Determining parameters and chronology of a sustainable water harvest system in desert oases – case study Qurayyah, NW Arabian Peninsula

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The ancient oasis Qurayyah, located in the northwest of the Arabian Peninsula, has been proven to be lacking a groundwater spring - the formation of a permanent settlement in Qurayyah was made possible by surface-water harvesting. Archaeological and interdisciplinary research in Qurayyah is a Saudi-Austrian Joint Project under the direction of Marta Luciani and Ahmad Abualhassan. We are grateful to the Director General of the Archaeological Researches and Studies (National Heritage Sector), Dr. Abdullah Al-Zahrani, and the entire Saudi Commission for Tourism and National Heritage (SCTH) for their unstinting and far-sighted support.

First numerical dating results from optically stimulated luminescence (OSL) dating of quartz confirm that the water-harvesting system was erected in a period characterized by changing climatic conditions from the Holocene climate optimum to the recent arid phase.

The dates suggest that this oasis was one of the earliest in the entire Arabian Peninsula to establish a water-harvesting and irrigation system encompassing several hundred hectares in extension.

The reconstructed irrigation system functioned as a flood irrigation system. Dams and canals were built to maximize the flooded area and at the same time to prevent catastrophic flooding under high discharge conditions.

In addition to the system's reconstruction, a new reverse engineering approach based on palaeobotany was developed for Qurayyah to reconstruct the climate conditions during the time of its operation and to verify its functionality.

The main water supply originates 2 km upstream of Qurayyah where a stone-built dam, area E, regulates the water of the Wadi Ghubai. The wadi sidearm of Wadi Ghubai splits in two before crossing the outer wall of the oasis through the Main inlet, area J, and at least one smaller inlet, area R. From there, the water is utilised for different purposes before the residual streams reunite in the field area in the north of the settlement, within the outer walls and exit the oasis through an outlet in the north, area F (Fig. 2).

From the main inlet (Fig. 2), the water flows through the field area. Here, the wadi was crossed by two types of structures, steps and low dams with water ducts on top (figure 1). The steps were used to reduce the velocity of the water flow as well as the erosive force of the water and thus to allow more time for the water to dwell in the field section before reaching the outlet. The low dams had the function of restrain the water to certain sections of shallow water basins and pools inside the wadi bed. The water canals and ducts, built on and around the dams, channelled the water from these shallow basins to the fields and flooded them. The basins also slowed the water down and increased the time the water needed to cross the field area, reducing its erosivity. The longitudinal structures were used to channel the water inside the wadi course and prevent the water from overflowing its banks in sections where areas were not meant to be flooded.

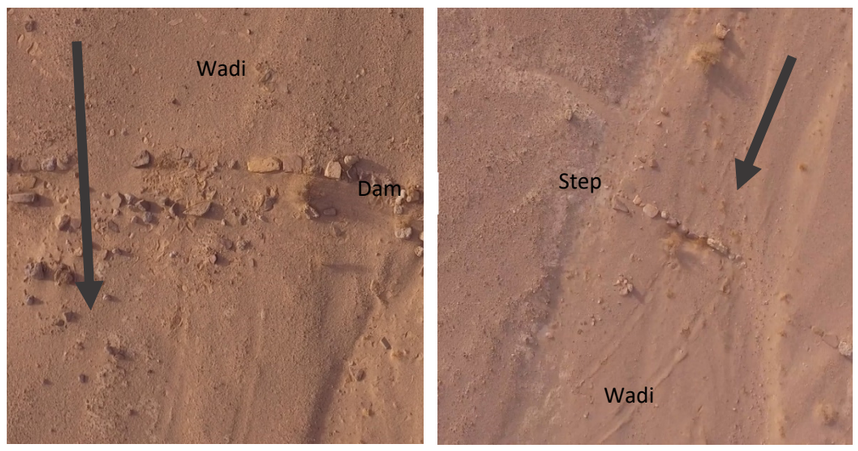

Figure 1: Left: Two lines of stones marks a dam with a water channel on top. Right: One line of stones is recognized as step

Figure 2 gives an overview of the water flow and system of Qurayyah, started at the dam in area E. Figure 1 shows the difference between the two types of cross structures. Figure 3 is a map of the northern field area, including the so-called roman site. All documented cross- and longitudinal stone constructions are included.

