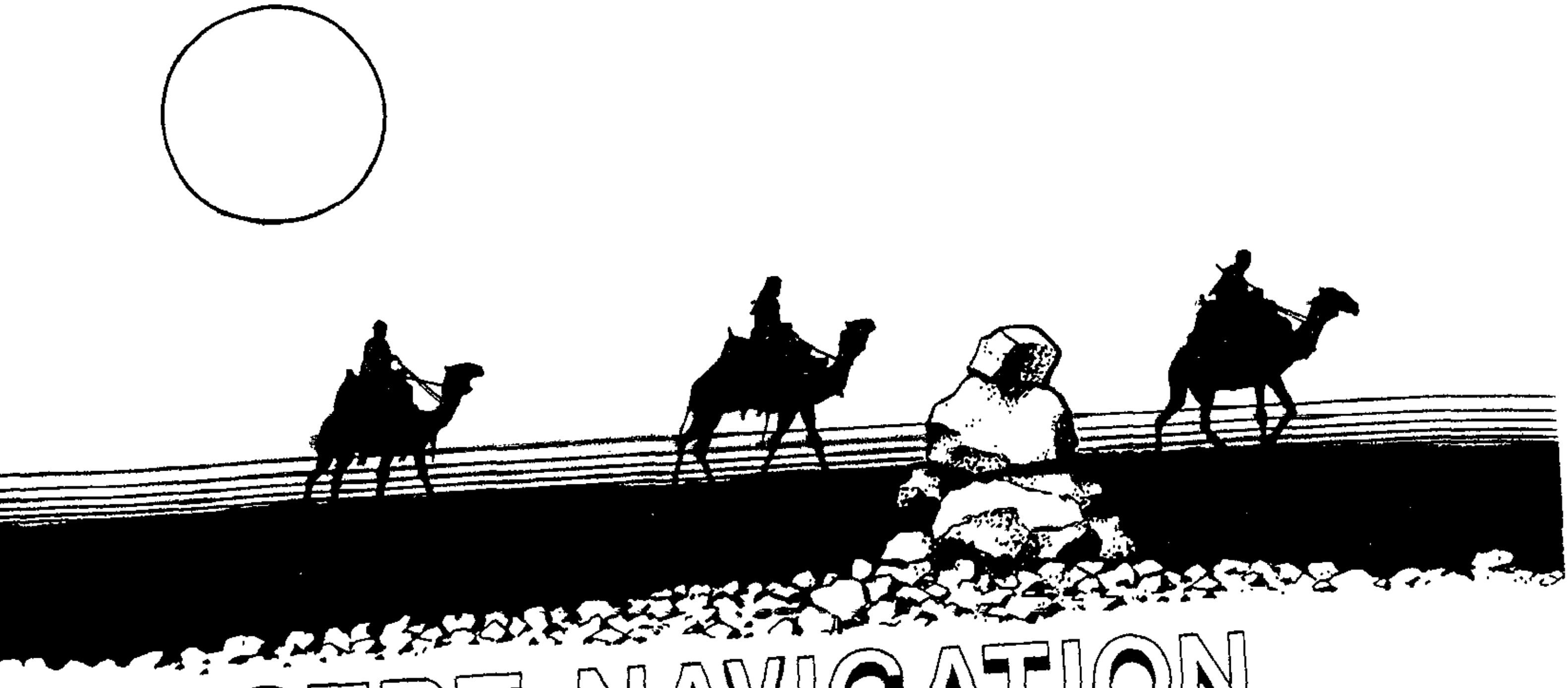


DESERT NAVIGATION

MAJOR RICHARD G. REYNOLDS

Over the past few years, there has been a great deal of discussion in United States military circles concerning strategic mobility and the Middle East. Although plans have been made that show how U.S. forces can be moved to that region, little has been said about tactical mobility or the complexities of movement that will confront a unit once it gets there. (See the three-part desert series in INFANTRY, July-August 1981, pages 16-20; September-October 1981, pages 27-32; and November-December 1981, pages 22-27.)

The Arabs have a word (*ma mah*) that describes a land in which one wanders from the right road. In modern warfare, however, tactical mobility implies staying *on* the "right road." That may not be easy in the Arab world, because to a U.S. soldier that world remains largely unknown.

