John Peter Oleson
Department of Classics
University of Victoria
Victoria B.C. V8W 2Y2
Canada

John Peter Oleson

The Water-Supply System of Ancient Auara: Preliminary Results of the Ḥumeima Hydraulic Survey

Introduction

After three seasons of field work (1986-87, 1989), the Ḥumeima Hydraulic Survey has now entered the stage of study and analysis. This paper will provide a brief summary of the research problems the project was designed to solve, the model proposed as a possible solution, and the significance of the results of the field work. The analysis presented is provisional, since study of the finds and of cultural parallels is still not complete. Furthermore, there is no space in the present context for complete citation of documentation.

The site of ancient Auara, now called Ḥumeima, was the major Nabataean centre in the Ḥisma, Jordan's southern desert. According to Ouranios's *Arabika* (*FGrH* 675 frag. A.1.b) Auara was founded by Aretas III (87-62 B.C.) in response to an oracle.

> Auara: town in Arabia, so named by Aretas, son of Obodas, as a result of an oracle given to his father. For Aretas set out to investigate the oracle, which was "to seek a place *auara*" — that is "white" in Arabic or Syrian. When Aretas had arrived and was keeping watch, there appeared to him an apparition, a man clothed in white riding a white camel, and when the apparition disappeared, there appeared spontaneously a craggy hill, firmly rooted in the earth. There he founded a town.

The account seems to imply that Aretas founded the settlement during his father's reign, but the vagueness of expression does not make such a deduction inevitable (*pace* Eadie 1986: 247; Graf 1983: 658-659). Trajan's *Via Nova*, built along the course of a pre-existing Nabataean north/south road, passed through or very close to the settlement, and archaeological and literary evidence reveal that Auara flourished in the Late Roman, Byzantine and Umayyad periods (see Eadie and Oleson 1986: 50-53). At present, the site is 15km west of the modern Desert Highway, approximately equidistant between Aqaba on the south and Ma'an on the north. The relatively good preservation of the settlement, which contains domestic, military and ecclesiastical structures, and the concentration of the visible remains around several dramatic structures obviously connected with an extensive water-supply system excited the comment of numerous travellers in the late nineteenth and first half of the twentieth centuries (Oleson *et al.* 1989: 270). Graf once again focused the attention of scholars on the site by his survey of the road system in the region in the late 1970's (Graf 1979), but a programme of complete excavation has not yet been undertaken.

In 1983, Eadie, Graf and Oleson executed a preliminary survey of the site and carried out some soundings in selected structures (Eadie and Oleson 1986). Eadie and Graf concentrated on the military and ecclesiastical structures and the road system, Oleson on the water-supply system (Oleson 1984). In 1985 Oleson organized the Ḥumeima Hydraulic Survey, with the goal of assembling all evidence for the water-supply system of Auara extant in the settlement centre and surrounding region. The rationale for the project is the preparation of a case study of the interrelationship between water-supply and settlement design at a Nabataean desert site. Much has been written about Nabataean skills in intercepting and storing water in the arid region they inhabited, but no integrated analysis of their capabilities has yet been prepared. In addition, the origins of this skill in indigenous Iron Age and foreign Hellenistic or Roman hydraulic technology must still be traced. Finally, the character of the later reworking of this technological inheritance by the Roman, Byzantine and Umayyad inhabitants has never been properly documented. The survival of an obvious settlement centre at Auara, the clear definition of the regional hydraulic catchment and hydraulic resources, and the survival of literary information concerning the foundation and development of the settlement, make it an excellent candidate for such a case study of technological history.

Preliminary research in 1983 revealed that the water-supply system of Auara was regional in scope and based on a strategy making careful use of a variety of water sources.

There were small (private?) cisterns in the settlement centre and the surrounding hills, and the houses of the settlement seemed to have been laid out around two larger (public?) cisterns/reservoirs that were identical in size and design and built at right angles to each other. All these cisterns were designed to be filled by run-off water. A larger reservoir 350m northeast of the settlement centre was filled by an aqueduct system fed by springs on the ash-Sharah escarpment. Assuming that Ouranios was correct in attributing the foundation of Auara to Aretas III, it seemed a reasonable research model to propose that this king built the two large cisterns, the aqueduct, and its reservoir at the time of the foundation, and that the smaller cisterns were constructed over several decades or centuries as population in the region increased. The cisterns with their dependable water supply would have attracted some permanent inhabitants, while the fresher but also more vulnerable supply of aqueduct water might have been intended to service both caravans using the Nabataean north/south road and nomadic or semi-sedentarized bedouins drawn to the site for occasional trade or seasonal agriculture. Aretas (or his father Obodas) may have had in mind the related goals of fostering convenient and safe movement along this road and of increasing livestock and grain production through incentives to sedentarization.

