Geological Society of Oman Newsletter

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AL HAJAR

www.gso.org.om

Contents

Syncline Camp , Huqf, 3rd March 2010

PRESIDENT'S MESSAGE

Dear GSO members,

GSO executive committee welcomes you to the new edition of Al Hajar newsletter. Few activities were made since we celebrated the AGM. The low number of activities was mainly due to summer holidays and Ramadan. However, in the background the committee is working on two main projects. The Society has initiated a continuous education facilities program by which we aim to establish a permanent geosciences exhibition in all educational directorates of Oman. The Ministry of education represented in the Directorate generals at the regions will provide the society with an exhibition space/hall in their studies centers and the society will populate that room with education interactive materials. This project aims at giving first hand knowledge to students and teachers into geological sciences and the geology of Oman. The Sharqyia region was selected as pilot project because of their proactive approach and the availability of the hall in their study center. Once the first pilot project is completed and well received, the society will then proceed to the other regions.

The second project is a joined project with the Geo-group of SQU to produce a guide on the geo-tourism in Oman. The booklet will contain information on selected geological locations across the country. It will contain a brief and simplified geological description of the locality, its location and how to get to it. This is also a pilot project that will be in Arabic language for the first edition and English language for the second edition. The draft has already been completed and is under review.

We also would like to inform you that the documentary film on Oman Geological Heritage is ready and will be launched at the end of October, 2010. Invitations will be sent shortly. The film is in Arabic language and with English subtitles. Another version with English voice over is currently in progress. The film will be broadcasted though Sultanate of Oman TV during the celebrations of the 40th National day in November 2010. We will send a reminder to all GSO members once we get the specific date from the ministry of Information.

At the end I would thank all of you for your commitments and contribution and urge you to forward your views, suggestions and contribution to any of the executive committee members.

Regards,
Dr. Mahmood Saif Al Mahrooqi
GSO – President

NOTE FROM THE EDITOR

Welcome to this, the 17th edition of Al Hajar.

It is a great pleasure to take on the role of editor of the magazine. We wish Caroline Hern, your former editor, great success as she begins a new life in Argentina, a country which like Oman boasts spectacular geology.

Geologists often develop a deep affection for the geological treasures of Oman and a passionate illustration of this is in evidence in the article on Geological Conservation by Mike Searle.

There is a strong palaeobiological flavor to the other articles in this issue, with very ancient copepods, new chitinozoa and Cretaceous ammonites all under discussion.

You will also find the regular sections on fieldtrip reports and exploration news in the region.

Enjoy!

Ru Smith, editor

FIELD TRIP REPORT

Cambro-Ordovician Tight Gas Reservoirs Sultanate of Oman,Haima Supergroup (Barik, Al Bashair and Miqrat Formations) 3-5 March 2010.

By Ru Smith, SDO

In conjunction with the Geo2010 conference held in Bahrain this March GSO organized a field excursion to the Cambro-Ordovician exposures of the Barik, Al Bashair and Miqrat formations in the Huqf area . The able leaders of the trip were John Aitken of PDO and Salmeen Al-Marjibi, who had recently completed his PhD on the Al Bashair.

The first stop involved some physical labour as John had volunteers digging trenches to gain a view of the near-surface stratigraphy of a modern sabkha, nicely decorated by polygonal salt structures at its surface. Cross-stratified fluvial gravels overlain by unstructured silts were revealed. After all this physical effort it was a very short journey and a larger jump back across about 500 million years of time to examine ancient equivalents in the nearby Miqrat Formation outcrops.

What a spectacular wealth of sedimentary structures! Casts of halite hoppers, shrinkage cracks, current ripples, load structures, laminated sheet-flood sandstones with scours, wave ripples, a set of dune-scale cross-stratification with pinstripe lamination and more. Disrupted fabrics were attributed to "haloturbation".

Camp was made in a beautifully-formed small syncline of Al-Bashair Formation rocks, sheltered in places, a wind-tunnel in others. Mobile telephones functioned only from the top of the highest hill. The bases of thin bioclastic limestones around the camp revealed beautiful examples of trilobite burrowing activity in the form of Cruziana and Rusophycos traces. This occurrence of these trace fossils was made famous by Richart Fortey's popular book "Trilobite!".

The link between the outcrops and the Miqrat and Barik tight gas reservoirs in the subsurface was made by John using posters illustrating petrophysical properties in the subsurface, trap types and correlation patterns over large distances, with special evidence on the Barik. Participants from Saudi Aramco discussed equivalents in Saudi Arabia.

In his book "Trilobite!" Fortey describes working in this area: "Sandstones and limestones formed low bluffs, so if you followed a single bedding plane you could crawl on your hands and knees over a Cambrian sea floor which preserved every scratch and footprint."

The return journey to Muscat was broken with a lunch stop in Wadi Andam surrounded by evidence for ancient copper mining from the ophiolite.

This was a highly successful and enriching event, enjoyed by all participants – a combination of wonderful geology and a wonderful remote landscape. Congratulations to the organizers and an excellent contribution from GSO to the GEO2010 event.

"Maybe we are getting as close to a particular moment in trilobitic time as we ever should: one scrape of a limb, one flick of a hair."

Sunset from the syncline camp.

Conference Announcement

International Conference on the Geology of the Arabian Plate and the Oman Mountains
(ICGAPOM) 7- 9 January 2012

By Sobhi Nasir, Department of Earth Sciences, SQU, 123 Al-Khod, Oman.

The Department of Earth Sciences, Sultan Qaboos University, is situated in close proximity to the Oman Mountains and has for the past 25 years been actively involved in advancing geological knowledge of the Arabian Peninsula in general and the Oman Mountains in particular. Progress in this understanding has been reviewed during two previous geological conferences on the Oman Mountains in 1990 and 2001, with attendance by delegates from 37 countries. In order to review new developments during the last ten years and to promote ongoing geological research, the department is organizing a third conference in this series for 2012.

This conference will present the latest developments across a broad spectrum of Earth-science disciplines, including sedimentary and hard-rock geology, the base and precious metals industry, petroleum geology, groundwater, geophysics, and geohazards. The conference is intended to be a broader consideration of not only the geology of Oman but also the entire Arabian Plate.

Conference Objectives

The overall objective of the 2012 conference is to gather Earth scientists from all parts of the world to encourage research and promote better understanding of the geology, economic potential, and environment of the Arabian Plate and Oman Mountains. The specific objectives of the conference are:

1) To provide a forum for presenting recent research on the geologic framework of the Arabian Plate.

2) To encourage the exchange of knowledge, ideas and experiences between scientists regarding the geological evolution of the region.

The Conference will be held at the Sultan Qaboos University over 3 days. Pre- and post conference field excursions will be organized.

In a number of keynote addresses international experts will summarize recent developments in the geological understanding of the Arabian Peninsula and the Oman Mountains. Oral and Poster presenters will share their research results in a diverse range of thematic sessions.

Keynote Speakers

ROBERT STERN,University of Texas

"Continental Lithosphere of the Arabian Plate: A Geological and Geophysical Synthesis"

MIKE SEARLE, Oxford University

"Emplacement of the Oman Ophiolite, from Subduction to Foreland Fold-Thrust Belt"

SYLVIE LEROY, Paris University

"Structure and Evolution of the Southern Boundary of the Arabian plate: from Rifting to Spreading of the Gulf of Aden"

ALAN HEWARD,Petrogas Rima

"Oil in Oman - the main plays so far"

ADOLPHE NICOLAS,Montpellier University

"High-Resolution Mapping in the Omani Ophiolite - Role of Water in Crustal Accretion and at Tips of Segments"

PETER KELEMEN,Columbia University

"In situ carbonation of peridotite from Oman for CO2 capture and storage"

Abdulrahman Al Sharhan, UAE University

"Petroleum System of the Middle East"

Technical Themes

1.The Arabian Plate Lithosphere and Boundaries

2.The Sedimentary Cover of the Arabian Plate

3.Hydrocarbon Systems of Arabia

4.Ophiolite Genesis and the Oman Mountains

5.Environment and Water Resources

Correspondence and abstract submission

For further information, please visit the conference website (http://www.geoman2012.com) or
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Preserving
Oman's Geological Heritage

By Mike Searle, Department of Earth Sciences, Oxford University, Parks Road, Oxford OX1 3PR, UK

The Oman Mountains contain a number of unique and very special geological sites of World Heritage importance. Here I recommend a number of important sites to be recognized as GeoParks or Sites of Special Scientific Interest (SSSI). I believe that at least three sites are worthy of UNESCO World Heritage Site status – the ***Semail Ophiolite***, the ***Jebel Akhdar massif and*** the ***Musandam peninsula***. A careful balance needs to be struck between preserving the geological sites and future construction developments. There should be sharing of information between geologists, planning authorities, developers and construction workers in order to avoid the loss of irreplaceable geological sites.

