TWIXT DESERT AND SOWN: THE POPULATION DYNAMICS OF SOUTHERN JORDAN FROM BYZANTIUM TO THE MAMLUKS - A NEW GIS PROJECT[1]

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The Desert and the Sown

"The eastern side of the Ghawr is much more fertile than the western. Enough water flows from the beautiful hills of 'Ajlūn to turn the plain into a garden, but the supply is not stored, and the Arabs of the 'Adwan tribes content themselves with the sowing of a little corn. At the end of March the eastern Ghawr is a carpet of varied and lovely bloom, which lasts but a month in the fierce heat of the valley, indeed a month sees the plants through bud and bloom and ripened seed" (Bell 1907: 16).

On 5th February 1905, the future English writer, traveller, political officer, administrator, archaeologist-explorer and cartographer Gertrude Bell (1868-1926), who became highly influential in British imperial policy-making owing to her extensive travels in Greater Syria, Mesopotamia, Asia Minor and Arabia, and who – along with T.E. Lawrence – helped establish the Hashemite dynasties in Jordan and Iraq, set off from Jerusalem to Damascus on horseback in order to revisit the Druze country, crossing the stony and flower-carpeted desert margins of Jordan[2]. Having left as-Salṭ with its wealth of apricots and vineyards, she journeyed with guide, cook and camping equipment through wide valleys: "treeless, uninhabited, and almost uncultivated. A generation or two hence", she mused, "it will be deep in corn and scattered over with villages. I shall not be there to see. In my time the uplands will still continue to be that delectable region of which Omar Khayyam sings: 'The strip of herbage strown that just divides the desert from the sown'". She was glad that during her lifetime the uplands would "be empty save for a stray shepherd standing over his flock with a long-barrelled rifle; and when I meet the rare horseman who rides over those hills and ask him whence he comes, he will still answer: 'May the world be wide to you! from the Arabs'. That was where we were going, to the Arabs" (Bell 1907: 23).

1. Fattoh al-Banna (1975 - 2009).

Like this *bint al-'arab*, or 'daughter of the desert' as she was dubbed by the wandering Bani Sakhir *bedouin* (Kamm 1956: 114), let us follow the camel depicted on the 1930s dress of a *bedouin* woman from southern Jordan **(Fig. 2)**

1. In memory of Fattoh al-Banna (1975-2009),Computer expert at the Department of Antiquities of Jordan and friend **(Fig. 1).**
﴿وبشر الذين آمنوا وعملوا الصالحات أن لهم جنات تجري من تحتها الأنهار كلما رزقوا منها من ثمرة رزقا قالوا هذا الذي رزقنا من قبل وأتوا به متشابها ولهم فيها أزواج مطهرة وهم فيها خالدون﴾. **البقرة.25**

2. For Gertrude Bell's 1905 trip see Kamm 1956: 111-115; Winstone 1980: 59-62.

2. Camel crossing field of flowers; embroidery on a 1930s bedouin woman's dress from southern Jordan.

across the floral plain (Weir 1970) and, with our faces turned towards the desert, let us go towards the first black tents – to the Arabs.

"With me along the strip of herbage strown
That just divides the desert from the sown"
(*Rubā'iyāt of Omar Khayyām* 11)[3]

The Exploration of Palestine and Jordan

Although Palestine and Jordan have been explored by numerous archaeological surveys since the Survey of Western Palestine by C.R. Conder and H.H. Kitchener (1881-1883) and the explorations across the River Jordan by G. Schumacher (1886), a scientific investigation of fluctuations in population dynamics in Palestine and Jordan – including the whole area between the Palestinian coast and the vast deserts of southern Jordan – has never been attempted. Our project, "*Fallāḥīn* and nomads in *Palaestina Tertia* from Byzantium to Saladin: population dynamics in the light of new research tools (Geographical Information System [GIS])", otherwise known as the "Palestine III Project", combines for the first time GIS and traditional archaeo-historical interpretations of the past, the one enriching the other.

From Byzantium to the Abbasids: The Depopulation of Palestine

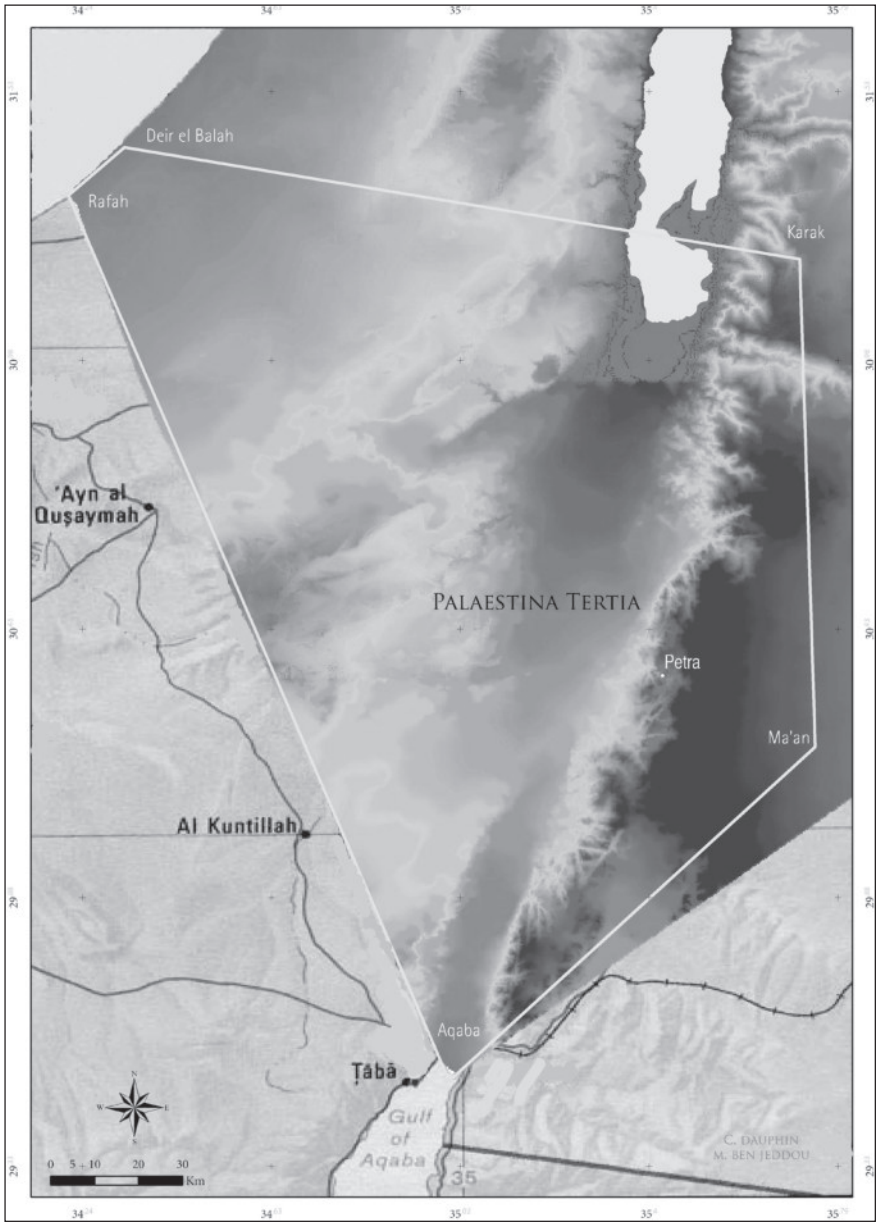
The settlement distribution map of Palestine at the beginning of the 7th century indicates dense occupation on both banks of the River Jordan on the eve of the Muslim conquest. A century later, by time of the Abbasid take-over of 750, western Palestine appeared to be a 'demographic desert'. Attributed simplistically to the Persian (614-617) and Arab invasions (636-640), this decline was already inherent in the late Byzantine period (6th - early 7th centuries). With a young and expanding population, described as "progressive" (Waugh 1990: 295-296, figs. 13.13-14), by the 6th century Palestine had reached the beginning of the second stage of the 'demographic transition' model, *viz*. 'early expansion', which characterises modern Bangladesh or Kenya (Britain reached this stage of development between 1760 and 1880; see Waugh 1990: 292, fig. 13.9). By accelerating and developing beyond agricultural potential, demographic growth inevitably engenders the "poverty trap" (Witherick 1990: 150). Weakened by endemic infectious diseases (e.g. tuberculosis, syphilitic *bejel*, leprosy, endoparasites, malaria), the population of Byzantine Palestine was also undermined by an iron-deficient diet. Droughts and locust invasions, which devastated harvests and pastures in the 6th century, resulted in famines with catastrophic demographic consequences, not only because of the number of deaths, but also because of the negative impact of malnutrition

3. The *Rubā'iyāt of Omar Khayyām* is a selection of quatrains in Persian attributed to the poet, mathematician and astronomer Omar Khayyām (1048-1131), native of Khorasan (the north-eastern province of Persia).

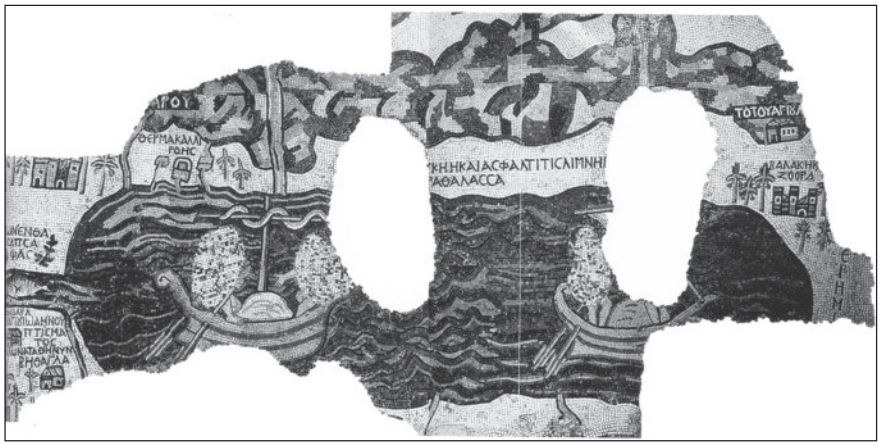
on reproduction (e.g. amenorrhea, impotence). Wiping out entire families over several generations, the plague of 541-542 killed between 20 and 25% of the population, the initial death toll being doubled by cyclical returns of the scourge, notably the Plague of 'Imwas (639-640) at the beginning of the Moslem occupation (Dauphin 1998 I: 445-518).

