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Backs to the sea? Least-cost paths and coastality in the Southern Early Bronze Age IIA Aegean

Christopher Nuttall

Abstract

This paper provides an interrogation of the spatial relationship between Early Bronze Age IIA (EB IIA) settlements and the sea in the Southern Aegean using Geographic Information Systems (GIS). Cartographic and intuition-based interpretations of coast accessibility were tested using ArcMap GIS software and the "cost-path" analysis function. A "cost value" was generated based on the positioning of settlements in three-dimensional space, which allowed comparison between the archaeological settlements and their relation to the coast, factoring elevation and travel cost. This analysis was chronologically situated in one of the more enduring interpretative paradigms of Aegean prehistory, the "international spirit" phenomenon, a period of increased maritime interaction. The results show that some settlements that have been classified as "more coastal" were not as close in human terms, owing to local topographical features making the journey to the coast of a higher value, and that there was variety in the range of positions occupied by EB IIA settlements.

Introduction: Seascapes and Coastality

In the past few decades, there has been an increasing interest in human-environment interaction, with seascapes currently one of the dominant interrogative devices for research in maritime culture (Vavouranakis 2011; Berg 2013). Drawing upon theoretical advances in landscape archaeology, the primary concern of the seascape perspective is to redress the perception of the sea as a passive space, advocating the sea as a potentially significant and symbolic space, facilitating specific and variable ways of life (McNiven 2003). Central to this perspective is the concept of space. "Space" is a location that has no social connections or meaning, while "place" is created by human experience, and given meaning by humans, transcending physical properties (Tuan 1977: 4, 6). According to Tuan (1977: 6), the process of giving meaning can be derived from two sources, either an intimate, sense-based embodied experience (physical/spatial) or a conceptual experience associated with symbols and arts (metaphorical/symbolic). Within the context of these arguments, the sea can be both space or place. I argue that

the creation of a seascape is this very process of "place creation". The two concepts have a strong proximal character, with the meaning given to space correlating with the distance from the human to the place (Cloke *et al.* 1991: 79).

A concept that can give us an index of the spatial distance between settlements and the sea is coastality. Coastality asks the question "how coastal is a coastal area?" through observing the spatial relationship between *loci* of human action and the sea. In basic terms, coastality is an expression of proximity to the sea (Plane 2005; Kiousoupoulos 2010: 230). Coastality on the macro-scale can allow us to determine how attractive coastal spaces were in specific periods, through the proximity of settlements to the sea.[1]

The EB IIA in the Southern Aegean and the 'international spirit'

This analysis is chronologically situated in one of the more enduring interpretive paradigms of Aegean prehistory, the *international spirit* phenomenon of EB IIA (c. 2750–2400 BC), a period of increased maritime interaction and shared material culture trends (Renfrew 1972). This increase in maritime connectivity, according to Renfrew (1972: 455), was a result of the pre-eminence of the Cycladic islanders as navigators, while also being driven by exchange in metals and exotic goods.

Within the scope of this paper, a GIS analysis was undertaken to critically assess the degree of coastality of EB IIA settlements in a catchment area encompassing the Southern Aegean and Attica (Figure 1). With maritime interaction a primary driver in EB IIA, one would assume that access to the sea would be of paramount importance in the choice to build settlements in specific locations and this assumption is to be tested. The overriding question driving interrogation is how coastal were EB IIA settlements in the Southern Aegean? (Figure 1).