The Oman Mountains contains the World's largest, best-exposed and most complete ophiolite (oceanic crust and upper mantle) section. The Semail Ophiolite was emplaced from the Tethyan Ocean onto the passive continental margin of Arabia during the Late Cretaceous (approximately 95 – 79 million years ago). The Semail Ophiolite stretches the length of the Oman Mountains from the Dibba zone south of Musandam to the Sur region in the east. Wadis draining off the mountains provide superb 3-dimensional cross-sections through the ophiolite and geologists have used these sections to map out the structure of the oceanic crust and upper mantle. Millions of dollars have been spent by the international scientific community on the International Ocean Drilling Project, coring holes in all the World's oceans, but these expensive drill holes have barely scratched the surface, penetrating only the oceanic sediments and volcanic upper crust. In Oman geologists can walk along any of the major wadis cutting the ophiolite and map out the structures of the entire crust and upper mantle sequence in intricate detail.

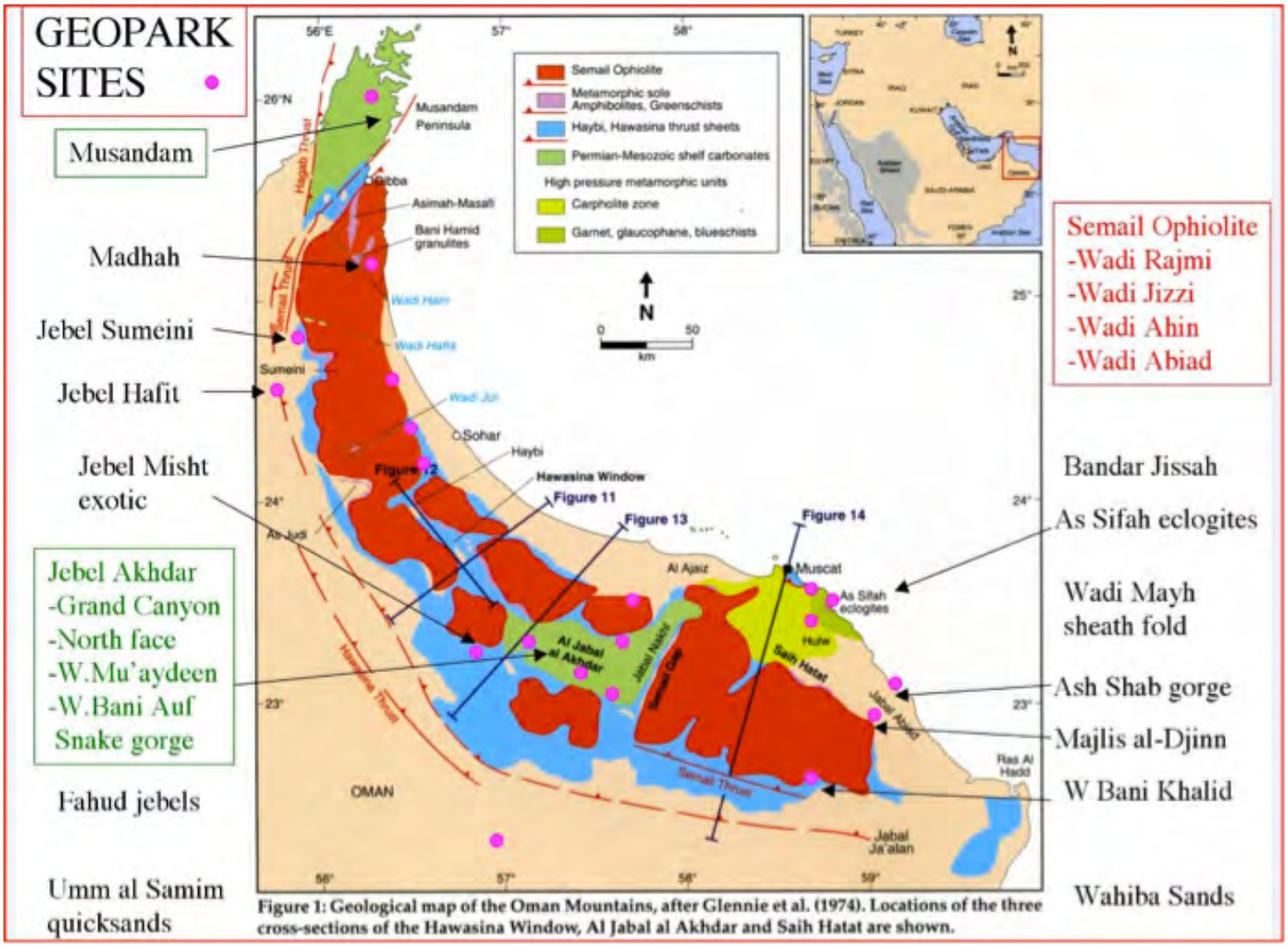

Figure 1. Geological map of the northern Oman Mountains showing locations of the main sites proposed as GeoParks or SSSIs.

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Figure 2. Three main sites proposed as UNESCO World Heritage sites in Oman.

It is from the geological studies of the Oman ophiolite that we now have a very good idea of petrological composition of the oceanic crust and mantle and many geological processes of crucial importance. Mantle melting processes have been studied, mapping the gabbroic blebs and dunite flow lines in harzburgite. Magma chambers have been mapped out in the gabbroic lower crust. Sheeted dykes and pillow lavas beautifully exposed in the northern mountains around Wadi Jizzi reveal unique information about extensional tectonics at oceanic spreading ridges and how magma is channeled upwards from the magma chamber to the actual ridge axis. Radiolarian cherts interbedded with the pillow lavas have been dated to provide a precise Cenomanian age of ophiolite formation. This age is the same as that obtained from Uranium-Lead dating of zircons within plagiogranites, the last felsic differentiate component of the ophiolite (95 million years old). Probably the best sections through the ophiolite occur in the Wadi Jizzi, Wadi Salahi and Wadi Ahin region inland from Sohar and this area is a prime candidate for National GeoPark status. The Oman ophiolite is so special and unique in the World that this site must surely be collectively preserved as a UNESCO World Heritage site.

The Jebel Akhdar massif in the Central Oman Mountains is the most impressive and stunning part of the mountains. Here an extremely large-scale anticlinal fold has domed up the entire Permian, Triassic, Jurassic and Cretaceous shelf carbonates as well as the pre-Permian basement and the Cenozoic cover rocks. The north face of Jebel Akhdar has spectacular near vertical cliffs cutting the entire shelf carbonate sequence that have been used by geologists to compare the stratigraphy of the oil well sections in the desert interior to the Arabian continental margin. Wadi Mu'aydeen has been the most studied section since the early days of Shell-PDO exploration. To this day almost every geologist working in exploration and production must surely have studied the magnificently exposed strata along the wadi. The Grand Canyon of Wadi Nakhr is probably the most impressive of all the wadi gorges that cut through Jebel Akhdar, and this alone is surely worthy of GeoPark status. Wadi Tanuf is another canyon cut through the southern flank of the anticline with wonderful trekking routes around it. On the northern flank of Jebel Akhdar, Wadis Sahtan, Bani Auf, Hajir, and Mistal are all unique and wonderful places, not only geologically but also scenically. Snake gorge in Wadi Bani Auf is probably the most impressive canyoning route anywhere in Arabia. The north face of Jebel Shams from the headwaters of Wadi Sahtan to Wadi Bani Auf is the most important region to preserve, but in reality the entire Jebel Akhdar massif justifies preservation as a UNESCO World Heritage site.