A detailed analysis of archaeological demography, a new discipline based on landscape archaeology allied to historical geography, which borrows its analytical tools from physical anthropology, religious sociology and socio-economic history, was developed by Dauphin (1999) between 1980 and 1990 and applied to Byzantine Palestine. However, until recently it had not been applied to Jordan east of the rift valley or *ghawr*.

Archaeological and historical data clearly indicate that the scenario for Jordan was somewhat different. As the Byzantine infrastructure collapsed in Palestine, preachers such as Patriarch Sophronius of Jerusalem whipped up fear of the Saracens. In a sermon on the Epiphany which he delivered at the Church of the Holy Sepulchre in Jerusalem on 6th January 637, he lamented: "Abomination of the desolation clearly predicted to us by the Prophets. The Sarrasins rampage



3. Palaestina Tertia (GIS M. Ben Jeddou and C. Dauphin).



4. Mādabā mosaic map (6th century AD); on the right, south of Zoara, note Greek inscription eremos (= "desert") (courtesy of Studium Biblicum Franciscanum, Jerusalem).

across lands forbiddent to them, destroy the cities, devastate the fields, put fire to the villages, torch the holy churches, topple the holy monasteries, defy the Roman armies, gain trophies in war, progress from victory to victory and behave towards us with increasing arrogance" (*Homilia in Theophaniam* 10: 24-31; Papadopoulos-Kerameus 1898: 166). However, according to Patriarch Eutyches of Alexandria in his *Annals*, on launching the conquest the first successor of God's envoy (*khalīfat rasūl allāh*), Caliph Abu Bakr (r. 632-634), ordered the Muslim armies: "Do not kill neither children, nor the elderly, nor women. Do not strip the palm tree of its bark; Do not burn it; do not fell down fruit trees and do not destroy tilled fields; Do not slaughter lamb, ox, or camel, except for your subsistence" (Eutychius, *Annals* 276; Breydy 1985a: 131, 1985b: 111).

In panic, thousands of refugees took to the roads of Palestine in an attempt to cross the River Jordan amidst chaos probably not dissimilar to that of the 1948 catastrophe, or *nakba*, whilst others scrambled to embark on ships to Cyprus or the capital of the Byzantine empire, Constantinople. The 'Palestinian refugees' swelled the numbers of and brought new blood to the populations beyond the River Jordan, which had been depleted by famine and plague, much as in Palestine west of the *ghawr*. The Christian communities of *Palaestina Tertia*, which was renamed the *jund* of Urdunn, prospered under the Umayyads (Schick 1995a). For example, there were fifteen churches at the garrison town of Kastron Mefa'a (Umm ar-Raṣāṣ), ranging in date from the 6th century to the final phase of the Umayyad period, the most impressive being the mosaic-paved Church of St. Stephen, dated 718-756 AD (Piccirillo and Alliata 1994).

From 'Archaeological Demography' to GIS

Following the publication of Dauphin's major study, *La Palestine Byzantine: peuplement et populations* (1998), she expressed a wish that a new generation of researchers apply her approach of archaeological demography, refining it methodologically and extending it in time and space. In the mid 1970s the Cambridge school of 'new archaeology' had established the theoretical bases of spatial analysis (Hodder and Orton 1976; Clarke 1977), whilst geographers were developing Geographical Information Systems (GIS) which K.L. Kvamme (1989) was the first to apply to archaeology some twenty years later.

Whilst carrying out research in Israeli archaeological archives and in the field before the peace agreement between Jordan and Israel, there were sound political reasons why Dauphin had been unable to access data concerning that part of Jordanian territory which lay within Byzantine *Palaestina Tertia*, *viz*. an irregular polygon extending from 'Aqaba (Byzantine Ayla) in the south, to Ma'ān in the east, al-Karak in the north-east and Dayr al-Balaḥ / Raphia in the north-west **(Fig. 3)**. This constitutes a transitional climatic zone between 'sub-tropical Mediterranean' and 'arid continental', historically the border zone between the land of the *fallāḥīn* ("sedentary farmers") and the desert **(Fig. 4)** of the *badu* ("nomads"). *Palaestina Tertia*, with Petra as its capital, comprised the Negev desert south of Eleutheropolis – modern Bet Guvrin – the Wādī 'Arabah valley and the southern part of *Provincia Arabia* from the

Arnon River – Wādī al-Mūjib – to the Gulf of ʻAqaba[4], a total of some 7,000 km^2. Bisected by the rift valley, or *ghawr*, which separates it from the Negev desert, it is characterised by inclined uplands set symmetrically from south to the north which create favourable conditions for movement, trade and conquest (*viz*. Roman, Persian, Arab, Crusader, Ottoman Turkish). The plateaus are higher on the east (*ca.* 1700m) than on the west (*ca.* 1000m). Annual rainfall is greater in the north (*ca.* 300mm) than in the south and east (*ca.* 100-50mm, with evapotranspiration of between 1300 and 2400mm).

The sides of this polygon had never been impenetrable; pastoralists paid no attention to its boundaries. The deserts to the south and east of *Palaestina Tertia* were occupied by nomadic *badu*. To the south, the *Limes Palaestinae* was established as a defensive line within Byzantine territory itself. To the east, the Byzantine administration entrusted control of the *limes* to Ghassanid *bedouin* (who came from Yemen in the 5th century in search of pasture and had been converted to monophysite Christianity by itinerant monks) and recognised their domination over all the tribes "from the snowy mountains unto the territory of Ayla" (Caussin de Perceval 1847-1848: 249).

Moreover, in 1998 – when *La Palestine Byzantine* was published – the intensive surveys of the Negev desert (being that part of *Palaestina Tertia* lying west of the rift valley) by the Israeli Negev Emergency Survey were neither complete nor fully published.

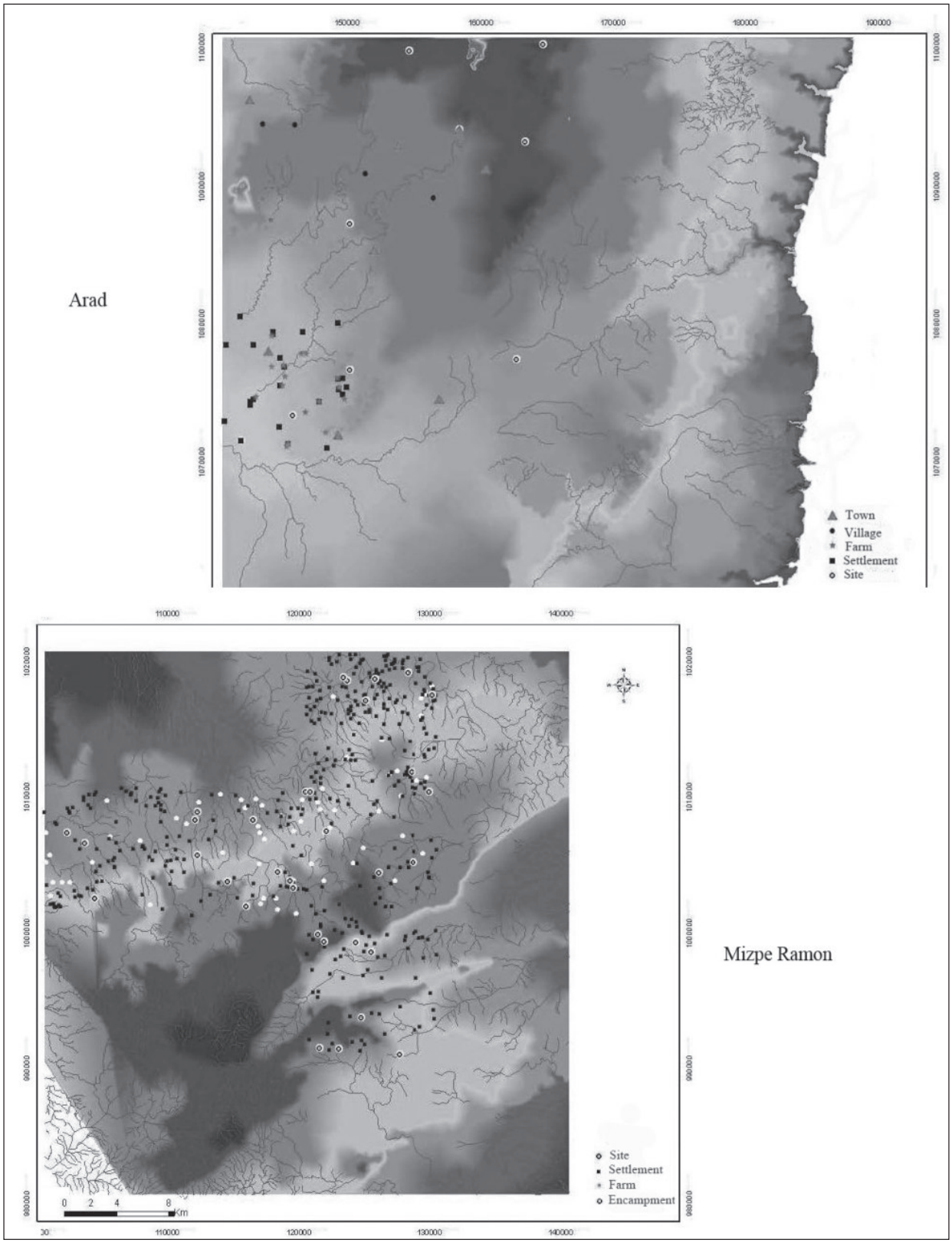
Since Dauphin's discovery in 1981 of a sanctuary to St. John the Baptist at er-Ramthaniyye in the Jaulan – Byzantine *Gaulanitis* – and her 1985-1988 study in which she interpreted it as a pilgrimage centre for Ghassanid nomadic tribes (Dauphin 1995), she had been interested in the processes of sedentarisation. For his part, Mohamed Ben Jeddou – formerly a member of the Tunisian Heritage Institute – had participated in several projects in the Near East and wished to test the GIS methods which he had pioneered in Tunisia (Ben Jeddou 2007) in a physically and anthropologically similar area, i.e. one occupied by both farmers and nomads. Dauphin and Ben Jeddou therefore decided to pool their knowledge and join forces with the French geographer J.M. Castex in an attempt to fill the gap of *Palaestina Tertia* in Dauphin's demographic study. The aim was to cross archaeological demography with GIS, combine analysis of literary and historical sources with geographical interpretation, and apply geospatial approaches to landscape archaeology in order to explore fluctuations in the relationships between man and environment, and between nomadism and sedentarism in this semi-arid area over eight centuries.

