscat

The fascinating geology of the Muscat area was explored by eleven motivated ladies lead by the radiant geologist Mia VanSteenwinkel. The field trip was the first "Ladies Only" trip organised by the Geological Society of Oman and it was received with great excitement and enthusiasm. The participants of the trip included both geologists and amateur geologists and started with a complimentary coffee and cake at the top of an Ophiolite outcrop in Qantab area. The location provided an overview of the Mesozoic carbonates, Ophiolites and Tertiary conglomerates and marls which stimulated a comprehensive discussion aided with sketches and schematic diagrams.

The relaxed atmosphere promoted energetic participation from the ladies including the non-geologists and encouraged detailed discussions on Oman geology. This atmosphere was sustained throughout the trip and especially whilst visiting the next two stops to see the Tertiary coastal plain channel fill deposits in Wattayah and the Pleistocene Aeolian dunes in PDO Ras Al-Hamra camp.

The trip ended with a delightful lunch at the Crown Plaza Hotel which was enjoyed by everyone and provided an excellent setup for end of the day discussions for a very successful trip. GSO presented a thank you gift for the field trip leader and promised to organise a series of ladies only field trips to cover more of the vibrant geology locations scattered all over Oman.

By: Nadia Al-Abry
Nadia.SN.Abry@pdo.co.om

The Ladies exploring the Ophiolite in Qantab, Muscat area.

Snowball Earth Paul Hoffman GSO monthly lecture (6th January 2004)

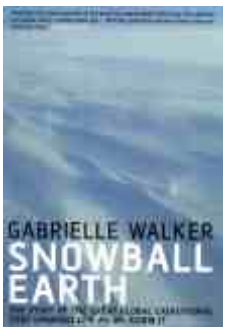
Professor Paul Hoffman, a passionate advocate of Snowball Earth. Photo courtesy of Felicity Heward.

We were there to wonder. It was not a lecture for people who like geology. It was a story for those who love this mysterious, wonderful earth and admire those who try to understand it, to unlock its past natural history. Paul Hoffman was there at the GSO monthly meeting to tell us the story of the snowball earth. Hoffman's lecture was a tale of the evolution or revolution of the history hypotheses.

He started his tale by talking about physics, which was basically, reflection and thermal physics. Half way through his talk he mentioned some terms one being erosion. This was really a switch to move to another science subject…Chemistry.

The star of the ring there was CO2. He then merged both physics and chemistry in a fantastic fashion to move to geology, which constituted the last part of his talk. He impressively demonstrated that geology is a science that uses all other sciences. To be an exceptional geoscientist there is no way out but mastering all the subjects.

The story was about the natural history of the period between 500 and 700 million years and was a joy to listen to. He lectured powerfully and simply and as, it seems, almost overwhelmed us with a sense of beauty, intellectual excitement and never ending discovery. His lecture was rich in detail. Its breadth and readability are complemented by his feelings and elegant presentation. I have witnessed a double vision that brings the vast scale of planetary processes into the realisation of human experience. It was an excellently presented topic and thoroughly informative talk.



By: Mohamed Al-Harthy
Mohamed.Harthy@pdo.co.om

Snowballs in Oman?

The idea that the earth was once in the grip of ice ages so severe that even the tropics froze may sound like a nightmare out of science fiction, but Professor Paul Hoffman of Harvard University believes that's exactly what happened in Neoproterozoic times1. He has championed 'Snowball Earth' to explain how there could be widespread glaciations at low latitudes on every continent. Professor Philip Allen, an eminent sedimentologist, who with his students has worked on these rocks in Oman, is less convinced by the evidence2. So when the GSO organised a trip to the glacial rocks of the Huqf Supergroup with Paul and Philip as 'distinguished guests', it was too good an opportunity to miss.

The trip began with us all standing on a small hill near Nakhl, whilst Joachim Amthor gave us an overview of the geology. Paul Hoffman asked a seemingly innocent question – why were the Oman Mountains there? – and provoked quite a discussion. It was 60 million years since the ophiolites had been thrust over the land and ~20 million years since the mountains had been uplifted. This should have been quite long enough to reduce them to nothing, yet there they were, shimmering in the haze ahead of us. It seemed that no one really had a convincing answer, but Jean-Paul is working on it!

As we stood and talked, the clouds started to thicken and a cool wind began to blow, and the jokes about the only ice that we find would be in the cool box, suddenly seemed not quite so funny, and I momentarily wondered whether hot chocolate and soup would be more appropriate for lunch than chilled pepsi and iced tea. But I need not have worried – the field trip was entitled 'From Snowball Earth to Hothouse' and the cool phase soon passed.

