14th International Soil Conservation Organization Conference.
Water Management and Soil Conservation in Semi-Arid Environments. Marrakech, Morocco, May 14-19, 2006 (ISCO 2006).

Yardangs in the Um Al-Rimam depressions (N Kuwait)

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Abstract

This work reveals the existence of yardangs in Um Al-Rimam depression at northern Kuwait Bay. The high wind speed, the low erosional resistance to wind of most rocks, the dominantly of long-term unidirectional winds, topographic smooth surface of the two depressions, and lower density of vegetation are suitable conditions for yardang development in the area. The yardangs are developed in horizontal Tertiary calcretic and sandstone and flat Quaternary mud. Three main types of yardang have been identified; 28 rock yardangs formed Lower Fars Formation (lower to middle Miocene) and two in Ghar Formation (Oligocene to lower Miocene), and 11 yardangs developed in Quaternary deposits. There are two main depressions have been formed in the continental sediments of this area connected by neck area, both of them hosting muddy playas. Most of the yardangs occur on margin of the northern depression and on the neck area connecting between the two depressions. Their mean orientation NW (297^0) coincides with the prevalent direction of the strong local wind called *shamal*. The maximum length, width and height of the yardangs are 92, 53 and 7.5 m, respectively. The average length/width ratio is 1.5:1. Quartz, feldspar and carbonates are the abundant minerals within the surface sediments of the depression.

Author Keywords: Yardang; Playa; arid region; Um Al-Rimam depression; Kuwait

Introduction

Yardang is a Turkmen word (Hedin, 1903), now used in geomorphology for erosional landforms produced by wind action. Most yardangs occur in unidirectional regimes. In the geomorphological literature, yardang is generally used to designate elongate streamlined hills developed in different lithologies in numerous deserts of the world. The initial investigations of yardangs had a local character and were focused mainly on their description rather than on their genesis and sedimentological characteristics. The use of airborne imagery (i.e. aerial photographs and satellite images) gave rise to a significant advance for the study of yardang. These analyses have been complemented by laboratory experiments, field observations, and theoretical considerations. Although the Arabian Peninsula including Kuwait is a common arid environment where wind is the most active erosional process, depositional landforms attracted many researchers in comparison to

erosional landforms. The geological studies of erosional landforms in general and yardangs in particular in the region are rare if not absent. The principal aim of this work is to reveal the existence of a suite of yardangs associated with playas of the Um Al-Rimam depression.

Methods

To study the playa–yardang systems, a preliminary geomorphological map of the study area was produced by interpretation of aerial photos 1972 and 1992 of 1:33,000 and 1:29,000 scales respectively. In addition, digital aerial photos with 30 cm resolution were also used to produce geological and morphological maps of the pilot area. All the recognisable yardang-like morphologies were represented in this map. Subsequently, a detailed field survey of the area was carried out. All the mapped yardang morphologies were carefully checked and analysed in situ in order to gain information about their geometry, morphometry, and spatial relationship with other geomorphological and sedimentary features. Additionally, a detailed geomorphological map of the largest closed depressions was made in the field on a 1:25000 scale topographic map with contour intervals of 5 m. This map includes a precise representation of the playa terraces and the aeolian morphologies identified in the field. Combining the maps produced in the field and by stereoscopic analysis of the airborne imagery, a final geomorphological map was delineated on the 1:25000 topography. The grain size and carbonate content of several samples collected from terraces, yardang slopes, corridors, and playa bottoms were analysed in the laboratory. Morphological parameters (width, length, height, slope mesurments..) for 41 yardangs were measured within the two main playas of Um Al-Rimam depression. Sample locations were identified by GPS. Grain size and statistical parameters were analyzed using graphical method. Sampling was also extended to cover two yardangs in order to identify the mean grain size and statistical variations over yardang body. Carbonate percentages were measured and minerals were identified using XRD. Contour maps were also prepared for statistical parameters, minerals and carbonate variations in the depression.

Geology

The study area is located in the northern sector of the Kuwait Bay, northern Kuwait. It is situated 20 km to the southeast of Jahra City, forming part of a depression called Um Al-Rimam. The study area is about 81 km^2 and represents the largest depression in Kuwait. The area is located between 29^o $30^/$ and 29^o 35N and 47^o 42 and 47^o 46 . The yardangs are scarped within four main terraces in Tertiary and playa sediments. The playa–yardang systems are developed on Quaternary alluvial sediments (around 48 m a.s.l.), deeply entrenched on an exhumed structural platform. The subhorizontal topography of the platform is interrupted by two closed depressions of Um Al-Rimam. These closed basins show extremely flat bottoms and may have scarped or gentle margins. This platform (75 m a.s.l.) is composed of Tertiary sediments and extended from Jal Al-Zor (3 km) to the south covering the northern desert of Kuwait. The depression is elongated and preferentially orientated in the N–S direction. The flat bottoms of the two basins host playas, called *khabra* in the region.