Sea level change since the Early Bronze Age

One of the most vital elements to determine the proximity of EB IIA settlements to the coast is a general estimation of how the EB IIA coast compared with that of the modern day. It is clear, since the discovery of partially or fully submerged Early Bronze Age sites such as Pavlopetri (Harding *et al.* 1969), Lambogianna (Beck 2016: 18–21) and Salanti Bay (ArchDelt 54: 1028–29), as well as Late Neolithic Saliagos in the Cyclades (Evans and Renfrew 1968), that the sea-level has shifted considerably in the last 5000 years. There are a range of factors that can affect the elevation of the coastline, which include, for example, tectonic movements upwards or downwards, erosion, sedimentation and sea level rise and therefore any reconstruction of paleo-sea levels on a macro-scale are an approximation and not in

[1] There are more microelements of coastality, which can be applied in Environmental Management in modern populations (for example "Coastal feeling" and "Anthropogenic intensity") which are more problematic in the field of archaeology. See Kiousoupoulos 2010 for an in-depth treatment of coastality.

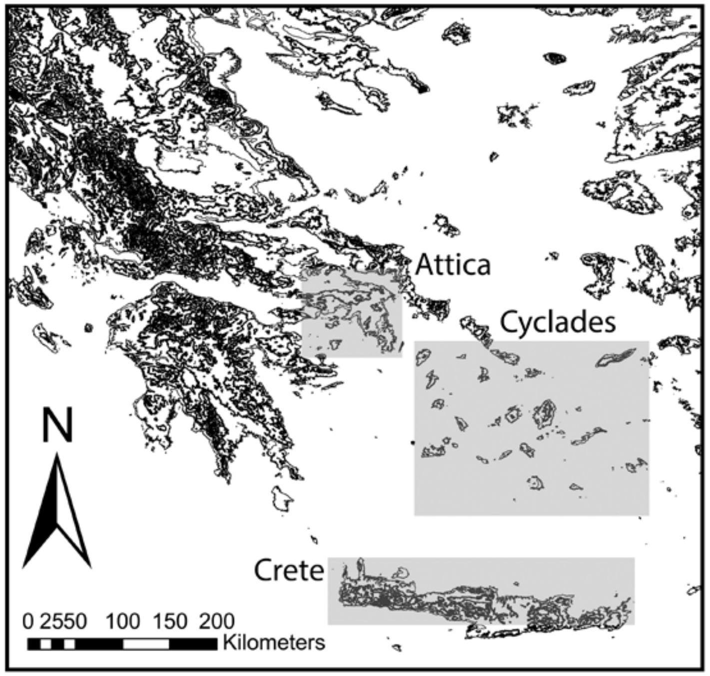

Figure 1. Aegean Sea and coverage area (created by the author with ArcGIS)

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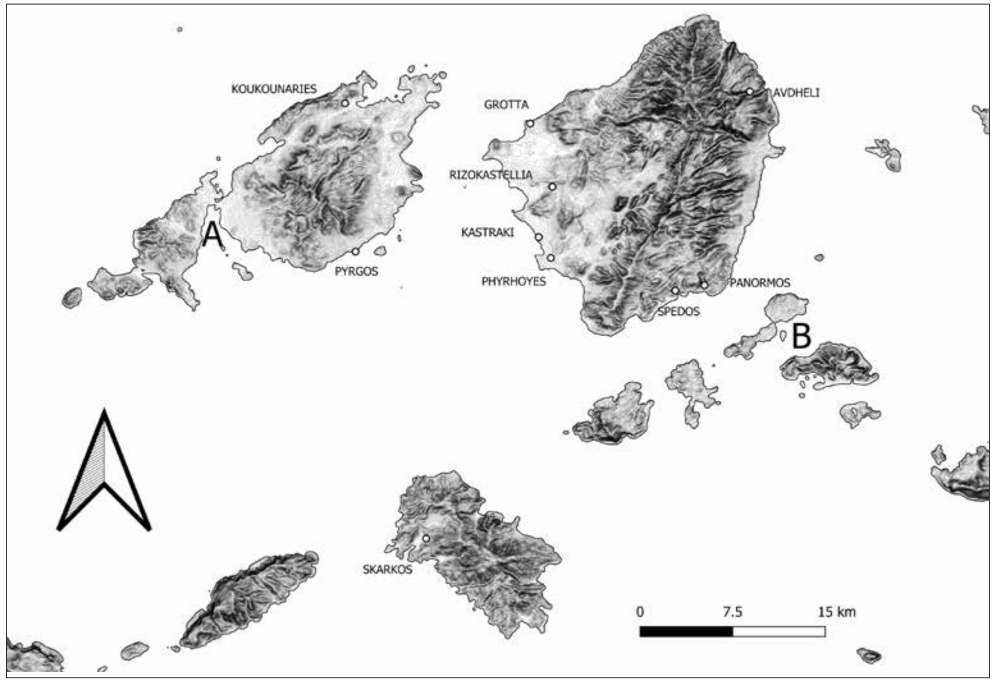
Figure 2. Predicted EB II coastline for central Cyclades (created by the author with ArcGIS)

