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Hydrologic and Topographic Change During and After Early Bronze Occupation at Bab edh-Dhra and Numeira

Synposis
Bab edh-Dhra and Numeira, two Early Bronze settlements, are located on alluvial fan surfaces within the tectonically active Dead Sea rift. Bab edh-Dhra, located on the south edge of the Wadi Kerak, had a much gentler topography and most probably an interior spring at the time of occupation by Early Bronze populations. Post-occupation fault movement has resulted in extensive erosion, especially of the northern edge of the site and loss of the interior spring. Numeira, situated on the south edge of Wadi Numeira, is presently some 50 m. above the Wadi Numeira stream. At the time of Early Bronze occupation the wadi stream flowed past the south side of the site and was a readily accessible water source. Fault movement and greatly increased erosion has resulted in loss of the northern half of the site. The stream, adjacent to the site in Early Bronze times, is now north of the site and some 50 m. lower.

Introduction

Archaeological geology, a new interdisciplinary field, can be described as the interface between archaeology and geology. The interaction between specialists from both fields often generates new information valuable to both disciplines. The archaeologist is primarily interested in cultural sequences and often does not have the training to evaluate the impact of the physical setting on the culture he is examining. For the geologist, the insertion of cultural dates offers a much finer temporal resolution with which to examine geological processes.

In the present paper, I hope to convey how archaeological geology is of use in a better understanding of the physical environment of the southeast Dead Sea Plain during and after Early Bronze time.

Regional geologic history

A brief sketch of the geologic history of the Dead Sea area is helpful before discussing details of the geology for Bab edh-Dhra and Numeira. The history for the region, although complex if examined in detail, can be divided into three major phases.

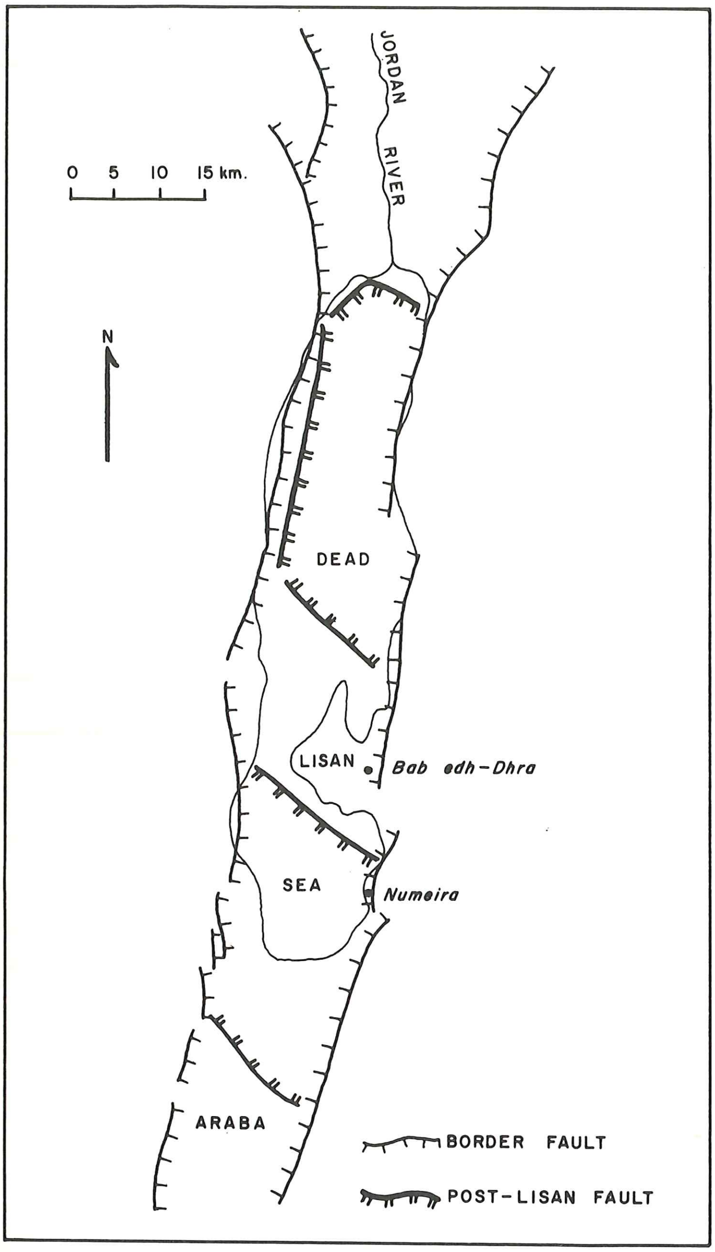
The oldest exposures in the area are Pre-Cambrian (older than 600 million years B.P.; B.P. means before present) igneous and metamorphic rock sequences within the Arabian Shield. They represent a period of mountain building associated with igneous activity. Topographic relief established during the Pre-Cambrian was largely eroded and removed before the end of that period. Thus, by the close of Precambrian time, the Arabian Shield, a low relief feature, was established (Bender 1974).

The second phase of history involves deposition of sedimentary rocks upon the Arabian Shield. The period of time involved is Cambrian (600–500 million years B.P.) through at least Eocene (55–38 million years B.P.). The area west and northwest of the present Dead Sea tended to be a site for marine sediments while terrestrial deposits were more common to the east and southeast (Bender 1975: 110). The Lower Paleozoic (600–345 million years B.P.) sedimentary rocks tend to be terrestrial reddish sandstones which have commonly been described as Nubian Sandstone (Burdon 1959). The Middle Paleozoic through Upper Mesozoic (345–66 million years B.P.) rocks show a change to light colored fine-grained sandstone and fine-grained limestones which can be fossilferous and/or cherty. These units commonly thicken toward the northeast; subsidence increased in that direction which was toward the Tethys geosyncline. The region to the southeast tended to remain a stable shelf, the Arabian Shield (Bender 1975).

