Philip C. Hammond
Department of Anthropology
University of Utah
Salt Lake City, Utah 84112
USA

Philip C. Hammond

Nabataean Architectural Technology

The first detailed commentary on Nabataean architecture was the work of those intrepid explorers, Ernst Brünnow and Alfred von Domaszewski, in their monumental exploration of Petra, published from 1904 onward. Surface survey at Petra was, in turn, followed by the excavators and researchers who variously investigated Nabataean rock-cut installations, defensive architecture, house and cave-dwellings, water control, civic constructions and architectural decoration. Likewise, more widely ranging surveys also contributed to the identification of Nabataean architectural sites. These explorations paralleled, in the southern sector of Nabatene, the early surveys which were done in the wide-spread northern sphere of Nabataean cultural influence.

In general, however, most of these studies were descriptive in nature, not analytical, with but a few exceptions. In spite of often detailed plans, adequate photographs and descriptive texts, little was done to analyze the architectural technology of structures identified as Nabataean.

Still further, some archaeologists labored under two misconceptions of basic Nabataean culture: first, that the "Nabataeans" were relatively recently sedentarized bedouins, without a history of architectural background; and, secondly, that all of their structures, except, perhaps, the rock-cut monuments, were therefore the work of more enlightened foreigners, especially "Romans", in both inception and construction. The work of Parr on the Qaṣr al-Bint (1960; 1967-8), with the discovery of inscriptional data, did much to allay the latter misconception, as did the work of the American Expedition to Petra at the Main Theater and at the Temple of the Winged Lions (Hammond 1965; 1986; 1987; 1989). It is hoped that recent thoughts regarding Nabataean-Edomite symbiosis (Hammond 1991) have also disposed of the former viewpoint, by providing both a time-lapse and a basis for a shared technological background — and have opened the way to the understanding of how "Nabataean" technology, in a variety of crafts and directions, was able to mature and be locally developed.

When architectural technology is addressed, however, the breadth of the subject involved becomes enormous, for "architecture" must consider hydraulic installations, defense works, public buildings, house types, caravanserais, workshops, and — in the case of the Nabataeans — rock-cut structures as well.

Likewise, the term "technology" also presents a vast range of aspects which must be considered: prospecting, quarrying materials, transport and processing, construction techniques, machinery, painting, chemistry, surveying, labor involvement and craft systems, tools, economics, and even the overall philosophy of architecture.

Still further, the question arises as to the originality of any given technological item found in the possession of a people. The question of the actual originality of technology, aside from that found in pristine states, involves the two aspects of origin which must be addressed concerning the presence of any phenomenon found within the attributes of a cultural group: independent invention and diffusion.

The former source for a culture trait — i.e. independent invention, or innovation — can be recognized more readily: namely, the presence of a feature for which there is no parallel outside of the culture involved, or for which there is no readily apparent access for diffusion from another culture possessing the same, or a similar, feature.

In all of Coele-Syria the question of innovation is complicated by the duration of occupancy of the area, from prehistoric through historic times, as well as by the relatively unrestricted access throughout the area because of the lack of significant natural barriers to the movement of peoples.

These importations ultimately became standards, and hence, Nabataean and other local usages should probably be referred to as "derivative", or even, as Patrich (1990: 11), "stimulated", rather than "influenced".

Sorting out examples of local innovation of technology therefore becomes extremely difficult. The trading activities and the wealth of the Nabataeans made it

even more possible both to observe and to import technology encountered in their widespread ranging throughout both the Eastern and the Western worlds. The presence of a mixed population at Petra, as reported by Strabo's informant, Athenodorus (XVI. 4. 21), also suggests a direct avenue for the acquisition of technological information and even for the presence of foreign craftsmen. Still further, by the Nabataean period, technological information was being widely circulated in written form, as well. At the same time, certain architectural features and technological practices occur in the Nabataean area which must be considered Nabataean, *s.s.*

The identification of the second possible mechanism, diffusion, for the presence of a cultural trait is likewise extremely complex, since the practical solving of similar problems encountered by two, or more, cultures, often results in the same solution (convergence), a phenomenon which can be illustrated, world-wide, from Palaeolithic through modern times.