In the far north of the Oman Mountains

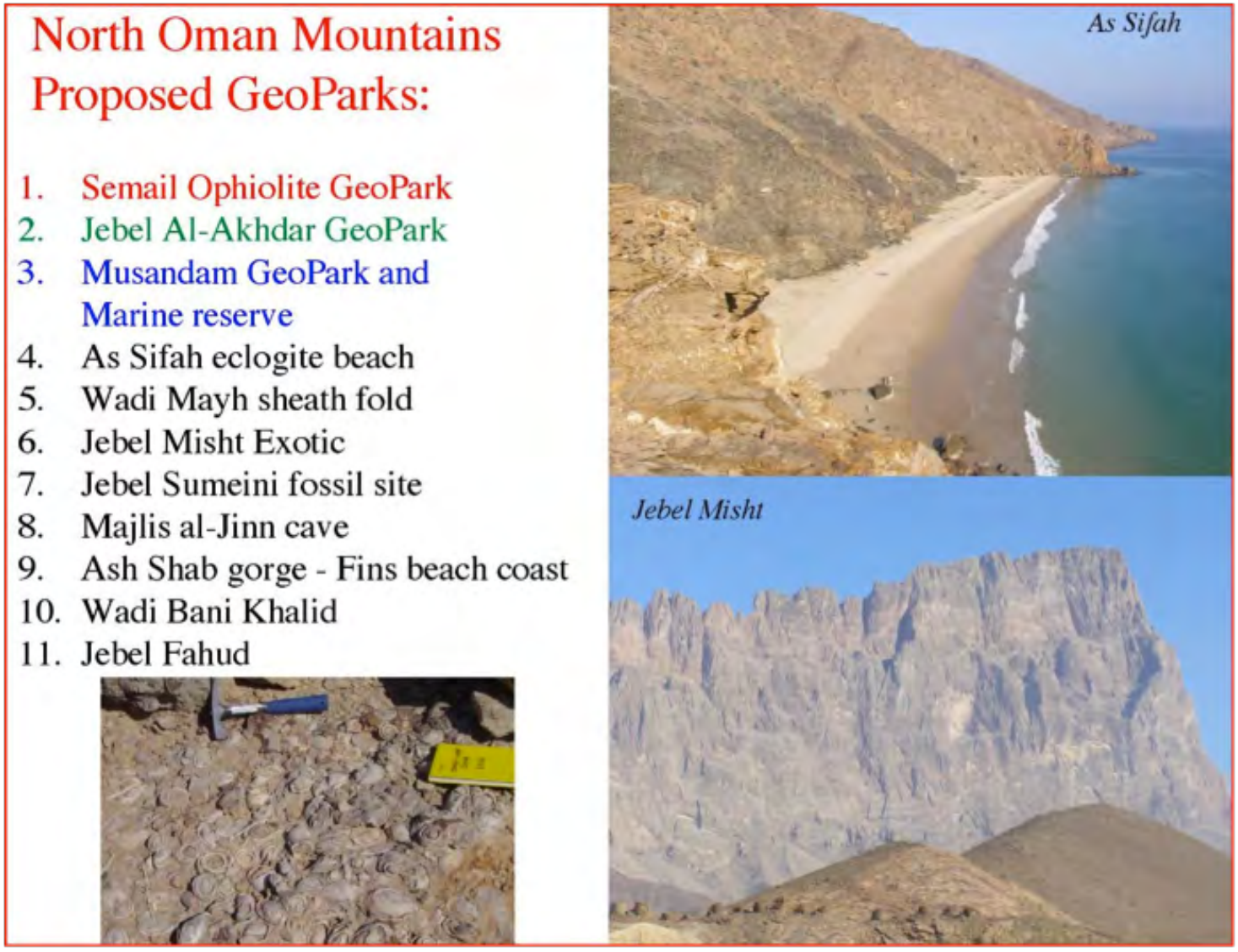


Figure 3. Major GeoPark sites in the northern Oman Mountains

the Musandam Peninsula is another very special and unique locality. The entire 3 km thick shelf carbonate succession has been thrust up over the Arabian Platform in one giant west-verging fold-nappe structure. This Oligocene – Miocene Hagab thrust culmination marks the first contact between Arabia and the northern Iranian plate, the earliest phase of continent – continent collision and beginning of the Zagros orogeny seen in Southern Iran. The frontal fold of the Musandam culmination is exposed along the western mountains in Ras al Khaimah, but most of Musandam lies within Oman territory. In the north the fold plunges northwards under the Straits of Hormuz. Recent eastward tilting of the whole Musandam peninsula has resulted in a wonderful and spectacular drowned coastline. The drowned fjords of Khawr ash Sharm, Khawr Najd and Khawr Habalayn are truly unique parts of Arabia. Not only is the geology here unique but the seas around Musandam are special sites for marine life where schooling dolphins, sharks of at least six species, sailfish, whales and eagle rays are regularly seen. The coral reefs of Telegraph Island are some of the northernmost coral reefs known, again with a rich variety of marine life. The Musandam is so unique and special that the entire peninsula in Oman, but especially the north and east coasts justifies preservation as a UNESCO World Heritage site.

A total of 29 GeoPark Sites throughout Oman are here proposed for preservation and conservation (Figures 1-4) together with 19 more Sites of Special Scientific Interest (SSSI). Some of the more important sites are briefly described here, and there are surely others not on the list that also deserve special protection.

Metamorphic rocks exposed along the base of the Oman ophiolite provide valuable information about the subduction of crustal rocks to great depth and subsequent exhumation back to the Earth's surface. In Oman these rocks form a very narrow zone of inverted metamorphism (garnet clinopyroxene amphibolites and greenschist facies marbles and quartzites) only exposed in a few rare and special places. Of crucial importance is the preservation of the Sumeini Window site in the north and the Wadi Tayyin site in the south, both areas that are certainly the best exposed such rocks beneath ophiolites anywhere in the World. In the As Sifah region southeast of Muscat, one very special locality is unique in the World. At As Sifah beach a dome of eclogite facies rocks

within intensely sheared calc schists have pressures of over 20 kbar indicating burial of the Arabian continental margin rocks to depths of nearly 100 km in a subduction zone environment. These eclogites have been dated by Uranium-Lead on zircons at 79 million years and provide concrete evidence of the subduction zone environment of ophiolite emplacement.

Another geological spectacular is the World's largest and best-exposed sheath fold beautifully exposed along Wadi Mayh, the access route to Yiti from the Saih Hatat bowl. The folds and thrusts exposed along the Wadi Mayh gorge are a structural geologist's dream with wonderful 3-dimensional exposures around every twist and turn of the wadi. The Wadi Mayh

to have a few sightings of the endangered Arabian Tahr in these hills – a further reason to preserve this area in a GeoPark.