We began the drive up Wadi Bani Kharus, through the gorge into Wadi Hajir, and then on to the head of the wadi. All the time we marvelled at the impressive mountain scenery around us, but unfortunately our convoy of eight vehicles stirred up a large cloud of dust. At the village of Halhal, Philip was our guide to the sediments of the Fiq Member exposed in the wadi walls. The prospect of doing fieldwork in the wadi, where there is such massive exposure must have been somewhat daunting – where to start? – and I wondered what further secrets would be revealed from the inaccessible peaks high above us.

Philip led us up the wadi, showing us the unmistakable signs that ice had once been there – thick sequences of diamictite, with assorted boulders and clasts floating in a grey fine matrix. Intercalated with the diamictites were sediment gravity-flow deposits. Dating these sediments has been done by radiometric dating of zircon crystals within the sandstones and in rare ash beds.

Back at the village and into the cars for the drive to the next stop – for lunch. Many thanks to Hisham and his wife for providing a tasty and filling lunch. There was plenty of food for thought as well with an interesting discussion about 'Snowball Earth' issues.

Professor Philip Allen engaged in the discussion after lunch

After lunch we climbed the hill behind us to see the Hadash Formation - the cap carbonate of the Snowball theory. All around the world, Neoproterozoic glacial deposits are capped by a transgressive carbonate of varying thickness with no sign of hiatus between the two. It's quite incredible to see the grey diamictite pass suddenly upward into an orange laminated dolomite and realise that the one was deposite in a cold glacial sea and the other in a warm tropical sea. Paul asserts that the Snowball Earth theory is the solution to this dilemma.

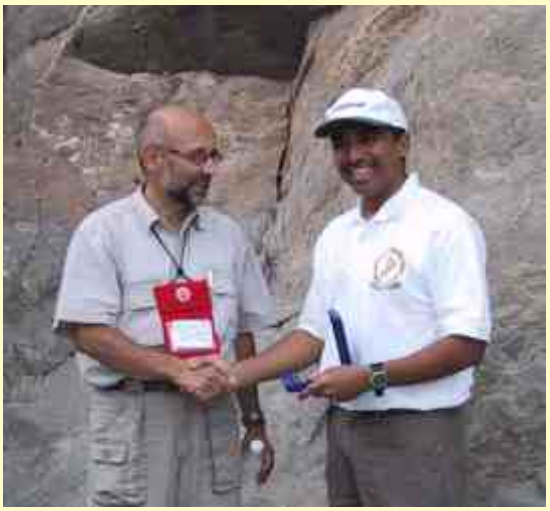
Sitting on the cap carbonate Hadash Formation, Paul pointed out that its low levels of ?13C indicated an inorganic origin, as would be predicted by the Snowball theory3. He maintains that the carbonates are the product of the sudden massive chemical weathering that occurred when the hydrological system restarted as the ice began to melt, and acid rain from high levels of CO2 in the atmosphere fell on the siliciclastic debris left behind. The products were washed into the sea, which became saturated and carbonates were precipitated. It was the greenhouse effect of CO2, which had built up to massive levels in the atmosphere over several millions of years through normal volcanic activity, that eventually overcame the runaway albedo effect caused by highly reflective snow and ice, and allowed temperatures to soar and the ice to melt.

Joachim Amthor at the Hadash cap carbonate (cap for scale!). Photo courtesy of Yousuf Al-Sinani

The carbonate is also iron rich, due to the oceans being anaerobic during the Snowball event, and thus capable of holding iron in solution, but the iron precipitated out again once the ice melted and the oceans became aerobic once more. In some parts of the world, the peculiar chemistry of oceans at such times is indicated by aragonite fans and primary growths of barium sulphate.

As we drove back, the unconformity between the Buah and the Khuff was dramatically exposed in the sides of the wadi. Our last stop was to view some domal stromatolites, ancient forms of simple life. Modern day stromatolites can be seen in Shark Bay, Australia, but they have apparently ceased to grow as they are no longer in the subtidal zone where they like to be. In contrast the stromatolites of the Bahamas are much healthier and are even quite happy to begin a new patch by growing on a discarded drink can.

Walking to the outcrop, we passed some Arabic graffiti on the rock face that Nadia told me were mainly names and dates. It seems that the desire to leave one's mark for posterity is a universal instinct. I wondered if this graffiti would ever attract as much attention as the single celled creatures that lived over 550 million years ago and left behind their 'signature' in the rocks that we had just been to see.



Hisham Al-Siyabi, GSO President, thanking Joachim for leading the trip, against a backdrop of Buah stromatolites

Many thanks to Hisham for organising the trip, to Joachim for guiding us and to the 'distinguished guests' for sharing their knowledge and enthusiasm for these intriguing rocks.