Further, analysis of the degree of direct borrowing of a feature (adoption), or partial borrowing with variation of technique (adaptation), must also be considered in regard to individual cases, as well as the essential nature of the borrowed feature.

When one enters the area of borrowed, or adopted architectural technology employed by the Nabataean architects, the list is quite considerable because of the widespread commercial travel of the people, their fantastically eclectic taste, and the pervasive presence of both "Hellenized" and "Orientalized" architecture around them, as well as because of the extent and varieties of architectural remains. Adapted, or modified, technology is less represented, although identifiable. Unique, or innovative technology is even more obscure, but a few examples may be cited and future excavation, or future technological analysis of excavated remains, may produce a more definitive list. As a consequence, examples of Nabataean architectural technology coming under these headings can only be broadly categorized, with relevant examples as illustration.

Support Technology

Under this heading must be considered all of those aspects of technology generally ignored when architecture is considered. Among those aspects are materials procurement, source prospecting, mining, quarrying, raw materials transport, materials processing and chemistry, materials fabrication, site location and preparation, surveying, architectural planning, economics, labor management, artisan types required, and similar factors.

The fact of Nabataean caravan traffic provides the possibility for securing raw materials far beyond the limits of any one site, or of Nabatene as a whole, because of the monarchical centralization of political power and the trade networks of the kingdom.

The precise technologies for processing and fabricating items were long-held methods, shared throughout the Middle East from Neolithic times onward (Oleson 1986: 63-76). Although the extent of Nabataean quarrying, refining and processing, as well as fabricating metals cannot be precisely determined (cf. Forbes, VIII, 1964: 222 ff.), the amount of rock-cutting for tombs, as well as the quarry to be seen on Jabal al-Madhbaḥ, does provide a glimpse of considerable local activity, at least at Petra and probably to be found elsewhere as well. Moreover, the degree of purity of some copper fixtures from the Main Theater is exceptional (Hammond 1965: 70-71), but whether it was done by Nabataean smelters cannot be determined. Certain features recovered at the Temple of the Winged Lions do suggest on-site metal processing, even if the details are vague. The quantity and standardization of iron nails and copper tacks recovered at the Temple of the Winged Lions suggest mass production of such items, although importation of these items cannot be ruled out. But the probability exists that processing and fabrication technology, if utilized by the Nabataeans, was part of the commonly-shared metal technologies of the day, perhaps even directly inherited from the Edomites, and needing little change by local cultures for quite some time to come (Oleson 1986: 76-99).

The production of mortars and plasters likewise show no innovative features, nor do the paints used in decoration. The spectroscopic analysis of paint samples taken from the painted plaster of the Temple of the Winged Lions, recently completed by David Johnson and and Chun Shuk Jung (forthcoming) have indicated that the Nabataeans were using the basic chemistry of paints to be found in Vitruvius (VII).

The transport of raw, or partially processed raw materials from quarry, or source sites, cannot be clearly defined. As a caravan nation, the Nabataeans possessed a variety of beasts of burden, including camels, donkeys, and horses. Transport is once again, however, a shared technology and no Nabataean adaptations, nor innovations, in animals used, yoking, nor cartage devices, are identifiable from recovered remains (Oleson 1986: 200-211).

The technology of finishing of stone, both building and decorative, can be seen more clearly than that of most of the raw materials encountered on sites, because of the presence of saw, chisel, and hammer working marks, as well as cutting and sculpting guide-lines, seen on various recovered examples (Hammond 1965: PL. 36.4). Such indicators also provide information regarding the tool types employed by the artisans involved.

