Managing survey data from Helawa, Erbil Plain (Kurdistan Region of Iraq)

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Abstract

The project of the Italian Archaeological Expedition in the Kurdistan Region of Iraq (MAIPE) of the University of Milan focuses on a small part of the Erbil plain, namely the area of Helawa/Aliawa, 27 km south-west of Erbil. In 2013 and 2015, a topographic survey with differential GPS was carried out at Helawa. The ensuing GIS-based spatial analysis of diagnostic materials made it possible to reconstruct the site's main occupational phases and estimating its extension at different times in its history. In this paper, we will focus on additional aspects that emerged from our spatial analysis. The distribution of selected categories of finds (e.g., furnace wasters, lithic artefacts) throughout the site points to possible functional distinctions. Furthermore, our analysis of morphological data bears witness to processes of multilayer deposition and erosion, which contributed to shaping the site's mound morphology through time.

Keywords

GIS, spatial analysis, predictive analysis, slope analysis, Late Chalcolithic, Helawa, Iraqi Kurdistan

1. Introduction[1]

In 2013 and 2015, the Italian Archaeological Expedition in the Kurdistan Region of Iraq (MAIPE, University of Milan) carried out systematic surveys at the sites of Helawa and Aliawa, in the south-western Erbil Plain (ca. 27 km S-W of the modern city of Erbil).[2] The main goals of these surveys were to obtain chronological data and estimate these sites' extension from one period to the next. Another objective was to preliminarily identify possible functional distinctions across the sites based on quantitative and qualitative analyses of survey data in a GIS environment. This analysis, in its turn, was to provide the basis for a predictive strategy to be defined prior to the start of excavation (§ 2.1).

In this article, we discuss several aspects of the site of Helawa relative to its morphology and the distribution of specific categories of finds compared with evidence gathered from the excavation.

Helawa is a prehistoric site, occupied continuously at least since the Hassuna to the Late Chalcolithic 3 period (seventh to mid-fourth millennium BCE), with a later reoccupation during the Late Bronze Age I (mid-second millennium BCE) (§ 2.2).[3] The site has a peculiar morphology, with a high conical main mound and two lower secondary mounds to the north. Excavations, carried out since 2016, have documented a packed sequence of monumental buildings and the generalised use of high, and in some cases relatively narrow, terraces during the Late Chalcolithic 1-3 (hereafter LC). This probably contributed, together with erosion processes and, possibly, landslides, to shaping the highly stepped profile of the southern side of the main mound. Based on the distribution of surface materials, it appears that occupation of the main mound was substantial in the LC 1-2, while during the LC 2/3 occupation seems to have mainly been concentrated on the small mound to the north-east and on the top of the main mound. The hypothesis of a substantial change in occupation strategies during the LC 1-3 period is discussed here, on the basis of cross-correlation of the evidence from the excavations and the results of the survey in a GIS environment (§ 3).

Moreover, the investigation of the surface materials produced high-resolution spatial data, which allow for a preliminary identification of possible functional distinctions throughout the site. For instance, the distribution of furnace wastes supports the identification of possible LC 1-2 workshop areas, and that of lithic artefacts allows us to formulate hypotheses about the possible localisation of knapping activities during the Ubaid and LC 1-3 periods (§ 4).

The combined discussion of excavation and survey data analysed within a GIS environment has allowed us to refine our overall interpretation of the site and speculate on the natural processes and human activities that contributed to shaping the morphology of the mounds through time (§ 5).

[1] The Italian Archaeological Expeditionin in the Erbil Plain (MAIPE) of the University of Milan, directed by L. Peyronel, and by A. Vacca as deputy director, carried out archaeological surveys at Helawa for two brief seasons (2013 and 2015), followed by targeted excavations since 2016. This study is the result of a joint work of the authors on the GIS processing and spatial analysis. A. Vacca wrote §§ 2, 3, 4.1, 4.2; D. Moscone § 4.1, 4.3; P. Rosati §§ 3, 4.1; the introduction and conclusions were written jointly. This study was carried out by the Research Unit of the University of Milan (coordinated by L. Peyronel) in the framework of the financed national project PRIN 2015 "Paesaggi Archeologici dell'Antico Iraq fra preistoria ed epoca islamica (PAdAI): formazione, trasformazione, tutela e valorizzazione" (P.I. Morandi Bonacossi, Udine University). Work at the site was supported by the Ministry of Foreign Affairs, Regione Lombardia, the University of Milan and the Italian Ministry of Education, Universities and Research (MIUR), and was possible thanks to the permission, help and encouragement of the General Directorate of Antiquities of the KRG (director Mr. K. Ali Mustafa and former director Mr. Othman Zaineddin Abubakir), the Erbil Directorate of Antiquities (director Mr. Nader Babakr) and the State Board of Antiquities and Heritage in Baghdad. We would like to thank L. Peyronel for his thorough comments on this article, and the two anonymous peer reviewers for providing very helpful suggestions, which substantially improved the manuscript. Needless to say, any mistakes are the authors' responsibility.

[2] Helawa and Aliawa are located in the "Shamamak area" investigated by the EPAS Survey of the Harvard University in 2012 and in 2016-2017 (EPAS sites n. 272 and n. 246; Ur et Al. 2013). The sites are located along a secondary E-W road branching off the main Makhmur road at Du Sara Fatah (35°59'57.75"N; 43°47'19.17"E), ca. 27 km south-west of Erbil. The modern village of Helawa extends at the foot of and above the south/south-eastern portion of the ancient sete tlement. The peripheral lower eastern part of the site is partly damaged by agricultural activities.

[3] Peyronel, Vacca 2015.

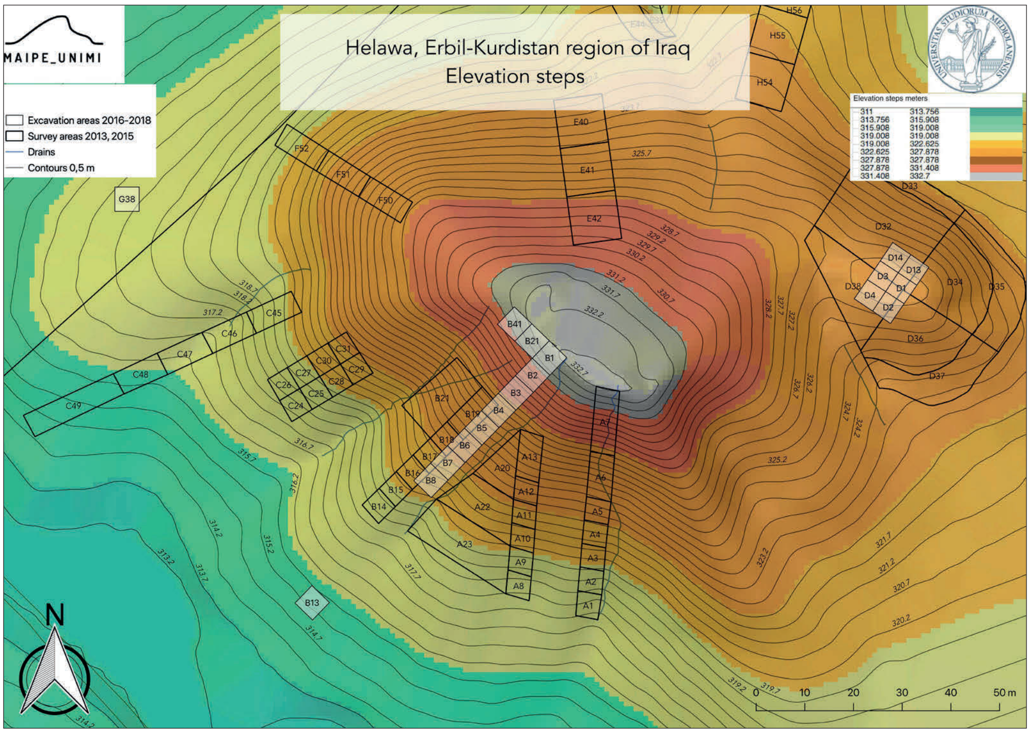

FIGURE 1
Digital Elevation Model (DEM) with the survey Collection Areas, Collection Units and excavation areas. The colours represent elevations (©MAIPE)