The exhumed platform is composed of Oligo-Pleistocene continental sediments locally named as Kuwait Group. There are three main formations within Kuwait Group, namely: Ghar, Lower Fars and Dibdibba formations. The Lower Fars Formation (Middle Miocene) fossiliferous mudy sandstone and Ghar Formation (Oligocene-Lower Miocene) non fossiliferous calcretic sandstone were described by Milton (1965). Land surface of the study area is composed of clastic sediments locally known as the Dibdibba Formation. The Dibdibba Formation (Miocene to Pleistocene) is composed of sand and gravels with minor clay and gypsifereous sandy clay beds. Sand and gravel act as a low conductor for solar radiation which results in the increase of temperature of the top surface and the surrounding air.

Results and discussion

Up to 41 yardangs have been identified in the study area found in four main terraces. They can be grouped lithologically in three types. Twenty-eight yardangs are developed in calcreatic bedrock (rock yardangs) within Ghar Formation, two have been formed in consolidated sand stone of Lower Fars formation and eleven have been recognized in the unconsolidated alluvial deposits. The mean direction of the yardangs, N297W, coincides with the most frequent wind direction. There is consistent relationship between the orientation of the yardangs and the strike of the joints measured in four locations within the study area. The yardangs are more frequently developed on plateaus dissected by the drainage net with unidirectional winds. The gullies parallel to the wind direction are widened, whereas wind erosion tends to obliterate the gullies of the windward slopes. The terrace levels give evidence of several morpho-sedimentary episodes in the evolution of the playas. The relatively thick deposits of the playa terraces record periods of vertical aggradation.

The maximum length, width and height of the yardangs are 92, 53 and 7.5 m, respectively. The average length/width ratio is 1.5:1. The studied yardangs correspond to the meso- and mega-yardangs of Cooke et al. (1993) and to mega-yardangs following the terminology of Livingstone and Warren (1996).

The windward and leeward slopes of the yardangs have mean angles of 11° and 10°, respectively. The slopes generally show a stepped profile controlled by the horizontal bedding of the bedrock. The incline of the windward and leeward slope shows a progressive decline, but windward side is slightly steeper. Signs of undercutting at the foot of the slopes gentle, indicating that, at the present time, wind deflation and abrasion (sandblasting) exceeds sediment accumulation. However, the gypsiferous silts slope deposits locally show aeolian pits and flutes. The pits are small (2–5 cm) irregular, closed depressions, which commonly occur on steep slopes.

Length and width interrelationship is clearly illustrated within Figure 1. Variations in mineralogical, carbonates and statistical parameters is very limited in the depression, But a trend of statistical parameters variations in clearly observed on the yardang body.

Quartz, feldspar and carbonates are the abundant minerals within the surface sediments of the depression.

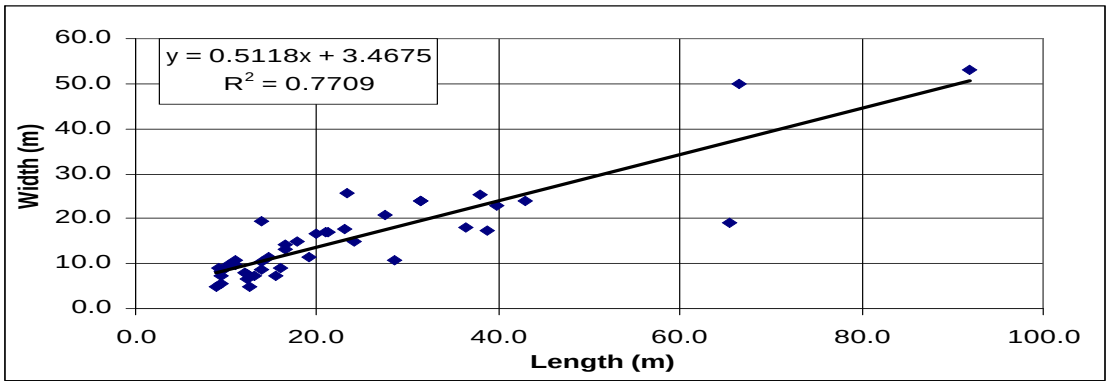

Figure 1. Width and length bivariate diagram.

Conclusions

The yardangs are developed in horizontal Tertiary calcretic and sandstone and flat Quaternary mud..They exist within 4 main terraces. There are two main depressions have been formed in the continental sediments of this area connected by neck area, both of them hosting muddy playas. Most of the yardangs occur on margin of the northern depression and on the neck area connecting between the two depressions. Their mean orientation NW (297^0) coincides with the prevalent direction of the strong local wind called *shamal*. The maximum length, width and height of the yardangs are 92, 53 and 7.5 m, respectively. The average length/width ratio is 1.5:1. The strong northwesterly wind and lower density of vegetation are suitable conditions for yardang development in the area. Three main types of yardang have been identified; 28 rock yardangs formed Lower Fars Formation (lower to middle Miocene) and two in Ghar Formation (Oligocene to lower Miocene), and 11 yardangs developed in Quaternary deposits. Yardang contour map illustrates larger mean grain size on the erosional resistant cap sediments in comparison to flanks.

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