By: Felicity Heward
Alan.Heward@pdo.co.om

References:

1. Hoffman, P.F. and Schrag, D. P., 2000. Snowball Earth. Scientific American vol. 282, no. 1, p. 50 – 57.

2. Leather, J., Allen, P.A., Brassier, M.D., and Cozzi, A., 2002. Neoproterozoic snowball earth under scrutiny: Evidence from the Fiq glaciation of Oman. Geology, vol. 30, no. 10, p 891-894.

3. Hoffman, P.F., and Schrag, D.P., 2002. The snowball earth hypothesis: testing the limits of global change. Terra Nova, vol. 14, p 129-155.

Ken Glennie

Ken Glennie is widely regarded as the father of Oman geology. In the 1960's he led a team that mapped the geology of the Oman mountains. In addition to this monumental task, to many geologists, the name Glennie is synonymous with desert sedimentology (through his 1970 publication Desert Sedimentary Environments) and with petroleum geology of the North Sea (with a book of the same name published first in 1984 and now in it's fourth edition [1998] of which he was editor and a major contributor). Ken has worked tirelessly to refine and update concepts developed through his working career as a Geologist with Shell and continues to do so in retirement with a seemingly never-ending stream of books, papers and presentations.

Born in England of Scottish parents, Ken spent part of his childhood in Reading. His father died when Ken was only seven and he and his older brother were sent to boarding school. Their mother, then, took in lodgers to support the family. Ken developed an interest in science from spending holiday times conversing with a few of his mother's lodgers, most of whom were scientists.

At the Royal Commercial Travellers' School, Ken's favourite subject was geography. One of the older students suggested that he teach himself geology, something not included in the curriculum. So he obtained a few geology texts and began reading. Occasionally, his geography master set him essays, but the time came when the master recognized that Ken had moved beyond his own knowledge of the subject. And yet, during this time, Ken never had the opportunity to look at outcrop.

World War II broke out while Ken was still in secondary school. Recognizing a likely shortage of engineers during and after the war, the British government recruited Ken into a 21 month basic engineering training course. Ken began this training immediately on leaving school. By the time he had completed it, the war was over. To fulfil his military obligation, Ken was sent to Libya in the Royal Corps of Signals. This was Ken's first exposure to the desert while out on exercises with his troops.

Prof. Ken Glennie

Following army service, Ken enrolled at Edinburgh University to study geology. During his last year, for his BSc dissertation, he spent considerable time in the field in the Lake District. At the time Ken completed his BSc, Shell was offering scholarships to bright geology students to study for advanced degrees. Ken accepted one of these scholarships, continued on at Edinburgh University and went back to the Lake District to work more on his structural problem. At that time Scottish universities did not offer MSc degrees. But Shell agreed that a written report on his Lake District work would satisfy them. The MSc degree, however, was instituted in Scotland as Ken was finalising his report for Shell. And he was allowed to submit the report as a thesis for a degree, enabling him to become the first person to be awarded an MSc degree at a Scottish university.

Ken joined Shell in 1954 and spent the next 18 years mostly as a field geologist, initially in New Zealand, Canada, and Nepal before returning to Head Office in The Hague, Netherlands to take-up the lead position in turbidite (deep sea sediment) research. But shortly before his arrival, the revelation that the biggest gas field in Europe (Groningen, located in The Netherlands) was possibly hosted in desert sediments, resulted in cancellation of the turbidite budget and a challenge for Ken to 'go a find out what makes deserts tick!' Thus a new era of fieldwork began, the results of which placed Ken in the minds of many as one of the Fathers of desert sedimentology.

Following the discovery of the Fahud and Natih fields in Oman in the mid 1960's, Ken's desert work was followed by leading a team mapping the geology of the Oman Mountains. Using photogeology as a guide, Ken and his colleagues measured sections and mapped during the winter months from a tented camp but returned to Holland to work out their results during the hot summer months. The results of their endeavours were used by Ken to compile an integrated picture of the history of the Oman Mountains region and, to all extents, the conclusions of this early work still stand today. After Oman, he and his team studied similar rocks in Iran (Makran) and Turkey. The Oman geology was published in 1973 and 1974, but not until after a provisional report and completed maps were sent to PD Oman.

Transferred to Shell Expro in London in 1972, Ken spent the next eight years working on North Sea Geology and, after another four years in The Hague, returned to London for an additional two years (after being pensioned by Shell in 1985) to be technical editor of the first of the Barbican meetings on the Petroleum Geology of NW Europe (meeting in 1986, published 1987). Just before being pensioned, Ken was awarded a DSc degree by Edinburgh University on a thesis entitled Deserts, Present and Past, comprising mostly past publications on the subject.

