Historical Water Springs in the Eastern Desert of Egypt: A geomorpho-archaeological Study

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HISTORICAL WATER SPRINGS IN THE EASTERN DESERT OF EGYPT: A GEOMORPHO-ARCHAEOLOGICAL STUDY

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Abstract

Water springs have a long history of human appreciation, providing accessible drinking water and shaping human settlements into green oases. They have also influenced cultural perceptions and hydrogeological studies. However, they have received little attention from geoarchaeologists. This study investigates the geological, geomorphological, and geoarchaeological attributes of ancient water springs in the Eastern Desert of Egypt, which were crucial to ancient human settlements and mining activities. This paper investigates the geoarchaeological record of springs in the Eastern Desert of Egypt, focusing on the Water Temple and Kanais Temple. Fieldwork, geoarchaeological analysis, and sediment testing help understand climate change and carbonate soil features. The Eastern Desert of Egypt, characterized by the Red Sea and Nile, is home to natural water springs and ancient settlements. To accurately predict seasonal spring water flow, local driving forces must be considered when applying a regional model. This research aims to identify historic water systems in Egypt's Eastern Desert and their location and mapping. It also examines the need for further research and exploration. Despite the dry desert landscape's challenges, most sites are easily identifiable during vegetation or rain.

Keywords: Springs; Water Temple; Kanais Temple; Eastern Desert; Egypt.

1. Introduction

Water springs form an intriguing landscape feature with a long history of human appreciation. Springs provide accessible drinking water in otherwise dry terrain, and the services stemming from springs helped to shape human settlements into green oases surrounded by deserts. Springs positioned along ancient trade routes provided the ability to resupply beyond the volume limits of canyons and poles. Springs continue to influence cultural perceptions, from the personified water nymphs in classical antiquity to the image of the spring, which has haunted historians of ancient Alexandria. Springs have also been studied from a hydrogeological perspective, and fossil springs and their associated deposits provide information on the past hydroclimate regime of a region (Stevens et al., 2021).

Despite the extensive interest in water springs on various levels, they have received scant attention from geoarchaeologists. The current study addresses this understudied landscape feature and aims to investigate the geological, geomorphological, and geoarchaeological attributes of ancient water springs within a largely undescribed landscape: the Eastern Desert of Egypt. Springs in this region, which bordered the western edge of the Nile Valley, were crucial to ancient human settlements, such as the quarrying and mining activities established in Egypt's gold-bearing Eastern Desert during antiquity (Pascual et al., 2024) (Fig.1).

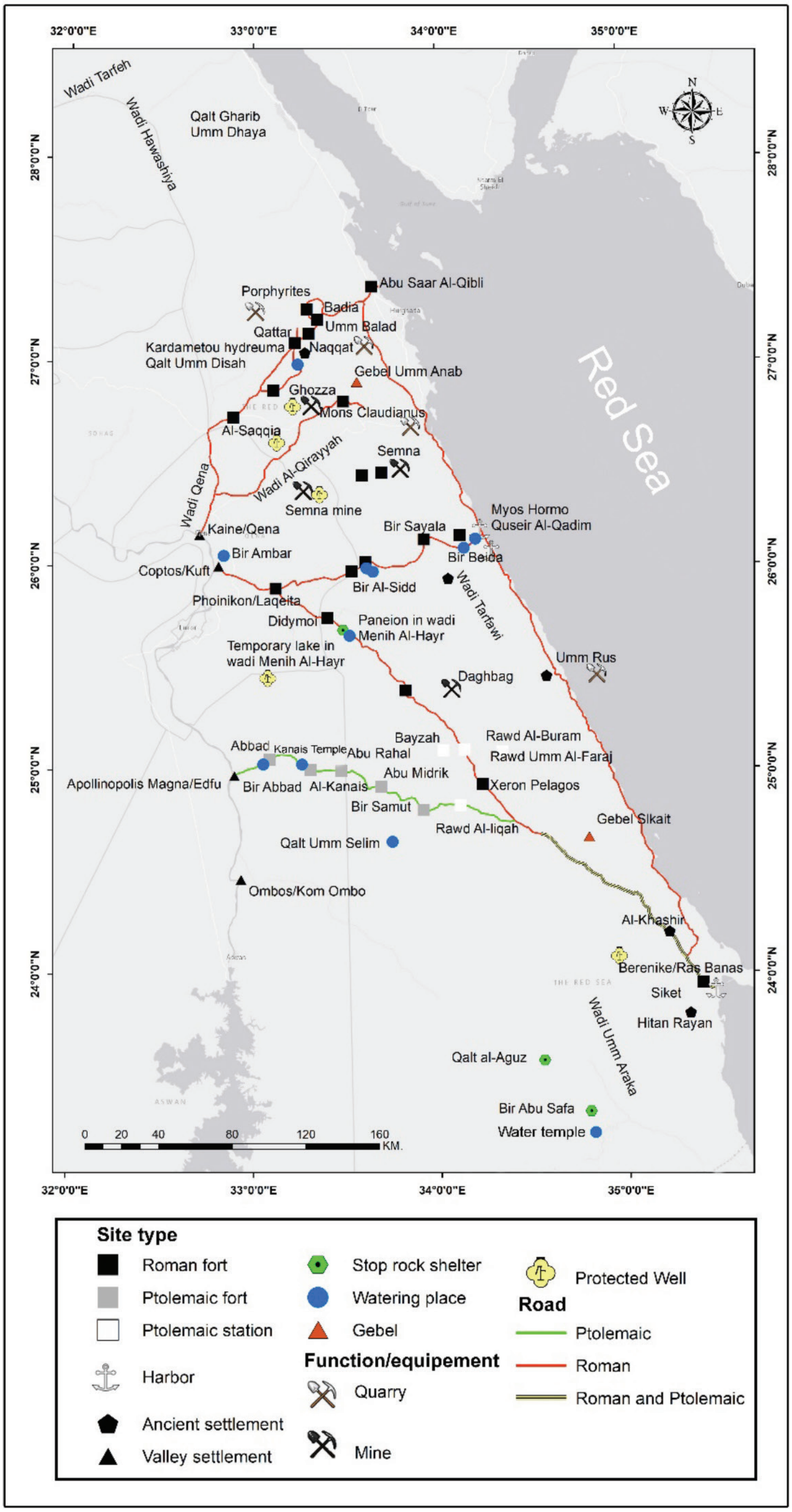

Fig.1: Location of major archaeological sites in the Eastern Desert
(After: Crepy & Redon, 2022)

1.1. Objectives

The objective of this paper is to better understand the geoarchaeological record of springs in the Eastern Desert of Egypt by a case study of the historical Water Temple at Bir Abu Safa north of Shalateen City and the Kanais Temple on the Edfu-Quseir Road. We conducted fieldwork to investigate the locale's archaeological and geomorphological record. We applied geoarchaeological analysis to learn more about the locale's individual evaporation–precipitation balance. We also tested local sediments and waters to understand how the climate has changed over the past few thousand years and to look at the landforms and timing of carbonate soil features.

