Hunting in the skies: Dating, paleoenvironment and archaeology at the late Pre-Pottery Neolithic B site of Naḥal Roded 110, Eilat Mountains, Israel

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Hunting in the skies: Dating, paleoenvironment and archaeology at the late Pre-Pottery Neolithic B site of Naḥal Roded 110, Eilat Mountains, Israel

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Abstract. *This paper presents findings from the first season of excavations conducted at the mountain-top site of Naḥal Roded 110, located in the southern Negev Desert near Eilat, Israel. Both radiocarbon and optically stimulated luminescence date the site to the Late Pre-Pottery Neolithic B (LPPNB, late 8th millennium BC). Palaeoenvironmental data from pollen and charcoal indicate that arid conditions prevailed in the region, with a strong Saharo-Arabian influence. The finds—flints, marine shells and stone objects—show affinities to LPPNB settlement sites in the region, while the faunal assemblage is unique and comprised solely of raptors. These features raise the question as to the function of the site—a specialised hunting camp, ritual site or our preferred explanation, a combination of the two.*

Résumé. *Cet article présente les résultats de la première saison de fouilles menées sur le site montagneux de Naḥal Roded 110, situé dans le sud du désert du Néguev près d'Eilat, en Israël. Les datations ^{14}C et par luminescence datent toutes deux le site de la fin du Néolithique acéramique B (LPPNB, fin du 8e millénaire av. J.-C.). Les données paléo-environnementales extraites des traces de pollen et de charbon de bois indiquent que des conditions arides similaires à celles d'aujourd'hui prévalaient dans la région, avec une forte influence saharo-arabe. Les objets trouvés – silex, coquillages marins et objets en pierre – montrent des similitudes avec les sites de peuplement du LPPNB dans la région, tandis que l'assemblage faunique est particulièrement original et composé exclusivement de rapaces. Ces caractéristiques soulèvent la question de la fonction du site : camp de chasse, site rituel ou, notre hypothèse préférée, une combinaison des deux.*

Keywords. *Pre-Potery Neolithic, Levantine deserts, palaeoenvironment, raptor exploitation, ritual sites, hunting camp*
Mots-clés. *Néolithique acéramique, déserts du Levant, paléo-environment, exploitation des rapaces, sites rituels, camp de chasse*

Examination of the Pre-Pottery Neolithic B (PPNB; *ca*. 8500-7000 cal. BC) record for the Southern Levant shows some degree of cultural cohesion in contemporaneous material culture (*e.g.*, lithic techno-typologies, burial customs: Bar-Yosef and Belfer-Cohen 1989, 2002; Bar-Yosef and Meadow 1995; Cauvin 2000a, 2000b). However, regional diversity in other traits, mainly related to settlement and subsistence patterns, is also evident (*e.g.*, papers in Kuijt 2002; Rollefson 2004), such that it seems that a diverse range of processes was taking place, in different geographic localities and at different tempos (Bar-Yosef 2007; Goring-Morris and Belfer-Cohen 2010). While some of this heterogeneity can be attributed to cultural and social variation, local ecology must have had a major influence on indigenous adaptations. This is especially likely when dealing with the arid

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margins, *i.e.*, southern and eastern Transjordan, the Negev and Sinai deserts, where distinct regional and sub-regional developments can be discerned throughout the period.

From the onset of the PPNB, the arid zones seem to have witnessed the same population increase as identified in the Mediterranean zones, although a more mobile, foraging way of life was maintained until relatively late in the Neolithic (Simmons 1981; Bar-Yosef 1984; Goring-Morris 1993; Rosen 2017). Notably, in the arid regions, there is evidence for settlement continuity throughout the PPNB as manifested at sites such as Naḥal ʻIssaron, Naḥal Reʻuel and Maʻale Shaḥarut in the Negev, ʻUjrat el-Mehed in the Sinai (Goring-Morris and Gopher 1983; Bar-Yosef 1984; Goring-Morris 1993; Carmi *et al*. 1994; Ronen *et al*. 2001; Barzilai 2010) and Ayn Abū Nukhayla, Bawwabah al-Ghazal, the Wadi Jilat sites, Dhuweileh, Jebel Naja, Wisad Pools and Burqu' in the arid areas of southern and eastern Jordan (Henry *et al*. 2003; Martin *et al*. 2013; Rollefson *et al*. 2014). In contrast, in the Mediterranean zone west of the Rift Valley, the archaeological record attests to a certain discontinuity of occupation during the Late PPNB (Rollefson 1989; Kuijt and Goring-Morris 2002; Simmons 2007; Jacobsson 2017; Birkenfeld 2018). This is particularly evident in the Galilee and adjoining regions, between 7250 and 7000 cal. BC, albeit with a few possible exceptions such as the site of Beisamoun (Bocquentin *et al*. 2014). Currently, we have little in-depth information with which to understand whether the observed inter-regional differences relate to environmental, demographic, socio-political shifts, or a combination of these or other factors.

Paleoclimatic data for the southern Levantine desert margins indicate arid conditions during most of the Holocene, with episodes of milder and perhaps slightly moister regimes than at present (Frumkin and Elitzur 2002; Bar-Matthews and Ayalon 2005; Amit *et al*. 2006; Migowski *et al*. 2006; Robinson *et al*. 2006; Babenko and Khassanov 2007; Rambeau 2010; Litt *et al*. 2012). PPNB desert sites are substantially smaller than their Mediterranean counterparts but show considerable inter-site variation based on lithic technotypology (Gopher 1994; Goring-Morris *et al*. 2009; Barzilai 2010; Miller *et al*. 2018). By the LPPNB, inter-site diversity is also found in subsistence patterns, which range from hunting and gathering in the Negev and Sinai (Goring-Morris and Gopher 1983; Dayan *et al*. 1986) to early pastoralism in some of the Jordanian arid zone sites (Martin 1999; Rollefson *et al*. 2014; Miller *et al*. 2018). It is also apparent in architectural forms: curvilinear architecture in habitation sites such as ʻEin Qetura, Naḥal Reʻuel and Naḥal ʻIssaron (Avner and Naor 1978; Goring-Morris and Gopher 1983; Gopher *et al*. 1994; Ronen *et al*. 2001) *versus* camp sites lacking architecture such as Naḥal Shaḥarut 1 and 2 (Avner 1982; Barzilai 2010: 108). Some desert sites have been identified as special-activity locales, such as production sites dedicated to specific products, or seasonal camps for hunting or herding. It has been suggested that these specialised sites were connected to larger settlements located in Transjordan, as there is evidence for exchange of material goods (and perhaps even dietary items) between these communities (Bar-Yosef and Belfer-Cohen 1989; Goring-Morris 1993; Bar-Yosef and Bar-Yosef Mayer 2002; Kuijt and Goring-Morris 2002; Barzilai 2010).

Intensive surveys of the hyper-arid southern Negev and Arava regions over the past 20 years have yielded an abundance of sites provisionally dated to the Neolithic, based primarily on surface lithics and the lack of pottery (Avner *et al*. 2014, 2019). These stand to expand our perceptions of the human exploitation of the arid zones during this period. Many of these are small sites, termed "Rodedian" after the wadi of Naḥal Roded located north-west of the town of Eilat where they are concentrated. These sites, although by no means representing a unique or discrete PPNB cultural entity, can nonetheless be distinguished from contemporaneous habitation sites in the region based on their repertoire of unusual architecture, material culture and their remote location (see below).

The current paper presents the preliminary results of the first excavation conducted in a PPNB site in the Eilat Mountains, at Naḥal Roded 110 (hereafter NR110; fig. 1). Our main aims were to investigate the site's chronology, stratigraphy and layout. Additionally, we sought to obtain samples of archaeobotanical and faunal remains in order to provide further information concerning subsistence, the nature of site use and to reconstruct the palaeoenvironment, since, as noted above, climate change has been implicated as a driver, though perhaps not the sole one, of the pattern of settlement in the PPNB. Finally, it was hoped that the resulting data would elucidate the relationship among different types of sites within the arid zone.

THE REGION

The southern Negev stretches from the Gulf of Aqaba/Eilat in the south to the Ramon Crater in the north, between the Sinai Peninsula on the west and the ʻArabah Valley to the east. This region is hyper-arid, currently experiencing an average annual precipitation of 20 mm (Ginat *et al*. 2011) while annual potential evaporation reaches 3600 mm and maximum summer temperatures are above 40°C. There are only a few, small permanent

Fig. 1 – *Map showing the location of Naḥal Roded 110 and other Neolithic sites in the region (map M. Birkenfeld).*

water sources and vegetation is confined to wadi beds (Danin 1988). The current vegetation cover is characterised by Saharo-Arabian shrubs and semi-shrubs such as *Anabasis articulata, Anabasis setifera, Retama raetam*, *Artemisia herba alba*, *Hammada scoparia* and *Zygophyllum* sp. (Danin 1988), with relatively few trees, though in the Yotvata region there is dense acacia savannah due to the localised high-water table (Danin 1995). Overall, during the Holocene, vegetation and climatic conditions in the Negev were arid. Trees may have been more common in the mid-Holocene as evidenced by identifications of *Pistacia atlantica, Tamarix* sp. and *Haloxylon persicum* in archaeological charcoals from sites in the 'Uvda Valley (Liphschitz 2001). In addition, based on pollen from sites in the Ramon Crater area, Babenko and Khassanov (2007) have suggested a more diverse vegetation at this time associated with a moist phase. Undoubtedly, these physical conditions influenced the extent, intensity and nature of the prehistoric human occupation, though may not have been the sole driver of these parameters.

"RODEDIAN" SITES

"Rodedian" sites are small, and most cluster above Naḥal Roded, *ca*. 5 km north-west of the town of Eilat (Avner *et al*. 2014, 2019). The sites are distinguished from contemporaneous habitation sites in the desert region by several unique characteristics:

– Geographic location: they are found in rugged topography, on high igneous mountain ridges. Sites are usually located just below the mountain summit, on topographic shoulders and saddles, or other relatively flat spots (see details in Avner et al. 2014, 2019).
– Architecture: built features consist of small and low cells built of unworked fieldstones, as well as other, small stone installations or flagstones set into the ground (Avner et al. 2014, fig. 6-7).
– Stone objects: aside from flint artefacts, the "Rodedian" sites contain numerous stone objects: standing stones, perforated stones, schematic anthropomorphic images, stone bowls and others (Avner et al. 2014, fig. 9-12). Many types are unique to these sites, some are worked and some natural, and they have been interpreted as having a symbolic nature. The vast majority of these objects are made of limestone, carried up to the igneous mountain tops from some distance.

The absence of pottery at the sites and the presence of distinct bidirectional blades, cores and other lithic components on the surface of some, have led to the suggestion that the "Rodedian" sites span the Early and Late Neolithic (*i.e*., 8th-6th millennia BC). Two ^{14}C dates taken during the survey support this attribution (Avner *et al*. 2014). Nonetheless, optically-stimulated luminescence (OSL) ages from one site (Roded 360) are later and could represent a subsequent intervention in the late 3rd millennium BC (Sohbati *et al*. 2015).

