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Relation Between Paleoclimate and the Settlement of Southern Jordan during the Nabataean, Roman and Byzantine Periods

Introduction

Harlan has described the Wādī al-Ḥasa region as marginal for farming but stable for grazing and, as such, it would be the first "to empty out" and the last "to fill up" compared to more favourable regions (1988: 46). He thought that the Wādī al-Ḥasa watershed would probably not be farmed unless more favourable sites to the north or on the west bank were fully occupied. With depopulation of the more favourable regions, farmers of the Wādī al-Ḥasa area would abandon their fields and villages and move to better locations. Based on this thinking, Harlan writes: "it was probably a 'filling up'" elsewhere that caused the Nabataeans to move into the desert and attempt to farm in areas of 100-150 mm annual rainfall" (1988: 46). He concludes by stating: "I find no evidence that the 'filling up'" during the Nabataean-Roman times was accompanied by an improvement in climate" (1988: 47).

Despite Harlan's position, I have been intrigued, for the past number of years, by the number of Nabataean/ Roman and Byzantine sites in areas surveyed by both the Wādī al-Ḥasa (MacDonald *et al.* 1988) and the Southern Ghors and Northeast 'Arabah Archaeological Surveys (MacDonald *et al.* 1992). I have wondered whether or not the presence of so many sites from the periods under discussion in areas that are today almost devoid of human population may indeed be explained, at least in part, by climatic conditions.

One of the most noteworthy, and perhaps celebrated, recent attempts to relate climatic change to the history of the Ancient Near East is the work of Weiss *et al.* at Tell Leilan and neighbouring sites in the Habur Plains of northeastern Syria (1993). The site in question, at one time a northern city in Mesopotamia's Akkadian Empire, along with a number of other sites in the region, was abandoned around 2200 BC. The traditional interpretations of history have attributed this abandonment to human activities. More recent archaeological and soil-stratigraphic data indicate, however, that a marked increase in aridity and wind circulation induced a considerable degradation of land-use conditions, in other words, a severe drought. This change in climate was probably the cause, in the opinion of Weiss *et al.*, of the abandonment of Tell Leilan, regional desertion, large-scale population dislocation, and the eventual collapse of the Akkadian empire (1993; see also Issar 1995: 352-54).[1]

It is generally agreed that archaeological data does not suffice on its own as an indicator of paleoclimates. Other evidence, for example, palynology, paleomorphology, faunal remains, and dendrochronology, must also be taken into consideration (see, for example, Henry 1985; Henry and Turnbull 1985; Rosen 1995; Munro *et al.* 1997). In fact, the interpretation of paleoclimates should be based on multidisciplinary studies. It must be noted, however, that natural evidence such as pollen and paleomorphology, does not always record pure climatic events. Natural evidence may also suffer from human interference such as deforestation and agriculture (Frumkin *et al.* 1994: 315).

Settlement in Southern Jordan and the Negeb during the Nabataean, Roman and Byzantine Periods

Archaeological surveys south of Wādī al-Ḥasa, e.g., Glueck (1934, 1935, 1939); Jobling in the Ḥisma (1984, 1989); Hart between aṭ-Ṭafīla and Rās an-Naqab (Hart and Faulkner 1985; Hart 1987); King *et al.* in the northern 'Arabah (1987, 1989; King 1985, 1986); MacDonald *et al.* along the south bank of Wādī al-Ḥasa (1988) and in the Southern Ghors and Northeast 'Arabah (1992); Parker for the southern segment of the Roman frontier (1976, 1986); and, more recently, Smith in the southeastern Wādī

[1] Weiss *et al.* (1993), however, were not the first to point out the drought conditions were probably the agency that accounts for a number of collapses of civilizations in the Ancient Near East. In fact, in 1966, British archaelogist James Mellaart had blamed drought for the downfalls of a whole spectrum of third-millennium civilizations, from the Early Bronze Age communities in Palestine to the pyramid builders of Egypt's Old Kingdom. When Mellaart put forth his hypothesis, however, he did not have much in the way of data to back him (Wright 1998: 96).