The next map stems from the related paper Living at the Wadi – Integrating Geomorphology and Archaeology at the Oasis of Qurayyah (NW Arabia) by Hüneburg et al. 2019 (full article https://doi.org/10.1080/17445647.2019.1576068). This map gives a geological and hydrological overview of Qurayyah.

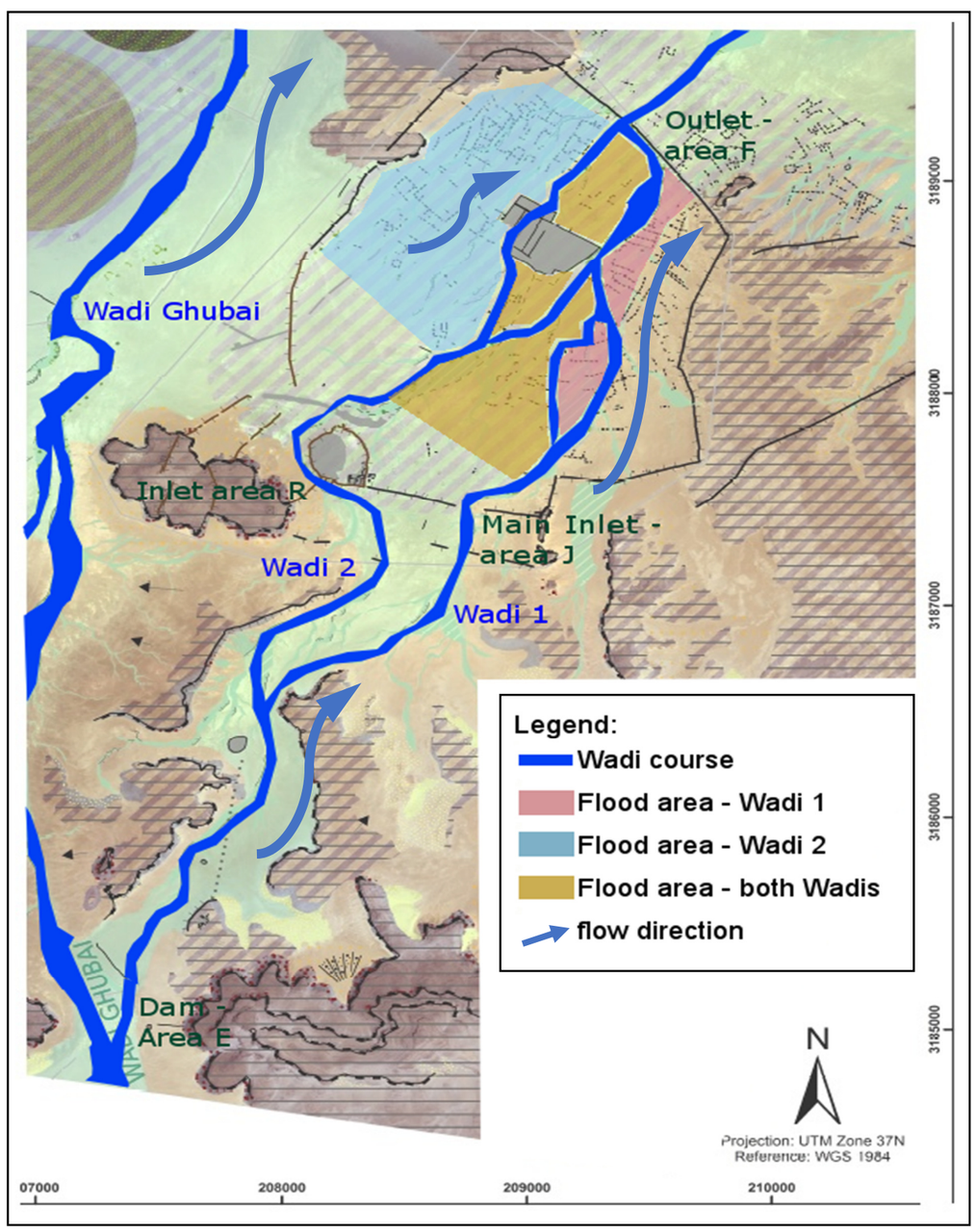

Figure 3: Overview of the water flow and system of Qurayyah, started at the dam in area E (Prochazka 2018)