Numerous historical water springs, alongside many other archaeological relics, remain a largely undescribed part of the Eastern Desert of Egypt's geoarchaeological record. There is a general agreement about the importance of ancient water springs in the Nile Valley as archaeological and geoarchaeological sites, where there is enormous potential to address important questions regarding landscape evolution, climate change, and human adaptations to arid environments. Despite the extensive interest in the more celebrated water springs of archaeologists and historians, little geoarchaeological attention has turned to the better preserved and less known springs, which are largely unaffected by disturbances and can provide a clearer view of the past.

Studying certain ancient water sources, like the water temple in Bir Abu Safa and the Kanais Temple on the Edfu-Quseir Road, shows how we can explore lesser-known ancient springs in an area that hasn't been studied much and is mostly unprotected.

1.2. Research question

The primary question of this research is, “Which historic water systems exist in the Eastern Desert of Egypt, and how might they be situated and mapped?” The thesis also explores the sub-research question, "What additional work, analyses, and explorations are necessary for these water systems and their preservation status?" The dry desert landscape presents challenges because it contains fewer archaeological sites, which are often larger in size, compared to other research regions. On the other hand, the majority of sites are easy to identify when there is vegetation or rain, according to her studies (Kinahan, 2022).

1.3. Methodology

The Eastern Desert of Egypt has a unique hydrogeomorphic setting that provided the necessary environmental conditions for the creation of natural water springs, around which various ancient settlements, trade routes, and roads were built. The location of this study area is characterized geographically by the Red Sea to the east and the Nile to the west, while it is bounded by the quaternary Nile fan deposits to the north and the older sedimentary and volcanic rocks to the south. To accurately convey the seasonal spring water flow, these local driving forces must be considered when applying a regional model on a large scale (Parks, 2016).

To clarify when and how these springs have formed, it is critical to apply the appropriate spatial and temporal scales in which the major climatic and hydrological processes influencing spring flow can be included. Because there aren't enough measurements from the N regimes in Egypt, we need to use a good method to estimate this water-related climate condition while still being able to model how the eastern desert's climate and land shape interact and affect water spring behavior.

Field data and satellite images were put together in a special database to create a clear timeline of natural changes in the desert over the last 90,000 years and to develop new ways to accurately reconstruct past climates. Currently, only basic sedimentological analysis is available for the Egyptian eastern desert. We aim to achieve this regional characterization by combining sedimentological and geomorphological data from extensive field campaigns.

1.4. Field Surveys

During the geomorphological survey of the Eastern Desert of Egypt, remote sensing work and subsequent field investigations revealed numerous water springs in the desert. The regions studied included the Wisad Water Springs region in southern Qena Governorate, located near the Red Sea coast in the southern part of the Eastern Desert, west of Hurghada city, east of the Nile Valley near Gabal Abu Rabeia close to Al-Minya, as well as several ancient water springs in the Red Sea Governorate.

These water springs created oases and scenic landscapes, which in turn led to the emergence of numerous attractive and diverse Typon Botanical Gardens that are unique for their biological diversity, educational value, research opportunities, and tourist significance. The study looked at the soil in areas with water springs, checking its distribution, color, texture, how well it dissolves, and the underlying rock layers, while also trying to understand what affects the flow of groundwater and the creation of oases (Parks, 2016).

We recorded the locations of water springs and their surrounding surfaces using a GPS device and plotted them on maps for easy reading and access. We conducted investigations into the physical conditions and general situation of the water spring, flora, and plant cover. We directly inspected the soil color, texture, the presence of soil salts and moisture, and the bedrock layer using hammers, chisels, and soil augers.

2. Geographical and geological setting

2.1. Geographical Context

The Eastern Desert of Egypt is a mountainous region characterized by a unique geological configuration made up of igneous and metamorphic rocks that formed before the Phanerozoic Era, which encircles the exceptional sedimentary deposits from the Phanerozoic Era (Parks, 2016).'

Geological and hydrogeological maps of the Eastern Desert show two types of aquifers: one is a confined aquifer system made of Nubian Sandstone, and the other is a non-confined shallow aquifer system found in the fractured metamorphic and igneous rocks. The Nubian aquifer system is one of the world's most significant groundwater supplies, covering an overall surface area of 2 million km² beneath Egypt, Sudan, Libya, and Chad. A few shallow springs and seeps feed the system. In contrast, the fractured rocks are a valuable aquifer that has been tapped for groundwater in numerous oases and in major cities (Hosseini et al., 2024).

The lack of groundwater exploration and the drainage of groundwater by the Nile River in the northern Egyptian Plateau have been impeding the establishment of a groundwater model for the Eastern Desert. However, the lack of sediment and gas deposits, combined with the use of surface data from airborne laser mapping, has made it possible to study how the land was shaped by older rock layers before the Quaternary period (Morgan et al., 2022).

The results showed that using a mix of remote sensing, terrain analysis, geological mapping, and field surveys helped us understand how the land has changed over time from 34 to 12 million years ago. We examined unique land shapes, patterns, and the connections between habitats created by large landforms near energy sources. The record of ancient environmental changes has immense geoarchaeological implications, but connectivity has been ill-defined (Khan et al., 2022).

2.2. Location and Topography

The Eastern Desert, located between the Nile Valley and the Red Sea, is approximately 600 km long and 100 km wide. It stretches from the northern latitude of 22°04′ to the southern latitude of 25°42′. The western boundary is marked by the Nile's cliff escarpment, while the eastern side is defined by the Red Sea coastline and the eastern mountains (Parks, 2016). A flat, sandy plateau characterizes the desert, covering almost half the area toward the Nile Valley. This region is flanked by the rugged Red Sea mountains to the east, where a narrow and jagged coastline with rocky shores and foothills bordering the Red Sea is found. Seasons in this area are roughly demarcated into a winter to April, characterized by cool to cold temperatures with average daily highs of 18–22°C, and a summer with higher temperatures, averaging 30–37°C daily. Rainfall is highly variable and negligible, with less than 10 mm per year falling mainly between October and May. Most of the land surface receives no rainfall at all (Abd El-Wahed et al., 2021).