Oman is renowned for several superbly well-preserved fossil sites. Apart from the fossiliferous Mesozoic shelf carbonates perhaps the most spectacular sites are the ex-

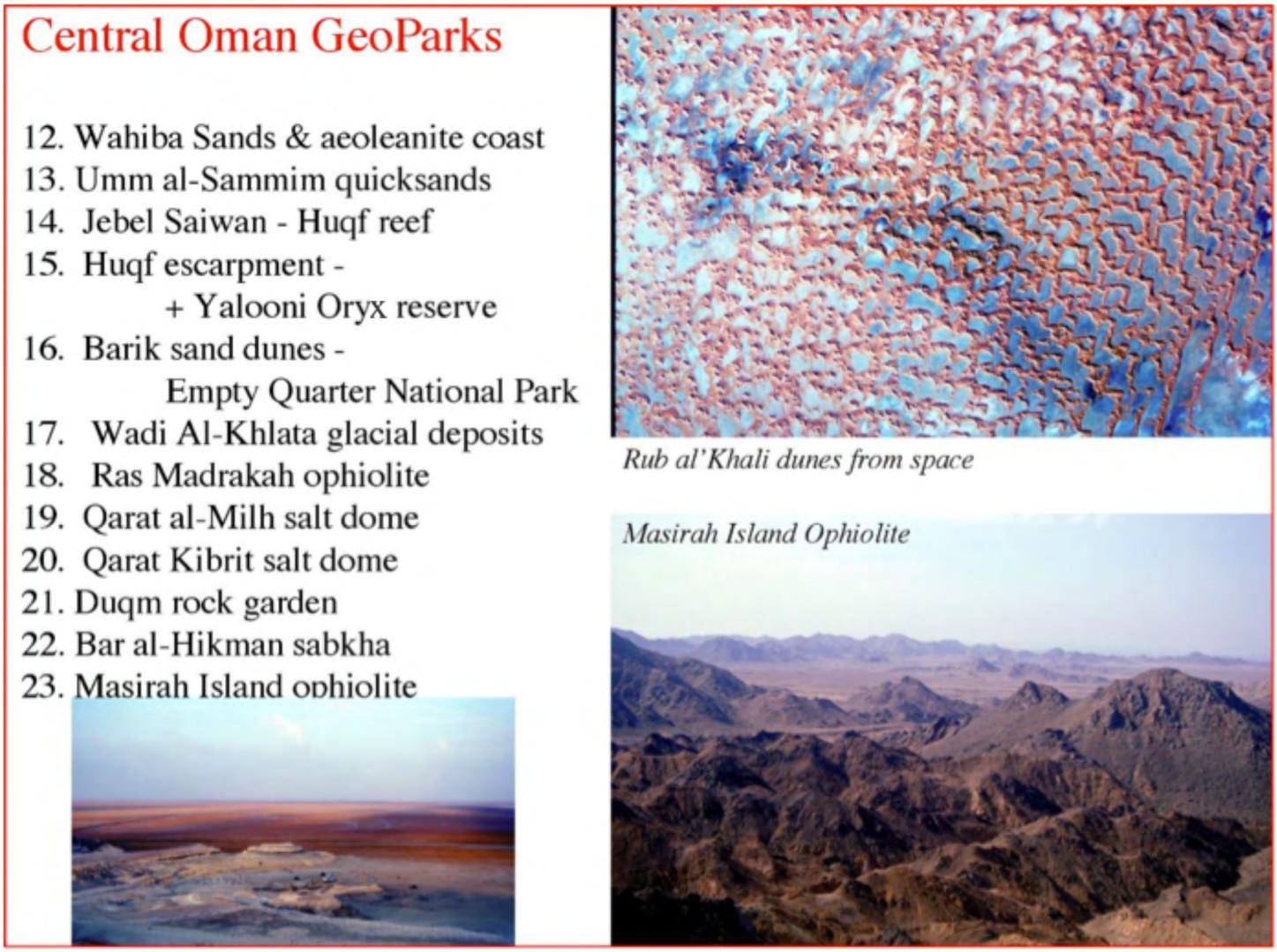


Figure 4. Major GeoPark sites in central Oman.

Nowhere else in the World can it be proven without doubt that continental crustal rocks were subducted to great depth beneath an oceanic upper plate (Semail Ophiolite) and then returned back up the same subduction channel to the Earth's surface. Large-scale development of the main Sifah beach to the south makes it imperative to preserve the Sifah eclogite beach north of the village.

mega-sheath fold is 25 km long and the largest, and by far the best exposed such structure. Wadi Mayh drains a large area of mountains east of Muscat and regularly floods. As the access road is an important link to new developments on Yiti beach any new road building should respect the geology of this unique and precious locality. When I was mapping the area in the late 1990s I was lucky enough

tensive rudist-coral 'death assemblages' near the end Cretaceous mass extinction. Two sites in particular are so especially well-preserved that they deserve GeoPark status, the Jebel Saiwan reef in the Huqf, and Jebel Sumeini in northern Oman. Whereas the Huqf reef is a fabulously preserved intact rudist reef, the Jebel Sumeini site is a death assemblage of solitary corals and large coiled gastropods of the Du-

rania facies which make up the entire rock. Both sites have already suffered from amateur collection which apart from removing the valuable fossils has also contributed to destruction of these unique sites. These sites deserve to be fenced off and controlled by park wardens.

The Oman Mountains are well-known for their unique 'Oman Exotics'. These isolated Late Permian or Late Triassic oceanic seamounts or guyots still frequently preserve their alkali volcanic substrate and are preserved as huge thrust sheets immediately beneath the ophiolite. Jebel Misht east of Ibri is the most spectacular of all the Oman Exotics with its 1000 meter vertical west face. This face is the most challenging rock climbing cliff in Arabia and has over 8 routes up it. Nearby the huge massifs of Jebel Kawr and Jebel Misfah are also World-class sites worthy of preservation as part of one large GeoPark with Jebel Misht, or individually as SSSI sites. These exotics are all Late Triassic in age but perhaps the best-preserved Permian exotic mountain is the Baid Exotic in the eastern mountains.

Majlis al-Jinn is the World's second largest cave and a very special site. This amazing hole in the jebel has an access route that is only accessible from a 200 meter long free-falling abseil descent. This incredible place must be preserved.

South of the Oman Mountains the country contains a set of important sites – the Wahiba Sands with its unique exposures of long, linear seif dunes and coastal exposures of fossil sand dunes, the Umm al-Sammim quicksands, the Huqf escarpment with its Neoproterozoic glacial deposits of 'Snowball Earth' importance, the salt domes of Qarat al-Kibrit, Qarat al-Milh and Qarn Nihayda, the Duqm rock gardens, the wonderful barchan dunes of Ramlat Barik and Ramlat Fasad.

In Dhofar there are more GeoPark sites of World Heritage importance. Jebel Samhan, the last stronghold of the Arabian leopard, is also important geologically with Cenozoic limestones resting unconformably on Proterozoic basement. The travertine waterfalls of Wadi Darbat and deep caves of Tawi Atair are astounding examples of geological sites ideal for GeoPark status. The 1000 meter high sea cliffs at Raysut west of Salalah are again unique sites where the khareef summer monsoon rains result in a spectacular local fauna and flora. The monsoon driven moist deserts of southern Arabia are where the World's best frankincense is grown.

The future economy of Oman will include a large tourism (and geo-tourism) sector and it is vital that these sites are protected before urban development destroys them. Naturalists have done a great job in Oman setting up important wildlife reserves such as the Yalooni Oryz reserve, Wadi Serin Tahr reserve, the Ras Jinz turtle nesting beach and the Daymaniat islands nature reserve. Many GeoParks could also easily be combined with Natural History - wildlife parks. Oman has a totally unique and special heritage and Omanis are rightly proud of their wonderful culture, traditions and heritage. Now it is the turn of the geologists to advocate the establishment of these GeoParks and SSSI sites. We must do this now, quickly and efficiently, before any of these unique and valuable sites disappear forever, seeking the appropriate political and financing support.

