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Original Paper

Describing and Comparing Archaeological Spatial Structures Case Study Meymanat Abad

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Abstract

Traditionally, occupation phases, without clearly identifiable contexts, have been excavated according to arbitrarily defined vertical spits. The disadvantages of this approach are obvious—where occupation occurred on an undulating or sloped surface, stratigraphic levels or activity horizons, if they existed, are often unlikely to be identified and it becomes almost impossible to differentiate different phases of occupation within any period. Recently, three-dimensional recording of artefact locations with survey equipment, such as total stations, has become more common on these types of sites. In this paper, this method for recording and modeling stratigraphic relationships using 3D analysis a "Arcmap" programs is applied.

Keywords

GIS, interpolation, stratigraphic excavation, tepe meymanatabad, occupation phase

1. Introduction

Interest in the analysis of patterns of spatial distribution of artifacts on prehistoric occupation floors has been growing rapidly in recent years. Virtually all archaeological examples of analysis of spatial patterns have been based upon inspection and impressionistic interpretation (de Lumley et al., 1969). The methods used for excavating sites with few defined features or clear contexts have evolved with time, however they have tended to have at the basis of any method a "vertical spit" approach (Mellars, 1987). Sites are rarely excavated stratigraphically as, although phases of occupation may exist, apparent differences in context often prove to be geomorphologic in origin, or more commonly, clear differences in soil color or texture are not apparent. Given the problems with their definition, any stratigraphic (or rather sedimentological) levels are often left recorded only as sections, although their relationship to artefact distributions is obviously important. The disadvantages of this system are obvious. Unless the palaeosol was perfectly level, "intact" phases of occupation on a once sloped or undulating surface become separated into many different vertical "spits", and artefacts related to each other may never be associated (Figure 1).

In recent years, more and more attention has been focused on the retrieval and analysis of information from smaller scales within archaeological sites as it becomes easier to record artefacts at higher resolutions (and in three dimensions) with specialist survey equipment (Dibble & Lenoir, 1995). However, the means of relating artefacts to potential stratigraphic levels (whether clearly visible or not) is far from straightforward (Harris & Lock, 1996). Significant progress has been made since the 1980s on visualizing three-dimensional relationships in excavations, such as using solid modeling techniques (Reilly & Shennan, 1989) or linking databases to graphics facilities (Reilly, Locker, & Shennan, 1988), an area of research made more feasible recently by developments in three-dimensional Computer Aided Design packages. Displaying three-dimensional relationships can be an important aid in understanding stratigraphical relationships and identifying potential patterning.

However the further step towards three-dimensional spatial analysis is proving a serious challenge. The need to develop a method for analyzing phasing on prehistoric sites has become more pressing, particularly with increasing interest in the subsequent occupation of particular sites. Identifying repeated occupation by human communities with similar technologies depends on differentiating phases of occupation on excavated sites.