Topographically, the region is classified into five units or subregions: the sandy plateau of the western desert, the Hamada gravel plateau, the Red Sea Mountain range and highlands, the rift valley, and the coastal area, including the deltas, cliffs, and beaches. The sandy region includes the Qasr and Qattara depressions, which yield salt and clay minerals. The Hamada plateau is generally flat-topped but has areas of sandstone mesas and quartzite. To the east, the Red Sea Mountains have the highest peaks in the desert, reaching 2500 masl, and contain a wide range of rock formations and landforms that control drainage and erosion. The Red Sea rift is an unstable block characterized by steep cliffs, grabens, rift valleys, and several offshore islands. The coastal region contains numerous caves, caverns, cliffs, and marine inlets (Khaleal et al., 2023).

2.3. Climate and Hydrology

Egypt is mostly desert and waterless, but it is far from being completely arid. Rainfall, occurring mainly between late autumn and early spring, is scarce and erratic over much of the country, apart from the area around Alexandria that gets over 200 mm of precipitation a year and the higher topography of the Red Sea Coast. The enormous volume of inflow from the Nile has made most of the Nile Valley and Delta fertile, enabling a population density above the world average. The Nubian Valley's population density is now the same as the Nile Valley's due to its adaptation to dry-land farming. However, even under the hostile climate of the desert, there are indications of past richness and population, as shown by fossil remains of lakes, rivers, or wetlands and relics of human activities. New areas of water-making potential have begun to receive considerable attention lately (Parks, 2016).

Both climatic and hydrological aspects are therefore noteworthy for understanding the conditions under which the ancient communities utilized the water springs in the desert. The eastern desert climate is semi-desert; covering localities with both fossils and remains, it has a higher average annual relative humidity (40%) and dust storm days (15 days) than other deserts, resulting in sporadic rainfall. There is a sharp seasonal and spatial distribution of rainfall; however, between years, it is highly erratic and sometimes dry—except at the Red Sea Coast, where a much higher total is received. Yet, most places except hot spots are dry, with a few cases of annual rainfall exceeding 100 mm. While the area is relatively less dry than other deserts so that ancient communities seeking fish and arable land still could pursue the Nile economy, the rainfall is insufficient to explain the growth of permanent communities. Also, compared to the now-abandoned non-Nile oases, the geology and climate have more places where living things and water can develop for the springs (Bagheri et al. 2021)

The phenomenon of desert springs has recently attracted attention from various viewpoints; however, no geoarchaeological investigation in relation to ancient human understanding of the springs has been conducted. Such investigation is significant not only for reconstructing the extinction of the springs and prehistoric topography but also for assessing the relative relevance of ensuing lands and scenes. It may show how these were built from ancient to modern times and how each layer was formed differently.

3. Historical Significance of Water Springs

The historical significance of the water springs on the eastern edge of the Egyptian desert is linked to modern and historical hydrogeological investigations of the Nubian aquifer system. The Nubian aquifer system takes its name from the southern part of ancient Egypt, where the thickest sedimentary deposits accumulated. Even though the Nubian aquifer system is found in other countries, it is often described as sediments less than 3 million years old that are trapped in a basin stretching from Libya to the Nile Valley, which were key areas for the ancient Egyptian civilization. These studies led to many groundwater models that are now used to assess water resources based on water flow, climate, and engineering factors (Parks, 2016).

The findings are of significance for understanding Pleistocene lakes in the Kharga and Dakhla basins that modified the present arid settings of Southwest Egypt. However, the models used for these findings do not provide an accurate timeline globally, as they misinterpret the Upper and Middle Pleistocene shores and lakes. Additionally, the areas around these lakes were connected to underground valleys near the limestone plateaus in the eastern Sahara and the sand desert and, at one time, to the Mediterranean; this information should change how we view the geological and archaeological details of the eastern Sahara floods and, most importantly, how the Pleistocene lakes functioned and eventually dried up. These drainage systems directed the water flow east of the Nile, while the Pleistocene reactivation of the Nile Valley began at its western border. However, the original fates and conditions of many ancient Egyptian sites located in the eastern pastures are still unclear. The details about these lost lakes and water springs, along with memories of their overflow, are important for understanding the situation, even if it means changing the models used for the western side of the Nile Valley to better match the actual conditions of the ancient Egyptian settlements (El-Asmar, 2023) (Fig. 2).