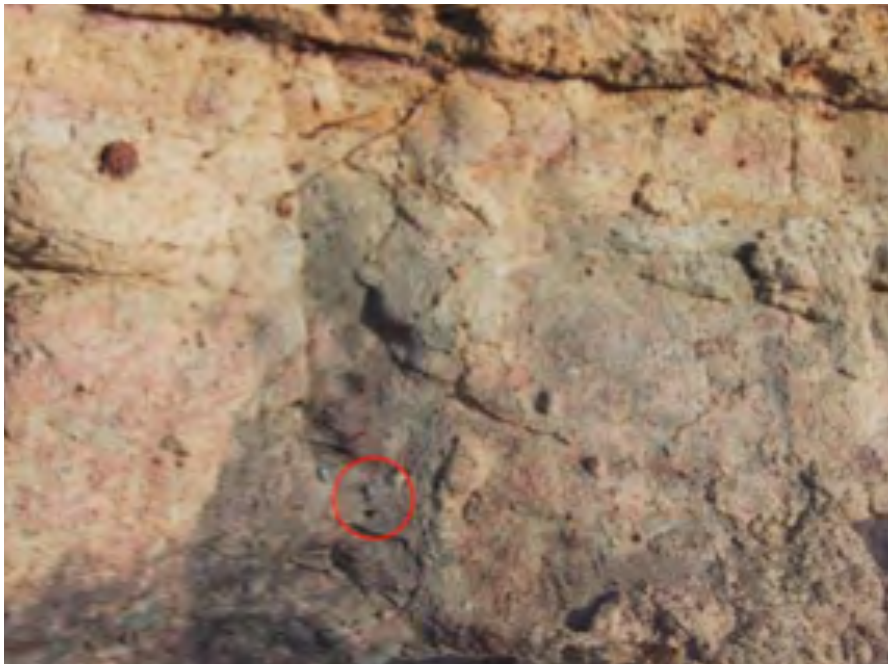
A bitumen clast from Al Khlata South Wadi and its implications for oil seepage on the Eastern Flank and the fossil record of copepods

By Alan Heward (Petrogas Rima LLC) alan.heward@petrogas.com.om

Back in January 2004, I led a field excursion to Al Khlata for Phil Allen, Paul Hoffman and a number of their students. The intent was to show them something of a reasonably well time-constrained glacial succession for comparison with the Cryogenian (Neoproterozoic) glacial units they were working on.

Salim (Shuram) and I arrived at Al Khlata early and went to check some outcrops. Phil, Paul and co turned up at the South wadi campsite whilst we were out and several of them wandered down into the wadi to begin looking at the outcrops. That evening one of the students, Gion Kuper, produced a piece of a black clast he had hammered off which had a dull black exterior and shiny interior. We passed it around and commented that clasts of volcanic glass had not been noted in the Al Khlata before. Gion pocketed the fragment and we thought no more of it. On the morning we were to leave, he produced it again, saying that it was too 'light' to be volcanic glass. We heated a corner with a match and a bituminous odour came off. It was not volcanic glass, but a clast of pitch (or more correctly bitumen). We were in a hurry to leave for Salalah to be taken around the Mirbat outcrops. I asked Gion to quickly show us the locality from where he had obtained the fragment. After a couple of attempts he found the spot with the remaining bitumen clast sticking out of the outcrop. Felicity and I returned a few weeks later to record the location and to collect the remainder of the pebble-sized clast. We searched up and down the wadi and in other wadis for more. Plenty of black laminated chert clasts, but no more bitumen ones. Since then no further bitumen clasts have been reported from the Al Khlata outcrops, despite a number more visits and lots of searching.

There were two obvious things to do with the clast: 1) analyse its geochemistry and try to relate it to a subsurface oil or source rock, and 2) to see whether the seeping oil had trapped any spores, pollen or other biota as it came to the earth's surface and solidified as bitumen (as with the famous La Brea tar pits in California, USA). Paul Taylor, of Shell Rijswijk, analysed and interpreted the geochemistry, and Mike Stephenson, of BGS, set out to dissolve small pieces of the clast to liberate any contained organisms. Both these types of analysis yielded



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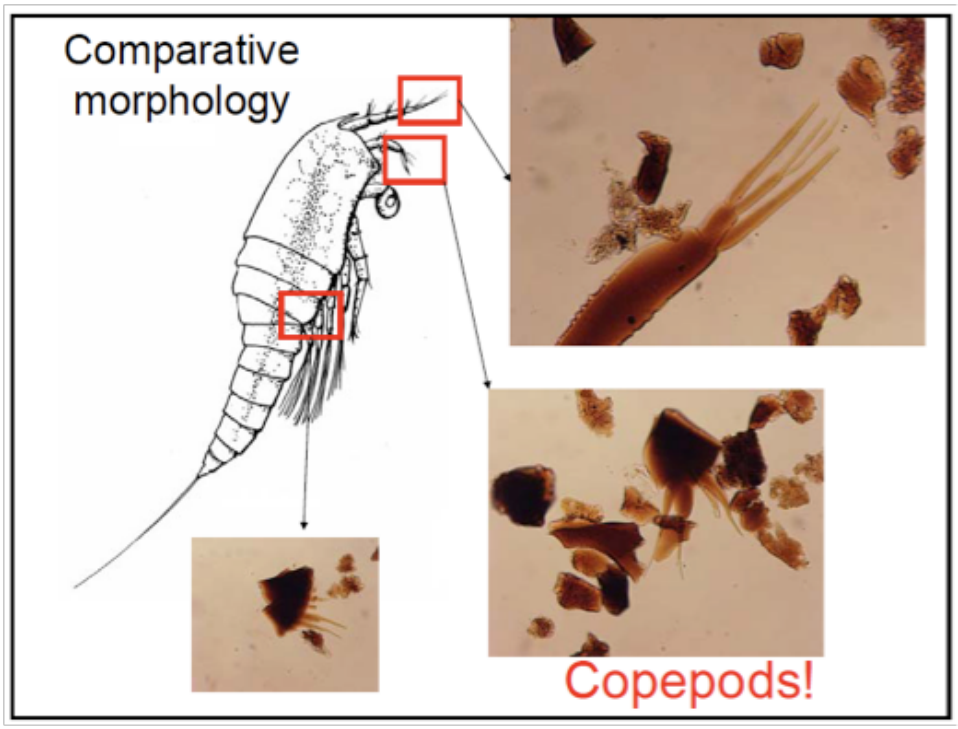
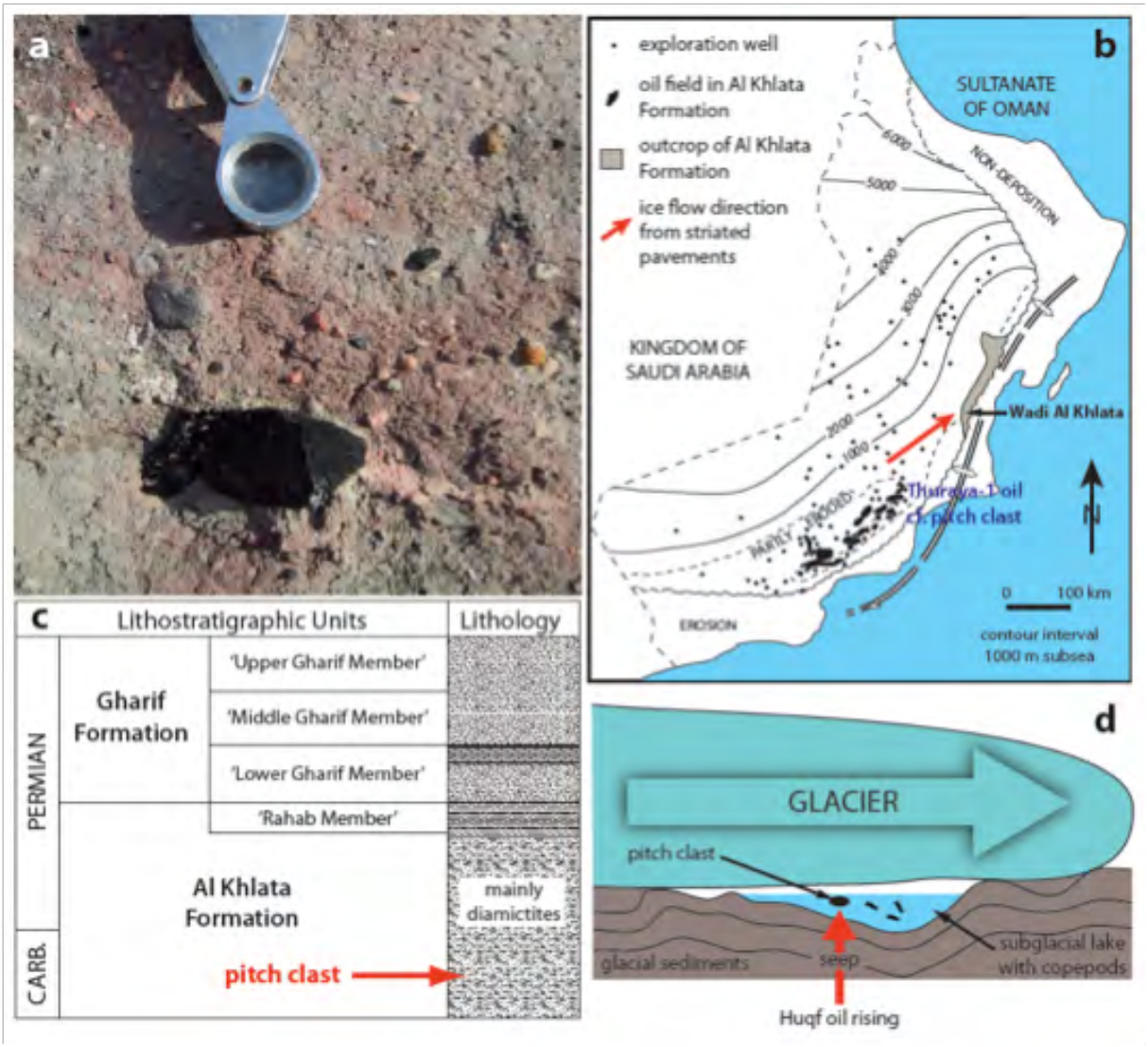