In Oligocene (38–22.5 million years B.P.) or Miocene (22.5–6 million years B.P.) time, a radical change in tectonic style occurred. The Dead Sea–Jordan River rift valley developed; the center of this long narrow valley, extending from north of Lake Tiberias to the Gulf of Aqaba and the Red Sea, is a downdropped fault block or graben (FIG. 1). Major movement on the fault has been strike-slip or horizontal but enough vertical displacement has occurred to form the rift. The high-standing escarpments to the east and west are erosional remnants of the upthrown fault blocks. Sporadic earthquakes within the Dead Sea area indicate that fault movement is still taking place.

During Miocene and Pliocene (22.5–1.9 million years B.P.)

1. Tectonic map of the Dead Sea rift showing the location of Bab edh-Dhra and Numeira. Major displacement has occurred on the eastern and western, north–south border faults. A smaller amount of displacement has occurred on the east–west faults north and south of the Lisan Peninsula and at the Araba Escarpment after deposition of the Lisan Marl (After Neev and Emery, 1967).



time, a seaway connection apparently existed with the Mediterranean (Neev and Emery 1967) and perhaps the Red Sea. Marine limestones and evaporites were deposited along the central axis of the Dead Sea rift while conglomerates and sandstones were emplaced along the east and west border of the rift valley; alluvial fan deposits consisting of sediments transported from the adjacent high-standing escarpments. Before Pleistocene (1.9 million–12 thousand years B.P.) time, seaway connections were terminated but because of the predominantely arid climate in the region, evaporite deposition continued from fresh water. Alluvial fan sedimentation continues up to the present time along the margins of the rift.

Several deep wells (4,000 m.) have been drilled into the rift sedimentary sequences, but it was not possible to drill through the complete fill in the graben. Seismic methods have been used to estimate the thickness of the rift deposits. Nettleton (1948; 1958) estimated that the Dead Sea rift was filled with sediments to a depth of 3–6 km. Zak and Bentor (1972) using somewhat different assumptions, recalculated data from Nettleton (1958) and Nasr (1949) and estimated that the sedimentary fill reaches a depth of possibly 8–10 km.

The final sequence of events for the rift valley has involved the shrinkage of Lake Lisan, which filled a large portion of the valley from the Araba escarpment, south of the Dead Sea, to north of Lake Tiberias. The lake was present from about 60,000 years B.P. to 18,000 years B.P. (Begin, Erlich and Nathan 1974). Since that time, the shoreline has apparently retreated to the present position of the Dead Sea.

Geologic structure and especially the location of faults strongly control present topography within the southern Dead Sea valley. The prominent north–south faults which are responsible for the high standing eastern and western escarpments, have been active since perhaps Late Cretaceous (ca. 80 million years B.P.). The earlier movement is apparently predominately strike-slip; pronounced vertical movement did not occur until Late Pliocene (ca. 2.5 million years B.P.) time (Neev and Emery 1967; 21) when a thick sequence of sediments, evaporites in the center of the rift and sand and gravel on the margins, began to accumulate. Bender (1974; 1975; 120) places the first significant vertical movement somewhat earlier, Oligocene to Miocene (38–6 million years B.P.) with deposition of syntectonic, mildly deformed, sedimentary rocks within the rift. Bender (1975; 121) also states that evaporite deposition apparently began in Miocene time (22.5–6 million years B.P.); seismic records indicate an evaporite sequence at a depth of 4,000 m.

Although the data are not unequivocal, Neev and Emery (1967) suggest the presence of northwest trending faults on the north, west, and south borders of the north and south basin of the Dead Sea (FIG. 1). The Lisan Peninsula is interpreted as a high-standing horst structure. The Araba escarpment, 15 km. south of the Dead Sea, was formed by movement of the southernmost fault, a feature which is well documented from field evidence. Movement on these faults is thought to have occurred in Holocene time (less than 12,000 years B.P.), after deposition of the Late Pleistocene Lisan Formation. Interpretations discussed below suggest that differential movement has occurred on the fault bounding the southern border of the Lisan Peninsula since Early Bronze time.

The placement of wadi systems, presently eroding into the eastern escarpment, may also be fault controlled. Bender (1975) shows large fault traces in the position of Wadis Kerak, edh-Dhra, and Hasa. Shorter fault traces are also indicated in the position of Wadi Khanazir. No faults are located near Wadis Numeira or Feifa, but these may have been missed during fieldwork for preparation of the geologic map. It is reasonable that the present wadis would be located along fault zones; the faults provide a zone of weakness which would be preferentially eroded.

Regional setting of Bab edh-Dhra and Numeira

Bab edh-Dhra and Numeira are both located on alluvial fan surfaces just east of the Dead Sea. Bab edh-Dhra is adjacent to the Lisan Peninsula while Numeira is located east of the south basin of the Dead Sea (FIG. 1). In both cases, the sites are adjacent to wadis, the Wadi Kerak and the Wadi Numeira, which drain from the 1,000 m. high escarpment to the east. Both Early Bronze sites are situated on the south side and about 50 m. above the streams that presently flow through the respective wadis. The alluvial fans themselves consist of silts, sands and gravels that were transported from the eastern rift escarpment and deposited as coalescing fans on the margins of the Dead Sea Basin. Both fans are presently being eroded because of gradient changes in the wadi streams.

Pre-cultural stratigraphy at Bab edh-Dhra and Numeira

A number of pre-cultural stratigraphic units are exposed within the immediate vicinity of both sites. They range in age from possibly Oligocene up to Holocene (38 million years B.P.–present). The units were examined during field work at the sites and are as follows:

Bender (1975) describes a number of syntectonic units from the Dead Sea rift valley; sedimentary rocks which were mildly deformed contemporaneously with deposition by fault movement during development of the rift. They range in age from Oligocene to Miocene (38–6 million years B.P.) (Wetzel and Morton 1959; 167). They are only exposed at Bab edh-Dhra.