fact a determinable reality. A figure of -5 m is utilised as an estimation for EB IIA (Lambeck 1996: 599).[2] This is justified by the general consensus that the aseismic and geologically stable Attic-Cycladic massif had a sea-level of approximately between -5.5/-4 m below that at present (Poulos *et al.* 2009: 16; Ghilardi *et al.* 2014: 233) and had to have been lower than the -2.5 m as suggested for Late Classical Delos (Desruelles *et al.* 2007: 231) in c. 400 BC. The fact that Dhaskalio appears to have been joined to the mainland of Keros by a narrow causeway in the Early Bronze Age further supports this figure (Dixon and Kinnaird 2013). For Crete, being a tectonically unstable region, there are regional variations in the reconstructed sea-level accounting for seismic events (Mourtzas *et al.* 2016). This has led to a general division between Western Crete and Central/Eastern Crete meaning a potential difference of between -5 m and -7/-4 m respectively (Mourtzas *et al.* 2016, 65). Taken together, and given the prediction set out by Lambeck (1996: 599), a general figure of -5 m is proposed for the purposes of this model. It must be stressed that this is not an attempt to reconstruct the ancient sea-level in *minutiae*, but to give a figure closer to the Early Bronze Age sea-level than that we have in the present-day sea-level (Figure 2).

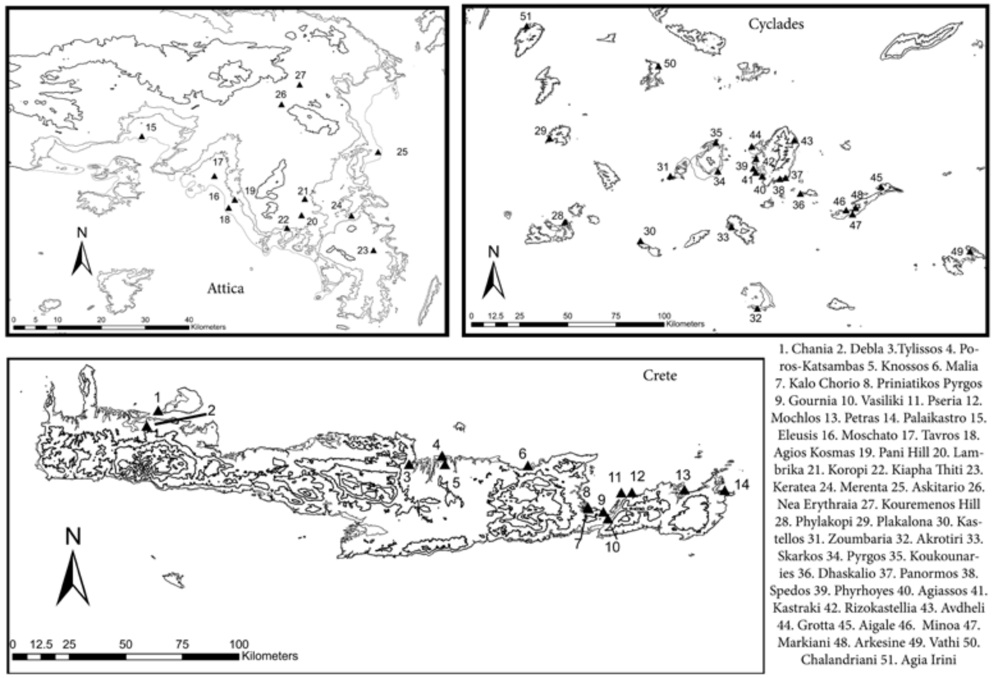
[2] The well-established sedimentation event in the Argolid (Finke 1988), and the difficulties in integrating this regions' sea level fall into an otherwise sea-level rise analysis, mean that this area is excluded.