Results of the Field Work

The three field seasons of the Ḥumeima Hydraulic Survey have been funded by the Social Sciences and Humanities Research Council of Canada and the University of Victoria.[1] The first — completed in 1986 — involved the careful survey of the natural catchment area of Auara, 240 square kilometres surrounding the actual habitation centre, to locate and catalogue all water resources and the structures associated with their exploitation (Oleson 1986; 1987b) (FIG. 1). During the second season, in 1987, all structures related to water-supply within the settlement centre were searched out and catalogued, particularly cisterns and reservoirs (FIG. 2). Where necessary, excavation was carried out to determine the nature of the internal distribution system and its chronology. During the third season, in 1989, a small bath building in the settlement was excavated, and further soundings were made to determine the chronology and design of some of the major public and private cisterns (Oleson 1990).

Sixty-one sites were recorded during the 1986 survey of the region outside the settlement centre. Some of these contained several different types of structures or several examples of a single type. The results can be tabulated as follows:

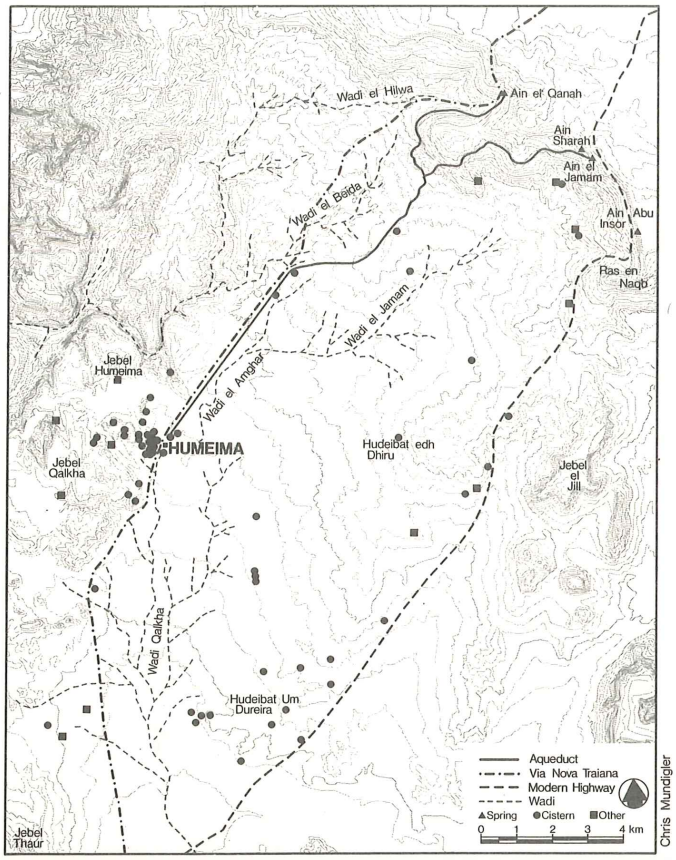
51 cisterns
4 springs and associated conduits
1 aqueduct
1 dam
2 sets of wadi barriers
6 sets of terraces or stone piles

Obviously, since the region was occupied intensively from the first century B.C. to the Umayyad period, and re-occupation has gradually taken place over the last century, not all of these structures may be attributed to the early Nabataean period. Unfortunately, determination of the precise chronology is often very difficult. Even around the cisterns, the type of structure most numerous and most likely to have been the focus of constant activity, the survey recorded very little pottery. Where ceramics did occur, the chronology usually extended from the first century B.C. or A.D. through the Byzantine or Late Byzantine period. The design or present condition of 32 of the cisterns mark them out clearly as ancient in origin. Of these, all but two were cut in bed-rock, and 14 were roofed by means of stone slabs carried on arches springing from the side walls of the cistern basin. Although this method of roofing continued in use through the Islamic period, it was first used in this region by the Nabataeans, and some of the cisterns probably belong to the first century of Auara's existence.