The initial focus was on demographic fluctuations at the transitional period between the end of the Byzantine era and the emergence of the Abbasids in 750 AD. The study area was not only a border zone between the sown of the *fallāḥīn* and the desert of the *badu*, but one which had also experienced Arab infiltration before the Moslem conquest of 636.

Pilot Project

A pilot project was conducted in 2007-2008 in order to shed light on fundamental questions concerning three types of relationship: 'time / space', 'sedentary, semi-sedentary and nomadic peoples' and 'pagans, Jews, Christians and Moslems'. In order to better trace the infiltration of Arabs who went on to co-exist with Byzantine rural communities by settling in the central Negev desert, two regions of *Palaestina Tertia* were selected for closer study: Arad to the southwest of the Dead Sea (Dauphin 1998 I: 108-110, III: 961-979) and Mizpe Ramon with its extinct volcanic craters in the heart of the central Negev desert (Haiman 1986, 1991, 1993; Lender 1990; Rosen 1994). Against the background of general demographic decline, of Christianity penetrating into the Jewish stronghold of the *Darôm* in the 5th century (taking it over in the 6th century) and – further south in the central Negev uplands – of Islam becoming consolidated (manifested archaeologically by several hundred Arabic inscriptions and the construction of open-air cult-places [*masjid*]), two contrary demographic movements met in the central Negev. The hypotheses put forward by the Negev Emergency Survey **(Fig. 5)** were confirmed, *viz*. (1) a move towards the south and central Negev uplands and (2) terrace agriculture maximising the resources

4. On geo-historical *Palaestina Tertia* see Gutwein 1981: 5-40.



5. Distribution of types of Byzantine sites in relation to the hydrographic network in two sub-regions of the Negev desert: Arad and Mizpe Ramon (GIS M. Ben Jeddou and C. Dauphin).

of *wadi*s - a characteristic feature of the northern Negev plains. This resulted in an increase in the number of farms in the Late Byzantine period and under the Umayyads. These were abandoned under the Abbasids, during which time there was a south-north infiltration of Arab nomads who gradually became sedentary (Dauphin and Ben Jeddou 2009).

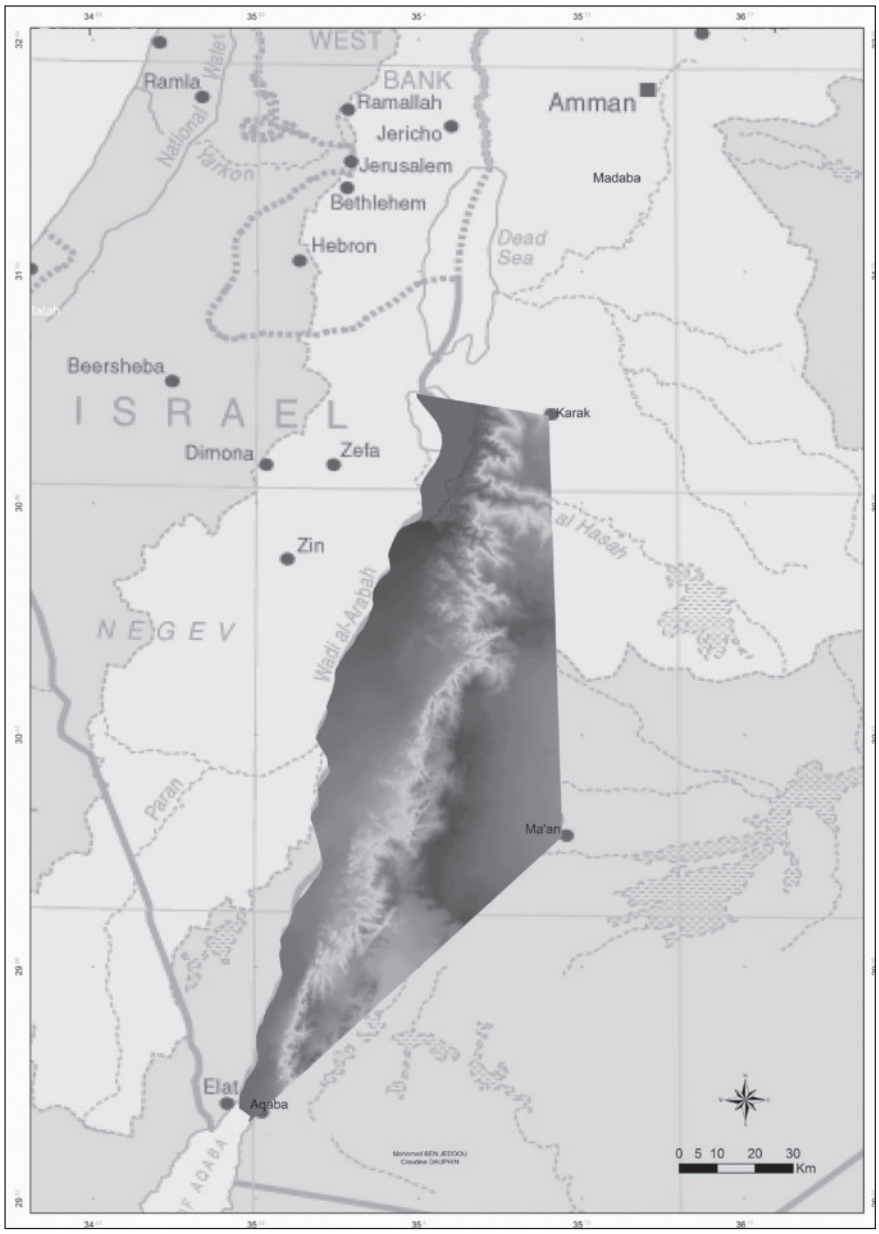
Chronology and Archaeological Databases

The long chronological span of our study – from the Byzantine period to the victory of Saladin over the Crusaders at the battle of Ḥiṭṭīn (4th July 1187), which precipitated the collapse of the Latin Kingdom of Jerusalem and, by way of the Ayyubids (1188-1260) the rise of the Mamluks (1260-1516) – includes two major chronological breaks: between the Umayyads and Abbasids (750), and between the Crusaders and Ayyubids (1187).

A database of all Byzantine and Arab sites in *Palaestina Tertia* west of the *ghawr* was created by Mohamed Ben Jeddou on the basis of sites recorded in the catalogue of Dauphin's *La Palestine Byzantine* (1998 III). This was updated with data published by the Negev Emergency Survey and the results of recent excavations, augmented by Arab sites found in the archaeological archives of the State of Israel and the Negev Emergency Survey. This database comprises 1,099 archaeological sites described by 20 descriptors, which were in turn divided into 70 variables (e.g. date: Byzantine, Byzantine-Arab, Arab).

For the area east of the rift valley **(Fig. 6)**, i.e. southern Jordan, our corpus of archaeological sites is essentially based on the inventory of sites recorded in the 1973 *Archaeological Heritage of Jordan*: *The Archaeological Periods and Sites (East Bank)* and on JADIS (Jordanian Archaeological Database and Information System), the latter being the computerised database of the Department of Antiquities of Jordan[5]. The reason for using JADIS rather than MEGA (Middle Eastern Geodatabase for Antiquities) is that MEGA, which was created by the Getty Conservation Institute in Los Angeles in cooperation with the Department of Antiquities of Jordan, does not yet include all the data on JADIS. All Byzantine (330-636 AD), Islamic (636-661), Umayyad (661-750), Abbasid (750-1258), Fatimid (969-1171), Crusader (1099-