2. Survey Description, Excavation Data and Site Chronology

2.1. Survey Method

Helawa is located in a fertile hydrographic basin, with a rolling terrain crossed by several irregular ancient watercourses, including the two major water systems of the rivers Chai Kurdara and Chai Siwasor, both flowing into the Upper Zab.[4] One of the ancient tributaries of the Chai Kurdara, flowing from the south-western anticlinal hills of Awena Dagh, ran along the western and south-western edges of the Helawa mound (fig. 1).

Helawa is a multi-period site, covering a minimum surface of ca. 7 ha, with a maximum elevation of ca. 22 m above the surrounding plain.[5] The site includes a high mound to the south (top at 332.7 m AMSL), characterized by a steep slope, and two low and gently sloping extensions to the north and north-east (figs. 1-2). The north-eastern extension is a sort of small secondary mound, flattened at the top (326.7 m AMSL) (figs. 2-3).

The MAIPE team carried out a topographic survey with differential GPS, registering a high number of Ground Control Points, which were used to calibrate the satellite image (WorldView2, acquired on 12 March 2011) and produce a DEM.[6]

The site was surveyed using two different approaches (fig. 1). The mounded area (ca. 1.2 ha) was subjected to an intensive survey, in which a large selection of materials was collected and their location registered in a geo-referenced grid system. The lower area, instead, part of which had been affected by mod-

4 UR ET AL. 2013, p. 93, fig. 2.

5 CORONA satellite imagery suggests a larger extension of the site, up to 10 ha, with the south-western and western limits of the site lying below the houses and farms of the modern village: PEYRONEL, VACCA, ZENONI 2016, p. 309.

6 PEYRONEL, BURSICH, DI GIACOMO 2016.

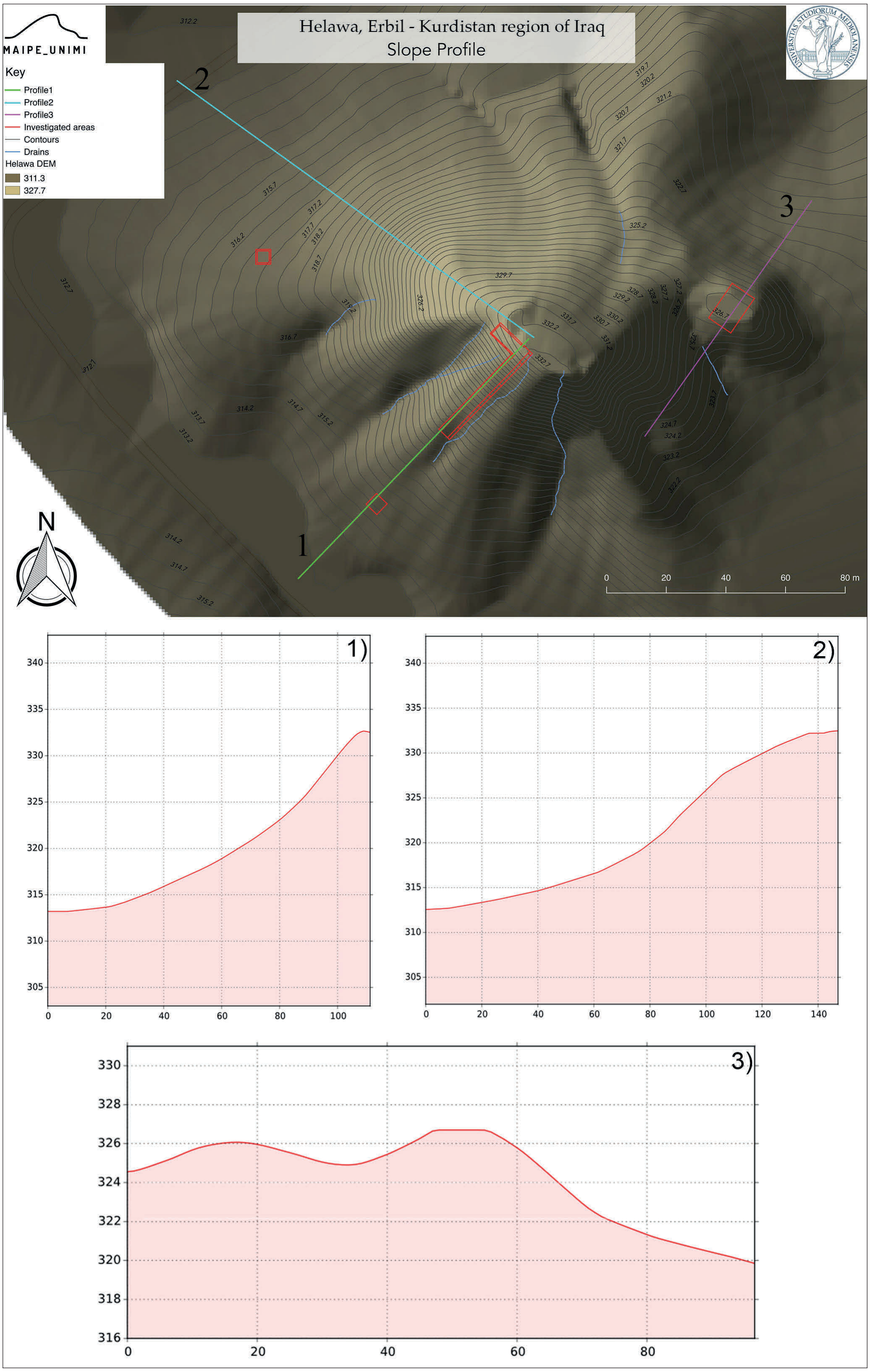

Figure 2
Digital Elevation Model with slope profiles and excavation areas: southern slope of the main mound (in green); western slope of the main mound (in light blue); north-south section profile of the lower north-eastern mound (pink) (©MAIPE)