A dam found in a small canyon just south of Ḥumeima was built of sandstone set in mortar in a head-and-stretcher arrangement, while the spillway was cut into the bed-rock at one end. The design, the coursing of the blocks, the large Dushara block carved into the rock face adjacent to the barrier and access stairs, and the presence nearby of Nabataean inscriptions cut into the canyon wall all strongly suggest a Nabataean date. The wadi barriers, terraces, and field of stone piles identified in the Auara catchment area cannot be dated, but they make the most sense in the historical and cultural context of Nabataean and Byzantine Auara. In addition, these types of structures occur most frequently in the vicinity of the settlement centre, along the course of the aqueduct, and near the three springs that fed it.

This supply of spring water must have been very important to Ḥumeima, because it was brought to the settlement at enormous effort through 27km of conduit (FIG. 1). Continued human activity around the springs up to the present has destroyed or scrambled the ancient strata in their immediate vicinity, but the 1987 field work revealed that the aqueduct they fed dates to the first century B.C. This structure is one of the most remarkable surviving examples of Nabataean hydraulic technology so far reported anywhere. The main line extends from 'Ain al-Qanah at an elevation of 1425m for 18.901km to the Nabataean reservoir at the north end of the habitation centre, at 955m. A branch line 7.625km long connected 'Ain aj-Jamam and 'Ain ash-Sharah, also at an elevation of

[1]I am grateful to both these funding institutions. I received invaluable assistance from Dr. Adnan Hadidi and Dr. Ghazi Bisheh, Directors of the Department of Antiquities during this period of time, and from Dr. David McCreery and Dr. Bert de Vries, directors of the American Center for Oriental Research. I would also like to thank for their assistance Mr. Suleiman Farajat and Dr. Wael Rushdan, representatives of the Department of Antiquities, and my staff: Andrew Sherwood, Erik de Bruijn, Daniel Ritsema, Essam el-Hadi and Dr. Robert Schick.