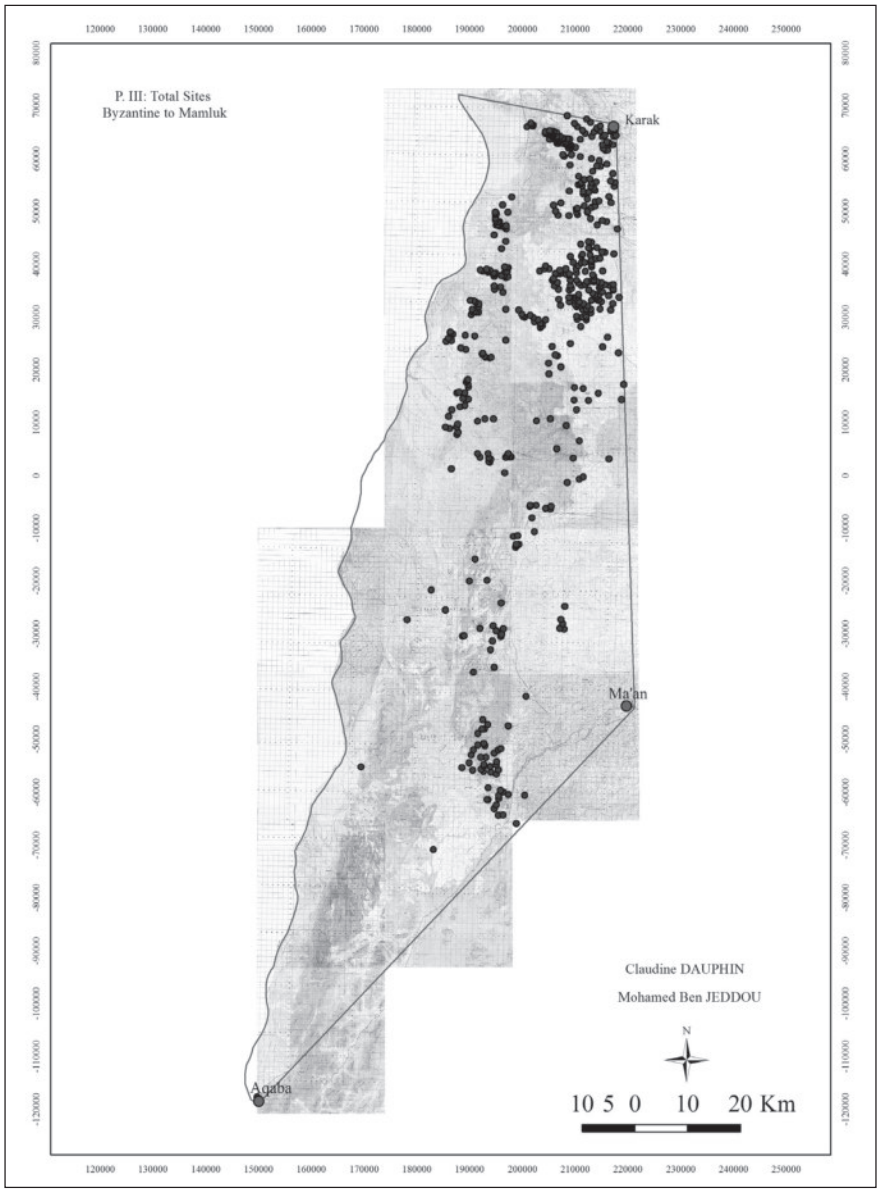
5. In January - February 2008, Mohamed Ben Jeddou carried out research for the Palestine III Project with a short-term bursary from the Institut Français du Proche-Orient (IFPO) at ʻAmmān. We are extremely grateful to the late Dr Fawwaz al-Khraiysheh, then Director General of the Department of Antiquities of Jordan (DoA), for permission to access the JADIS database and acquire topographic maps from the Royal Jordanian Geographic Center, ʻAmmān, as well as pedological maps of southern Jordan from the Directorate of Agriculture and Irrigation. We would particularly like to thank the Director of the Directorate of Agriculture and Irrigation, Eng. Riyad Beqeen, and Dr Mahmoud Al-Freehat and Ahmad Eid Aloweidi, both of the Department of Land Use, for their good will towards us and their interest in the Palestine III Project. Professor Bill Finlayson, then Director of the Council for British Research in the Levant (CBRL), ʻAmmān strongly supported our applications for (1) an Honorary Professorship in Archaeology and Theology at the University of Wales Trinity Saint David, Lampeter and (2) access to JADIS and the Jordanian archaeological archives. Our application was followed up with rigour and warm cooperation by CBRL Administrator, Mrs Nadja Qaisi. At the DoA, Catreena Hamarneh, then Director of Archives, and Mrs Samar Habahabeh greatly facilitated our work in the JADIS database; access problems were solved by Fottoh al-Banna (Information Technology). Qutaiba al-Dasouqi and Jamal Safi (Topography, Mapping and Drawing) guided us through the administrative complexity of the Royal Jordanian Geographic Center, ʻAmmān. We thank them all wholeheartedly. Our debt of gratitude is particularly great to Dr Mark Merrony, Director of the Mougins Museum of Classical Art (MMCA) founded in 2011 by Mr Christian Levett, and Mrs Julianne Coutts, in charge of Finance and Marketing at the MMCA, for the Museum's financial support of the Palestine III Project as well as for their enthusiasm. The present article is based on a lecture with the same title which we delivered at the British Institute, CBRL, ʻAmmān on 28th November 2011. We wish to thank Dr Carol Palmer, Director of CBRL ʻAmman, for her perfect organisation of the lecture and Mrs Qamar Fakhoury, Director of Studies and Publications at the DoA, for bringing to light the educational value of the combination of archaeology, history and GIS in our work.



6. Jordanian Palaestina Tertia east of the ghawr (GIS M. Ben Jeddou and C. Dauphin.)

1291), Ayyubid (1171-1341) and Mamluk (1250-1517) sites in *Palaestina Tertia* east of the *ghawr* were recorded. The 'sites' table provides a unique site number which serves as link between the new inventory and the JADIS database. The total number of sites was 517 (Byzantine = 420, Islamic = 134, Umayyad, Abbasid and Fatimid = 59, Crusader, Ayyubid and Mamluk = 135). Five chrono-spatial maps of *Palaestina Tertia* east of the *ghawr* were generated **(Figs. 7, 8)**.

In JADIS, sites are recorded in 'chronological blocks'. For example, Umayyad, Abbasid and Fatimid sites constitute a single 'block', so that unless one has consulted the Jordanian archaeological archives and / or recent archaeological publications it is impossible to know which sites are Umayyad and which are Abbasid or Fatimid. Similarly, in order to conduct a detailed analysis, it is imperative that site-type (e.g. city, village, hamlet, farm, fortress, encampment) and architectural components (e.g. domestic structures, cult places, reservoirs) are identified, none of which are described on JADIS. Historical sources (e.g. Arabic geographical treatises and itineraries, in particular those of the 19th and early 20th centuries) mentioning sites and describing landscapes before modern development must also be examined.



7. Distribution of Byzantine to Mamluk sites in Palaestina Tertia east of the ghawr (GISM. Ben Jeddou and C. Dauphin).

Environmental Databases and Methodology

Within the context of the creation of an integrated Geographical Information System, the archaeological database was linked to an environmental database on which a number of spatial analyses were conducted. Geographical data were produced for spatial modelling on the basis of sixteen 1:50,000 topographic maps obtained from the Royal Jordanian Geographic Centre at ʻAmmān. These maps were geo-referenced by M. Ben Jeddou.

Spatial Vector Data

Point data

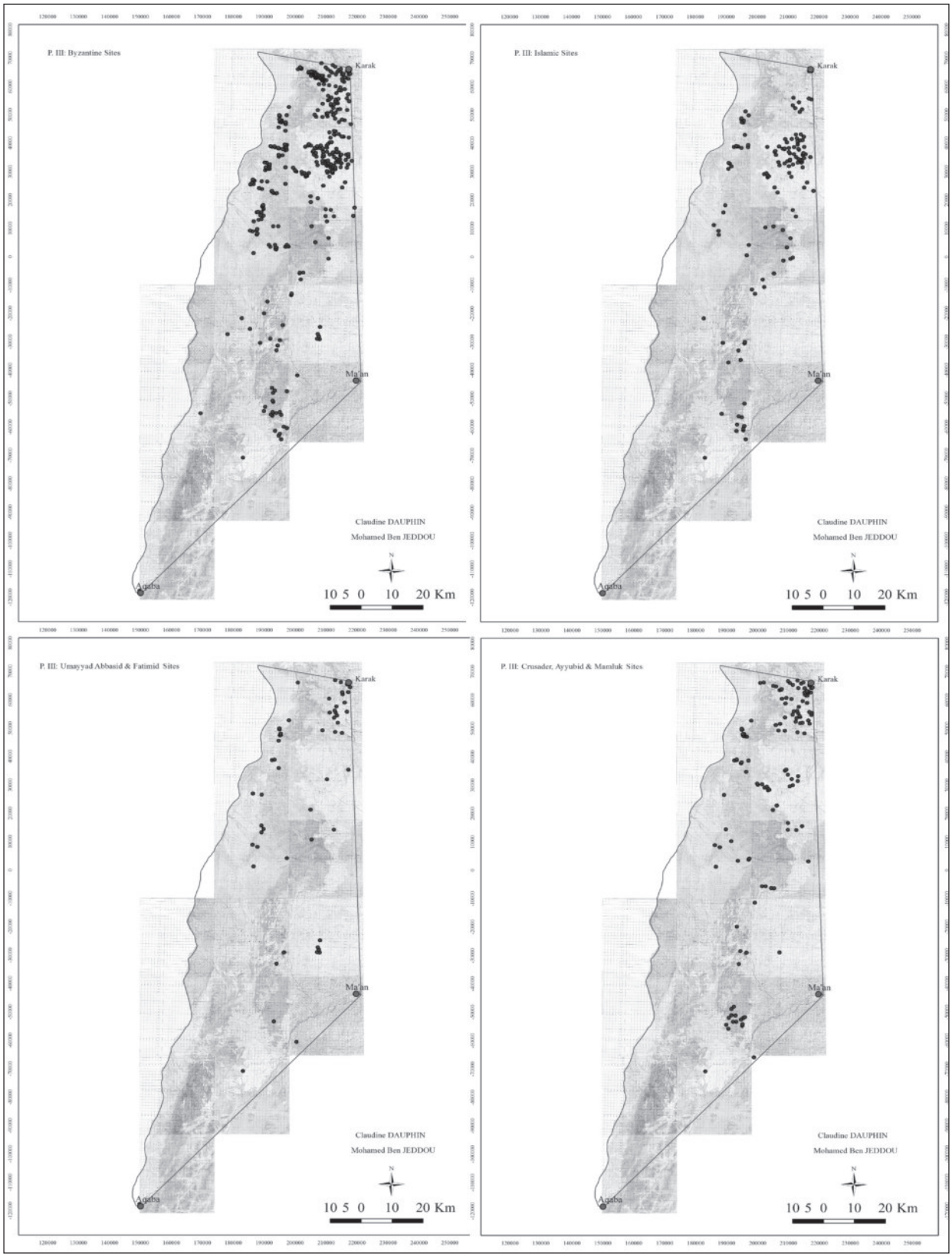
These include hydrographic information, e.g. springs, wells. This layer was produced on the basis of the 1:50,000 topographic maps. Very few springs were recorded.

