Palaeoenvironments

4.1 Aims and overview

The palaeoenvironment sub-project is led by Dr Stuart Black. Dr Stuart Robinson resigned his position as a post-doctoral research fellow in September 2005 to take up a Royal Society University Research Fellowship at University College London. He was replaced by Dr Claire Rambeau in May 2006 who did her PhD in carbonate sedimentology and geochemistry at the University of Neuchâtel, Switzerland. Mr Richard Fitton resigned his PhD studentship in May 2006 to take up a position as a geologist in Canada. His post will not be replaced. Ms Rachel Goodship is undertaking an undergraduate dissertation on the Lake Lisan sediments to be submitted in March 2007.

The WLC palaeoenvironmental studies have benefited from collaborations with several groups doing related work. A collaboration with Nottingham University and Badia research centre has resulted in two applications for funding for research on the records of hydrological change in the Badia sequence in E. Jordan. Prof Abdulkader M. Abed (University of Jordan) has also agreed to provide field support and scientific input to the Lisan project. Dr Stuart Robinson, University Research Fellow at University College London, has agreed to continue an involvement with the project and has offered analytical facilities, as well as Mr Bernhard Lucke, from Friedrich-Alexander-Universitat, Institut fur Geographie, Erlangen-Nurmberg, Deutschland.

The overall aim of the palaeoenvironment sub-project is to reconstruct prehistoric, historic and modern landscapes to interpret river flow regimes (and hence water table, fluvial power and flow dynamics), sedimentary deposition and vegetation history of the Jordan Valley area. This year substantial progress has been made with the collection and analysis of samples from several sites.

4.2 Beidha

The palaeoenvironment group is exploring the link between potential climate change, as recorded in sedimentary and human occupation deposits, and human occupation at the Beidha archaeological site, S. W. Jordan. Beidha is best known for its Pre-Pottery Neolithic B occupation (PPNB), but for also containing Natufian components. Both Natufian and Pre-Pottery Neolithic B sites are numerous and occupy a wide range of environments than do Pre-Pottery Neolithic A sites. It is generally held by archaeologists that this pattern is associated with climatic changes following the end of Pleistocene glaciation. In particular, the colder and drier Younger Dryas, from about 13,000 to 11,500 years B.P., is thought by many to have rendered most sites unsuitable for the production of grains in quantities sufficient to support populations that had grown up during the Natufian. Thus Beidha offers an excellent opportunity to test the theory of climate-induced human occupation.

At Beidha, a series of samples have been collected throughout the archaeological deposits (Figure 4.1A) and underlying sequence of materials (Figure 4.1B), as well as throughout a two-metre thick travertine section (Figure 4.1C), which are being dated using 14C and U-Series techniques and the carbonate materials analysed for stable isotopes to interpret the water regime at the time.

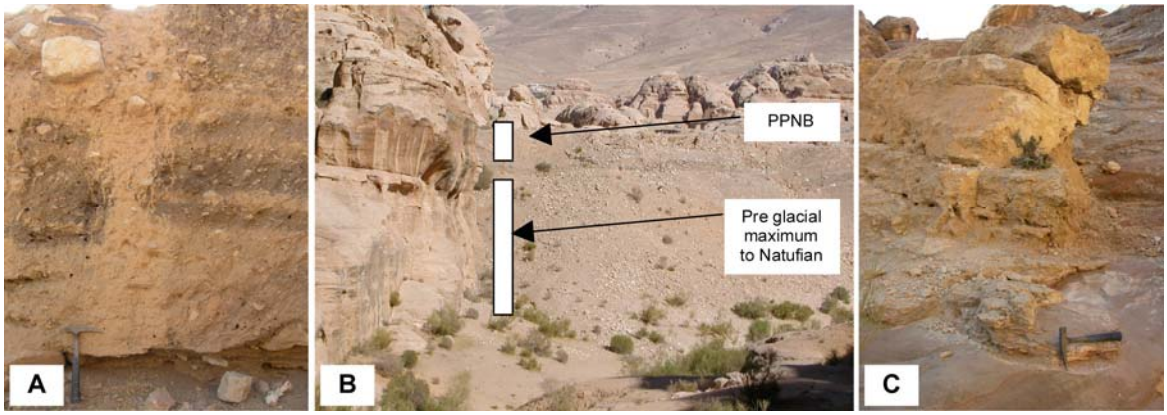


Figure 4.1A: *Section through the PPNB deposits at Beidha.* ***4.1B:*** *View of the Beidha archaeological site and underlying sediments.* ***4.1C:*** *Travertine series related to ancient spring activity adjacent to Natufian and PPNB settlements.*

