SAUDI ARAMCO world
January/February 1988 Volume 39, Number 1
In This Issue

Secrets of the Sands

Written by John Lawton
Photographed by Tor Eigeland

At first glance, it looked like a touch too much of the sun.

First, Captain Bill Rudd of the Sultan of Oman's Armed Forces half-buried four old truck tires in the sand. Then he doused them with gasoline and set them on fire. Next, Nigel Winser of Britain's Royal Geographical Society began chanting, "One, two, *three!* " at the top of his voice. And at each shout of "three," two scientists simultaneously photographed the windblown stream of oily smoke as it swirled and eddied over the crest of a nearby dune.

"The forefront of science," said Rebecca Ridley, the expedition's education officer, with a grin.

And so it was.

The scientists were actually developing an easy, alternative method of monitoring and recording sand movement: The thick, black smoke showed clearly the flow of the invisible wind and its burden of near-invisible sand particles, and gave the scientists a clearer view of how the wind builds and shapes dunes. And although it had been done before using smoke grenades, the "Rudd method," as it was dubbed, was cheaper and more practical: Grenades are expensive and a problem to carry around in the security-conscious 1980's, while discarded tires can be had locally for free.

Burning tires to attract attention in an emergency is, in fact, an old desert travelers' trick. So why didn't science adopt it earlier? Because, the scientists said, despite much debate in recent years about the growth of deserts and the problem of desertification of formerly fertile land, very little scientific research about deserts has actually been done.

It was with this in mind that the Royal Geographical Society (RGS), which previously had focused on rain forests in Sarawak, mountains in Pakistan and rangeland in Kenya, decided to turn its attention to desert, and launched an expedition to the Wahiba Sands in the Sultanate of Oman.

It was the most intensive desert study ever conducted. Between December 1985 and April 1986, the expedition carried out a total of 32 research projects in the fields of earth, life and human sciences and in the water economy of the desert.

The projects involved over 30 scientists, seconded from British universities and research organizations, and hundreds of support personnel, including administrative volunteers, military "babysitters," commercial sponsors, a prince and a sultan. A significant contribution to the knowledge of the Sands was also made by its Bedouin inhabitants.

The results of this unusual partnership, says the RGS, included "many new scientific secrets" ranging from the dew-drinking beetle to the largest aeolianite (fossilized sand) beds in the world. The expedition also disclosed the economic importance of the *ghaf* tree *(Prosopis cineraria)* in reforestation of arid areas, uncovered the potential of the Sands in reconstructing the environmental history of Arabia, and established new theories of dune formation. In addition, said Amer 'Ali Omair, vice-chancellor of Sultan Qaboos University, it unraveled "some of the complex interacting factors which affect sand movement."

This virtual encyclopedia of survey data establishes a baseline - a scientific basis for comparison - in all future desert research, and makes the Wahiba Sands a valuable scientific resource in themselves. The Omani government is considering declaring the Sands a national conservation reserve as a living laboratory for the future benefit of science.

But why, with bigger and better-known deserts to choose from - the Sahara, for example, or Arabia's vast Rub' al-Khali -single out an obscure corner of Oman for special study? Because, says Winser, the RGS expedition officer, Wahiba is "a perfect 'hand specimen' of a sand sea."

It is small as deserts go - only 12,000 square kilometers (4,650 square miles) - yet contains an extraordinary variety of dune forms. It is well defined - bounded by mountains and the sea - and only three hours' drive from Muscat, the Omani capital. And

this compactness and accessibility reduce the logistical difficulties of field research.

It is, says Winser, "as if the Sahara and the Rub' al-Khali had been compressed into one small unit. No other body of sand in the world contains such a full range of sandy terrains, or has so much to offer scientists urgently trying to piece together the complex jigsaw of arid-zone areas."

Of all the world's deserts, for example, Wahiba probably contains the best evidence of environmental changes over the last few tens of thousands of years. There are also significant traces of human occupation in neolithic times.

The Sands also contain an ancient relict woodland - an ecological left-over - of drought-resistant *Prosopis cineraria* which, besides being of biological and historical interest, has potential economic uses in other sand seas.

Another important reason for choosing the Wahiba Sands for the RGS research project, however, was Oman's exemplary environmental policy.

The sultanate was one of the first countries in the world to establish a ministry of the environment, to ensure that its dramatic, 15-year transformation from a medieval to a modern state (See *Aramco World,* May-June 1983) did not bring ecological destruction with the modernization.