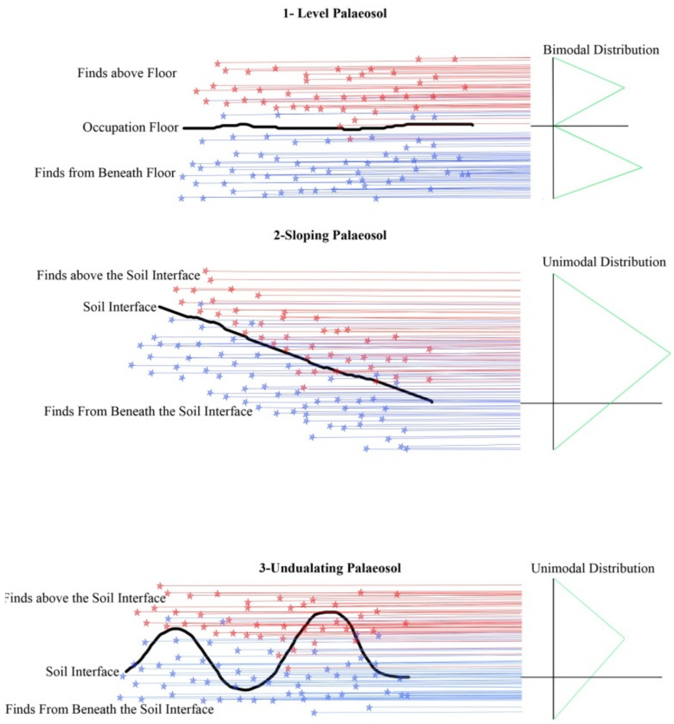

Figure 1. The Effect of Palaeosol Topography on the Interpreted Vertical Distribution of Artefacts (Yosefi Zoshk, 2011)

2. Method

In the summer 2011, during the first season of excavations at Tepe Meymanatabad (Yousefi, 2011), all artefacts including pottery sherds, bone fragments, metal object and etc… were registered by recording the artefact locations in three dimensions as well as a grid of points describing sedimentological boundaries (using laser Total Station TS02-7 based survey equipment). The analysis and interpretation of Tepe Meymanatabad—one from the most important late Chalcolithic sites—allowed the development of a method for linking artefact distributions to recorded stratigraphy and assessing the disturbance of artefacts, and thus forming the basis for interpretations of the nature of occupation at Tepe Meymanatabad. He site of Tepe Meymanatabad stands near the margin of the fertile Tehran Plain, which is one of the largest plain in Northern Central Iranian Plateau. Today, what remains of the mound covers approximately 5.3 ha, much of which is quite low, rising only 4.731 m above the surrounding ground surface. A modern village, also called Meymanatabad, now lies to the west of the site. It appears that, the site was deliberately damaged by bulldozers and ploughing, particularly on the eastern side. As a result of these site formation processes, it is particularly difficult to estimate how large Tepe Meymanatabad was before the recent damage, and this makes it virtually impossible to estimate how large the site was in antiquity. The site consists of two low mounds hereafter called northern mound and southern mound.

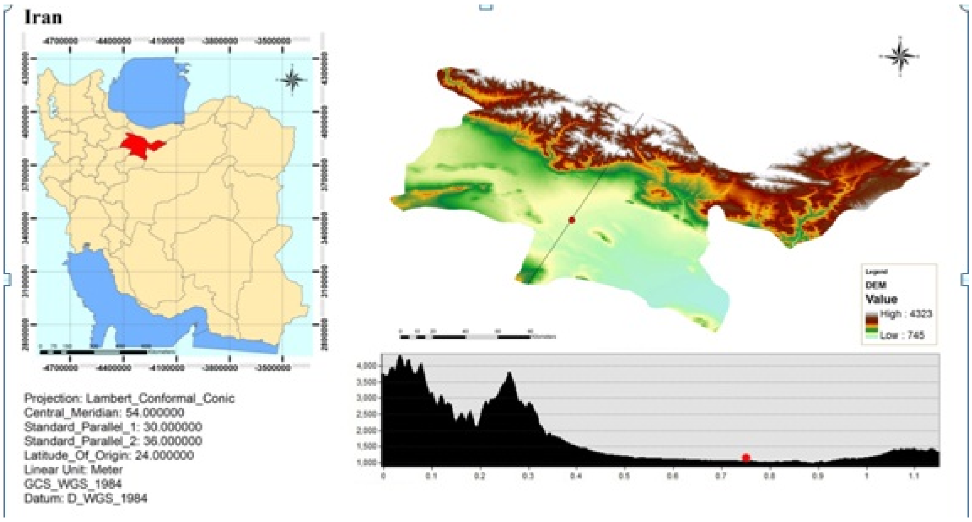

Figure 2. Digital Elevation Model of Tehran Province and Location of Tepe Meymanatabad (Yosefi Zoshk, 2011)