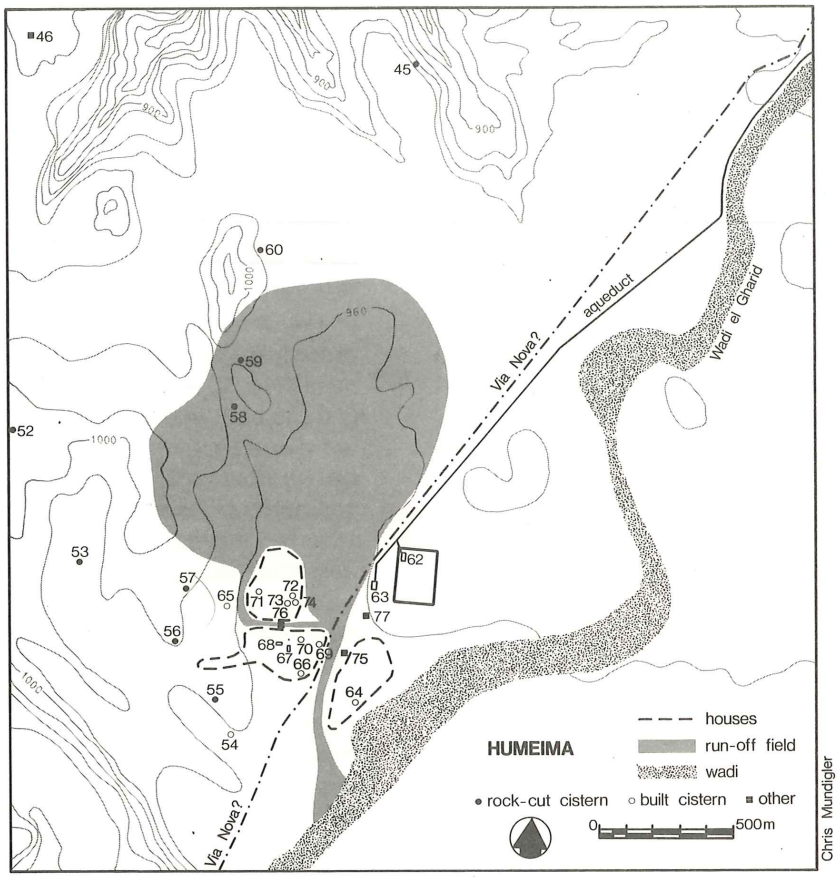


1. Humeima Hydraulic Survey: map of survey area (Chris Mundigler).

1425m, to the main line, joining it 6.557km downstream from 'Ain al-Qanah at an elevation of 1180m. The structure consists of a heavy rubble foundation wall 0.80m across, carrying long stone conduit blocks framed by rubble packing set in mortar. A water channel 0.12m wide and 0.14m deep has been carved lengthwise along each of the monolithic conduit blocks. These are made of yellow marl or white sandstone, depending on the geology of the region the aqueduct traverses, since the material was quarried locally. Fist-sized pieces of rubble were set in a hard mortar on the upper edges of the conduit blocks alongside the trough and smoothed over with stucco on the interior. Untrimmed but for the most part flat slabs of limestone were laid over the top, covering the water course. This roofing was designed to protect the water from evaporation, contamination, obstruction by falling debris, and possibly from unauthorized diversion. The technique can be paralleled at almost all Nabataean sites, although the length of the system serving Auara was exceptional: it is approximately five times longer than the aqueduct that carried water from 'Ain Musa to Petra — itself an exceptional accomplishment. The average slope from the springs to the city is 2.45%. The actual slope varies constantly, however, from slightly less than 1% at either end to 10%, 20% and even 45% for precipitous sections along the ash-Sharah escarpment. At other points along the descent of the ash-Sharah escarpment there were bridges and viaducts.

The 1987 field season concentrated on the investigation of the water-supply system within the ancient settlement centre (Oleson 1988a; b). Special emphasis was placed on defining the structure, chronology, and function of two large reservoirs, one Nabataean (FIG. 2.63) and one Roman (FIG. 2.62), and of the two main Nabataean cisterns in the centre of the settlement (FIG. 2.67,68). As work proceeded, ten cisterns were identified within the settlement (FIG. 2, empty circles), along with a drain (FIG. 2.76), and the bath building (FIG. 2.77). As a result of this work, the overall scheme of the water-supply system of Auara and the chronology of its development are much better understood. Excavation at several points along the aqueduct during this season yielded ceramics that suggest it was constructed early in the Nabataean period and was kept in use through at least the Byzantine period. The aqueduct was built to feed water to a reservoir (FIG. 2.63) located on a ridge 6.0m above and 350m northeast of the settlement centre (L 27.6m; W 17.0m; depth 1.75m). Excavation of the foundation deposits showed that this reservoir too belongs to the earliest phase of Auara's existence. Later, a second reservoir was built nearby, inside a contemporary military camp of the typical Roman *castrum* design (FIG. 2.62). Measurement showed this reservoir to be 50 × 100 × 10 Roman feet in size (W 14.2m; L 29.4m; depth 3.05m). Water from the Nabataean aqueduct was diverted through a conduit branch to fill it. Probably at the same time, the simple overflow discharge of the nearby Nabataean reservoir, which originally fed another aqueduct, was replaced with a pressurized lead pipe system laid directly in the aqueduct channel. The flow into this pipe was regulated by a massive bronze stopcock, which was found in its original position in a niche outside the reservoir. The design of the valve, and the fact that it measures precisely one Roman foot in length (L 0.296 m; 3.350kg), reveal its Roman character. Still later, the lead piping was torn up, the valve plugged with mortar, and the reservoir by-passed by a terracotta pipeline.

Both these pipelines may have been intended to supply water to a small bath building of typical Roman type 100m south of the Nabataean reservoir (FIG. 2.77), excavated in 1989. This structure was probably constructed in the second century A.D. on the walls of a Nabataean house and remodelled in the fifth or sixth century. In the final stage of development it included a large reception room with seven stone beds for undressing and for relaxing after the bath, along with an adjacent reception room with three similar beds, a cold bath chamber with a basin at which the bathers could splash themselves with water, a sweat room with heated floor where the visitors could sit in a hot moist atmosphere, and a hot bath room with heated floor and walls where they could wash themselves at a basin of hot



2. Ḥumeima Hydraulic Survey: map of settlement centre (Chris Mundigler).

water. A vaulted furnace room built of bricks was well preserved.

