



AL HAJAR

Geological Society of Oman
Quarterly Newsletter

For Internal
Circulation Only

President's Message

My fellow GSO members, it is with great pride that I write to you at the end of the life of the current Executive Committee and approach the beginning of summer. Our achievements this year are clear for all to see and are covered in our Annual Report. I would really like to dedicate this message to all the Executive Committee members who have contributed in one way or another in making the dream of the GSO a reality. Since the formation of the Society in 2001 to the 2006-2008 committee, 26 members of the society have been in the executive committee and wore the "ExComm" badge. They have been cranking the wheel to contain the energy and the enthusiasm of the members and deliver on the mandate given to them by you, the faithful members, who delegated the task of running the Society to them.

It is becoming more and more apparent that the Society has reached a level of maturity that makes it difficult to make step changes in delivery without changing the organisation. As pointed out by Dr Hisham Al-Siyabi (GSO's first president) through personal communication, the society needs to look beyond the Executive Committee to deliver on our core targets and leave enough thinking space for the ExComm leadership to contemplate what the step changes may be. This way we keep our activities portfolio evergreen. A great example of this is the role played by Dr. Juma Al-Belushi and Dr. Alan Heward in representing the society on the Geological Conservation Committee. We wish to see more of these examples in the future.

The outlook for the coming years is very bright. I can see a lot of energy and enthusiasm in our members and I expect this to be channeled towards delivering more success to the Society.

Regards,
Dr. Mohammed Al-Mazrui

Note from the Editor

Welcome to the 12th edition of Al Hajar and the last edition that I shall be involved with as editor. After almost three and a half years as the GSO Editor it is time to hand the reins over to someone new. My time as editor has been both enjoyable and rewarding and I extend sincere gratitude to everyone who has assisted me, both by contributing articles for Al Hajar and assisting with proof reading, liaising with the publishers and all the various other odd jobs that are involved in the production of this Newsletter.

My duties as editor have been picked up by Caroline Hern, who works for Shell (Oman). Caroline is an accomplished geologist and reservoir modeller, with particular specialisation in aeolian systems. She has had a long association with the Sultanate of Oman, undertaking fieldwork in the Sharqiya Sands as part of her post-graduate research. Subsequently, she spent several years in the Study Centre of Petroleum Development Oman, mainly working on eastern flank oil fields of the South Oman Salt Basin. Recently Caroline has moved to her new position with Shell (Oman). I am sure you will welcome her to her new role.

John F. Aitken
editor@gso.org.om

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Geologically Speaking

Preserving Oman's Geological Heritage – GSO's Perspective



Rudist Reef, northern Huqf.



Fossil tree, northern Huqf.

Geology plays an essential role in all our lives. Geology is of immense scientific importance, providing us with a means of studying and understanding the history of our planet and the evolution of life. It provides us with the foundations on which we have built our society and with many of the natural resources which support our day-to-day existence. It underpins the diversity of our natural environment and gives character to some of our most iconic landscapes. At its heart, geology is a field-based subject, and conservation and enhancement of the existing geological resource is vital for current and future scientific, educational and recreational use.

Geological features provide a fascinating scientific and educational resource, recording millions of years of history in which continents have moved, climates have changed, sea-levels have risen and fallen, and animals, such as dinosaurs and mammoths, have appeared, evolved and eventually become extinct.

In Oman, our geology is diverse and visually impressive, representing all the major divisions of geological time, illustrating a wide range of rock types, structures, natural processes and landforms, and yielding an outstanding array of fossils and minerals. Oman hosts some of the world's top class features, including the ophiolites that have attracted over many years much scientific interest.

Oman's fascinating and unique geology has caught the imagination of geologists who venture to the Sultanate. Considered as being amongst the world's top geographical areas — partly because of the ease of accessibility to unique rock formations and unusual, almost otherworldly, rare geological deposits, as well as for the geological expedience of being able to determine historical data and a geo-

logical time scale — it is something of a surprise to note that very little has been published about this important aspect of the Oman. For a detailed and colourful account of the geology of Oman, the reader is referred to 'Oman's Geological Heritage', which has recently been republished and re-edited by Ken Glennie and is available at most bookshops in the Sultanate.

Geological conservation involves the task of safeguarding and managing our most valued sites of geological importance especially those containing fossils.

The benefits of geotourism are primarily economic. Geotourism has the potential to boost the local economy and provide employment opportunities for the local population. In addition, it can be used to educate visitors, both locals as well as expatriate, and raise awareness of both the site and sustainable and environmental issues. Tourist operators, should play a proactive role in educating visitors not to destroy geological sites and to encourage visitors not to collect fossils.

From the giant stromatolites, glacial striated pavements, fossil trees and rudist limestone reefs of the Huqf to the spectacular Ophiolite sequence of the Oman Mountains. Other sites include the basement outcrops at Jobah, the salt domes near Ghaba, the trilobite tracks of Mahatta Humaid and the wave ripples of Wadi Amdeh, the glaciated surfaces of Al Khlata, the crinoid, fossil wood and rudist occurrences near Saiwan, the 'fossil bowl' near Ibra, as well as the desert roses of Mugshin and the geodes found near Rahab and Thumrait. Several of these localities are in the Huqf area, within the Arabian Oryx sanctuary. There are other classical sites in the Oman Mountains, Masirah and Dhofar with unrivalled exposures of ophiolites (ocean floor and crustal for-

mations), and deposits of very ancient ice ages.

There is an urgent need to conserve many of our key geological sites from damage and the casual collection of fossil, rock and mineral specimens. Preservation of these sites will provide our Omani students with the opportunities to develop their skills and enhance the research strength capabilities of our universities.

Some of the pioneering work that was conducted in Oman in the 1960s on the modern deserts of Oman provided the worldwide community with an understanding of desert environments. Also, the spectacular Ophiolite sequence, has provided the scientific community with a rare opportunity to study the upper mantle and oceanic crust.

Since its establishment, GSO has realised the dangers that face Oman's geological landmarks and has set-up a special committee with the aim of liaising with various government organisations and exploring ways of preserving the country's geological wealth.

Several options have been explored in the past: a geological museum, fencing some important geological sites, public education as well as meetings with key government officials. In addition, GSO has written some short articles, as briefing papers, on key localities featuring the Oman Ophiolites, Huqf area and the salt domes. Others are currently in preparation.

Back in 2005, GSO participated in the conference System Earth-Biosphere Coupling at the Friedrich-Alexander-University in Germany. In its presentation, GSO delegate, Dr. Omar Al-Jaaidi, highlighted the need for the various unique geological assets to be managed in a responsible and sustainable fashion. Furthermore, GSO outlined a vision for the future of Oman's geological heritage. That is that all these geological assets should be made known and accessible to a wide range of



500Ma old stromatolites, southern Huqf



Buah faulted anticline, Southern Huqf



Glacial striated pavement, southern Huqf



Spectacular pillow lavas exposed in Wadi Jizi (the 'Geotimes Pillow Lava')

users, enjoyed in a responsible and sustainable manner and passed on intact to future generations.

GSO's website (www.gso.org.om) contains a lot of material covering different aspects of Oman's geological heritage and natural resources. As an example, a section is devoted to the geological wonders of Oman, presenting some key features of the geology of Oman. Another example is the photographs section which contains a large collection of high quality photographs covering geological features, natural scenes from Oman and another wide collection on the caves of Oman.

There has been a recent Government directive to document sites of geological interest. GSO very much welcomes such a positive step which we think is a step in the right direction. GSO's view in this regard is to build a database of geological sites of scientific interests. The database would include extensive documentation of the site, its location and its importance. This database will enable the identification of top priority sites that require quick attention for their preservation. The mode of preservation will vary depending on the nature of the site, its location and surroundings. Rare fossils can be displayed at a new museum. Other sites could be transformed into geoparks while others could be signposted. Parallel to this, GSO is calling for the development of legislation that puts the force of the law into the protection of geological sites.

The Geological Society of Oman (GSO) has and will remain proactively involved in promoting the understanding of geology and seeking to conserve sites of special geological interest.

**Juma Al-Belushi
BG (Oman)**

Don Sheridan (1929 – 9 February 2008)

Don Sheridan, one of the first geologists to work in Oman in 1954-7, died recently in Ireland aged 78. We are fortunate that he wrote a book about his experiences as a field geologist in Oman and Libya and that he was able to share some of them with us at a Society of Petroleum Engineers (SPE) lecture in Muscat in 2002 and on a Geological Society of Oman (GSO) field trip to Fahud in 2006.

In Don's words

'Having majored in geology, in December 1953, I received my degree from Trinity College, Dublin. Early in 1954 an advertisement in the Daily Telegraph led me a few days later to an interview at the head office of the Iraq Petroleum Company (IPC) in Oxford Street in London. An eventual meeting with F.E. Wellings of that company, resulted in an offer of employment as a junior field geologist. It was agreed, subject to medical examination, that I should commence work in Aden in a few days.'

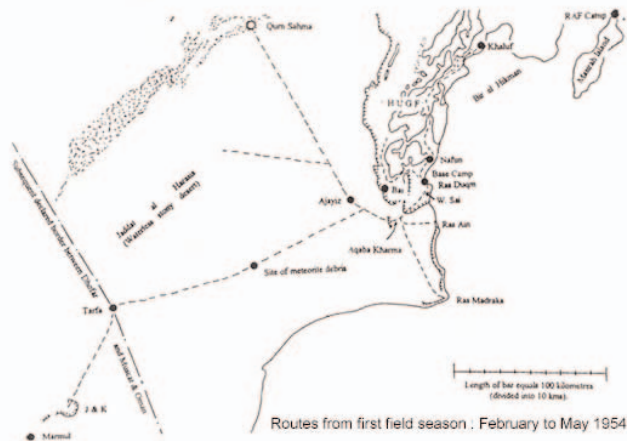
So he set out on 18 February 1954 for Aden. Unknown to him he was actually to be part of a secret project 'DEF' and his final destination would be Duqm in Oman. IPC's operating company PD(O) had just established a base there from where it planned to explore the oil prospects of interior Oman and, in particular, to reach Fahud.