2.1 Operation at Trench 1 at Tepe Meymanatabad

Preliminary excavations at Tepe Meymanatabad were carried out in late summer of 2011. The initial aim of this excavation was to expose a stratigraphically defined sequence of occupation at the site, and when this was combined with the results of the excavations at Tepe Ghabrestan (Fazeli et al., 2005, 2009; Matthews & Fazeli 2004; Majidzadeh, 1976, 1981), it was hoped that this would provide a preliminary insight into the ceramic sequence and the occupational history of the Northern Central Iranian Plateau as a whole during the 4th millennium B.C. Furthermore, an area of 5 m by 5 m at Tepe Meymanatabad, hereby called "Trench 1" was excavated. Excavation proceeded by the identification and removal of discretely stratified layers or "units", whether they were originally produced by natural deposition processes or as a result of human action. A unit can be any type of stratified deposit, such as pit fill, a wall, foundation material, floor surface, bench, hearth, collapse, fill, and wash etcetera. During the excavation, each stratigraphic unit was referred to as a Locus, which was delimited, excavated separately, and allocated a sequential ID number, in this case, from 1001 to 1054. Each locus was recorded on a separate data sheet, where the nature of the deposit was characterized through the selection of a relevant tick-box and a written description. The location and extent of each locus was also drawn in plan, and absolute levels were taken so that it could be defined in three-dimensional space.

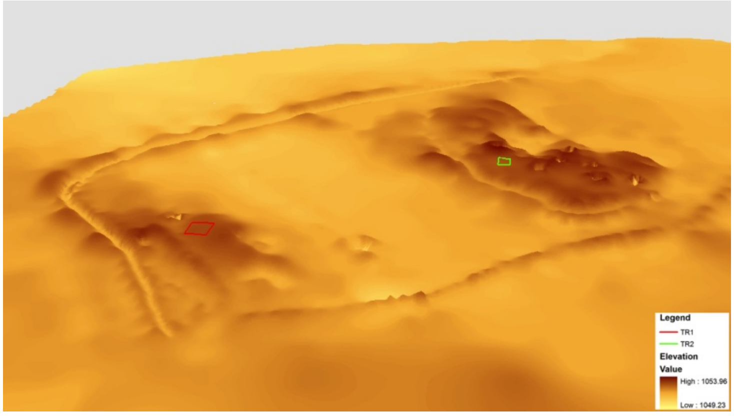

Figure 3. Digital Elevation Model of Tepe Meymanatabad and Location of Trench 1(Yosefi Zoshk, 2011)

The small size of the sounding sometimes meant that individual deposits were excavated in a number of different parts, which were each allocated their own locus number, but which could be combined later. The stratigraphic relationships between each locus were also recorded, and the relationships for all of the deposits in the sounding are illustrated using a standard Harris matrix. After digitally recorded, all cultural artefacts, animal bone or carbonized material and pottery sherds recovered from a locus was placed in a clean plastic bag together with a separately bagged label marked with the date, site name, the trench number, the sequential locus number and a description of the type of object. Apparently associated with these artefacts were three occupation phases, dated to approximately 3400 to 3200 B.C based on pottery classification. Careful excavation began from 1052.993 m above the sea level. All artefacts with no exception—3699 artefacts in total—were individually numbered and recorded in three dimensions using a Total Station, TS02-7 and planned on recording sheets (Table 1).

Table 1. Absolute Heights of Tepe Meymanatabad and Sounding (Yosefi Zoshk, 2011)

Location of Measurement	Absolute Height (m asl)
Highest point on Tepe Meymanatabad	1053.966
Top of Sounding	1052.993
Lowest Level Reached in Sounding	1050.198
Level of Surrounding Plain	1049.235

