# Petras, Siteia The Pre- and Proto-palatial cemetery in context

Acts of a two-day conference held at the Danish Institute at Athens, 14-15 February 2015

Edited by

Metaxia Tsipopoulou



Monographs of the Danish Institute at Athens Volume 21

This volume is dedicated to all those individuals who participated over the years in the excavation, conservation, study, site development and publication of the results.					
This lofty vision for Petras and its region was made possible by their hard work, dedication and support.					

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#### Front cover:

The Petras cemetery (photo M. Tsipopoulou) and Protopalatial silver signet ring from HT 9 (photo C. Papanikolopoulos) Graphic design: Garifalia Kostopoulou and Metaxia Tsipopoulou

Back cover: Excavation of House Tomb 1, Room 6. Prof. S. Triantaphyllou (photo G. Kostopoulou).

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The conference participants gathered in the courtyard of the Danish Institute at Athens 15 February 2015

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## Abbreviations

Archaeological periods		PTSOU	Petras Rock Shelter
EBA	Early Bronze Age	$\Sigma$ -palace	Stratigraphical trenches of the palace
EH	Early Helladic	W	Wall
EM	Early Minoan		
FN	Final Neolithic	Other	
LH	Late Helladic	A.S.L.	Above Sea Level
LM	Late Minoan	diam.	diameter
LN	Late Neolithic	gr	gram
LBA	Late Bronze Age	h	height
MBA	Middle Bronze Age	kg	kilogram
MH	Middle Helladic	W	width
MM	Middle Minoan	wt	weight
MN	Middle Neolithic	th	thickness
		lt	liter
Petras Are	a	MMD	Mean Measure of Divergence
HT	House Tomb	MNI	Minimum Number of Individuals
R	Room	NISP	Number of Identifiable Specimens
L	Lakkos	SM	Archaeological Museum, Siteia
P	Petras	vol.	volume
PTSK	Petras Cemetery		

The form of the English language for the native speakers (British or American) was the author's choice. For the non-native speakers the American form was used.

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## Bibliographic Abbreviations

AAA – Archaiologika Analekta Athinon

ActaPalaeobot - Acta Palaiobotanica

AJA - American Journal of Archaeology

AJPA – American Journal of Physical Anthropology

AJS - American Journal of Sociology

AmJHumBiol - American Journal of Human Biology

AnnMathStat - Annals of Mathematical Statistics

AR - Archaeological Reports

Arachne – (on-line access to the CMS, with corrected information and enhanced illustrations) http://arachne.uni-koeln.de/drupal/?q=de/node/access date March

ArchDelt - Archaeologikon Deltion

*ArchEph* – Archaeologike Ephemeris

AS – O. Krzyszkowska, Aegean seals: an introduction (BICS Suppl. 85), London.

ASAtene – Annuario della Scuola Archeologica Italiana

BAR-IS – British Archaeological Reports, International

BCH - Bulletin se correspondence hellénique

BICS – Bulletin of the Institute of Classical Studies of

the University of London

BSA – Annual of the British School at Athens

*CHIC* – J.-P. Olivier and L. Godart, *Corpus hieroglyphicarum inscriptionum Cretae* (Études Crétoises 31), Athens and Rome 1996.

CMS – Corpus der minoischen und mykenischen Siegel, Berlin 1964-2000, Mainz 2002-

CretChron - Kretika Chronika

EtCret - Études Crétoises

JAS – Journal of Archaeological Science

JMA - Journal of Mediterranean Archaeology

*Kentro* – Kentro: The Newsletter of the INSTAP Study Center for East Crete

MA – Monumenti Antichi

OJA - Oxford Journal of Archaeology

Prakt – Praktika tes en Athenais Archaeologikes Etaireias

SIMA - Studies in Mediterranean Archaeology

SMEA - Studi Micenei ed Egeo-Anatolici



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# East Cretan networks in the Middle Bronze Age\* Carl Knappett & Cristina Ichim

### Abstract

What kinds of relationships can we trace between the various settlements of east Crete during the Middle Bronze Age? Are there very close cooperative ties all across east Crete, from Malia and Myrtos-Pyrgos in the west to Palaikastro and Zakros in the east? Or is there competition and conflict? To what extent do relations shift from the beginning to the end of the period, from MM IA to MM IIIB? In tackling these questions, this paper will draw principally on ceramic evidence (production, exchange and use), while also making reference to architecture and settlement patterns, with a view to assessing the position of Petras in broader regional networks of interaction.

#### Introduction

In this paper we adopt a regional network perspective in an attempt to explain the emergence of a palatial centre at Petras during the early part of the Middle Bronze Age. We ask what the regional dynamics are that might account for this development in Middle Minoan (MM) IIA, and then for the apparent strong links between the site and the Maliote administration in MM IIB. How do these changes compare with what we then see at Petras and indeed at other east Cretan sites in the following Neopalatial period? Our approach is first to discuss qualitatively some of what we know about inter-site connections in east Crete during MM IB, MM IIA and MM IIB, based principally on pottery, burial and settlement evidence. However, differentiating these phases in east Crete is not always straightforward, and certainly requires study of excavated assemblages. Survey data cannot provide this level of temporal resolution, with these phases usually lumped together as Protopalatial. What one can then do with survey data is compare Protopalatial site distributions with Prepalatial on the one hand, and Neopalatial on the other. We use these distinctions, working from published survey data across east Crete, to model aspects of changing settlement patterns in order to contextualize Petras