It does not appear in the literature that any attempt has been made by excavators to seek building-stone

modules, nor size standardizations, nor to ascertain weights, prior to that previously done at the Main Theater (Hammond 1965: 38, 45-47, 499-450) and currently being done with the building materials from the Temple of the Winged Lions. The results of the analyses again suggest adaptation of conventional standards, essentially Roman (as Vitruvius, X. ii.1ff.; Drachman 1963: 11, 142ff. and 94-105, on earlier documentation).

What do appear to be innovative, however, are the presence of alphabetic and numeric building "instructions" to be found upon both column drums, especially encountered at the Main Theater (Hammond 1965), upon stacked ashlar at the Temple of the Winged Lions (Hammond 1978), at-Tannūr (Glueck 1965), Wādī Ramm, Mampsis (Negev 1988), and even at Kourion (Soren 1987). By this method, an architect could designate a set number of column drums for each column and its place in the line of columns, as well as the destination of specific ashlar blocks. Hence, on-site supervision, by the architect, could be decentralized to a workman who could read the markings in the correct order.

The use of the alphabetic and numeric indicators noted above may suggest quarry-site mass production of both ashlar and, more probably, column drums, to predetermined sizes. This technique was used by others and is evidenced in the literature (Schmidt-Colinet 1990). Still further mass production is to be seen in the ring-bases used in place of drum-cut Attic bases at Petra (Hammond 1978). These are unique and permitted rapid completion of a column, regardless of variation in bottom-drum sizing. The literature only notes one other example of such a feature (Creswell 1958: 25), which may indicate continued Nabataean artisanship well into the Early Islamic period.

Labor involvement, skilled and unskilled, is also a question hither-to-fore not addressed in the literature because of lack of documentation. That architectural craftsmen did exist, however, is apparent from the results of their work. Likewise, the finding of the workshops at the Temple of the Winged Lions (Hammond 1987) indicates local artisan presence, as does the Nabataean graffito scratched into the side of one of the columns of the cella. The named "architects" of rock-cut tombs at Madā'in Ṣāliḥ (Schmidt-Colinet 1987) suggest family craft development in the society, as well as the fact that the artisans were Nabataean and their craft skills probably hereditary (Negev 1986). It is possible, of course, that along with visiting commercial or diplomatic groups, some of the non-native population were artisans. That importing foreign artisans was necessary for all the architectural skills needed in Nabatene cannot be supported, however.

There is no reason to suggest that the Nabataeans, themselves, had not developed the expertise in all the architectural support crafts and services required. The temporal duration of Nabataean occupation in the area of their kingdom, as well as the prior architectural development of the Edomites, would have been sufficient to develop all of the requisite skills. The availability of "textbooks" dealing with specific details makes that premise even more possible. The probability of itinerant artisans reaching Nabataean territory in the course of three or four centuries obviously cannot be ignored, but the continued need for such personnel cannot be supported. That ceramic technology is a valid measure of general technology within a culture has been suggested some time ago (Hammond 1972). When the ceramic skill of the Nabataeans is evaluated against this premise, the probability of other craft skills can be placed at a reasonably high local level of development.

The relative standardization of rock-cut monuments, of ceramic sizes and forms, the extent of architectural development, the adaptation of certain borrowed technology, rather than its slavish reproduction by culturally-related foreign artisans, as well as innovations and "Semiticisms" ("orientalisms" — as Zayadine 1970, and others) within the general technologies of the people, also speak to the degree of craft organizational and management levels within the society. Precisely how labor was either organized, or managed, cannot be determined, but kinship-based craft relationships are most probable, given evidences in that direction. That Nabataean artisans were at work throughout Nabatene, as evidenced by the tomb inscriptions at Madā'in Ṣāliḥ, as well as the presence of pottery workshops recovered at Oboda and Elusa, along with the probability of Nabataean architects at Mampsis, Masada and Khirbat al-Murāq (Negev 1988), also raises the question as to whether these were local, or part of larger "guilds", centrally located, which served to standardize products. In the case of pottery, this later possibility seems to have some degree of support.