To date, over 370 "Rodedian" sites have been recorded in the southern Negev. In-depth research is of course needed to clarify whether or not we are dealing with a single phenomenon, as well as its chronological and geographic boundaries. As only 12 km^2 around the wadi of Naḥal Roded have been surveyed systematically, detailed surveys are still needed to understand the magnitude and extent of this phenomenon. The identification of two such sites by one of us (U.A.) on a

Fig. 2 – *Location of NR110, view to the west (photo M. Birkenfeld). White arrow marks the location of the L1017 stone heap.*

mountain north of Khirbet Naḥas (Jordan), located in the north-eastern part of the ‘Arabah valley, indicates that this type of site might not be “endemic” to the southern Negev.

THE SITE OF NAḤAL RODED 110

NR110 is situated *ca. 5* km north-west of the town of Eilat, above the wadi of Naḥal Roded, at an elevation of 420 m a.s.l. The site covers an area of *ca.* 200 m^2 and is located in the south-western part of a small, flat embayment, surrounded by granite peaks (fig. 2). It sits on “steps” formed in the igneous bedrock, rising gently from the base of the embayment upwards towards a rocky outcrop that protects the site on the west. A natural channel caused by run-off from the top of the ridge cuts the site on its northeast edge.

NR110 was first identified during a survey of the area in 2004. Aside from the presence of typical “Rodedian” stone objects, there were numerous characteristic PPNB flint artefacts on the surface. The site was selected for excavation due to the presence of several unusual features: an atypical heap of fieldstones, *ca.* 5 m in diameter, that appeared to be the remains of a structure; the presence of an ash deposit, presumably a hearth, northwest of the stone heap; and preservation of bone as attested by bone fragments on the surface of the ash deposit.

The excavation

The excavation was conducted according to standard procedures for prehistoric excavations; a 1 m^2 grid, divided into four sub-units was placed over an area of 160 m^2, encompassing the stone heap (the suspected structure) in the south-west corner to the presumed far edge of the hearth in the north-east (fig. 3). All sediment was sieved using a 2-mm mesh to ensure maximum recovery of small finds. Drone-based aerial photography was used during different phases of the excavation, to record the continuing exposures of the different features. While the provenance of the vast majority of artefacts was recorded according to their context (*i.e.*, locus) and grid location, salient finds were piece-plotted to enable distribution and statistical analysis of their relative locations.

Initially, following the preliminary survey, the site was thought to represent a superficial occurrence. Thus, work at the site began with a surface collection of all visible artefacts. These surface finds were hand-collected and documented by square within the 1 m^2 grid. As work progressed, it became apparent that the deposition at the site is more complex, and that

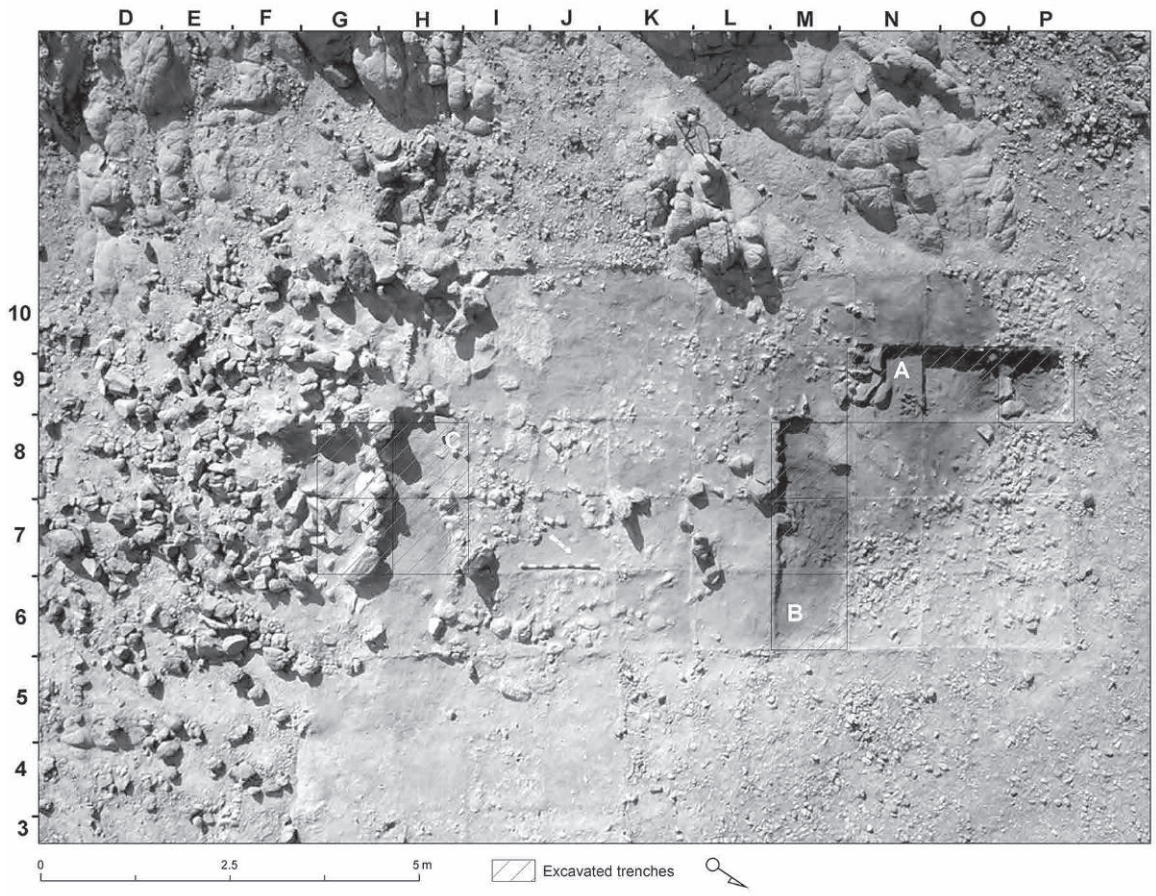

Fig. 3 – *Top plan of the tested area, showing the location of the three test trenches (A-C). The stone heap L1017 is on the left (photo U. Avner, GIS mapping M. Birkenfeld).*

artefact densities continued below the surface. Consequently, three test trenches (A-C) were excavated (fig. 3): Trenches A and B, each measuring 3 × 1 m, traversed the suspected hearth. Trench C, measuring 2 × 2 m, traversed the stone heap (the suspected structure). In the trenches, excavation was conducted in sub-squares and in maximum spit depths of 5 cm. Distinct contexts were given loci numbers and excavated as separate units while following the excavation grid.

Stratigraphy and features

As excavation proceeded, it was evident that the archaeological deposit was deeper than first assumed, occurring in pockets of sediment and arkose within the igneous bedrock of the mountain. Given this uneven bedrock surface, depth of deposition ranged from 1-2 cm in parts of the open area between the ash deposit and the stone heap, to over 60 cm within the stone heap itself. Beneath a very thin layer of loose dust, the entire deposit was covered by a thin layer of desert crust, *ca*. 1 cm thick. Beneath this crust, sediments were loose and rich in artefacts. In large parts of the area, a layer of small, fist-sized stones was recorded as well. Lithic artefacts, faunal remains, as well as marine shells and limestone flakes were found throughout the excavated area.

The ash deposit

During the survey, a patch of dark ashy sediment was discerned, *ca*. 5 m northwest of the suspected structure, thought to be a shallow hearth, some 2 m in diameter. However, during excavation, it was found to be far deeper and larger, covering an area of at least 5 m in diameter (fig. 3). Within this ash deposit, several small stone-built features were found, perhaps representing small hearths. Concentrations of ash and charcoals not accompanied by built installations were also identified, perhaps representing fire-spots. The ash deposit yielded abundant remains

of lithics, fauna and charcoal. Excavation in two squares, N9-O9, reached a depth of 20 cm, but the final depth of the ash is still unknown and awaits further excavation. The intensity of the ash deposit, its expanse and the identification of distinct events within it (built features, ash concentrations), suggest that it represents multiple episodes, rather than a single pyrotechnic event. The magnitude of these activities was surprising, given that all kindling, whether trees or large brushes, would have had to be carried up to the site from the wadi bed (see *infra*).

The stone heap

Limited excavation was conducted in the suspected structure. It comprises a large heap of unworked local granite rocks, approximately 5 m in diameter (fig. 3). After it was recorded, the stone heap was partially excavated in a 2 × 2 m test trench (Trench C), in an attempt to clarify the original layout of the structure. The trench reached a maximum depth of *ca*. 60 cm, but at this stage the original form of the structure is still unclear. It may either represent a circular structure as originally thought, or alternatively, represent a series of semi-circular walls. The latter, reminiscent of ancient hunting blinds recorded in the Near East (Lönnqvist and Lönnqvist 2011). Very few finds were collected from the structure/s; the spaces between the rocks were however filled with sediment and a few lithic artefacts that may have been washed downslope. Further excavation of this feature is planned.

SEDIMENTS

FOURIER-TRANSFORM INFRARED SPECTROSCOPY ANALYSIS (FTIR)

For an initial investigation of the sediment composition of the site, five samples, each comprising *ca*. 300-100 g of sediment were taken from different excavated squares and levels and analysed by Fourier transform infrared spectroscopy (FTIR; table 1 and fig. 4A). In addition, for comparative purposes, the same analysis was undertaken on four sediment samples from the non-archaeological deposit (L1018) that derives from a shallow pit, 5 cm deep, dug *ca*. 11 m to the east of the site (fig. 4A). To assess the intensity of burning, eight bone fragments from different excavated squares were also analysed (table 1 and fig. 4B).

All samples were powdered and mixed with 5 mg of KBr. The mixture was pressed into a 7 mm die using a Pike™ hand press and analysed with a Thermo Nicolet iS5 FTIR

Table 1 – *FTIR analysis of sediment samples and bone fragments from NR110 (F. Natalio). I: ilite; C: calcite; MC: microcline; G: Gypsum; N.d.: no data.*

Sample ID	Description	Discoloring	FTIR Analysis	Integrated interpretation
Sediments				
Sed. 12	Natural deposit top 1 cm, coarse powder/grains	Dark and light brown	I+C+MC	Unheated
Sed. 13	Natural deposit between 1-2 cm, fine powder/grains	Brown	I+C+MC	Unheated
Sed. 14	Natural deposit between 2-3 cm, fine powder/grains	Brown	I+C	Unheated
Sed. 15	Nnatural deposit between 3-4 cm, fine powder/grains	Brown	I+C+MC	Unheated
Sed. 28, Sq. N10	Between 0.86 and 0.90 cm, fine powder/grains	Black	I+C+G+MC	Unheated
Sed. 28, Sq. N10	Between 0.94 and 0.98 cm, fine powder/grains with coarse powder/grains	Black fine powder/grains and brown-grey coarse powder/grains	C+G	N.d.
Sed. 28, Sq. N10	Between 1.02 and 1.04 cm, fine powder/grains with coarse powder/grains	Black fine powder/grains and brown-grey coarse powder/grains	C+G	N.d.
Sedi. 7, Sq. O7	L1004, fine powder/grains	Dark brown	I+C	Unheated
Sed. 26, Sq. G8	Between 1.39 and 1.43 cm, fine powder/grains with coarse powder/grains	Brown	I+C+MC	Unheated
Bones			**Splitting factor**	
Sq. L6B	L1005, between 1.35 and 1.42 cm	Brown	3.339	Typical range for fossil bones
Sq. H6	L1004-1005	Pearl	3.095	Typical range for fossil bones
Sq. O9A	L1010	Light brown	3.403	Typical range for fossil bones
Sq. L7D	L1005, between 1.32 and 1.37 cm	Brown	3.111	Typical range for fossil bones
Sq. L7D	Between 1.37 and 1.41 cm	Dark brown	3.246	Typical range for fossil bones
Sq. L7D	L1010, between 1.37 and 1.41 cm	Light brown	3.606	Typical range for fossil bones
Sq. G8	L1009	Lighter brown	2.969	Modern (intrusive?) or very well preserved
Sq. H9	L1004	White-yellow	4.707	Highest value for site but in range of fossil bones