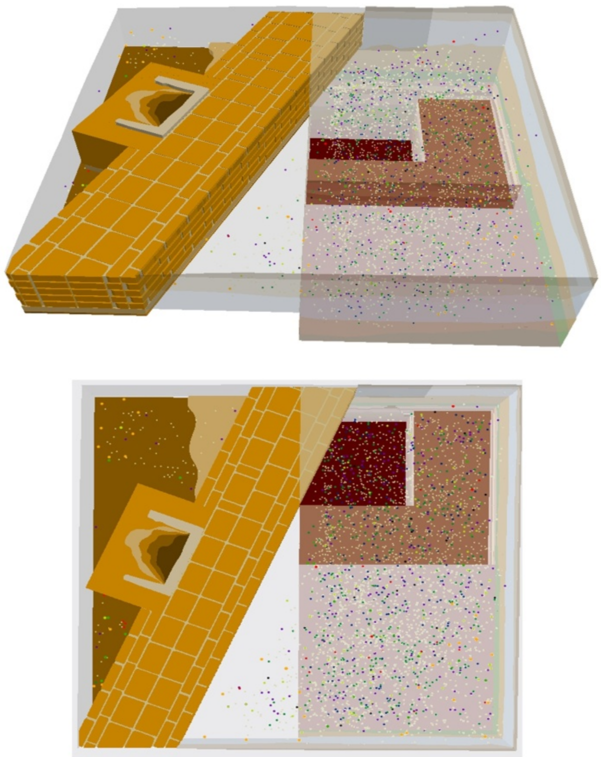

Figure 4. Artifact Distributions at Trench 1, Tepe Meymanatabad (Yosefi Zoshk, 2011)

All excavated deposits were sieved both dry and wet to check for artefacts and micro artefacts. Three major sedimentological changes were visible in the field—first occupational phase (about 87 cm in depth from the datum) which overlay a pale brownish soil, under which lay an interface between this soil and the virgin soil which it covers. A further lower level within the sandstone consisted of a very distinctive soft fine grained soil (Table 2).

Table 2. Three Major Sedimentological Phasing at Tepe Meymanatabad (Yosefi Zoshk, 2011)

<table>
<tr><td rowspan="6">Phase: I</td><td colspan="8">Deposit Table</td></tr>
<tr><td colspan="2">Equally with LN</td><td colspan="2">Deposit Type</td><td>Upper Phase</td><td>Lower Phase</td><td>Upper Limit</td><td>Lower Limit</td></tr>
<tr><td colspan="2">101, 105, 106, 107, 108, 112, 114</td><td colspan="2">Clay silt</td><td>-</td><td>IIa</td><td>1052.993</td><td>1052.118</td></tr>
<tr><td>Compaction</td><td colspan="3">Soft/very soft fine grained sediments</td><td>Grain Size</td><td colspan="3">FINE SAND : 0.02-0.06 mm</td></tr>
<tr><td>Soil Type</td><td colspan="2">deposit percentage</td><td>Deposit Sorting</td><td>Sphericity</td><td colspan="2">Deposit Shape</td><td>Color</td></tr>
<tr><td>clay & silt</td><td colspan="2">15-30%</td><td>moderately sorted</td><td>Low Sphericity</td><td colspan="2">angular & sub – angular</td><td>pale brown/mid</td></tr>
</table>

