Water Systems of Petra

Hannah Harrington

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Introduction

Water is one of the most valuable resources on the planet. Every human must consume water to survive. In a desert climate, finding an adequate water supply is the difference between life and death. For thousands of years civilizations in the desolate regions of the Near and Middle East have fought to control the water sources around them. These harsh conditions pushed these civilizations to engineer intricate water storage systems and pipelines to support their community's survival.

In the 1989 blockbuster, Indiana Jones and the Last Crusade, viewers are taken to the desert city of Petra. The movie highlights the ingenius feats of architecture of rock cut temples and dwellings. The thrilling scenes also feature the arid climate of the middle east's deserts. In its prime, Petra was a marvelous city, not only for its architecture but also for the lush green oasis it became. The city was a hotspot for trade due to its location situated near the Mediterranean, the Red Sea, Egypt, and Greece. By collecting rainwater and using springs, Petra became a glistening beacon of green in the tan, sandy desert.

Historical Periods

For much of the history of the middle east, humans traveled in bands, stopping from spring to spring to stop for water in their desert homes. Beginning in the Neolithic Period, between 8500 and 4500 BC, the nomadic bands settled in small communities (Shiqarat 2019, 43). The introduction of community farming into their lives created a larger need for consistent sources of water within their small communities. Agriculture consisted of goat herding and cereal farming. Farming for water also became a part of their daily lives. While the term may

bring up thoughts of Luke Skywalker on his small moisture farm in Star Wars, the need for water farming was just as real to the ancient Middle Eastern peoples. Archaeologists have discovered evidence of water systems in the Neolithic site at Beidha, Jordan from as early as 9,000 years ago (Shiqarat 2019, 43). Though these systems were basic compared to the later systems found in Petra, the spring water harvesting set the new settlers apart from their nomadic brethren.

The Bronze Age was a period in which the first cisterns began to be dug for reliable water storage. As the community became a regular practice in Petra, cisterns cut into the rock also became popular. Evidence has been found that shows rock cut cisterns were covered in a waterproof plaster to prevent leaking through the limestone walls (Shiqarat 2019, 3). The use of this plaster significantly extended the timeframe in which water could be stored. Also, during this time, vegetation and agricultural practices flourished in Jordan. The growth of plants helped prevent soil erosion common to the rocky and sandy valleys of the desert. This in turn helped slow water contamination. Barriers began being built to again prevent erosion but also to divert water during the flood season (Akasheh 2002, 222). During the winter months, copious amounts of rainfall sweep across the desert's rocky floor leading to flooding and erosion. By creating barriers, the communities were able to prevent destruction and give way to rainwater harvesting.

As civilization transitioned into the Iron Age, they were met with outsiders in the form of Alexander the Great and his armies. Alexander gave way to the blending of Greek culture with the cultures of the Middle East, creating what we now call Hellenistic cultures. A practice borrowed from the Greeks was a new system of enclosed cisterns (Shiqarat 2019, 4). These new cisterns were covered with long stone slabs held up with arches. Sometimes these roofed designs were used as walkways as many were constructed underground. The cisterns were also lined with the same waterproof plaster used during the Bronze Age.

The height of water system design and use came during the Nabataean and Roman periods. Pipelines and cisterns became an exact science and the water flowed freely throughout the city. The civilization that had been built by the former nomadic cultures blossomed into a garden oasis in the desert. Trade was a major factor in the growth of Petra. With connections to the Roman Empire through the Mediterranean, merchants and consumers would travel far and wide to reach the city (Bedal and Ramsey 2015, 621). The Roman occupation influenced the building of fountains and public baths. The splendor of the Roman Empire touched the star in the desert. This prosperity lasted until the Byzantine Empire came into power. Slowly earthquakes damaged the city and its great architecture and eventually the desert oasis was abandoned.

Major Innovations

As spoken of before, the city of Petra housed many feats of ingenious architecture and engineering. The most important of these feats were the many distinctive designs of cisterns. Bottle cisterns were the first widely used shape in the area (Shiqarat 2019, 47). These shapes were cut into limestone either on the side of cliffs or deep into the ground. They are called bottle cisterns due to their thin neck and wide base, a shape similar to any bottle seen today. These were covered in waterproof plaster that began to be used during the Bronze Age.

The next most popular shape was the enclosed cisterns introduced by the Greeks (Shiqarat 2019, 4). The covered design allowed for cleaner drinking water and sedimentation. Sedimentation is the process where as the water flows from one tank to the next slowly, the sediments contaminating the water separate and settle on the bottom (Balsom 2020). They are then caught by barriers so the water can continue flowing cleanly without extra sediments. The roofed systems feature archways and larger tank sizes. The coverage of the cisterns allowed the

drinking water to stay cleaner for longer. These cisterns were also cut out of the limestone underground.

Dams and terraces were another innovation that helped the collection and diversion of water. The limestone and sand surfaces of the valley create flash floods during the rainy winter season. Due to the location of Petra within the low valley, the rainwater flows quickly down from the high mountains and cliffs surrounding the city. By utilizing the wadi or ravine shape of the landscape, it was easy to transform the area into drains (Ortloff 2005, 103). The wadis were cut and softly slopped or terraced to slow the rush of the water and catch any sediment. Intricate channel systems were used to divert water to storage tanks or irrigation systems for later agricultural use. In modern Jordan, ideas were developed to begin restoring original dams and terraces while adding modern systems to control flooding in the valleys (Akasheh 2002, 222-223).