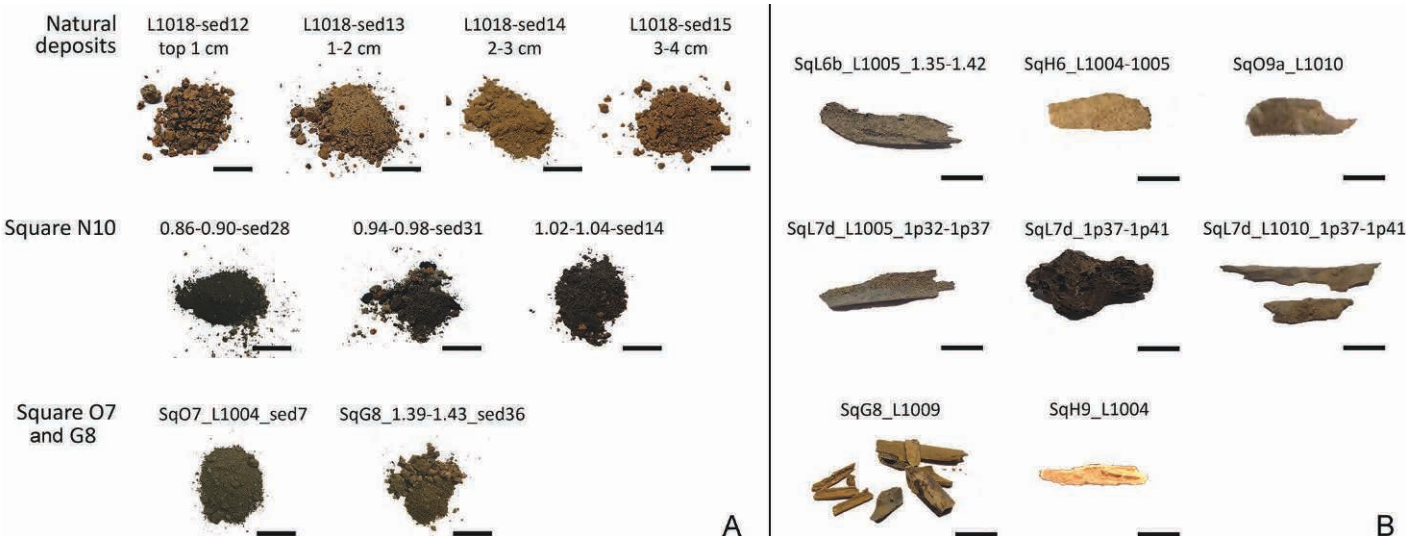

Fig. 4 – ***A.*** *Sediments retrieved from NR110 (two bottom rows) and the surrounding non-archaeological deposits (top row; scale bar 1 cm);* ***B.*** *Bone fragments excavated at NR110 (scale bar 1 cm; CAD F. Natalio).*

spectrometer. FTIR spectra were collected by performing 32 scans with a resolution of 4 cm^{-1} in the 4000-400 cm^{-1} spectral range. The FTIR spectra were analysed using *Omnic* software and replotted using *OriginLab Pro* 2018 (b9.5.0193). The splitting factor of carbonate hydroxyapatite was determined as described elsewhere (Weiner and Bar-Yosef 1990).

Non-archaeological sediments

While sediment in the top 1-cm layer of the non-archaeological deposit is composed of coarse grains with colour variations between light and dark brown, samples from the three layers below consist of relatively fine, powdery sediment displaying similar colouration. As shown in Figure 5 (grey box), for the FTIR analysis, the first two layers and the fourth layer are composed of illite (I), calcite (C) and microcline (MC), as representative of the presence of potassium feldspar such as orthoclase. The third layer is composed of illite and calcite only. No signal for kaolinite and smectite were found in the spectra of the non-archaeological sediment and no signs for heating were found in any of these sediments.

Archaeological sediments

Samples collected from different positions and depths within the grid show distinctive chemical composition (fig. 5). Three samples were taken in Square N10 at different depths

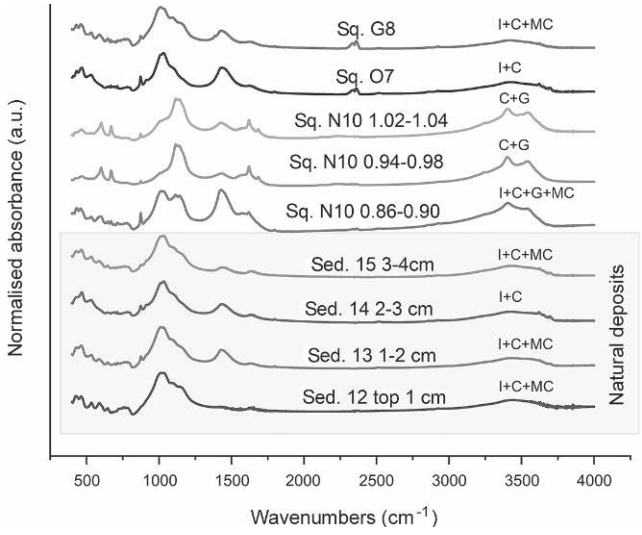

Fig. 5 – *FTIR spectra of sediments (CAD F. Natalio) retrieved from NR110 and the surrounding non-archaeological deposits (grey box). C: calcite; G: gypsum; I: ilite; MC: microcline.*

and analysed by FTIR. The upper layer consists of black fine powder (identified on-site as the ash deposit) containing illite, calcite, gypsum and microcline. In the two samples from underneath, the sediment is also characterised by fine black powder but here it is mixed with brown-grey coarse grains. The FTIR revealed the presence of gypsum and calcite only. The

calcite was analysed further by measuring the heat-induced disorder, though the ν_2 and ν_4 position in predetermined grinding curves (Poduska *et al*. 2011). Evidence for ash was confirmed in three of the sediment samples examined from the burnt patch (Sed Samples from Sq. N10, O7, G8).

Bone samples

Eight bone fragments were analysed by FTIR (Berna *et al*. 2012; table 1 and fig. 6) with the focus on the splitting factors that can result from heat-induced transformations (*e.g.*, original biogenic carbonate hydroxyapatite [CHA] transformation into hydroxyapatite [HA]; Weiner and Bar-Yosef 1990). Most of the analysed bone fragments show a splitting factor between 3 and 4, a value typically found in fossil bones that have undergone diagenetic changes (Weiner 2010). The colouration of these bone fragments ranges from light to dark brown due to chemical adsorption of soil organic molecules. The absence of a peak at 630 cm^{-1} in all spectra demonstrate that the bones, if heated, were not exposed to temperatures above 500°C (Berna *et al*. 2012). Thus, based on FTIR and splitting factor, we are unable to determine whether the bones were heated at all.

Among the analysed bones, two other samples stand out. The bone fragment from Square G8 (L1009) is lighter coloured when compared with others. In fact, the splitting factor is 2.969—a value typical for modern bone. A closer inspection of the IR spectrum shows that this bone fragment is composed of original biogenic carbonate hydroxyapatite. Although it might be intrusive, it seems unlikely due to the depth at which it was found. A second bone fragment recovered in Square H9 (L1004; in the ash deposit) also shows a lighter colouration than the other analysed samples. However, IR spectrum analysis shows a slightly higher splitting factor (4.707) when compared with all other analysed samples suggesting that it may have undergone a more extensive diagenetic change.

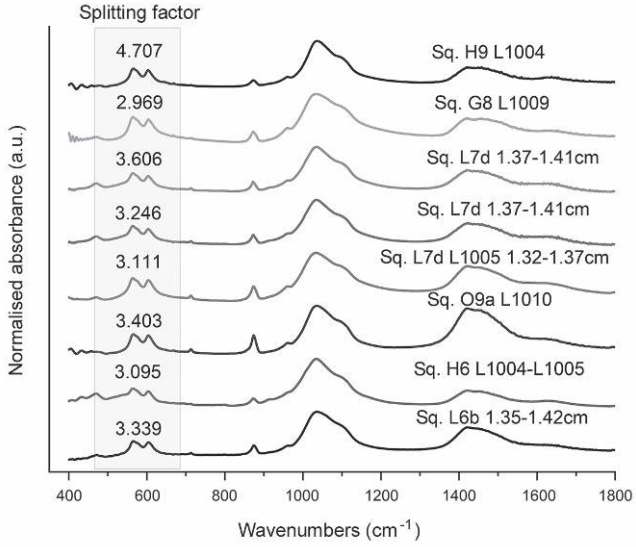

Fig. 6 – *FTIR spectral overview (CAD F. Natalio) of bone fragments retrieved from NR110 showing the values of the splinting factors (grey box). All the samples consist of original biogenic carbonate hydroxyapatite (CHA).*

MICROMORPHOLOGY OF SEDIMENTS

In two of the excavated trenches (A and B), undisturbed sediment blocks were collected using robust plastic boxes—in Trench A, two square boxes each *ca*. 10 × 10 cm were used for sampling, and in Trench B, two plastic electrical outlet boxes *ca*. 8 × 7 cm were used. In each trench the blocks covered the vertical exposure of the section from top to base. Sampling procedures followed those outlined in Goldberg and Macphail (2003).