In the past, regional exercises for U.S. forces were held near major cities and facilities, but conducting such exercises differs greatly from undertaking tactical operations across the extensive land masses of the Middle East or North Africa. And despite the training of the kind that is conducted at such places as the National Training Center, Dugway Proving Ground, Fort Bliss, and Yakima Firing Center, most U.S. soldiers have never been exposed to a desert at all, much less to one as large and diverse as those in the Arab world.

Before your unit undertakes any kind of operation in that region, there are several things that you need to know about it and about how to stay on "the right road."

First, the region is large. The Sahara (*sahara* is the Arab word for desert) measures 3,200 miles from north to south. The land area of this desert alone is between 3.25 and 3.5 million square miles (or 90 to 95 percent of the size of our 50 states). When the deserts of the Arabian peninsula and Iran (more than 2 million square miles) are added, the area of desert terrain totals nearly 5.5 million square miles.

A traveler in this region often must cross expanses that are devoid of life, water, and fuel. The analogy that compares the desert to a sea has merit. Indeed, the Arab word *hawmah* can mean either high seas or an open area of sand, and population centers in the desert are described as either "ports" or "islands" on a vast parched sea.

In some areas there are few "ports," and missing a fuel or water point can prove fatal. In the two million square miles of the central Sahara, for example, there are virtually no paved roads and only a score of "islands." Although the expanse of desert makes the "islands" difficult to find, the environment makes finding them imperative.

One of the biggest problems in trying to navigate in the desert is that reliable maps are difficult to find. From the 9th to the 12th centuries, the Arabs were the cartographers of the world; then their pre-eminence declined. While great progress has been made recently in mapping the Arab world, for vast sections there are still no adequate military map products on a scale smaller than 1:500,000. The maps that are available are often geological or archaeological surveys (1:1,000,000 scale or larger), local planning documents compiled by development agencies or contractors, road maps put out by tire and oil companies, or tourist maps. Complete map coverage of some regions is available only in 1:1,000,000 or 1:500,000 scale.

The few maps that are available may be outdated, especially military maps. In the region, road-building and urbanization proceed much faster than the updating of the maps. The paved roads, with few exceptions, were all laid after World War II. And the principal roads of many countries date from the 1960-1970 period, while their military maps were surveyed decades earlier. Fortunately, though, the paving was often laid over tracks and, in some cases, over old Roman roads that had already been mapped. The King's Highway in Jordan, for instance, was in use before the days of the Biblical exodus but was not completely paved until 1955.

Another problem is that some of the roads that do appear on maps may not really exist. For example, the president of Algeria once gave his engineers a few supplies and a short time to build a road to the southern border through Tamanrasset. Given the restrictions, the engineers resorted to laying asphalt over an unprepared base of rocks, bushes, and sand dunes, then finally just sprayed oil or tar along the rest of the route. When the president flew overhead, he believed that the road existed, and so apparently did many map makers. Soon, virtually no physical evidence of the charade remained but the "paved" road is still clearly marked on numerous maps. Other roads that were completely destroyed during the French withdrawal from Africa also still appear on older maps.

There are problems even with U.S. operational maps of the area. For unknown technical (or political) reasons, many of these maps are mostly blank sheets that show a sharply defined "limit of mapping."

GRID SYSTEMS DIFFER

In addition, the grid system on some maps differs from the UTM (universal transverse mercator) grid system on U.S. maps. In many of the Middle East countries that were previously under British influence, for example, the Palestine grid system is used on the military maps. These maps, generally last surveyed during World War II or the following decade, are widely used, not only in the area of Palestine but also in Egypt and much of Arabia. And since they are commonly produced in either 1:100,000 or 1:500,000 scale, they do not mesh with standard U.S. maps.

The Palestine grid system uses three-digit zone designators that are read right and up. As a result, an eight-digit grid location is accurate only to 100 meters instead of 10 meters as it would be for a U.S. map. (Some of these British maps, however, do include tribal designations that can be useful.)

Military maps of North Africa are generally reprints of previous French surveys and are annotated in French and Arabic. They date from the French colonial period, and the most detailed ones were compiled at the time of the Algerian war. (Almost all maps of Algeria are considered classified by the current government.)