We are most grateful to Metaxia Tsipopoulou for the invitation to contribute to the workshop; and although we were unable to attend in person, our paper was kindly read by Gerald Cadogan. Many thanks also to Donald Haggis for his very helpful comments and input on MM east Crete. Andrew Bevan has, as always, given freely of his expert advice on GIS and modelling issues, and we thank him for advice on the DEM model, which is courtesy of ASTER and FORTH (see Chrysoulakis *et al.* 2004). The point process model and hypothetical site predictions, as well as the network analysis, were written in the R statistical software using the packages maptools, raster, rgdal, spatstat and igraph.

regionally. This is the second part of our paper – the development of a spatial model that analyses the network properties of settlement patterns over time as a means to assess likely patterns of interaction more quantitatively.

### A qualitative approach to interaction in MM I-II east Crete

First, let us start with the pottery evidence. It seems that in MM IA-B there is a moderate degree of commonality across many sites in their fine wares. We see polychrome bands on cups in MM IA and B,1 and in MM IB the polychrome 'Alternating Floral Style' appears across much of east Crete, albeit sporadically and in small quantities, suggesting nonetheless a certain degree of interaction between sites.2 The potter's wheel is adopted in MM IB, for small tablewares at least, with seemingly no delay from the centre of the island, again suggesting interaction and integration.3 MM IA and B deposits are by no means widespread, but they have long been identified at Mochlos (Block D) and Vasiliki (House B),4 as well as more recently at Palaikastro5 and Myrtos-Pyrgos.<sup>6</sup> From Petras there is the 'Lakkos' deposit of MM IB - suggestive of some kind of communal feasting at the site in which different corporate groups came together, using distinct tablewares that suggest a kind of horizontal rather than vertical differentiation.7

In MM IIA the pottery evidence also indicates regional interactions in east Crete. In terms of actual movement of ceramics, some Mirabello products are

imported from the Gournia area to both Palaikastro<sup>8</sup> and Myrtos-Pyrgos.9 There are also stylistic links across this area, with substantial deposits of MM IIA pottery from Palaikastro showing similarities with sites to the west - for example, some of the pottery from Papadiakambos<sup>10</sup> looks similar to that from Palaikastro. Even though the MM IIA pottery from Palaikastro is largely from fills, we can posit the existence of feasting broadly similar to that seen at Petras in MM IB. Given the similarities that appear to exist between Papadiakambos and Palaikastro in MM IIA, one might expect the contemporary pottery from Petras to follow similar lines. Certainly, there are some connections even further west, with the plates from HT 2 at Petras<sup>11</sup> very similar to those presented by Gerald Cadogan from Ossuary 2 at Myrtos-Pyrgos, assignable to MM IIA.

Turning to MM IIB, pottery from various sites suggests considerable interaction and integration across east Crete. The strong similarities between Malia and Myrtos-Pyrgos have been much discussed,12 but we should also include Gournia, Petras and to some extent Palaikastro.<sup>13</sup> This is arguably the first time in the Protopalatial period that one can really identify a centre for regional interaction - and it seems that it is Malia that is making efforts to bring east Crete under its influence.<sup>14</sup> This may have been a short-lived attempt at hierarchical control, but arguably it paved the way for a much more pronounced hierarchy in the subsequent Neopalatial period, though emanating from Knossos.

Secondly, we have evidence from burials. The prevalence across much of east Crete during the

Knappett 2007a. 1

<sup>2</sup> Floyd 1997.

<sup>3</sup> Knappett & van der Leeuw 2014.

Andreou 1978.

Knappett & Collar 2007.

Cadogan & Knappett in preparation.

Haggis 2007.

Knappett & Cunningham 2012.

<sup>9</sup> Cadogan & Knappett in preparation.

<sup>10</sup> Sofianou & Brogan 2012.

Tsipopoulou 2012, pl. 6. 11

<sup>12</sup> E.g., Cadogan 2013.

It will be interesting to see in the work of Giorgos Doudalis at Mochlos the degree of similarity in MM II with Maliote pottery.

Knappett 2007. 14

Middle Minoan period of a particular type of burial – the rectangular house tomb— – oints to a high level of interaction and integration throughout the region. The Petras cemetery is of course one of the best examples of this phenomenon, as well as Palaikastro, Malia (Chrysolakkos), Sissi, Gournia and Myrtos-Pyrgos.<sup>15</sup> They certainly see considerable use in MM I, and into MM IIA - but for some of these tombs the extent to which they continue into MM IIB is debatable. Chrysolakkos at Malia appears to contain pottery mostly assignable to MM IB-IIA, and not MM IIB.16 The recently excavated house tombs at Sissi are reported also to be largely out of use by MM IIB.<sup>17</sup> As far as is possible to tell from the published pottery, the tombs at Palaikastro similarly may not stretch later than MM IIA. The Myrtos-Pyrgos house tomb, however, does see some burial activity in MM IIB, with the deposition of some Maliote jars.<sup>18</sup> At Petras too, while there is considerable burial activity in MM I-IIA,19 there is also good evidence for continued use of the cemetery into MM IIB.20 This is somewhat contradictory to the general pattern identified by Legarra Herrero,<sup>21</sup> of significant changes in burials between MM IIA and IIB. Thus although it is tempting to suggest that MM IIB is the period when Malia seeks to assert some degree of hierarchical control over the wider region, <sup>22</sup> perhaps this move is not entirely at odds with the heterarchical, integrative customs of communal burial, which the Petras evidence indicates are not universally in decline. We could imagine