His next 3 years in Oman are graphically described in his book, written through the eyes of a young field geologist, with the heat, frustration, camaraderie and adventure of the early days of oil exploration. Don's book was written initially in the early 1960s and lay unpublished in a bottom drawer for many years. He published it privately in 2000 and, when we met in 2006, his wife Catherine was looking forward to the books being sold so that the space they were taking up on the landing of their house could be available again.

It is not the intention here to summarise his book, but rather to preserve some additional email correspondence with Don about the geology and exploration of Oman, namely - the location of Alphabeticals J and K, the discovery of the oil seepage at Haushi, why the geologists were so interested in the rocks in Wadi Mu'aydin and why the efforts were focussed on Fahud, rather than the wonder-



Don explaining how the Fahud structure was mapped in 1954, photo
Xiomara Marquez



ful surface anticlines of Jebel Hafit or the Salakh arch.

The 'Alphabeticals' were land-form features spotted from the air when flying over the south of Oman. In early 1954 the geologists set out to locate them on the ground and see whether there was any evidence of oil accumulations. Alphabeticals J and K correspond to the Qaaharail and Marmul structures, and Don was rather cagey in his responses. It seems clear that they knowingly strayed into Dhofar and the Cities Service's concession to map and sample these features. As he points out later in his book,

'It is a well known belief, perhaps credo to those not in the profession, that geologists never know where they are in the pursuit of an outcrop.'

Q. How did you come across the oil seepage at Haushi and was it documented in company reports? Did you come across any other evidence of surface seepages of oil in Oman? These questions revealed that the target of Fahud-1 was the

Jurassic Arab Zone and also the tensions present between rival oil companies the Iraq Petroleum Company and Aramco.

A. *'We were actually packing up the Haushi camp but I had one further thing to check. I asked who would come with me and Tom Jameson said he would. We drove perhaps 1/2 hour from camp. It was when I was checking my problem that I came across the seep. We spent no great time examining it but noted that it came from a sandy section between two different species of Orbitulina. When I got back to camp I sent a radio message in 'Bentley's Second Code' to Fahud. Fahud-1 had just spudded and the principal target was, not unexpectedly, the Arab Zone. I was excited about the Cretaceous age of the host rocks at Haushi and thought that the company geologists should be aware of this new potential – without the ever-listening Aramco knowing. The sum total of my efforts was that they thought I had lost my marbles.'*

'To the two reports: because Tom had come with me, not like Rodney Collomb who had refused and stayed in camp, I said he could write up the 'Interim Report'. This he did, for all my knowledge now, it might have been his first 'IR TBJH1'. Interim reports were considered a badge of honour at the time. This one would be credited, if extant, to Tom and myself as co-author. Shortly afterwards Doc Hudson came to Oman on a visit and I brought him to Haushi. He wrote up his visit in Notes et Memoires sur le Moyen Orient (Tome VII of 1959). It was entitled Permian Brachiopoda. Before he wrote this paper he mentioned the seepage in a discus-



sion after a paper at the Geol Soc. He used the term 'volcanoes' – his comments were just after Dan Gill had described sand volcanoes in Co. Clare. In my time in Oman nothing further was done, i.e., no trenching etc. Hudson's comments would be in the Journal, probably 1956 and 1957. As I recall he used comment time after papers to refer to Oman on two occasions. The seepage and the probable Permian glaciation.

Fahud was massive, it was in friendly Duru territory. As you go east towards Salakh you were moving into territory loyal to the Imam. A bad move until that problem was sorted out. By the time we got access to the Salakh area Fahud was under way. When Fahud failed, I think it is in a report of Wellings, 'attention was turned to geophysical targets'. I suspect that this might have been a struggle between old surface geologists and the 'modern' geophysicists. The same philosophy might have been true in the



IPC Chief Geologist F.E. Wellings at the Haushi seep in 1957, photo Quentin Morton



Don explaining the Wadi Mu'aydin access issues outside Bait Al-Rudaydah, 19 January 2006, photo Xiomara Marquez



Don with the sons of Aziz over lunch at the Nizwa Hotel 20 January 2006. Quentin Morton and Bader Al-Barwani in the foreground, photo Xiomara Marquez

To answer your second question, no we came across no other signs of seepage'.

On the GSO field trip in 2006 we heard that the geologists interest in gaining access to Jebel Akdhar, and particularly to Wadi Mu'aydin, was stimulated by the descriptions of the geology there by Wellstead in the 1830s. They were led to believe that he mentioned boulder beds with granites in them that might be equivalent to the Haushi boulder beds (that we now know as Al Khlata).

We checked Wellstead's 1838 book and papers in libraries in Oxford and found little mention of geology. His description of the descent from Shirazi (Saiq plateau) to Wadi Mu'aydin is probably the major part - 'It consequently resembles an enormous cliff and we have a good opportunity of investigating the geological structure of the range, which consists of, 1st, Alpine limestone; 2nd, old red sandstone, with an occasional micaceous vein; 3rd, alternately mica slate and granite.'

Q. Any thoughts on where the idea of boulder beds may have arisen?

A. 'We (it wasn't from me alone as I never saw a reference) always believed Wellstead had seen 'boulder beds' with granite. If the belief came from the reference above it was some imaginative thinking by someone! Having seen the Haushi boulder beds, the desire was to get into the wadi behind Suleiman's fort. I can tell you no more than that. Has Quentin Morton come across any reference in his father's papers? As we got closer to Suleiman, and as an early fill in whilst awaiting Suleiman's pleasure, we sampled a wadi in the Sumail - Wadi Misduht in late 1956. There we found conglomerates galore but no 'boulder' beds with granite. These remained our target in Birket al Mauz.'

Q. Why the choice of Fahud... rather than the wonderful string of anticlines of the Salakh arch?

A. 'I can only hazard a reply to your question. You spoke for example about Indago geologists having a go at Jebel Hafit. The same question might be asked why work took so long? To revert 50 years, Hafit was a sore thumb sticking up in the middle of the area of conflict and dispute about Buraimi. Pretend it doesn't exist, or has no interest, and the problems will go away.

PDTrucial Coast concession area, no one can appreciate the potential size of subsurface structure beneath desert plains - so at least drilling geophysical targets might postpone any political problems as to ownership. It's interesting that you wrote of Jebel Madmar. There was a lot of interesting geology on its southeastern flank but we got pulled off that, prematurely in my view - a similar story to the one I told you about the NW plunge of Fahud which had a wealth of information about Tertiary movements. I got angry at being pulled off that Fahud mapping - I think that Rodney Collomb and myself were beginning to see a little light.'

In one of the last PDO News magazines (2002/2) there is an interview stemming from Don's talk to the SPE. There he mentions that he regretted his visit was too short to return to Fahud with his wife, and go to Wadi Amairi and meet the sons of Aziz Luwehi, the loyal driver of the field geologists and the first Duru employee of IPC/PD(O).

In January 2006 GSO organised a field trip to mark the 50th anniversary of the spudding in of Fahud-1. It was wonderful that Don and Catherine were able to join that trip and we could take him back to Fahud and meet the sons of Aziz. We all benefited from Don's reminiscences and his answers to our many questions. When asked at the Fahud-1 overview what it had felt like in 1957 when they realised that the well was dry he responded,

'We were gutted' and he added 'it was made even worse a few years latter by the discovery of the Fahud field a few hundred metres away. It made one question ones ability as a geologist.'

Xiomara described Don's damp eyes and emotions when driving through the Fahud field in 2006 (Al Hajar March 2006). Don also promised a write up for Al Hajar about the trip. Sadly a hectic oil business life in Yemen and Sudan (yes, still busy at 77!) and then failing health robbed us of more.

Thank you Don for your book and your insights....

Qarn Sahmah Salt Dome: Ara evaporites, stringers and volcanics, Al Khlata glacial deposits, and salt mining by PD(O) and the Duru.

13th-14th March 2008

Excursion Leaders: Alan Heward (Petrogas LLC) and Zuwena Al Rawahi (Petroleum Development Oman)



Modern 'ships of the desert', at the end of the 'EnCana road' approaching Qarn Sahmah.

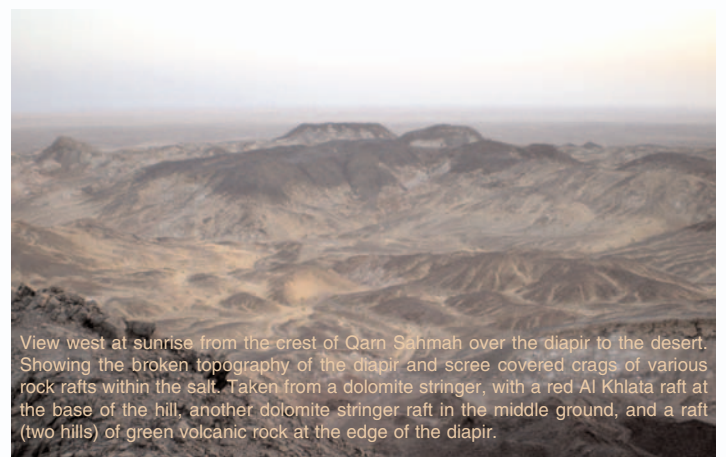
Uummh, the smell of cooking. Another dash of 'Qarn Sahmah' salt, extracted, packed and distributed by the GSO, and the food should be perfect. This is the story of salt, as told during, and reflected in, the explorations of the GSO fieldtrip to the heart of the Omani desert to visit the Qarn Sahmah salt dome on the 13-14th March 2008.

After collecting together the expedition along the way we had the first pit stop at Adam. A briefing on the country ahead pointed out the several diapirs that can be seen in the distance from the road as one travels south. Driving on south, passing the Qarat Al-Milh, Jebel Majayiz and Qarn Nihayda diapirs, another stop at Ghaba, with the Qarn Alam salt dome as a backdrop, provided a good overview point to set the scene for salt in Oman and its wider geographic context. The Ghaba-1 well derrick visible on the horizon provided the focal point for a historical note on the early oil exploration history of Oman by the Iraq Petroleum Company (IPC – the predecessor to PDO). Their early mapping identified salt structures and observations linked these to an extension of the Hormuz salt fairway from the Persian Gulf and Iran. With the presence of subsurface salt, a local source of salt was required to provide an additive to saturate the drilling muds. What better source than the surface breaching salt diapirs themselves.