						brown
	Inclusion	frequent pottery, occasional bone, unknown object, complex pottery, pottery cluster, mandible, slag, occasional charcoal, moderate mud brick, a bronze object, a lithic, clay bead				
	Findings RN	1001, 1002, 1003, 1004, 1079, 1080, 1081, 1090, 1091, 1092, 1017, 1019, 1038, 1041, 1020, 1022, 1016, 1023, 1191, 1192, 1030				
	SF RN			**EN No**		**DS No**
	1005, 1006, 1007, 1008, 1009, 1010, 1011, 1012, 1013, 1014, 1015, 1018, 1031, 1032, 1033, 1035, 1036, 1039, 1040, 1042, 1045, 1046, 1047, 1048, 1049, 1060, 1064, 1067, 1068, 1069, 1070, 1071, 1072, 1074, 1075, 1076, 1078, 1082, 1083, 1088, 1089, 1093, 1094, 1096, 1097, 1101, 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1110, 1111, 1112, 1113, 1114, 1115, 1116, 1117, 1118, 1119, 1120, 1121, 1122, 1123, 1124, 1125, 1126, 1127, 1128, 1129, 1130, 1131, 1132, 1133, 1134, 1135, 1193, 1194, 1195, 1196, 1021, 1024, 1027, 1026, 1059, 1065, 1034			1056, 1057, 1051, 1055, 1050, 1054		1028, 1029, 1062, 1037, 1043, 1044, 1052, 1053, 1063, 1053, 1061, 1084, 1095, 1100
Phase: IIa	**Equally with LN**		**Deposit Type**	**Upper Phase**	**Lower Phase**	**Upper Limit**	**Lower Limit**
	113, 115, 116, 121, 123		silt	I	IIb	1052.118	1051.650
	Compaction	Soft fine Grained sediments		**Grain Size**	MED SAND : 0.06-0.20 mm		
	Soil Type	**deposit percentage**	**Deposit Sorting**	**Sphericity**	**Deposit Shape**		**Color**
	clay & silt	10-20%	well sorted	high Sphericity	rounded		pale brown
	Inclusion	frequent pottery, frequent bone, occasional charcoal, bead, bitumen, grinding stone, slag, mandible , unknown object,					
	Findings RN	1136, 1137, 1139, 1142, 1150, 1197, 1198,1199, 1200, 1201, 1221, 1222, 1224, 1225, 1226, 1262, 1263, 1264, 1273, 1274					
	SF RN			**EN No**		**DS No**	
	1138, 1140, 1141, 1143, 1144, 1145, 1146, 1147, 1148, 1151, 1152, 1154, 1155, 1156,			1271		1149, 1160, 1175, 1178, 1243, 1245, 1239, 1279,	

	1157, 1158, 1159, 1161, 1162, 1163, 1164, 1165, 1166, 1167, 1168, 1169, 1170, 1171, 1172, 1173, 1174, 1176, 1177, 1179, 1180, 1181, 1182, 1183, 1184, 1217, 1218, 1219, 1220, 1223, 1228, 1229, 1230, 1231, 1232, 1233, 1234, 1235, 1236, 1237, 1238, 1240, 1241, 1242, 1244, 1246, 1247, 1313, 1248, 1249, 1250, 1251, 1252, 1253, 1255, 1256, 1257, 1258, 1259, 1254, 1265, 1266, 1267, 1268, 1269, 1270,1276, 1278, 1280, 1281, 1282, 1283, 1284, 1286, 1287, 1288, 1289, 1290, 1291, 1292, 1293, 1294, 1295, 1296, 1297, 1298, 1299, 1300, 1301, 1277				1291, 1302, 1303, 1275, 1285, 1314	
Phase: IIb	**Equally with LN**	**Deposit Type**	**Upper Phase**	**Lower Phase**	**Upper Limit**	**Lower Limit**
	124, 125, 126, 127	peat	IIa	Virgin Soil	1051.650	1051.318
	Compaction	compact coarse grained sediments	**Grain Size**	MED SAND : 0.06-0.20 mm		
	Soil Type	**deposit percentage**	**Deposit Sorting**	**Sphericity**	**Deposit Shape**	**Color**
	clay & silt	10-20%	moderately sorted	Low Sphericity	rounded & sub – rounded	Light reddish brown
	Inclusion	moderate pottery, moderate bone, occasional charcoal				
	Findings RN	1304, 1305,1306, 1307,1311, 1312				
	SF RN		**EN No**		**DS No**	
	-		-		1308, 1309, 1310	