surprises.

The geochemical surprise was the complete lack of biodegradation evident from gas-chromatography. Oil from surface seepages is often strongly biodegraded (as is the case with the present-day Saiwan seep). The lack of biodegradation suggests this oil solidified to bitumen quickly. The bitumen clast was typed to South Oman Huqf sources (a mix of pre- and intra-Salt) and the closest comparable oil on record is one from Thurayah field, one of the Rima Small Fields unconnected accumulations. The implication is of Huqf source rocks being mature and oil migrating and seeping to the surface along the Eastern Flanks during Al Khlata P5 time (Late Carboniferous).

The biostratigraphic surprise was the lack of spores and pollen and, in



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contrast, abundant arthropod debris. Mike sent these off to various arthropod experts and eventually it was Paul Seldon (Univ. of Kansas) and Rony Huys (NHM) who confidently identified the remains as those of copepods. Copepods are super abundant, microscopic zooplankton which underpin the food chains in both seas and fresh waters. They have probably been prevalent since the Neoproterozoic and only have a meagre fossil record (the appendages in the image below are 30-100 microns in length).

If you want more details, particularly of the copepods, then read the paper recently published in Nature Communications. This solitary bitumen clast, from Oman, when analysed by experts has extended back the fossil record of different types of copepods by 188-289 million years!

The lack of spores and pollen is explained by oil seeping into a lake beneath an ice sheet in Al Khlata P5 time, entraining and probably fragmenting copepods as it cooled and solidified, and then the bitumen mass being broken-up as it was transported the 150 km north-eastward to Al Khlata.

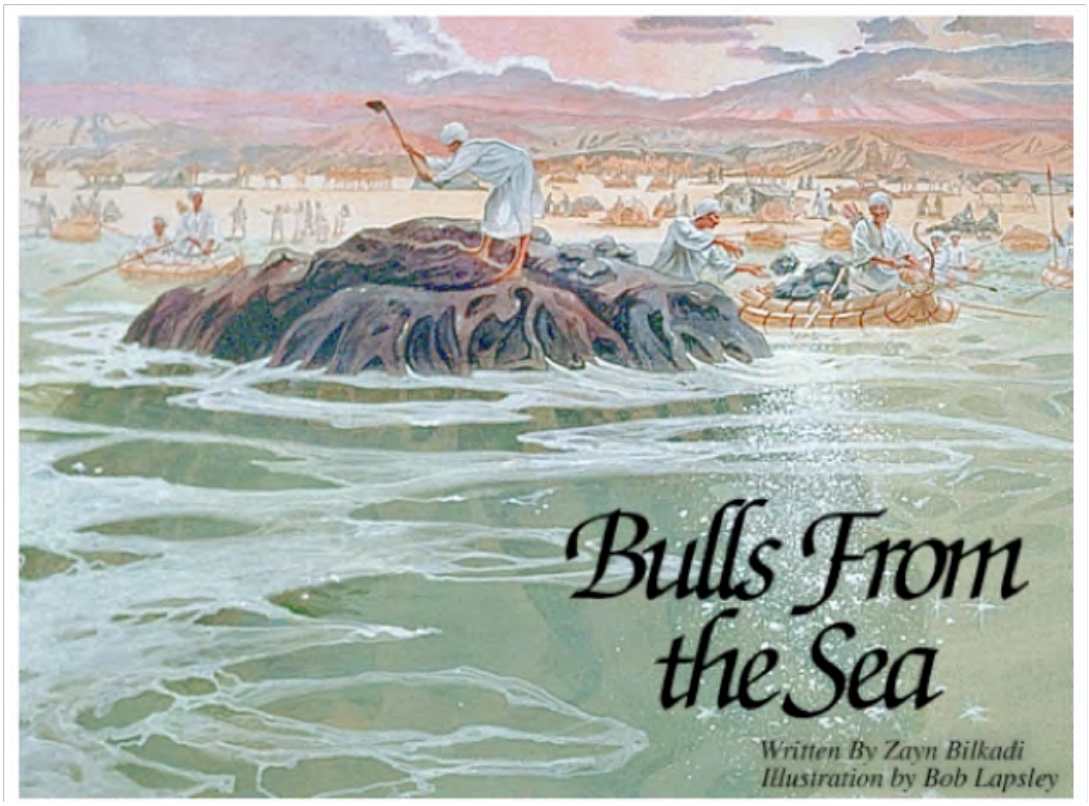
Are more bitumen clasts likely to be found in Oman? Yes probably, either in cuttings, cores or in the outcrops. The Eastern Flanks of the South Oman and Ghaba Salt Basins have probably had oil seeping to the surface periodically in the past 500 Ma.

Faisal Al Abri and Ahmed Al Brashdi, two of our wellsite geologists, identified what appear to be large cuttings of bitumen from the Mafraq interval of the Reihan field. I have a bag of them sitting in my office and have yet to organise having them analysed or dissolved. Will they result in still more surprises and another paper in Nature?

Published online at www.nature.com/naturecommunications :

> *Paul A. Selden, Rony Huys, Michael H. Stephenson, Alan P. Heward & Paul N. Taylor, 2010. Crustaceans from bitumen clast in Carboniferous glacial diamictite extend fossil record of copepods. Nature Communications, DOI: 10.1038/ncomms1049.*

For comparison with the Al Khlata bitumen occurrence, bitumen masses seeping to the surface of the Dead Sea have been common events during various periods of history where they were fought over, 'harvested', traded and used for various purposes by the surrounding peoples (illustration below from Aramco World July/ August 1994).