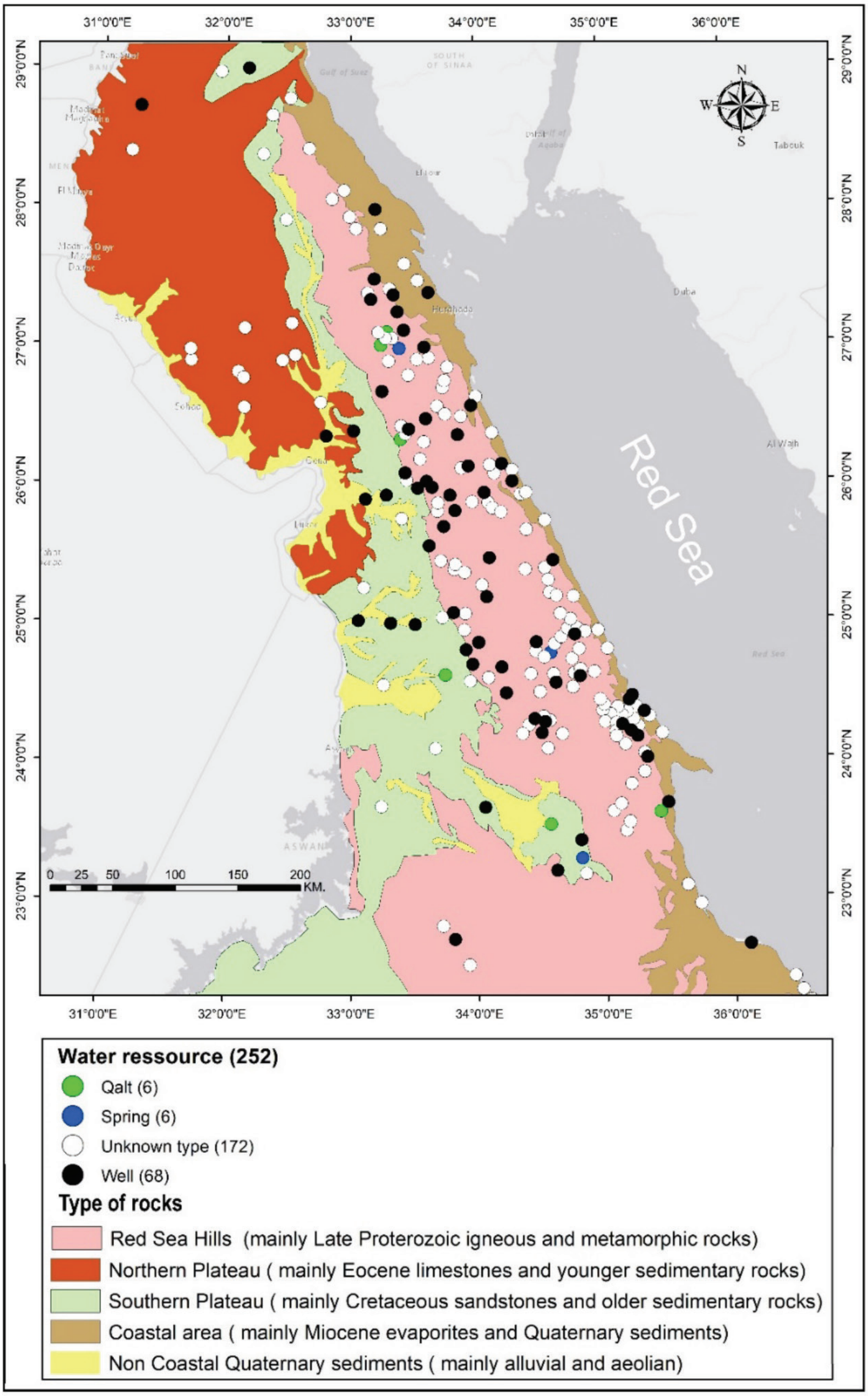

Fig.2: Water resources in the Eastern desert of Egypt

5. Geoarchaeological Framework

The geological setting of the water springs is associated with the trough system of the Eastern Desert of Egypt, which contains Cambrian to Oligocene bedrock formations that have experienced several tectonic events. Tertiary and Quaternary sediments exposed in several basins influence the sedimentary regime, leading to a noticeable topographic difference. The Nubian aquifer system primarily influences the present-day hydrological regime within this relatively tectonically stable region (Parks, 2016). The Nubian aquifer system primarily influences the present-day hydrological regime, including water springs that existed in the past. The key factors include how sediment built up in the basin, movements in the Earth's crust during the Holocene that caused the land to rise and sink, the climate conditions during the late Pleistocene, and the very dry conditions that affected the local water supply during the early Holocene due to climate changes in the middle to late Holocene. The group of springs known as Elsawwan Springs is located in the plateau area of Jabel Elba Bahari, and it consists of newer layers of Tertiary to Pleistocene sediments along with rock formations made of limestone and sandstone mixed with different types of sand, gravel, cobbles, and pebbles. The water springs are located in the coastal plateau area, where the land has shifted due to tectonic activity, creating faults that help control the direction of the underground water flow.

Understanding the interplay between hydrological processes and geological formations is crucial to evaluating the significance of these historical water springs in the Eastern Desert.

5.1. Paleoenvironmental Reconstruction

Understanding the springs, how they connect with the old shorelines, river systems, and land features is key to choosing specific areas for detailed airborne LIDAR surveys. For this reason, first, an overview of the history of the springs in the Eastern Desert is given, especially focusing on the pre-YD or early Holocene springs that developed before the major climatic abruption 12,800 years ago. This overview covers the thermodynamics of springs, the reasoning behind their locations, and the context of paleolake development. Additionally, we regard the impact of recent anthropogenic changes as a significant alteration in the functional aspects of the springs. We discuss the wadi systems on a smaller scale, emphasizing their importance in the movement of freshwater and alluvial sediments. On the much larger scale, geomorphology and geology are included, as those give the broader context in which the springs and wadis developed.

Gaining an understanding of the springs in geologic time yielded insights into the conditions necessary for spring development in the region, as well as the timing of the development of many springs. All springs in the present climate are situated on top of a clayey sediment layer, which directs shallow groundwater flow toward the surface. The springs were certainly still active during the last glacial maximum, when the groundwater recharge area had moved further inland, and currently active springs were buried by aeolian sediments, rendering them unrecognizable. North of the present spring line, active springs developed after flooding water had penetrated the aquitard against less permeable geology. Springs continued to develop further north until approximately the time when hydrogeologically recent accessible Nile River water arrived south of Qurun, after which natural springs fell into disuse.

6. Case Studies

We selected two case studies for analysis, of historical water sources identified by researchers, the first is the water temple in Bir Abu Safa, and the second is the Kanais Temple, also known as Paneion or El-Kanayis, located on the Qeft road. We sought water spring, statuary, and quarry sites and cross-referenced them with previous findings.

After selecting the sites, we wrote an overview of the case study and summarized all available archival information. We gathered all available archival photographs. This document included the case study references, the lowest level of processing, and the existing archives. These documents served as crucial sources for understanding the hydrological patterns and usage of water springs throughout history. The analysis highlighted key archaeological findings and gave an explanation for the socio-economic impacts of these water resources on ancient settlements.

The Eastern Desert of Egypt has a rich history of water supply springs and sustainable water management systems. We used map data from GIS at regional scales to research four case study areas, noting the acquisition years and sources related to water resources and land management. In this research, springs are defined as surface water bodies occurring naturally. As such, the systematic mapping of historic water springs in geocoded maps, archaeological site reports, and gazetteers is the main focus of this research. We attempt to map the systemic distribution and localization of historic quarries in the Eastern Desert of Egypt in relation to historic water springs. The research also aims to map archaeological sites and topographic features and identify springs, reservoirs, and the land cover of the Eastern Desert of Egypt.