Farther south, we turned west onto the 'Encana road' to the Encana well site towards the Qarn Sahmah salt dome. Three wells have been drilled in the vicinity of the Qarn



Qarn Sahmah Salt Dome in the distance from the Qarn Sahmah North-1 well site



View west at sunrise from the crest of Qarn Sahmah over the diapir to the desert. Showing the broken topography of the diapir and scree covered crags of various rock rafts within the salt. Taken from a dolomite stringer, with a red Al Khlata raft at the base of the hill, another dolomite stringer raft in the middle ground, and a raft (two hills) of green volcanic rock at the edge of the diapir.

Sahmah salt dome; Qarn Sahmah North-1, by Elf in 1983, Maeen-1, Encana 2007; Neimah-1, Encana 2007. We stopped at the Qarn Sahmah North-1 well pad for an

overview of the salt dome, the wells, and the rocks they encountered in relation to the salt dome. These discussions provided a reference for the observations to be made at the salt dome and the hydrocarbon system potential of the diapirs.

Then onto the salt dome. Small crags of different coloured rocks are dotted over the low irregular dome, picking out the rafts of intra-salt carbonate stringers and pieces of various wall/host rock plucked as the salt moved upwards. Driving around to the east side of the diapir, over the alluvial fans being shed from the rafted blocks of rock in the salt, we passed through a small wadi entering the core of the salt diapir. An area of undulating and pitted topography marks the site of various salt excavations by the Bedu and by PDO expeditions from 1959. Soon after arriving at the salt dome to extract salt for drilling mud the PDO expedition was visited by a Duru bedu party who had also arrived to dig for salt. Rather than bulldozers and explosives, the bedu were a punishment party and were equipped only with hammers and chisels.

Alan Heward showed us a number of different rock types collected from an earlier trip, illustrating the wide range of



Part of a dolomite stringer outcropping at the crest of Qarn Sahmah. Intervals of crinkly laminated and planar laminated dolomite. Pencil for scale.



Gypsum spheres /roses in red siltstone (unknown formation)

sediments to be found in the diapir. These include several different types of volcanics, inviting discussion on their source, the possible correlation to the various subsurface volcanics of Oman, particularly those of the Ara in the South Oman Salt Basin, and the implications for the Ghaba Salt Basin. We then started our own explorations, walking over a number of crags of dark green rock. A finely crystalline igneous rock with bright green translucent phenocrysts and evidence for chilling.

Volcanic rock number 1... 2... 3... phenocrysts, feldspar laths, amygdales, chilled margins.....its beginning to feel like an igneous petrography class. Then there is the planar laminated, wrinkly laminated, stromatolitic laminated, the thinly, not so thinly and thickly laminated dolomites.... Did someone say olivine phenocrysts? Wow a mantle derived salt dome! Ohh... in the volcanics, could the salt have at least come from the ophiolites??

Armed with our own hammers, chunks of salt were excavated from an old pit for tasting and taking home for the pantry. Rock salt is surprisingly hard and took some effort to dig, though not quite like the excavations of the Bedu. Back around the diapir saw us to the campsite and a splendid view of sunset, replaced by the electric lights of the Anzauz Field at night. A fantastic curry was served for dinner.

We arose at dawn climbing to the peak of the salt dome, formed by a raft of carbonate stringer, to view sunrise over the desert. A discussion of laminated dolomite facies to warm up and back down to camp for breakfast. The morning of day two was a walking tour over various crags of different rock rafts: Dolomitic and anhydrite stringers - stromatolitic or thrombolites?, Al Khlata conglomerates, yielding glacially striated and fractured cobbles; more vol-

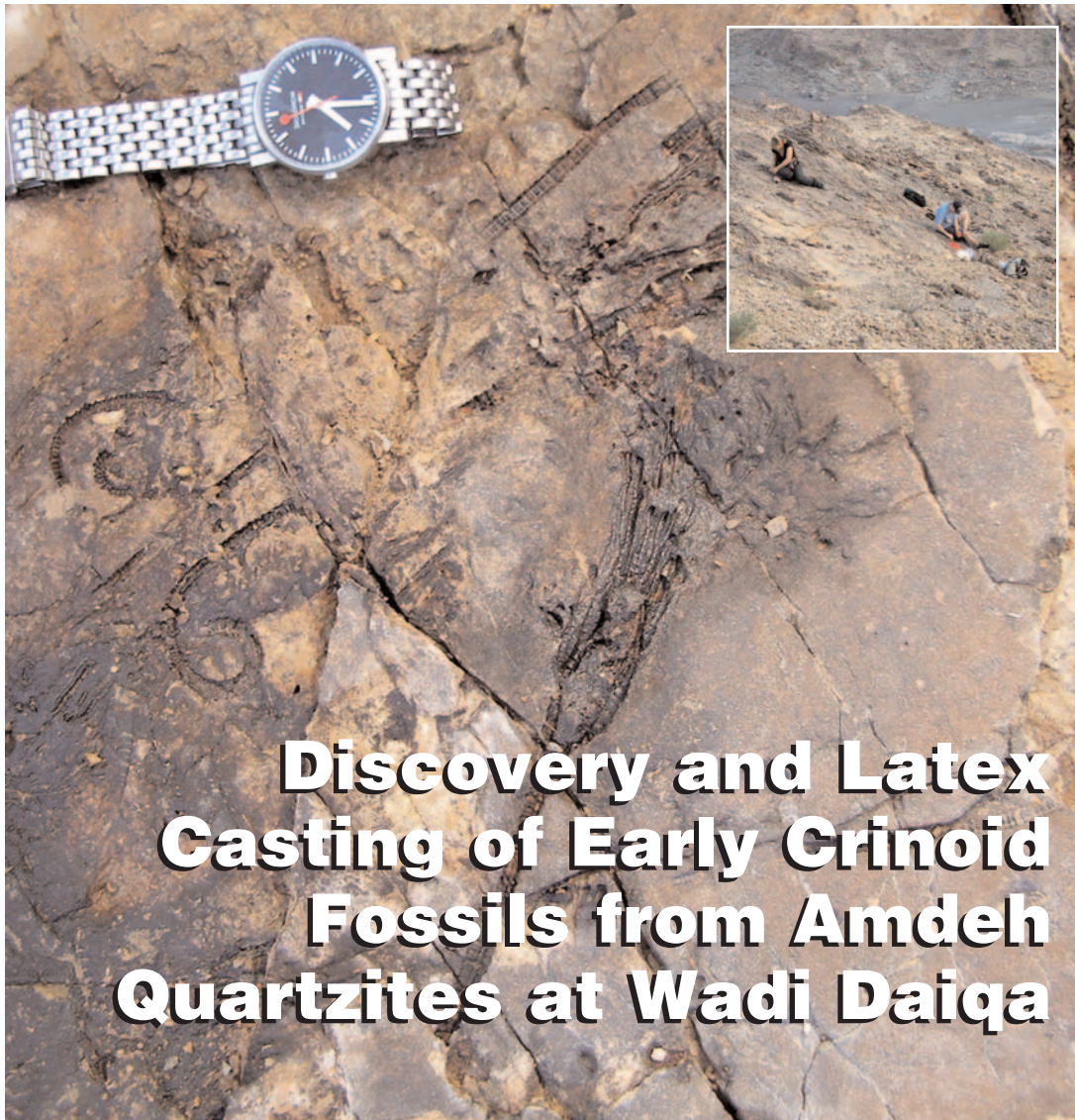
canics and undetermined red silts. The Al Khlata here is a deep red colour with specular haematite mineralization on fracture surfaces, indicating the passage of oxidizing fluids. Comparison with the Qarn Sahmah North-1 well, where the Al Khlata is grey, suggests periods of vertical water flushing up the flanks of the diapir and breaching of any salt flank seals.

At the end of the morning we drove to a wadi a bit farther around the diapir looking for the location of a reported rhyolite outcrop. No rhyolite, but red siltstones containing fine examples of gypsum cemented spheres/roses. The drive back to the main road saw one car stuck on the crest of a small sand dune. Perched like a modern day 'ship of the desert' on the crest of a wave, but maybe not quite so elegant! A quick tow and on our way again. Following a lunch stop in the shade of two trees the expedition headed back to Muscat.



Most of the participants gathered around Alan and Zuwena (back to camera)

Thank you to the leaders of the trip, Alan Heward and Zuwena Al-Rawahi for organising the trip, and to all who provided the food and refreshments, feasts one and all. For a trip to a salt dome we saw a surprisingly wide range of rock types, sedimentary, igneous and metamorphic. As one participant commented a veritable 'zoo' of rocks. But still no Haushi Limestone!



Discovery and Latex Casting of Early Crinoid Fossils from Amdeh Quartzites at Wadi Daiqa

Moulds of crinoids as they appear on the sandstone surface, highlighted by wetting with water. Note the curly stems.

The Discovery

Back in 2006 I was involved in PDO with a study on the Safiq/Ghudun (Haima Supergroup) and therefore also interested in the Amdeh Formation, described in 1981 by PDO colleagues (Lovelock et al. 1981) as being time equivalent to the Haima in Oman's interior basins (see also Droste 1997). On top of work-interest, there was also the private interest, seeing the spectacular pictures of trace fossils from the Amdeh Formation in the Lovelock paper. Combining geology and a family outing is easy in Wadi Daiqa and that's where we spent a few weekends enjoying the scenery and the pools, while roaming the ridges surrounding the wadi to find the beds described by Lovelock. Walking along the rocks is easy in Wadi Daiqa, but also on the crest of the ridges flanking it. Access was easy before construction of the dam started. Simply driving into the wadi, at the famous picnic grounds near Mazara, and then following the wadi upstream, partly along a track that leads up a terrace on the right side. It is worthwhile to read Colonel Miles' (1896) description of his journey through the wadi in 1884 as this story is a great introduction to its magnificent setting. No problem to find the beds either. Blocks with *Cruziana* tracks that litter the slope inevitably draw you higher and higher, hoping to find the big trilobite at the end of the trail.