Four different lithologies are presently exposed along the floor of the Wadi Kerak. The syntectonic units in Wadi Kerak are gently folded with dips reaching a maximum of about 30°. Minor faults with small displacements are also present. No effort was made to measure thicknesses within these units as they probably were not exposed at the time of occupation at Bab edh-Dhra; they are not found in the cultural materials at the site.

The upper boundary of the syntectonic units is an eroded surface having an irregular relief; this surface may be responsible for the spring presently located near the wadi floor immediately below Bab edh-Dhra. At the spring itself, the contact between the syntectonic units and the overlying gravels is obscured by travertine deposits and vegetation. It probably is less than 10 m. above the wadi floor. In a downstream direction, 100 m. west of the spring, the contact is at a height of about 15 m. An additional 100 m. west, the contact has risen to a height of 25 m. The syntectonic units are fine-grained and relatively impermeable, while the overlying gravels are coarse and permeable and serve as a good aquifer. The spring located immediately beneath Bab edh-Dhra as well as the spring located in Wadi edh-Dhra, a tributary of Wadi Kerak located 100 m. northeast of Bab edh-Dhra, are caused by emergence of ground water flowing through gravels from the uplands to the east. Their emergence is probably caused by the rise in the syntectonic erosional surface at this point.

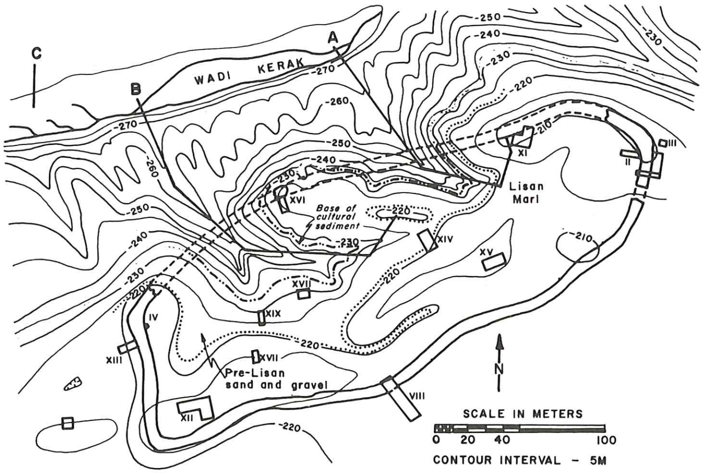
After erosion of the upper portion of the syntectonic units, renewed fault movement regenerated the eastern escarpment as a sediment source. Flat-lying gravel- to silt-sized sediments were deposited within the Bab edh-Dhra area during Middle Miocene through Middle Pleistocene time (15–1 million years B.P.).

Three stratigraphic sections were measured at Bab edh-Dhra to establish what types of sedimentary units are present in the area. Two of the sections, A and B, extend from the Wadi Kerak floor up tributaries into Bab edh-Dhra itself. A third section, C, was measured on the north side of Wadi Kerak, about 100 m. west of the beginning point for section B (FIG. 2).

Although the three sections are somewhat different, they show a generally similar depositional sequence. In all three sections, a coarse gravel including boulder-sized material with a sand- to silt-sized matrix is present above the syntectonic unit. The sediment is very poorly sorted with upper size limits of up to 90 or 100 cm. The gravel- to boulder-sized material is consistently well rounded. In all three sections, a fining upward or decrease in grain size is seen. The gravel is cemented by calcium carbonate, undoubtedly precipitated from ground water evaporation in this arid environment. Because of cementation, present erosion of the gravel produces vertical or very steep valley walls.

The gravels probably represent channel fills within an arid alluvial fan sequence (Doeglas 1962; Hook, 1967). After

2. Topographic map of Bab edh-Dhra showing location of site wall and excavation fields. Dashed continuation of wall line shows probable position before removal by erosion. Positions for stratigraphic sections A, B and C described in text are shown. Distribution of pre-Lisan sand and gravel and Lisan Marl are indicated. Finally, the position of cultural material at −223 m. and above is indicated in the western tributary of the site.



erosion of the underlying syntectonic units and uplift of the eastern escarpment, the present wadi system was probably established along fault zones in the escarpment. The gravels represent initial build-out by the ancestral Wadi Kerak.

In section C, a 10 m. sequence of well-sorted silt to sand overlies the coarse gravel. No cross-bedding was noted within the sequence. This may represent a lens of sheet flood deposit, emplaced by water flowing over the surface of the alluvial fan itself (Doeglas 1962). Overlying it is about 15 m. of medium- to fine-grained gravel with a sand matrix at some horizons. The relatively good sorting within this unit would again suggest sheet flood deposition with transport of coarser-grained sediment.

In sections A and B, about 15 m. of tan calcareous silt occurs at the level of sand and gravel in section C. At first glance this sequence, located on the side walls of the tributaries presently cutting into Bab edh-Dhra, appears to be part of the natural stratigraphy. Closer examination reveals the presence of abundant cultural materials: mudbrick, pottery sherds, fire lenses, and stone 'door sockets'. This material is actually a much younger cultural sediment deposited during Early Bronze time and now covering the natural stratigraphy on valley sides within the Bab edh-Dhra site.

The uppermost unit exposed in all three sections is the Lisan Marl; it ranges in thickness from 5 to 15 m. In section A, its base is concealed by overlapping, younger cultural sediment so total thickness is not known.

The Lisan Marl is characterized by alternations of white aragonite and dark detrital laminations. The white aragonite layers range from 0.5–1.5 cm., while the brown detrital clay layers vary from 1.5–3.0 cm. in thickness.