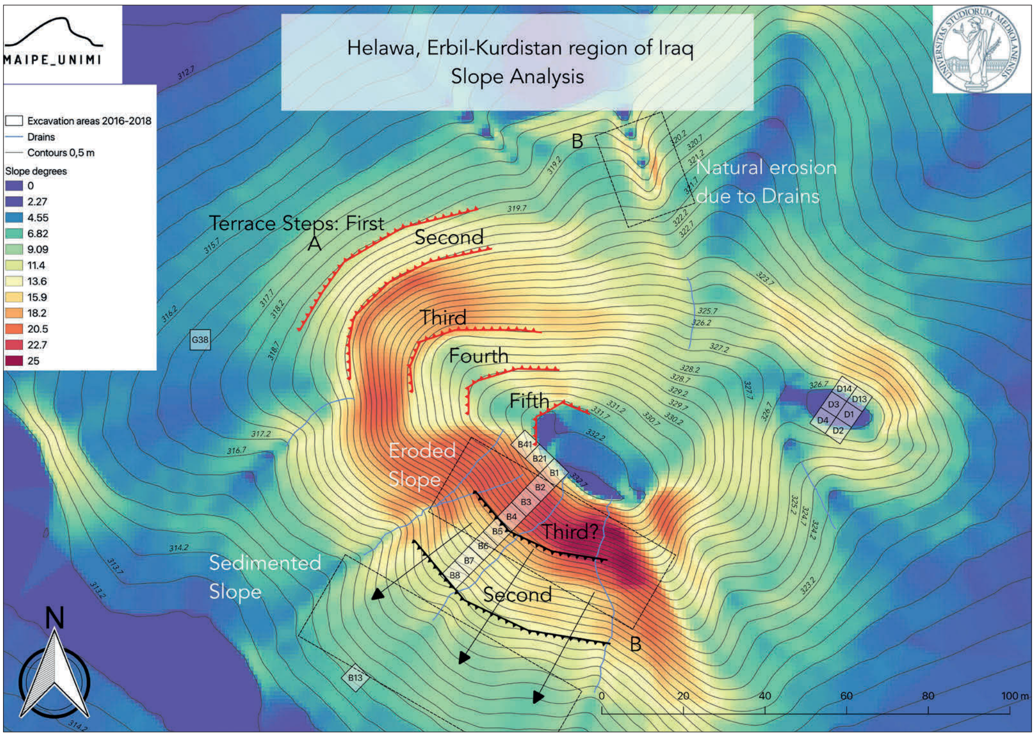

Figure 3
Slope Analysis with the indication of excavation areas. The colour shades indicate steepness in degrees. A) Localisation of hypothetical terraces. B) Localisation of hypothetical eroded and sedimented slope, and natural erosion due to runoff (©MAIPE)

ern ploughing, was investigated by means of extensive surveys collecting only diagnostic finds and accurately positioning them on the basis of differential GPS.

The mounded area (fig. 1) was divided into eight large Collection Areas (CA), distinguished by their topographic features, labelled from A to H. The gullies on the southern slope of the main mound were used as natural boundaries to delimit CAs (CA A-C). Each CA was subdivided, in its turn, into smaller CUs (with the exception of CA G) of different sizes based on morphological features and elevation steps. The CUs generally measure 5x5 m, but irregular and larger areas were defined as well, such as CUs E43-44, which follow the profile of the northern gullies (fig. 1).[7] Descriptive metadata for each CA and CU (such as presence of vegetation, quantity and distribution of surface materials, vestiges of illicit digging, *etc.*) are stored in an SQLite database and integrated in the GIS platform. A selection of diagnostic materials was collected for each CU, whereas a complete sampling of surface findings (including small finds, pottery diagnostics and walls) was carried out only in CUs A1-7 and D43, in order to obtain a comprehensive reference sample for statistical analyses on post-depositional events.

A total amount of 3165 sherds was collected, including 1784 rim fragments and 1381 body sherds (some of which have a painted, incised or impressed decoration). The diagnostics from the field-scattered survey of the lower area (700 units) were counted and registered, but not collected. A total amount of 600 small finds (including different categories of objects, namely lithics, stone objects, clay objects, shells, bone and metals) was also collected and filed in the GIS/Database framework. This allowed a chronological modelling of our survey data,

[7] In order to map archaeological finds within each CU, we generated a GIS layer of "random coordinate points", assigning one point to each record (1:1).

resulting in the definition of a general periodization for the site and an estimation of the settlement extension by phase.[8]

2.2. Site Chronology

The results of the spatial analyses of diagnostic materials show that Helawa was a substantial prehistoric settlement with an uninterrupted occupation spanning from the Hassuna to the LC 3. The site was then abandoned — since no diagnostic sherds dating to LC 4-5 or to the third millennium BCE were identified [9] — and reoccupied for a short time around the middle of the second millennium BCE, only to be abandoned again before the Middle Assyrian period. Sporadic occupation during the first millennium BCE and the Islamic period is attested by low percentages of diagnostics scattered on the mound's surface. Based on the distribution of surface materials, we hypothesised that the site reached its maximum extension (c. 7 ha) during LC 1-2 and in the Late Bronze Age.[10]

The chronological distribution of the survey data was cross-checked with the data from the ongoing excavations at Helawa, so far confirming the initial hypothesis of a gradual expansion of the settlement, a subsequent contraction and an abandonment in the course of LC 1-3, and also confirming that it was then reoccupied around the mid-second millennium BCE.[11]

In Square B1 of Step Trench B, in Operations B1 and D, substantial LC layers were documented (fig. 1). In Square B1 of Step Trench B and in Operation B1, located on the top of the main mound, a LC 2/3 tripartite building destroyed by a fire was discovered, with *in situ* cretulae with stamp-seal impressions, pottery vessels and objects. In Operation D, on the lower mounded area to the northeast (fig. 1), only domestic structures dating to early LC 3 have been excavated thus far (see also § 4).[12] In both excavation areas, second millennium BCE levels directly overlie early LC 3 layers, confirming the hypothesis of a prolonged abandonment of the site in-between those periods.

The ongoing excavation of a 45 x 3 m Step Trench (Step Trench B, fig. 1) along the southern slope of the high conical mound is documenting a continuous Halaf to Late Chalcolithic sequence of well-preserved structures with primary contexts, identified immediately underneath the surface.[13] Immediately beneath the most recent phase (Phase 1), dating to the modern age, and the monumental LC 2/3 building (Phase 2, Square B1), the excavation revealed a packed sequence of LC 1-2 levels consisting of at least 3 main architectural phases, each articulated in further sub-levels (Phases 3-5, Squares B2-5). Phase 3 (Square B2) can be dated to the (late) LC 2 and is divided into 4 sub-phases of use of a storage area equipped with circular silos lined with mud-bricks and processing facilities. Phase 4 (Squares B2-3) corresponds to the construction of a substantial building, dated to the (initial) LC 2, erected on sloping terraces, with 1 m thick walls and stone door-sockets. This large building, only partially detected, is built directly over a thick stratification of very sloping alternate red-loamy and grey sand-clay layers (Phase 5, Squares B3-4), a dump or filling of sorts, probably related to the presence of a pottery kilns area, as the recovery of several furnace wasters and overfired vessels would seem to suggest. During Phase 5, assigned to the LC 1, extensive cutting and leveling activities are evidenced by a 5 meter long pit that cuts deeply into the Ubaid stratigraphy (Squares B 4-5). The pit was probably

8 The results of the 2013 survey are published in Peyronel, Vacca 2015 and Peyronel, Vacca, Zenoni 2016. In 2015, new collection areas were investigated (CA 45-49, CAs F, G and H). In CAs F to H, surface finds mainly date to the Late Chalcolithic (especially LC 2–3) and late Middle/Late Bronze Age. On the survey method employed, see also Peyronel, Vacca 2015, pp. 104-106; Peyronel, Bursich, Di Giacomo 2016.

9 It is nevertheless interesting that when Helawa was abandoned during the third millennium BCE, the nearby site of Aliawa, located 2.5 km away to the north-east, was a quite large settlement of ca. 10 ha. The two sites show, indeed, alternated period of occupation (Peyronel, Vacca in press).