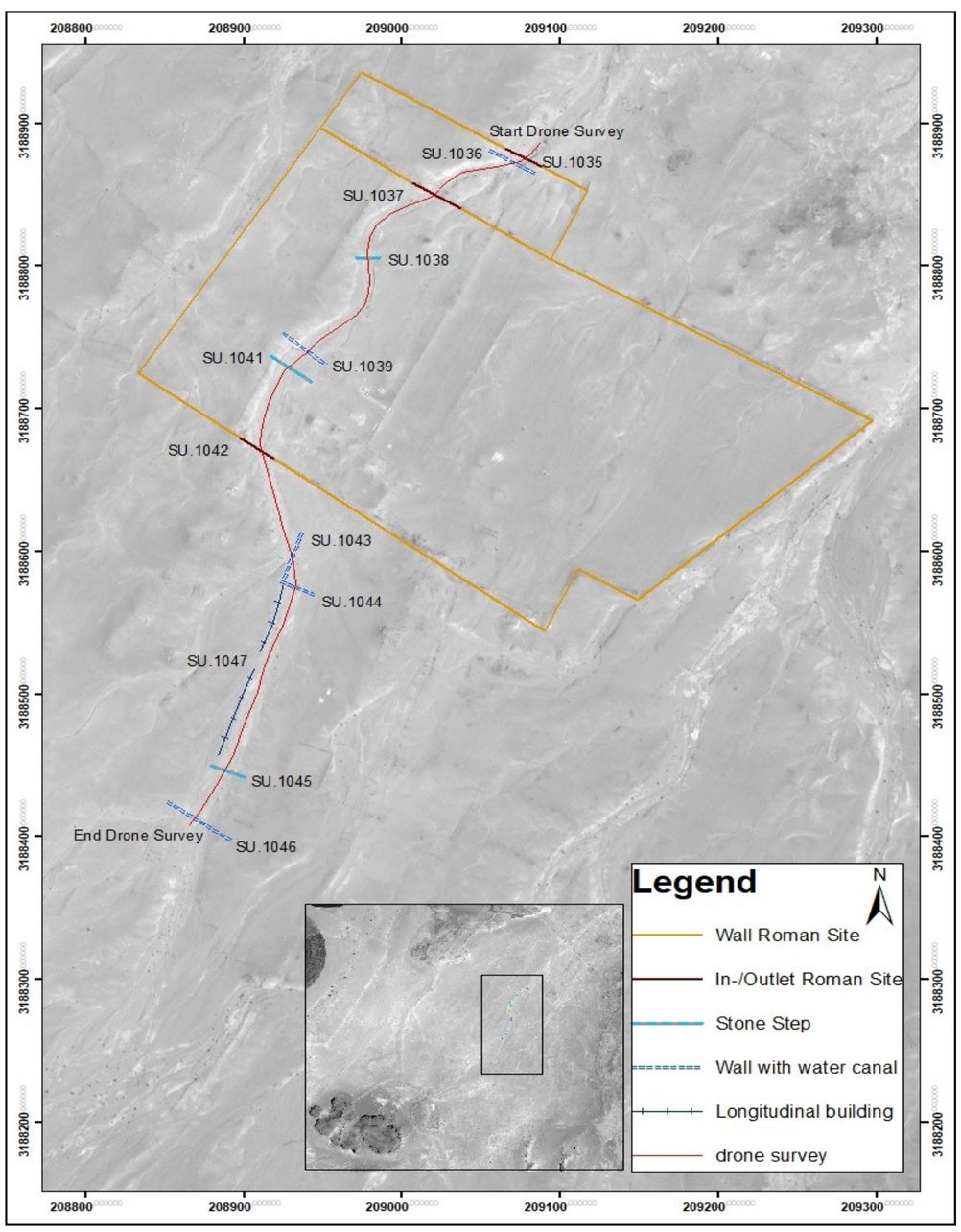

Figure 2: Map of the northern field area, area U, with the so-called roman site in the middle. All found cross and longitudinal buildings are marked (Prochazka 2018)

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Living at the Wadi - Integrating Geomorphology and Archaeology at the Oasis of Qurayyah (NW Arabia)