4.3 Wadi Faynan

The palaeoenvironment group is also exploring the link between potential climate change and human occupation (Natufian – Islamic period) at Wadi Faynan. Wadi Faynan lies on the eastern edge of the active Dead Sea Rift system (Wadi Araba). The latter has created a complex series of fault systems that have left some areas of the rift walls upstanding. The mountains around Wadi Faynan rise from the Wadi Araba (-125 mbsl; metres below sea level) up to 1500 masl (metres above sea level), and represent the eastern edge of the rift valley. Continuous human occupation has occurred in Wadi Faynan for long periods of time and a series of differing approaches to human occupation and response to climate change has taken place. The sites around the early (PPNB and PPNC) occupations have been sampled to provided contextual information on rates of accumulation of materials (and hence palaeo-flow regimes within the wadi) and chronologies. Samples from younger geological units that cover the time periods 8500 years B.P to the present are also being explored.

4.4 Climate during the Nabatean to Early Islamic periods

The climatic conditions during Nabatean to Early Medieval periods are also being explored to interpret high-resolution, historical climatic changes. These climate changes have good proxies (Dead Sea lake levels, cores etc) and can provide a useful comparator for links between the palaeoenvironment and the human occupation of sites. The sites are being analysed through a series of mortar, plaster and carbonate crust that have accumulated at five Nabatean to early Islamic (namely: Humayma, Ma'an, Jilat, Qastal, Hallabat) sites in the semi-desert regions of Jordan. This work is being undertaken in conjunction with Dr Rebecca M. Foote, Harvard University. Chronological and stable isotope information on the carbonate materials will allow a better understanding of the extent and timescales of cultivation, particularly in the early Islamic period in Jordan.

4.5

Lake Lisan

The general evolution of climatic conditions from 20,000 years B.P. to present-day from analyses of Lake Lisan and Dead Sea sediments is also being undertaken. Lake Lisan existed from 70 to 15 cal ka B.P. and extended up to 200 km along the Dead Sea Transform at its highest level. During its history, the lake fluctuated between high-stands of 165-185 mbsl (Figure 4.2) and low-stands of around 700 mbsl. During this time the Lisan deposited laminated sequences of gypsum aragonite and clastic sediments in response to the regional climate. Studies on the Dead Sea system have shown that during high freshwater inputs aragonite plus clastics are deposited, whereas gypsum deposition is characteristic of dry, evaporitic conditions. Thus, these sediments give a high-resolution record of climate on a bi-annual from 70 cal ka B.P through to present day (using Dead Sea levels and sediments from 15 cal ka B.P. to present).

Figure 4.2. *Lisan sequence outcropping on eastern bank of Dead Sea (left) and the modern Dead Sea showing receding lake levels over the past 20-30 years.*

Work is underway to date a series of four sequences of Lisan material collected on the eastern bank of the Dead Sea (Figure 4.2). In addition, samples have been located that cover a time sequence up to the end of Lake Lisan (circa 15 cal ka B.P.) through to and including travertine deposition around the lake margin deposits.

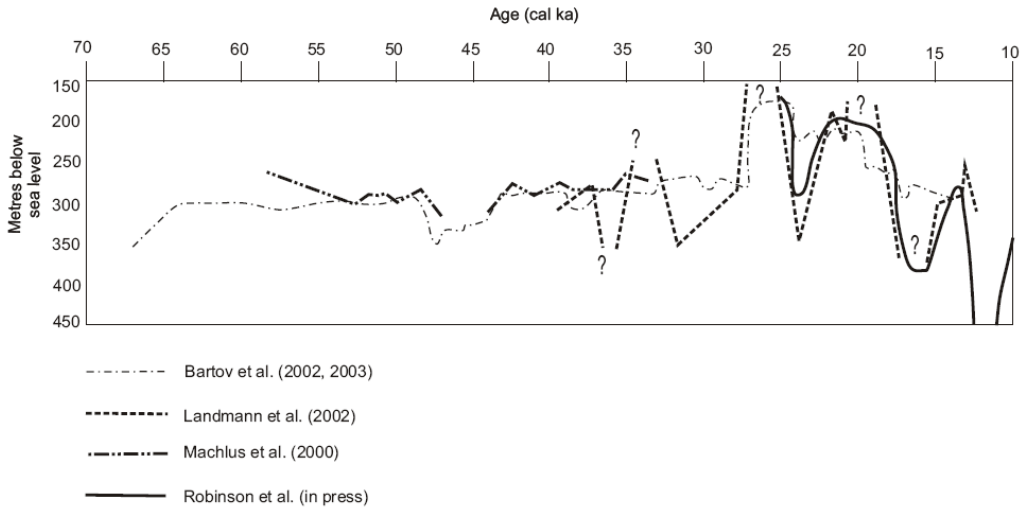
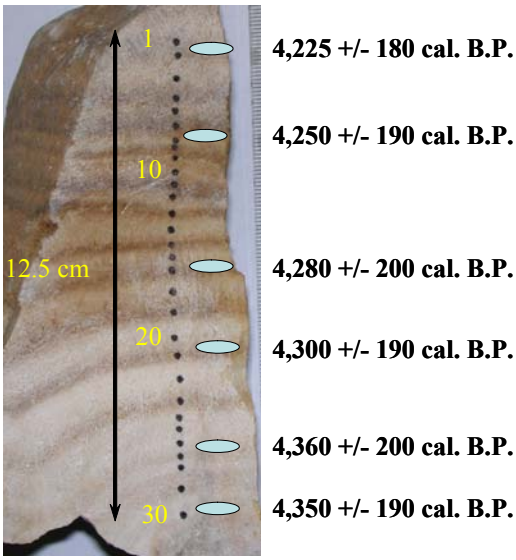