role in regional integration during MM I–II, though it is impossible on current evidence to differentiate MM IIA from IIB in their use. However, it does seem that some peak sanctuaries, such as Petsophas and Prinias for example, see continued use into the subsequent Neopalatial period.<sup>23</sup> We could take this as a sign of efforts to continue local integration, or instead as part of a Knossian intrusion into local cult practices (given intensified cult practice at Juktas in the Neopalatial period too).

Thirdly, there is the settlement evidence. One of

that the peak sanctuaries of east Crete also played a

the most conspicuous changes in settlement in east Crete during MM I–II is the building of the palace at Petras in MM IIA.<sup>24</sup> This may indicate a consolidation of power following a more fluid situation during MM I, if the nearby sites of Ayia Photia and Chamaizi are anything to go by, with their defensive orientation and unique forms. Chamaizi in particular is located at what must have been an important pass in the mountains between the Siteia bay and the Mirabello regions. Both buildings are normally assigned to MM IA, though recent study shows that Chamaizi must have had a later MM IB-II occupation too.25 The competitive yet heterarchical situation of MM I is also indicated by the Lakkos deposit from Petras,<sup>26</sup> and indeed the Petras burials concentrated in this period. Recent work at Gournia points to energetic building activity in MM IB,<sup>27</sup> and the Mochlos Block D and Vasiliki House B material, though excavated 100 years ago, may indicate similar levels of activity.28 Elsewhere, though, it is MM IIA that sees new building activity, with Papadiakambos apparently having its first substantial phase of occupation in

<sup>15</sup> Legarra Herrero 2014.

<sup>16</sup> Poursat 1993; contra Stürmer 1993.

<sup>17</sup> http://www.sarpedon.be/first-results/cemetery/ (accessed 09/05/2016).

<sup>18</sup> Cadogan 2013, 107.

<sup>19</sup> Tsipopoulou 2012.

<sup>20</sup> Tsipopoulou pers. comm.

<sup>21</sup> Legarra Herrero 2014.

<sup>22</sup> Consider in this context the burial cave of Hagios Charalambos on the Lasithi plateau – see Betancourt 2007; it does show use into MM IIB, and a swing of influence from the Mesara in MM IB to Malia in MM II.

<sup>23</sup> Nowicki 2012.

<sup>24</sup> Tsipopoulou 2002.

<sup>25</sup> Lenuzza 2011.

<sup>26</sup> Haggis 2007.

<sup>27</sup> Watrous et al. 2015.

<sup>28</sup> Andreou 1978.

MM II,29 and arguably MM IIA.30 At Malia it is likely that the Quartier Mu building complex was established in MM IIA, and fill deposits of MM IIA have recently been uncovered in Quartier Pi, with numerous pouring and drinking vessels suggestive of feasting activities broadly comparable to those at Petras.<sup>31</sup> There is an issue concerning the association of MM IIA with architecture, as at Myrtos-Pyrgos too there is MM IIA from the Ossuary 2 context, but little to speak of in connection with domestic contexts. Further east, at Palaikastro, substantial fills of pottery can also be dated to MM IIA (see above), though it is hard to say exactly what the nature and extent of the site is at this time; one could reasonably suggest some expansion compared to MM IB, which is a bit thinner on the ground. Elsewhere in the far east of Crete, at Zakros, the locally-defined 'Zakros III' phase appears to be equivalent to MM IB-IIA.32 It is difficult to say if sites in the Zakros and Palaikastro hinterland, such as Karoumes and Choiromandres, were already established in MM IB-IIA, as sufficiently diagnostic pottery is lacking.<sup>33</sup>

When we turn to MM IIB, the situation changes considerably, as argued above in relation to both the pottery and the burial evidence. Petras sees significant developments, as signaled by the Cretan Hieroglyphic archive dated to MM IIB,<sup>34</sup> with its strong links to Malia. Some of the pottery also seems to show strong connections with Malia now. Gournia has evident occupation in MM IIB, such as House Aa, with a destruction at the end of the

period.35 The nearby Pacheia Ammos Pefka purple dye installation dates to MM IIB.<sup>36</sup> We might also mention here the evidence for MM occupation on Chryssi Island, off the coast south of Ierapetra, which may have been exploited for the molluscs (Hexaplex trunculus) needed to make purple dye, though a more precise date than MM IB-II is not currently offered.<sup>37</sup> At Myrtos-Pyrgos we do now have substantial pottery deposits associated with what must have been a precursor to the Neopalatial country house on the top of the hill; it would seem that the construction of two massive cisterns and a defensive tower can be assigned to this phase too.<sup>38</sup> At Palaikastro the first signs of urban organization emerge, with the street system, drainage and the hall in Block M all seemingly put in place in this period.<sup>39</sup> The situation at Zakros is intriguing, where 'Zakros IV' (MM IIIB-LM IA) is found stratified over Zakros III (MM IB-IIA) on the NE hill; where does this leave MM IIB? Platon's solution<sup>40</sup> is to summon up the old argument for cultural lag, such that at Zakros they continue to use pottery that is stylistically MM IB-IIA (in central Cretan terms) into MM IIB. Even if this works, it still leaves a gap in MM IIIA too. More likely, it would seem, is the lack of a destruction horizon in MM IIB and hence no clear deposits; this is after all a phenomenon seen elsewhere (not least Palaikastro). Whatever the reasons, it seems difficult to say much about differences between MM IB-IIA and MM IIB at Zakros. In its hinterland, however, it is possible that sites like Choiromandres and Karoumes were first occupied in MM IIB.41 If one considers the defensive aspects of these and other far east Cretan sites, together with the MM