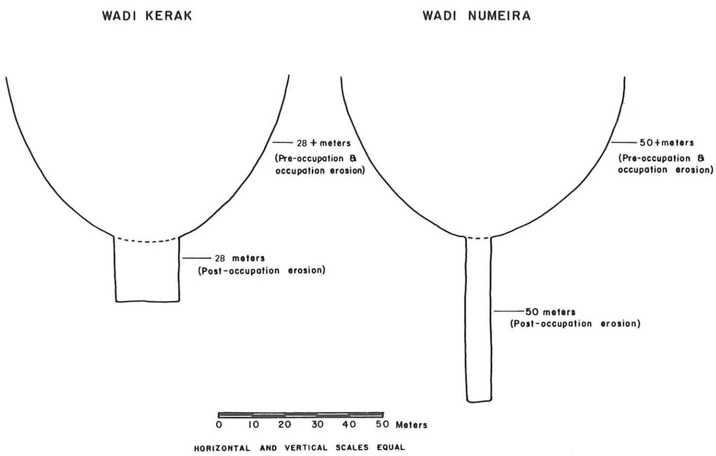
Pre-cultural stratigraphy at Numeira consists of much younger units. The Lisan Marl is not exposed and is probably a subsurface unit here. The south basin of the Dead Sea has been downdropped relative to the area of the Lisan Peninsula. The alluvial fan complex at Numeira is post-Lisan in age and consists of gravel- through silt-sized sediments similar to those deposited at Bab edh-Dhra below the Lake Lisan deposits.

Pre-cultural topography of Bab edh-Dhra

Detailed field work during the 1977 (Donahue 1981) and 1979 (Donahue 1982) field seasons of the Southeast Dead Sea Archaeological Expedition has made it possible to determine probable topography for the Bab edh-Dhra area before occupation. The site is located on the south edge of the Wadi Kerak and is being eroded by two tributaries which drain into the wadi. The western tributary drains a large part of the interior of the site with two east–west trending branches (FIG. 2). The head of the smaller eastern tributary is just breaching the northern edge of the site and has caused the erosion and removal of a portion of the northern wall of Bab edh-Dhra. This tributary is presently cutting into the nothern east–west branch of the western tributary.

Prior to and during occupation, the Wadi Kerak was shallower than at present by at least 28 m. This has been documented at two points in the wadi. The western tributary, where it enters the Wadi Kerak, has a gentle, bowl-shaped profile down to an elevation of −250 m. Below that elevation, the tributary is a narrow, deeply cut valley with vertical walls. A similar relationship can be seen about 500 m. east of Bab edh-Dhra on a profile across Wadi Kerak (FIG. 3). The wadi has a gentle, bowl-shaped profile or cross section down to an elevation of −250 m. and then vertical walls to −278 m., the elevation of the present wadi floor. Additionally, cultural or occupation sediment occurs down to elevations of −233 m. within the western tributary in Bab edh-Dhra (FIG. 2). Below that elevation, the tributary has a narrow, vertical-walled profile cut through non-cultural sediments. These observations suggest that prior to occupation, the Wadi Kerak was some 28 m. shallower than at present, with relatively gentle slopes leading down to the wadi floor. After occupation, uplift and rapid downcutting produced vertical walls in Wadi Kerak and its tributaries.

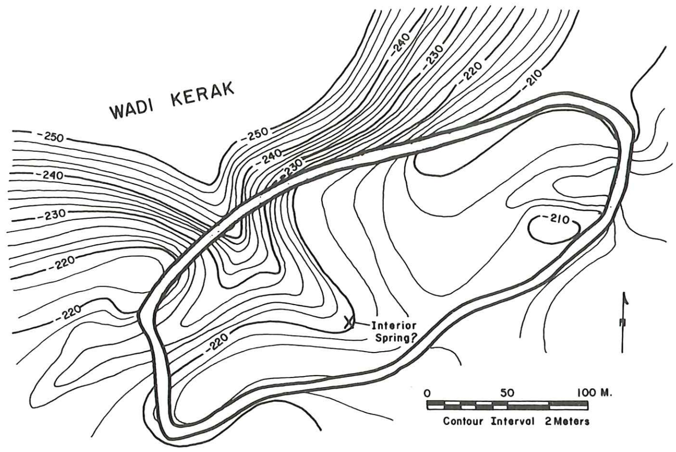
3. Profiles across Wadi Kerak and Wadi Numeira showing the upper bowl-shaped and lower straight-sided nature of each wadi. Wadi Kerak has had 28 m. and Wadi Numeira 50 m. of rapid downcutting.



The eastern, southern and western boundaries of Bab edh-Dhra, where a wall is still present, had approximately the same topography as is present today (FIG. 4). The eastern and especially the western edge of the site where the wall is now situated were somewhat lower than at present. Excavation along the eastern wall (Lapp 1966) demonstrates the existence of cultural sediment beneath the stone wall foundation. This area was built up in Early Bronze I and II before construction of the wall. The western wall is also probably situated on cultural material. The enclosed basin west of the wall is the head of a valley which drained into the western tributary of the site prior to wall construction.

The most dramatic topographic changes have occurred along the northern edge of Bab edh-Dhra. The slope leading down into Wadi Kerak was probably situated slightly north of its present position (compare Figure 2 and 4). The eastern

4. Probable topography at Bab edh-Dhra just prior to and during occupation. The position of the site wall and a possible interior spring are indicated.



tributary and Wadi edh-Dhra, just east of the site, were either minor tributaries or did not exist. The western tributary was present but was shallower by at least 28 m. and had relatively gentle side walls. Under these conditions, the ground water level in the area of Bab edh-Dhra would have been higher. It seems quite likely that the western tributary may have been initiated and eroded by a spring which was situated in the center of Bab edh-Dhra. This spring may have been present prior to and during occupation of the site.