As this analysis takes into account bathymetric data (the elevation of the ground surface below the present shoreline), this -5 m divergence will see a variable amount of land reclaimed in the model. For example, where the coastal shelf is steep, such as on Crete, relatively little land is added to the present configuration of the island. Elsewhere, where the gradient of the subsurface ground is gentler, comparatively more land is added. In this model a few changes are immediately noticeable. Firstly, is the creation of "Greater Paros", the combination of the present-day islands of Paros, Antiparos and Despotikon (Figure 2: A), as well as the amalgamation of both Epano and Ano Kouphonisi (Figure 2: B). Other than these changes, however, the morphology of the land in the catchment area is not altered drastically (Figure 3).

GIS and Coastality: Method

The investigation of prehistoric maritime people in the Aegean has been guilty of considering the relationship between communities and the sea from a cartographic lens (Broodbank 2000: 23). Settlements that may seem to be close to the coast from a map perspective, may not be as coastal as believed, especially if we consider elevation and the time and difficulties involved in travelling from the site to the ancient coast. Though there have been a range of studies utilising GIS in the prehistoric Aegean (Farinetti 2011; Oikonomou 2012; Déderix 2015) and attempts at sea-level reconstruction using GIS (Zickel *et al.* 2016; Oikono-



1. Chania 2. Debla 3.Tylissos 4. Poros-Katsambas 5. Knossos 6. Malia 7. Kalo Chorio 8. Priniatikos Pyrgos 9. Gournia 10. Vasiliki 11. Pseria 12. Mochlos 13. Petras 14. Palaikastro 15. Eleusis 16. Moschato 17. Tavros 18. Agios Kosmas 19. Pani Hill 20. Lambrika 21. Koropi 22. Kiapha Thiti 23. Keratea 24. Merenta 25. Askitario 26. Nea Erythraia 27. Kouremenos Hill 28. Phylakopi 29. Plakalona 30. Kastellos 31. Zoumbaria 32. Akrotiri 33. Skarkos 34. Pyrgos 35. Koukounaries 36. Dhaskalio 37. Panormos 38. Spedos 39. Phyrhoyes 40. Agiassos 41. Kastraki 42. Rizokastellia 43. Avdheli 44. Grotta 45. Aigale 46. Minoa 47. Markiani 48. Arkesine 49. Vathi 50. Chalandriani 51. Agia Irini

midis *et al.* 2016), GIS analyses have not considered proximity to the coast and in particular the effort of a journey to the coast. This project then interrogates intuition-based interpretations of distance from the coast using GIS analysis.

The method used here is the "cost-path" analysis function of ArcMap, where the geospatial coordinates of selected EB IIA settlements (Figure 3) were plotted in three-dimensional space. Bathymetric digital elevation models (DEM) were added into the ArcMap program, focusing on the region of interest (35N to 37N in the Southern Aegean) and were used to generate a sea-level of -5 m below the present day (From the Emodnet data service: https://www.emodnet-bathymetry.eu). In this analysis, one GPS (Global Positioning Systems) value was taken from the archaeological remains of the settlement (Point A), while a series of values are taken for the entirety of the coastline (Point B).[3] This means that the analysis will locate the "least-cost" route from Point A (the site), to *any* part of Point B (the paleo-coastline). This encompasses the calculation of thousands of alternate permutations from Point A to Point B, of which only the "least-cost" is presented. The "least-cost" route in itself is not central to the data presented in this analysis, rather the "least-cost value" for the route is important. This is presented in the form of a numerical value, which although having no meaning by itself, can be useful for comparison between sites and as an index of coastality.