Who the skilled and unskilled laborers were, who did the actual work, aside from the "architects" of certain monuments, can only be inferred, here and there, from graffiti and possibly from stylistic elements. However, when the extent of Nabataean architecture is viewed, the number of required laborers is seemingly rather vast. In addition, the number of able bodied men required to conduct the equally vast caravan trade, even though seasonal, further extends the necessary labor pool. Since the actual demographic makeup of the various Nabataean populations throughout the kingdom cannot currently be determined, this aspect of support technology must likewise remain unresolved. At the same time, the wealth brought into the culture by trade, may well have provided some way in which relatively large, non-commercially related craft guilds, including the military,

could have been supported.

Since the matter of economics is also involved in the general support technology of the architectural endeavors of the Nabataeans, that same factor of rather grand financial position, resulting from trade, enters the picture. Obviously, certain architectural works were public in nature — hydraulic systems, temples, probable *fora*, probable administrative centers and residences, and similar works. Whether general taxation, or other local public financing, provided necessary funding cannot be determined, except once again, by inference from the examples of neighboring states, where both sources were utilized. Royal enterprises were among the most extravagant, as the various public works and generous donations for architectural embellishment made by Herod the Great demonstrate (Josephus, *Antiquities* XVI.v). However, the private sector of Nabatene, as elsewhere in affluent societies, assisted in specific building operations as expressions of public beneficence, as inscriptions attest (Glueck 1965; Negev 1961; 1963; 1988 at Mampsis and at Elusa). The commercial wealth of the Nabataeans certainly placed some citizens in an unusually favorable position in regard to affording expensive and expansive public works and equally impressive personal architectural enterprises, as the façade tombs illustrate. The lack of "tickets" recovered in the Main Theater excavations (cf. public banquet tickets at Palmyra, Starcky and Gawlikowski 1985), as well as the lack of seat, or seat section, numbering may, however, attest to some degree of public benefaction by the wealthy to the poorer classes.

Construction Technology

It is perhaps in the area of architectural types that the Nabataeans appear to have borrowed the technology of others. Yet, at the same time, in that same area, the Nabataean penchant for adapting, and even for innovating, becomes equally apparent in the tremendous number and diversity of their enterprises (Hammond 1965). Architectural plans of all sorts became part of Nabatene's landscape: pipelines, reservoirs, aqueducts, dams, temples, high places, villas, the colonnaded *cardia*, street-side shops, funerary types (including rock-cut cists, the façade tomb types, the ledge-with-*arcosolia*, the "*ṣahrīj*" monuments, *triclinia*, and even an attempt at a *columbarium*), baths, odeons, theaters, workshops, and probably further types still unrecovered.

When, for example, temple plans are considered, the Nabataeans appear to have adopted a variety of available plans, which scholars have attempted to classify geographically and otherwise (Hachili 1975; Negev 1976). It would appear, however, that plan-choice was a matter of adaptation, selecting the plan to adopt to the particular needs of the local cult involved. But the inclusion of workshop areas adjacent to a temple, not reported except for the Temple of the Winged Lions, may be innovative, at least for the commonly found Semitic area temples.

Site-location choices cannot be characterized as to origin, since the location of various buildings, or tombs, or of hydraulic installations, had, of course, to vary from culture to culture and area to area, according to the topographic situation of the settlement. To some extent, however, a case may be made for some degree of site-choice adoption, with appropriate adaptation at least in theory, from Vitruvian models, or mimicry from general contemporary urban models which appeared in the area. Semitic ancestry may be apparent in the retention of altars, within remodelled versions, at at-Tannūr (Glueck 1965), as a carry-over of ideas of the preservation of sacred space, once so designated.