The pre-occupation geology of the site has a relatively simple outcrop pattern and can be easily reconstructed (FIG. 2). Only three units crop out within the Bab edh-Dhra area. The older syntectonic units (Miocene to Pliocene) mentioned above would have only occurred in the subsurface during pre-occupation time, when Wadi Kerak was some 28 m. shallower than at present. From an elevation of about −250 m., the probable floor of Wadi Kerak, to −221 m. at a higher level, the sands and gravels above the syntectonic units were cropping out on the sides of the western tributary. These units are cemented by calcium carbonate precipitated from ground water evaporation and tend to form relatively steep slopes. The Lisan Marl crops out from −221 m. to about −208 m. elevation and would have been exposed over the southern and eastern portions of the site. The Lisan Marl is eroded rather easily and thus tends to form relatively gentle slopes. Finally the Lisan Marl is capped by a thin gravel interbed which is more resistant to erosion and tends to produce flat surfaces. In addition, two outcrops of fluvial sand are situated at the top of the Lisan Marl and form two small hills on the southwest and southeast portion of the site (FIG. 2).

Cultural modification of Bab edh-Dhra

Distribution and abundance of pottery types and other artifacts suggest that the maximum occupation density at Bab edh-Dhra occurred during Early Bronze III. The stone and mudbrick wall surrounding the site may not have been in place until Early Bronze III. Thus, in all probability, during Early Bronze I, and II, relatively limited human modification occurred in the region of Bab edh-Dhra. The area was apparently in a stage of aggradation with deposition of sediments occurring, rather than erosion. The western tributary was present and was being filled with sediments. The northern slope of the tributary preserves a record of this sedimentation with cultural material (fire or ash layers and pottery fragments) appearing at elevations above −233 m. In addition, cultural sediment is present beneath the stone wall on the eastern edge of the site (Lapp 1966). Thus, during Early Bronze I and II natural sedimentation, probably aided by cultural modification, was infilling at least the western tributary of the site. Wadi Kerak, the local base level for the area, was probably also aggrading at this time.

During Early Bronze III a more extensive cultural modification of the site occurred. Boulders moved from the alluvial fan surface in the vicinity of Bab edh-Dhra were used to construct a foundation for the wall which ringed Bab edh-Dhra. The foundation was then capped by a mudbrick wall. The eastern tributary was not present at this time and the wall most probably extended straight across the northern edge of the site. The western tributary was much shallower than at present and the wall extended across this low point, possibly with a gate for access to the wadi floor. The eastern and especially the western wall were built across minor drainages, causing impoundment and increased sedimentation. The flat areas within both the east and west wall of Bab edh-Dhra are depositional flats caused by blockage after wall construction.

Considerable boulder and mudbrick wall construction occurred during Early Bronze III, both on high points and on slopes and tributary bottoms. Although excavation has not proceeded far enough to be certain, there is a suggestion that the slopes of the western tributary might have been terraced. The net effect of this construction was to halt erosion and in fact promote sedimentation or infilling, especially within the western tributary. Up to and perhaps in excess of 10 m. of cultural sediment, including mudbrick wall, can still be seen along the slopes of the western tributary. The area of the western tributary is still largely unexplored; future excavation will allow a much better definition of conditions within Bab edh-Dhra during Early Bronze III.

Conditions during Early Bronze IV are unclear but there is a suggestion that occupational density was not as great as in Early Bronze III. The major mudbrick walls exposed thus far appear to be mainly associated with the Early Bronze III phase, suggesting that the Early Bronze IV people did not make heavy use of the town site, although they established a considerable settlement in areas beyond the site (T. Schaub, personal communication). The town area was apparently in a state of ruin during this phase, with Early Bronze IV recorded mainly as pottery fragments occurring in slope wash sediments overlying *in situ* Early Bronze III walls. Their position in transported slope or sheet wash sediment suggests that the site was being subjected to greatly increased erosion. The ultimate cause of this was most probably fault movement, with uplift of the area, and thus an increased stream gradient for Wadi Kerak. The result would be downcutting within Wadi Kerak as well as within the tributaries leading into the wadi. If, as suggested here, fault movement and uplift occurred during Early Bronze IV, the occupants of this phase would have found themselves facing two possible problems. First would be a change from aggradation to degradation or active erosion, causing a loss of the northern wall of Bab edh-Dhra. Secondly, there may have been the decrease or complete loss of spring activity within the site. Both factors may have been present already at the time the Early Bronze IV people decided to settle at some distance away from the Early Bronze III site.

Patterns of post-cultural erosion and deposition

As noted under the section of pre-occupational topography, Bab edh-Dhra, especially the northern half of the site, has been strongly affected by erosion. During occupation the site was in a stage of aggradation. That is, sediments were being deposited, primarily in the Wadi Kerak, outside the site, in the relatively shallow western tributary within the site, and within the depositional flats inside both the east and west walls of Bab edh-Dhra. Although no specific data have yet come to light documenting fault movement, the change from an aggradational to a degradational or erosional regime was most likely caused by fault movement and uplift of the area around Wadi Kerak. This movement would lower the base level for Wadi Kerak and initiate erosion in the wadi and its tributaries. As mentioned above, at least 28 m. of downcutting has occurred within Wadi Kerak.

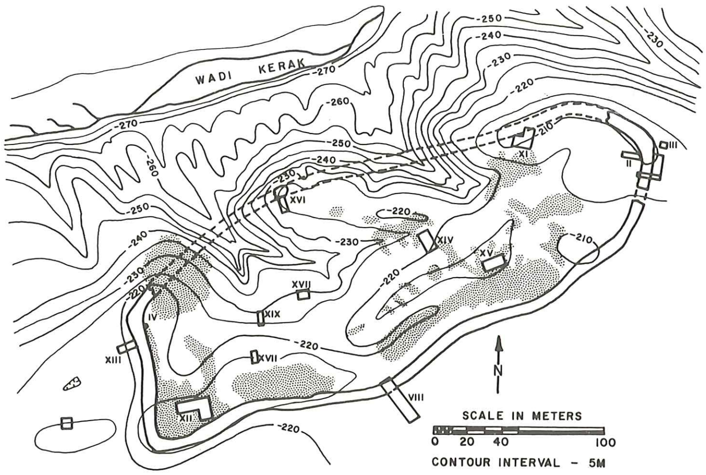
After fault movement, the western tributary was affected by downcutting, producing a narrow, straight-walled canyon which cuts down through the syntectonic units now exposed in the tributary and Wadi Kerak. This downcutting undoubtedly breached the foundations for the north wall, removing it where it crossed the western tributary. At the same time, the eastern tributary extended by headward erosion and breached the eastern half of the north wall. The entire southern slope of Wadi Kerak was probably also moving southward through erosion so that the boulder foundation for the northern wall eventually rolled downslope.