10 Peyronel, Vacca 2015.

11 Peyronel, Vacca 2015; Peyronel, Vacca, Zenoni 2016; 2017.

12 Peyronel, Vacca in press; Vacca, Peyronel in press.

13 This is a summary of the stratigraphic sequence uncovered in Step Trench B, which will be presented in detail in Vacca, Peyronel in press.

dug to level the imposing underlying destruction and obliteration levels of the Ubaid period. Beneath this multilayer LC 1-2 sequence, two architectural phases dating to the Ubaid period have been documented thus far (Phases 6-7, Squares B5-6). They consist of kilns (Phase 6) and mud-brick buildings, probably domestic (Phase 7).

The excavated sequence allowed us to fine-tune the chronology of the area (partly thanks to the redating of some sherds and small finds from the survey based on typological comparisons with stratified material) and observe the spatial relationship between the archaeological layers and the scattering of surface diagnostics due to post-depositional and erosive processes.[14]

3. Modelling the Settlement Morphology through Time

One of the lines of enquiry to be explored through the use of the GIS concerns the nature of the current site morphology, which encompasses a high conical mound and two lower secondary mounded areas to the north. The steep profile of the southern side of the high mound raises questions about how this stratigraphy was formed (terracing operations? intense short-period building activities? post-settlement transformations, such as destruction?) and to what extent the evolution of the surface morphology (especially due to erosion or landslides) has affected this side of the mound, giving it its current sloping profile (figs. 2-3). A GIS-based analysis is currently underway in order to investigate the post-depositional changes undergone by the mound by producing an erosion/sedimentation model based on survey and excavation data combined with geomorphological evidence (from slope analysis to erosion potential). However, the preliminary results from the slope analysis already allow a few working hypotheses to be tested.

We began by investigating the morphology of the site. Based on excavation data, we have evidence of massive excavating and terracing activities carried out along the southern slope of the main mound. Overall, LC structures identified in Step Trench B were built one on top of the other by raising previous structures, reinforcing the cuts with mud-brick walls and filling the area with a compact layer of clay leaning against the terrace walls. Extensive cutting and filling activities are documented especially during the LC 1 (Phase 5 in Squares B4-5); they were probably carried out to level the imposing underlying destruction and obliteration levels of a large kiln dating to the Ubaid period. The LC 1 stratigraphy is a sequence of superimposed layers, about 2.5 m thick in total. In the subsequent period, LC 2 (Phases 3-4), intensive building further contributed in the rapid growth of the tell. In Phase 4, for instance, a monumental LC 2 building was erected on terraces sloping from north to south. The floors of its southern and northern rooms had a 70 cm difference in elevation. The rooms were separated by 1 m thick walls, and were probably connected by a staircase or a ramp lying to the north-east. During Phase 3 (LC 2), the area was converted and equipped with stockpiling structures rebuilt several times (at least four sub-phases have been recognized), probably in rapid sequence. Interestingly, the LC period (and especially the LC 2) appears to be a period of intensive building activities, resulting in a rapid vertical growth of the stratigraphy and consequently of the mound. Thus, the height of the mound profile might be due to substantial building efforts concentrated in this area of the site, including high terraces and monumental public buildings. The steepness of the profile of the mound may be due to a combination of construction activities (including levelling, filling and terracing) and soil erosion.

In order to understand to what extent the building activities and the erosion affected the southern side of the mound, resulting in its steep profile, we carried out a Slope Profile Analysis with the "QProf" plug-in for the generation of topographic and geological profiles (figs. 2-3). [15] Comparing the profiles of the southern and western slopes of the main mound, it appears that the southern one is much steeper, with a maximum slope of 12% (fig. 2: 1-2). Looking at the southern

[14] Peyronel, Vacca in press.

[15] In QGIS, the contours were interpolated to obtain a DEM with cells of about 0.5 sq. m (fig. 3).

profile of the mound, for the first 60 m — from the wadi surrounding the site to the south up to mid-slope along the mound – the slope is gentle, with a difference in height of ca. 6 m (fig. 2: 1, from 0 to 60 m). In the next 50 m, instead, from mid-slope to the top of the mound, the profile becomes steeper, with a difference in height of about 12.7 m (fig. 2: 1, from 60 to 110 m). By overlapping Step Trench B and the profile of the mound, it appears that the steeper part corresponds to the very packed stratigraphy of LC structures described above and exposed in Squares B1-5 (fig. 2).

A relief analysis of the mound profile based on a DEM model (visualized as a stepped colour map) shows the existence of at least 5 different "steps", corresponding to considerable changes in elevation (fig. 3). The most significant of these steps is the third one, which abruptly cuts the profile of the hill. Along the southern slope of the mound, the fourth terrace is missing, while the fifth lies very close to the flattened top of the high conical mound. On this side of the mound (fig. 3) we recognized a large cut (shown in red to deep red), followed by a higher zone (in yellow, green and blue) which has been interpreted as the result of tons of material accumulated after a landslide. Thus, the relief analysis suggests that erosion was higher at the third step, and that the steeper slope of the southern side might be due to heavy erosion (possibly including landslides) that had probably already begun in antiquity. Evidence of erosion is also documented in the excavation; most of the *loci* dated to the Late Chalcolithic period brought to light along the southern mound, in Step Trench B, were largely missing, with the walls and floors of the room cut nearly clear through. A large quantity of Late Chalcolithic sherds and several complete vessels, mostly dating to LC 1-2, were found during the survey in Collection Area B (fig. 4: A). They derive from the partial destruction of rooms with *in situ* materials and the accumulation of these materials along the southern slope. Our profile analysis supports the hypothesis that erosion processes destroyed later occupation, eventually reaching down to the LC 2 levels. Moreover, on that part of the mound it seems that there was no other occupation after LC 2, as the rarity of LC 3 sherds seems to suggest.

We then turned to another aspect, which is connected to the morphology of the site, namely, the extension of the settlement, which we estimated on the basis of the distribution of surface materials and evidence from excavations. The distribution of LC 1-2 materials over a wide area (fig. 4: A) indicates that it was a period of substantial growth of the site. Occupation in this period is documented on top of the mound, on its southern and western slopes (CAs A-C), on its lower reaches to the north (CA E), and in the lower area surrounding the site (CAs G, H59-60 and isolated findspots). A significant difference can be observed during the LC 3. Only few LC 3 materials from this period, as opposed to the large amount of LC 1-2 sherds, have been collected around the main mound, while a large number of diagnostic sherds is concentrated on the small mound to the north-east (fig. 4: B). The evidence that the area around the main mound was mainly occupied during the LC 2 and that around the small north-eastern mound mainly in the LC 3 fits with data from the excavation. The lower mounded area seems to be the result of a later stratification, formed starting at least from the LC period, based on excavation evidence (fig. 2).[16] The earliest levels brought to light thus far in Area D (fig. 1), dating to the early LC 3, are located at the 326 m AMSL contour line and consist of a sequence of badly preserved houses which were refurbished several times. The sequence uncovered in Area D overlaps with that identified in Area B, where a monumental building was erected on the top of the main mound (Operation B1 and Square B1 of Step Trench B), lying ca. 4 m higher than the domestic structures in Area D, at the ca. 330 m AMSL contour line. Moreover, excavation along the southern slope of the main mound (in Step Trench B) did not reveal any other LC 3 levels.

The survey and excavation data seem to suggest that during the LC 3 the southern slope of the high

[16] Excavations in Operation D, carried out by V. Oselini, revealed a sequence of LC 3 houses covered by thick abandonment levels, sealed in their turn by a Late Bronze Age multilayer occupation (Peyronel, Vacca in press; Vacca, Peyronel in press; Oselini in press). Future investigations at this spot are envisaged, which will shed light on the occupational sequence of the small mounded area and the possible presence of earlier levels.