[3] Generally, a value close to the central part of the settlement is taken.

What is the exact relation between the "cost-path" and the landform? The "cost-path" function of GIS analysis determines a route between two points which would be of least cost, in terms of energy expenditure. The model takes into account elevation to produce values for slopes, which would hinder movement. This would mean, for example, that areas of high slope would be avoided as they would cost more in terms of energy expenditure, while areas of lower slope are preferred as aspects of least-cost paths. It is again to be stressed that this in no way is suggestive of the *exact* route that people in the EB IIA would have taken, as there are a range of cultural and socio-political reasons to avoid specific places and routes, unbeknownst to us, rather this is a reconstruction of the least-cost route that would have been possible.

Effectively, the "least-cost" path analysis determines the most energy efficient route towards a specific point through the landscape, taking into account the shift in sea level since the Early Bronze Age, here taken to be -5 m below the present level. The settlements included in this analysis are based on the reported evidence of EB IIA architectural horizons, from fully published settlements and rescue excavations, of a general range of 15 km from the coast. This 15 km distance was selected to impose an upper limit to the number of settlements contained in the GIS model.

Discussion

The results of the analyses are presented in Table 1, which are sorted in ascending order of their value for the cost value. The cost value refers to the cost of the travel between the settlement and paleo-coastline as generated by the ArcGis analysis. Euclidean distance, the distance between two points as the "crow flies", serves as both a comparison to the cost-value but also as a key element in calculating the discrepancy index. The discrepancy index is calculated by dividing the cost value by the Euclidean distance in metres. This serves to determine how "costly" the least-cost path is, relative to the settlements' distance to the paleo-coastline (Table 1).

There is a wide discrepancy between the least coastal settlements and the more coastal settlements. For example, Agia Irini on Kea (51) is considerably more coastal than its Cycladic island contemporary, Markiani on Amorgos (47). Despite the sea being only 540 m away from the settlement at Markiani, its high elevation and steep descent down to the rocky coast below, means that it has a higher cost path value to the coast than Knossos on Crete (5), where the sea is around 5 km distant, though on a much lower elevation and easier path. This goes to show that our assumptions on whether a site can be deemed to be coastal and just what being "coastal" actually means, must be called into question and interrogated.

At the higher end of non-coastal values, Debla (2) on Crete and Kouremenos Hill (27) in Attica stand out as being particularly estranged from the coast. For these sites, it can be posited that the sea played little to no role in the daily con-