In the case of the façade tombs at Petra and at Madā'in Ṣāliḥ, parallels for the general type can be found elsewhere, but the Nabataeans adapted the façade schemae to suit some unknown expression of taste and apparently also modified those schemae through time, as the attempts to classify them have suggested (Brünnow and von Domaszewski 1904; Zayadine 1970; Patrich 1990: 114-123 — where the term "selectivity" is a synonym for "adaptation" *et alia*). Even within the elements of façades, adaptation of orders as in the Khazna (Hammond 1965; Dalman 1911) and the inclusion of foreign elements (e.g. the Egyptian cornice) are common. More extensive adaptations also took place, however, for example at the Main Theater, the normal height of the *vomitoria* was reduced, no colonnade was included, no awning appears to have been accommodated, stairway modifications were made, no acoustical devices were built-in, and podium and impost variations suited local height, among other variations (Hammond 1965).

Adaptations of other adopted architectural elements and methodologies were also made to suit local needs, or local taste. The Nabataean "lugged" capital has traditionally been seen as a Nabataean innovation, although recent commentary on its origin raises some questions (Soren 1985; but Patrich 1990). Likewise, the "Nabataenized-Corinthian" capital, variations in the proportions of the Attic base, the plugging of affixed elements into walls with either plaster, lead, or wooden plugs (Hammond 1965; 1975), and similar practices, all represent adaptation of borrowed technologies.

Where it was suitable to local requirements, many technologies were taken over without change and apparently the requisite elements to employ them were locally produced. Thus, ceramic water pipes were adopted for bringing water into Petra from a distance, even though Roman conventional wisdom suggested open canals because of maintenance and pressure control problems (cf. the two sets of pipes below the later open canal system

same time, open rock-cut runnels and drains were widely used elsewhere in the city (covered drains are merely variations of the "open-canal" type) and throughout all of the Nabataean area, indicating choice in adopting technology as it was fitting.

Nabataean dams, encountered throughout the area, are generally of the types found elsewhere, also, but the damming of wadis for future use of winter-rain water, is at least an adaptation of the conventional damming of running streams and serves well for dry-farming use. The development of the "*tulaylā tal'inab*" (Glueck 1965: PL. 213a-c) as a dry-farming feature, appears, however, to have been a significant Nabataean innovation in hydraulic engineering. The great barrage dam, at the entrance to as-Sīq at Petra, is an interesting adoptive item, in that it appears also to have served as a defensive barrier, and must thus be considered adaptation. Its use, in conjunction with the rock-cut diversion tunnel adjacent to it, is rather innovative in principle, even if obviously adopted technologies are involved in the constructions.

The Roman method of wall plastering, complete with the common Augustan Age reduction to only two, or three, coats, instead of Vitruvius' suggested multiple coats, appears as another straight-forward adoption of technology (Forbes 1955; Vitruvius VII. iii.5-6; Negev 1988). The Nabataeans appear to have innovated in this area, however, in their practice of keying the base coats to rough ashlar by the use of iron nails and then keying the final coat by the use of small copper tacks (Hammond 1965; 1975).

A generally recognized innovation of the Nabataeans, however, appears to have been their ubiquitous use of diagonal dressing of ashlar and the walls of rock-cut installations for keying plaster. The use of herringbone incisions in the rough under-coats, another plaster keying device (Negev 1988) was probably adopted from elsewhere.

Extensive uses of plaster (stucco) appear at most Nabataean sites, including residential sites (Zayadine 1987; Negev 1988; Villeneuve 1986; 1988) and was obviously borrowed from neighboring cultures.

The application of paint, including fresco painting, was adapted from conventional practice, at least in some examples, since that encountered in the Temple of the Winged Lions appears to have been simply brush-work without the more complex methods suggested by Vitruvius (VII.iii; 7; ix, 3; x, 4).

Attachment of architectural elements, such as veneers and *crustae*, are another problem in architectural technology and became one for the Nabataeans, as well. But the securing of veneer to ashlar, via copper fixtures, may possibly represent an innovative Nabataean approach to solving an adopted-feature problem (Hammond 1965).