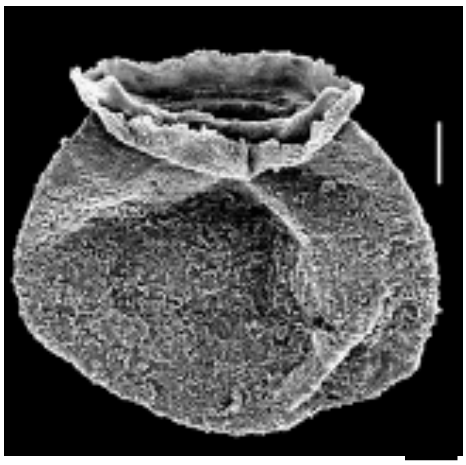
Nabataeans race out to one of the bitumen "bulls" of the sea-floating mounds of jellied crude oil-and then toss chunks they've cut off into their reed boats, finally for export to Egypt

New Omani Chitinozoa

By Graham A. Booth

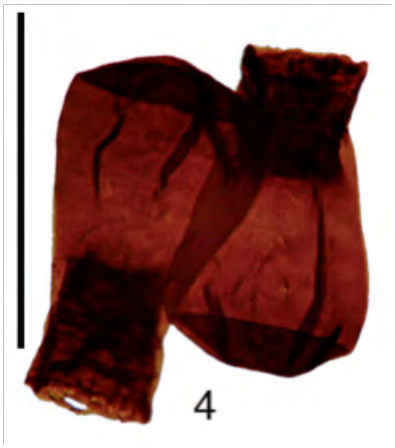
Chitinozoa are organic-walled microfossils which are found in marine sediments of Ordovician to Devonian age. In Oman we find them in the Saih Nihayda, Hasirah and Sahmah Formations. They have a characteristic bottle-like profile and range in size from about one twentieth to two millimetres. Being extinct we are not absolutely sure of their origin but the most established explanation is that they are the eggs or egg cases of soft bodied metazoans. Over time their creators evolved and so did chitinozoan morphology. While the bottle form was preserved, there developed great diversity in overall shape and surface ornament. Some species have restricted stratigraphic occurrence and this has made them very useful for correlating well sections.

It was during the detailed study of rich chitinozoan assemblages from core 22 of Ghaba-1 that several chitinozoa were found, which we recognised as being different from any other described species. They came from the Ordovician Saih Nihayda Formation, which based on age-significant graptolites occurring at approximately the same horizon, we know to be of middle to late Darriwilian (Llanvirnian) age i.e. within the time interval 466 – 461 million years.



Desmochitina mortoni
Scale bar 1/100th millimetre

Euconochitina sheridani
Scale bar 1/10th millimetre



Lagenochitina? sp. aff. L. deunffi.
Scale bar 1/10th mm.

Because of their wall thickness, chitinozoa are difficult to study using a normal transmitted light microscope, especially when it is necessary to describe all the details required for species definition. Consequently, this work was undertaken by Prof. Florentin Paris at the University of Rennes and Mutasam Al-Ghammari at the University of Sheffield using a Scanning Electron Microscope (SEM). Mutasam is in the final year of his PDO sponsored PhD in palynology studies at Sheffield, but studied chitinozoa under the guidance of Florentin. The SEM enables the chitinozoan surface to be seen in great detail and provides the information required for good species description. However, the specimens need careful preparation before examination and must be systematically dried, mounted and then coated with gold to provide a conductive and electron reflective surface.

Having defined our species and satisfied ourselves that they were not within the circumscription of already described forms, we had to provide them with names. To comply with the rules of Latinised binomial nomenclature established by Carl Linnaeus, we needed to assign a generic name and a species name.

Assignment of the generic names was automatic as the characteristics of the specimens allowed us to place them

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in existing genera, but the species names were something which we had to decide on ourselves. It is always a privilege to be in the position of assigning species names as they will be attached to the defined types for as long as they are studied. It is usual to try and choose a name which is relevant to the specimen, or to the area in which it was found, or one may choose to honour a person who, for example, has contributed in some way to the history or development of the region. Alan Heward made the good suggestion that we might honour two geologists, Mike Morton and Don Sheridan, both of whom played significant roles in the early years of oil exploration in Oman. We were therefore pleased to assign the names Desmochitina mortoni and Euconochitina sheridani. Choosing the two other names, Desmochitina omanensis and Belonechitina ghabaensis was not too difficult a choice either, as it is entirely appropriate that we should honour both the country and the well in which they were found.

Note: Ghaba-1 was the second oil exploration well to be drilled in Oman and was completed in 1959. While it did not find oil, the PDO personnel in charge of the well had the foresight to take numerous cores throughout the section (41 in total), which left us with a rich legacy of stratigraphic information. For example, core 21 from this well provided evidence of the earliest land plants (Wellman et al., 2003), while recent work on the graptolites from core 22 (Rickards et al., in prep.) confirms the age of the Maximum Flooding Surface O30 (Sharland et al., 2000) to be equivalent to the murchisoni graptolite zone (c. 463 my).

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A large ammonite from the **Natih Formation**

By Ru Smith, SDO

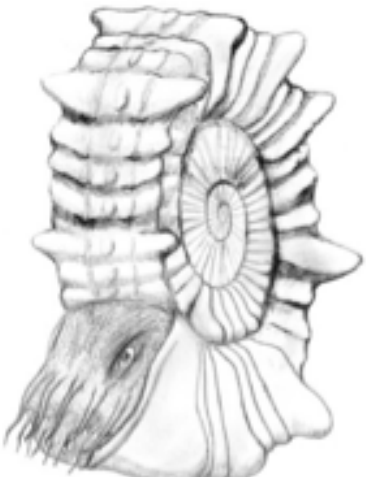
Ammonoids were marine cephalopods which first appeared in Early Devonian times and survived up until the end Cretaceous extinction event. Their beautiful planispiral shells are widely appreciated and here in Oman the symbol of Petroleum Development Oman is (probably) an ammonite (though it could also be a nautilus or even a spiral foram).

Many fossils occur in great abundance in Oman (think of the uncountable large foraminifera present in the Paleogene limestones around Muscat), but others are scarce and should be publicly recorded. Large complete ammonites are rarely seen in Oman so when a spectacular complete Cretaceous ammonite of the genus Cunningtoniceras was stumbled upon during a structural geology field excursion (21st December 2009) it was natural to donate it to the growing collection of the Geological Society of Oman (for a future Geological museum) in Muscat.

The specimen was discovered in one of the jebels forming the Salakh Arch. It measures 27 cm across and displays striking ribs and horn-like tubercles. The ammonite lay in a bed densely packed with marine bivalve shells. This species was described by Basse in 1940 and is found in strata of Middle to Lower Upper Cenomanian age (first stage of the Upper Cretaceous) and so is in the region of 95 million years old.

What did it look like in life? Nobody knows for sure since no fossils showing the preserved head and tentacles have yet been found. Ammonites are typically reconstructed with squid or octopus-like arms, advanced squid-like eyes and a hyponome for jet propulsion. They probably had less well developed arms than modern squid and may have eaten small food items whole (as does the modern Nautilus) whereas squid use their strong arms to hold prey while they take bites with their parrot-like beaks.

BASSE, E. 1940. Les céphalopodes crétacés des massifs côtiers syriens, pt. 2. Notes Mém. Ht.-Comm. Syrie Liban 3, 411-472, pls. 1-9. Our ammonite is described on p. 446, and figured as pl. 6, fig. 2a-b. She called this form Acanthoceras meridionale Stol. var multicostata nov. It is now referred to as Cunningtoniceras multicostatum Basse, 1940.



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Regional Exploration News

INDIA

Gas flowed at the rate of 5.4 MMcf/d, with 7.5 bc/d, at an onshore wildcat drilled by ONGC in the Krishna Godavari Basin. The Pennugonda 1A well on the Block 1B PEL was tested on a 6mm choke in the Cretaceous Raghavapuram Formation sandstones perforated at 3,062-3,071.5m, 3,080-3,086m and 3,092-3,099m intervals (Object I). In addition, the well yielded 500 Mcf/d through a 6mm choke from intervals in the Object II at 3,253-3,261m, 3,271-3,276m and 3,278-3,280m. Spudded in November 2007, the well was drilled to a total depth of 5,259m. ONGC is also reporting it has made an oil discovery on the Sibsagar District (Assam Shelf) PEL. Few details have been released on the onshore Geleki North 1 well, which reached a total depth of 3,545m in September 2009.

ONGC has made a gas discovery in the Kutch Basin offshore north-western India. The GK-28-1 (GK-28-A) exploration well within the Kutch Offshore Block 1 Extension shallow water concession flowed 4.5 MMcf/d through a 12mm choke. The closure has been interpreted as a fault influenced structure. The well was spudded in October 2009 by the Transocean's "F. G McClintock" J/U and drilled to a total depth of 1,550m. The original prognosed total depth was 3,500m.