Linear Data

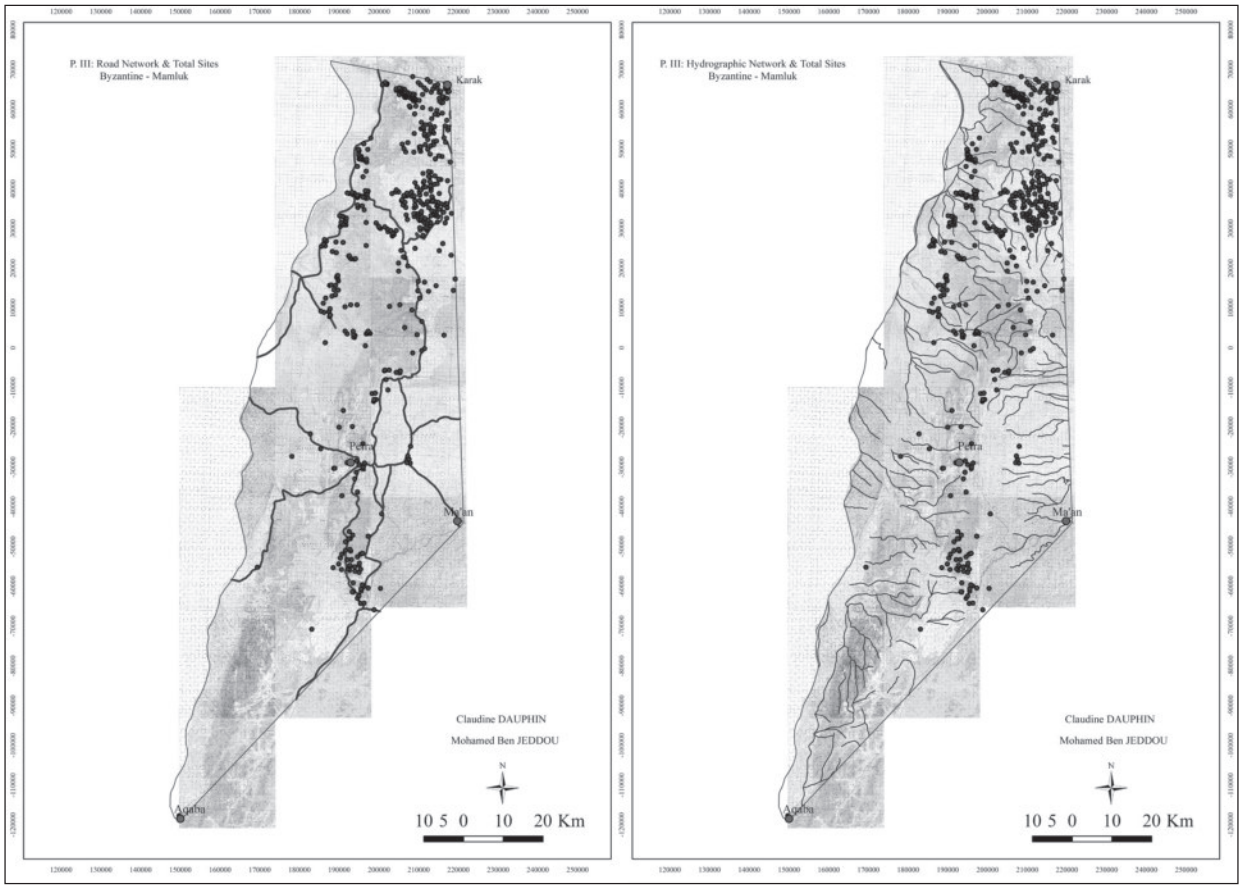
This layer was produced through digitisation of contour lines on the 1:50,000 topographic maps.

Hydrography

This layer reflects the present state of the hydrographic network. It shows all information on perennial and seasonal *wadi*s, as well as on irrigation channels. It may be possible to trace past hydrographic networks owing to a relative



8. Distribution of sites in Palaestina Tertia east of the ghawr: (top left) Byzantine; (top right) Islamic; (bottom left) Umayyad - Abbasid - Fatimid; (bottom right) Crusader - Ayyubid - Mamluk (GISM. Ben Jeddou and C. Dauphin).



9. All sites in Palaestina Tertia from Byzantine to Mamluk periods against (left) road network; (right) hydrographic network (GIS M. Ben Jeddou and C. Dauphin).

lack of human disturbance in southern Jordan.

In our study area, the hydrographic system derives from the orography: *wadis* run parallel to folds. This hydrographic network is dense with many ramifications. It covers the entire region, generally in a south-westerly or south-easterly direction **(Fig. 9)**. The hydrographic network is subject to significant variations of flow based on annual rainfall.

Ancient Roads

The ancient road network is particularly relevant to the study of ancient populations. It played a major role in *Palaestina Tertia* on both sides of the *ghawr*. Examined in the light of historical sources, archaeological remains (e.g. roads, *wadi* crossings, milestones) have enabled us to trace a number of routes following Roll (1999).

The vector layer shows Roman and Byzantine roads. The close relationship between site distribution and the ancient road network recalls both the movement of agricultural and commercial products between settlements and the south-north axis of the *Via Nova*, and the caravans which carried Indian spices from Ayla (‘Aqaba) to Damascus (Dauphin 1998 I: 117). At Petra, they were joined by the caravans of the ‘incense road’, which carried loads of Yemeni incense and myrrh from the port of Qani’ on the Gulf of Aden to Marib, and thence across the immense desert of *Rubat al-Khali* (the “Empty Quarter”), stopping at Najran and Yathrib-Medina (Groom 2002: fig. 29). After the Moslem conquest, the direction of commerce was reversed, with Moslem pilgrims travelling from Damascus to Mecca. Caravan stops, with reservoirs and cisterns which were filled each year before the *ḥajj*, were established along *Darb al-Ḥajj* (Petersen 1991). From Ma‘ān, this followed a south-easterly route towards Tabûk and then went on to Medina.

Pedology

Pedological maps were kindly provided by

the Pedological Section of the Jordanian Ministry of Agriculture. These comprise two modern 1:250,000 maps of southern Jordan which classify soils into several categories according to type (Al-Qudah, El-Rihani and Sartaoui 1993).

Our study area was divided into 18 types of land region and 147 units of soil association, of which 55 appear in the table of our pedological layer. Our approach is different but complementary, classifying soil types according to agricultural potential. This classification is based on numerous factors: e.g. crops grown, agricultural potential, slope, rock outcropping. Seven categories of agricultural capacity were defined: (1) non-existent: uncultivated, zero potential, (2) very weak: small areas of grazing, (3) weak: pastureland, (4) medium: cereals (barley), (5) quite good: cereals (wheat), irrigation, (6) good: two cereal harvests, irrigation, orchards and (7) very good: all types of cultivation, good harvests.

The Petra Church, *Papyri* and Fields

In order to reconstruct the landscape in any given period, it is necessary to compare the agricultural potential of certain sites with the results of environmental studies (e.g. pollen analysis) and data from historical sources. For example, light was shed on agriculture in the hinterland of Petra, capital of *Palaestina Tertia*, in the 6th century by 152 *papyri* discovered in December 1993 in a storeroom of the Byzantine church at Petra excavated by the American Center of Oriental Research (ACOR), ʻAmmān. Charred in the fire which had destroyed the church, those *papyri* which were still legible comprised contracts concerning the property and land of Theodoros, son of Obodianos, and his family, as well as legal documents including transactions, property descriptions and disputes between several Petra families over at least two generations (Frösen, Arjava and Lehtinen 2002; Arjava, Buchholz and Gagos 2007; Arjava, Buchholz, Gagos and Kaimio 2011). This particular Theodoros was a deacon, who became archdeacon of the church where the *papyri* were discovered. The *papyri* mention orchards, vines, grain fields, wheat and barley threshing floors, and farms. It is now imperative to investigate the information contained in the Petra *papyri* in the field and to analyse the results in the context of GIS.