The Main Theater, which during the Roman period might well have been adopted as a totally built structure, was partially rock-cut, because of the need to adapt the adopted concept of the theater as the frontispiece to a sophisticated city (Hammond 1965).

The inset-outset cornering of the rear walls of the Temple of the Winged Lions, also evidenced at the Palace Tomb, appears to be an innovative Nabataean construction feature, whether decorative or functionally conceived. However, that this was simply buttressing, which later appeared in Nabataean structures, does not seem architecturally (i.e. structurally) indicated, nor necessary in either case.

Construction, using both of the building methods noted by Vitruvius (II.viii, 5-7), indicates adoption of conventional, known, techniques (Parr 1960; Hammond 1975; Glueck 1965), with adaptation of methods only visible in block measurements, as noted earlier. The extent of construction practice to be attributed to prior Edomite building cannot be determined.

The general construction methods for road building site preparation, foundations, subfloorings and floorings, stairways, walls, doorways, and other architectural elements, do not seem differently handled from those seen throughout the Roman period world, and were probably all totally borrowed techniques (Parr 1960; Hammond 1975; Negev 1988; Glueck 1965).

The earthquake protection beams, seen in the west wall of Qaṣr al-Bint and in the arches of the "*liwān*" area of the Temple of the Winged Lions appear to have numerous parallel applications throughout Nabatene (cf. Negev 1988), and proved to be relatively effective. Pending report of similar construction technology used by others, this device would appear to be a Nabataean innovation.

Construction machinery appears to have been that generally used during the period (Vitruvius X. ii.1ff. and Landels 1978) and was most dramatically illustrated in the davits cut into the bedrock floor of the Main Theater, as well as by the more generally encountered "levis" holes to be seen on the tops and sides of column drums (Hammond 1965).

Extensive evidence exists, in the surfaces of recovered materials, for Nabataean adoption of the conventional small tools employed by other craftsmen throughout the world: scribing tools, saws, hammers, brushes, chisels, straight-edges, and similar items. No new tools seem indicated, either from excavated examples, nor from observation, with the possible exception of a toothed hammer, the presence of which is accepted by Negev (1988) and others, for achieving the characteristic Nabataean diagonal dressing, both on ashlar blocks and on interior walls of rock-cut installations.

The extensive use of the round arch, without a keystone, is virtually a characteristic of Nabataean building

(Hammond 1965; Negev 1988 and *passim*; and the impressive arch over the entrance to Qaṣr al-Bint, among many other examples), but represents another borrowed technological feature. Certain aspects of springing (e.g. from impost capitals as Negev 1988) may be a Nabataean innovation, however.

The borrowed barrel vault, was apparently first used with caution — and built of stone, not cement (concrete), although cement was used above the stone-built example at the Main Theater (Hammond 1965). Stone built examples continued to be rather widely used throughout Nabatene for a variety of purposes. Corbelling also occurs, but again is not an innovation of the Nabataeans.

Security even entered the area of architectural technology, with typical Roman door locks and keys being adopted with virtually no modification, in addition to earlier reliance upon internal door bars. This aspect of life probably entered Nabataean life when the tent gave way to permanent houses and a different view, as well as protocol, of privacy developed — along with the need for protection of an increasing volume of personal property.

Decorative Technology

The question of Nabataean decorative art, in terms of influences, sources, and relationships has been ably considered by others in the field of art history. However, a few observations may be made concerning some aspects of Nabataean decorative art, in the general vein of the present discussion.

One small, but interesting, adopted decorative technique was recovered at the Temple of the Winged Lions, which does not seem to have been reported elsewhere — namely the addition of small painted cast plaster flowers to stone-sculpted capitals. Perhaps these were votive donations of pilgrims, or had some other, now lost, religious meaning. In any case, their application appears innovative.