Post-cultural erosional facies

A number of degradational or erosional facies are present within Bab edh-Dhra and when their significance is understood, they are quite valuable in 'reconstructing' the site, especially during Early Bronze III.

1. Boulder fields

There are numerous large cobbles and boulders distributed within the walls of Bab edh-Dhra. At first glance, these appear to be natural accumulations of rock on the alluvial fan surface such as are seen at many points outside the confines of Bab edh-Dhra (FIG. 5). Once the natural or pre-occupation stratigraphy is examined, however, it becomes obvious that there



5. Location of boulder concentrations at Bab edh-Dhra. Comparison with figure 2 shows that most concentrations are located within the Lisan Marl outcrop which is a fine-grained calcareous sediment not containing boulders or cobbles. Rectangles with Roman numerals indicate excavation fields.

is no source for rocks of this size in the area of the site. The only units outcropping at this elevation consist either of Lisan Marl or alluvial deposits consisting of fine gravel and sand. The areas with cobble and boulder accumulations then, represent material transported by the Early Bronze people for use within the site, most probably for stone foundations for buildings which are now totally gone. This is especially obvious along the east–west ridge in the center of the site where a number of the boulder fields show a linear distribution. Field examination shows these to be obvious stone wall foundations. The boulder concentrations especially in the eastern half of Bab edh-Dhra must represent stone foundations and buildings which have been disrupted and transported downslope. Erosion and transport have been so extensive that original wall lines are no longer detectable.

2. Mudbrick detritus along the site wall

Where excavation has been done adjacent to the stone wall around Bab edh-Dhra, a distinctive degradational facies can be seen. This consists of whole and fragmented mudbricks contained within a fine-grained matrix which probably represents degraded mudbrick. Over most of the area of the extant stone wall and especially on the outer side, a slope exists; excavation into this slope should reveal the presence of a degraded mudbrick facies. As discussed earlier (Donahue 1981), the stone wall around Bab edh-Dhra was most probably capped by mudbrick. Erosion by intermittent rain storms and perhaps human destruction has resulted in removal of the mudbrick from the stone wall and deposition of mudbrick detritus, especially on the outside of the wall. Since working at Bab edh-Dhra, I have had the opportunity of visiting coastal Peru where a similar type of construction was used by pre-Inca cultures (Moche and Chemu). In Peru, however, a mudbrick wall is often still in position over a stone foundation. Where the mudbrick wall has been eroded, a mudbrick detrital slope is often present along the edge of the stone wall foundation.

3. Sheet wash

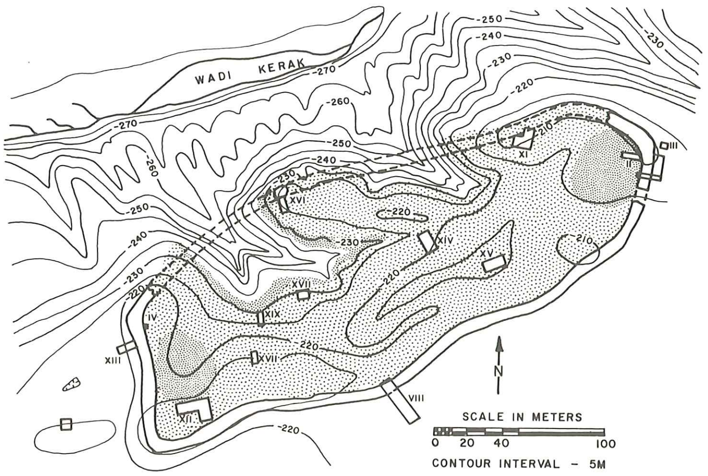
These are fine- to coarse-grained poorly-sorted and crudely stratified deposits which typically contain pottery sherds and cobbles. They are usually upper or surface deposits at most fields. The layering is typically at an angle with the upslope being in the direction of the source for the wash. They are generated by downslope movement of sediment over degraded mudbrick structures during intermittent rain storms and cap the intermediate and lower elevation slopes at Bab edh-Dhra. The deposits are typically 10 to 100 cm. thick and must be removed to reach *in situ* deposits. They are, of course, absent on hill tops and tend to increase in thickness downslope, except where vertical slopes exist. This is a characteristic, widespread deposit and its presence can be observed at all excavation fields.

Present distribution of cultural material at Bab edh-Dhra

This section is an attempt to predict distribution of the remaining *in situ* cultural deposits at Bab edh-Dhra. This should assist in planning the best locations to site fields for further excavation. The prediction is based entirely on field observations and the insight gained of pre-cultural stratigraphy as well as the cultural overlay at the site.

There are several key areas where cultural materials still remain at Bab edh-Dhra (FIG. 6). As noted previously, the northern edge of the site has suffered considerable erosion. The northeast corner of the site contains a thin veneer of cultural material. Moving westward, the eastern tributary is post-occupational in nature and its head is presently cutting into the site; the erosion caused by this tributary has removed all cultural remains. The ridge in the north-central part of the site contains cultural material on its western end. It's central and eastern end appear to be largely non-cultural. The western tributary has been eroded through a cultural sequence; it is largely non-cultural especially at lower elevations where it enters Wadi Kerak. The tributary itself contains a thick wash of transported cultural debris and non-cultural sediment.