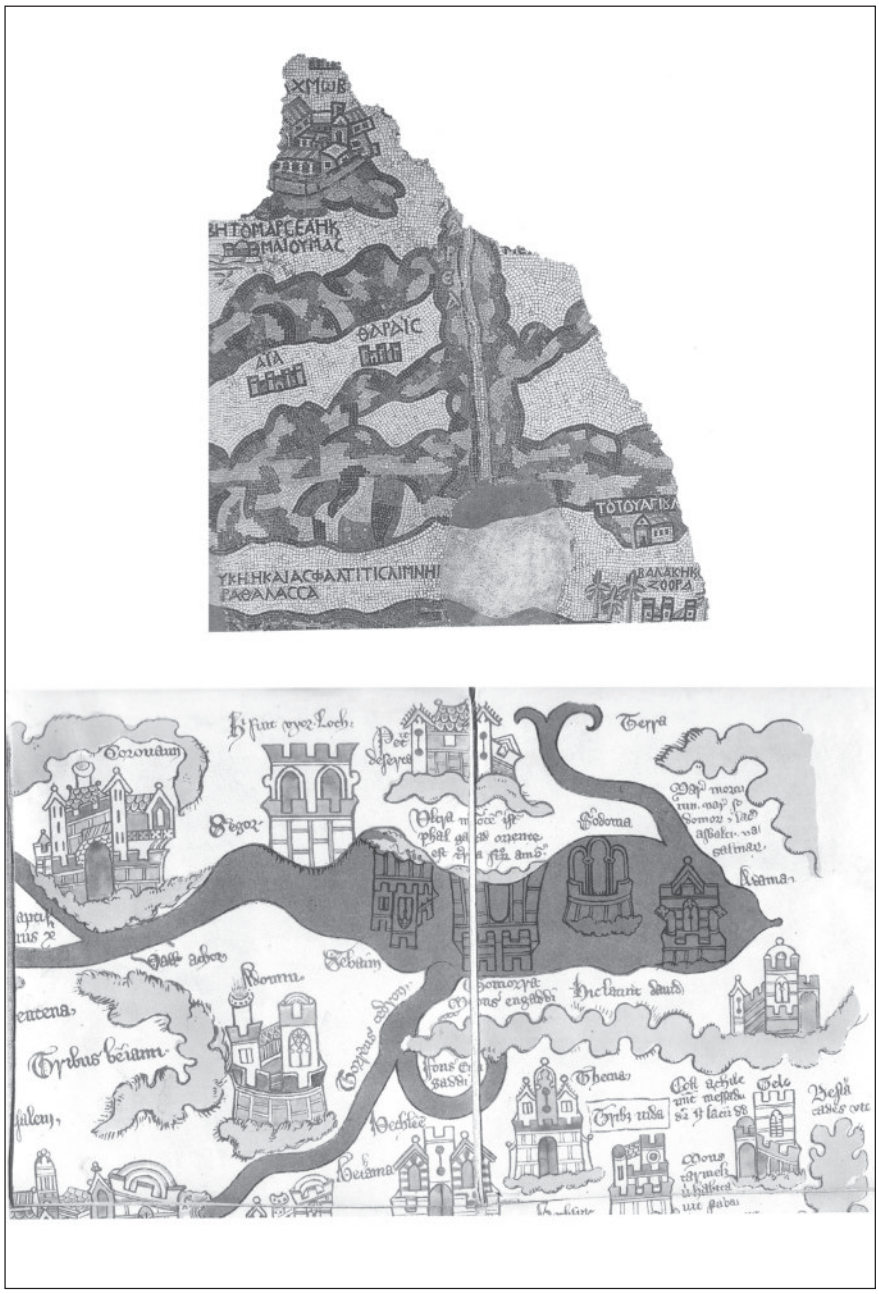
In the next stage of analysis, we will refine our research and consider other factors and approaches, whilst taking into account the spatial dimension in order to answer the following questions: Where and why are sites situated? Did changes take place in the factors governing site location over time?

Statistical Analyses

Density Calculations

This type of spatial calculation takes the notion of ‘neighbourhood’ into account, by examining the distribution of archaeological entities / sites over an area of 7000 km². Zones of concentration are depicted by colour shading, making it easier to visualisation the spatial context of the results.

During the Byzantine period, there was a great density of occupation in the northern part of study area **(Fig. 11)**, on fertile soils in the vicinity of al-Karak, the episcopal see of Characmoba **(Fig. 10)** located at the ancient crossroads of the north-south Kings’ Highway and east-west road linking al-Karak with the Dead Sea. By the Islamic period, this concentration seems to have moved south of al-Karak, corresponding to the initial billeting of the Moslem conquerors on the arable margins (Dauphin 1998 II: 370-371). During the Umayyad - Abbasid - Fatimid period, zones of concentration are clearly visible near al-Karak, west and north of Fīfā and north of Maʻān. As the Umayyad caliphate became established, both administratively and militarily, troops left their cantonments and settled down. The centre of gravity thus shifted from the desert towards semi-arid and, later, agricultural land. The creation of sites on the pilgrim road from Damascus to Mecca is also evident. *Darb al-Ḥajj* crossed Jordan from north to south via al-Karak and Maʻān (broadly corresponding to the modern Desert Highway), then headed off towards the south-east in the direction of Tabûk (Peters 1994: map 1; Kennedy 2012: 92-109; Petersen 1991, 2012). In the Crusader-Ayyubid-Mamluk period, the Karak region continued to play a central role, with sites clustering around the Crusader castles of Shawbak and Karak **(Fig. 10)**, despite the existence of three Crusader castles in Petra and its environs (Vannini and Nucciotti 2009; Voisin 2009). Moreover, the province (*mamlakat*) of al-Karak was of great economic and strategic importance



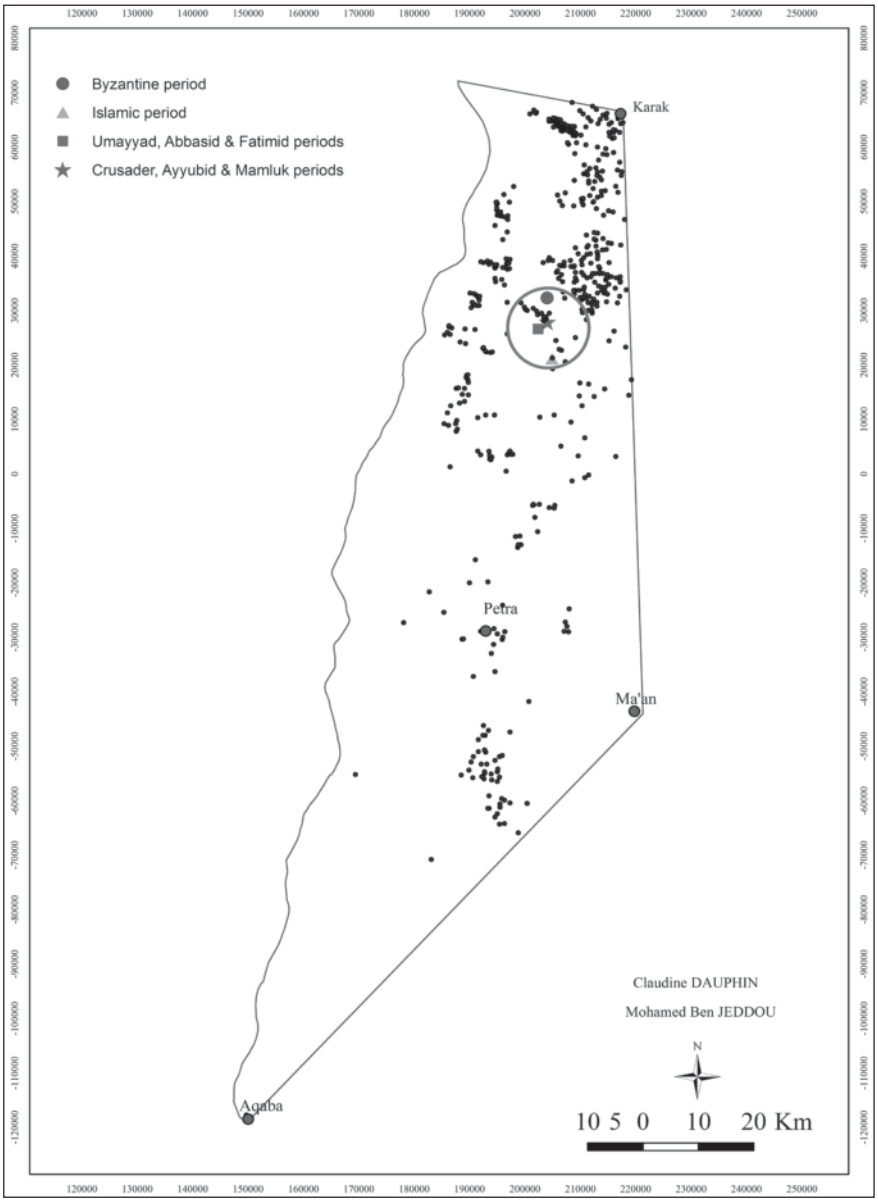
10.(Top) Mādabā mosaic map, including vignette of Byzantine (Chara) cmob (a), modern al-Karak (courtesy of Studium Biblicum Franciscanum, Jerusalem); (bottom) map of the Holy Land showing the itineraries of William Wey, Fellow of Eton College, in 1458 and 1462; depiction of the Dead Sea, cities and castles (courtesy of The Board of Trinity College, Dublin).

to the Mamluk state. At times of food shortage in Egypt, Karak wheat was exported to Cairo, the centre of Mamluk power. Furthermore, the sugar industry which the Crusaders developed in the Jordan valley was subsequently one of the most profitable sectors of the Mamluk agricultural economy (Walker 2008).

Mean Centre

The technique of 'mean centre', based on Euclidian distance, consists of measuring the value of x and y coordinates for all points, or centroids for linear and surface entities. This technique was used in order to identify the geographic centre (or centre of concentration) of archaeological sites for each period. This has enabled us to measure general patterns of settlement concentration and check whether any shifts occurred. Our map **(Fig. 12)** suggests that the average centre remained circumscribed within a circle averaging 11km in diameter from 330 to 1517AD. Thus, the distribution of population remained constant through time, with a focus on the northern area, despite minor nuances specific

11. Density calculations in Palaestina Tertia east of the ghawr: (top left) Byzantine; (top right) Islamic; (bottom left) Umayyad - Abbasid - Fatimid; (bottom right) Crusader - Ayyubid - Mamluk (GISM. Ben Jeddou and C. Dauphin).



12. Mean centre in Palaestina Tertia east of the ghawr (GISM. Ben Jeddou and C. Dauphin).

to each period.