"The impact of development," said Sultan Qaboos bin Sa'id, "must be skillfully directed so that our woodlands are not destroyed, our soils are not eroded and our valuable species of plants and animals are not prevented from playing their vital role in maintaining the environment."

The sultanate also played a pivotal role in the successful reintroduction of zoo-bred Arabian oryx *(Oryx leucoryx)* to the wild - where they had been hunted to extinction - by guaranteeing the threatened species sanctuary on Oman's Jiddat al-Harasis plain (See *Aramco World,* July-August 1982).

The Royal Geographical Society too was given a warm welcome. "No other expedition," says Winser, "has ever been so well supported."

Backed by the state, sponsored by business and looked after by the Omani Armed Forces, the RGS was able to complete in three weeks reconnaissance that under other circumstances would have taken three months, and performed a year's worth of field work in four months. Indeed, said RGS patron Prince Michael of Kent, "I know our expedition officer dreams of borrowing a unit of Omani soldiers to help with future projects."

The expedition got its first good look at Wahiba in January 1985, when an eight-man multi-disciplinary team spent three days overflying the Sands, another three days helicopter-hopping to specific locations in it, and then ground through more than 6,000 kilometers (3,700 miles) of dunes in four-wheel drive. Additionally, the United States provided satellite imagery from Landsat's thematic mapper.

The Wahiba Sands lie in the eastern corner of Oman, between the Hajar Mountains in the north and the Arabian Sea in the south and east. To the west are boulder-strewn gravel plains extending to the Rub' al-Khali desert and the Saudi Arabian border.

The north and central portion of the Sands are dominated by long sand mega-ridges, as the scientists called them - some 100 meters high (325 feet) and about a kilometer wide (1,100 yards). Local Bedouin call them *habl,* or rope, for their sinuous shape. Single ridges are up to 30 kilometers (19 miles) long and are oriented north-south, parallel to the southerly prevailing winds. These are very old dunes, the RGS investigators believe: The last time winds blew long and strong enough to build such massive sand ridges was the height of the last glacial period, some 20,000 years ago. The dunes' red color comes from an iron-oxide coating on the sand grains that takes many centuries to form.

By contrast, the sand in the southern Wahiba is light yellow, sometimes almost white, in color. Near the coast it is piled into large linear dunes, oriented east-west, with loose slopes up to 80 meters (260 feet) high. These dunes are the result of contemporary sand movement from the shore, and are actively growing today.

Besides the mega-ridges and coastal linear dunes, there are also curved and crescent-shaped transverse dunes in the Wahiba Sands and, overlapping the larger dunes, smaller ones of many other shapes and sizes. The effect is wave-like - which is why it is called "sand sea."

Beneath the loose sands of the modern dunes lies a vast rock shelf of fossilized ancient dunes. The rock appears as cliffs on the coast and as escarpments in the west, and also forms the floors of some of the deep valleys, or swales, between the dunes. Remains of ancient streams, in the form of raised wadi channels, are also evident on the Sands' western perimeter.

The northern boundary of Wahiba, where intermittent flooding of Wadi Batha gnaws at the edge of the Sands, is very abrupt. Here mega-ridges plunge precipitously to the floor of the valley, whose floodwaters wash away accumulated sand and prevent the desert from encroaching on the chain of fertile oases along the Sands' northern rim.

Prosopis woodlands, in whose shade the Bedouins pitch their tents, grow along the eastern and western margins of the Sands. The southern coastline stretches about 100 kilometers (62 miles). There is no road: The beach serves at low tide to link palm-frond fishing villages that are tucked away among the dunes to escape the ever-blowing inshore wind.

The mapping and sampling of the Sands was followed in December 1985 by a four-month intensive study of its orgin, ecology, conservation and development by the full RGS research team.

This study combined the traditional approaches to field work with modern technological aids, and was run with the precision of a military campaign.

The team operated from a main camp at al-Mintirib, an oasis town on the highway skirting the northern perimeter of Wahiba, and from a fixed field base and various mobile bases in the Sands themselves. All bases were staffed and supported by the Sultan of Oman's Armed Forces.

Main camp at al-Mintirib was a modern research base of portable buildings with accommodations for 40 people. Facilities included an air-conditioned computer room, a laboratory, print shop and library. The camp also served as the expedition's tactical headquarters, supporting and supplying team members in the field and coordinating their activities by radio.