<sup>29</sup> Sofianou & Brogan 2012.

<sup>30</sup> Haggis in Tsipopoulou 2012, discussion, 338.

<sup>31</sup> Knappett et al. in press.

<sup>32</sup> Platon 1999, 674. Platon defines Zakros III on the basis of contexts from Kalyvomouri, Pezoules and Mavro Avlaki. Little pottery is illustrated and described other than in N. Platon's preliminary reports, though the presence of Alternating Floral Style at least would suggest a date in MM IB.

<sup>33</sup> Vokotopoulos 2007; 2011; Vokotopoulos et al. 2014.

<sup>34</sup> Tsipopoulou & Hallager 2010.

<sup>35</sup> Boyd-Hawes et al. 1908; Watrous et al. 2015.

<sup>36</sup> Apostolakou et al. 2010.

<sup>37</sup> Chalikias 2014.

<sup>38</sup> Cadogan 2013; 2014.

<sup>39</sup> Knappett & Cunningham 2012.

<sup>40</sup> Platon 1999, 674.

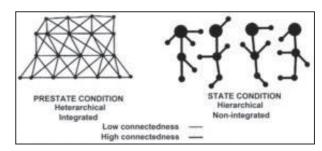
<sup>41</sup> Vokotopoulos 2007; though see above – we cannot rule out MM IB-–IA.

IIB occupation of a clearly defensible site like Katalimata in the Mirabello region,<sup>42</sup> and the defensive efforts at Myrtos-Pyrgos, one could perhaps explain these in the context of resistance to the expansion of Malia's regional claims; or even, given the evidence from Quartier Mu at Malia, which suffers a severe destruction, with bronze cauldrons buried beneath the floors, perhaps even Knossian expansionism as early as the end of MM IIB.

What does all this qualitative evidence tell us about interaction in east Crete? First, it would seem to point to a change happening in MM IIB in terms of the organization of regional interaction. With the apparent erosion of communal burial (except Petras, Myrtos-Pyrgos) and cult practices, growing administration and stronger commonalities in material culture seemingly centered on Malia, we argue that this change reflects an effort towards greater hierarchical control. This may have been relatively short-lived during MM IIB, and ultimately not all that successful, but it did perhaps pave the way for even greater hierarchical influence in the following MM III period, albeit centred on Knossos rather than Malia.

Secondly, although the evidence is suggestive, it is also very patchy – not only in terms of the extent of unpublished material (or material published from excavations a century ago), but also what must be a considerable number of sites that remain to be discovered, notwithstanding the relatively large number of projects underway in the region. The level of intensive research is high, but we are still a long way from being able to draw systematic connections between sites to understand their interactions in detail.

However, there is another kind of data that we have barely mentioned – survey data on settlement numbers and distributions. Survey data do not feature in our account above because they are not of much help when it comes to discussing changes be-



**Fig. 1**. Haggis' diagram of pre-state and state conditions (after Haggis 2002, fig. 7.4).

tween MM IB, IIA and IIB. Survey pottery does not allow for such fine distinctions, and these phases usually get lumped together under 'Protopalatial'. The coarse resolution in the data does often enable, however, the separation of material into Pre-, Protoand Neo-palatial periods. This could still be useful for our current purposes, because our assumption is that the end of the Protopalatial is quite like the Neopalatial period, and so we could perhaps see if the Neopalatial settlement distributions show any signs of centralization. Alternatively, it may be that Protopalatial settlement distributions resemble more strongly those of the Prepalatial period. The hope is that changes in the regional settlement distribution over time might tell us something about the emergence of Petras as a center.

We are not the first to consider long-term changes in settlement distribution in east Crete. Donald Haggis takes as his starting point the survey data from Kavousi, and looks at changes between the Prepalatial, Protopalatial and Neopalatial periods. <sup>43</sup> He identifies a broadly similar "integrated" pattern in MM I–II as in EM III–MM IA, and suggests that it is not until MM III–LM IA that the settlement pattern becomes nucleated, with a loss of integration. This nucleation is in the interests of connectivity across longer distances, and there is a greater orientation towards the coast. What is especially interesting in his approach is the way in which he abstracts from the

<sup>42</sup> Nowicki 2008.