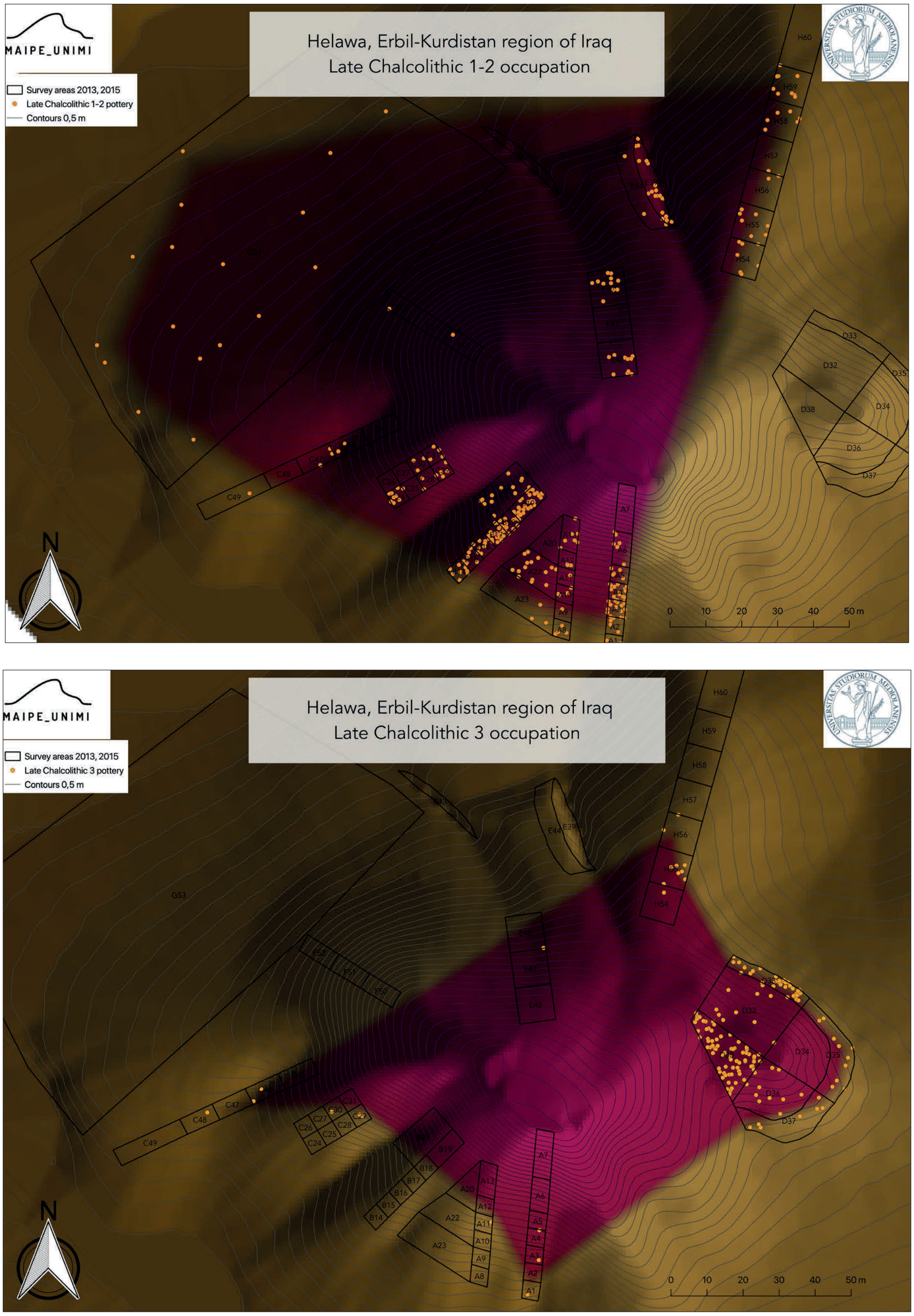

FIGURE 4
Modelled distribution of A) LC 1-2 sherds and B) LC 3 sherds. The dots do not represent the actual position of the sherds; they are randomly generated on the basis of the density of sherds per Collection Unit. This mode of visualisation was chosen in order to make the map easier to read. The colour polygon represents the estimated extension of the site in LC 1-2 (4:A) and LC 3 (4:B), based on the distribution of diagnostic sherds (©MAIPE)

mound was no longer occupied, while LC 3 occupation is mainly documented around the small mounded area to the north-east (fig. 4: B).

This evidence, compared with the results of the slope profile analysis, allows us to go further and put forward some hypotheses concerning settlement dynamics at Helawa.

The substantial building activities and the quick growth of the stratigraphy during the LC 1-2 probably made the southern side of the mound unstable, compromising additional terracing and building activities, probably also as a result of landslides. This determined a reduction of the settlement area around the main mound and a concomitant extension of occupation around the small north-eastern mound during the next phase. By the LC 2/3, the settlement had shrunk to the top of the mound, where a monumental building with an administrative function (the "Burnt-Building") now stood, while the lower mounded area to the north-east was settled with a domestic neighbourhood. The difference in elevation between the LC structures excavated on both mounds (ca. 4 m) suggests that the high conical mound was converted into a sort of "acropolis" in the course of the LC 2/3. The absence of LC 3 sherds along the southern slope of the mound also suggests a contraction of the settlement; it is probably because erosion had already started in antiquity that the inhabitants moved, abandoning this side of the mound. Future investigations, coupled with geo-morphological analyses, will contribute to test these hypotheses through a chronological modelling of long-term settlement patterns.

4. Identification of Workshop Areas through an Analysis of Correlating Features

4.1. Methodology

A spatial analysis of selected categories of findings revealed significant patterns related to the structure of the site. The formation of specific archaeological deposits as a result of continuous occupation and use of the same space over a prolonged period of time generates meaningful patterns of surface artefact distribution (§ 4.1). In particular, by plotting the distribution of some categories of small finds relative to pottery production (i.e., furnace wasters and ring scrapers) we were able to hypothesize the existence of several potential pottery kilns or workshops, as well as their spatial extent and location, and also to propose a date for them based on chronological information associated with recorded items (§ 4.1). However, besides patterns of human activity at the site (such as excavations, levelling and dumping), other factors shall be considered as well, such as natural post-depositional processes (§ 4.2).

Our density-analysis of different categories of finds per Collection Unit (no. of finds/ sqm, figs. 5-8) allows us to address a number of questions regarding the potential function of specific areas within the site, such as the predictive identification of pottery workshops and kilns (based on the distribution of furnace waste), food-production areas (based on grindstones and Cooking Ware vessels), and lithic production contexts (based on the distribution of chert, obsidian and other raw materials artefacts).

The majority of what is defined here as "pottery-production correlates" comes from the southern slope of the high conical mound, from CUs that yielded Ubaid and Late Chalcolithic 1-2 sherds (CAs A-C; § 4.1). Similarly, lithic artefacts, although distributed all over the site, are much more frequent on the southern slope of the mound (CAs A-C), where the prehistoric layers are heavily eroded (§ 4.2).