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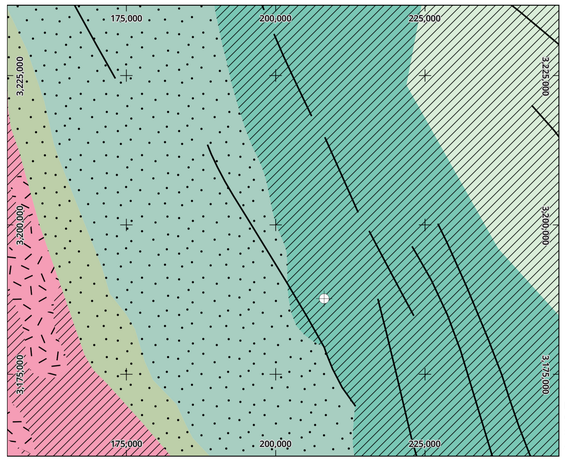
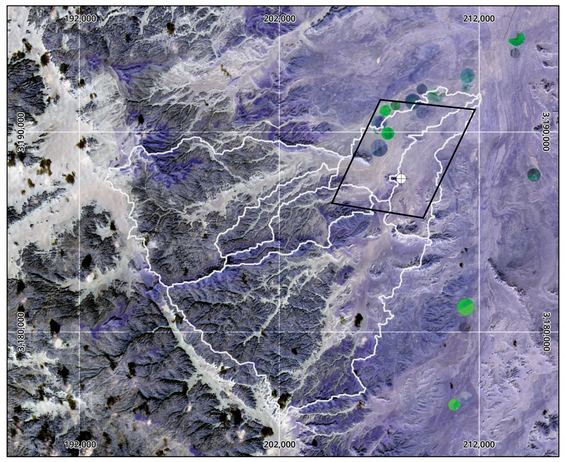




Geomorphological Map

Geomorphic structures

- plateau
- level plateau
- plateau remains
- talus cone
- aeolian
- sedimentary rock
- break of slope

Geomorphic processes

- denudation
- aeolian deposits
- alluvial deposits
- colluvial deposits
- vegetation
- sheetwash
- alluvial fan

Anthropogenic features

- high-standing stone wall
- high-standing mud-brick-and-stone wall
- low-standing short stone wall
- hydraulic linear features
- tower
- A standing architectual features (compare with text)
- productive installations (likely clay production)
- circular stone structures
- depressions (likely graves)

Hydrology

- river valley with aperiodic discharge
- braided palaeo run-off
- linear palaeo run-off
- A hydraulic features (cf. text)
- fracture spring