<sup>43</sup> Haggis 2002; see also 1999.

evidence to create a kind of generalized model of settlement structure. He creates a "diagram of pre-state and state conditions", with the pre-state condition characterized by a crystal lattice of sites of equal size as the nodes, and weak, evenly distributed connections between them as the links; the "state condition" shows a series of more strongly connected nodes, of variable size, though the network as a whole is sparsely connected (Fig. 1).44 So the argument goes that in the prestate condition (i.e., late Prepalatial and Protopalatial) sites are integrated, heterarchically organized, and with widespread but low-level connectedness. Actually this is very much what one would call clustering in network science - without any of the random long-distance connections that make for small worlds. And then in the state condition (i.e., Neopalatial) we have stronger connections between some sites, presumably over longer distances, at the expense of local clustering.45

What Haggis effectively does in this study, by not only identifying patterns on the ground but also offering a simple model and an explanatory mechanism, is lay the basis for a network approach that gets to grips with patterns of connectivity over time and space, in a way that has barely been attempted for MM Crete. We take his study as a starting point and inspiration for a new network model that covers a wider area and uses quantitative modeling techniques. In order to cover a wider area, indeed all of east Crete from the Bay of Mirabello to the far east of the island, we cannot safely extrapolate from the Kavousi survey data alone. We should really extrapolate from all the available survey data, as it covers more of the region and incorporates a wider spectrum of landscapes than those seen in the Kavousi area, and so should, in theory, be more representative of regional site distributions. However, when

# A quantitative approach to MM settlements and interactions

Bevan and Wilson<sup>47</sup> take Crete as a whole and focus on the upper end of the settlement hierarchy in the palatial periods, working from the better-known settlement sites, some palatial and some not (see Fig. 2a). Recognising that the 35 known sites probably do not give the complete picture and that there must have been other major settlements, they input in addition 100 hypothetical ones (see Fig. 2b), "conditioned on the positive relationship between observed settlements and access to flatter, more agriculturally favourable, land" (and the more yellow, in this map, the better the access).<sup>48</sup>

From this distribution of points one can ascertain, using spatial interaction models (SIMs), which sites might have had greater centrality. When the authors do this, they are able to generate reasonable approximations for central places – as seen here (Fig. 3a).

However, they do not quite match the reality of the archaeological evidence because "(a) they have not yet taken into account the impact of Crete's rug-

one does this, and looks at how much of east Crete is actually covered by survey, one quickly realizes that there are still large areas that are unsurveyed (*terrae incognitae*). This problem of incompleteness may at first seem largely intractable, but there are modeling techniques that have been devised to take account of such problems. Here we draw on the recent work of Bevan and Wilson,<sup>46</sup> which specifically takes the example of Bronze Age Crete to present ways of modeling incompleteness, showing that the resultant model outcomes can tally quite well with observed data.

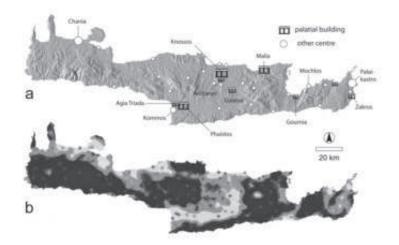
<sup>44</sup> Haggis 2002, fig. 7.4.

NB one might actually expect clustered links to be strong, and long distance ones to be weak – see Granovetter 1973.

<sup>46</sup> Bevan & Wilson 2013.

<sup>47</sup> Bevan & Wilson 2013.

<sup>48</sup> Bevan & Wilson 2013, 2419.



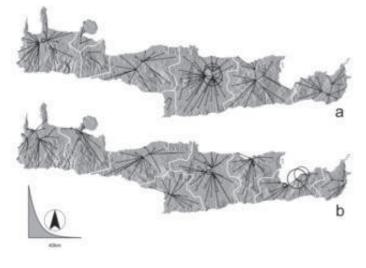
**Fig. 2a.** Simplified distribution of central settlements on Crete in the Middle to Late Bronze Age (after Bevan & Wilson 2013, fig. 2a).

**Fig. 2b.** A simulation showing the addition of settlements, based on available agricultural land (after Bevan & Wilson 2013, fig. 2b).

ged topography on patterns of interaction, and (b) they have not yet addressed the fact that settlement hierarchy on an island will often be substantially affected by interactions with communities in neighbouring regions overseas".<sup>49</sup> They respond to the second of these problems by assigning extra interactions to sites, proportional to their on-island importance. These adjustments can be seen in Fig. 3b, with settlements more likely to be central now closer to the coast. The picture fits more closely with the expected reality.

Their response to the first problem, of Crete's rugged topography, involves calculating actual physical paths between sites rather than just shortest distances. Based on these calculations, their model does create quite sensible predictions for central places.