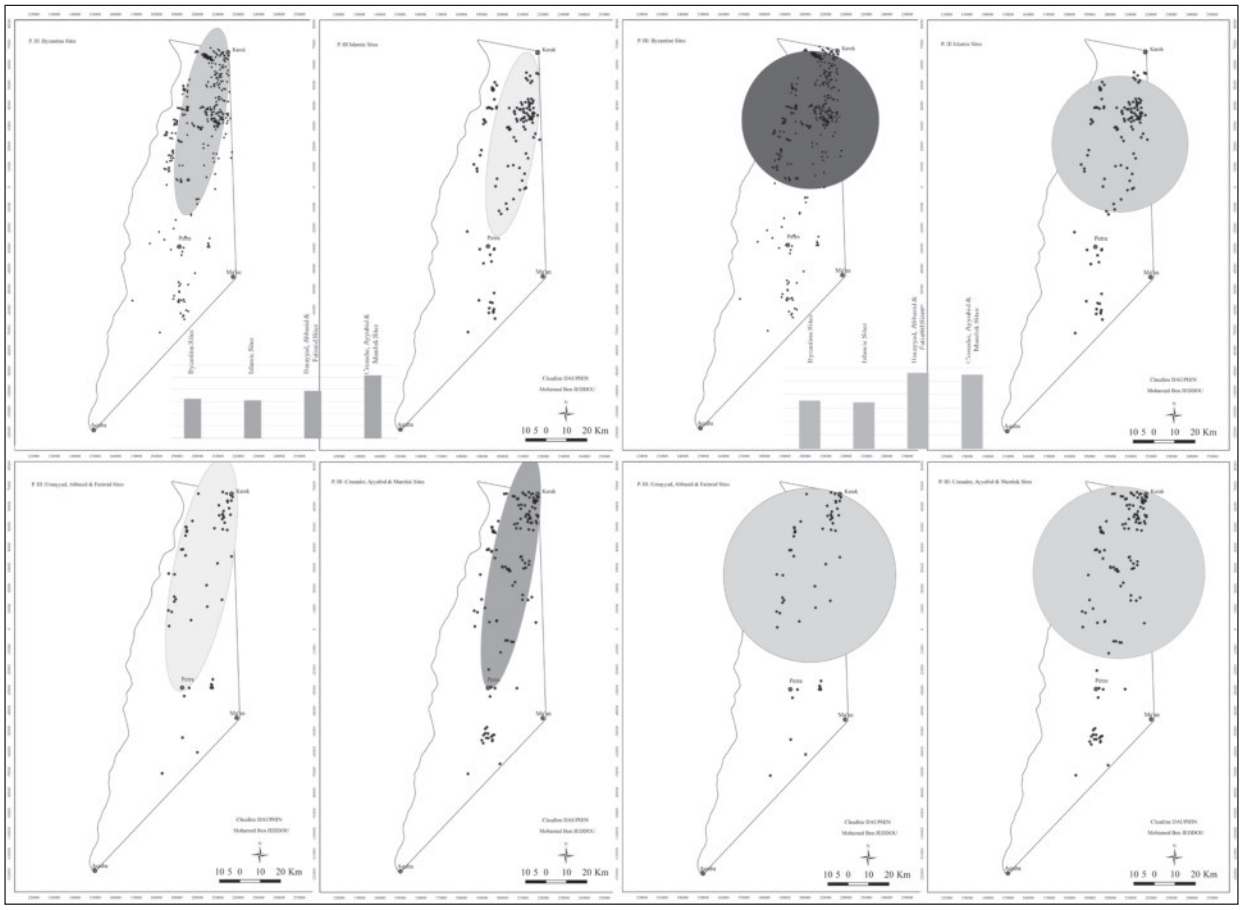
An 'interpretative system' is thus set up, with spatial analyses requiring frequent 'returns' to the environmental database in order to garner historical explanations.

Spatial Statistics

By using statistical methods to analyse spatial distribution, patterns, processes and relationships, the location of centres or the manner in which features were distributed around centres can be investigated.

Directional Distribution

Does the distribution of sites around a mean centre follow a certain pattern? To measure the trend for archaeological sites of each period (or 'set'), the standard distance from the mean centre was calculated separately in the x and y directions in order to define the axes of an ellipse. This shows whether the distribution of features has a particular orientation or not. As is evident from the four ellipses of **(Fig. 13)**, the general orientation for all periods is south-west - north-east. However, both the extent and shape of the ellipses change over time. The Islamic period is characterised by a shift southwards, representing a population movement out of the densely-populated Byzantine districts, particularly in the hinterland of al-Karak, in favour of new areas further



13. (left of page) Directional distribution: (top left) Byzantine; (top right) Islamic; (bottom left) Umayyad - Abbasid - Fatimid; (bottom right) Crusader - Ayyubid - Mamluk; (right of page) Standard distance: (top left) Byzantine; (top right) Islamic; (bottom left) Umayyad - Abbasid - Fatimid; (bottom right) Crusader - Ayyubid - Mamluk (GISM. Ben Jeddou and C. Dauphin).

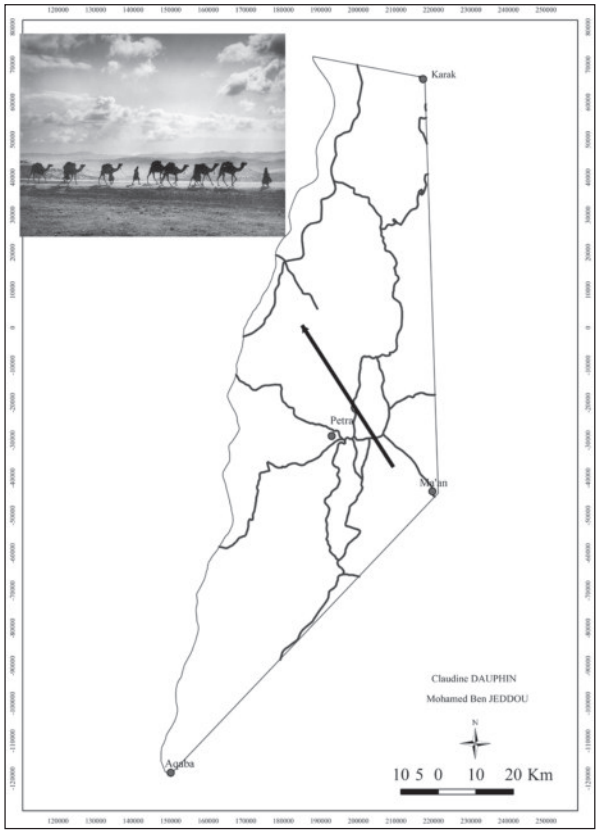
to the south. The Umayyad - Abbasid - Fatimid ellipse resembles that of the Byzantine period, witnessing a return to former 'Byzantine districts' manifested on the ground by the Umayyad establishment of large agricultural estates on the fringes of Byzantine villages (Hamarneh 2010: 98-99). Density of demographic occupation and intensity of land use reached a peak in the Crusader - Ayyubid - Mamluk period, with demographic expansion in all zones.

Standard Distance

This technique is used to answer questions related to the spatial distribution of archaeological sites. It allows one to measure the degree to which features are concentrated or dispersed around a geometric mean centre. Which period had the most extensive territory? How dispersed are features around that centre? The greatest territorial extent coincides with the Islamic and Crusader - Ayyubid - Mamluk periods **(Fig. 13)**, supporting the results of the directional distribution analysis.

Linear Directional Mean

This method is used to identify direction (or orientation) by calculating the average angle of a set of lines. What is the predominant direction? Is it possible to identify the mean direction, length and geographic centre for a set of lines, such as the roads of Byzantine *Palaestina Tertia*? The Byzantine road network east of the *ghawr*, as drawn by I. Roll (1999), is incomplete. The results of the linear directional mean analysis are therefore provisional. Although the Byzantine road network has all the appearances of being orientated north-south, the linear directional mean analysis brings out a hidden feature, *viz*. east-west communications across the River Jordan in the direction of the holy



14. Linear directional mean against Byzantine road network in Palaestina Tertia east of the ghawr (arrow emphasises east - west communications with Jerusalem) (GISM. Ben Jeddou and C. Dauphin); (top left corner) camel caravan on Mount of Olives, Jerusalem with the hills of Moab in the distance, 1930s (courtesy George Khavedjian, Photo Elia, Jerusalem).

city of Jerusalem, the focal point of the entire region **(Fig. 14)**. The north-west - south-east linear directional mean is supported by historical sources. Notably, in order to alleviate successive periods of famine in Palestine west of the *ghawr* between 518 and 521, wheat was imported from Moab on the backs of female camels (Schwartz 1939, *Vita Sabae* 186: 15-17; Festugière 1962: 116)[6].

Thus, in addition to enabling us to model distribution, direction and relationships, spatial statistical analyses have so far revealed at least one pattern that was not immediately apparent and have allowed us to consider our data in a spatial manner.

Spatial Analyses

Although the spatial dimension of human activities is an essential element of archaeological research, it was neglected for many years. However, archaeologists now admit the possibility of reconstructing human activity, the agrarian landscape and population dynamics by means of spatial analyses (Kvamme 1992: 37; Zhang and Goodchild 2002: 115-122; Goodchild 2005: 3-33; Ahearn and David Smith 2005: 387**)**.

Our current research on *Palaestina Tertia* aims to integrate historical, archaeological and environmental data in order to gain a better understanding of the relationship between man (whether sedentary or nomadic) and space across the long span of eight centuries.

Slope and Aspect

Slope and aspect do not seem to have played an important role in the selection of areas for settlement in any of the periods under consideration. Could this be due to the burial of sites under accumulations of soil, a lack of site identification or even erroneous geographic coordinates?