4.2. Spatial Distribution of Pottery-Production Correlates

The confident identification of pottery workshops is, in most cases, strictly dependent on the interpretation of the associated materials found during their excavation. A pottery workshop is difficult and problematic to recognize, since several phases of the manufacture process are archaeologically elusive, and virtually impossible to identify based on survey data alone.[17] The presence of pottery kilns lying un-

[17] On classes of archaeological indicators of manufacture turing contexts and kilns, see Tosi 1984, p. 25; Vidale 1992, pp. 114-116; Huot-Delcroix 1972. On the analysis of ma-

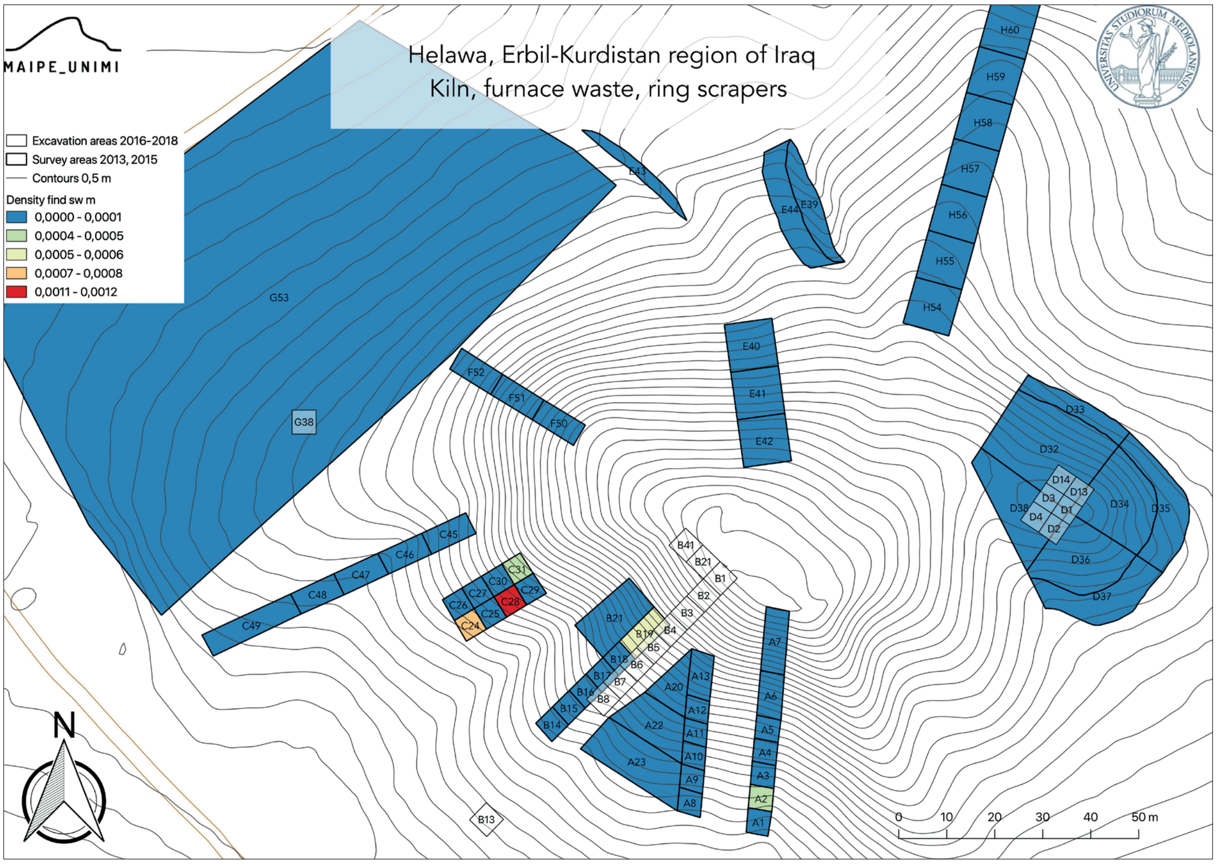

Figure 5
Spatial distribution and density analysis of pottery-production correlates: kiln and surface waste, pottery slags and ring scrapers (no. of finds/ sqm) (©MAIPE)

der the topsoil is more easily recognizable when specific markers occur among surface materials, such as misfired, vitrified or misshapen pottery sherds and furnace wastes. Beside these, another category of objects, the so-called "ring-shaped clay scrapers", can be considered as significant indicators of pottery production, especially during the Late Chalcolithic period. They are well-depurated ceramic open rings with a truncated-conical shape — with smoothly polished working edges — most likely used for trimming the surfaces of vessels at the leather-hard stage.[18] Ring-shaped clay scrapers are widely attested in Susiana and Southern Mesopotamian Uruk contexts where pottery was manufactured.[19] They are also frequently found at Northern Mesopotamia and Jezirah sites dating to the Late Chalcolithic, such as at Tell Nader,[20] Kosak Shamali,[21] Brak HS1 and especially Tell T2.[22]

We performed a spatial analysis of furnace wasters and ring scrapers (fig. 5). Significant clusters are recognizable in CAs A (A13, A23, A2, A4), B (B16, B18/19, B21) and C (C24-25, C28, C31), whereas CA D (D36/37, D38) and G53 only yielded scattered items. The majority of ring scrapers (4 items

nufacturing processes and techniques see Roux-Courty 1998; Rice 2005; Laneri 2009.

18 Alden 1988.

19 Alden 1988.

20 Kopanias, Beuger, Fox 2014, p. 144.

21 Sudo 2003, pp. 220-221, type 2b, fig. 15: 6, pl. 15.4: 1, 6-9.

22 McMahon 2013, fig. 3.

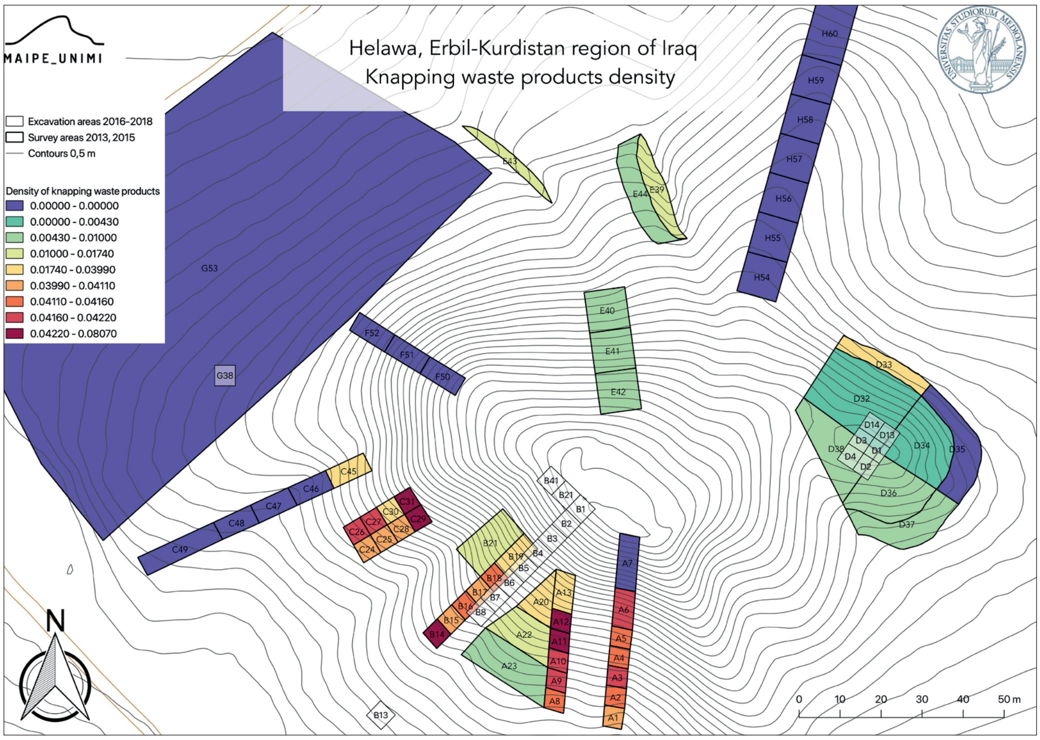

Figure 6
Spatial distribution and density analysis of lithic waste products (no. of finds/ sqm) (©MAIPE)