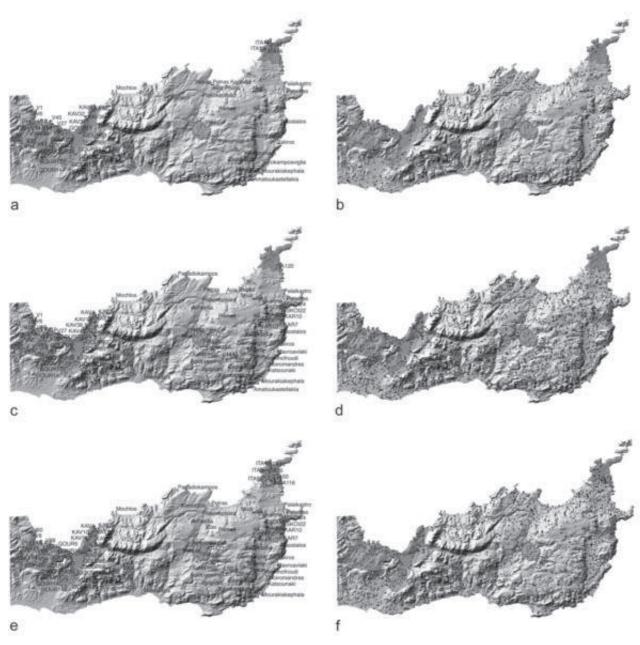
As Bevan and Wilson would concede, their model is necessarily reductive – it neither considers the *smaller sites* in the settlement hierarchy nor addresses *changes over time* in the settlement pattern. What ideally we should try to do is combine this sort of network modeling with the kind of concern Haggis shows for connections across scales. That is to say, between very local patterns (e.g., Kavousi) and island-wide dynamics – such as the rise of Knossos in the Neopalatial period and its apparent effects



**Fig. 3a.** An output from the interaction model used by Bevan and Wilson, without weighting for off-island interaction (after Bevan & Wilson 2013, fig. 3a).

**Fig. 3b**. An output from the interaction model used by Bevan and Wilson, including weighting for off-island interaction (after Bevan & Wilson 2013, fig. 3b).

<sup>49</sup> Bevan & Wilson 2013, 2419.

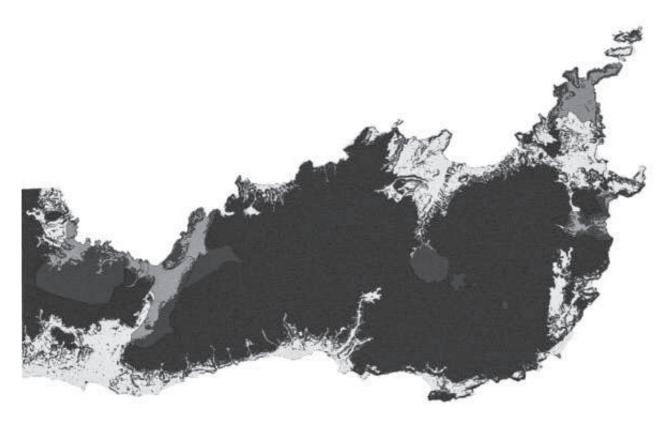


**Fig. 4**. Maps a, c and e display the known sites in surveyed and non-surveyed areas, as well as the surveyed areas considered in this study for the Prepalatial (EM III–MM IA), the Protopalatial (MM IB–II) and the Neopalatial (MM III–LM I) periods respectively. Maps b, d and f display the hypothetical site distributions for the corresponding periods according to the fitted point process model.

on settlement patterns and connectivities. Haggis highlights very well the need to think across different scales, from the micro-scale of farmsteads, to the macro-scale of island geopolitics. And, of course, the sense of significant changes *within* the palatial

periods is also crucial, as well as an added level of resolution we need in network models.

Our method thus involves compiling a distribution of known sites in east Crete from surveyed and non-surveyed areas. The survey data derive from



**Fig. 5**. The light-colored areas of east Crete represent lowland agricultural soils, defined to be under 200 m elevation and at a slope of less than 20 degrees, while the dark-coloured areas (pastoral) are highlands. The overlaid dark gray highlights represent areas that have been surveyed.

publications, final and preliminary, of the Vrokastro, Gournia, Kavousi, Ziros, Praisos, Itanos and the 'Minoan Roads' project areas.<sup>50</sup> The sites are separated into Prepalatial, Protopalatial and Neopalatial periods, so that we then have distributions by period, as well as a wide spectrum of the settlement hierarchy, ranging from towns to farms and field sites. Based solely on the survey areas, where we assume

full knowledge of the settlement distributions, we fit a point process model to our data – "an equation which combines a prediction of (a) the varying density of observed points across a study area (the first order trend), calculated either solely from the observed point distribution or, in our case, as correlated with one or more predictor variables (in a manner similar to a traditional predictive model of site location using logistic regression), and (b) the degree to which the location of one point inhibits or attracts other points (and over what distances, i.e., second order properties)".<sup>51</sup> Thus, by determining the relationship between site locations and intensities and the underlying environmental variables of

Hayden 2004; Watrous *et al.* 2012; Haggis 2005; Branigan *et al.* 1998; Whitley *et al.* 1999; http://prospectionitanos.efa.gr (accessed 09/05/2016); Vokotopoulos 2011. We have not currently included the site data from the Hagia Photia survey (Tsipopoulou 1989). Although we intend to make this addition in a further iteration, we do not anticipate that it will make a substantial difference to the overall extrapolated distributions and centrality measures.

<sup>51</sup> Bevan & Wilson 2013, 2417; also Baddeley & Turner 2006.