Somewhat similar, was the use of small, individually sculpted and painted plaster human faces, apparently affixed to walls within the Temple of the Winged Lions. Although these may simply be adaptation of another borrowed decorative feature, the "ancestral" bust of the Romans, or of honorific sculpture, in general, they may possibly represent recognition of donors to the temple. In any case, they represent further Nabataean adaptation and, at the same time, innovation, by miniaturization (Hammond and Mellott, *Nabataean Faces from the Temple of the Winged Lions,* forthcoming).

The interior decoration of the temples at Wādī Ramm, Khirbat adh-Dharīḥ and Petra is, in itself, somewhat unusual, given the austerity of both Greek and Roman temples of the period. That interior decoration of Greek temples was done, is known, but was early and apparently never widely accepted (Wheeler 1964). However, it may be that Nabataean interior decoration must be assigned to the orientalized background of the people, if not innovative. The interior orders (e.g. *aediculae*) of other regional temples, as well as even non-decorated Roman examples, at least suggested appropriate loci for such decoration. The use of conventional egg-and-dart, dentils, modillions, and other sculpted, moulded and painted (generally exterior) decorative elements were certainly borrowed from classically oriented neighbors, as was the use of marble elements, especially under the impetus of the Augustan Age proliferation of the use of that material.

The philosophy of Nabataean architectural technology is thus related to those anthropological aspects noted at the beginning of this study. The Nabataeans, as any rising cultural group, followed the rule of the adoption of new cultural traits from others only if they promoted the needs, well-being, or social aspirations of the people. In the jargon of the system theorists, such action reflects the "maximizing of the minimal amount of culture dislocation", or as Glueck commented, the Nabataeans "steadily assimilated in new environments whatever might promote their well-being" (1965: 5).

Likewise, some adopted features were modified, or sub-traits ignored as extraneous, and some fewer architectural problems required innovation to solve them locally. That the majority of Nabataean architectural technology was borrowed, as a whole, or in part, rather than being innovated, is logical, given the time period in which they lived, surrounded by the already developed technologies of their neighbors, which did not require reinventing. Still further, it is less necessary for a wealthy culture to innovate, than one without great resources, which must struggle to attain a level equal to their neighbors, and it is even less necessary for a culture whose commercial activities brought them into contact with most of the civilized world of the day.

Nabataean innovation did occur, where necessary, and many more examples of it may probably be advanced, but innovation may also be seen in the nature and level of technologies acquired from others, in the adaptations they made to them and in the execution of the choices they made. A discernible flavor, uniquely Nabataean, pervades their architecture — and the support technologies associated with it — as it does in the remarkable phenomenon of a previously semi-nomadic culture achieving predominance as a major international commercial kingdom and as a major socio-political force in the entire Middle East of their day.

Practicality appears to have ruled Nabataean architectural technology, as it appears also to have done in other facets of their history — trade, politics, and religion.

Obviously, it has neither been intended, nor been possible, to address all aspects of Nabataean architectural technology in this paper, but it is hoped it will provide a basis for more extensive research and for more assiduous attention to the technological aspects of all of Nabataean life.

Bibliography

Brünnow, R. and Domaszewski, A. von 1904. *Die Provincia Arabia, I.* Strassburg.

___ 1909. *Die Provincia Arabia, III.* Strassburg.

Creswell, K. A. C. 1958. *A Short Account of Early Muslim Architecture.* Oxford.

Dalman, G. 1911. The Khazneh at Petra. *PEQ*: 95-107.

Dentzer-Feydy, J. 1992. Le décor architectural en Transjordanie de la période hellénistique à la creation de la Province d'Arabie en 106. Pp. 227-232 in *Studies on the History and Archaeology of Jordan,* IV. Amman.

Drachman, A. G. 1963. *The Mechanical Technology of Greek and Roman Antiquity.* Copenhagen.

Forbes, R. J. 1955-1964. *Studies in Ancient Technology.* Leiden.