The blocks were wrapped for transport to the laboratory and subsequently air-dried. They were shipped to the thin section laboratory of PACEA (CNRS, Université de Bordeaux, France), where they were embedded under vacuum using a mixture of polyester and styrene, with the addition of a hardener. The hardened blocks were then cut with a rock saw and the resulting slices were mounted onto glass slides and polished to a thickness of 30 µm. Micromorphological analyses were carried out using a Leica DM2500 P petrographic microscope at different magnifications (25×, 50×, 100×, 200×, 400×). Descriptions and interpretations are based on conventional criteria developed in the specialised literature (Stoops 2003; Stoops *et al*. 2010; Macphail and Goldberg 2017; Nicosia and Stoops 2017).[1]

Samples SNQ10-1 from Trench A (Square N9)

These samples are mainly comprised of quartz sand and silt mixed with aggregates of elongated biotite sheets, likely derived from the degradation of granite bedrock (fig. 7A). Part of the sand fraction is of aeolian origin. The granite occurs as pebble-sized fragments throughout the sample. Coarse fraction components are not tightly packed, suggesting that the deposit was not trampled. In addition to minerals, brown-coloured bone fragments are found in small clusters at four locations

1. Detailed thin section descriptions are listed in Table 2 and Figure 7 and follow the terminology of Stoops 2003.

Table 2 – *Description of micromorphology samples collected at NR110, following the terminology of Stoops 2003 (M. Toffolo).*

Sample #	Description
SNQ10-1	**C/f related distribution:** fine to coarse enaulic. **Structure and voids:** intergrain microaggregate microstructure with complex packing voids. **Coarse fraction:** angular and sub-angular, fine sand-sized quartz grains (frequent); angular, fine sand-sized plagioclase and hornblende grains (few); angular, medium to coarse pebble-sized granite fragments (common); sub-angular, silt-sized quartz grains (few); elongated (~500 µm) biotite sheets in aggregates (frequent); sub-angular to sub-rounded, sand-sized charcoal and bone fragments (very few). **Fine fraction:** aggregates of pale-brown clay showing striated and stipple speckled b-fabric (very dominant); finely comminuted charcoal (common). **Pedofeatures:** calcium carbonate coatings on bone fragments and intergrowths (very few); calcium phosphate intergrowths (very few); gypsum typic orthic nodules (few).
SNQ10-2	**Cc/f related distribution:** fine to coarse enaulic at the top of the sequence, open porphyric at the bottom. **Structure and voids:** intergrain microaggregate microstructure with complex packing voids at the top of the sequence, massive microstructure at the bottom. **Coarse fraction:** angular and sub-angular, fine sand-sized quartz grains (frequent); angular, fine sand-sized plagioclase and hornblende grains (few); angular, medium to coarse pebble-sized granite fragments (common); sub-angular, silt-sized quartz grains (few); elongated (~500 µm) biotite sheets in aggregates (common); sub-angular to sub-rounded, sand-sized charcoal and bone fragments (few). **Fine fraction:** at the top of the sequence, the fine fraction includes finely comminuted charcoal (dominant) and aggregates of pale-brown clay showing stipple speckled and striated b-fabric (frequent). At the bottom of the sequence, the fine fraction is mainly composed of gypsum needle intergrowths with faint b-fabric (dominant), finely comminuted charcoal (frequent) and aggregates of pale-brown clay showing stipple speckled and striated b-fabric (few). **Pedofeatures:** calcium carbonate intergrowths (very few); gypsum typic orthic nodules and intergrowths (few).

(fig. 7B). The fine fraction includes weathered biotite in small aggregates and a significant amount of finely comminuted charcoal, which occurs also as sand-sized fragments. Calcium carbonate crystals occur in two pockets, also in association with bones in the form of coatings (fig. 7C). This type of pedofeature is consistent with the precipitation of secondary calcium carbonate (Karkanas and Goldberg 2019), possibly originating from calcitic ash, in agreement with the FTIR results. In a few instances, secondary calcium phosphate intergrowths and gypsum nodules occur as well. These lines of evidence suggest that SNQ10-1 represents a deposit of local sediment mixed with wood ash. However, the ash underwent dissolution and reprecipitation processes that caused the loss of pristine pyrogenic calcite and the nucleation of secondary phases, presumably due to the slightly acidic environment of the local granite geology (Toffolo *et al*. 2019).

Samples SNQ10-2 from Trench B (Square M8)

These samples are characterised by the same mineral composition as SNQ10-1, although less biotite is present. The fine fraction includes pale brown aggregates of weathered biotite and a dominant component of finely comminuted charcoal. In addition, the lower portion of the sample is characterised by an extensive groundmass of gypsum needles grown within pores as a result of secondary precipitation. Gypsum is concentrated also in mm-sized nodules (fig. 7D). This post-depositional process gives the sediment the misleading appearance of a compact deposit (fig. 7E). However, the upper portion of the sample features considerably less gypsum and more free pores, thus excluding compaction. Furthermore, bedding was not observed. Brown-coloured bone fragments occur at four locations (fig. 7F), whereas calcium carbonate is almost absent, except for a single secondary crust (fig. 7G). The almost complete lack of calcium carbonate derived from wood ash is consistent with the FTIR results and with dissolution in an acidic environment. On the other hand, charcoal appears to be fairly well preserved, and in a few cases, it preserves its anatomy (fig. 7H). The large amount of charcoal and the presence of bone fragments in sample SNQ10-2 lend support to the evidence collected during fieldwork and with other analytical methods and points to the presence of an ash deposit that underwent diagenetic alterations consistent with an open-air site located on igneous bedrock.

DATING

AMS RADIOCARBON DATING

Two lumps of charcoal and three samples of micro-charcoal obtained from Squares M8 and O9d (table 3) were submitted for charcoal identification and radiocarbon analysis. The two samples were taken from within the ash deposit: Sample Char 3 from Square O9d (PRI-5938) was collected from the top of the ashy deposition, below the desert crust, in Square O9d. Sample Char 1 from Square M8 (PRI-5937) was collected from the

Table 3 – *Provenance, wood identification and ^{14}C dates for NR110 (L. Scott Cummings).*

PRI AMS no.	Site location	Elevation	Sample id.	AMS ^{14}C date	1σ cal. date BC (68.2%)	2σ cal. date BC (95.4%)	$\delta^{13}C$ (‰)
PRI-5937	Sq. M8, L1014	433.64	*Tamarix* charcoal	8217±26 RCYBP	7310-7170	7340-7130; 7110-7080	-25.00
PRI-5938	Sq. O9d, L1010	433.93	*Tamarix* charcoal	8178±25 RCYBP	7190-7080	7310-7210; 7200-7070	-24.00
PRI-4397	Surface of ashy area		Micro-charcoal	8146±29 RCYBP	7170-7070	7300-7270; 7260-7220; 7190-7050	-22.8
PRI-3033	Surface of ashy area		Micro-charcoal	7950±250 RCYBP	7180-6560; 6550-6530	7520-6400	

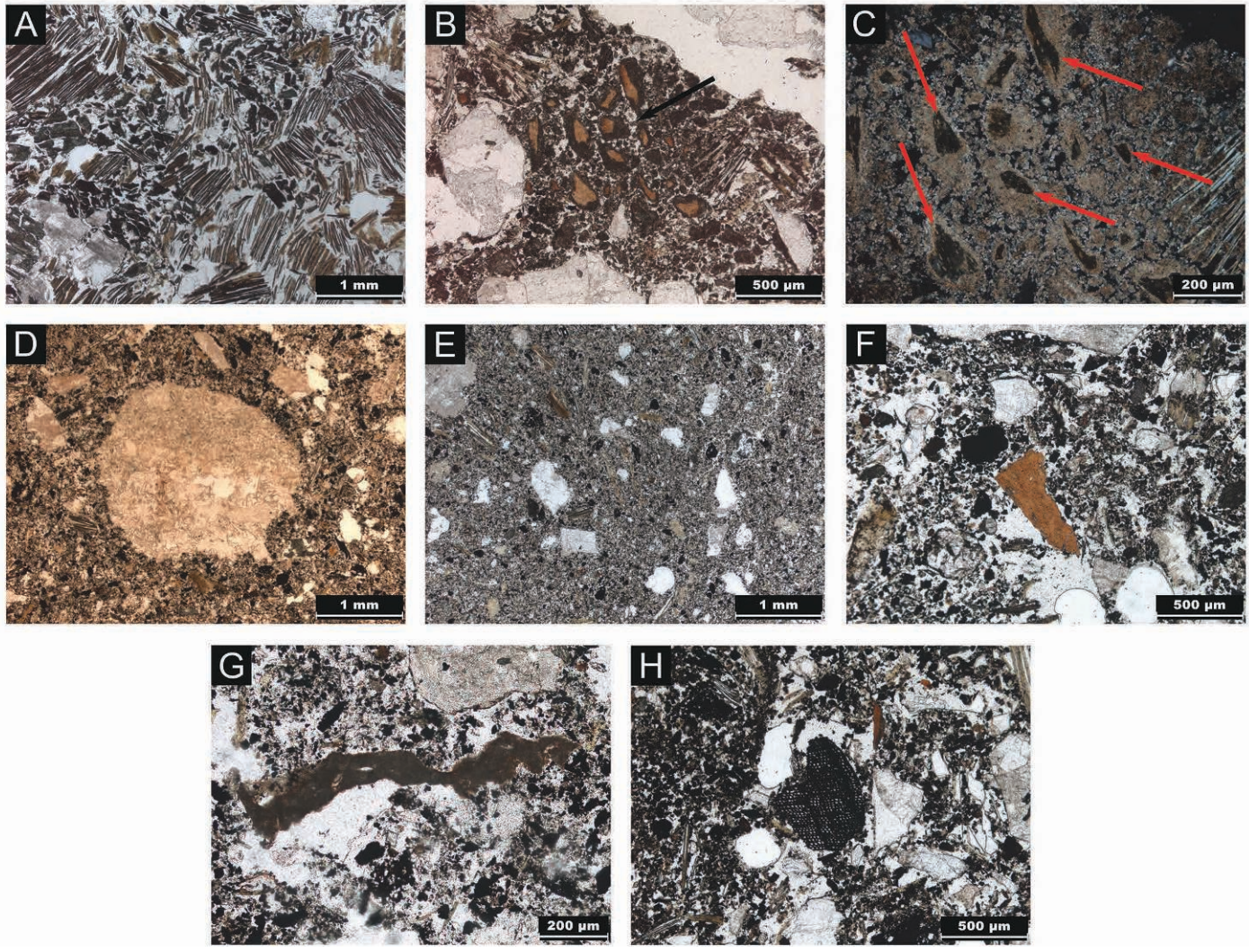

Fig. 7 – *Micromorphology slides of samples SNQ10-1 and SNQ10-2 (CAD M. Toffolo).* ***A.*** *Microstructure of sample SNQ10-1, showing aggregates of elongated biotite sheets (PPL);* ***B.*** *Cluster of bone fragments in SNQ10-1 (arrow; PPL);* ***C.*** *Pocket of secondary calcium carbonate coating bone fragments in SNQ10-1 (arrows; XPL);* ***D.*** *Large gypsum nodule (centre of image) in sample SNQ10-2 (PPL);* ***E.*** *Microstructure of SNQ10-2, showing the apparent compact nature of the sediment. Note the large amount of charcoal occurring as sand-sized fragments and fine fraction between coarse grains (PPL);* ***F.*** *Bone fragment (centre of image) mixed with charcoal in SNQ10-2 (PPL);* ***G.*** *Secondary calcium carbonate crust (centre of image) in SNQ10-2 (PPL);* ***H.*** *Charcoal fragment exhibiting preserved wood anatomy (centre of image) in SNQ10-2 (PPL).*

very bottom of the ashy deposition exposed in Square M8, almost 30 cm lower in absolute height.

The wood species was identified, and both samples weighed prior to selecting subsamples for pre-treatment. Selected subsamples were vacuum freeze-dried, freezing out all moisture at -107 EC and <10 millitorrs. Then samples were treated with cold pH2 hydrochloric acid (HCl), followed by cold 6N HCl. Samples then were heated to approximately 110 EC while in 6N HCl. This step was repeated until the supernatant was clear. This step removes iron compounds and calcium carbonates that hamper humate compound removal. Next, only sample PRI-5937 was subjected to 0.5% potassium hydroxide (KOH) to remove humates using both cold solutions and solutions that were heated. Once again, the samples were rinsed to neutral and re-acidified with pH2 HCl between each KOH step. This step was repeated until the supernatant was clear, signalling removal of all humates, then was rinsed to neutral. KOH treatment was not used on PRI-5938 because the first pieces of charcoal for this sample disappeared in the application of hot KOH. The remaining charcoal fragments were treated with HCl only so a date could be obtained.