6.1. Water Temple

The ancient water temple was constructed with corridors that run from the mountain to the lowland, positioned in front of large rock basins. Moreover, this site features various types of inscriptions from three different periods that possess archaeological significance and a high historical value. Quarrying and construction techniques indicate that this temple was built on more than one occasion. This temple is located in the Abu Safa Wadi, near the Eqat gold mine, about 80 km northwest of the modern town of Shalateen. The temple is situated just east of the wadi, on a rocky limestone plateau. A bit more than one hundred archeological and inscription features were documented during this survey, among which were two basins of oblong shape, built using large stones set in mortar. We also conducted an inspection of the three primary stone quarries southwest of the temple, characterized by their blood-red hue and extreme hardness (Fig. 3).

The site is in the southern part of Abu Safa Wadi, which is located about 530 km south of Hurghada, 466 km south of the port town of Safaga, and 583 km southeast of Qena. The site is located 2.5 km up the wadi from its mouth, near a small tributary valley that leads to a spring. The valley is about 250 m long and up to 35 m wide. Researchers have discovered the ruins of a temple and associated waterworks at its upstream end (Hosseini et al., 2024).

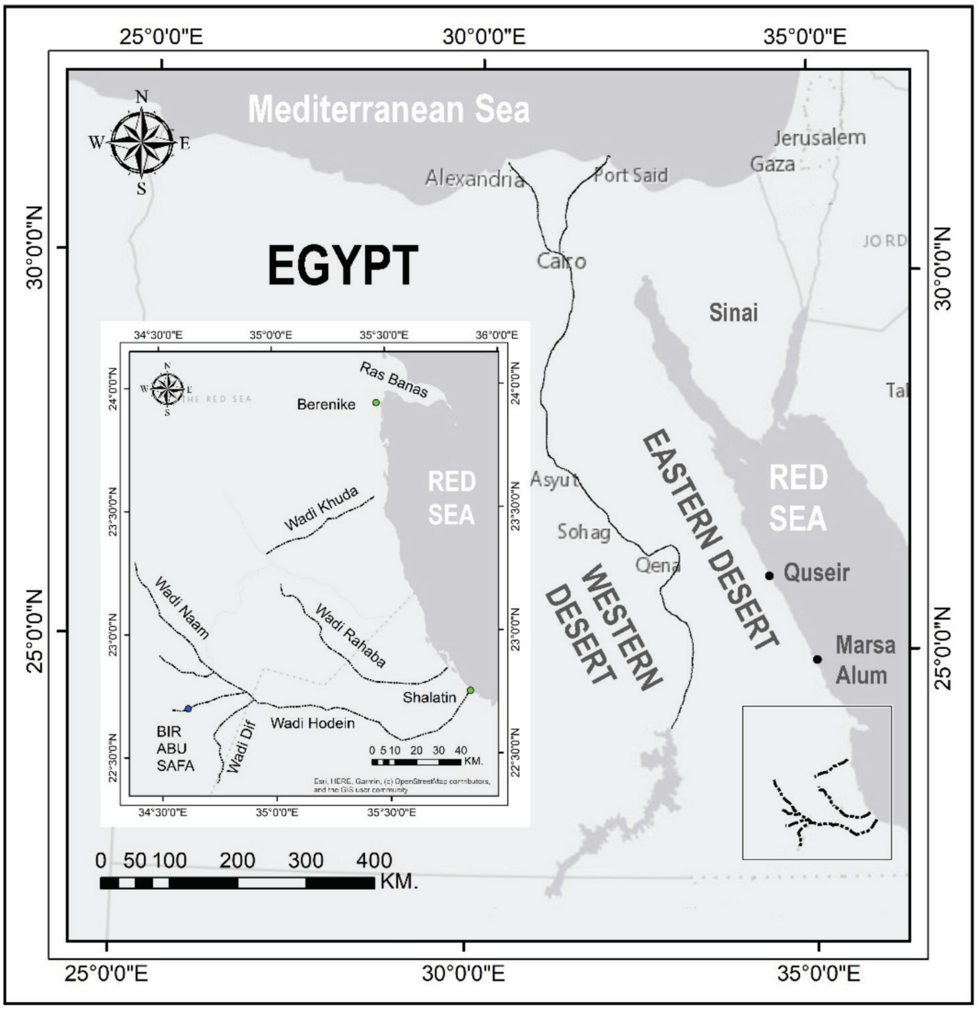

Fig.3: Location of the Water Temple in Bir Abu Safa

The Water Temple is located in the Eastern Desert of Egypt, Abu Safa Wadi, at latitude 25° 57' 15" N and longitude 32° 59' 10" E. The site is in the southern part of Abu Safa Wadi, which is located about 530 km south of Hurghada, 466 km south of the port town of Safaga, and 583 km southeast of Qena. The Water Temple is situated 2.5 km upstream from the mouth of the wadi, near a small tributary valley that leads to a spring. The valley is about 250 m long and up to 35 m wide. Researchers have discovered the ruins of a temple and associated waterworks at its upstream end (Hamed et al., 2024). The site is composed of a sandstone hill surrounded by an arid basin called the Wadi Abu Safa. In Egypt's Eastern Desert, there were five enormous water temples dedicated to the sun god Ra.

The monument is accessible to the courier from the Nile Valley via Abu Safa Wadi and other peripheral wadis in the region. You can reach the wadi from the Nile, via Nahas Wadi some distance to the south, or through smaller wadis elsewhere in the region. Reaching the temple site requires approximately three hours of travel by a four-wheel-drive vehicle. The entire route from the Nile Valley to the temple site lies inside the militarized zone, marked by a chain-link fence (Hassan & Masoud, 2015) (Fig. 4).