Some Tunisian maps from the French era were printed in segments and glued to a linen fabric to allow for easy and frequent folding. These maps tend to be inaccurate, though, because the linen has stretched or become deformed, and some segments may have been glued imprecisely or may even have become detached.

In North Africa, Michelin road maps are valuable because of their accurate depiction of current routes and also of well locations and water depths. (If you must use one of these wells, it is nice to know its depth so you can carry a rope of the appropriate length to draw water.)

Throughout the region, maps that depict the surface material (sand, lava, mudflat, or flintbeds) are generally more important than those that show the relief, because the surface material is usually the deciding factor in mobility. The exceptions are the mountain regions of Arabia, Persia, and the Atlas and Hoggar ranges in North Africa where relief considerations are most important. In those regions, the preferred maps are those that accurately depict current roads, tracks, and passes.

ORIENT MAP

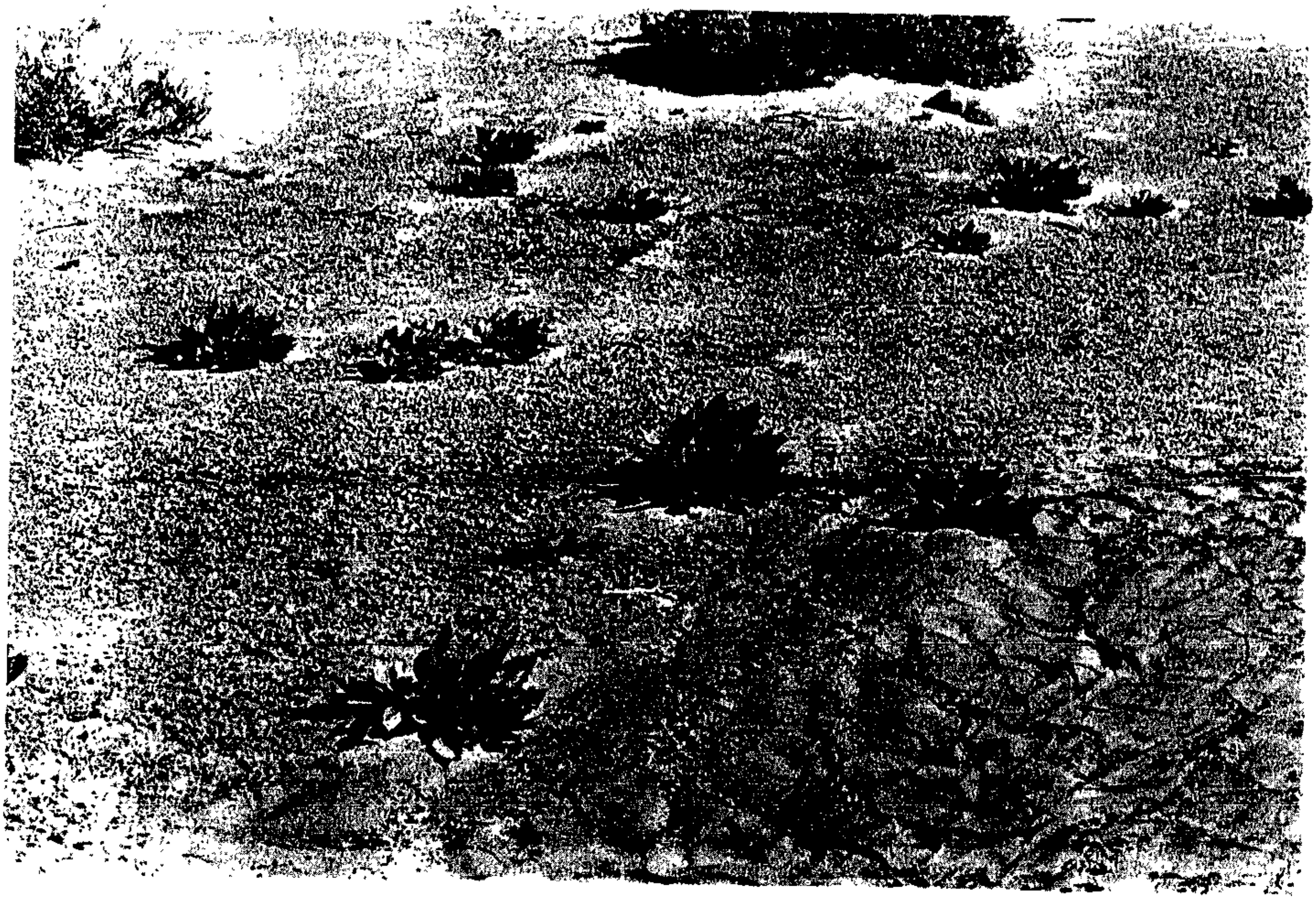
Once you have obtained the best available map, orienting it to the terrain can be a real challenge. Large areas of the region are virtually flat with no distinguishing manmade or natural terrain features, or even vegetation. Under these conditions, locating positions through intersection or resection is virtually impossible.