After humate removal, samples were made slightly acidic with pH2 HCl. Each sample was freeze-dried, then combined in a quartz tube with a specific ratio of cupric oxide (CuO) and elemental silver (Ag) in quantities based on the mass of carbon in the sample. The tubes were hydrogen flame-sealed under vacuum.

A radiocarbon "dead" wood blank from the Gray Fossil site in Washington County, Tennessee, dated to the Hemphillian stage of the Late Miocene, 4.5-7 MYA (currently beyond the detection capabilities of AMS) was used to calibrate the laboratory correction factor. In addition, standards of known age, such as the third international radiocarbon inter-comparison (TIRI) Sample "B" (Belfast Pine) with a consensus age of 4503±6, and TIRI Sample "J" (Bulston Crannog wood) with a consensus age of 1605±8 (Gulliksen and Scott 1995), were used to help establish the laboratory correction factor. After the requisite pre-treatment, a quantity similar to submitted samples of each wood standard was sealed in a quartz tube. Once all the wood standards, blanks, and submitted samples of unknown age were prepared and sealed in their individual quartz tubes, they were combusted at 820 EC, soaked for an extended period of time at that temperature, and allowed to cool slowly, enabling the chemical reaction that extracts carbon dioxide (CO_2) gas.

Data presented are displayed as conventional radiocarbon ages and calibrated ages using IntCal13 curves on OxCal version 4.3.2 (Bronk Ramsey 2009; Bronk Ramsey and Lee 2013; Reimer *et al*. 2013). The combusted ^{14}C samples were submitted to the accelerator at the Center for Applied Isotope Studies in Athens (CAIS, Georgia, USA).

Ages

Sample Char 1 from Square M8 (PRI-5937) comprised a single charcoal fragment identified as *Tamarix* sp. It yielded an AMS radiocarbon age of 8217±26 BP, which calibrates, at the two-sigma level, to 7340-7130; 7110-7080 BC (table 3 and fig. 8). Sample Char 3 from Square O9d (PRI-5938), contained six pieces of *Tamarix* sp. charcoal, which yielded an AMS radiocarbon age of 8178±25 BP. This date calibrates, at the two-sigma level, to 7310-7210; 7200-7070 BC (fig. 8). These two dates are very close to one another and calibrate to a very

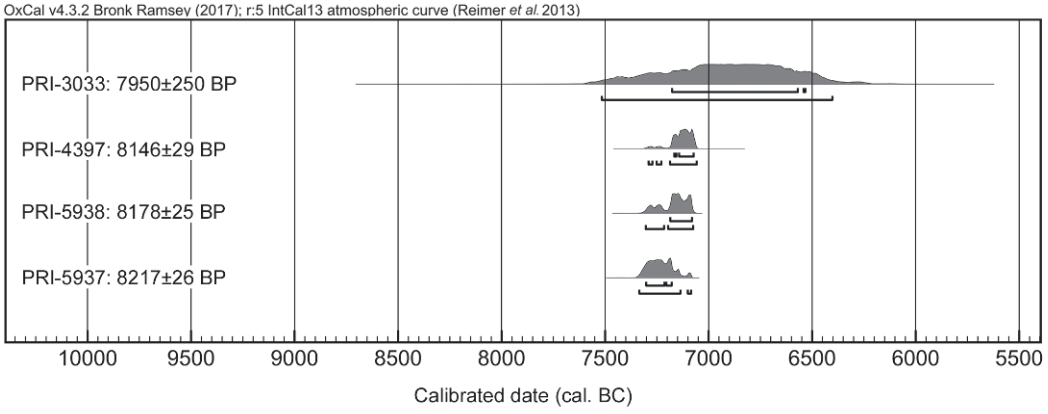

Fig. 8 – *^{14}C multiplot of calibrated ages BC (CAD L. Scott Cummings).*

similar interval, suggesting that the ash and charcoal throughout both areas represent the same occupation. They both compare favourably with two dates previously obtained from the top of the ash deposit, both on micro-charcoal (PRI-4397, PRI-3033), dated *ca*. 7100 and 6900 cal. BC (table 3 and fig. 8; Avner *et al*. 2014). Together, the four dates provide a period of *ca*. 200 years for the presently excavated depth of the ash.

OPTICALLY STIMULATED LUMINESCENCE (OSL) DATING

Optically stimulated luminescence measures the time that has passed since the last exposure of quartz grains to sunlight (Wintle 2008). The resulting ages are burial ages of the sediment containing the target mineral. The quartz at the Naḥal Roded site has two sources; the first is the disintegration of the local igneous bedrock of quartz-porphyry and granite, and the second is the aeolian contribution from dust. These have different grain sizes, >200 µm and <125 µm, respectively. We targeted the aeolian quartz as when deposited it is well bleached, and its luminescence properties are by far better than the igneous quartz regarding bleachability, signal intensity and recuperation (Porat *et al*. 2013; Sohbati *et al*. 2015). Additionally, *in situ* disintegration of the bedrock will result in the contribution of non-bleached quartz grains to the sediment, and excluding this granitic quartz is necessary. We used sieving to select for the aeolian quartz and reject that derived from the bedrock.

Sediment samples were collected during the excavation using a trowel, to target the fine sediment that accumulated in specific locations during or after use. Sampling was carried out under an opaque cover to prevent any exposure to sunlight, and the sediment was placed immediately in black, light-tight bags. Two samples are from the L1017 stone heap (structure/s) in Square G8, and one from the ashy deposit in Square O9b (table 4 and fig. 9). Samples NRD-3 and NRD-4 were obtained from the very base of two large stones revealed when excavating within the L1017 structure/s, at the bottom of the excavation. Sample NRD-5 was recovered from the base of the thick ashy deposit, at a depth of 13-15 cm below surface, and was collected horizontally from this 2-cm layer. In all cases, the sampled sediment is dust that was deposited after the archaeological use of the site. Very-fine-sand quartz (90-125 µm) was extracted using routine laboratory protocols (table 4; Faershtein *et al*. 2016) and all laboratory work was done under suitable dim orange lighting, not to erode the OSL signal. The equivalent dose (De in Gray), the amount of environmental dose absorbed by the sample, was measured using the single aliquot regenerative dose (SAR) protocol (Murray and Wintle 2000), following dose recovery tests that selected the most appropriate preheat temperatures. Dose rates were calculated from the concentrations of the radioactive elements K (measured by ICP-OES) and U and Th (measured by ICP-MS). The cosmic dose rate was estimated from current burial depths. The OSL signal of the samples is bright and the distribution of replicated aliquots from the same sample is tight (table 4 and fig. 9), increasing our confidence in the reliability of the ages.

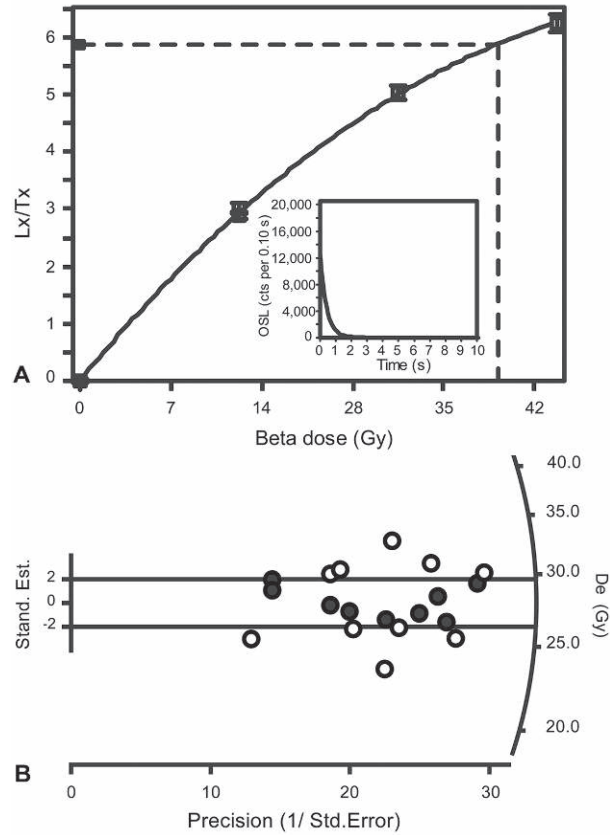

Fig. 9 – *OSL ages (CAD N. Porat).* ***A.*** *A dose response curve for one aliquot from sample NRD-3 showing the normalised regenerated signals (y-axis) against the given beta dose (x-axis). The De for that aliquot is marked by the dashed line, 31.7±1.7 Gy. The dose point at ~14 Gy is a superposition of three dose points; the second and third are recycling points before and after the depletion of the IRSL signal. The superposition indicates that the SAR successfully corrects for any sensitivity changes, and that there is no contamination from feldspars. Inset shows the decay of the natural OSL signal as a function of illumination time for that aliquot. Note bright signal and rapid decay to almost background levels within 1.5 s.* ***B.*** *Radial plot of all aliquots measured for sample NRD-3. The average De, calculated using the central age model (Galbraith and Roberts 2012) is 29.7±0.8 Gy.*

Table 4 – *OSL data for samples from NR110 (N. Porat). 90-125 µm quartz was purified by wet-sieving to the selected grain size, dissolving carbonates by 8% HCl, removing heavy minerals by magnetic separation, and dissolving feldspars and etching the quartz with 40% HF (for 40 min), followed by soaking in 16% HCl to dissolve any fluorides which may have precipitated. Moisture contents were estimated as 3±2 %. De was measured on 2 mm aliquots using a modified single aliquot regenerative (SAR) protocol. The average De and errors were calculated using the central age model (CAM). Alpha, beta and gamma dose rates were calculated from the contents of the radioactive elements measured by ICP MS (U&Th) or ICP-OES (K). Cosmic dose rates were estimated from the current burial depths. OD: Overdispersion, a measure of scattering within the sample beyond that expected from analytical noise. Aliquots used: the number of aliquots used for the average De out of the aliquots measured.*

Lab code	Sq.	Archaeological description	Depth (m)	K (%)	U (ppm)	Th (ppm)	Ext. α (µGy/a)	Ext. β (µGy/a)	Ext. γ (µGy/a)	Cosmic (µGy/a)	Total dose (µGy/a)	No. aliquots	OD (%)	De (Gy)	Age (yr. b. 2017)
NRD-3	**G8**	Base of L1017 structure	0.4	2.2	1.8	3.9	8	1813	888	219	2927±87	19/19	11	27.9±0.8	**9540±400**
NRD-4	**G8**	L1017 structure	0.3	2.4	1.6	4.7	8	1937	952	229	3126±95	18/19	17	25.4±1.1	**8130±440**
NRD-5	**O9b**	Ash deposit	0.15	3.1	1.4	6.2	8	2398	1152	253	3811±119	19/19	9	26.4±0.6	**6930±270**

Ages

The oldest age, 9540±490 BP (years before 2017), is from the collapsed structure (L1017), below one of the fallen construction stones (Square G8). This age indicates a time either during or after the use of the site. It agrees very well with radiocarbon dates from the site of 9200-9300 BP (accounting for the 67 years passed since 1950).

A somewhat younger age, 8130±440 BP, comes from the same square but from the outer side of the structure (Square G8), from sediment that accumulated between two fallen construction stones. This sample also provides a time during or after the collapse of the structure.