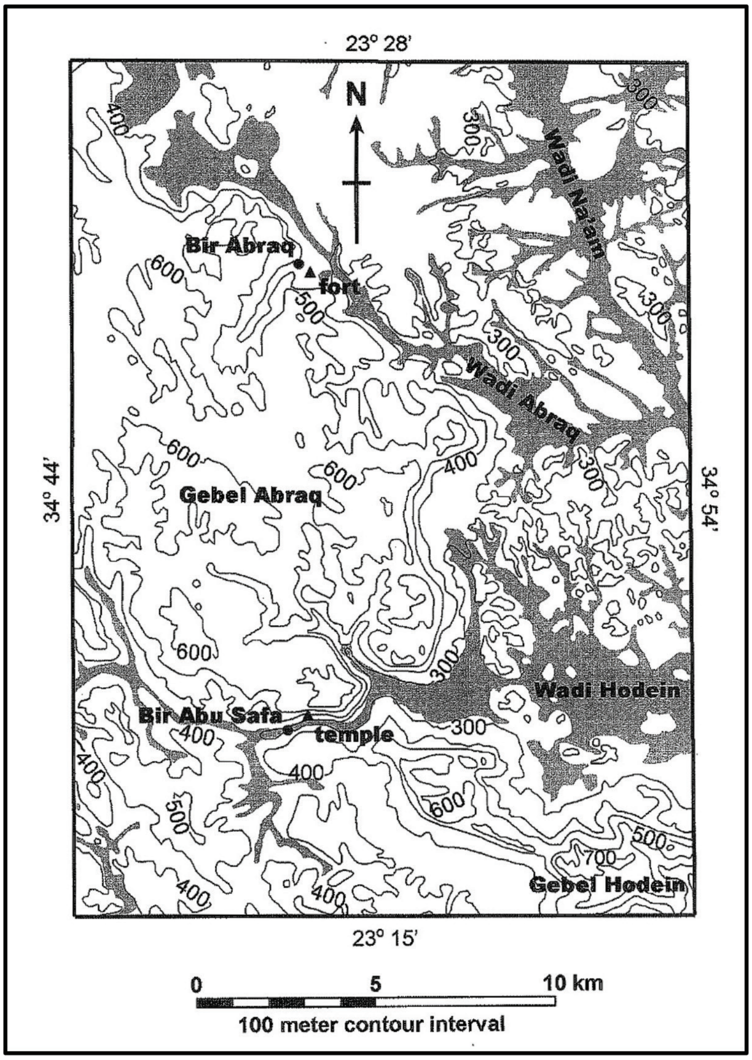

Fig.4: Location of Bir Abu Safa (After: Sidebotham et al., 2004).

The site boasts a variety of features, including a basin, a lengthy inscription, six block inscriptions, and a badly damaged offering area. Besides, the site has another basin built of white limestone masonry blocks with a curbed window, headless sphinxes, ritual pools, and an off-centered crevice were found here during its excavation. On the northern slope of the valley, quarries unearthed another pair of monolithic basins, adorned with a battle scene and sacred hieroglyphs. There is also a basin dating to the Ptolemaic or Roman periods with abstract hieroglyphic alphabet engravings. There is a water pool and two very dilapidated shrines on the bedrock of the valley. In the immediate vicinity of this temple, we found a number of ancient inscriptions and graffiti on the blocks, indicating quarrying.

We conducted a comprehensive study of the site by collecting original data, aiming to address the aforementioned challenges and questions. We conducted a field survey spanning a distance of 5 by 6 km. The collected data was processed and analyzed using GIS. We correlated these analyses with geo- and topographic factors to extract the essential parameters for the location prediction. In this study, we present a case that exemplifies a data-rich site. A group of water temples, built by the ancient Egyptians to extract water in the desert, can provide additional insights compared to other known temples. Unlike other temple distributions, this group disperses its temples across the entire area of climatic influence (Fig. 5).

Fig. 5: The entrance of The Water Temple

6.2. Kanais Temple

In 1991, archaeologists discovered the Temple of Kanais, also known as the Temple of Seti at Kanais, located in the Wadi Kanais, part of the Eastern Desert, on the road between Edfu and the Red Sea. It is specifically situated along the Edfu-Quseir Road, approximately 35 miles from Edfu. The temple is carved into a cliff face.

The eastern slope is salified, reworked, and shielded; the western slope is active, not channeled by older valleys, and without sediments. The temple is built to utilize the accessible bedrock and its protective overhang and to provide minimum infill working for the portico below the altar and the naos. The temple's outline follows the unusual contour of the exposed rock wall, with separate constructions of high and lower parts. Despite the availability of local construction materials, the temple did not use mud brick. The temple is architecturally a simple one; its main sanctuary consists of only one closed room. The temple has lost its original pyramidal roof over the inner sanctuary and its rear wall between a grand shaft and the highest point of the rock wall. All façades were damaged due to the quarrying of stone boulders during antiquity. Boulders, both large and small, at the western site and its vicinity clearly show extensive blockfall (Fig. 6).

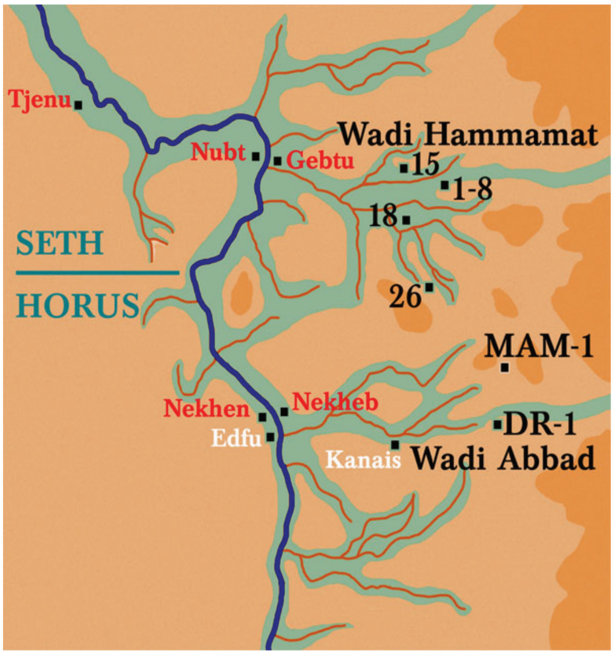

Fig.6: Location of Kanais Temple

One of the important features of Kanai's Temple is the preserved open-air basin for purification, which is deepened in boulders and can only very roughly be dated to the time of the temple's construction. Stones, debris, and earth now fill the basin. Its southern reentrant angle is being corroded by rainwater flowing during rare rain events. The basins backfill exhibits extremely low permeability to superficial grease and oils. A terraced and backfilled boulder structure fills up the space over the southern corner of the rear cliff and surrounds the back and east of the open-air basin. It seems to have represented a support for a large canopy, presently not otherwise recognized. There is no other basin like it in a rock-cut temple. Where designs of temple interiors are not well preserved, attention turns to alternative evidence, such as backfill constructions like those outlined above, for better understanding of architecture and iconography (Hassan & Masoud, 2015) (Fig. 7 & 8).