Glueck, N. 1965. *Deities and Dolphins.* New York.

Hachili, R. 1975. The Architecture of Nabataean Temples (Eng. title). *Eretz Israel* 12: 95-106.

Hammond, P. 1965. *Petra, the Excavation of the Main Theater at Petra, 1961-1962.* London.

___ 1973. *A History of the Nabataeans.* Studies in Mediterranean Archaeology. Lund.

___ 1975. Survey and Excavation at Petra 1973-1974. *ADAJ* 20: 5-30.

___ 1978. Excavations at Petra, 1975-1977. *ADAJ* 22: 81-101.

___ 1987. Three Workshops at Petra (Jordan). *PEQ*: 129-141.

Josephus, Flavius 1960. *The Antiquities of the Jews; The Wars of the Jews* (William Whiston, transl.). Kegel.

Landels, J. G. 1978. *Engineering in the Ancient World.* University of California.

Negev, A. 1961. Nabatean Inscriptions from 'Avdat (Oboda). *IEJ* 11: 127-138.

___ 1963. Nabatean Inscriptions from 'Avdat (Oboda). *IEJ* 13: 113-124.

___ 1986. Die Nabatäer. *Antike Welt*: 3-79.

___ 1988. *The Architecture of Mampsis, Final Report,* Volume I: *The Middle and Late Nabataean Periods. Qedem* 26; Volume II: *The Late Roman and Byzantine Periods. Qedem* 27.

Oleson, J. P. 1986. *Bronze Age, Greek and Roman Technology.* New York.

Parr, P. J. 1960. Excavations at Petra, 1958-59. *PEQ*: 124-130.

___ 1967-68. Recent Discoveries in the Sanctuary of the Qasr Bint Far'un at Petra, I. *ADAJ* 12-13: 5-19.

Patrich, J. 1990. *The Formation of Nabatean Art.* Leiden.

Schmidt-Colinet, A. 1990. Considerations sur les carrieres de Palmyre en Syrie. Ch. 7, pp. 88-92 in *Pierre éternelle du Nil au Rhin, carrieres et préfabrication.* Paris.

Soren, D. (ed.) 1987. *The Sanctuary of Apollo Hylates at Kourion, Cyprus.* Tuscon.

Strabo 1983. *Geography* (G. P. Goold, transl.). The Loeb Classical Library, Vol. 7. Cambridge, Mass.

Starcky, J. and Gawlikowski, M. 1985. *Palmyre.* Paris.

Villeneuve, F. 1986. Khirbet edh-Dharih (1985). *RB*: 247-252.

___1988. Fouilles à Khirbet edh-Dharih (Jordanie), 1984-1987: Un village, son sanctuaire et sa nécropole aux époqes nabatéenne et romaine (Ier-IVe siècles ap. J.-C.). Pp. 458-479 in *Comptes rendus des séances de l'année 1988,* Académie des Inscriptions et Belles-Lettres. Paris.

Vitruvius 1962. *De Architectura* (F. Granger, transl). Loeb Classics. Cambridge, Mass.

Wheeler, M. 1964. *Roman Art and Architecture.* New York.

White, K. D. 1984. *Greek and Roman Technology.* Ithaca.

Zayadine, F. 1970. Die Felsarchitektur Petras: Orientalische Traditionen und hellenistischer Einfluss. Pp. 212-248 in M. Lindner (ed.), *Petra und das Königreich der Nabatäer.* München.

___ 1986. Temple, Gräber, Töpferöfen. Pp. 214-169 in Die Ausgrabungen des Qasr El-Bint. Pp. 237-248 in M. Lindner (ed.), *Neue Ausgrabungen und Entdeckungen.* München.

___ 1987. Decorative Stucco at Petra and other Hellenistic Sites. Pp. 131-142 in A. Hadidi (ed.), *Studies in the History and Archaeology of Jordan,* III. Amman.