'Arabah (1994; Smith and Niemi 1994; Smith *et al.* 1997), indicate a "filling up" relative to the previous Persian-Hellenistic periods and an "emptying out" at the beginning of the Early Islamic period. Data from both the Wādī al-Ḥasa Survey (Table 1) and the Southern Ghors and Northeast 'Arabah Survey (Table 2) reflects this general trend.[2] Furthermore, Petra may have sharply declined in the mid-sixth century, never to recover (Schick 1994: 154). As well, there are indications from excavations at al-Ḥumayma that the population in the late sixth century and later was smaller than it had been earlier in the Byzantine period and a virtual cessation of habitation after the mid-eighth century (Oleson 1997: 176). During this same time period, there was an enormous development of irrigation and agricultural systems of the Nabataean and Byzantine cities of the Negeb and the Beer Sheba Plain that reached its peak in the fifth century (Issar 1995: 351 and 352-53, fig. 2). Can this "filling up," contrary to the position of Harlan, be explained, at least in part, by a cooler and more humid climate than today's? Moreover, can the "emptying out" at the beginning of the Early Islamic period be due, again, at least in part, to climatic conditions?[3] It is important to point out that even without

TABLE 1. Number of Hellenistic to Early Islamic Sites of the Wādī al-Ḥasa Archaeological Survey (1979-1983).

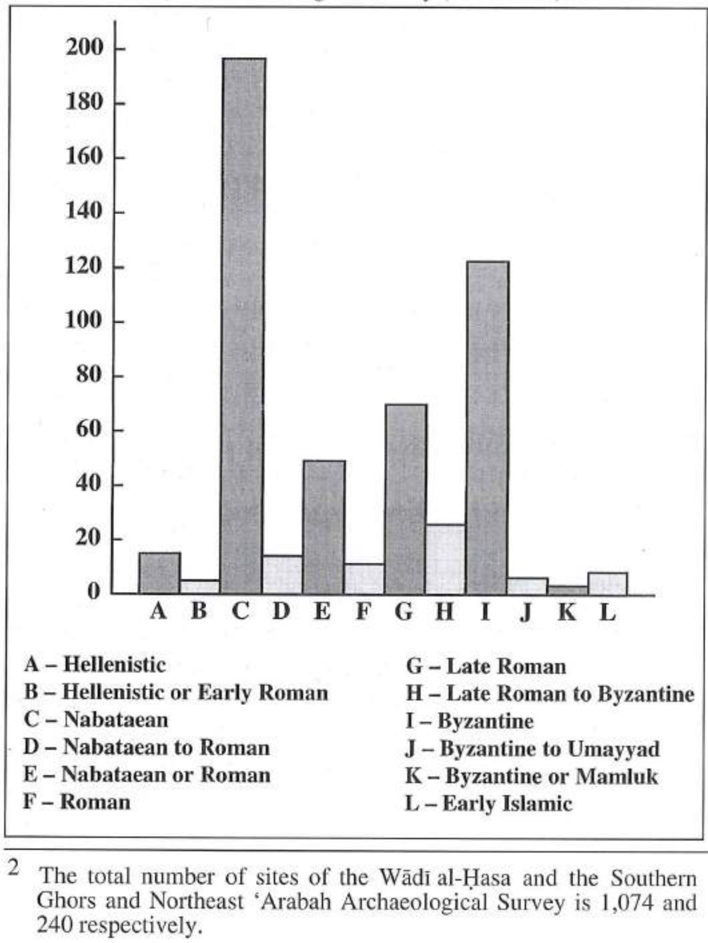
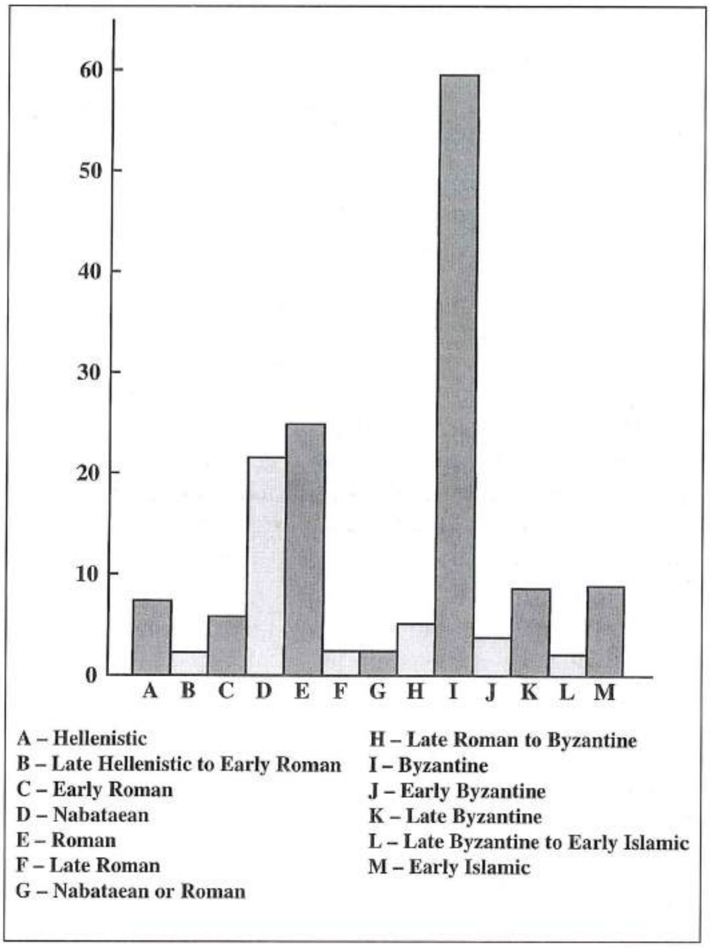