Field base was a permanent tent camp at Qarhat Muammar in the eastern margin of the Sands. It included a mobile laboratory on loan from Sultan Qaboos University and a meteorological station.

Mobile bases operated from Land-Rovers for two to three weeks at a time. They had limited scientific facilities and fewer comforts, but they did allow the scientists, once they had mastered the art of driving in soft sand, to range freely over the Wahiba. By the time they had finished, says Winser, "very little of the desert remained unstudied."

The scientists concentrated on five study areas: the formation and history of the Sands, modern sand movement, biological resources, economic interrelationships among the area's human inhabitants, and the impact of recent change.

The Sands, the investigators found, have a complex history. For earth scientists, they represent a unique record of the development of a sand sea.

About a million years ago, during a dry glacial period when the sea level was much lower, sand blew inland from the exposed sea bed to form the first of a succession of sand seas at Wahiba. Most sand deserts are composed mainly of silicate mineral grains and rock fragments, but Wahiba's early dunes contained mainly calcium carbonate and magnesium carbonate particles, derived from the shells of marine animals or precipitated from sea-water by marine algae. When the sea level rose again during a later, wetter interglacial period, those carbonate particles dissolved, cementing the ancient dunes together into a stone called aeolianite and preserving evidence of their formation.

The cemented dunes were then planed off by strong winds during another dry period, and the sand produced by this erosion blew further inland to form the mega-ridges that dominate the central and northern portions of the Sands today. Later, more sand blew in from the beach, forming a new layer of dunes along the coast on top of the remains of the ancient, planed-off ones.

At least three distinct cycles of dune formation, cementation and subsequent wind erosion were recorded by the scientists in Wahiba's stratigraphy.

Three stranded shorelines, marking sea levels of the past, were also discovered. The highest of these lies 30 meters (100 feet) above today's estimated mean sea level. The longest stretch of ancient shoreline, covering more than 50 kilometers (30 miles) near Khuwaymah, was 11 to 13 meters (36-42 feet) above mean sea level; radiocarbon dating showed it to be a minimum of 20,000 years old. The lowest stranded shoreline - 1.5 to 2 meters (60-78 inches) above mean sea level - probably dates from the middle of the Holocene Epoch, which runs from 10,000 years ago to the present.

The swales between the mega-ridges apparently held seasonal lakes during the early- to mid-Holocene period: Investigators found the remains of snail-like lake-dwelling creatures there and subjected them to radiocarbon dating. Dr. Rita Gardner of King's College, London, says the results "suggest a late Pleistocene age for the mega-ridges, and an even earlier age for the aeolianite." The Pleistocene Epoch dates from 1.6 million to 10,000 years ago.

The Wahiba is probably the largest Pleistocene aeolianite field in the world. Because the sand it comprises must be carried by the wind, aeolianite seldom reaches more than 20 kilometers (12 miles) inland from the coast, but the Wahiba aeolianite extends more than 100 kilometers (62 miles) inland and at least three kilometers (3,250 yards) offshore. "As such," says Dr. Gardner, "it is the most extensive continuous deposit so far identified in the world."

The aeolianite field has been extensively eroded and planed off. On the coast north of Ras Ruways, it is cut by the sea into cliffs up to 20 meters (65 feet) high. But the most spectacular outcrops occur in the swales between the coastal dunes, where strong inshore winds have eroded the rock into weird shapes.

As landforms, however, the raised stream channels along the western perimeter of the Sands are even stranger: miles of sinuous ridges that, from the air, stand out black against the bright sand.

These gravel outcrops are the beds of ancient rivers that flowed across the plain west of Wahiba in much wetter times, and whose beds, like the aeolianite, were preserved by cementation. Dry glacial-period winds then removed the finer material from around these coarser deposits, leaving them exposed, the skeletons of dead streams.

Later, river erosion by Wadi Andam, which today cuts a much straighter path across the plain, dissected the meandering ridges, revealing excellent evidence of climate change.

"These systems," says Dr. Paul Munton, the expedition's biological resources program director, "are a unique record of the alternation of wet and dry periods over the last few tens of thousands of years." As such, he adds, they offer great potential in reconstructing the environmental history of the Arabian Peninsula.