The Ordovician inlier in Wadi Daiqa is not that big, but it has not

Giles paints the rocks red whilst Martha makes moats of plasticine. Wadi Daiqa in the background

had more than a cursory geological description either. That's why it is relatively easy to find unexplored rocks, giving a feeling like walking across unspoiled snow. That's how I ended up on top of one of the ridges, sitting down to have a drink and looking at the thin shell beds packed with small bivalves. There were also the unmistakable pieces of crinoid stems, but these I did not remember from the descriptions in Lovelock's paper. Looking more closely I noticed on the flat sandstone surface a large curl almost like an engraving in the rocks. On closer inspection it was clearly the bas-relief of a complete crinoid stem. Crinoid fragments are very common in Palaeozoic rocks, but to find such complete stems is rare as they almost always disintegrate to their individual columnals. My surprise became solid excitement when I realised that the stem was attached to a complete calyx,

which are even rarer to find. Here were at least two, partly on top of each other and leached from the rocks showing them in bas-relief. I called the family, meanwhile searching the area for more. Regrettably we did not find any others. We took photographs and I built a little pile of rocks to mark the place.

Back home I refreshed my dusty knowledge of crinoids, realizing while doing so that Ordovician crinoids are rather early in their evolution. Back at PDO I discussed with Alan Heward and together we visited the site a few weeks later. We realised that it would be best to leave the magnificent fossils in place, not risking damaging them. The opportunity to make a cast of the fossils came when fish remains were discovered in nearby rocks.

Jan Schreurs
Petroleum Development Oman

The Latex Casts

High up on the mountainside overlooking Wadi Daiqa, the view is splendid, but the fossil crinoids that Jan showed us were even more spectacular. In the late afternoon sunlight, a surprising amount of detail could be seen preserved as an external mould. A

slender calyx supported arms that were hardly branched, whilst the long stem had a peculiar curl at the end. Two other curled stems lay close by, as did part of a calyx with arms. Some catastrophe must have buried these creatures instantly to allow their intact preservation, in such contrast to the usual preservation of scattered stem fragments.

In December 2006, we visited Wadi Daiqa with some Palaeozoic fish experts who were hunting for ancient fish fragments. As they were too busy searching the lower slopes for tiny black specks of scales, we took a photograph of the crinoids to show them. Even on the digital display of the camera, the picture impressed, so it was later emailed to a crinoid expert, Steve Donovan of the Natural History Museum, Leiden, who was eager to know more. Since it



Latex cast of the same view showing more detail of the star-shaped stems, the calyxes and the arms.

was agreed that any attempt to collect the specimen would probably result in its destruction, it was suggested to take a latex cast instead.

In November 2007, Giles Miller and Martha Richter from the Natural History Museum in London visited Oman, and they kindly brought the materials needed to make a cast. Surprisingly, the latex was a deep red colour – experience has shown that casts in red latex photograph most clearly.

So having obtained the latex and received permission to enter the wadi through the dam construction site, we set off to make a cast. The theory of making a latex cast is very simple: you just paint on layers of latex until you have filled in all the relief, next you lay a piece of gauze over the back and add a couple more layers of latex to give a stiff backing, then you wait until the whole specimen is dry and peel it off.

But up on the hillside, it was not quite so simple. Firstly, the bedding plane was not horizontal, nor was it completely flat. We used some plasticine to make a moat around the best specimen to stop the liquid latex running away, but the latex still managed to seep out through cracks and joints.

Then we made the mistake of giving the latex a shake before we

started – only to find that the slightly viscous liquid was full of bubbles that became trapped in the cast.

Next we found that the brush we were using was really too coarse for the first few layers when we wanted to catch every bit of detail.

And then we found that the sunshine and warmth dried the latex very quickly and before we were half way done, we had a brush caked in dried red latex.

However, we persevered, painting a layer of latex, waiting for a few minutes whilst the latex changed colour from deep red, to pinkish red as it dried, before painting on the next layer. It was a fairly hot day, it seemed to take forever to build up the layers but slowly the mould became shallower until finally all there was to see was an almost flat patch of red latex. At that point, we covered it with strips of gauze and then plastered these with a couple more layers of latex. After that, we left it for half an hour to dry out properly.

Then came the moment of truth! Carefully, the edges of the cast were peeled back from the plasticine and then the main cast was peeled slowly off the rock face. Apart from a couple of places where the latex had sunk deeply down a crack, it came off surprisingly easily. And the result was impressive – a bright red relief cast of a complete crinoid, spoilt only by a few bubbles here and there and with the odd extra lump where a joint had allowed the latex to seep further.

We made two more casts during the morning, but the brush became progressively more caked in dried latex. Not surprisingly, the third cast seemed to contain rather a lot of bubbles.

Back in London, the casts were photographed at the Natural History Museum. Recently, we were sent copies of the photographs, and they are impressive – red latex photographs well in black and white! But the biggest surprise came when we found that the quality of the photo is so good that it is possible to enlarge it several times greater than actual size and reveal amazing details that were hardly noticeable on the original specimens.

So far, the crinoids have not been properly identified, but they are probably iocrinid crinoids. Our dated palaeontology texts, second-hand from student days, identify iocrinids (or eocrinids) as primitive attached echinoderms that resemble crinoids but have characteristics of cystoids and blastoids. They appear sometime in the Cambrian, and are common in the Middle and Upper Ordovician. The Oman specimen is of Lower Ordovician Arenig age so Steve is very excited by it and its discovery in this part of the world.

There is always the possibility that the crinoid will be something new to science, but then there will be a difficult dilemma. In order to define a species, there has to be a type specimen stored in some collection, and a latex cast by itself just won't do. We did find some further fragments in the talus slope below but would they be enough? Maybe we need to visit wadi Daiqa again next winter and search harder.

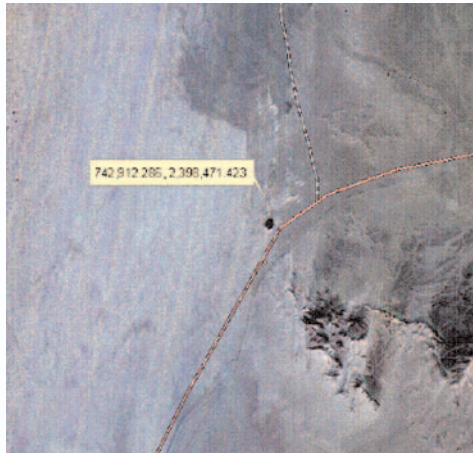
Felicity Heward

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A meteorite illusion... and more about the real stuff

Late 2007 one of my acquaintances told me about a weird feature he had observed on a satellite image on his laptop that he used for navigating while driving on a track along the eastern side of the Al-Sharqiya Sands. He promised to send me the coordinates to check what it could be, indicating it could be a meteorite impact crater. As he moved job it took a bit longer before he could send me the details, half a year later. Checking these on satellite imagery indeed confirmed a concentric feature, albeit clearly elongated in a northeastern direction. Another check on the geological map indicated that the location was very close to a basanite intrusion.



Landsat Image of the possible impact site. North is up. The feature measures approximately 100m across. Note the surrounding sand dunes.

Basanite is a basaltic rock composed chiefly of plagioclase, olivine, and augite. They occur in intercontinental settings and are associated with lithospheric extension and/or mantle plumes. In Oman's Batain area they intrude Triassic deep water cherts and carbonates that were emplaced as nappes (the Batain nappes) associated with the obduction of Oman's Eastern Ophiolite Complex in Late Cretaceous to Early Tertiary times and have been dated as late Eocene (Worthing & Wilde 2002).

Basanite intrusions typically cap small conical and elliptical hills, some 5-20m or even more above the surrounding plains. Hills or impact craters are clearly different geomorphological features that can easily be recognised in the field. Recognition is far more difficult from imagery without high resolution topographic data available. The best way to check is to go and have a look. That is exactly what we did. After an early rise on a Friday morning and after a rather long drive, also struggling through soft sand, we finally approached the area around noon. Seeing the black-topped hill from many kilometres away on the horizon we got more and more worried that it would correspond to the location we were heading for on our GPS. It did, thereby crushing our hopes to find an impact crater in Oman.

A couple of years ago I was involved with the check of another possible meteorite crater as reported by local

Bedouins near Muqsin. That one turned out to be a collapsed cave (sinkhole), but I have heard that local people still refer to it as a meteorite crater. I also receive regular requests to check possible meteorites found in the deserts of Oman, but all that I have seen to date are ophiolite fragments. That does not mean there are no meteorites in Oman, but it does indicate a bit more background is needed to explain what the meteorites in Oman are all about.

Meteorites: the real stuff

Since 2000 many meteorites have been discovered in Oman in systemat-



Conical hill topped by a basanite intrusion at the location of the assumed meteorite crater seen on the satellite image above. Photograph courtesy Gordon Forbes

ic search campaigns. Why were people looking in the Omani deserts in the first place? Meteorite falls are very rare. They have become well known from the Antarctic ice cap, where the ice evaporates in the sun and wind, leaving behind meteorites as a lag deposit. The stones are easily recognisable and cannot be confused with other material as there is none. At first sight, the Antarctic has little to do with the Omani desert, but in the early 1990's researchers realised that ancient desert surfaces could also be enriched in meteorites. These are areas where the surface of the

Earth remains undisturbed for very long times. Meteorites can accumulate over thousands of years, remaining where they fell. The scarcity of rain means that they do not easily wash away or become buried. The wind has free play, removing fine-grained material that, therefore, does not bury the meteorites either. Many discoveries have since been made in the Sahara and, subsequently, also in the deserts of Oman.

Recognising meteorites is not easy as the desert plains are generally covered by many rock fragments. The interior desert plains of Oman are no exception. Desert varnished cherts are locally very abundant. The desert varnish is often difficult to distinguish from the fusion crust of real meteorites. Recognition therefore requires a trained eye.

Systematic collection and mapping of meteorites has revealed a few areas with dense meteorite finds in Dhofar and in Central Oman, notably the Sayh Al Uhaymir area and the Jiddad Al Harasis. The meteorites vary in weight from tiny 0.3 grammes to heavy weights of up to 10kg. A number of these areas appear to be partly overlapping strewn fields associated with meteorite showers. The meteorites include pieces of rocks from the moon, but also a few, very rare rock of probable Martian origin.