The youngest sample, 6930±270 BP, comes from a small hearth in the middle of the ash pile (Square N9). Taking into account the standard deviation, this date is still 1000 years younger than the radiocarbon ages obtained on charcoal from the same layer. The sediment sample may contain more recent, intrusive grains. Further samples will be taken for OSL dating to elucidate this issue.

LITHICS

The surface collection, as well as the trenches, proved to be rich in lithic material, comprising thousands of artefacts. A sample totalling 2,118 artefacts (*ca*. a quarter of the entire assemblage) has been analysed to date, consisting of tools (2.8%), cores (1%), debitage (41.5%) and debris (54.8%; table 5). The sample was selected from different loci in an attempt to represent the entire range of depositional contexts identified at the site. Raw materials are relatively varied, including tan coloured flint as well as grey flint with dark stripes and brown flint. A clear distinction can be made between the material that originated from the surface collection and the material that originated in the excavated trenches: while the surface finds were probably subjected to certain deflation processes and bear heavy patination, the artefacts originating from the trenches are very fresh, with minimal to no patination.

Cores

Cores comprise *ca*. 1% of the assemblage (table 5) and are divided between bidirectional blade cores (fig. 10) and amorphic flake cores. The bidirectional cores are quite small and very exhausted and seem to have only been discarded when critical flaws (usually hinges) appeared. Small to medium-sized nodules appear to have served as the main blank, which in turn limited the final core size as well.

Table 5 – *General breakdown of the lithic assemblage sample from NR110 (M. Birkenfeld).*

Debitage	**N**	**%**
Primary elements	149	17.0
Flakes	339	38.6
Blade/lets	294	33.5
Core trimming elements	79	9.0
Core tablets	1	0.1
Ridge blades	14	1.6
Burin spalls	2	0.2
Total	**878**	**100.0**
Debris	**N**	**%**
Chunks	92	7.9
Chips	1069	92.1
Total	**1161**	**100.0**
General	**N**	**%**
Cores	20	0.9
Tools	59	2.8
Debitage	878	41.5
Debris	1161	54.8
Total	**2118**	**100.0**

Fig. 10 – *Flint tools and cores from NR110 (CAD M. Birkenfeld).*

Debitage

The debitage comprises a total of 878 items (table 5). These include mainly flakes (38.6%), blades (33.5%), primary elements (17%) and core trimming elements (CTE; 9%). Ridge blades, burin spalls and core tablets appear as well, but less frequently (1.6%, 0.2% and 0.1%, respectively). The high percentage of primary elements, as well as artefacts related to core rejuvenation (mainly core trimming elements, core tablets and ridge blades), indicate that flint production was performed on-site at NR110. This is further corroborated by the high numbers of cores within the assemblage and the discovery of a knapping refuse pit in Squares L7-M7 (and see below).

Tools

The tool assemblage comprises 60 artefacts (table 6 and fig. 10). Most common are retouched blades (28.3%) and scrapers (18.3%). Also frequent are retouched flakes, notches and denticulates (11.7% each) and projectile points (10%). Other tools include perforators and burins (3.3% each).

Most tools were fashioned on blades (38.3%), including all of the more formal tool categories such as projectile points and perforators. The remainder of the tools, including mainly *ad hoc* types, were made on flakes (28.3%), primary elements (13.3%), CTE's and on exhausted or broken cores (*ca*. 7% each).

Projectile points are the most indicative tool group in terms of chronology. They were fashioned on bidirectional blades, and shaped by abrupt retouch, or a combination of abrupt and pressure retouch. Typologically, the projectile points at NR110 can be identified as 'Amuq points (fig. 10). These are typical of the Late PPNB, especially in the arid zone, and very similar morphologically to those found at Naḥal 'Issaron (Gopher 1994; Gopher *et al*. 1994).

Tool type	N	%
Projectile points	6	10.0
Perforators	2	3.3
Retouched blades	17	28.3
Scrapers	11	18.3
Retouched flakes	7	11.7
Notches and denticulates	7	11.7
Burins	2	3.3
Varia	8	13.3
Total	**60**	**100.0**

Table 6 – *Tool types at NR110 (M. Birkenfeld).*

The lithic refuse pit

In Squares L7-M7, a small pit was identified, *ca*. 1 m in diameter, dug into the ashy deposit. It contained large amounts of flint artefacts, including cores, core trimming elements, debitage and debris, seemingly the waste of several knapping sequences. At least five different sequences are represented—as evidenced by the five bidirectional cores found inside the pit. This, as well as high frequencies of core trimming elements in the general assemblage, indicate that even if the knapping activity at the site was episodic, these were clearly repeated occurrences, which at times were quite intensive.

The evidence for on-site lithic production is intriguing as no raw material sources of flint are available on the igneous mountain or its immediate vicinity. Thus, all of the exploited raw material had to be deliberately brought up to the site. The large quantities of cortex-bearing primary elements, as well as a large preform, found on-site, indicate that the exploited raw material was in the form of flint nodules, probably originating from wadi-beds in the area or from the limestone ridge west of the site.

STONE OBJECTS

During the initial survey of the site in 2004, several stone objects were collected on the site's surface and in its vicinity (Avner *et al*. 2014). These included a large broken sandstone bowl, other rim fragments of smaller ones (fig. 11.1 and 3); a broken stone with an elongated perforation and a meander engraving; a perforated stone with a biconical perforation that was first made by chiselling and then smoothed, and a fragment of another, larger perforated stone (fig. 11.2); and two elongated stones, also of limestone, interpreted as anthropomorphic images (fig. 11.4 and 6). The limestone objects are typical of the repertoire of finds from "Rodedian" sites in the southern Negev (Avner *et al*. 2014, 2019) and are the main reason NR110 was originally linked to this phenomenon. Presently, we do not have an interpretation for all these objects, but it seems clear that at least some of them, *e.g*., the anthropomorphic items, could have had a more symbolic function (Avner *et al*. 2019).

Several other ground stone objects were recovered during the excavation. A large, broken limestone slab (19 × 15 × 5.8 cm), with a large depression made by pecking (fig. 12), was found broken on the surface, lying face down on top of the ash deposit, towards its northern edge. Additional finds include a small rounded sandstone cobble with a plano-convex section (4.0 × 4.1 × 2.4 cm), that might have been used as a rubbing stone (fig. 12), and a small limestone rock with a biconical perforation (8.94 × 7.92 × 3.41 cm); the latter was found on the surface, at the northern edge of the excavated area (fig. 12). This small assemblage seems more utilitarian than the one collected during the survey, however as in other sites on the igneous mountains, these stones had to be deliberately carried up to the site from some distance.

ARCHAEOBOTANY

Two large charcoal fragments from NR110 were broken to expose fresh cross, radial, and tangential sections, which were then examined under binocular microscopes at magnifications ranging from 70× to 800×. Images were obtained using a PhenomWorld desktop scanning electron microscope. Charcoal was identified using standard manuals (Carlquist 2001; Crivellaro and Schweingruber 2013; Schweingruber *et al*. 2019) and by comparison with modern and archaeological references.

Both charcoal samples were identified as representing *Tamarix* sp. Two species of tamarisk occur in the Negev, *Tamarix niloticus* and *Tamarix aphylla*, but it is not possible to distinguish between them in sections of charcoals. Tamarisk trees grow only in the wadis of the arid zone, though none occur in the region today.

For palynology, twenty-one sediment samples were taken from ten sections and various loci of the site (fig. 13) and were processed in the palynology laboratory at the Department of Plant Sciences, University of the Free State (Bloemfontein, South Africa), utilising 10% HCl, HF and 10% KOH (standard method after Faegri and Iversen 1989). This procedure was finalised by heavy liquid mineral separation with $ZnCl_2$ (specific gravity 2) and microscope slides were permanently mounted in glycerine-jelly. The slides were stored and analysed at the Evolutionary Studies Institute (University of the Witwatersrand).

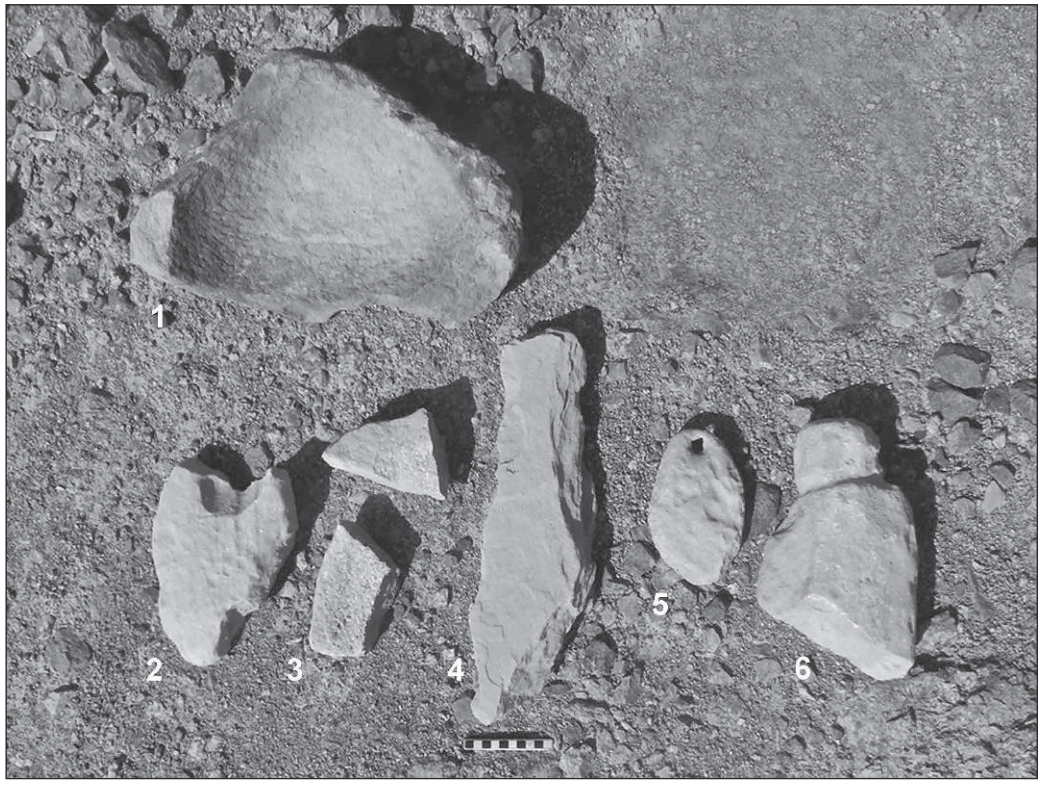

Fig. 11 – *Groundstone objects recorded during the Mount Roded survey (photo U. Avner).*

Fig. 12 – *Groundstone objects recorded during excavation at NR110 (photos E. Ostrovskiy and C. Amit).*