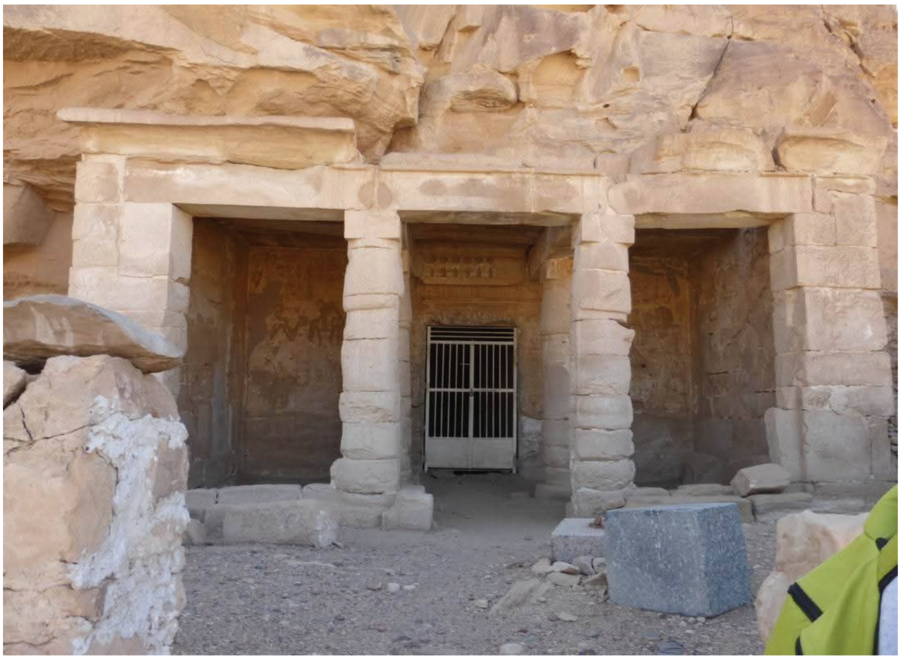

Fig.7: The entrance of Kanais Temple

Fig. 8: Water well (Bir) in Kanais Temple

6.2.1. Architectural Features

Water confronted its users with an elemental decision: it could be distributed within a built environment to support cultivation on the one hand or allowed to flow across an unmodified natural environment to support fishing on the other hand. Procedures for targeting water from, ejecting water into, or controlling water on the land parcel accompanied the invention of certain architectural forms. They embodied the decision, identity, and dignity of one settlement. What is more, these architectural forms continued to exert their power in the absence of their users (Hassan & Masoud, 2015).

Three Egyptian historians from the fourth century B.C. through the first century A.D. have bequeathed us vivid accounts of temples. The oldest is a Greek historian who claimed to have toured the temples of Egypt with a native priest. He compared the Egyptian temples to nothing he had seen elsewhere. The inscriptions overcrowded the vast and intricate temples, treating them as the gods' possessions. The priests took care of the images of the gods and their sacred grounds, particularly the bees in the temple of Edfu. Along with these tasks, priests enjoyed many privileges. Producing this itinerary required knowledge of the written words and accurate pronunciation. That was no easy task, for the signs afforded no clues whatsoever (Kurth, 2004).

Another historian went on to remark on the educational system, which dated back to the days of the gods. The training of priests took place in the temples. The priests underwent creation, learned to memorize untaught tales, and meticulously maintained their atomization. The priests prepared two temples and a culinary recess in the courtyard of the temples of philosopher priests, and everything was prepared with care. They had to fulfill their obligations to these temples, or else they risked facing retribution. Similar acts took place on the banks of the Nile. On an auspicious day, the priests of a temple would lead the pharaoh, the veil-headed icon of the god, and the ceremonial bark into the sacred lake. They were known for their music and dancing, and they prohibited animal sacrifices.

6.2.2. Cultural Importance

Temples must be considered as more than two-dimensional isolated structures. Their changing three-dimensional world must be considered alongside them. Sacred space incorporates not only the structural elements such as walls and pavements, roofs and floors, but also the organic and cultural elements of rock terrain, desert, flora, fauna, sky, sun, and moon, which together meld into an environmental cognition of the sacred. Enshrined sculpture, ceremonial furnishings, sacred vessels, and filtered light from doors, windows, and skylights cast their effects upon and engage the viewer's consciousness within a kaleidoscopic sense of place and space in time (Kurth, 2004).

Philosophically, the Egyptian temple must be addressed as a sacred structure whose components were designed in their universal relationships to meld together as texts containing cosmological and theological meaning. Studying the architectural components adorned by the ancient Egyptians reveals an evolving interpretation of the structure's originality. Like writing, architecture requires translation. Temples repeat a set of components that compose the architectural language of culture in varied and fluid assemblages. Therefore, each temple, despite its uniqueness, incorporates elements or symbols from the architectural alphabet that shapes its construction (Morgan et al., 2022).

As with language, an examination of the

components of architecture alone is insufficient to understand the cultural reality it expresses. We must view architecture in conjunction with the other cultural systems involved in its construction and representation. Likewise, individual structures speak of the cross-cultural relations and social processes necessary for their construction. Ephemeral structures, like temples, tombs, urban centers, palaces, and monuments, are also important components of cultural expression that deserve scholarly examination, although their archaeological remains are minimal or nonexistent. The shallow and transient nature of rock art may hinder cultural understanding of these sites, but such considerations do not minimize their significance as important forms of cultural expression. Their invisibility argues for a more concerted effort to bring them into view within the discipline of Egyptology. Moreover, it is important to widen cultural interpretations of Egyptian life and death beyond hereditary status to all levels of society to promote a better understanding of ancient Egypt's cosmopolitanism.

7. Results and Discussion

Two interrelated phenomena are studied in this work: 1) how geologic features of the Eastern Desert of Egypt influence the occurrence of historic water springs and 2) how these water springs are represented in historical literature. Using a geoarchaeological approach that includes studying landforms, remote sensing, and translating historical texts has allowed for a detailed examination of five different spring sites. We first discuss the correlation between landforms and the geologic context of these springs, then move on to discuss the orientation of their physical characteristics and human impacts on them. Next, we provide evidence for the second main phenomenon, which pertains to the description of these springs in historical literature, at a different scale.

The first category of results is the identification of geologic features at spring sites that relate to their position in the landscape. We correctly used digital elevation models to discover the springs and regional landforms. We successfully interpreted these landforms based on their dominant geologic processes and primary influence on water flow. Image processing illustrates and explains the general geologic context of spring occurrences. Differences in the springs link many landform features, demonstrating how landscape changes can impact the continuous flow of water. We evaluated the construction of the springs using natural materials, taking into account their visible physical features. Results show how human alterations have changed how the springs appear today, especially in terms of the imposition of walls and sluggish motion.