TABLE 2. Number of Hellenistic to Early Islamic Sites of the Southern Ghors and Northeast 'Arabah Archaeological Survey (1985-1986).



major climatic changes the region can become inhabitable due to droughts (Koucky 1987: 18).

Evidence for the Climate of Southern Jordan and the Negeb during the Nabataean, Roman and Byzantine Periods

Work is just beginning on the paleoclimates of Southern Jordan (see, for example, Jobling 1984; Henry 1985, 1994; Clark 1992; Schuldenrein and Clark 1994; Munro, Morgan and Jobling 1997; Barker *et al.* 1998). Of this work, only the findings of Jobling (1984) and Barker *et al.* (1998) on the Nabataean to Byzantine periods are immediately relevant.

Morgan, working with the 'Aqaba-Ma'ān Archaeological and Epigraphic Survey, generated a preliminary generalized time chart for the al-'Aqaba to Ma'ān area. With his chart, he attempts to show the perceived relative rainfall against time. From his work and the findings of other authors he concludes that the times of favourable climate,

2 The total number of sites of the Wādī al-Ḥasa and the Southern Ghors and Northeast 'Arabah Archaeological Survey is 1,074 and 240 respectively.

3 An exception to the above is the case for al-'Aqaba (see, for example, Parker 1997; Whitcomb 1997).

that is, those with higher rainfall, are paralleled with times of greatest occupation (Jobling 1984: 195). According to Morgan's findings, the Nabataean to Roman periods experienced a moister climate than periods either before or after (Jobling 1984: 196, Fig. 2).

Preliminary interpretation of coring by The British Institute at Amman for Archaeology and History in Wādī Faynān, specifically at Khirbat Barqā, indicates that "a considerable environmental change has occurred in the study area during the past 2500 years" (Barker *et al.* 1998: 23). The base of the core is dated to 2500 BP and indications are that aridification occurred around 200 AD: "Preliminary pollen analysis ... indicates a relatively stable steppic landscape for a considerable period, followed by a much more desertic landscape in which cereal cultivation was minimal" (Barker *et al.* 1998: 25).

In contrast to the above, a great deal of work has been done on the paleoclimates of Israel, especially in the southern part of the country and in the area of the Dead Sea (see, for example, Horowitz 1971, 1974, 1978, 1979; Marks 1976; Goldberg 1981, 1984, 1986, 1995; Goldberg and Bar-Yosef 1982; Issar and Bruins 1983; el-Moslimany 1994; Goodfriend and Magaritz 1988; Frumkin *et al.* 1991, 1994; Frumkin 1997). One, thus, has often to extrapolate from information about paleoclimates to the west of the 'Arabah, the Dead Sea, and the Jordan River and make judgments relative to climatic conditions in Jordan.

Present evidence indicates that in the Levant the climate became colder, that is, colder than the present, beginning between around 300 and 200 BC. Evidence for this is based on a number of studies.