Figure 4.3. *Overlay of selected Lisan lake level curves to illustrate the variability in timing and amplitude of previous reconstructions. Note the work of Robinson et al. (2006) is an integration of a large number of previously published lake curves.*

The general evolution of climatic conditions from 20,000 years B.P. to present-day will also be quantified by overlaying the detailed Lake Lisan and Dead Sea records from banded sediments and nested travertine sequences on the shores of the Dead Sea, Wadi Faynan and Beidha. The travertine sequences have been collected over a large area and are being prepared for a series of analyses that include dating using U-series and stable isotopes (see Figure 4.4).

Figure 4.4. *Banded travertine sequence from the shore of the Dead Sea with drill points for oxygen isotope samples and samples taken for U-Series dating. Note dates show a very rapidly accumulating sequence.*



4.6 Study of carbonate paleosol concretions from northern Jordan

The Palaeoenvironment group is also undertaking a carbonate palaeosoil concretion study from northern Jordan as part of a joint project with Dr Bernhard Lucke and Prof. Rupert Baeumler from the Institut fur Geographie, Erlangen. The materials have been sampled from a sequence of soils from the Irbid area of northern Jordan and cover a range of highland through to lowland, well cultivated soils. The soils have concretions of carbonate that have precipitated in response to soil moisture and aridity conditions and when sectioned will give a record of soil water conditions over the period.

4.7 Research priorities for 2007

Beidha
At Beidha, a two-metre thick travertine section was sampled with a high resolution. Istopic composition of these travertine samples, along with sedimentological observations, will allow for an accurate reconstruction of the evolution of climatic conditions and vegetation cover before, and during the Neolithic occupation of the site.

Samples from the Beidha travertine series are currently being prepared for isotopic analyses (carbon and oxygen stable isotopes). Dating of major environmental changes, deduced from these curves, will be then undertaken. The results of this work will be submitted to the science journal Nature early in 2007.

Wadi Faynan
First steps has been taken to organize a two-week field session at Wadi Faynan in March 2007, with Dr Samuel Smith (archaeology sub-group) and Dr Andrew Wade (hydrology sub group). This field work will have as a goal to sample the travertine series adjacent to PPNA to Byzantine settlements in Wadi Faynan. Analytical results from the Wadi Faynan travertines will be compared to archaeological information and hydrological models for this site.

Carbonate crusts from Nabatean to Byzantine archaeological sites
The well preserved carbonate deposits (a few millimetres thick) from aquaducts, water channels, cisterns and reservoirs sampled during the October 2006 field session will be carefully dissect using a micro-drill and each layer will be analyzed for its isotopic composition. Dating techniques will also be chosen and performed (U series on carbonates and/or ^{14}C from charcoal fragments).

Dead Sea travertine series
Key samples from the twelve sections investigated during the October 2006 session will be dated (U series) and analysed for their isotopic composition. We aim at obtaining composite isotopic curves covering the last 20,000 - 22,000 years quantifying the periods of major environmental change for the Dead Sea area.

Dead Sea and Lake Lisan sediments
Samples from the Lake Lisan sequences collected over the past 12 months will be analysed for isotopic composition (carbon and oxygen stable isotopes), dated using U-Series and analysed for radiogenic isotopes (Pb and Sr) to elucidate their source.

Reviews
Further reviews of the climate of the Jordan Valley during the periods in question are being undertaken.