No.	Site Name	Region	Cost value	Euclidean distance (m)	Discrepancy index	Reference
51	Agia Irini	Cyclades	366	45	8.13	Caskey 1962, 263-283
8	Priniatikos	Crete	414	50	8.28	Molloy *et al* 2014, 307-358
28	Phylakopi	Cyclades	440	40	11	Atkinson *et al* 1904
18	Agios Kosmas	Attica	521	40	13.03	Mylonas 1959
41	Kastraki	Cyclades	675	30	22.5	Stephanos *1904, 60*
12	Mochlos	Crete	1035	40	25.88	Seager 1909, 273-303
34	Pyrgos	Cyclades	1042	40	26.05	Tsountas 1898, 170, 174.
11	Pseria	Crete	1155	40	28.88	Betancourt and Davaras 1988
44	Grotta	Cyclades	1442	50	28.84	Hadjianastasiou 1998, 11-20
6	Mallia	Crete	1546	540	2.86	Demargne and Gallet de Santerre 1953
13	Petras	Crete	1723	290	5.94	Bosanquet 1901/2a, 282-5
15	Eleusis	Attica	1914	390	4.91	Mylonas 1933
14	Palaikastro	Crete	1919	290	6.62	Bosanquet 1901/2b, 286-316
7	Kalo Chorio	Crete	2089	540	3.87	Haggis 1996, 645-681
39	Phyrhoyes	Cyclades	2121	440	4.82	*ArchDelt 17, 138*
16	Moscato	Attica	2390	2240	1.07	*ArchDelt 65, 316-317*
25	Askitario	Attica	2709	50	54.18	Theocharis 1955, 109-16
9	Gournia	Crete	3273	580	5.64	Boyd Hawes *et al* 1908
32	Akrotiri	Cyclades	3930	230	17.09	Doumas 1978
35	Koukounaries	Cyclades	4271	190	22.48	Schilardi 1974, 181-88
17	Tavros	Attica	4709	3860	1.22	*ArchDelt 66,136–42*
38	Spedos	Cyclades	5025	160	31.41	*ArchDelt 17, 114*
33	Skarkos	Cyclades	5165	1110	4.65	Marthari 1997, 362–82
4	Poros-Katsambas	Crete	5468	1120	4.88	Alexiou 1953, 299-308
37	Panormos	Cyclades	8859	340	26.06	Doumas 1972, 156, 164-5;
29	Plakalona	Cyclades	10634	180	59.07	Philaniotou *et al* 2011, 157-164
10	Vasiliki	Crete	12299	3060	4.02	Seager 1905, 207-21
42	Rizokastellia	Cyclades	12719	1830	6.95	Doumas 1972, 166
24	Merenda	Attica	13771	3690	3.73	Kakavogianni *et al* 2009, 159–76
22	Kiapha Thiti	Attica	16566	3890	4.26	*ArchDelt 37, 60*
5	Knossos	Crete	17975	5170	3.48	Evans 1900, 3-70
21	Koropi	Attica	21184	11650	1.82	*ArchDelt 42, 97*
46	Minoa	Cyclades	22035	660	33.39	Marangou 1981, 303-320
20	Lambrika	Attica	23373	11230	2.08	Kakavogianni *et al* 2008, 45–57
50	Chalandriani	Cyclades	24275	960	25.29	Tsountas 1898-9: 115–21
23	Keratea	Attica	26138	3420	7.64	*ArchDelt 62, 211*
47	Markiani	Cyclades	28408	540	52.61	Marangou *et al* 2006
3	Tylissos	Crete	29512	5680	5.2	Hatzidakis 1934
43	Avdheli	Cyclades	29852	930	32.01	Doumas 1977, 122
26	Nea Erythraia	Attica	37260	13750	2.71	*ArchDelt 65, 142-148, 206*
27	Kouremenos Hill	Attica	54678	11420	4.79	*ArchDelt 65, 156-7*
2	Debla	Crete	55794	6800	8.21	Tzedhakis & Warren 1972, 66-72

Table 1. Results of the Cost-path analysis

duct of the lives of its inhabitants. A worthy discussion point centres around the cemetery (and presumed settlement) at Chalandriani on Syros (50). The figure calculated gives the settlement a high cost value, given the difficulty in traversing downwards and back upwards from the coast. Yet despite this, several tombs at Chalandriani provide evidence for ceramic "frying pans" depicting boats and the sea, suggesting that the sea did have some form of significance to society at the site (Broodbank 2000: 253). Referring back to the scheme of "giving meaning" to space presented earlier, it could be argued that rather than the society at Chalandriani giving meaning in an embodied, sense based manner (for example direct coastal living), the community had more of a conceptual, iconographic derived meaning for the sea (Figure 4), rather than a high degree of coastality in physical terms.