The map sheets for these areas are often nearly blank (except for the grid lines). They show no contour lines and are marked only with "indefinite wadis" (valleys or stream beds) that at first glance may not be apparent on the ground. The terrain is uniformly flat with no variations in elevation of more than a few inches. It may be half a day's journey to the nearest major terrain feature.

In such a situation, vegetation is the key to successful navigation. Few areas are totally devoid of plant life, although the plants may not be readily apparent. In fact, only dead plants may be detectable. In flat terrain, vegetation grows in depressions, even in shallow ones only inches lower than the surrounding area.

How, then, do you establish your unit's location? First, orient the map to north using a compass. Then choose a compass route that is perpendicular to any series of intermittent streams or indefinite wadis shown on the map. Follow the bearing until you encounter the first patch of vegetation. As you continue, compare measured distances between the bisected patches of vegetation until you are confident that you have identified a particular "indefinite wadi." Then travel parallel to it to a terminal point. You should now have located a known point on both the map and the terrain. Mark the spot and then verify it by traveling to another wadi terminal point. This technique will usually allow you to locate your position within a kilometer.

In a sand sea, however, this type of orientation is generally impossible. Although vegetation exists there, too, it grows



Desert vegetation.

without regard to elevation. In fact, it is more prevalent on the tops and sides of dunes than in the low areas. There are two reasons for this — the plants at the base are usually the first to be buried by the shifting sand, and the birds and camels responsible for dispersing the seeds tend to rest at the tops of the dunes where they can see better.

In North Africa, you will find tree lines that are visible from a distance, and these almost always correspond to an older principal road. The French planted millions of eucalyptus trees to shade their roads, which generally date back to the same era as the military maps. Thus, a road with trees or stumps along it is more likely to be the principal road shown on an older map than is a wider or newer route. In Arabia, however, roadside plantings (such as the one between Abu Dhabi and Al Ain) are windbreaks and therefore have several rows of trees, and shrubs as well, instead of the single row of trees common in North Africa.

Navigating is difficult on a mudflat (or *qa*) because of its total lack of terrain features, vegetation, or relief. Sometimes, though, it is useful to know the distance to the visible horizon. This distance varies with the height of the observer, and it is easy to compute. Standing on the surface, you can find the distance to the horizon in nautical miles by multiplying your height in feet by 3/2 and taking the square root of the product. If you are six feet tall, for example—6 times 3 = 18; 18 divided by 2 equals 9; and the square root of 9 is 3. The distance to the horizon, then, is 3 nautical miles.

Since a nautical mile equals 1.852 kilometers, a man of average height standing on a mudflat can see about 5.5 kilometers. By standing on the roof of most commercial four-wheel drive vehicles, he can extend this range of observation to between 7 and 8 kilometers. (Observing from this greater height will also help defeat the effects of mirages.)

A simple sextant is useful in ascertaining locations in flat areas and may be necessary to find a given point in the sands. The alternative may be to travel a great distance to find some terrain features.

Satellite navigation systems (such as LORAN or NAVSTAR) or other specialized systems (such as the Litton point positioning system) are useful, but all such technical means require considerable support and training and their effectiveness is easily reduced by the harsh desert environment.