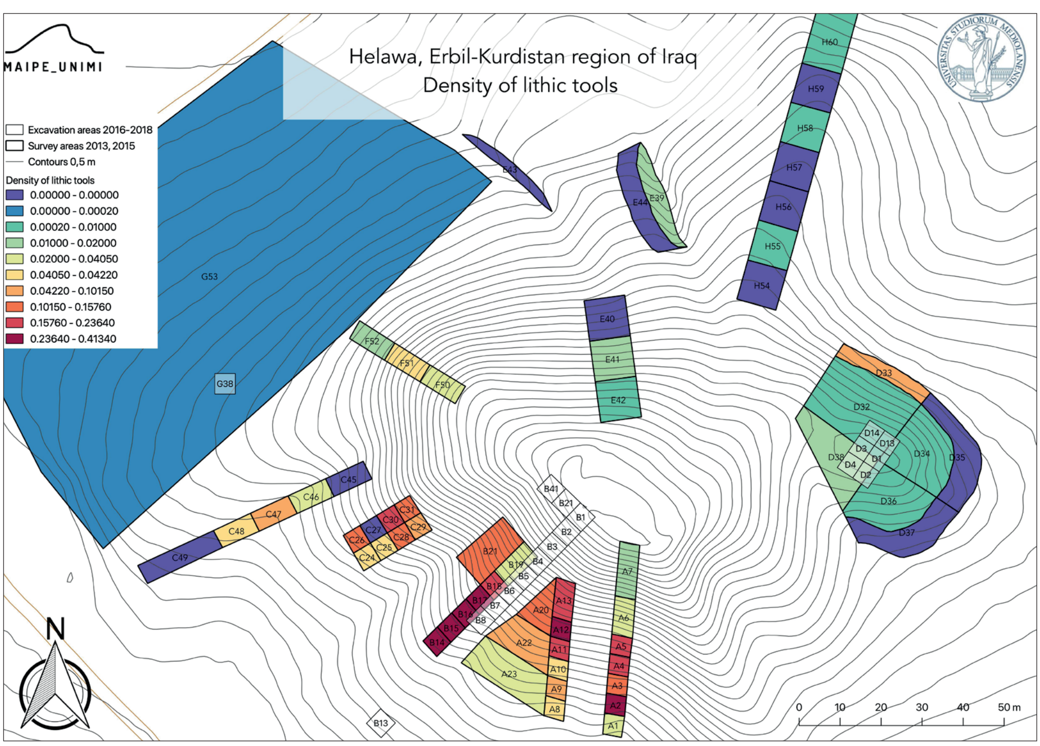

Figure 7
Spatial distribution and density analysis of finished lithic tools (no. of finds/ sqm) (©MAIPE)

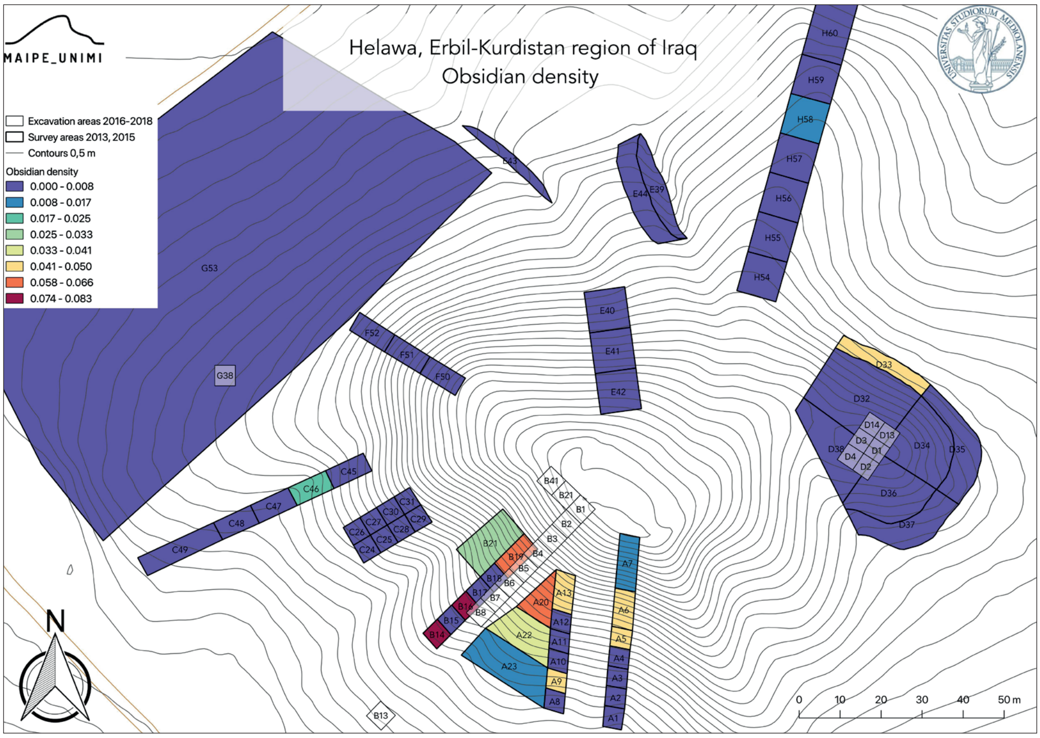

Figure 8
Spatial distribution and density analysis of obsidian artefacts (no. of finds/ sqm) (©MAIPE)

out of a total recorded amount of 7) come from CUs C24-31, providing, together with pottery slags, evidence of kiln-fired ceramic production around or near this spot (also considering erosion and sliding of artefacts) during the Late Chalcolithic.

In CA B, no scrapers were found; however, the presence of several vitrified and overfired sherds in CUs B18/19 and B21, pertaining to a type of bowl characteristic of the LC 1-2 assemblage of Qalinji Agha and Nineveh,[23] suggests the presence of contemporary kilns, which were indeed found in Step Trench B (in Square B4, fig. 1), dug immediately east of Collection Area B in 2016. Further furnace wasters were retrieved in Square B16, eroded and washed away from primary archaeological contexts (fig. 5). The excavation of the Step Trench also documented the presence of an earlier Ubaid kiln (in Squares B5/B6), immediately underneath, and partially cut by LC 1 layers. These data suggest a prolonged use of the area for pottery production (from the Ubaid to the LC 1), which generated meaningful patterns of surface artefacts distribution. The choice of this spot for locating pottery kilns is probably due to its peripheral position in the southern part of the mound, at the margin of the settlement, where it took advantage of the prevalent north-eastern winds to minimize malodorous and unhealthy smoke emissions. The location of these kilns and the evidence for a prolonged use of this area of the mound over several generations might be indirect signs of an intensification of pottery production from the Ubaid to the Late Chalcolithic periods.

The hypothesis of an intensification of pottery production at Helawa will be explored through future excavations and supported by archaeometric analyses of vessels to reconstruct their circuits of production, distribution and consumption; it is nevertheless remarkable that the Helawa evidence is not isolated,

[23] Peyronel, Vacca 2015, fig. 12: 17.

being comparable with data from many other sites in the Bakun area[24] or in the Trans-Tigris region, where recent excavations are documenting firing complexes and workshops for the mass production of ceramics (Girdi Qala Trench C,[25] Bab Level 2[26]).