Thus Ken was pensioned but he did not retire. He consults in a minor way, lectures to MSc students and supervises PhD candidates, continues field studies and writes and edits publications. Recently he contributed to the Geological Atlas of the Central & Northern North Sea (published 2003) and earlier co-edited an English translation of Walther's 1924 classic text: The Law of Desert Formation – Present and Past He is currently at work on a book about the Desert of Southeast Arabia.

As for advice Ken might give to young geologists, he believes that being on one's own in the field forces geologists to develop their own working hypotheses rather than relying on co-workers to do their thinking for them. Also, the outcrop is where so much valuable information can be studied in detail, especially in Oman where the rocks are so well exposed; only then can one apply this experience to cores or wireline logs. And as 'The Present is the key to the Past', a good knowledge of modern geological processes is always invaluable when trying to interpret the preserved rocks of the subsurface data . The best geologists are usually those who have seen the most geology, so field work is always very important.

In 2003, Ken was awarded Honorary Membership of the American Association of Petroleum Geologists (AAPG).

When not in the field or at his desk, Ken cuts and polishes rocks for book ends. He also regularly walks in the hills of Scotland with a group of local walkers and, in mid winter each year, he can be found in his kitchen making orange marmalade for his family and for clientele of his daughter's bed and breakfast.

He lives in Ballater, Scotland.

By: Caroline Hem & Franci Bager
sfandflf@omantel.net.om

Asian International News

INDIA

ONGC plans to offer 19 marginal oil and gas fields for development in the Heera-Panna-Bassein (Bombay Offshore) area in an effort to develop some 500 MMbo and 1 Tcf not previously considered economic. Tenders for the 19 marginal fields are understood to have been floated, with ONGC giving the deadline for interested parties to notify their expressions of interest by 15 January 2004. This would then be followed by a lengthy period of bidder conferences, data viewing in Bombay, sale of bid documents and pre-bid clarifications. ONGC reportedly is hoping to announce the awards by the end of 2004.

IRAN

According to reports attributed to Seyyed Mahmud Mohaddes, Director of Exploration for NIOC, a light oil discovery has been made in the Aran and Big Dol region by the Aran 1 wildcat drilled by a subsidiary of Sinopec. It is located on the 4,670 sq km Zavareh-Kashan block in the Qom Basin and is the first of two obligation wells. No comment has been made with regards to reserves and officials estimate that oil recovery will be at a rate of up to 5,000 b/d.

KUWAIT

While further testing is planned KOC has already advised that it has recovered both oil and condensate from its Ruhaya 2 well. Located close to the suburbs of the town of Al Jahrah, some 40km south-west of Kuwait City, the well flowed 5,400 b/d of 52o API condensate from the Jurassic Sargelu and Najmah formation at a depth around 4,816m. Earlier the well had produced 630 b/d 46º API crude from the Lower Jurrasic Marrat Formation. Ruhaya 1 was drilled prior to the 1990-1 Gulf War, but under went little evaluation.

PAKISTAN

Petroleum Exploration Ltd (PEL) has been exclusively awarded the Salam 2769-13 EL in the Middle Indus Basin. The 200.22 sq km block in the Ghotki and Jacobabad districts of the Sindh province is located between its Badar D&PL, OGDC's Qadirpur D&PL and Pakistan Petroleum Ltd's (PPL) Kandhkot D&PL. The work program for the initial two years is believed to include G&G studies and 30km 2D seismic reprocessing, with a financial commitment of about US$ 500,000. Reportedly, at least one exploration well has also been planned.

BHP Billiton has completed its footwall appraisal well on the Zamzama D&PL in the Middle Indus Basin as a producer after finding gas in both the Cretaceous Pab Formation and the Paleocene Khadro Formation. Zamzama East 1 was drilled to a total depth of 4,051m, encountering 36.3m of net gas bearing sandstone within a 61.3m gross gas column in the Pab Formation and the accumulation shares a gas-water contact with the main field. Gas flowed at the rate of 40 MMcf/d through a 48/64" choke from an 8.5m perforated interval.

QATAR

In announcing its planned spending for 2004 Talisman Energy confirmed plans to acquire 1,000 km of 2D and 400 sq km of 3D seismic on its offshore Block 10 concession during the year. This 3,173 sq km tract was awarded in November 2002 and carries a US$ 30 million minimum work commitment, to include the reprocessing of existing 2D seismic data, the acquisition of new 2D and 3D seismic and the drilling of three exploratory wells. Block 10 is a high profile license as it is believed to contain an extension to Iran's offshore Balal oil field, in which operatorship has recently been transferred from Total to NIOC. Talisman has assigned 3P reserves of between 100-300MMb to the prospect, presumably contained in the Arab Formation.