Are there regional patterns in the data? For the Cyclades, given the stated important role it is assumed the islanders played as "middlemen" in inter-regional contact (Renfrew 1972), the majority of Cycladic settlements have reasonably large cost values for their routes to the coast and in particular the discrepancy in-

Figure 4. 'Frying pan' from EB II Chalandriani (50) cemetery on Syros depicting boat, fish and spiral waves (Wikimedia Commons)

dex between the cost value and the Euclidean distance. This indicates that although some settlements were close to the coast in Euclidean terms, there was a choice to occupy a more defensive location, such as Markiani (47) and Minoa (46) on Amorgos, Koukounaries (35) on Paros, Spedos (38) and Panormos (37) on Naxos and Plakalona (29) on Siphnos. This can be explained in two ways which may not be mutually exclusive. One reason may be to work with metals, in order to take advantage of the wind draft and another may be as a result of the darker side of maritime interaction (raiding and violence) which may have prompted communities to situate themselves a little further from the coast for safety, a pattern which reaches a further elaboration in the EB IIB, when several sites are fortified (Angelopoulou 2017). Despite this, there are several Cycladic sites immediately beside the coast, such as Agia Irini (51) and Phylakopi (28) on Melos, suggesting that the negotiation of coastality was variable, or that these sites occupied areas favourable to longboat activity and could thus deploy enough defences against sea-borne attack (Broodbank 2000: 256-257) (Figure 4).

Parts of Attica appear to have been linked to the Cycladic world during the EBA (Nazou 2010) and generally, the pattern observed in the Cyclades carries over into Attica. Agios Kosmas (18) could be an Attican equivalent of Agia Irini (51) and Phylakopi (28), though elsewhere the pattern is remarkably non-coastal. While Askitario (25) occupies a coastal location in Euclidean terms, its position elevated on a headland affords it some degree of protection from the coast (Figure 5). As a point of comparison Moscato (16) has a cost value at *2390* with a distance 2.24 km from the coast, while Askitario has a cost value only slightly larger at *2709*, despite being only 0.05 km from the coast. For the rest of Attica there is a general preference for lower degrees of coastality, for example at settlements such as Koropi (21), Keratea (23), Kouremenos Hill (27) and Nea Erythraia (26) (Figure 5).

On Crete there is much more of an even distribution in the spatial relationship between sites and the coast in EB IIA. There are several settlements where we can determine a higher degree of coastality, such as Priniatikos Pyrgos (8), Mochlos (12) and Malia (6), though there are others with a significantly less coastality, such as Tyliossos (3), Knossos (5) and Vasiliki (10).

Figure 5. Askitario (25) Attica, from the settlement looking east to the sea (by the author)

Conclusion

This analysis has shown that even in a period of increased maritime contact, there is a choice to live in a coastal location or not and that the conceptual realities of "international spirit" were not all-entangling (from a spatial perspective) communities that had to live directly beside the coast in order to participate in the network. As shown from Chalandriani and likely other sites in this assemblage, the degree of coastality of a community can be overcome through directed and sustained contacts with the sea and the spatial relationship between a community and the sea is just one element of a complex relationship. The coastality of a settlement, however, is a good starting point to try to determine the relationship between habitational spaces and the sea in the past and, as a concept, can be expanded and has significant potential for the understanding of human-environment interactions in the past.

This pilot study has some implications as a tentative first step away from a cartographic-based analysis. The concept of coastality is useful and can be taken further in the future to determine how coastal habitation was in specific periods in Aegean prehistory. One potentially fruitful suggestion is to incorporate survey data in order to get long-term diachronic comparisons for coastality in geographically defined regions.

This analysis focused only on one c. 300-year time-slice, comparisons with the periods before (EB I) and after (EB III–MB) are desired to generate a longer term understanding of whether the pattern observed in EB IIA is enduring, or fluctuates over time. The analysis provides the basis for an expansion encompassing the entire Aegean region. This expansion will also allow for a longer chronological time-span to the analysis, determining when settlements were close to the coast and when they were not, in terms of the least-cost value of the journey from the site to the coast. Going forward, the aim will be to determine a method to calculate the values in terms of human time, such as minutes/hours. This information can then be used to categorise settlement coastality, allowing for the incorporation of a more humanistic understanding of movement within a landscape, placing the central emphasis on the main agent of movement, the human body.

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