Martian rarities

In 2003 there were only 31 Martian meteorites known worldwide, three of which have been found in Oman. The most famous piece of Mars in terms of publicity is Sayh Al Uhaymir (SaH) 094, found in a 2001 search campaign by geologists of the University of Bern, supported by the Oman government. From studies of its age (much younger than other meteorites) and its gas inclusions (which precisely match the composition of the Martian atmosphere), it is very likely that this meteorite originates from Mars.

Rocks from the moon

Sayh Al Uhaymir 001 (SAUH 001) is one of Oman's largest known meteorite showers, with 2670 fragments found and mapped. The total weight of the collected samples is more than 450kg. These may represent a large proportion of the total mass of the stone meteorite body. The surface in the Sayh Al Uhaymir area is hard and it is likely that only a small portion of the fragments penetrated the surface.

The distribution of the samples shows a systematic strewn field indicating that the SAUH 001 bolide traveled from northeast to southwest, bearing 233°, breaking-up in several stages under a trajectory angle of 70°.

Most meteorites probably originate from the Asteroid belt, circling the Sun between the orbits of Mars and Jupiter. So how do we get meteorites from the Moon and Mars? Granted, they are our closest companions in space, but one still needs to propel rocks from their surfaces into space to get them to Earth. The only process that can create enough energy to do this is....., yes, another meteorite impact, "ping-ponging" rocks through space. Meteorites crashing into the Moon or Mars can launch rock material into space, and some of this may ultimately cross the orbit of Earth and be captured by our gravity field.

Some of the Sayh Al Uhaymir meteorites have been directly tied to the craters on the moon based on analytical data. One of these, Sayh al Uhaymir (SaU) 169, discovered in 2002, made world news as its unique composition allowed it to be connected with the Imbrium impact basin on the lunar nearside. It was dated at the respectable age of approximately 3.9 billion years. Further studies showed that the rock was ejected from the moon approximately 340,000 years ago by a meteorite impact. Less than about 9700 years ago, SaU 169 finally fell on Oman. SaU 169 is the first meteorite for which researchers have been able to reconstruct its full story.

Clearly the meteorite finds in Oman represent mainly meteorite showers of larger objects that broke apart in the Earth atmosphere.

A circular feature, known locally as Lehub, some 10 km WSW of Jaaluni, has been considered as a possible impact crater (Hughes Clark 1990). It has an outer diameter of 5.2km with an inner, elevated circle of 2.2km across. The rim is about 3m higher compared to the inside, with the inner ring again 3m higher. The feature is also recognisable on the surface geological map. The absence of any impact related characteristics, and indication of a possible salt plug from seismic data suggest a relation with salt tectonics in the subsurface (Levell et al.

2002).

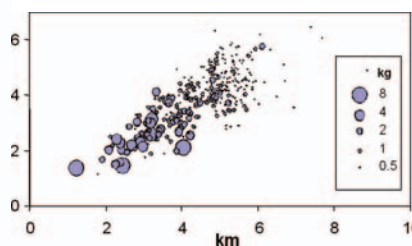
A subsurface impact site has been interpreted from seismic data at Murshid, 35km west of the Marmul Oil Field in south Oman. It is buried to a depth of approximately 380m sub-sea (680m below ground level) and may have hit the earth during Albian-Late Cretaceous times. No other surface impact craters are known from Oman. The nearest is the famous Saudi Arabian impact crater at Wabar. This site was discovered by Philby in the Rub Al-Khali in 1932. It has been linked to a visual meteorite sighting in 1863, but is perhaps even younger.



Shergottite (Martian Meteorite), SaH 094, image released on the internet by the Naturhistorisches Museum Bern. Maximum size of the meteorite is 7cm.

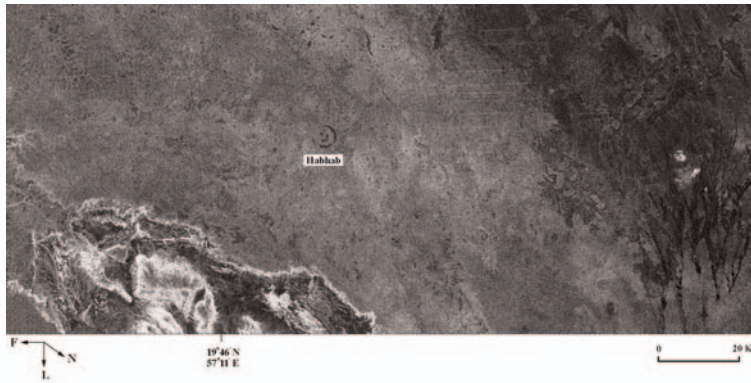


Photograph of SaU 169. Maximum dimension is 7 cm. Photograph: Peter Vollenweider. The SaU rock has been compared to a ping-pong-ball because its story demonstrates how rocks can travel from one celestial body to another in space. Detailed information released on the Internet by the University of Bern

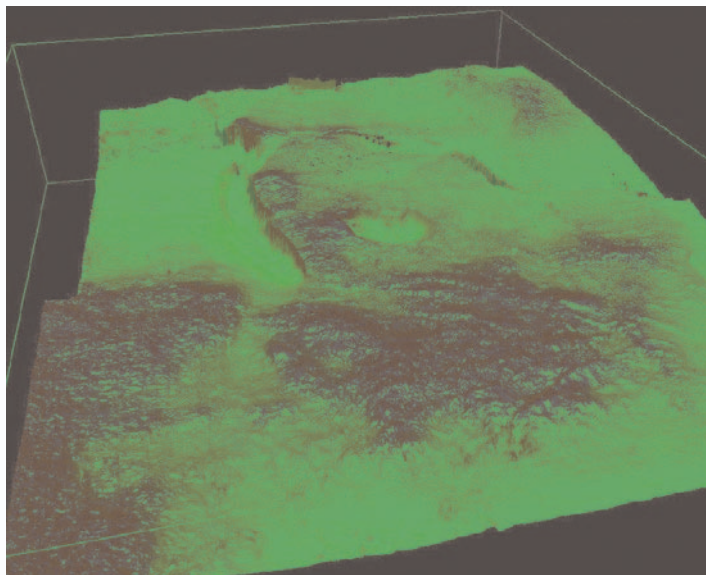


Map of meteorite ground track and weight distribution Sayh Al Uhaymir 001, courtesy Korochantsev et al., 2003

Philby's travels in search of the lost city of Ubar took him into the Empty Quarter in 1932, his guides told him that they had actually seen 'a large buried camel forged of iron' and offered to take him there. What he found was not the lost city of Ubar. Yes, there were blackened sands, scorched by fire. It certainly was the setting of a catastrophic event that came out of the skies as described vividly in 'the day the sands caught fire', published in a 1998 Scientific American paper. From the traces left behind, the crash would have been comparable to a nuclear blast of about 12



Circular feature in centre of radar image (just West of Jaluuni); possible impact crater – or more likely a salt induced structure? Image released by NASA Jet propulsion laboratory.



A close-up view of the Murshid impact structure looking NE, mapped from seismic data. Maximum relief is about 50m from rim to floor. Diameter is 2.5km, location Lat 18 deg 10' 59" Long 54 deg 55' 08. Image from Levell et al. 2002). Published with permission of GeoArabia.

kilotons, such as the Hiroshima bomb. Philby transliterated its name to "Wabar (as Ubar was also known)," which has become the name of the impact site (Lat. 21deg 30.2min N and Long. 50deg 28.4min East). The real site of Ubar is currently interpreted to be the ruins near the sinkhole at Sishr north of Thumrait.

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Acknowledgement

With thanks to John Aitken and Gordon Forbes who eased the long 10 hours of driving to find the meteorite illusion that started this story.

Jan Schreurs

Petroleum Development Oman



BP has a long history in the Sultanate of Oman dating back to 1959 when the Royal Charter granted BP the right to market oil products in the Sultanate.

More recently, in January 2007, BP signed a major exploration and production sharing agreement with the Government of Oman for the appraisal and development of Block 61 and the Khazzan and Makarem gas fields. The Block covers an area of some 2,800 square kilometres in central Oman and contains a number of 'tight gas' reservoirs. First discovered in the late 1990's these have remained undeveloped due to the complexity of the reservoirs which lie four to five kilometres below the ground.

As one of the world's leading specialists in the production of tight gas BP will apply innovative technology and expertise to unlock resources previously trapped in the scattered low permeability rock.

Under the agreement BP has six years to appraise the blocks before deciding whether to develop the field for production. This appraisal programme includes reprocessing of existing seismic data, new seismic acquisition, drilling appraisal wells and extended well testing.

A 3-D seismic acquisition programme was completed on the Khazzan/Makarem field in August 2008. This 2,800 square kilometre survey is, to date, the largest onshore 3-D Survey ever acquired, and took less than 5 months from first vibration point. New world records of productivity were set three times on the survey culminating in a daily production of 12,208 vibration points. BP Oman will spud its first well in 4Q 2008.

With offices in Shatti Al Qurum BP Oman currently employs



80 people comprising 16 different nationalities. Almost half of our team are Omani.

Other BP activities in the Sultanate of Oman include

- the distribution of BP lubricants through the Oman Oil marketing Company SAOG (OOMCO)
- technical and commercial services provided by Air BP at Seeb Airport
- an extensive BP Marine fuel bunkering operation at Salalah port in southern Oman.

BP Oman

PO Box 1649, Shatti Al Qurum

PC 130 Al Azaiba, Muscat, Sultanate of Oman

Tel: +968 2468 4000, Fax: +968 2469 7510

www.bp.com

8th Middle East Geosciences Conference and Exhibition

Bahrain International Exhibition Centre
3rd-5th March 2008

The GEO conference, held once every two years in Bahrain, is one of the most reputed conferences in the Middle East region. It attracts oil and gas companies from all over the globe to witness new advances in the oil and gas business. This year, the conference theme was "Integrated Geosciences – Technical, Business and People Solutions".

During GEO2008, I was asked to run the Geological Society of Oman (GSO) booth. My role was to explain to visitors about GSO in general; its activities and membership. I also gave brief introductions about the Geology of Oman. Visitors were very impressed with Oman's Geology and the rapid growth of the GSO from just a few members in 2001 to over 500 today.