SAUDI ARABIA

In the space of one week during the middle of January 2004, there were two important developments that will impact on foreign investments in the Kingdom. Firstly the cabinet approved a 10% reduction in corporate tax for foreign-owned businesses from 30% to 20%. This is to become effective 90 days after its publication in the government gazette and is intended to stimulate foreign investment to diversify the country's oil-based economy. On the downside, the Saudi Press Agency also stated that during the same meeting the cabinet approved a 30% tax on "investments" in natural gas ventures and 85% tax on oil and "hydrocarbon" production. Further details are currently being sought particularly in light of the announcement by oil minister Ali Al Naimi that three new gas blocks will be offered on 25 January 2004 as part of a new gas bid round aimed at international companies. The current policy of the authorities is to strictly limit the development of any new gas reserves to domestic usage.

SYRIA

The launch of a bid round has been talked about since third quarter 2003 but on 19 January 2004, the Ministry of Petroleum and Mineral Resources finally issued an invitation. Carried by the local media, international oil companies are invited to participate in the acquisition of Production Sharing Agreement's in the first bid round of 2004, the country's fourth in three years. The deadline for submitting bids has been set for 31 May 2004. More information can be found at the MOPMR official website (http://www.mopmr-sy.org/opport.htm)

YEMEN

Details remain incomplete at this time and certainly the time frame seems uncomfortably short, but the chairman of the Petroleum Exploration and Production Authority (PEPA), Eng. Nabil Saleh Al-Gawsi has opened a bidding round for seven newly created blocks. A closing date of 15 February 2004 has been set. The seven blocks are identified as follows.

Mashef Block 69 Area relinquished by Vintage in Block S1 (October 2003)

Atiq Block 70 Area relinquished by Vintage in Block S1 (October 2003)

Markha Block 75 First relinquishment by Vintage in Block S1 (2002)

Qarn Block 71 Area relinquished by Nexen in Block-51 (December 2003)

Ain Block 72 Area relinquished by Nexen in Block-51 (December 2003)

Ras Huira Block 73Area relinquished by both Nexen and Gallo oil in Block-51 and Block R-2

Quza Block74 Arearecently relinquishedby MOLin Block-48

UNITED ARAB EMIRATES

A meeting was scheduled for 20 January 2004 between the Pakistan Government and Sharjah-based Crescent Petroleum to revive negotiations on the Gulf-South Asia (GUSA) gas project. It is recalled that the GUSA project calls for an initial supply of 1.6 Bcfg/d from Qatar's North Field to Pakistan to be increased to a maximum of 3.4 Bcfg/d when required. In November 2002 Crescent confirmed that general parameters for a Sales and Purchase Agreement (SPA) had been finalized and that draft fiscal and development terms had been negotiated and agreed with Qatar Petroleum. This latest move follows reports that Pakistan, despite a number of recent domestic gas discoveries, is still facing a shortfall in gas-supply by 2010. Project cost estimates have varied between US$ 2.7 billion and US$ 3.2 billion.

IHS ENERGY
Stuart Lewis
Enterprise House
Cirencester Road
Ilsom Tetbury
Gloucestershire
GL8 8RX, UK
Tel: +44 (0) 1666 501 275
stuart.lewis@ihsenergy.com

GSO Events Calendar

March 2004

6 **8th GSO Talk**
Tom Aigner
Sequence Stratigraphy of Shoals

16 **9th GSO Talk**
John Grotzinger
Mars Exploration

2 to 5 **GEO Arabia-GSO Field Trip**
Alan Heward & Omar Al Ja'aidi
Huqf (Permocarboniferous)

25 **4th GSO-SPE Field Trip**
TBA

10 to 11 **GEO Arabia**
GSO Shuaiba Workshop

April 2004

10 **10th GSO Talk**
Andy Kwartang
TBA

21 to 24 **5th GSO Field Trip**
Alan Heward
Huqf (Permocarboniferous)

GSO Elections
TBA

May 2004

11th GSO Talk
TBA

6th GSO Field Trip
Gordon Coy
Siq Plateau
TBA

25 GSO Annual Meeting

TBA: To Be Announced

Contact Details
AL HAJAR
Geological Society of Oman
P.O. Box 993, Ruwi
Postal Code 112
Sultanate of Oman
E-mail: info@gso.org.om
www.gso.org.om