Pipelines were created later as another way to move water across the city. Pipe systems were used in Rome, Greece, Egypt and Mesopotamia. The technologies of other civilizations came into play when creating the Petra pipe systems, however, the citizens of Petra mastered their creation (Ortloff 2005, 94). The biggest challenge the designers faced was in making sure the water flow was stable enough to prevent breakage of piping or leaking. The pipes were most often made of handmade terracotta forms and cemented together at joints making the pipelines extremely fragile. Nabataeans mastered the exact volume and angle of water in order the control the movement most efficiently as found in pipe channels. The most well-preserved example of these pipelines is in the Wadi Mataha (Akasheh 2002 221).

Roman influence in the area brought innovation in a decorative way rather than a structural one. The Romans are famous for their baths and fountains found across their entire

empire. In the first century BC, a large Roman style bath was constructed at the Temenos gate of Petra. (Shiqarat 2019, 8). The main bath area was a circular pool spanning 5.12 meters in diameter and was topped with a large dome. The rooms were adorned with colorful plaster, stucco, and tile as seen in almost all Roman style baths. Water was sent through channels to fill both the baths and the sauna and warmed through a hypocaust system. The Romans also influenced the fountain construction within Petra (Shiqarat 2019, 5-6). The baths and pools within the city often consisted of a hydraulic system which can be seen in the market and pool complex (Bedal and Ramsey 2015, 623). The Nymphaeum was a large public fountain in a Roman style at the eastern end of the city (Shiqarat 2019, 6). It was adorned with statues of water nymphs and became a meeting place for many citizens and travelers alike. The reverence of water was a widespread practice before the settlement of the area began but it continued into Roman occupation. The use of fountains helped the citizens continue their veneration of water during their lifetime.

Both natural and manufactured waterfalls could be found throughout the valley region. These supplied the city with the calming sound of running water at all times. Whether for practical use or purely decoration, waterfalls were large and ornamental. Many featured arches for walkways and catchment basins below for water collection and use. The largest fabricated waterfall found within Petra stood around 20 meters high, falling into a system of basins and cisterns (Shiqarat 2019, 6-7). The water came from the northern end of the valley and supplied a constant water flow. It is important to look at the waterfall as another way to worship the water supply as grandeur created a negative impact to the water supply. A large waterfall was constructed inside the city's theater to boast about the many ways in which water was controlled

in the city. It is thought that the waterfall cascaded into a basin which then released into the theater to allow for water spectacles as seen in many Roman theaters.

Agriculture

Archaeobotanical investigations and papyri analysis have greatly improved the understanding of the diet and environment of Petra during its height. Scholars wrote that it was a garden city within the desert, but it was not fully known what the diet and lifestyle of the people was like. A project named the Petra Garden and Pool Complex has been under investigation since 1998 to study the flora remains of the city. Historians have also begun to study papyri that details legal affairs discussing agriculture and land usage which has helped narrow the understanding of daily life in Petra.

The Petra Garden and Pool Complex project is a multiyear excavation project within areas of Petra named the Upper Market, Lower Market, and Pool Complex. Although it is labeled as a market it did not serve as an area for trade but instead was filled with two large garden complexes (Bedal and Ramsey 2015, 622). Within these complexes, ancient root systems and flowerpot fragments have been found, which proved to archaeologists that the area was covered greatly with plants. The excavations have discovered nine phases of occupation that the group has studied so far.

Thousands of soil samples were taken from the area and put through bucket flotation to remove the botanical remains from the soil. Bucket flotation consists of pouring dried soil samples into a large bucket and churning the water while breaking up large chunks. The soil will slowly sink to the bottom while any plant remains will float to the top. After the soil has completely settled the water is gradually poured over a screen and analyzed (Fuller 2010). The

study found 1,354 different specimens (Bedal and Ramsey 2015, 626). Grains, figs, dates, nuts, grapes, and legumes species were the most common seed types found within these samples.

Hundreds of papyri dating within the Byzantine period have begun to be examined to understand the daily practices of those living within Petra. A large storeroom of these ancient, carbonized papyri was discovered within a church found in Petra. These documents date from the 6th century AD to the Byzantine period (Shiqarat 2019, 3). The papyri support the findings of archaeobotanists because they describe the cultivation of dates, figs, grapes, legumes, wheat, and barley. It also describes the use of irrigation systems through pipe channels and cisterns to cultivate their land. The rolls supply detailed records accounting for the legal and agricultural practices concerning water management, crop growth, and land distribution.

Conclusion

It is often assumed that ancient cultures were all primitive cultures. In reality, the societies that flourished thousands of years ago had technologies similar to or better than those we use today. Water management could mean life or death when living in a desert civilization. The people living in Petra created systems of pipes, cisterns, dams, and terraces and were able to sustain themselves in one of the most intense climates in the world. The city was a marvelous green spot in a sea of dry sand. By harvesting water, the people of the desert grew crops, played in pools, and watched water shows in their theater. Petra may seem desolate to the average tourist now, but in its height, it was a spectacle that could have riveled the Hanging Garden of Babylon.

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