I also attended different presentations which were very interesting and informative. As part of the conference, an exhibition also ran in parallel to the presentations. This



Exhibition was very impressive. Different companies from all around the world showed the latest advances in geoscience. A set of posters session were also held either in companies' booths or in a specific area allocated for posters.

I am happy with my contribution to the GSO and GEO2008 although it was my first time to attend the conference. I had a chance to exchange and share lots of new ideas with many people from all around the world.

I strongly recommend students to attend this conference as it is a golden opportunity for geoscientists and engineers to learn about different aspects and advances in the oil industry.

Special thanks to the GSO for their financial and other support during the conference. My thanks is also extended to Mr. Adil Al Kiyumi (GSO VP) who assisted me a lot in running the booth during the conference.



Ruqiya Al-Faris
Sultan Qaboos University
5th year Geology student



Regional Societies Field Meeting

The Geological Society of Oman welcomes Dhahran and Bahrain Geosciences Societies and American Association of Petroleum Geologists President-Elect

As part of its endeavor to promote the concept of “geology without borders” to understand regional geology and connect geoscientists around the world, the Geological Society of Oman (GSO) welcomed the Dhahran and Bahrain Geoscience Societies and American Association of Petroleum Geologists [AAPG] President-Elect (Scott Tinker) to the Sultanate in April.

Two days were spent in the field looking at different aspects of the geology of Oman. The first day was a journey through the Jebal Al-Akhdar where some 20 visitors had the opportunity to see a geological traverse from Rustaq to Nizwa. The Jebal Al-Akhdar is part of the crescent shaped Al-Hajar Mountain range, which is about 300km in length, trending northwest to southeast, and 50-100km inland from the Batinah coast of the Gulf of Oman.

Using six 4x4 vehicles, the visitors cruised through some 500 million years plus of history recorded in rocks and in gaps between the rock formations. Apart from geology, there was a fascinating local village that took the attention of our visitors; the beautiful green Blad Seit. We stopped at the majestic Jabal Shams (the mountain of the sun) to have lunch. The peak is around 3,000 metres elevation; the highest point in Oman and the whole of eastern Arabia. Our final stop before returning to Muscat was Nizwa and its traditional market (the souk).

The second day was devoted at looking at the geology of greater Muscat area. The region is famous for exposures of

Cretaceous (Tethys Ocean) ophiolites, thrust from north to south onto the Arabian plate and covered largely by younger Tertiary shallow water carbonates rocks.

Among the participants were Ahmed M. Al-Otaibi, (ARAMCO and President of the Dhahran Geological Society), Scott Tinker (AAPG President-Elect) and Abeer Al Zubaidi (AAPG Director of Middle East Operations).

At the end of the trip the visitors thanked the Omani community for their warm welcome and GSO for sharing and discussing the excellent geology in the field and for organising the logistics in a safe and environmentally sound manner. This trip would have not been possible without the excellent effort committed by GSO ExComm members, especially Adil Al-Kiyumi, Mahmood Al-Mahrooqi and the field leaders Mohammed Al-Wardi, Jan Schreurs and Mohammed Al-Kindi.



Mohamed Al-Harthy
Petroleum Development Oman

Geological Society of Oman International News



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INDIA



The ninth well to be drilled by Gujarat State Petroleum Corporation Ltd (GSPCL) on the KG-OSN-2001/3 (Krishna-Godavari Offshore) shallow water has successfully tested several zones. KG-22 was drilled by the Aban Offshore "Deep Driller I" J/U to a total depth of 6,007m (5,068m, true vertical depth) in the Basement. Three drillstem tests have recovered gas: an interval at 5,518-5,545m flowed 1.2 MMcf/d at a wellhead flowing pressure of 300 psi through a 28/64" choke; gas flowed at the rate of 3.4 MMcf/d, with 15.5 bc/d, at a wellhead flowing pressure of 883 psi through a 28/64" choke from a 102m perforated interval at 5,250-5,375m; and 23.7 MMcf/d with 84 bc/d flowed at a wellhead flowing pressure of 4,950 psi through a 28/64" choke from a 17m perforated interval between 4,652-4,672m. The well is located in 91m of water about 7.5km north-east of the KG-8 platform.

In a presentation to investors in Calgary, GeoGlobal Resources outlined exploration plans for several blocks it has a stake in that are operated by Oil India Ltd (OIL). In the onshore portion of the Krishna-Godavari Basin, a 50km experimental 2D seismic program to enhance imaging has begun over the 548 sq km KG-ONN-2004/1 block. According to Jean Paul Roy, GeoGlobal believes the offshore success extends onshore and that the basin "holds a lot of surprises." Drilling is slated for the fall of 2008, with a total of 12 wells planned. GeoGlobal is awaiting government approval to increase its interest in the acreage to 25%. Furthermore in the Rajasthan Basin, GeoGlobal has a 25% interest in adjacent blocks 20 and 21 awarded to OIL in January 2008. Plans call for acquisition of 700 sq km of seismic on each block, around a field in between that has 1 billion barrels of oil in place, and extend the concept. The seismic contract has been awarded to GT, which claims it is to be the largest onshore 3D acquisition in India to date. Drilling is slated to begin on the first of three wells during the third quarter of 2008.



IRAN

Two months ago Iran, Opec's second largest producer, estimated its oil reserves at around 136 billion barrels. This figure may now have to be revised upwards as a billion plus barrels discovery was announced in the middle of July 2008 and Oil Minister Gholam-Hossein Nozari has now declared a new find with in-place reserves of 525 MMB near the southern port city of Assaluyeh. The minister added that "A few other oil fields have also been discovered about which the public will be informed in the coming weeks." The IHS Middle East team believes this well to be Assaluyeh East 1,

a wildcat that was suspended in mid-April 2008 after testing up to 1,500 b/d of light oil in a gas-prone region of the Zagros Fold Belt. Drilled by the National Iranian Oil Company (NIOC) to a total depth of 2,530m, the well sought objectives in the Lower Triassic, Kangan and Upper Permian, upper Dalan formation objectives (Khuff equivalent) of the Deh Ram Group, as well as the deeper Lower Permian, Faraghan Formation (Unayzah / Gharif regional equivalent).

IRAQ



Western Zagros Resources continues to drill the Sarqala 1 wildcat in the Kalar-Bawanoor Block in the Kurdistan Region, the operator making no comments on some news wire reports that the well took a "kick" around the middle of June 2008. The company remains positive on the outcome of the well, the first in a multi-well drilling exploration program planned over the next three years." Spudded on 8 May 2008, it has a planned total depth of 4,800m and is targeting four potential reservoir zones and is estimated to cost US\$ 22 million. On completion of Sarqala 1, there are plans to drill the Kurdamir 1 (formerly Bawanoor North 1) wildcat. WesternZagros has a working 40% interest in the PSC which is not subject to further dilution by the Kurdistan Regional Government (KRG). The KRG will have a 20% direct interest. It is understood the KRG has until 28 August 2008 to allocate the remaining 40% to a third party or parties. Also on the license, Western Zagros completed the acquisition of 1,547km of 2D seismic mid July 2008 during its Phase I and II survey program.

There are strong indications that China National Petroleum Corporation (CNPC) and the Iraqi Ministry of Oil will sign an initial agreement during the third quarter of 2008 to develop the Ahdab field in Wasit province, southern Iraq. A statement from the ministry said, "Iraq and China are keen to show their cooperation by finalizing an agreement on the Ahdab field." The Ahdab field was discovered in 1979 by Iraqi Oil National Company (INOC) after the Ahdab 1 well was drilled to test the deep Cretaceous formations. In April 1998, a contract between Oasis Co, the subsidiary of CNPC, and OEC, acting as a contractor for the project, was signed for the execution of 3D seismic acquisition in the Ahdab field development area. However, work did not begin due to a number of technical and mechanical reasons and the lack spares further hindered progress. CNPC signed a US\$ 1.2 billion PSC for the 80,000 b/d capacity Ahdab field with the Saddam Hussein regime in June 1997. Iraqi Oil Minister Hussein Al-Shahristani announced during his visit to China in October 2006, that his ministry would start re-negotiations with CNPC for the development of the field. On 24 June 2007, the Iraqi Oil Ministry announced

that CNPC's US\$ 1.2 billion contract to develop the Al Ahdab field was still valid although costs are expected to have increased significantly.

NEUTRAL ZONE



It is reported that the Saudi Arabian cabinet has approved the renewal of the Divided Zone onshore concession that is due to expire in February 2009. Saudi Arabian Chevron has a joint agreement with the Kuwait state administered oil company Kuwait Oil Company (KOC) (50%) to produce and develop over a 5,720 sq km onshore concession in the Divided Zone between Kuwait and Saudi Arabia. Saudi Arabian Chevron represents Saudi Arabia's interests over the area under a 60-year concession signed in 1949. A joint committee with KOC manages operations; KOC and Saudi Arabian Chevron hold equal shares in the concession. The two companies produce from the Wafra, Umm Gudair South and Fuwaris South fields. Producing oil from the Eocene limestones, Cretaceous Wara Formation and Ratawi Oolitic Limestone reservoirs, Wafra is the largest of the three onshore fields and came onstream in 1954. Saudi Arabia Chevron is proceeding with a large project utilizing steam injection to produce heavy oil from the Wafra field. The reservoir targeted by the steam injection project is believed to be the Maastrichtian Tayarat Formation limestone reservoir, which was discovered in 1959 but has produced only 1% of its 1.5 billion barrels of reserves in place, mainly because of its variable low gravity and high sulphur content. The Maastrichtian heavy oil resource potential in the Neutral Zone may be much larger than current estimates.

PAKISTAN



The first of three zones to be tested has yielded 11 MMcf/d and 200 bc/d at an exploration well drilled in the Tando Allah Yar EL in the Lower Indus Basin. Kunar South 1 flowed through a 32/64" choke from the Cretaceous Lower Goru Formation (Massive Sands); wellhead flowing pressure was 2,125 psi. No water was produced during the test. The well, which was spudded by OGDC on 21 January 2008, reached a total depth of 3,355m.