In its study of modern sand movement at Wahiba, the RGS desert research team examined the dynamics of three active dune fields: a kilometer-square (250-acre) plot of mega-dunes near Quhaid on the coast, a 100- by 50-meter site (330 by 165 feet) in low dunes at Ras Dhaddhub, and a 200-square-meter plot (2,150 square feet) in a dune network at 'Urayfat, in the Sands' eastern margin.

Two of these dune fields were surveyed three times, months apart, to record changing dune shapes; the results were digitized for computer analysis. Additionally, a smaller area at 'Urayfat was observed with repeated low-distortion photography, and the investigators made very detailed observations of changing dune forms by studying certain dunes with graduated poles: They recorded changing sand heights on the poles at short intervals. And observations of wind flow over individual ridges were also made, using the "Rudd method."

All this produced a mass of data; in preliminary analysis, it shows that the dunes are very mobile. During the January-to-March period, changeable winds produced erratic movement - upper parts of ridges moved back and forth - but no major change in overall shape or structure. During the March-to-July period, in strong, southwesterly winds, however, the dunes' main slipfaces shifted northeastward, and their overall shape changed as well. The wind excavated the hollows between them and built some of the summits higher. More generally, the dunes became broader, with flatter summits.

These results, says Dr. Andrew Warren, director of the expedition's earth sciences program, "seem to call for a revision of some models of dune formation."

Indeed, claims Warren, the sand dune has been much maligned during debate on the problems of desertification. Although generally depicted as marching inexorably out of the desert to bury fertile land, dunes, he says, move mainly within sand seas. They rarely encroach on adjoining land unless it has been degraded by overgrazing, deforestation or other human intervention.

A study by three other Royal Geographical Society scientists at Wahiba supports this view. The trio carried out a survey of land systems and sand hazards at the Badiyal Oasis, on the northern fringe of the Sands. A report by the United Nations Environmental Program (UNEP) had asserted that sand encroachment was responsible for desertification of the oasis. But although more work is needed before their findings become a basis for policy, the RGS scientists say that "doubt is thrown on the UNEP conclusions," for "many [agricultural] fields are abandoned before rather than after burial by sandy."

"I am not saying there is no problem," said Warren, "but one of the big difficulties is diagnosis. Dune management is very hit-or-miss. We need to find out what makes dunes tick; only then will we find a better way of controlling them. Now we try to command them; we should be trying to understand them."

Meanwhile, the expedition's biological resources survey of the Sands may have pin-pointed part of a solution of the problem of desertification: *Prosopis cineraria,* a drought-resistant, acacia-like tree that forms woodland biotopes in the western and eastern margins of the Sands.

The Wahiba *Prosopis* stands turn out to be vital to both the human and non-human residents of the Sands. During long dry periods, when much of the ground vegetation is dormant, these trees maintain lush canopies of leaves and are often heavy with flower and fruit.

For the 3,000 Bedouins who live in the sand sea, the *Prosopis* trees, which they call *ghaf,* provide shade, wood for cooking, timber for shelters, food in the form of edible leaves and fruit, and fodder for their camels and goats - which in turn supply milk, butter, cheese and meat.

The woodlands also support large populations of insects that either feed on the trees or use them as shelter or habitat. The insects provide food for reptiles, birds and small mammals, on which, in turn, wild cats and desert foxes prey. And, because of the concentration of domestic and wild animals, the ground under the trees is well fertilized and produces rich undergrowth for grazing after occasional heavy rains. "This species," says Kevin Brown of Durham University, "is ideally suited for the reforestation of arid areas."

The survival of *Prosopis cineraria* in the harsh environmental conditions of the Sands - fierce temperatures, searing winds and high rates of water loss - depends mainly on tapping permanent underground water reservoirs: The taproots of mature trees can penetrate as deep as 30 meters (100 feet). Another survival factor is the tree's ability to propagate itself by producing new shoots from parent root systems, rather than depending on risky, biologically expensive regeneration from seed. *Prosopis* can also "absorb moisture from dew and mist carried in from the Arabian Sea," says Brown.

Dew - sometimes the equivalent of half a millimeter of rainfall (.02 inch) in a single night - is also a vital factor in the survival of many other life forms in the Sands. "At certain places and time of year," says Vice-Chancellor Omair, "dew and mist yield enough precipitation to support lichens and some invertebrates, such as dew beetles. There is enough dew, perhaps, to form a significant part of the water needs of larger animals, including gazelle."

It has long been known that the gazelle gets its water partly from life-giving droplets of dew that form on vegetation overnight, and that the dew that drips from plant leaves onto the sand waters the plants themselves.