A probe behind the walls of the better preserved public cistern in the settlement centre yielded a significant amount of Nabataean ceramic material. The chronology of the types of pottery recovered is still the subject of scholarly discussion, but the Nabataean character of the cistern has been established, and it is at least possible that the structure was built in the first century B.C. Excavation also demonstrated that the two public cisterns were filled by separate intake channels, providing a demonstration of the strategy of Nabataean skill in obtaining water from run-off. Excavation in the two private cisterns revealed that they were located in the courtyards of large houses, carefully roofed and paved over, and surrounded by a curb wall. Even on the outskirts of the habitation area this type of circular cistern can date as early as the first century A.D., suggesting that occupation of the habitation area to the south occurred quite rapidly.

Analysis of the Survey and Excavation Results

Three seasons of field work have more or less confirmed the model of royal enterprise at Auara proposed above. Around the periphery of the catchment area, where the bed-rock is at the surface and the topography fosters rapid, directed run-off of rain water, there were rock-cut cisterns and wadi barriers (see FIG. 1). Rainfall is too meager and evaporation too extensive to allow dependence on irrigation for major crops. The wadi barriers and terraces were designed to counteract these factors and enhance the moisture content of the soil. Few cisterns were built in the lowland area around the settlement centre, in the land most suited for agricultural use. Construction was more difficult here, since the bed-rock is inaccessible and local run-off is more scanty in the absorbent, sandy soil. Only in the habitation centre itself, where the concentration of population required it, where the aqueduct and house roofs supplied artificial catchments, and where a properly positioned run-off field was available, were cisterns and reservoirs routinely built entirely of blocks (FIG. 2, empty circles). The location of cisterns around the periphery of the Ḥumeima catchment, close to the border between bed-rock and arable land, made their water available both to farmers in the nearby fields and to herdsmen leading their flocks from field stubble to wild brushland and back again. This is still the pattern of use today.

All the small cisterns and subsidiary water-harvesting structures were most likely planned and built by individuals and were consequently privately owned. The aqueduct, by contrast, must have been a public structure. The concentra-

tion of resources needed for its construction and the fact that it was built at the foundation of Auara or soon after reveal that it was somehow crucial to the function or survival of the settlement. King Aretas III is the party most likely to have had both the means and the interest to build it. Since the Nabataean reservoir fed by the aqueduct was outside the apparent habitation centre itself, King Aretas III clearly had two foci in mind for his new regional centre. In fact, the focus of the structural remains visible at present may not represent the sole ancient centre of population. The character of Nabataean urbanism is still imperfectly known, but it is now clear that many Nabataean so-called "cities" had only a relatively small number of permanent inhabitants (see Negev 1986: 29-67). The populations of settlements such as Mampsis, Ṣubeiṭa and Auara seem to have fluctuated markedly from one season to another, as groups set up tents on the outskirts to take part in caravan trade, livestock markets, or agricultural work. At present, the remains of approximately 42 structures are visible around the settlement centre, of which approximately 35 seem to be domestic in character. The chronology of these structures cannot be determined without excavation, but it is unlikely that they all date as early as the first decade of Auara's existence. The original settlement may have consisted of as few as five or ten households. Ethnographic research by Köhler-Rollefson (1987: 538) near Ḥumeima has shown that permanent habitations can be associated with a largely mobile nomadic population. It is difficult to document the location of these seasonal encampments archaeologically (Negev 1986: 18-22, 36-44; cf. Banning *et al.* 1987: 323-326), but the open ground north and east of the Nabataean reservoir would have served such a purpose very well, particularly after the provision of a flowing supply of spring water through the aqueduct. Aretas may have built the aqueduct primarily to supply water to periodic encampments of nomadic or partially sedentarized Bedouins, to foster the development of Auara as a centre for agriculture and trade. It would have been more difficult to arrange for the necessary maintenance of a run-off cistern intended for the use of a large, changing and at least partially nomadic population that may have spent most of its time elsewhere in the Ḥisma. Later on, the Roman *castrum* may have occupied part of the same campground because of its physical suitability and because of the proximity of a supply of running water and of the Via Nova Traiana. From this vantage point the Roman garrison could also have conveniently kept watch over the settlement, the nomadic camp and the approaches to Auara from north and south.