One piece of evidence which supports a colder and wetter climate at the beginning of the periods in question comes from the study of isotopes from wood, in this case, tamarisk, buried in the Roman siege ramp of Masada. The study points out that the cellulose of the tamarisk trees, buried in the ramp, was depleted in carbon-13 (C13) isotopes, compared to the cellulose of the contemporary trees sampled in the same region. It noted, moreover, that the C13 composition of the ancient trees resembled the composition of the trees of the more humid central part of Israel. The depletion in this isotope supports the conclusion that the whole region had enjoyed a more humid climate during the time that these ancient trees thrived. Meteorological observations during the last century have shown that rainy years in this region coincided with colder years and *vice versa*. The final conclusion is that about two thousand years ago, the climate of Masada was colder (Issar 1990; Issar and Yakir 1997: 102).

Heim *et al.* (1997) have obtained sedimentological and palynological evidence for climatic conditions over the past 2500 years from a 3.6 m core (DS 7-1 SC), drilled in 1993, in the floor of the Dead Sea just to the Northeast of 'Ayn Gedi. Pollen obtained from the core includes cereals, olive, walnut, and grape. This, in the opinion of the authors, supports intensive cultivation of these Mediterranean plants (Heim *et al.* 1997: 399). Specifically, walnut and grape were grown, in particular, during the Roman and Byzantine periods (ca. 70 BC-AD 600). Following these periods, the pollen record indicates an abandonment of agriculture with reduced percentages of olive and a slight increase in natural, more arid Irano-Turanian vegetation (Heim *et al.* 1997: 399). This decline in agriculture triggered a process of forest regeneration starting with pine tree followed by evergreen oaks and other Mediterranean plants replacing olive in the hills around the Dead Sea (Heim *et al.* 1997: 399). The drier climate favoured transition from sedentarism to pastoralism (Heim *et al.* 1997: 399). 14C radiometric age determination of four embedded plant fragments date the lower laminated sequence of core DS 7-1 SC to around 2000 BP (Heim *et al.* 1997: 399). In summary, the palynological evidence, that is, the Roman period cultivation patterns during the lower laminated interval and AMS 14C radiometric age determinations as well as the sedimentological aspects, suggests a less arid period ca. 2000 BP. In the opinion of Heim *et al.*, this period continued until ca. AD 700 +/- 50-100 years (1997: 41, fig. 3).

There is additional evidence for a more humid climate during the periods of interest here. That evidence comes in the form of the changes of water levels of terminal lakes which are good indicators of past climate variations. These terminal lakes reflect the combined effect of precipitation and evaporation. The Dead Sea is such a lake.

Frumkin *et al.* (1991; see also Frumkin 1997), moreover, present a comprehensive climate record for the Holocene derived from the salt caves of Mount Sedom, an 11 x 1.5 km north-south ridge near the southwestern boundary of the Dead Sea. Mount Sedom, a salt diapir, has been rising above the local base level throughout the Holocene. Karst development within the salt body has kept pace with the rise forming subhorizontal cave passages with vertical shafts. Wood fragments found embedded in flood sediments that were deposited in the cave passages yielded 14C ages ranging from ca. 7100 to 200 BP (Frumkin *et al.* 1991; Frumkin 1997).

Frumkin *et al.*'s palaeoclimatic sequence is based on parameters that include: 1) relative abundance of plant types or floral communities; 2) the elevations of the corresponding cave passages; and 3) the ration of their width to present passage width (1991). They posit that passage width and morphology can be used as a palaeoclimatic indicator for changes in the Dead Sea level. During moist periods the water level rises, and with it cave passages rise and their width increases. More plant remains are deposited with the alluvium (1991: 194). 14C measurements were made on cellulose extracted from the wood samples (Frumkin *et al.* 1991: 194).

Frumkin *et al.* correlated the results to the Holocene sedimentary sequence of the Dead Sea Basin and other features associated with shifting lake levels. They found that moister climatic stages are indicated by relatively abundant wood remains, by wide cave passage, and by elevated outlets indicating high Dead Sea level. Conversely, they found that arid periods are marked by a scarcity of wood remains, by narrow cave passages, and by low-level outlets (1991: 191). As a result of the study, Frumkin *et al.* distinguished ten climatic stages, the chronology of which is based on 33 14C dates on wood, derived from flood sediments deposited in the various cave passages (1991; Frumkin 1997: 240; see also Bruins 1994: 302).