IRAN

Perhaps mindful of the global interest currently being shown towards its neighbor Iraq, and holding the world's second largest gas reserves after Russia, Iran has reminded it seeks US$ 85 billion in investments within a decade to bolster gas exports. According to Reza Kasaizadeh, managing director of the National Iranian Gas Exports Company, the oil ministry plans to attract the money from both foreign and private sector investors. The development of Iran's gas sector is hampered by a lack of productive investment and the growth of domestic consumption such that Iranians have faced gas shortages due to high consumption, especially in winter. The high demand has led Iran to cut gas supply to Turkey several times in the past. Having signed agreements with China and Malaysia, the Islamic republic has been seeking to compensate for the absence of Western companies in its energy sector amid a nuclear standoff with the West, a situation unlikely to change as things stand.

IRAQ

Gulf Keystone has published an independent evaluation of its Shaikan 1 new field wildcat in the Shaikan Block, which has confirmed the well as the largest industry discovery of 2009. Reviewing the data from the Cretaceous, Jurassic and Triassic formations, the range of oil in-place for the Shaikan structure has been increased to a gross 1.9 (P90) to 7.4 (P10) billion barrels of oil, with a mean of 4.2 billion barrels. Previous estimates were 1.0 (P90) and 5.0 (P10) billion barrels. There are also prospective resources below 2,950m (lower Triassic and Permian) for which the evaluation has assigned potential reserves of 1 to 5 billion barrels and 6 to 14 Tcf gas. The report concludes that Shaikan 1 has discovered a significant resource of oil and gas in the Cretaceous Sarmord, Jurassic Barsarin, Sargelu, Alan, Mus, Butmah, Baluti and Triassic Kurre Chine formations.

Targeting prospective intervals in the Cretaceous and the Jurassic, Kalegran, a subsidiary of MOL, has spudded Bijeel 1, its first well in the Akri Bijeel block that will be drilled to a total depth of 4,300m. Kalegran holds an 80% interest in the permit, the remaining 20% is held by Gulf Keystone and the latter's success with the Shaikan 1 well in adjoining acreage has de-risked this and a number of other prospects nearby. Located in the Kurdistan region of northern Iraq, the 889 sq km onshore Akre-Bijeel Block was awarded in November 2007 for an initial exploration period of three years. The work obligation includes the acquisition of approximately 200km of 2D seismic data, with an option to drill one exploration well within the first exploration phase. Under the PSC, the Kurdistan Regional Government has the right to a participation interest of between 20% and 25%, and it has retained the right to assign third party participation interests of between 15% and 25% to qualified Iraqi and international companies.

PAKISTAN

Pakistan Petroleum Ltd (PPL) has been awarded two onshore exploration licenses in the Lower Indus Basin that were offered in the 2009 Licensing Round. Gambat South 2568-18 EL comprises 2,435.95 sq km in the Sindh province. Five dry holes have been drilled on the tract, including most recently Tullow's Shahpur Chakar 1 which was abandoned at a total depth of 3,392. PPL was declared the successful bidder after the closing of the licensing round on 30 September 2009. Rival bids were submitted by PEL, OGDC, Hycarbex and NHEPL. In addition, PPL was awarded the Jungshahi 2467-12 EL. Also located in the Sindh province, it encompasses 2,459.26 sq km. It also includes five dry holes, the most recent of which was drilled -- again by Tullow -- in 1995. OGDC made a rival bid for

this block. The 2009 Licensing Round was launched shortly after the approval of new Petroleum Exploration & Production Policy 2009 and Model Petroleum Concession Agreement (PCA)/Pakistan Petroleum (Exploration & Production) Rules.

SAUDI ARABIA

Speaking in Bangalore, Saudi Aramco chief executive officer Khalid al-Falih said output from Manifa, a supergiant field, will begin in 2013 with full development completed in 2015, but that costs have risen US$ 7 billion and now stand at nearly US$ 16 billion. With a capacity to produce 900,000 b/d of heavy crude, 65,000 bc/d and 105 MMcf/d of associated sour gas to be processed at the Khursaniyah gas plant, the project is the last of a series of large oil field development projects scheduled by the company that in 2009 took its total capacity to 12.5 MMb/d. Saudi Aramco slowed work on the project as it looked to cut costs on oil service contracts at the field and across its energy industry while simultaneously, a slump in global energy demand made further oil field development less urgent. Manifa has six reservoirs containing heavy, sour oil that is being developed to compensate for declining capacity at other fields rather than to add to total capacity. It was brought onstream in February 1966 from the Manifa Zone and produced an average of 60,000 bo/d during the year. The Lower Ratawi reservoir started producing in 1974 and by 1990 there were 12 flowing wells. Further development of Manifa was planned in May 1990, but the project was deferred. In his address, Khalid al-Falih also let it be known that his company plans to further explore for oil and gas in the deep waters of the Red Sea off its eastern coast and will launch an extensive 3D seismic survey. It was implied that further emphasis would be given to non-conventional oil and gas resources given advances in technology. He had earlier commented that Aramco planned to drill in deeper offshore frontiers in 2012.

SYRIA

The Syrian Ministry of Petroleum and Mineral Resources (MOPMR) and General Petroleum Company are inviting successfully qualified international petroleum companies to participate in an International Bid Round. The round involves the exploration, development and production of seven oil areas in Syria under the basis of Production Sharing Contracts (PSCs). The seven oil areas have been divided into two groups; Group I comprises the Turaib West, Halimeh and Al Dahl oil field areas and Group II comprises the Jaideen, Tel Asfar, Zinati and El Halul oil field areas. All of the fields are currently located in the 'Central' block in the Palmyra Zone and operated by Syrian Petroleum Company. All companies wishing to qualify for the round are expected to submit qualification documents to MOPMR no later than 18 February 2010. The international bid round will close at 14:00 on 19 May 2010.

Gulfsands Petroleum has received confirmation from Syria's General Petroleum Corporation that it has been granted a 25-year production license to develop the Yousefieh oil field in Block 26 North East Syria, which it operates with a 50% interest. The license may be extended for a further 10 years. The Yousefieh field was assessed at the end of 2008 as containing gross proved plus probable reserves of 11 MMbo and first oil is anticipated early in April 2010. Production will commence from two wells, Yousefieh 1 and Yousefieh 3, at an expected initial combined rate of up to 1,000 bo/d. The current expectation is that the Yousefieh field has lower reservoir energy than the nearby Khurbet East field and planning is underway to install permanent down-hole artificial lift equipment in both Yousefieh wells later in the year. In addition, a further development well on Yousefieh is planned for 2010. It is anticipated that production from the Yousefieh field will reach a rate of approximately 6,000 bo/d by 2012.

TURKEY

Issuing a joint statement, ExxonMobil is joining Black Sea exploration acreage covering over 30,000 sq km that is currently held by TPAO and Petrobras. Subject to regulatory approval, the deal covers the Sinop, Ayancik and Carsamba sub-blocks of Block 3922. New equities will be TPAO (operator, 50%), ExxonMobil (25%) and Petrobras (25%). In March 2009, Petrobras contracted the Ocean Rig "Leiv Eiriksson" S/S for a seven-well, three-year period of drilling in the Black Sea in a deal valued at US$ 630 million. TPAO has stated that it hopes to find a minimum of 5 billion barrels of oil in the Black Sea region jointly held with Petrobras. The rig is now in Turkish waters and is expected to spud the Sinop 1 well for Petrobras in February 2010. Petrobras' International Director, Jorge Zelada, had previously stated the company was planning to invest US$ 300 million to drill two exploration wells in the Black Sea in 2010. Block 3922 has an average water depth of 2,200m and is undrilled. Note that since June 2008, ExxonMobil has had a 50% interest in the Samsun sub-block of 3922 and the eastern part of Block 3921. ExxonMobil will become the operator during the initial exploration phase and will earn 50% interest in the 8,500 sq km Samsun Block and the eastern part of Block 3921 (21,000 sq km). ExxonMobil and TPAO will invest between US$ 400 to US$ 450 million in this first stage of exploration.

With thanks to **IHS Energy**

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