The silt pan is likely to have formed after before the occupation initiated, its formation relating to the development of the peat. However (as is often observed) the undulations of this level were clearly related to the structure of the upper two surfaces. The spatial distribution of artefacts themselves and in relation to the features proved particularly interesting. The artefact re-fit patterns (shown in Figure 5) appeared to relate to distinctive activity patterns on the floor of the first occupation phase. The dimensions of the artefact concentrations accorded well within the first apparent level. An obvious query thus arose as to the integrity of site—in effect whether a coherent explanation could be put forward to explain the apparent distribution patterns, or whether in fact, post-depositional processes had had a major influence on the distribution of artefacts, forming a chance association in the upper deposits. Since the upper levels at many of low mounds are often assumed to be fairly disturbed contexts, a site of this type with minimal post-depositional disturbance and a coherent "story" could be significant not only in the context of the specific activities which might be reconstructed, but also in terms of the potential for recovering other similar late Chalcolithic sites. One accepted method of assessing the integrity of these types of sites is to assess the vertical displacement of artefacts (Barton 1987). The vertical displacement of the finds from the 2010 season's excavations at Trench 1 is shown in (Figure 7 & 8). Points on each of the soil interfaces had been recorded as the area was excavated. First, the gridded points taken from each sediment interface was interpolated to produce three surfaces (see Figure 8) corresponding to the soil interfaces. The method used for this interpolation is essentially the same as that for modeling much larger scale landscape surfaces.

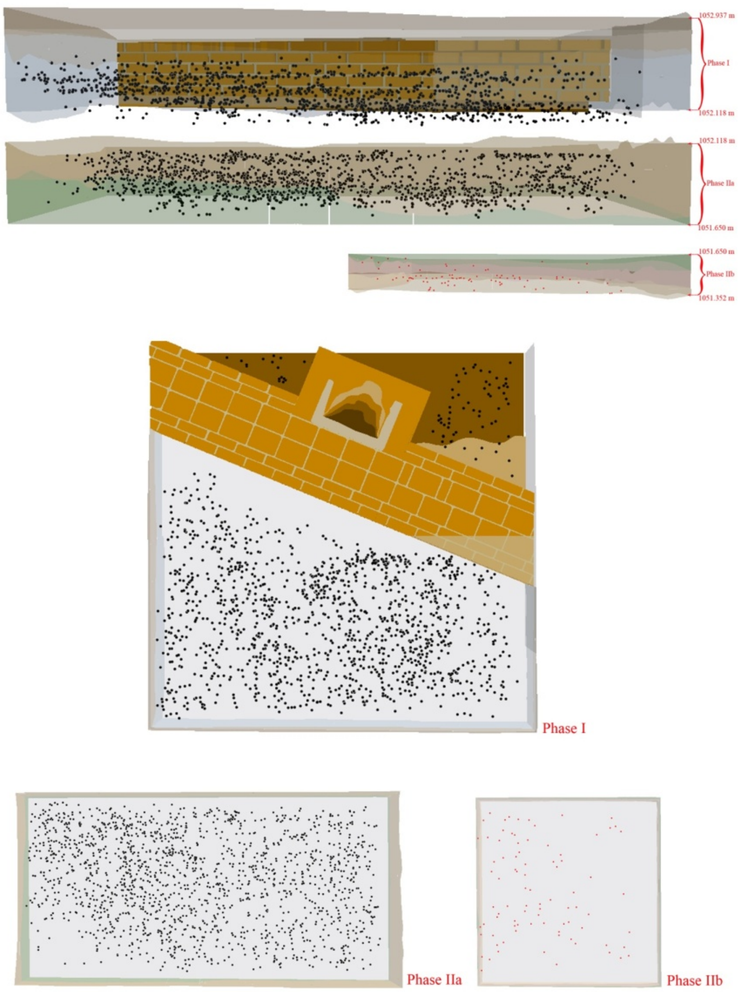

Figure 5. Stratigraphical Phasing at Tepe Meymanatabad and Related Possible Floors (Yosefi Zoshk, 2011)

In this case, the points were entered into ArcInfo as a series of points used to form a TIN surface and interpolated using quantic interpolation to calculate a surface from which the z coordinates of any point could be determined. These surfaces (which had similar forms, although at different heights) provided a model of the shape of the past land surface, and as such a guide to the original relative locations of the artefacts. By calculating the vertical disturbance of each artefact from each of the surfaces (which would have been "parallel" to the past land surface) we can get a measure of the relative displacement from the past land surface on which they were deposited. This is done within GIS by "projecting" the artifacts onto each surface and subtracting the "projected" height from the actual excavated height.