But tiny mounds and trenches found by the RGS research team along the crest of many of Wahiba's dunes led to rare observations of five species of nocturnal dew-drinking Tenebrionid beetles - three of them new to science.

The beetle's home is about ten-to-20 centimeters (4-8 inches) below the surface of the sand. When dew has formed a wet crust, the beetle burrows up to the crest of the dune and drinks the free water held by capillary action between the loose sand grains of the mounds, or gathered in the trenches it has constructed. As the sun rises and the dew dries up, the beetle burrows down again into the cooler layer of sand below.

The most noticeable plant in the Sands, *Calligonum comosum,* grows best atop dunes of conical shape; it apparently owes its survival partly to its ability to absorb dew through its leaves. These plants remain green for long periods without rain and make excellent forage, contributing, says Dr. Paul Mounton, "to the success of local people in raising racing camels."

Other plants lie dormant during long dry periods - springing back to life when it rains, compressing into hours or days a whole life cycle of germination, growth, flowering, seed formation and death. During that short time, the plants literally turn parts of the desert green.

In the past, the Bedouin of the Wahiba Sands sought to maintain a balance between their needs and nature's gifts through self-imposed bans on tree felling and the creation of temporary grazing reserves. Now, says Roger Webster, the expedition's human-studies program director, there are signs that these practices are weakening.

Traditionally, when an area was declared *musawwan* (reserved), all camps and small livestock were removed from the vicinity for about two months to allow vegetation to recover and develop.

"But now that they are no longer dependant on the Sands for their resources," says Dr. Tom Gabriel of Cardiff University, "they are neglecting them." Today, for example, at least one member of each family goes off to work in the army or the oil fields, sending back money to buy food and fodder. And new wells have increased water extraction in the woodlands -lowering groundwater levels and threatening the *Prosopis* trees.

Modernization is threatening the range-lands, too: Bedouins are settling permanently, with their livestock, within reach of clinics and schools, giving local grazing no chance to regenerate.

Although a few families remain in scattered camps within the Sands throughout the year,

most of its inhabitants live along the Wahiba's perimeter: pastoralists in the *Prosopis* woodlands along the Sand's western and eastern margins, fishermen on its southern coast, and farmers in the oases in the north.

Some 450 or 500 Bedouin families live most of the year in the woodlands, moving their livestock to fresh grazing within the Sands after winter rains. The largest and most widespread tribe is the Al Wahibah. Others include the 'Amr, Hikman, Al Bu-'Isa and sections of the Janaba tribe; each tribe is associated with a particular sub-region of the Sands that includes wells and summer and winter grazing.

These tribes also look to particular settlements on the edges of the Sands as "their" administrative and market centers. And it is in these centers that they are now agglomerating. As one Bedouin said, camped in the *Prosopis* woodlands near Bilad Bani Bu 'Ali, "How can I take my children to school each morning if I am living in the middle of the Wahiba Sands?"

In contrast, the fisherman of the Wahiba's coastal strip, says Scottish anthropologist William Lancaster, "seem to prefer their retiring way of life."

Economically, he says, they depend entirely on fishing - mostly sand shark, sardines, kingfish and barracuda - with almost no one employed beyond the community. Fishing is so profitable, in fact, that most men need do it only part-time. They can pay cash for new boats and trucks without resorting to government aid, and still have enough money left to take care of their community's needy.

So, the RGS asks in one of its Wahiba-project publications, "What need have they for change?"

Indeed, the policy of the Omani government is to discourage people living in rural regions from moving into urban areas. But the government is not blind to the pull that urban amenities provide.

"Development in Oman is bound, sooner or later, to have its impact on the Wahiba Sands," Vice-Chancellor Omair told a symposium at Sultan Qaboos University, held last April to discuss the RGS survey project. "I hope," he said, "the studies made will help to find suitable solutions which will make living standards in the Sands attractive enough for the tribes to remain."

The RGS, however, expects much more. "It is hoped," says Winser, "that Omani and international scientists will work closely together to unravel further secrets of this remarkable area. That will contribute to the growing pool of knowledge about the arid regions of the world."

John Lawton*, a contributing editor of* Aramco World*, joined the RGS team in the Wahiba Sands last year.*

This article appeared on pages 6-15 of the January/February 1988 print edition of *Saudi Aramco World*.

Copyright © 2004-2014 Aramco Services Company. All rights reserved.