The residents of the permanent houses down in the settlement centre (FIG. 2, outlined area) could have used this water too, but they were also served by the two nearby public cisterns and by private cisterns within the houses. These cisterns were filled by water funneled from a 100ha run-off field immediately north of the settlement that was kept clear of building in antiquity (FIG. 2, shaded area). The area of the field was not so great or its slope so steep that the run-off would pose a threat to the settlement it sustained. This combination of large, protected run-off field and central set of large, interrelated cisterns also suggests royal planning and patronage. Given that Auara might have been located anywhere in this part of the Ḥisma along the north/south caravan road, it may be that its actual location was influenced as much by the presence of the perfectly positioned and adequately proportioned run-off field just to the north of the settlement as by the availability of excellent grain-growing land to the east, and the proximity of the route down into Wadi 'Arabah through the wadis behind Jabal Ḥumeima.

King Aretas' ability to locate this settlement at a position suitable all at once for agriculture, trade and water-harvesting was due in large part to the use of block-built cisterns roofed with slabs carried on transverse arches. The typical early Nabataean cistern (as described by Diodorus 19.94.6-9) was the bottle-cistern cut in bed-rock and lined with plaster, fed by run-off from an adjacent rock slope. Obviously, such cisterns had to be located where bed-rock was accessible. Sometime in the late Hellenistic period, however, the new design of built cisterns roofed with slabs carried on transverse arches was imported from the Greek world and quickly became typical of virtually every Nabataean site. The design continued in use through the Islamic period. The precise chronology of its spread is still not known, but this type of roof had appeared in exactly comparable form in the Greek world by at least the third century B.C. Cisterns of this type can be seen at the waterless, treeless site of Delos (Chamonard 1922-24: 323-356), and the roof design also occurs in early Hellenistic architecture where rooms must be placed beneath a heavy paving, as in the Temple of Apollo at Claros (Bean 1967: 190-196). The question of the means by which the design was brought to Nabataea is tantalizing. Nabataean merchants probably played an important role, since they seem to have roamed the whole Mediterranean world. Inscriptions in Aramaic or in Aramaic and Greek set up by Nabataeans, or in Greek relating to Nabataeans, have been found in Egypt, at Sidon, Cos, Rhodes, Delos, Puteoli, Ostia and Rome.[2] At sites such as Delos, Nabataean merchants would have seen this type of cistern in operation. The principle of the design in simple, and its appropriateness to conditions in the Nabataean lands obvious.

However the design for the arch-supported roof arrived, it must immediately have helped foster the growth of

[2]The handiest list of Nabataean cultural artifacts outside the Nabataean homeland is now Wenning 1987. See pp. 22-24, 125-128.

Nabataean settlements and the sedentarization of their culture. Once cisterns with stable roofs could be constructed wherever they were needed, the Nabataeans were freed from their previous dependence on rocky outcroppings and the hazardous run-off fields associated with them. They could then settle sites such as Auara, arranging for run-off water supplies close to routes of travel and agricultural land. The built, arched roof was also applied to rock-cut cisterns, since it facilitated excavation and maintenance of the tanks, and concealment was no longer a major concern.

With its aqueduct, Auara reached out farther into the countryside for its water than any other Nabataean settlement and at the same time made use of the full array of typical Nabataean water-harvesting techniques. Bowersock (1983: 64), Hart (1986: 57-58; cf. Finkelstein 1988), and others have suggested that King Aretas IV (9/8 B.C.-A.D. 40) intentionally fostered sedentarization here and elsewhere in his kingdom to compensate for the decreasing importance of the caravan trade. The new data from Ḥumeima suggest that this development may have begun with Aretas III, or even with his father Obodas, at a time when the trade routes were still active. The cistern with arch-supported roof probably had already been in use in the region for several decades, but the scale of the aqueduct may reflect Aretas' personal familiarity with Hellenistic water systems in the eastern Mediterranean. After all, Aretas was given the epithet "Philhellene". The extent of his effort to supply Auara with water implies as well the existence of highly developed social mechanisms within the settlement for governing its distribution and use. The excavations have also shown that interaction took place between the Nabataeans and Romans as one culture succeeded the other and new techniques of managing water and new ideas of its proper use became current. The Romans diverted at least some of the aqueduct supply for the reservoir located within their camp, and they controlled the previously unregulated overflow from the Nabataean reservoir with a stopcock locked behind a grating. In this way they appropriated the water for their own physical needs within the camp, and for the important Roman social and hygenic ritual of public bathing. The bronze stopcock symbolizes the way Roman law, which had evolved to serve the needs of a cosmopolitan, urbanized empire, replaced the stern, but unwritten, informal tribal law of the local Nabataeans.