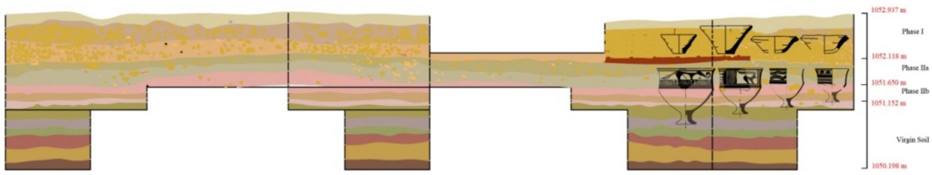

Figure 6. Stratigraphical Phasing Supplemented with Pottery Assemblage at Tepe Meymanatabad (Yosefi Zoshk, 2011)

In effect, by calculating the height of each soil surface at each x, y point (for each artefact) and then the difference between this height and that at which the artefact was recovered. The finds had a very similar vertical concentration in relation to each surface, displaying a bell-shaped distribution with a standard deviation. The vertical distribution of finds was remarkably tightly concentrated, shown with reference to the sandstone layer in Figure 8.

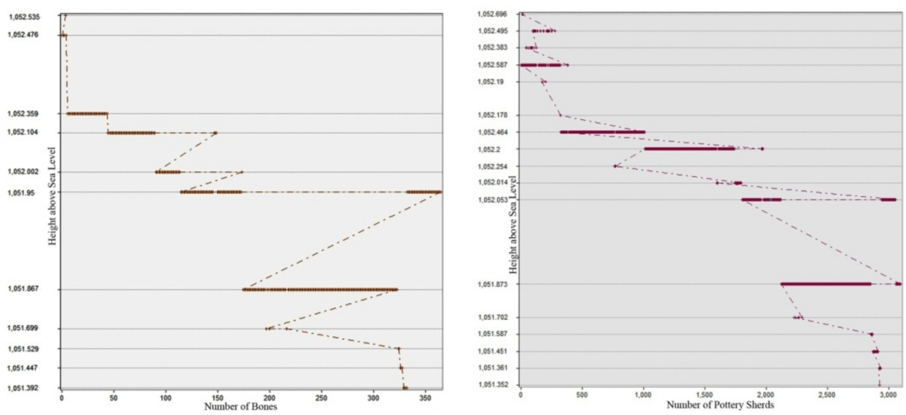

Figure 7. (a) Vertical Distribution of Bones at Trench1 on the Basis of Interpolated Stratigraphy. (b) Vertical Distribution of Pottery Sherds at Trench1 on the Basis of Interpolated Stratigraphy. (Yosefi Zoshk, 2011)

We may assume that maximum vertical concentration of artefacts marks the past land surface on which they were deposited. Other lines of evidence also support the idea of a minimal vertical dispersal of artefacts from the original land surface. Micro-debris analysis and micro-morphology studies revealed the same distribution patterns for micro-debris as shown for all finds above. Likewise the results of pollen concentration analysis at this site currently undertaken by Dr. Maghsudi from Tehran University demonstrated that pollen, spores and charcoal had not moved down the profile and become concentrated at the base of the deposits (Personal communications).