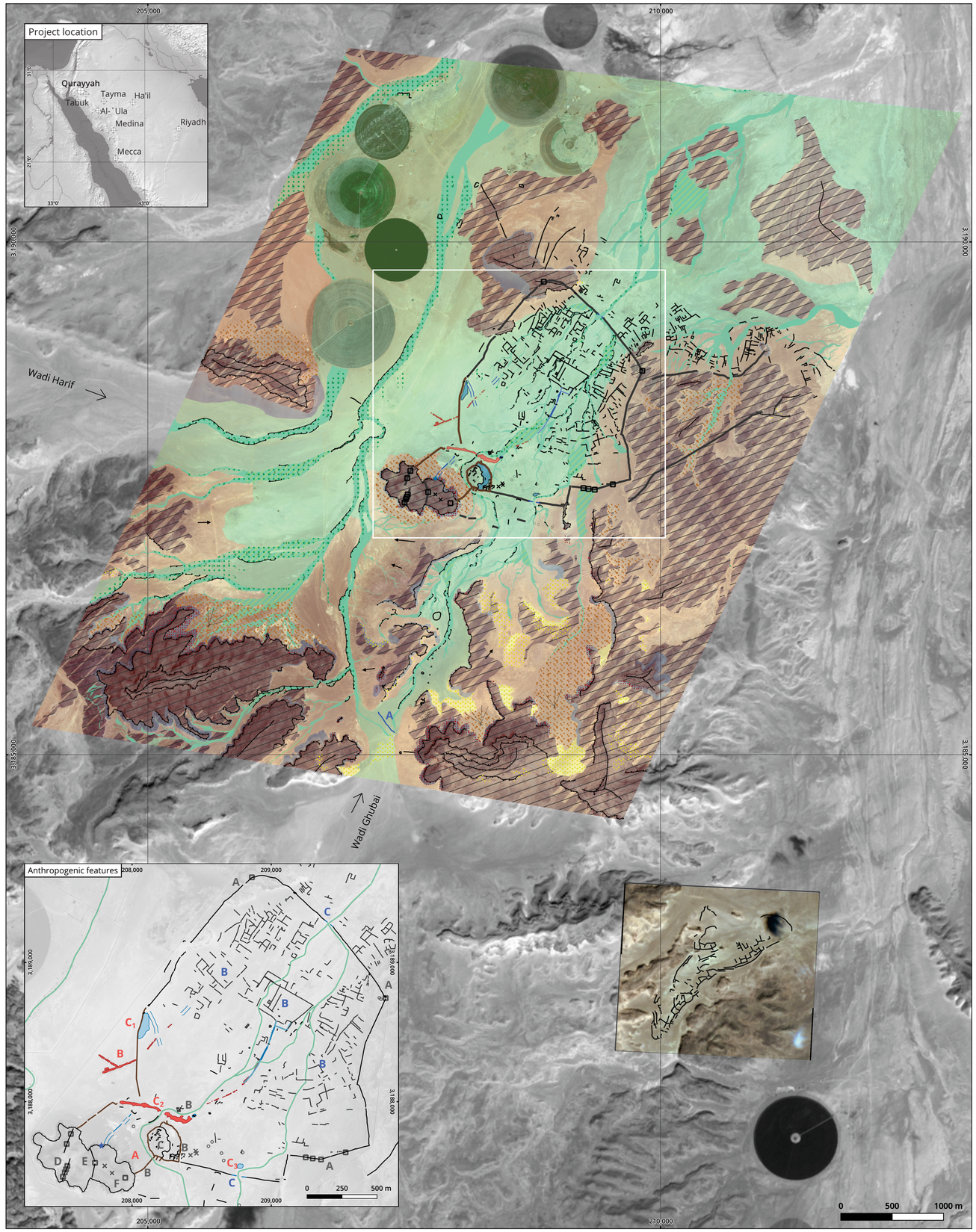
UTM 37N - WGS 1984

Basis of geomorphological map: satellite image from 15.09.2015, GEOEYE sensor, © Digital Globe, Inc. All Rights Reserved, georeferenced by Christiane Richter (HTW Dresden)

Map accuracy 20m (as determined by scale of digitalization)

Background map: Copernicus Seninel data (2015): "GS2A 20151125T08 1252 002220 N02.04" retrieved from https://scihub.copernicus.eu/dhus

Overview map based upom Natural Earth. Free vector and raster map data @ naturalearthdata.com



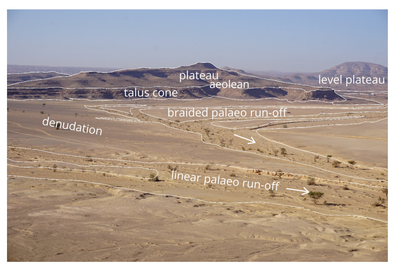


Figure 1 View to the west from the citadell hill, towards Wadi Harif that enters from the plateau of the Hisma Mountains to the transition zone where the landscape opens.

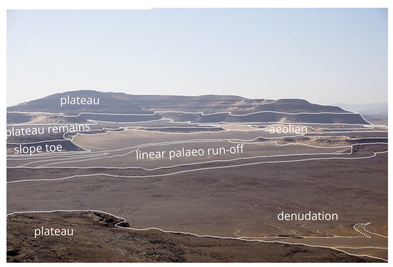


Figure 2 View to the south from the citadel hill, indicating the ensemble of denudational and aeolian areas dissected by linear palaeo-runoff.

Figure 3 View from the citadel hill to the north-west (compare with Figure 1). In the foreground the western escarpment of the citadel surface with surface drainage lines are visible.

Figure 4 The area of the fields in the northern extension of the site, with visible stone partition walls and canals (arrows), viewed from the NE corner of the city walls to the West.

Figure 5 a) View of the main wadi that runs through the archaeological site (arrow shows the flow direction). b) View to the wadi banks (arrow) that consist of gray substrate that show signs of hydromorphic mottling (oxidation-reduction) and that were used as agricultural fields.

Figure 6 View of the Wadi Ghubai before the confluence with Wadi Harif. The wadi walls are up to 4 m high. Note the white jeep for scale in the upper left corner.