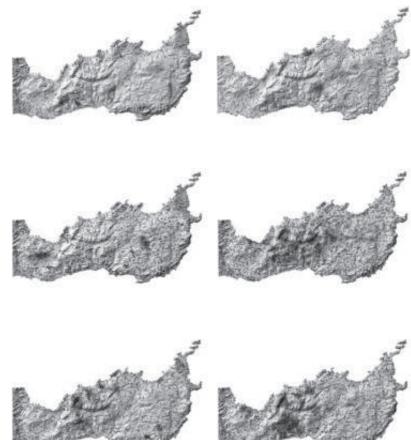


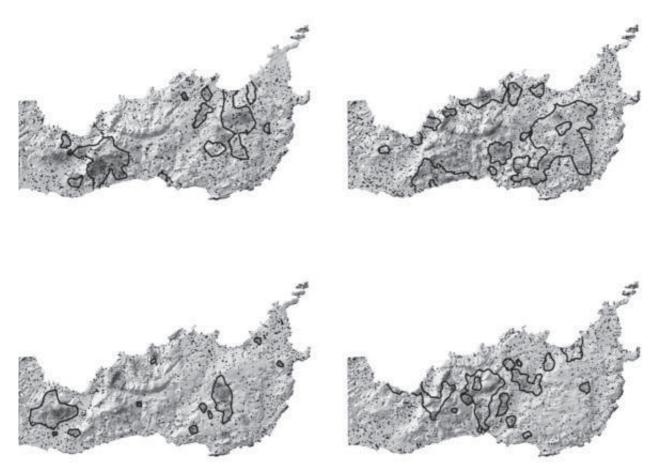
Fig. 6. The maps on the left side represent the first iteration including the input from all surveys, while the ones on the right are the second iteration, excluding the results from the Itanos survey. Areas of dark gray shading indicate high betweenness centrality value – areas that are integral in keeping the whole east Cretan network connected. From the top, the first two maps represent the Prepalatial, followed by the Protopalatial, and the Neopalatial.

slope, elevation, and coastal distance, as well as the clustering/dispersal tendencies between sites themselves, we are then able to project hypothetical site distributions across the remaining, unsurveyed areas of east Crete. These modeled distributions for the Pre-, Proto- and Neopalatial periods are shown in Figures 4a–f.

Several caveats must now be offered. It is clear from Figure 5 that survey areas are heavily biased in favour of lowland agricultural soils (under 200 m and at a slope of less than 20 degrees), to the extent that our knowledge and prediction of settlement patterns in the interior of the island, in the highlands and presumably pastoral areas, is based on somewhat shaky foundations. Another concern that arises from the modeling exercise is that settlement patterns in east Crete are not homogene-

ous – i.e., are not consistent across the region and behave differently at sub-regional and local scales. For instance, the projected number of sites for the Itanos peninsula in the Protopalatial period, based on the input from all the surveys, greatly exceeds (36) the number counted in the survey (1). Is this due to something very different happening here at this time, or rather to a relative lack of visibility of Protopalatial remains in the survey? Furthermore, for the Prepalatial period there are far fewer projected sites for the interior of the region due to the absence of reported sites in the Praisos and Ziros surveys.<sup>52</sup> This non-homogeneity of the east Cretan settlement pattern is further complicated by the fact that certain surveys (especially in the Mirabello

<sup>52</sup> Whitley et al. 1999; Branigan et al. 1998.



**Fig. 7**. The maps on the left side represent the first iteration, while the ones on the right the second. The maps highlight changes in betweenness value from one period to the next (Prepalatial to Protopalatial for the first set and Protopalatial to Neopalatial for the second), where black lines represent losses in connectivity and dark gray gains.

area), by virtue of their larger geographical extents, have a greater influence over the modeling results. The concerns raised here, and addressed in more detail below, question the appropriateness of creating pan-island and even regional narratives based on settlement results observed from single surveys.

From these hypothetical distributions we are then able to build a network of settlement connectivities across east Crete by linking up sites that fall within 5 km of each other – assumed to be one hour's walk. For our purposes we use the less computationally-demanding *as-the-crow-flies* distances, rather than GIS-computed least-cost path walking distances.

Recent work by Paliou and Bevan<sup>53</sup> has shown little modeling difference in using the more realistic GIS-derived walking distances as opposed to Euclidean ones for certain kinds of coarse spatial analysis. While this may be the case for the relatively flat Mesara, whether it holds true for the rugged terrain of east Crete remains to be established by future research.

Once we have our network, we are able to compute some basic network properties such as degree and betweenness centrality.<sup>54</sup> The betweenness value

<sup>53</sup> Paliou & Bevan forthcoming.

<sup>54</sup> E.g., Freeman 1977; Wasserman & Faust 1994.

indicates a node's position as a gateway community linking up different clusters in a network, while the degree value indicates how connected a node is (i.e., to how many other sites it is connected). Given the parameters for defining our network, we focus on betweenness centrality as being more revealing of a node's importance in relation to the entire east Cretan network, as opposed to degree centrality whose value relates to more local factors (i.e., degree of spatial clustering). Having computed the network metrics, we add the corresponding values back to our maps and interpolate betweenness centrality value surfaces in order to identify areas that exhibit changes in connectivity over time.