On the basis of the work of Frumkin *et al.*, it appears that climate was quite dry at the beginning of the Early Nabataean period, as the average Dead Sea level stood at ca. - 400 metres. It is important to note, nevertheless, that during this dry phase rainfall must have been adequate for Nabataean occupation in the southern Levant.

A change towards increasing humidity, which began during the second half of the Early Nabatean period, that is, ca. 190 BC, continued during the first half of the Roman period. In the southern Levant, the Roman period coincided with a relatively wet phase (Frumkin *et al.* 1991: fig. 12; Frumkin 1997: 244). Issar (1990) compares the Roman period with a miniglacial. According to the curve of Frumkin *et al.* (1991), the overall wet period during Roman times reached its average peak ca. AD 90. This position is supported by literary sources, namely, rabbinical sources in the Mishna and Talmud, which indicate that crop yields were very high in the wetter part of the Levant during the first century AD (Bruins 1994: 307).

In the second century AD, the climate began its drier trend, according to Frumkin *et al.* (1994, fig. 6; Frumkin 1997, fig. 22-4). This is supported by literary sources that attest to gradual desiccation and a sharp drop in crop yields during the third century (Bruins 1994: 307-8).

The Byzantine period began in AD 324, when the climate was significantly drier than during the first century BC and first century AD. The climate gradually became more arid in the course of the Byzantine period (Frumkin *et al.* 1994: 323, fig. 6; Frumkin 1997: 240, fig. 22-4).[4]

Dry conditions prevailed throughout the first half of the Early Islamic period until ca. AD 850, as indicated by the average Dead Sea level of ca. - 399 m. Several additional pieces of evidence, for example, the ratio between the isotopes oxygen-18 and oxygen-16 in carbonate deposits of lakes and caves, support a change in climate during the period under consideration. Low levels of oxygen-18 indicate that the ambient temperatures were low when the carbonates were deposited. A recent study of oxygen-18 levels in speleothems (stalagmites) in caves of upper Galilee reveals that there was an abrupt increase in temperatures between AD 700 and 900 (Issar 1995: 352).

Additional support for climatic change at this time comes from sea levels that provide their own indication of relative temperatures and rainfall. The level of the Mediterranean Sea, for example, rises and falls with the world's sea levels. A rise in global temperatures should, thus, melt the polar ice caps and raise the level of the world's oceans. Thus, any increase in the level of the Mediterranean Sea ought to indicate an increase in global temperature. Studies of the level of the Mediterranean show that its level peaked between AD 400 and 800, supporting the notion that global temperatures did rise at this time. In contrast, the level of the Mediterranean does not effect the level of the Dead Sea since the latter is not connected to it or the world's oceans. In fact, the levels of the Dead Sea are more closely tied to the amount of rainfall in the region. Frumkin *et al.* have shown, as indicated above, that the low levels of the Dead Sea in AD 800 are consistent with a dry period at this time in history (1991).

Conclusions

The climatic conditions described above may help explain how the Natabaean civilization flourished in Southern Jordan and how the Nabataeans were able to move from the Transjordanian highlands into the Negeb and practice agriculture based on water harvesting. They may help explain, at least in part, the proliferation of Nabataean, Roman and Byzantine settlements in areas that are today virtually devoid of human habitation.

It is necessary to add a cautionary note to the effect that not all or even most historical events are heavily influenced by environmental factors (Bruins 1994: 310). However, some are (Stiebing 1989, 1994)! Ancient agricultural societies were extremely vulnerable to even minor changes in climate. This is especailly so for an area such as Southern Jordan.

It must also be pointed out that influences other than climate may have been responsible for the profusion of settlements during the Nabataean, Roman and Byzantine periods. Nevertheless, the paleoclimate as noted above for the periods under discussion must be seriously considered in an attempt to understand settlement patterns in the southern part of the country for the periods of interest here.

[4] A discrepancy must be acknowledged since most researchers agree that the peak of rainwater harvesting, both for runoff farming and domestic water use in the Negeb Highlands, was reached during the Byzantine period. A surprising correlation exists between a prevailing dry climate and the peak of this impressive desert civilization (Bruins 1994: 308).

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