Altitude

The distribution of sites indicates that low-lying areas were deemed undesirable for settlement, with the majority of sites being located at higher elevations. 236 of a total of 420 Byzantine sites are to be found at elevations ranging from 700 to 1,700 m. This seems to have been a characteristic element of the southern Jordanian landscape in Antiquity. It may have been linked to visibility, communications and perhaps defence. Moreover, rainfall increases with altitude, resulting in the possibility of two harvests per year, lower air and soil temperatures, less evaporation and the presence of compost-producing vegetation.

Pedology

The distribution of sites in relation to soils is significant, with major concentrations of sites (notably in the Byzantine period) in the northern part of the study area, corresponding to the presence of fertile soils. In the southern area, sites are typi-

6. Likewise, at the end of the 19th century, the *bedouin* of Transjordan travelled to Jerusalem to sell their wheat (Spafford-Vester 1950: 153).

cally located near the remains of terraces, a technique to retain soils and protect them from erosion (Mayerson 1962). This system of terraces on slopes or in *wadi* beds was not linked to any specific type of agriculture, as they supported cereals, vegetables, vines and also fruit trees, notably olives.

Altitude and Pedology

The correlation between altitude and pedology indicates that the richest soils are situated either in the north or at higher altitudes, where sites of all periods are also concentrated. In the southern part of the study area, sites were most frequently situated mid-slope or on rock fans, whilst cereals were grown in catchment basins and valley bottoms.

Distance to the hydrographic Network

Observations of cost / distance in relation to hydrography show that the 'hydrographic' variable is particularly interesting. The tight concentrations of Byzantine sites coincide with the dendritic hydrographic network comprising a multitude of small *wadis* **(Fig. 9)**. The risks posed by flooding of alluvial plains (e.g. malaria [Dauphin 2006]) do not seem to have deterred the establishment of settlements during the Byzantine period. This was probably because the best arable land was to be found where tributaries joined the main *wadis* and in the *wadi* beds, which were terraced for agricultural purposes.

Dendritic Distribution of Byzantine Sites

A similar dendritic distribution of population in the Byzantine period is also found west of the *ghawr* in the central Negev desert, in the area of the extinct volcanic craters at Mitzpe Ramon (Dauphin and Ben Jeddou 2009: figs 5 and 10). However, although this dendritic distribution of sites continued into the Islamic period in the latter region **(Fig. 6)**, east of the *ghawr* in southern Jordan a deliberate distancing of sites from water seems to have occurred from the Islamic period onwards, continuing into the Umayyad - Abbasid - Fatimid period. The malaria-carrying anopheles mosquito lays its eggs in stagnant waterponds, in pools of water along stream banks and in stretches of water on alluvial plains with impervious soils and bad drainage (Sergent and Sergent 1947). Consequently, the Prophet Mohammad forbade his *bedouin* from camping in valley bottoms or next to springs and paths which were the "meeting-places of night insects" (Lammens 1914: 24-25). The 8th century poet Ibn Mayyada emphasised the natural tendency of Caliph al-Walid II to prefer the desert to the agricultural *rīf* by proclaiming: "The vicinity of springs is not suitable for us; mosquitoes and fevers consume us" (Lammens 1910: 95). Terrified by malarial fever which was unknown in the desert, the *badu* warned: "Beware of the *rīf* ! To approach it means death, short term perdition" (al-Jahith n.d.). Thus, the progressive sedentarisation of the *bedouin* followed a strategy of avoidance.

In a swing of the pendulum, land use by the Crusaders – who were Christians with a western mentality – reinstated the close relationship between settlement and access to water, leading to a distribution of sites similar to that of the Byzantine period.

Distance to Springs

No preference may be surmised from the relationship of sites with springs[7]. However, this statement reflects the modern situation where very few springs have been recorded. Textual sources contemporary with the periods under consideration permit some adjustments. Thus, whereas the immediate surroundings of Petra lack springs on the Jordanian 1:50,000 topographic maps, the Petra *papyri* mention no less than three springs which provided water to the settlement of Wādī Mūsā in the Byzantine period (Inv. 88, no. 36, Kaimio and Koenon 1997: 495; Gagos and Frösen 1998: 473; Arjava, Buchholz and Gagos 2007: 195).

Distance to Ancient Roads

The calculation of cost / distance indicates a strong correlation between the proximity of ancient roads and archaeological sites in all periods. There is a clear preference for areas located close to the road network, principally within thirty minutes travel time[8].

7. For cost / distance to springs see Dauphin, C. and Ben Jeddou, M. 2012b: fig. 2.

8. For cost / distance of archaeological sites in relation to the road networks of all periods combined see Dauphin, C. and Ben Jeddou, M. 2012a: fig. 5.

15. Along the Kings' Highway of Jordan, women's festive dresses: (left) as-Salt, ca 1935; (right) Ma'ān, ca 1930 (Widad Kamel Kawar Collection, 'Ammān.)

16. Bedouin eating mansaf, 1925 (courtesy George Khavedjian, Photo Elia, Jerusalem).

An Attempt at Modelling

Multivariate Analysis of Data: Fallāḥīn and Nomads

The decision to conduct a study of population dynamics in our region by means of statistical analyses should be viewed within the framework of a diachronic approach which allows for the possible combination of a number of different variables, as well for checking the weight of each archaeological variable in population dynamics. In order to conduct a multivariate analysis, it is necessary to include as much information as possible (in addition to that of JADIS), e.g. from site publications, the Jordanian archaeological archives etc. By means of this type of analysis, we hope to shed light on sedentary sites.

The situation regarding nomadic encampments is more complex, owing to the infrequent survival of such sites in the archaeological record (Rosen 1987: 34-35, 1988). Furthermore, there is a near-absence of surveys focused on such sites in southern Jordan. The Greek inscriptions on the mosaic pavement at the funerary church of St. Sergius in the ecclesiastical complex at Nitl (Piccirillo 2002: 209-217), 10 km east of Mādabā, testify to the presence of a section of the Banu Ghassan tribe at the gates of Mādabā. This confirms the tradition recorded by the Arab historian Ya'qubi (d. 897), *viz*. that the Ghassanids had established themselves in the Balqā', south of Philadelphia ('Ammān), during the reign of the Byzantine Emperor Anastasius (r. 491 - 518). However, no trace of semi-sedentary encampments has been detected, whereas evidence of these was found by Dauphin (1995) around the *martyrion* of St. John the Baptist at er-Ramthaniyye in the Jaulan.

We will thus have to adapt the descriptive categories of our database to reflect reality and reveal the settlement typology of ancient nomadic space (tents), as opposed to the sedentary space of the *fallāḥīn*. Anthropologically, the contrast between the desert and the sown in Jordan is striking, be it detectible only in dress **(Fig. 15)**[9] and food **(Fig. 16)**[10].

The Road Creates the Water Source; it Attracts Man

Analysis of the distribution of archaeological material in relation to environmental data illustrates varying choices over time. Reasons for this are diverse. Road networks and hydrography have always played an important role in structuring the man-made landscape, notably in

9. There are great differences between the black and blue *thawb khalaqa* in cotton, with enormous sleeves, worn on festive occasions at as-Salṭ *ca.* 1935 (**Fig. 6**, left), and the gold and orange Damascus silk *thawb qameh* worn on similar occasions in Ma'ān *ca.* 1930 (**Fig. 6**, right). Both are in the collection of Widad Kamel Kawar, 'Ammān (al-Banna-Chidiac 2011: 149-150). The presence of Damascus silk at Ma'ān, in the heart of southern Jordan, is linked to the *Darb al-Ḥajj* from Damascus, on which pilgrims to Mecca – and also merchandise and luxury goods – travelled southwards to Ma'ān and on to Tabûk and Medina.

10. On food as a differentiation marker between *fallāḥīn* and *bedouin* in Jordan see Palmer 2002.

the Byzantine and Crusader periods. The late French geographer Jean Gottmann (1959: 91), Professor of Geography at the University of Oxford, ended his 1959 study on the relationship between "Man, Road and Water in South-Western Asia" with these words: "The road creates the water source; it attracts man".

Ḥumaymah provides a fascinating example. Just as the Moslem conquerors had emerged from the Arabian desert, it was in the desert – at the 8th century palace of al-Ḥumaymah – that the Abbasid dynasty mounted its rebellion against the Umayyads. Its predecessor, the city of Auara (Arabic *ḥuwāra* = "white"), had been founded by the Nabataean King Aretas III or IV in the 80s BC in an area poor in water resources (Graf 1983) to serve as a centre for sedentarisation of the local nomadic Nabataean pastoralists. Numerous reservoirs were dug in order to catch the winter rains, while 27 km of covered aqueducts delivered water from springs in the mountains to the north, thereby encouraging *bedouin* in the district to semi-sedentarise, camping there on an annual basis to trade in provisions for caravans (Eadie and Oleson 1986; Oleson 1986, 1988, 1990). After the annexation of Nabataea by the Romans, the rectangular Roman fort became a camp of "autochthonous archers on horseback" (Schick 1995b: 320) at *ca.* 400 AD, which in turn encouraged further settlement around the site[11]. Once sedentary, groups tended to settle on the most fertile lands first, hence the importance of the third factor: agricultural potential.

Our project, which integrates environmental and archaeological data by means of spatial analyses, should enable us to reconstruct the landscape and evaluate more clearly and precisely the transformations which have left their marks on the relationships between communities of *fallāḥīn* and nomads on the one hand, and the natural environment on the other. Methods of *bedouin* land use, first involving pastoralism on semi-arid lands, then subsequently semi-sedentarising and sedentarising (and sometimes even returning to a nomadic state), stem from very different perceptions of the environment and its potential. Reconstructing these perceptions from the traces that remain etched upon the landscape is a major challenge for our research.

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11. For the results of the al-Ḥumaymah Excavation Project see Oleson 2005.

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