UNITED ARAB EMIRATES



Following on from the mid-February 2008 reports that ConocoPhillips was believed to have been declared the winner of the US\$ 10 billion Shah sour gas development project, the company has now signed an interim agreement with Abu Dhabi National Oil Company (ADNOC) to this effect. Under the terms of the agreement, ConocoPhillips (40%) and ADNOC (60%) will jointly share the ongoing cost of front-end engineering and design (FEED) and project mobilization for the Shah gas field development. Final project agreements are expected to be completed by year-end. The scope of the project covers the construction of gas-gathering systems and a 1 Bcf/d gas processing train to pro-

duce 570 MMcf/d of gas for the local transmission network. In addition, the project requires new gas and liquid pipelines, as well as sulphur export facilities at Ruwais. Once an agreement is finalized, the partners will form a new company to manage and operate the Shah facilities. The UAE holds the world's fifth-largest gas reserves at nearly 214 Tcf, much of it sour. The gas has a content of around 30% of hydrogen sulphide, making it tougher and more expensive to produce than conventional gas reserves. The initial tender included the development of sour gas at the Bab field, however, due to the complex nature of the project, the tender was revised in June 2007 and the Shah and Bab sour gas projects are now to be developed separately. The undeveloped sour gas reservoirs in the Shah field include the Upper Jurassic Arab A-D Formations. A primary incentive in the case of any proposed Shah development will be the presence and potential for development of over 200 MMbc in place.

YEMEN



Canadian explorer Epsilon Energy reported that its Duda 1 well located in the 6,000 sq km Block 41 in the Marib-al Jawf-Hajar Basin has encountered encouraging oil and gas shows in the Tithonian Nayfa Formation. These shows have been encountered over an interval of approximately 240m, below 1,400m and also in the Kimmeridgian to Tithonian Madbi Formation over an interval of approximately 210m, below 1,809m. Drilling is expected to continue to a depth of 2,681m in order to test a fractured Basement play. Epsilon also confirmed that additional oil and gas shows which were encountered while drilling at a depth of 2,043m will be the subject of further investigation. The well was spudded as Al Waya 2 on 17 May 2008 and renamed Duda 1 after mechanical problems (a directional steering tool malfunctioned). Al Waya 1 was drilled in 2002 to a total depth of 2,343m and tested 454 b/d of 34o API crude oil over a long-term production test from the Naifa formation between 1,195 to 1,368m. The Al Waya 1 well also had significant hydrocarbon shows in the Madbi formation over the interval 1,507 to 1,555m and the fractured basement between 1,637 to 1,644m. Pending government approval and positive results of its drilling efforts on the Al Waya field, Epsilon plans to commence a long-term production test of the Al Waya field by trucking up to 2,000 b/d of crude oil to a nearby production facility in mid-to-late 2008. Subject to the necessary consents, there are plans to construct a pipeline with the capacity to handle up to 30,000 b/d of gross production from Block 41.



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Ken White or Stuart Lewis
e-mail : ken.white@ihsenergy.com
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Book Review

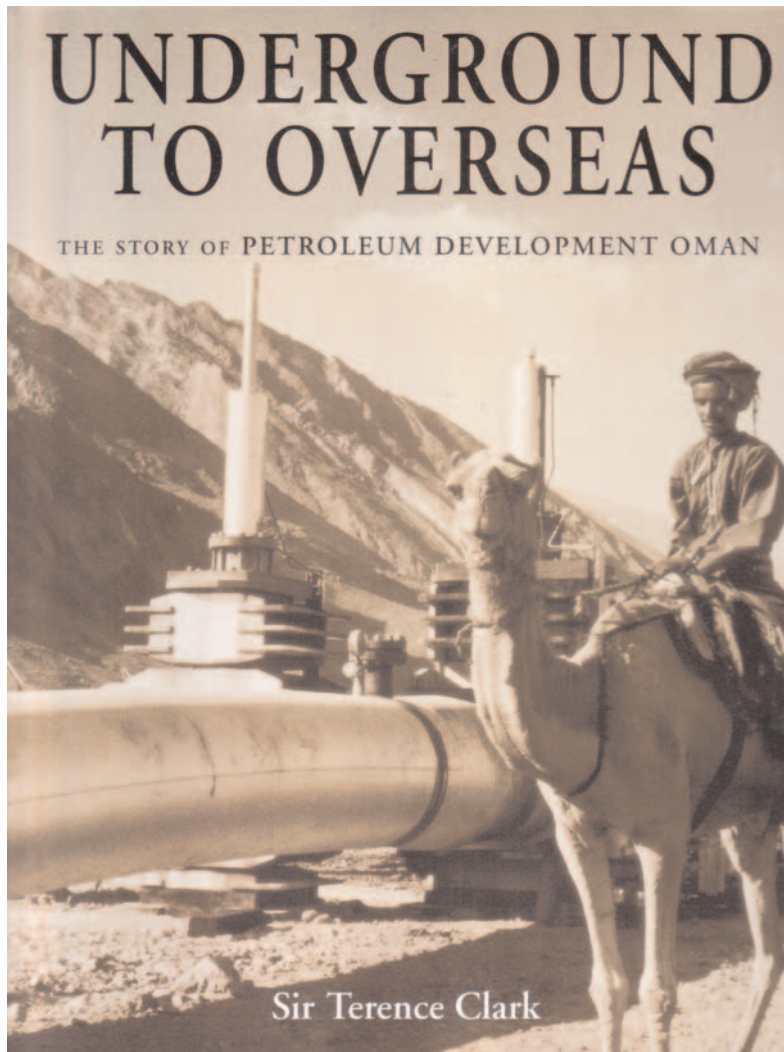
Underground to Overseas: the story of Petroleum Development Oman

By Sir Terence Clark

Petroleum Development Oman ISBN: 978-1-9052299-46-1

As part of its 2007 celebrations of the 40th anniversary of the first export of crude oil from the Sultanate of Oman, PDO published this book documenting the history of PDO. The book, with both Arabic and English sections, outlines the search for oil in Oman, from the early geological investigations of Pilgrim (1904-1905) and Lees (1925-26) through the trials and disappointments of the Iraq Petroleum Company (IPC) in the 1950s and the first discoveries by PDO and Dhofar Cities Services Company to the present day. Corporate histories can be extremely turgid volumes, but, as John Malcolm, PDO's Managing Director, states in his Foreword: "It is certainly not your typical corporate history. The author has managed to weave the personal recollections and anecdotes of those who participated in.....the discovery and development of Petroleum Development Oman's oil and gas fields into a narrative that is readily accessible to a wide readership."

The book is divided into eight chapters, the first of which recounts the tale of the first loading of crude oil from the terminal at Saih al Maleh (now Mina al Fahal)



to the 83,000 ton tanker, Mosprince in July 1967. While the Mosprince was still out of site from the terminal, a radio message was received from the captain enquiring about the approach, which, at that time, was not on the ship's charts! Additional problems are recounted during the loading of the Mosprince, but, in the end, all went well.

The subsequent chapters are divided into convenient time periods, albeit overlapping, related to PDO's growth and development. Chapter 2 documents the early hydrocarbon pioneers in Oman, as briefly mentioned above, including the signing of an exploration agreement between HH Sultan Said bin Taimur and the IPC in 1937 and the formation of Petroleum Development (Oman and Dhofar), up to the start of the Second World War. The third chapter documents the activities of IPC in Oman from 1946/1948 when two IPC geologists, Mike Morton and Rene Wetzel, arrived in Salalah to undertake a geological survey of Dhofar. The landings at Duqm in 1954 and the subsequent drilling of Fahud-1, Ghaba-1 and Haima-1 are documented. The chapter ends with the departure of IPC

from Oman in 1960 and the handing over of the licence to Petroleum Development (Oman). Chapter 4, 'Changing the face of Oman from land, sea and air – for ever' discusses the early years of PDO in, more or less, the form it retains today. The series of discoveries at Yibal (1962), Natih (1963) and Fahud (1964) are documented, both through narrative and through the eye's of those who were there. In this period, the downstream side of the business also began in Oman, with the construction of the main export pipeline from Yibal, through the Semail Gap to Mina Al Fahal, an incredible engineering feat in difficult terrain and undertaken in an amazingly short time, even by today's standards. However, it was not just in the oil-fields that discoveries were being made, it was also in this period that Ken Glennie and his co-workers from Shell International undertook their seminal fieldwork in the Oman Mountains and the complexity of Oman's geology began to be revealed.

Until 1967 the oil industry in Oman had little impact on Omani society, other than PDO employing a few Omanis. With the first load of crude on board the Mosprince and the resultant revenue for the country, things began to change, gradually at first but with an accelerating pace. Chapter 5 of the book basically covers the years 1967-1970, with some reversions to earlier years, and the first tentative steps to change brought about by oil revenue. Whilst this chapter largely covers senior management's role in negotiations with the Sultan and his government, it also includes the first establishment of the main office at Mina al Fahal, the expansion of the Ras al Hamra 'Camp' and the difficulties in travel when there were few black top roads in the capital area. Transport was supplied to Omani staff, living in distance parts, such as Muttrah and Muscat, with a one and a half hour journey to work at Mina al Fahal! Related to this, with the expansion of the Omani workforce and the dominance of expatriates in PDO the Omani employees took their first steps towards having an independent voice over their terms and conditions. The chapter ends with the ascension to the throne of HH Sultan Qaboos bin Said.

With the transition to the new Sultan, HH Qaboos bin Said, and the start of Oman's Renaissance, change was inevitable as is explained in Chapter 6. It was not an easy time for the country or for PDO. The change of old rules had traumatic effects in the country and PDO with staff and the population, in general, uncertain about the future. There were disagreements within the company about terms and conditions, rapidly

resolved with the formation of Omani staff committees, now a single representative group within PDO. On the technical side, it was begun to be realised that Omani oil was not the typical Middle Eastern oil. Extensive research was undertaken and it was realised that Omani oil was far older than most other Gulf States, probably some 500 million years older, a heretical concept at the time, but it led to further discoveries. Other unconventional thoughts were initiated by PDO staff, with an archaeological interest, finding tombs and artefacts in the Ras al Hamra-Qurm area, which led to archaeological investigations prior to the development of the area.