As can be seen from the two iterations in Figures 6 and 7 – one including and the other excluding the Itanos survey – the results of the betweenness centrality value vary greatly and tell quite different stories. This further emphasizes the earlier point concerning the probable non-homogeneity of settlement patterns across east Crete and the need for further work in effectively integrating and comparing data from different surveys to provide a

platform on which to base pan-island and regional narratives, as opposed to single surveys. In Figure 6, the blue shading represents 'hotspots' of high betweenness centrality - areas that are integral in connecting east Crete, or which benefit from their position in terms of regional connectivity. Figure 7 shows areas that benefit (blue) and lose (red) in connectivity at the transition to Protopalatial from Prepalatial, and Neopalatial from Protopalatial for both iterations. In the first iteration, considering all survey data, the Protopalatial period resembles more the Prepalatial, perhaps with a focus more on the interior of the island, while the Neopalatial period diverges with an emphasis more on the (north) coast. In the second iteration, excluding the Itanos survey and relying mainly on the Mirabello surveys, the Protopalatial period visibly differs from the Prepalatial with a much greater focus on the interior of the island. The Neopalatial does not show much of a difference from the Protopalatial (Fig. 7) and might hint at the same coastal pull in the general Mochlos area as in the first iteration considering all surveys.

## Discussion

The implications of this modeling of site distributions and network properties are very interesting for Petras. If the Protopalatial period represents an inland focus, as might be suggested by the modeling, it could be the case that the establishment of Petras as a palatial centre in MM IIA is best explained by its location in relation to the inland foci of the Protopalatial. One might say that it really looks inwards rather than outwards. This takes on further significance in the Neopalatial period when, as Tsipopoulou argues, the site is perhaps less important than it was in the Protopalatial<sup>55</sup> – ironic if one considers the strong coastal focus of the later period, but not especially surprising if one bears in mind this hypothesised inland focus of the site from an early period. The inland focus of Petras in the Neopalatial is relatively clear, with the villas of Achladia, Zou and Prophetes Elias in its hinterland.<sup>56</sup> However, it is difficult projecting this scenario back into the Protopalatial period, because "we cannot assign to the first palace a hinterland analogous to that of the Neopalatial central building. The evidence pertaining to the Middle Minoan II phase, as far as the area of the Bay of Siteia is concerned, is fragmentary".57 Tsipopoulou does mention some finds hinting at an earlier hinterland,<sup>58</sup> and cautiously suggests that "the earlier palace also had a decentralized hinterland identical or similar to that of the second, smaller palace".59 Our modeling exercise would seem to indicate that the emergence of Petras as a Protopalatial centre would indeed make perfect sense in these terms, given the importance of inland sites in this period.

Returning briefly to the qualitative evidence for interaction discussed in the first part of the paper, we might tentatively link the evidence for integrative, heterarchical structures in the Protopalatial period (e.g., burials, pottery) with the inland focus identified above; and the erosion of these structures with the coastal focus of the Neopalatial period.<sup>60</sup> This finds some agreement with what Haggis argues. The pattern also tallies with what Sylvie Müller-Celka and colleagues have identified in the region of Malia, where site distribution

<sup>55</sup> Tsipopoulou 2002.

<sup>56</sup> Tsipopoulou & Papacostopoulou 1998.

<sup>57</sup> Tsipopoulou 2002, 138-139.

<sup>58 &</sup>quot;The small investigation at Achladia, ten years ago, showed that there was a Protopalatial, probably small, settlement below the Neopalatial one, at Platyskinos, on a site different to that of the villa at Riza" (Tsipopoulou 2002, 138-139.

<sup>59</sup> Tsipopoulou 2002, 138-139.

<sup>60</sup> Whether or not the broader coastal connectivities and disruptions of local heterarchies are already underway in MM IIB is still difficult to tell.

is strongly focused inland during the Protopalatial period, but gives way to a more coastal orientation in the Neopalatial.<sup>61</sup>

Finally, we recognize that the results from our modeling exercise are far from conclusive. The variance in outputs generated when we include or exclude the Itanos survey results acts as a warning against extrapolating region-wide patterns from patchy survey data. Hopefully, though, this exercise can act as a spur towards further regional thinking, and signal the kinds of comparable data we need in the future if we are to make progress in understanding changes in regional settlement dynamics and interactions.

### Greek abstract

### Δίκτυα της Ανατολικής Κρήτης στη Μέση Εποχή του Χαλκού

Τι είδους σχέσεις ανιχνεύονται μεταξύ των διαφόρων οικισμών της Ανατολικής Κρήτης στη Μέση Εποχή του Χαλκού; Υπάρχουν πολύ στενοί δεσμοί συνεργασίας κατά μήκος της Ανατολικής Κρήτης από τα Μάλια και τον Πύργο Μύρτου στα δυτικά μέχρι το Παλαίκαστρο και τη Ζάκρο στα ανατολικά; Ή υπάρχει ανταγωνισμός και σύγκρουση; Σε ποια έκταση αλλάζουν οι σχέσεις από την αρχή ως το τέλος της περιόδου, από την ΜΜ ΙΑ έως την ΜΜ ΙΙΙΒ; Αντιμετωπίζοντας αυτές τις ερωτήσεις η ανακοίνωση βασίζεται κυρίως στα δεδομένα της κεραμικής (παραγωγής, ανταλλαγών και χρήσης), ενώ παράλληλα αναφέρεται στην αρχιτεκτονική και την οργάνωση των οικισμών, επιχειρώντας να εντοπίσει τη θέση του Πετρά σε ευρύτερα τοπικά δίκτυα δι-επαφών.



<sup>61</sup> Müller-Celka et al. 2014.