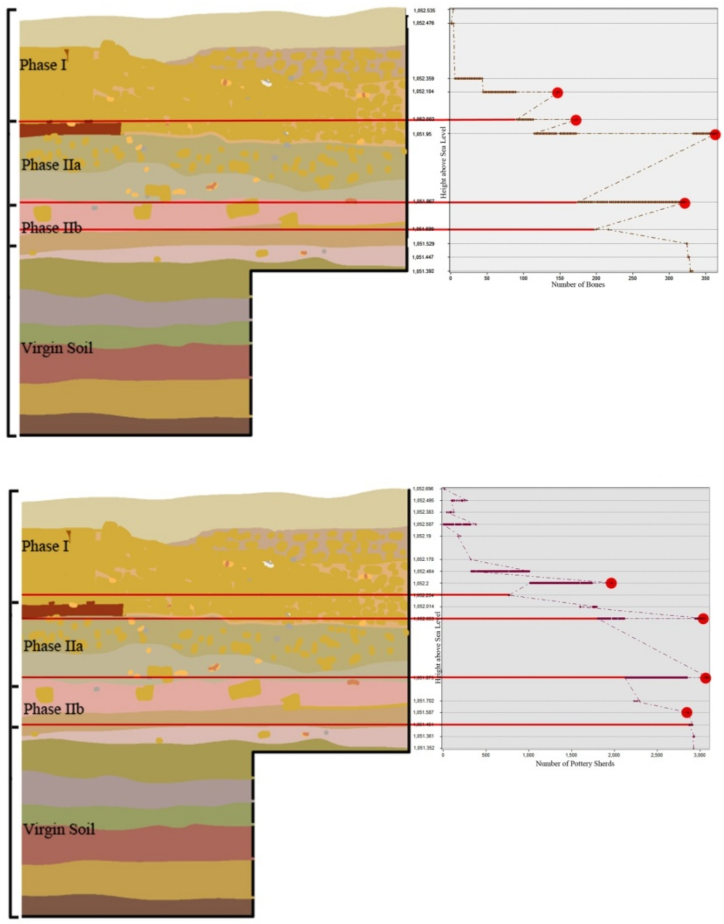

Figure 8. Comparative Analysis of Vertical Distribution of Bones and Pottery Sherds with Stratigraphic Occupation Phases at Trench1 on the Basis of Interpolated Stratigraphy (Yosefi Zoshk, 2011)

In order to test the relative movement of different size classes of artefacts, the vertical distribution from the modeled stratigraphy of the largest size class—big Pottery sherds and bones—was considered separately. The mean difference in depth between the two classes was 0·006 m (89% CI); a *t*-test on the difference in the mean depth between the two classes gave P=0·711. As the confidence interval included 0 and the P value was very large it is safe to conclude that there is no significant difference between the two classes. A possible explanation for the minimal influence of post-depositional processes may lie in the timing of occupation of the site. If occupation occurred at the time of incipient peat formation, the deposition of artefacts may have coincided with a low intensity of biological processes such as earthworm activity. It is clear that the GIS method used provides a "better" means of assessing disturbance than simply considering vertical heights (as shown in Figure 8). The results are particularly important in demonstrating the high integrity of the site, with apparently only a minimal influence of post-depositional processes in disturbing artefact locations, at least where the vertical movement of artefacts is concerned.

3. Result and Decoction

Careful excavation, three-dimensional recording and the use of GIS to model sedimentological levels jointly proved very valuable tools in the analysis of occupation phases at Tepe Meymanatabad. The results from the careful, albeit slow and painstaking excavation and three-dimensional recording of the site described above clearly justify the time involved in excavation. Whilst widely available and easy to use "truly three dimensional" programs for site analysis are still not available, we suggest that the GIS based method described above might provide a useful tool for the interpretation of many sites. It can provide a means of assessing the integrity of the site and the influence of post depositional processes where only a limited span of occupation has taken place, and the potential for identifying different phases of occupation where these phases are vertically separated. We recommend the use of this technique for most sites, at least as a preliminary study used before selecting an appropriate excavation method and look forward to seeing new applications and developments in this field.

Acknowledgement

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