4.3. Spatial Distribution of Lithic Artefacts

Since we are dealing with a multi-period settlement, it is important to consider two main human factors which can affect the intra-site occurrence of knapped finished tools and/or by-products:

a) the extreme variability of technical behaviours inside the different living spaces,[27] dependent on site-inhabitant organisation of knapping strategies – circumstances which may cause segmentation of the sequences – and finished products/knapping waste management[28] (use-related spaces, caches, waste pits, discarded areas, *etc.*);

b) dynamics of site-formation, such as living floor maintenance, superimposition and building up of new architectural phases, which frequently result in "artificial" assemblages of lithic objects belonging to different chronological phases.[29]

Thus, the identification of distinct areas by means of surface collections could be difficult and may require a critical assessment of the collected data. In the case of Helawa, the database of surface lithic collections has been organised into two levels of description, namely raw materials (including descriptions of lithotypes, origin, shape) and technology (knapping techniques, methods, morphology, blank retouch, *etc.*). A technological study of the lithic assemblages from the stratigraphic sequence excavated in Step Trench B highlighted the heterogeneity of the lithic raw materials processed (consisting of small pebbles and cobbles of fluvial origin) and the significance of these productions. There is scarce evidence of bladelet production on the site. Some chert types only occur as large blades, for which there is no evidence of in situ production. A more detailed technological analysis of the lithic assemblages from Step Trench B is currently underway.

Looking at the spatial distribution of knapping waste products[30] – exhausted cores, flakes, and debris – (fig. 6), we observe their relative ubiquity in most of the CAs located along the southern slope of the mound and, interestingly, their absence in lower CAs along its western and northern slopes. Specific clusters occur in CAs A (A11-A12), B (B14), and C (C29, C31), which also yielded sixth-fourth millennium BCE diagnostic pottery. The distribution of finished tools (chert and obsidian tools on blade/flake) (fig. 7) confirms this trend, showing a higher density along the southern slope, with significant clusters in CUs B (B14-17) and A (A12), and a low frequency in CA D (D33, D38) in the lower mounded area of the site located to the north-east.

Our spatial distribution and density analysis of knapping waste (fig. 6) indicates a major concentration in CAs located along the southern slope of the main mound (A-C), in contrast to the low density of waste and by-products in CAs E-F, located at the same elevation, but on the western and northern side of the tell. This could suggest that knapping activities were localized in CAs A-B-C, as also indicated by data coming from Step Trench B (see § 3). The erosive processes that resulted in the destruction and washing out of the layers and buildings lying on the upper part of the mound, which date to LC 1-3, contributed to the exposure of the stratigraphy and the accumulation of mixed deposits of artefacts originally from primary contexts at less steep contour lines. Thus, the lack of knapping waste in CAs E-F and the high density in CAs A-C could be also explained as a consequence of different post-depositional pro-

[24] Majidzadeh 1975-1977; Alizadeh 1988; Pollock 2015.

[25] Baldi, Naccaro 2015; Vallet et Al. 2017, pp. 69-74.

[26] Skuldbøl, Colantoni 2016, p. 8.

[27] Rosen 2010.

[28] Astruc et Al. 2003.

[29] Rosen 1997.

[30] This category includes all the siliceous rocks (chert, limestone, jasper, quartz, quartzite) exploited within the site. Obsidian knapping waste occurs less frequently, with the exception of the major concentration observed in CUs B14 and B16.

cesses. The evidence provided by CU B14 (figs. 6-7) (waste product density range 0.074-0.083; finished tool density range 0.258-0.455) possibly reflects the erosion of the LC 1 waste pits and room fillings documented during the excavation of Square B4 (fig. 1), which yielded a large quantity of knapping waste and discarded lithic artefacts.

The case of CA D, on the north-eastern part of the mound, is particularly significant. The high number of glossy blades made out of non-local cherts collected on the surface may date from the LC 3 occupation. The excavation uncovered domestic structures and associated deposits immediately beneath a thick Late Bronze Age (LBA) multi-layer sequence excavated at the top of the lower mounded area.[31] Thus, lithic artefacts – especially those found in CUs D33 and D38 – could be interpreted as an assortment of materials washed away by the erosion of the lower mound (which exposed earlier LC levels) and materials connected with levelling and building activities that occurred during the LBA.[32]

While the distribution of lithic artefacts (figs. 6-7) showed several significant clusters – to be studied more in-depth in the future – the distribution of obsidian artefacts (fig. 8) showed a single major density area of waste and finished products in CA B (and especially in CUs B14 and B16). This evidence is comparable with stratified data from the excavation of Step Trench B. Evidence of obsidian knapping activities at the site is clearly documented during the LC 1 period. In Square B4 (fig. 1), the excavation documented the presence of a compact layer of reddish clay (stratigraphic unit TH.17.B.60) which we have interpreted as a surface where obsidian was knapped to produce bladelets.[33] The concentration of waste products (core fragments, flakes, debris) and finished bladelets in CUs B14 and B16 suggests the accumulation of homogeneous materials eroded and washed down from the upper and mid-slopes of the mound or the existence of further evidence of obsidian knapping activities immediately beneath the surface, where Northern Ubaid and Late Halaf levels have been identified (Squares B7-8, fig. 1). Moreover, the evidence of obsidian knapping activities at Helawa suggests that the site may have played a major role in the area during some periods in the sixth to fourth millennium BCE.

5. Conclusion

The GIS of Helawa (Erbil Plain, Iraqi Kurdistan) allowed us to analyse the mound's morphology and the surface distribution of specific categories of findings collected during the survey.

We have suggested a preliminary reconstruction of the localisation of terraces, erosion processes and possible landslides that occurred in antiquity. Nevertheless, targeted geo-morphological investigations are needed in order to add further datasets allowing a thorough interpretation of erosive and post-depositional processes. Relief and Slope Analyses, combined with the estimation of the site's extension (obtained thorough the modelled distribution of LC 1-2 and LC3 diagnostic materials) and cross-checked with data obtained from excavations have allowed us to propose an interpretative model to explain the formation of the main mound. We suggest that, especially during the LC 1-2, substantial levelling, terracing and building activities were concentrated along the southern slope of the main mound, resulting in a rapid vertical growth of the stratigraphy. This situation, coupled with heavy erosion (possibly including landslides) of the southern slope of the mound, which could have already started in antiquity, probably resulted in the abandonment of this area and the conversion of the high conical mound into a sort of "acropolis" occupied by at least one public building in the course of the LC 2/3. While occupation of the top of the main mound appears to have contracted, as excavation and survey data suggest, it apparently expanded toward the northern side of the mound; this evidence appears to indicate that there was a shift of the settlement area.

Our analysis of the distribution density of different categories of finds has given interesting results regarding the potential function of specific areas

[31] Peyronel, Vacca in press; Oselini in press.

[32] Glossed blades made of non-local cherts have been also recorded in secondary deposition in LBA contexts in Area D.

[33] Peyronel, Vacca in press.

within the site. Our study of furnace wastes indicates the possible existence of a Late Chalcolithic pottery workshop. The distribution of lithic artefacts allows the formulation of hypotheses about the possible localisation of knapping and use-related areas during the Northern Ubaid and Late Chalcolithic periods. Our predictive identification of pottery kilns and knapping locations based on GIS analysis of survey data has helped us to refine our overall interpretation of the site and select potential areas for targeted excavations. In this paper we have sought to demonstrate the usefulness of this method and how it can contribute to the planning of future excavation strategies.

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