The second category of results is the identification and translation of ancient historical literature relating to the springs. Overlaying quality historical maps with spring interpretation leads to a geographical correlation between historical descriptions of springs and their locations. Petroglyphs that represent historical forms of the springs were also translated, with the results corroborating those from historical literature. Together, these independent results provide assurance of correctness in the identification of those springs. The ancient literature provides perspective on human perceptions of the springs, entirely absent from landform interpretations. Looking at the translations shows that people often felt nervous about getting close to the springs, saw them as having life-like qualities, and downplayed their social importance in favor of their geological, water-related, and beauty aspects. The literature explores the springs' role in solid time-space, memory, and myth.

7.1. Findings Overview

People often exploit water springs for various purposes, as they serve as a major source of fresh water. In desert areas, springs have been vital for the survival of early and present human communities. Water springs were essential sources for the settlement and development of many ancient communities and cities. Water springs have been a major concern for the geologists, especially in arid regions, to study the security and source of the water (Parks, 2016). Groundwater appears at the surface when water rises up from an aquifer when conditions are favorable because of local topographical structure(s) that force it to rise from the vertical water columns in the aquifers.

There are many water springs in the Eastern Desert of Egypt. Most of the widely known springs have been in use since Roman times; for instance, Al-Mansouriyah and Ain Danah are the most famous springs that provide surface water. The main aim of this research is to understand the origins of changes in the local climate and geomorphology affecting the water springs in the Eastern Desert of Egypt, particularly focusing on the spring water from Al-Mansouriyah, located in the governmental town of Ain Danah, as well as examining the hydrogeology and hydrochemistry of both springs.

The study looks at the geological setup and how it connects to the types of aquifers that can create springs in certain areas, and it also compares the surface and underground geology maps in the region. The geology was studied in four places in the eastern desert discussed in the above-mentioned heading, and an annotated lithostratigraphy table summarizing the usage of these rocks is included. Additionally, the study analyzed the area's structure using satellite and aerial photos to identify the lineaments. The hydrochemical study investigates the anthropogenic sources of water pollution in a small desert oasis and its effect on the quality of groundwater in that region. Environmental factors and industrial parameters serve as guidelines for assessing how anthropogenic sources of pollution affect the quality of water resources, including springs and wells, in Mersa Alam, Eastern Desert, Egypt (El-Bihery, 1993).

7.2. Interpretation of Results

This study looked at and explained the geoarchaeological and archaeobotanical analysis of the landscape with its springs, based on the different times people lived there and how the landscape changed over time. Each of the eighteen sites examined has been grouped according to its main spring or spring systems. The main spring systems, together with some neighboring spring systems, form a cluster. The sites are divided into the following clusters: (1) oasis-type springs; (2) Saharan-type spring systems; (3) public springs; (4) local springs focused on agricultural and garden activity; and (5) idyllic local springs. We follow the overview with a description of each cluster. Lastly, we offer some general conclusions to further rationalize the sites for future landscape studies.

(1) Oasis-type springs. Valleys and their sediment and moisture traps began their use for agriculture approximately 3,300 years ago, during a semi-arid period. At a later stage, not before the resumption of a humid climate, horticulture and gardening began in the nets of Holocene dunes south of the spring, boosting public development.

(2) Saharan-type spring systems. At 4000 BP, an extremely dry period began that lasted for over a millennium. This period brought with it the decline of agriculture, the dissolution of settlements, and the demise of the genius loci. About a millennium later, during a more humid period, habitation resumed. Spring systems, differing from pre-drought springs, arose in the neighborhood of some existing or resettled settlements or camping sites. They fostered sedentary life and short-lived local pastoral communities under harsh Saharan conditions. After a brief period, the springs and settlements once again faced abandonment.

(3) Public springs. During a humid phase, valleys were used. Flowing streams drained the channeled spring systems, which circulated water and sediments over large areas. The spring led to the establishment of a connected rim of public sites at the mouths of valleys and plains used for agricultural and watering activity. Eventually, people abandoned the rim.

(4) The local springs were primarily utilized for agriculture and gardening. Increasing aridity destabilized springs and led to the neotectonic disturbance of the water level. Steep-rimmed, tens of meters deep, wind-sculpted depressions emerged. Fresh or saline water surged discontinuously into troughs like seasonally drying ponds. After centuries of local detachment from the main public conduits of valleys, the settlement ceased to exist.

(5) Idyllic local springs. These are unique, thickly vegetated, widely used springs with upwelling water levels at eroded cliffs in arid or hyper-arid zones. They are scenic and vanishing waterholes maintained by dedicated elders for herding camels.

This paper highlights the results of a geoarchaeological study of water springs in the eastern desert of Egypt. These springs are a true desert phenomenon and a major enigma in the geographic, geomorphologic, and archaeological history of Egypt. The relatively sparse evidence of early prehistory forebodes an even more complicated history of interaction between the early inhabitants of Egypt and the desert basin. It is largely this relative sparseness of evidence that has led to the hypothesis of a brief occupation of the basin before the Sahara dried out. On the contrary, the manifestation of rock art of a wide variety and age, particularly during the green states, as some have argued, hints at significant and sustained interactions between hunter-gatherers of the basin and the Nile. In this regard, the rock art inscriptions are most likely excavated at sources of surface water, such as lakes and springs. On the fringes of both, hunting would have been aided by the convergence of game from surrounding arid areas.

The general consensus is that established geological and geographical frameworks relate to such phenomena. The concept of using springs as indicators of landscape evolution is an important one. As explained, a constant water source within a desert formed by springs is a local control on a landscape and subsequently affects its exploitation by early hominids. The presence of springs would create a vegetative swath along the watercourses in a desert, although dispersive clay-rich basins, such as the Qatia basin, also seem to have held permanent water. Water sources are not only highly important for the understanding of early human activity within the desert, as discussed above, but also for understanding the geologic evolution of both the Nile and the desert. (El-Bihery, 1993).

In the early desert and late Pleistocene periods, rainfall acted differently than it does today; large springs and lakes appeared because of higher groundwater pressure, changes in the water table, and the collapse of sand deposits. Continuous limestone plateaus and external drainage reflect the pre-desert-coring phases of this "inconstant" climate. These climates would have precluded major dune formation, although they would have limited fine sediment transport (Morgan et al., 2022).

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