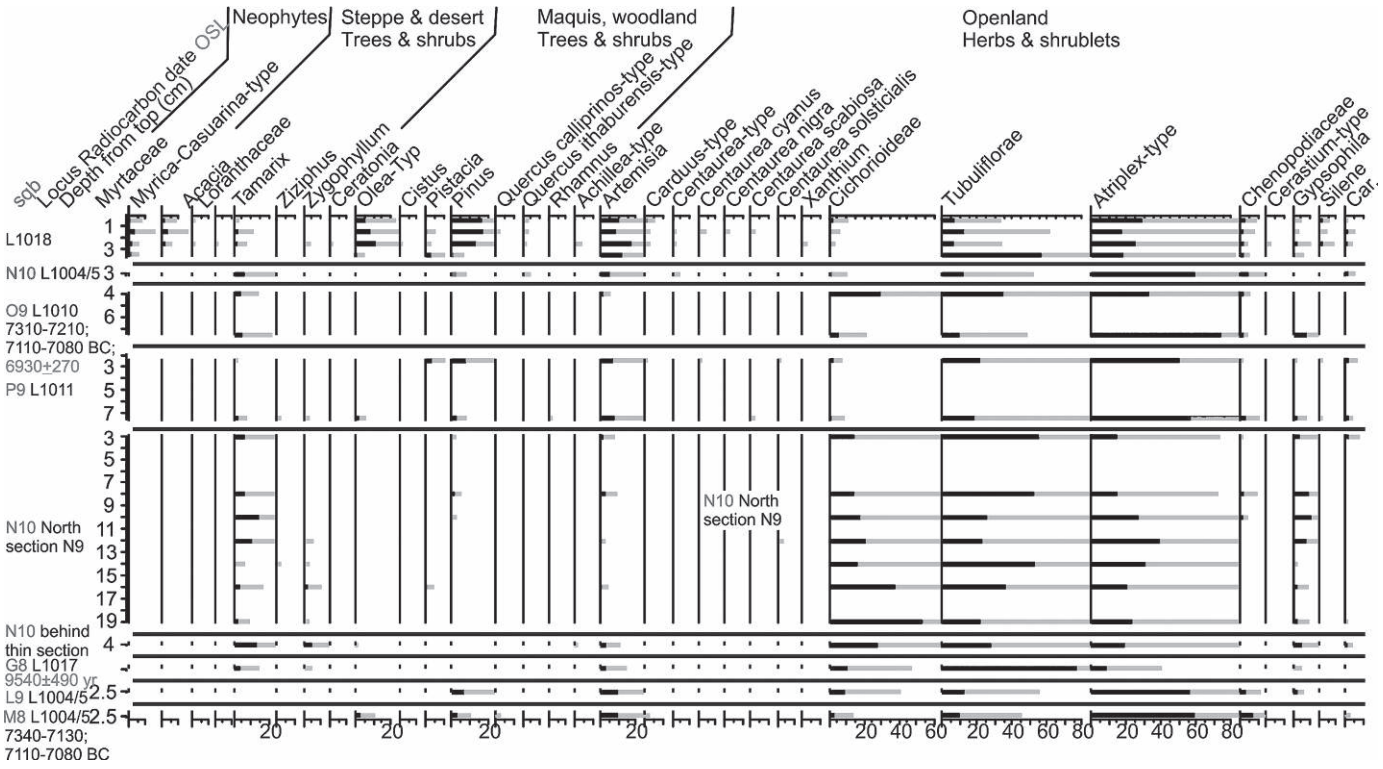

Fig. 13 – *Complete palynological histogram of NR110 including chronology (CAD F. Neumann and L. Scott). Car:* Caryophyllaceae. *Gray: 5x exaggeration*

Palynomorphs (pollen, spores, fungal remains) were identified under a light microscope at 1,000× using the pollen reference collection at the Evolutionary Studies Institute as well as research papers on the regional palynoflora (Horowitz and Baum 1967; Reille 1990, 1992, 1995, 1998). About 200 terrestrial pollen grains were counted per sample. If the pollen sum was <200, the whole pollen content of the residue was counted. The calculations of the pollen diagrams were performed with the TILIA 2.0.4.1. program (Grimm 1992).

Pollen preservation was moderate, showing a certain degree of oxidation that damaged the exine of the pollen. The median of the land pollen sum (terrestrial pollen) of the remaining twenty samples is 250.5. One sample, taken from a soil crust on top of loose sediments at a depth of 2 cm below the surface from L1004, Sq M8, did not contain any palynomorphs. The number of crumpled/corroded pollen (not included in land pollen sum) varied between 7 and 75 (median 28).

Seventy-nine types of pollen, spores and fungal remains were identified and reflect a predominantly open landscape with a predominance of Asteraceae, Chenopodiaceae-Amaranthaceae and *Tamarix* sp. This is a typical pollen flora of Saharo-Arabian origin with some influence of Irano-Turanian steppe vegetation. There is limited evidence for local humidity attested to by the presence of isolated pollen of sedges (Cyperaceae) and the common bulrush (*Typha* sp.) in section N10 and north section N9. The high number of monotypic pollen clumps, which appear to be—at least partly—anthers, is remarkable. These were transported into the deposits either by strong winds or pollen-collecting insects. When anthers were encountered, only a single pollen within the clump was counted in order to avoid biases. It is not clear whether, and to what degree, gathering of plant material by people could have contributed to the abundance of pollen clumps/anthers. Anthers were most common amongst those taxa that were already well represented within the analysed strata (predominantly Chenopodiaceae-Amaranthaceae, Asteraceae, *Tamarix* sp.).

Four samples were taken from a 4-cm long section within the natural (non-archaeological) sediment (L1018) to compare the vegetation pattern in undisturbed layers close to the surface with those from other sections that were deposited during the PPNB. L1018 shows a palynological sequence typical for modern samples, which were deposited during the last 100 years maximally. Australian neophytes like *Casuarina* sp. and *Eucalyptus* sp. are common and do not occur in any other

analysed section. *Casuarina* sp. and *Eucalyptus* sp. were introduced to Palestine during the end of the 19th century and early 20th century, respectively as evidenced in pollen records of the region, *e.g*., from lake Birkat Ram in the Golan Heights and the Ein Gedi sediment archive in the Dead Sea (Neumann *et al*. 2007; Litt *et al*. 2012). A strong representation of pollen of *Pinus* and *Olea*, increasing towards the top of the short section, as well as *Quercus ithaburensis*, *Q. calliprinos*, *Pistacia* sp., and even *Ceratonia siliqua* (Carob tree) signal recent afforestation and reflect increasing horticulture during recent times (compare with Neumann *et al*. 2007). *Xanthium* sp., missing from the LPPNB sections, is an important weed on fields and roadsides (Robson *et al*. 1991; Danin 2004). Other weeds include diverse *Centaurea* species including *Centaurea cyanoides*, the Syrian cornflower and *Polygonum aviculare*, common knotgrass. *Alternaria* sp., a common fungal pathogen on crops (Woudenberg *et al*. 2015), was identified here but not in the LPPNB sections. Irano-Turanian and especially Saharo-Arabian taxa, most prominently Asteraceae and Chenopodiaceae-Amaranthaceae, are well-represented but weaker than in LPPNB strata. The pollen record of L1018 also features elements of the Irano-Turanian steppe vegetation, *e.g*., Poaceae, *Ephedra fragilis* and *Artemisia* sp. Both Mediterranean and Irano-Turanian floral elements, indicative of moisture, occur more regularly in L1018 than in the LPPNB strata deposits. L1018 shows that modern pollen samples in Israel are affected by human disturbances including neophytes (*Eucalyptus* sp., *Casuarina*- type) and are therefore not always a good indicator of the natural vegetation. Fungal activity in the form of sub-fossil hypha, fruit bodies and ascospores is noted in all LPPNB sections. Here, *Glomus* sp. might signal soil erosion (Anderson *et al*. 1984).

ARCHAEOMALACOLOGY

The small molluscan assemblage of NR110 consists of fifteen items, all of which were collected along the Red Sea. They are described here in taxonomic order:

– Marine gastropods comprise a Nerita sanguinolenta shell that had a ground hole in the body whorl opposite the aperture; three fragments of Lambis sp.; a cowrie, Naria turdus, with its dorsum removed; a shell of Polinices tumidus with a hole in the body whorl, but it is unclear if it is a natural or artificial perforation, and one Conus cf. parvatus, complete and burned. Three fragments of Lambis truncata were found: one of the body whorl, one of the base and a third of a spine. In addition, one terrestrial gastropod, Pupoides coenopictus, known from Saharo-Sindian environments, is represented by two complete juvenile specimens.

– Marine bivalves are composed of three fragments of Tridacna cf. squamosa (fig. 14), one of which is large, about 15 cm long and contains dark sediment on the inside of the valve, possibly ash. In addition, a tiny fragment of mother of pearl likely represents a fragment of a bivalve from the Pteriidae family, but it could also be a fragment of a Trochoideae gastropod, both originating in the Red Sea, or a fragment of a freshwater bivalve of the family Unionidae. There is also one spine of a fossil sea urchin that was probably collected from rock exposures in the region. All these species are known from other PPNB sites in the Southern Levant and the Negev and probably served mostly as ornaments (Bar-Yosef Mayer 1997; Ronen et al. 2001; Spatz et al. 2014).

Fig. 14 – *A fragment of* Tridacna *cf.* squamosa *recovered from NR110 (photo M. Averbuch).*

VERTEBRATE FAUNA

Abundant and well-preserved vertebrate faunal remains were recovered from the ashy deposit, and around it. Some of the bones were grey in colour, suggesting that they had been

exposed to heat, although the FTIR analysis was not conclusive on this issue. The good preservation of fauna was unexpected given the relatively superficial nature of the deposit, and the fact that faunal remains are not preserved in many Neolithic sites in the Negev (*e.g.*, Naḥal Re'uel or Naḥal Ḥava; Ronen *et al*. 2001; Birkenfeld and Goring-Morris 2013). At Naḥal 'Issaron well-preserved fauna occur, but only in the lower levels of the site (Goring-Morris and Gopher 1983).

As noted in the field and corroborated by a preliminary archaeozoological study of about two-thirds of the fauna undertaken to date, the assemblage is singular in that the material studied only represent avian species, and these uniquely represent birds of prey, members of the Accipitridae, Falconidae and cf. Strigidae families. In this sample, about two-thirds of the number of identified specimens are bones of the Black Kite (*Milvus migrans*), while another fifth are those of the European honey buzzard (*Pernis aviporus*). Remains of several other species were identified, though these represent a scant 15% of the assemblage: the pallid harrier (*Circus macrourus*), Eurasian sparrowhawk (*Accipter nisus*), eagles—the lesser spotted eagle (*Aquila pomerina*) and golden eagle (*Aquila chyseatos*), buzzards—the long-legged buzzard (*Buteo rufinus*) and common buzzard (*Buteo buteo*), as well as two species of Strigidae—the eagle owl (*Bubo bubo*) and the long-eared owl (*Asio otus*). Skeletal element representation varies among taxa but, for some species, all skeletal elements are represented, including fragile vertebrae, pelves and even skulls, albeit in low numbers. No remains of immature birds have been found to date in the assemblage. Microscopic analysis revealed that cut marks indicating butchery are present on many bones; these await complete documentation and further analysis.

Such a selective avian assemblage is unprecedented in archaeozoological assemblages in the Levant and more so in the Late PPNB. Although bones of birds of prey occur in Neolithic archaeozoological assemblages throughout the region, especially in Pre-Pottery Neolithic A contexts (Tchernov 1993, 1994; Dobney 2002; Gourichon 2002; Reilly 2007; Horwitz *et al*. 2010), they usually occur in low frequencies and in concert with remains of other taxa—mammals, reptiles, fish as well as remains of other bird species. Moreover, in contrast to other species, it seems that although the meat of birds of prey was consumed, they were mainly exploited for decorative elements, such as talons and feathers (Tchernov 1993; Horwitz *et al*. 2010).