Even in the sands, though, you may be able to orient yourself generally without constantly referring to a map and compass. Sand dunes are like large wind-generated waves, with a gentle tail on the windward side and a steep pitch to the summit on the leeward side, and they tend to form into long "mountain ranges" or a series of horseshoe-shaped crescents. Between the ranges are troughs or valleys that usually run at right angles to the prevailing winds. A compass check will allow you to orient the ranges and the valleys. In some of the large sand sea areas, such as the Empty Quarter in Saudi Arabia, the ranges are often scores of miles long, and the distance between the crests and the valleys is fairly uniform. Once you have determined the interval, you can count crests to compute travel distances when bisecting the ranges. In sand, this method is generally more accurate than odometer readings.

In the absence of identifiable terrain features, the bedouin people can generally give you the bearing toward Mecca, often with compass-like accuracy. (Their directions to other cities may be a little suspect.) They may not be able to orient you on the map and may not always be precise about directions and distances, but they can generally tell you the names of even distant wadis and mountains. (Sometimes, to prevent loss of face, a bedouin may give you a fabricated answer because he is unwilling to admit he doesn't know a direction or location. But he will also go great distances out of his way to guide you to your destination, or to a well or other known point.) And even a bedouin uses a guide to cross an unfamiliar area.

In addition, every mosque has a surveyed *mihrab*, a marker or niche that indicates the direction to Mecca. On hilltops, you will often find a *mihrab* marked with stones. Although the rock piles you sometimes see on hilltops are often grave markers, you may find a *mihrab* among the graves. The farther these markers are from Mecca, the less precise they are, but they are always a useful navigational indicator.

Maps are often marked with existing trails or tracks that can be useful. These may be traditional routes such as the frankincense trail, which dates back thousands of years, or they may be Roman roads as found throughout North Africa, Palestine, and TransJordan.

Although these traditional routes and more recent ones are usually shown as a single line on maps, on the ground you may find scores or hundreds of vehicle tracks. Which is the correct one? Perhaps all of them. Desert travelers like to keep their distance from strangers, and vehicles traveling together often run abreast to avoid the dust. For these reasons, the tracks may fan out in a broad valley and then converge again into a single route when crossing into another valley or wadi. But you must constantly verify your location by any terrain features that may be around.

People die every year when they confidently follow a track that has bypassed the well or fuel point that was their destination. Vehicle tracks remain visible in some areas for scores of years, and routes to principal cities and oases are now crisscrossed with them. Although you will find these tracks useful at times, never follow them blindly.

Other phenomena that you may encounter are piles of stones that form what appears to be a chain of route markers, called *rujim*. These are not the product of someone who was mark-

Rujim **mark path across a basalt field.**

Desert track.

ing the way for a fellow traveler but of hundreds of years of religious or superstitious effort. As Arabs travel, they often make rock piles at every stop, perhaps to commemorate a prayer said, a meal eaten, or a night passed. Time and a multiplicity of travelers over common routes have thus produced what amounts to a series of route markers. Once again, though, do not follow them heedlessly, as the route may eventually cross sands or flats where there are no rocks, and the route markings will end.

Animal tracks are also unreliable in leading you to wells or springs. Wild animals mostly live off moisture in vegetation and avoid men and their built-up areas. And although camels are almost never wild, they can wander unsupervised scores of miles from their owner's tent or a water point. Besides, camel paths and their signs may be many years old and may lead you to a water point that has long since dried up.

Since the advent of water trucks, you may find goats and sheep many miles from wells or springs. Unlike camels, though, these animals are always accompanied by a usually unseen bedouin.

In much of the Middle East and the desert area of North Africa, the weather is fairly constant most times of the year, and this consistency can help you navigate. An invariable wind direction, for example, produces constant dune patterns that you can recognize and use. But such a wind can also cause problems with visibility.

In 1983, for example, the leader of the rugged Paris-Dakar rally drove for more than an hour in a direction opposite the correct course, and scores of other drivers followed him. Despite on-board compasses and other navigation aids, he was relying on "solar" orientation during mid-day in an area of perpetual wind-generated dust and haze.

Under this kind of obscurity, indistinct shadows conceal the sun's true position. Navigation is difficult because the wind-induced haze makes distant objects difficult to observe. In these conditions, intersection techniques may be of little value, or they may require long delays while you wait for a break or a clearing in the dust.