Along the central and southern portion of Bab edh-Dhra, the higher elevations may have thin cultural veneers. These areas have been subject to continued erosion so that most cultural material has been removed. The most likely areas for thicker *in situ* cultural deposits are along the slopes leading into the western tributary and especially at lower elevations near the tributary itself (FIG. 6). The entire slope area is covered by sheet wash deposits but excavation through this on both the north and south slope of the tributary during the 1979 season located *in situ* wall lines. Preliminary excavation during the 1979 and 1981 seasons has yielded profitable results. The north and south branches of the western tributary should also yield cultural deposits but these may be thinner.



6. Probable location of *in situ* cultural material at Bab edh-Dhra. More intense stippling indicates where thicker cultural sequences are to be found. Note that the western and eastern tributaries have eroded completely through the cultural sequences. Rectangles with Roman numerals indicate excavation fields.

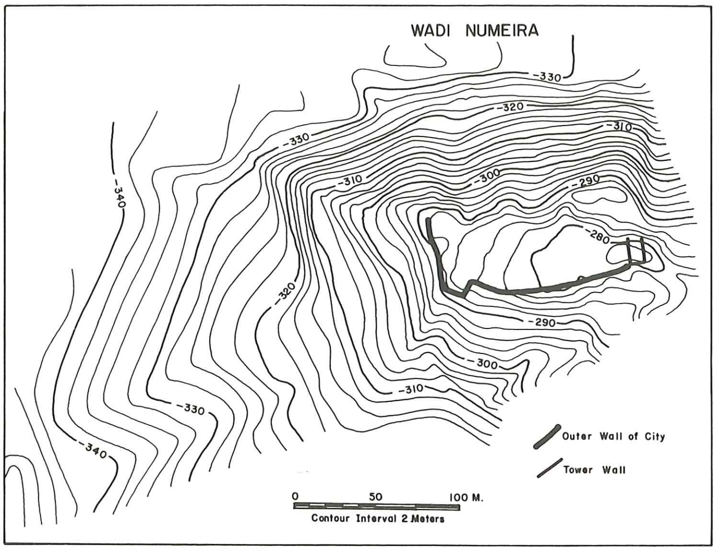
Finally, the depositional flats inside the east and west walls offer an excellent potential for thick cultural sequences. Both areas have been depositional sites and may cover an appreciable cultural sequence (up to 3.5 m.). Field IV is located on the north edge of the western depositional flat and has exposed over 3.5 m. of deposit with mudbrick wall at its base. The cultural material contained in these areas depends on whether sediment deposition was largely post-occupational or was contemporaneous with occupation.

Pre-cultural and cultural topography of Numeira

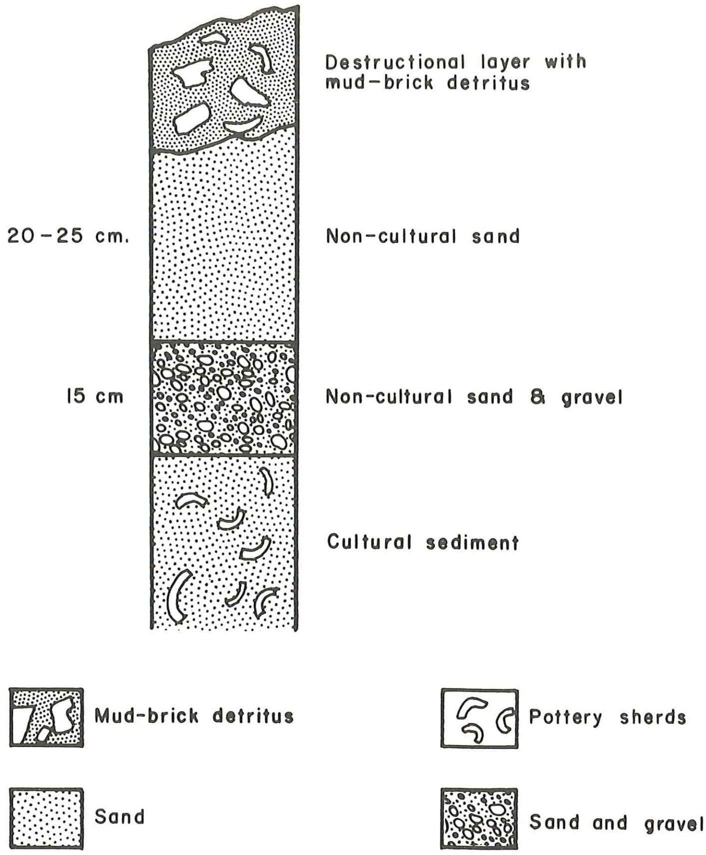
The Early Bronze occupants that settled in Numeira moved into a topographic setting markedly different from that seen today (FIG. 7). This statement is based on several lines of field evidence as given below.

The profile or cross-section of Wadi Numeira demonstrates that a significant increase in downcutting occurred later in its evolution. Thus, the lower 50 m. of the Wadi is quite narrow (5 to 20 m. wide in most areas) and straight sided (FIG. 3). About ½ km. within the wadi, a series of waterfalls occur showing that downcutting is still occurring. The narrow, straight-sided nature of the lower portion of the wadi indicates that a sudden change in gradient occurred, probably caused by fault movement. Either uplift of the highlands to the east or downdropping of the rift to the west caused a sharp increase in wadi stream gradient with resultant rapid downcutting. Whether this was the result of one large movement or a series of small movements is not known.

By contrast, the cross-section of the upper portion of Wadi Numeira is gentle and bowl-shaped. This indicates a long period of erosion without drastic gradient changes. Thus, Wadi Numeira has been affected by two different sequences of erosional history, an earlier, long lasting erosion which developed the upper, 'bowl-shaped' cross-section and a more



7. Present topography at Numeira showing truncation of wall line and tower. The dry valley south and east of the site is also truncated by the steep drop to the present Wadi Numeira stream.