Israel is part of a corridor connecting Africa and Eurasia that has been a major migratory route of birds throughout the Quaternary (Shirihai *et al*. 2002). The spectrum, but not the relative abundance, of raptor species found at NR110 follows that of the passage migrants that cross the Eilat region especially in spring, and to some extent also in autumn (Leshem and Yom-Tov 1996; Shirihai *et al*. 2002). Their presence in the site implies that it was occupied at least in one, or both, of these seasons, although the absence of immature birds, the presence of many different species, some of which are rare in the autumn migration like the pallid harrier, point to spring.

Worth mentioning is a single bone point that was recovered during the surface collection. It was made on a long bone shaft of a medium-sized mammal and preserved to a length of 4.5 cm. The manufacturing process of the point entailed the halving of the long bone shaft following which the inner medullary cavity and sides of the piece were smoothed. One end was whittled down so that it tapered to form a point. Such implements, probably used as perforators, are ubiquitous in Levantine Neolithic sites (Garfinkel and Horwitz 1988; Le Dosseur 2008).

DISCUSSION AND CONCLUSIONS

The first excavation season at NR110 yielded a surprisingly rich and varied corpus of finds. Notably, the excellent preservation of organic remains makes this site a valuable addition to our knowledge of the Neolithic from the region. These remains have facilitated the paleoenvironmental reconstruction as well as the dating of the site.

Presently, there are four radiocarbon dates for NR110, providing a minimal range of approximately 200 years—between 7300-7200 and 7100-6900 cal. BC. It must be taken into account, however, that the excavation did not reach the very bottom of the ashy deposit. Together with the OSL ages, the ^{14}C dates confirm the attribution of the occupation of the site to the Late PPNB.

The initial investigation of the sediments at NR110 leads us to conclude that the natural sediment ("non-archaeological deposit") has a chemical composition that differs from the sediment recovered from the site, a finding corroborated by the pollen data. The site sediment is mixed; in the same layer, some areas contain calcite and gypsum, while others contain calcite and illite. Thus, the sediment that composes the site is not a simple continuation of the surrounding natural deposits but is anthropogenic. Notably, there is evidence for low temperature burning activities in the sediment samples associated with the ash deposit. However, FTIR analysis has not been able to discern with certainty whether the raptor bones recovered were burnt. They were not heated to temperatures above 500°C, although many of the bones are grey in colour implying some degree of heating (Stiner *et al*. 1995).

In terms of the palaeoclimate, the charcoal and palynological records from the site reflect an arid environment. They exhibit characteristics of the Saharo-Arabian phytogeographic zone and reflect the arid conditions that prevailed at this time in the region. According to Litt *et al*. (2012), the PPNB was a moderately humid period and moister than, for example, the subsequent Pottery Neolithic. However, the pollen data from the LPPNB sections at Naḥal Roded point to an arid climate with an abundance of *Tamarix* sp. pollen from trees probably growing in the wadis below (Danin 2004), some *Zygophyllum* sp., a high number of *Atriplex*-type and Asteraceae pollen. Caryophyllaceae, especially *Gypsophila* sp. pollen, are common. Only a few indicators of Irano-Turanian steppe vegetation are noted, which include Poaceae, *Ephedra fragilis* and *Artemisia* sp. In the LPPNB strata, pollen of *Pinus* sp. is comparably low and was probably transported from the Mediterranean phytogeographic region. In general, Mediterranean elements are either absent or rare. There are no indications of agricultural activities visible in the strata allocated to the LPPNB and pollen of weeds are lacking. Some fluctuations within the Saharo-Arabian plant communities are apparent in the section of Sq. N10 and north section of Sq. N9. The reason for these fluctuations is unknown. However, the interpretation of the sequence as reflecting desert-like vegetation is not affected by these minor fluctuations. There is some evidence for local moist elements due to the presence of, albeit rare, wetland components (sedges, bulrushes). In comparison to the pollen record at ‘Ein Gedi (Litt *et al*. 2012), a stronger influence of the Saharo-Arabian desert vegetation and a weaker impact of Mediterranean vegetation (*e.g*., *Quercus* pollen), as well as Irano-Turanian taxa, are noted at NR110. This is explained by the fact that the coring locality at the western shore of the Dead Sea, although within the Saharo-Arabian plant-geographical territory, is very close to both the Mediterranean territory and a thin steppe belt with abundant grasses and *Artemisia herba-alba* (Litt *et al*. 2012).

Wood identifications from earlier Middle PPNB sites in the Negev indicate the presence of species that are common in the region today: *Haloxylon persicum* and *Retama raetam* at Naḥal ‘Issaron (Liphschitz 2007) and *Retama raetam* at Naḥal Efe (Borrell and Vardi 2015). In contrast pollen from later sites (*i.e*., 5th to 3rd millennia BC), such as Ramon 1 and Atzmaut shelters and charcoals from 3rd to early 2nd millennia BC sites in the ‘Uvda Valley (Lipschitz 2001), together with paleoclimatic reconstructions based on speleothems, show that conditions in the Negev were unstable but comparatively wetter than today (Bar-Matthews *et al*. 1998; Migowski *et al*. 2006) and vegetation possibly more diverse (Babenko and Khassanov 2007). At NR110, there is a possibility that anthropogenic plant collecting contributed to the strong occurrence of monotypic pollen clumps (pollen consuming insects may also have contributed but further research is needed to verify this). The plants were introduced to the site perhaps as food, but most certainly as kindling given the extensive evidence for pyro-technology.

As noted in the introduction, the apparent discontinuity in settlement observed in the Mediterranean area west of the Rift Valley during the LPPNB, clearly does not apply to the arid margins where several well-dated LPPNB sites are known. The currently accepted chronological range for the LPPNB is 7500-7000 cal. BC or 9400-8900 cal. BP (Kuijt and Goring-Morris 2002; Goring-Morris and Belfer-Cohen 2011, 2014). The only other radiometrically dated LPPNB site in the southern Negev is Naḥal ‘Issaron (Carmi *et al*. 1994), while in southern Jordan, the site of ‘Ayn Abu Nukhayla has also yielded a well-dated LPPNB occupation (Henry *et al*. 2003). Notably, these two sites have been identified as settlements that were seasonally occupied (Goring-Morris and Gopher 1983; Henry and Beaver 2014). Both sites show cultural affinities with NR110, specifically in in their lithic assemblages.

It was suggested by Goring-Morris and Belfer-Cohen (2014) and Barzilai (2010), that the southern Negev PPNB sites primarily interacted along an east-west axis connecting to settlements in southern Jordan. Quintero *et al*. (2004) proposed a similar connection between the LPPNB/PPNC towns in the Jordanian highlands and pastoralist sites in the arid *badia,* such that it is possible that NR110 was part of a similar network. Continued research is needed to better establish these possible connections and to articulate the wider interaction network in the region.

The location of NR110 and the nature of the finds recovered from it are unusual and set it apart from known domestic settlements in the southern Negev. Firstly, the position of the site on the uppermost reaches of the mountain, just below its summit, where there are no permanent water sources. There are no trees or edible vegetable foods growing on the mountain and the commonly hunted ungulates of this period (*e.g*., ibex) and even small game (*e.g*., hare) are absent or rarely found here. This location is exposed, windy and cold in winter, hot in the summer months. Moreover, the harsh environment of the site, both past and present, necessitates that all foods, water and firewood, would have had to be carried up the mountain from the wadis below, if not further away. Surprisingly, various stone objects and relatively large quantities of flint artefacts were found on site, including extensive evidence for on-site knapping. This means that all these had to be brought to the site from elsewhere, as they are both foreign to the local igneous mountains.

Secondly, the faunal assemblage recovered at the site is unique in its good preservation, but even more so in its content; the faunal remains recovered to date exclusively represent raptors that would either (1) have had to be trapped elsewhere, for example, while they roosted in the wadis below, and then transported to the site, or (2) were trapped at, or near, the site. In this case, raptors passing overhead were lured to descend to the site, probably using bait and decoys. Indeed, Martin *et al*. (2013) have suggested that in the Epipaleolithic site of Wadi Jilat 22, located in the arid desert of eastern Jordan, live tortoises may have served such a purpose. Alternatively, the raptors may have been hunted while roosting on the mountain top.

Without doubt, whichever scenario we select will dictate to a large extent our interpretation of the site. If we accept the first, then NR110 represents a cult site, to which raptors were brought, probably as offerings. This is supported by the presence of all skeleton elements for some raptor species in the assemblage, the widespread evidence for burning and the "Rodedian" symbolic/cultic paraphernalia. This explanation, however, does not fully account for the extensive evidence for on-site knapping.

Following the second scenario, where the raptors were trapped at the site, NR110 then represents a specialised and seasonal raptor hunting camp occupied to coincide with the migration of raptors over the mountains of Eilat, either in the autumn or the spring. This interpretation is supported by the presence of the stone-built structure/s, that may represent a hunting blind/s. The evidence for on-site knapping is more in keeping with this interpretation, as has been documented by Binford (1981, 1986) for modern hunters. The evidence for pyrotechnic activity can also fit this scenario, especially if we consider that the seemingly intensive burning activity might be the result of multiple, repeated occurrences of hearths at a single locale, as would be expected in a seasonal hunting camp. The fact that the bones analysed by FTIR, including those collected from within the ashy deposit, do not exhibit damage caused by high temperatures or direct fire, might imply that the pyro-activities were not, perhaps, primarily related to the treatment of raptors on-site, although cooking at temperatures below 500° cannot be excluded. It is also possible that the faunal remains were buried (whether intentionally or unintentionally) within the ashy deposits in proximity to fire or after it was out. Lastly, as mentioned earlier, during the Neolithic, birds of prey were primarily exploited for decorative elements, such as talons and feathers (Tchernov 1993; Gourichon 2002; Horwitz *et al*. 2010). Thus, the presence of all raptor body parts, at least for some species, may signify that the main processing of these birds was conducted on-site, with only selected target items (*i.e*., meat, feathers and some talons) carried off-site.

It is also possible, of course, that this seeming dichotomy between hunting and cult is completely artificial; in the Neolithic of the Near East, birds of prey appear to have played an important symbolic role in iconography and archaeozoology at least since the Pre-Pottery Neolithic A (Dobney 2002; Gourichon 2002; Peters *et al*. 2005; Marom *et al*. 2018; Russell 2019). The hunt itself could have been part of a ritualistic endeavour, connected perhaps to the changing seasons. Notably, the precise timing of the raptor migrations, assuming they resembled those taking place today, may have served as symbolic markers of life (spring) and death (autumn). Thus, the two interpretations offered here are not mutually exclusive. In this third, integrated scenario, which we feel best supports the available data, the site on the desert mountain-top can be seen as a liminal locality, a transitional space where earth and sky intersect, a meeting place where humans and raptors could interact. Clearly, the unique assemblage at NR110 is of importance in the discussion of Neolithic perceptions and ontologies.

NR110 represents a unique manifestation of Neolithic activity in the Levantine desert and sheds light on the range of different behaviours people engaged in within this harsh environment. Further research, including excavations at other "Rodedian" sites is needed to clarify whether more of these sites are indeed contemporaneous with Naḥal Roded 110. If so, it will change the way we should perceive the exploitation of the arid margins during the Neolithic.

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