References

Banning, E.B., Dods, R., McCorriston, J., Monckton, S. and Sheppard, P. 1987. Report on the Wadi Ziqlab Project, 1986 Season of Excavations. *Annual of the Department of Antiquities of Jordan* 31: 321-339.

Bean, G.E. 1967. *Aegean Turkey.* 2d ed. London: Benn.

Bowersock, G. 1983. *Roman Arabia.* Cambridge MA: Harvard University Press.

Chamonard, J. 1922-24. *Exploration archéologique de Délos, VIII: Le Quartier du théâtre.* Paris: École Française d'Athènes.

Eadie, J. 1984. Humayma 1983: The Regional Survey. *Annual of the Department of Antiquities of Jordan* 28: 211-224.

——, 1986. The Evolution of the Roman Frontier in Arabia. Pp. 243-253 in P. Freedman and D. Kennedy (eds), *The Defence of the Roman and Byzantine East.* Oxford: BAR Int. Ser. 297.

Eadie, J. and Oleson, J.P. 1986. The Water-Supply Systems of Nabataean and Roman Humayma. *Bulletin of the American Schools of Oriental Research* 262: 49-76.

Graf, D. 1979. A Preliminary Report on a Survey of Nabataean-Roman Military Sites in Southern Jordan. *Annual of the Department of Antiquities of Jordan* 23: 121-127.

——, 1983. The Nabataeans and the Hisma: In the Steps of Glueck and Beyond. Pp. 647-664 in C. L. Meyers and M. O'Connor (eds), *The Word of the Lord Shall Go Forth: Essays in Honor of David Noel Freedman.* Winona Lake: Eisenbrauns.

Hart, S. 1986. Some Preliminary Thoughts on Settlement in Southern Jordan. *Levant* 18: 51-58.

Köhler-Rollefson, I. 1987. Ethnoarchaeological Research into the Origins of Pastoralism. *Annual of the Department of Antiquities of Jordan* 31: 535-542.

Negev, A. 1986. *Nabatean Archaeology Today.* New York: New York University.

Oleson, J.P. 1984. Survey and Excavation of the Nabataean and Roman City of Humayma (Jordan). *Classical Views/Echos du Monde Classique* 28: 235-248.

——, 1986. The Humayma Hydraulic Survey: Preliminary Report of the 1986 Season. *Annual of the Department of Antiquities of Jordan* 30: 253-260.

——, 1987a. Humayma Hydraulic Survey: Preliminary Report on the 1986 Season. *Old World Archaeology Newsletter* 11.1: 14-17.

——, 1987b. The Humayma Hydraulic Survey: Preliminary Report of the 1986 Season. *Classical Views/Echos du Monde Classique* 31: 263-272.

——, 1987c. The Humayma Hydraulic Survey: Preliminary Report of the 1987 Season. *Old World Archaeology Newsletter* 11.3: 15-16.

——, 1987d. Technology and Society in Ancient Edom. *Transactions of the Royal Society of Canada* Ser. 5, vol. 2: 163-174.

——, 1988a. Nabataean and Roman Water Use in Edom: The Humayma Hydraulic Survey, 1987. *Classical Views/Echos du Monde Classique* 32: 117-129.

——, 1988b. The Humayma Hydraulic Survey: Preliminary Report of the 1987 Season. *Annual of the Department*

of Antiquities of Jordan 32: 157-169.
——, 1990 Ḥumeima Hydraulic Survey, 1989: Preliminary Field Report. *Annual of the Department of Antiquities of Jordan* 34: 285-311.
Oleson, J.P., Graf, D. and Eadie, J. 1989. Humayma. Pp. 270-274 in D. Homès-Fredericq and J.B. Hennessy, (eds), *Archaeology of Jordan, II: Field Reports*. Akkadica, Supp. VII. Leuven: Peeters.
Wenning, R. 1987. *Die Nabatäer — Denkmäler und Geschichte*. Göttingen: Vandenhoech & Ruprecht.