8. Stratigraphic section excavated at the outside base of the Numeira tower showing a basal occupation layer, sterile stream gravel and sand and an upper destructional layer.

recent, rapid downcutting which produced the narrow, straight-sided lower half of the wadi. This is quite similar to, and even more striking than the topography of the Wadi Kerak seen at Bab edh-Dhra.

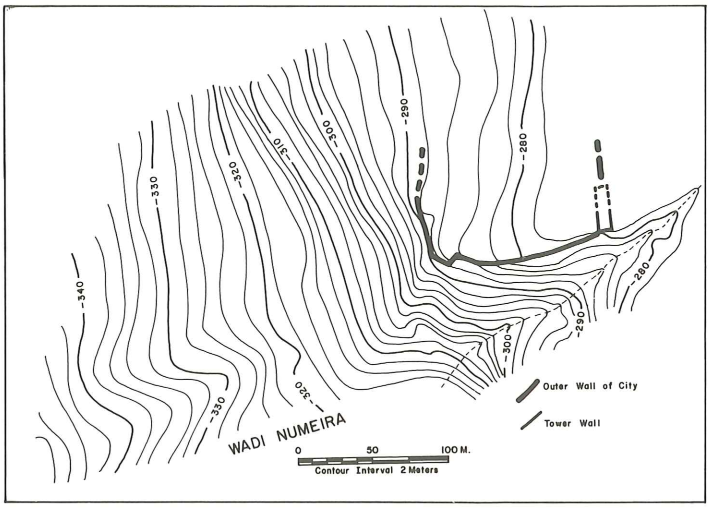
The increased erosional rate that generated the lower part of Wadi Numeira was also responsible for removing the northern half of the alluvial fan on which the Numeira site is situated. The present 50 m. drop from the site of Numeira down to the Wadi Numeira stream was not present before the above described erosion occurred. The alluvial fan probably had a smooth surface extending north to a small erosional remnant of the fan located to the north of the mouth of Wadi Numeira. Thus, the timing of the erosion becomes critical in reconstruction of the physical setting prior to and during occupation of Numeira.

The archaeological excavations carried out at Numeira during the 1981 field season uncovered several data points that strongly suggest that the extensive erosion of the alluvial fan is post-occupational. The first of these is the excavation of wall and building lines on the north edge of the site. The wall and building lines extend up to and are truncated by the slope edge at the 50 m. drop down to the Wadi Numeira stream (FIG. 7). The tower on the east side of Numeira is also truncated where it abuts on the slope down to the wadi stream. Finally, a small dry stream valley located just east of the tower is truncated on its up gradient end by the above-mentioned slope.

The most significant section exposed at Numeira is an interbedded sequence of cultural sediment, sterile gravel and sand, and destructional rubble located on the east side of the tower (FIG. 8). The 35 to 40 cm. of sand and gravel contain no large cultural material and directly overlie an occupational floor. The occupational floor is apparently contemporaneous with the tower. The sterile sand and gravel is, in turn, overlain by destructional debris, apparently from the tower. Thin sections were prepared from the sand for microscopic examination. It consists of sand- to granule-sized (from 0.5 to 3 mm.) grains of quartz, limestone and chert. The grains are rounded and the limestone fragments, especially, exhibit a weathering rind. These characteristics are identical to sands examined from the streams in the Wadis Numeira and Kerak (Beynon 1981; Beynon and Donahue 1982). Thus this sand is fluvial in nature and was deposited during the time of occupation at Numeira.

The sand thins away from the tower downslope into the dry stream valley just east of the tower. These patches of sand are found in other portions of the dry valley. The above data strongly suggests that a stream was flowing in the valley during occupation of the site. As mentioned above, this valley's head is truncated by the erosional slope leading down to the present Wadi Numeira stream. The gradient of the valley, from its truncated head down to the edge of the alluvial fan, is smooth and gradual, supporting the contention that a stream was flowing in the valley.

Putting all the field evidence together, a topographic reconstruction of the Numeira alluvial fan prior to and during occupation is as follows. The Wadi Numeira was some 50 m.



9. Topographic reconstruction of Numeira showing probable extension of site to the north before erosion by the Wadi Numeira stream. The most likely position for the stream during Early Bronze III time is indicated by the dashed line.

shallower than at present with a bowl-shaped cross-section and relatively gentle gradient. The wadi stream flowed out across a flat continuous alluvial fan surface which had been deposited after termination of Lake Lisan. The Early Bronze occupants of Numeira built their site on the banks of this stream and had ready access to a water supply (FIG. 9). The physical setting of the site during Early Bronze time was reasonably attractive with a convenient, nearby water supply and a high, flat alluvial fan surface with a good observational position.

Post-cultural changes at Numeira

Numeira has a short occupational sequence during just a portion of Early Bronze III time and is terminated by one or possibly two closely spaced, destructional sequences. Three individuals found adjacent to the tower during the 1981 excavations apparently had their demise by collapse of a portion of the tower. There is no direct evidence for warfare during destructions. It is suggested here that the tower collapse and extensive burn layers over the site were caused by an earthquake generated by fault movement. The epicenter or fault movement may have been distant from Numeira, but vibrations caused by such movement could easily have caused partial collapse of the tower and buildings. Actual fissures would not necessarily be generated by such a movement. The extensive burn layer was probably caused by collapse and ignition of wooden roofing materials.

After occupation, the major change that has occurred at Numeira is downcutting and erosion of the northern half of the alluvial fan on which the site is located (FIG. 7). This is in direct response to an increased gradient in the Wadi Numeira, probably caused by fault movements along the eastern border fault of the Dead Sea rift. The wadi stream which originally flowed past the site of Numeira shifted its course slightly northward and eroded the northern half of the alluvial fan. The exact timing of this erosion and how much of the northern portion of Numeira has been destroyed by erosion is not known.

Acknowledgements

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