A sun compass is sometimes useful in navigation if you have one. Of course, since it depends on sunlight to produce a shadow, hazy or overcast skies can make its use impossible. And even under the best of conditions, you have to use it continuously after leaving a known start point and take careful notes as you go along, especially in the sands.

Airborne dust may obscure the sun and make readings from a sextant impossible, and oblique observation from aircraft or from mountains may be equally difficult. Because this condition is nearly always present in many desert areas, dead reckoning with a compass is often the only way to navigate.

Dust storms can be violent and can last for days. Such storms as a *khamaseen* (defined as a dry, dust-laden wind that supposedly lasts for 50 days) can create or move dunes, cover roads and tracks, and obscure terrain features.

In clear weather, mirages that may appear can also complicate navigation. Mirages are caused by sunlight reflecting off layers of air of varying densities. They can actually be mistaken for water on a *qa* in Arabia or a *chott* (a salt-crusted mudflat) in North Africa. Generally, however, mirages are a nuisance to navigation only because they hide or invert distant objects. They can also conceal the horizon and make a sextant less precise. Or they may cause you to deviate from your course to verify the location or appearance of terrain features. Mirages occur in all kinds of terrain and on very cold days.

Cold weather itself is a factor in navigation. (Many people do not realize that the desert can be cold because of the lack of cloud cover and the resultant solar heat loss.) One effect of cold weather is that cold days are usually clear, and the clarity and increased density of the air makes objects appear closer than they are. In these conditions, if you need accuracy, navigational measurement, as opposed to an estimate, is important.

Another misconception is that the desert is always dry. While there are areas of the world's deserts where it rains only once each generation, this is not the rule. Often deserts are deserts because the soil cannot retain the seasonal moisture that does fall. Some areas may be absolutely dry most of the time and literally inundated for brief periods.

Seasonal rains can seriously reduce trafficability in regions where the surface material is clay instead of sand or stone, and clay soil is common in much of the region. In rocky or mountainous territory, flash floods can fill wadis. The flooded areas then become obstacles to travel, and they can also affect land navigation by changing the wadis' features and washing out marked roads or tracks. Fog, which is common during winter months, can be disorienting in lava beds or on a mudflat.

Because of these various difficulties with weather, terrain, and maps, navigating in the desert is never easy. But it will help if the Army begins to emphasize the tactical navigation peculiarities of desert operations both in training and in the procurement of equipment.

To keep a cadre with the necessary expertise, the Army should continue to fund and encourage remote desert travel by foreign area officers. These officers can help explain to commanders the cultural, geographical, and climatological factors that make navigation in the region so difficult, but more effort is needed to convey their experience to the user level.

Action should be taken to institute practical desert navigation classes at the National Training Center and in the desert phase of the Ranger Course. Other schools of the U.S. Army Training and Doctrine Command should certainly address the issue by producing appropriate texts and visual materials.

Simplified sextants and sun compasses should be procured for the Active Army and Reserve Component units that are earmarked for wartime deployment to this region. Training on their use and on dead reckoning techniques should be emphasized for all soldiers in scout platoons, CEWI (combat electronic warfare and intelligence) units, reconnaissance units, aviation and cavalry squadrons, special operations forces, as well as armor and mechanized infantry unit leaders.

Efforts should be made to update and expand military map coverage of the region. Large scale maps of urban areas need special attention. Much of the data is available. And adequate maps must be produced for areas where there are none.

The deserts of the Middle East and North Africa are indeed large and intimidating, and present certain difficulties with navigating. While these difficulties should not be overemphasized, they should be treated with realistic respect because of the dangers that can result from failure to navigate accurately. Inescapably, since the desert areas of the world are increasing, we must recognize that these problems will not go away.

Hopefully, the information presented here will help U.S. soldiers if they should ever need to find the "right road" in the Middle East or North Africa.

Major Richard G. Reynolds is a foreign area officer who has lived and travelled extensively in the Arab world. He recently completed a tour as a Middle East analyst in Washington, D.C., and is now attending the Command and General Staff Course at Fort Leavenworth. He previously served as the Army training officer for the Military Assistance Program-Jordan and served tours with both the 3d and the 9th Infantry Divisions. He is a graduate of Brigham Young University and holds a master's degree from Boston University.