Chapter 7 covers the period 1977 to 1995 which was a period of expansion for PDO with the opening up of South Oman, the development of the long fallow Marmul Field and the discovery and development of many fields in the south, including Rima, Mukhaizna and Nimr. The 1980s saw PDO become responsible for gas exploration and development on behalf of the Government and the discovery of the Saih Nihayda, Saih Rawl and Barik gas fields. In this same period, PDO built and donated to the nation the Oil and Gas Exhibition Centre (1979) and the Public Technical Library (1990). The final chapter covers the period up to 2006, which saw further gas discoveries at Burhaan West, Kauther, Khazzan-Makarem and Abu Butabal and the establishment of Oman's liquefied natural gas (LNG) industry, as well as the start of active exploration for the Precambrian intra-salt play. However this period also saw the levelling out and eventual fall in production from Oman's oil fields, which had been increasing steadily since 1979. The future for PDO looks bright, with oil output now slowly moving upwards again and the renewal of PDO's concession agreement with the Government.

This book is a fascinating account of the development of PDO. The manner in which the author has weaved narrative with 'oral history' from former and current PDO employees makes it eminently readable. Additionally, as the hydrocarbon industry has developed in Oman, so, in parallel, has the country. Consequently, this book not only recounts the history of an oil company, but also, to a certain extent, documents the development of Oman as a nation over the last 50 years.

John F. Aitken
Petroleum Development Oman

Sultanate of Oman

Geoscience Publications, 2007

The following is a listing of peer reviewed geoscience publications from 2007 concerning the Sultanate of Oman. Also included are papers from neighbouring countries that have a direct relevance to the Sultanate. It covers geology, geophysics, palaeontology/biostratigraphy, petrology/petrography, hydrogeology, hydrology and geomorphology. General reviews and summaries, articles in trade publications and published conference abstracts are excluded. Any omissions, corrections or additions will be gratefully received and should be sent to the compiler or through the GSO editor.

- Allen, P.A. 2007. The Huqf Supergroup of Oman: basin development and context for Neoproterozoic Glaciation. *Earth Science Reviews* 84, 139-185.
- Al-Belushi, B. 2007. Palynological and integrated geological study of the Gharif Formation of the Hasirah Field, west central Oman. MSc. Thesis, Sultan Qaboos University.
- Al-Futaisi, A., Ahmad, J., Al-Rawas, A. & Al-Hanai, S. 2007. Adsorption capacity and mineralogical and physico-chemical characteristics of Shuwaymiyah palygorskite (Oman). *Environmental Geology* 51, 1317-1327.
- Al-Kharusi, A.S. & Blunt, M.J. 2007. Network extraction from sandstone and carbonate pore space images. *Journal of Petroleum Science and Engineering* 56, 219-231.
- Al-Kathiri, A., Gnos, E. & Hofmann, B.A. 2007. The regolith portion of the lunar meteorite Sayh al Uhaymir 169. *Meteoritics and Planetary Science* 42, 2137-2152.
- Al-Lawati, H.M. 2007. Mylonite ductile shear zone and serpentinite diapir: detachment faulting and later thrusting around the Moho horizon, northern Oman ophiolite. *Earth Evolution Sciences, University of Tsukuba* 1, 3-13.
- Al-Rawas, A.D., Gismelseed, A.M., Yousif, A.A., Elzain, M.E., Worthing, M.A., Al-Kathiri, A., Gnos, E., Hofmann, B.A. & Steele, D.A. 2007. Studies on Uruq al Hadd meteorite. *Planetary and Space Science* 55, 859-863.
- Al-Shuaily, H.S.S. 2007. Stratigraphic framework of the Mafraq Formation in North Oman. MSc. Thesis, Sultan Qaboos University.
- Al-Wadhahi, M., Boukadi, F.H., Al-Bemani, A., Al-Maamari, R. & Al-Hadrami, H. 2007. Huff 'n puff to revaporize liquid dropout in an Omani gas field. *Journal of Petroleum Science and Engineering* 55, 67-73.
- Al-Wardi, M & Butler, R.W.H. 2007. Constrictional extensional tectonics in the northern Oman mountains, its role in culmination development and the exhumation of the subducted Arabian continental margin. In: Ries, A.C., Butler, R.W.H. & Graham, R.H. (eds.) *Deformation of the Continental Crust: The Legacy of Mike Coward*. Geological Society, London, Special Publication 272. pp. 187-202.
- Angiolini, L. 2007. Quantitative palaeoecology in the Pachycyrtella Bed, early Permian of Interior Oman. *Palaeoworld* 16, 233-245.
- Babadagli, T. & Al-Bemani, A. 2007. Investigations on matrix recovery during steam injection into heavy-oil containing carbonate rocks. *Journal of Petroleum Science and Engineering* 58, 259-274.
- Baud, A., Richoz, S. & Pruss, S. 2007. The lower Triassic anachronistic carbonate facies in space and time. *Global and Planetary Change* 55, 81-89.
- Bernecker, M. 2007. Facies architecture of an isolated carbonate platform in the Hawasina Basin: the Late Triassic Jebel Kawr of Oman. *Palaeogeography, Palaeoclimatology, Palaeoecology* 252, 270-280.
- Boudier, F. & Nicolas, A. 2007. Dating the geological history of Oman's Semail ophiolite: insights from U/Pb geochronology: discussion. *Contributions to Mineralogy and Petrology* 154, 111-113.
- Bowring, S.A., Grotzinger, J., Condon, D.J., Ramezani, J. & Newall, M. 2007. Geochronologic constraints on the chronostratigraphic framework of the Neoproterozoic Huqf Supergroup, Sultanate of Oman. *American Journal of Science* 307, 1097-1145.
- Coogan, L.A., Jenkin, G.R.T. & Wilson, R.N. 2007. Contrasting cooling rates in the lower oceanic crust at fast- and slow-spreading ridges revealed by geospeedometry. *Journal of Petrology* 48, 2211-2231.
- De Keijzer, M., Hillgartner, H., Al Dhahab, S. & Rawnsley, K. 2007. A surface-subsurface study of reservoir-scale fracture heterogeneities in Cretaceous carbonates, North Oman. In: Lonergan, L., Jolly, R.J.H., Rawnsley, K. & Sanderson, D.J (eds.) *Fractured Reservoirs*. Geological Society, London, Special Publication 270. pp. 227-244.
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- Fuchs, M., Woda, C. & Bürkert, A. 2007. Chronostratigraphy of a sediment record from the Hajar mountain range in north Oman: implications for optical dating of insufficiently bleached sediments. *Quaternary Geochronology* 2, 202–207.
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Shammas, M.I. & Jacks, G. 2007. Seawater intrusion in the Salalah Plain aquifer, Oman. *Environmental Geology* 53, 575-587.

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Sultanate of Oman

Geoscience Publications

2006: Addendum

In the listing of 2006 geoscience publications in the last issue of Al Hajar the following were inadvertently omitted.

Husseini, M. & Matthews, R.K. 2006. Orbital calibration of the Arabian Jurassic second-order sequence stratigraphy. *GeoArabia* 11(3), 161-170.

Ozkaya, S.I. & Richard, P.D. 2006. Fractured reservoir characterisation using dynamic data in a carbonate field, Oman. *SPE Reservoir Evaluation and Engineering* 9, 227-238.

Simon, L., Lécuyer, C., Maréchal, C. & Coltice, N. 2006. Modelling the geochemical cycle of boron: implications for the long term $\delta^{11}\text{B}$ evolution of sea water and oceanic crust. *Chemical Geology* 225, 61-76.

GSO Calendar 2008

October

14th October

Oily salt: A deep time perspective of the role of plate tectonics as a prime control on the evaporite-hydrocarbon association"

Dr. John Warren
Sultan Qaboos University

23rd October

Wadi Daiqa- Amdeh 4/5 facies, traces and fossils, Al Khilata P9 glacial deposits and evidence of pre-Al Khilata folding

Dr. Alan Heward
Petrogas LLC

Date to be confirmed

How to reconstruct Upper Palaeozoic climate: Silicified woods as a part of basinal sediments in equatorial Pangaea and their preliminary comparison with Omani specimens.

Dr. Tomas Grygar
Institute of Inorganic Chemistry ASCR, Rez, Czech Republic

Date to be confirmed

Palynological and Integrated Geological Study of the Gharif Formation, Hasirah Field, West Central Oman.

Mr. Bader Al-Baloushi
Petroleum Development Oman

November

26th - 28th November

The lower Haima Supergroup (Amin and Miqrat Formations), with a diversion into the Upper Huqf Supergroup, at Buah Anticline and vicinity, Huqf High

Drs. John F. Aitken & Raimond van der Pal
Petroleum Development Oman

December

Date to be confirmed

A Tertiary Walk-about in Muscat

Dr. Ed Follows
Petroleum Development Oman
2009

GSO Calendar 2009

January

Dates to be confirmed

The Permo-Carboniferous Al Khlata Formation Outcrops, Southern Huqf area

Dr. Juma Al-Belushi & Dr. John F. Aitken
BG (Oman), Petroleum Development Oman

Date to be confirmed

The Geological Evolution of the Laurentian Passive Margin: Late Cambrian - Early Ordovician of Eastern Ontario and SW Quebec, Canada.

Dr. Osman Salad Hersi
Sultan Qaboos University

March

Dates to be confirmed

Structural Evolution and Fracture Pattern of the Salakh Arch (foothills of the Natih Formation)

Dr. Mohammed Al-Kindy
Petroleum Development Oman

Dates to be confirmed)

Shuaiba and Nahr Umr equivalents along the Nakhl transect

Dr. Zuwena Al-Rawahi
Petroleum Development Oman

April

Dates to be confirmed

Evolution of the Jebel Al-Akhdar

Dr. Mohamed Al-Wardi.
Sultan Qaboos University

May

Date to be confirmed

Diagenesis of the Upper Shuaiba Reservoir in the Malaan Field

Suleiman Al-Farqani
Petroleum Development Oman

Copy deadline for future issues

Autumn 2008	Wednesday 12th October 2008
Winter 2008	Wednesday 3rd December 2008
Spring 2009	Wednesday 4th March 2009

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