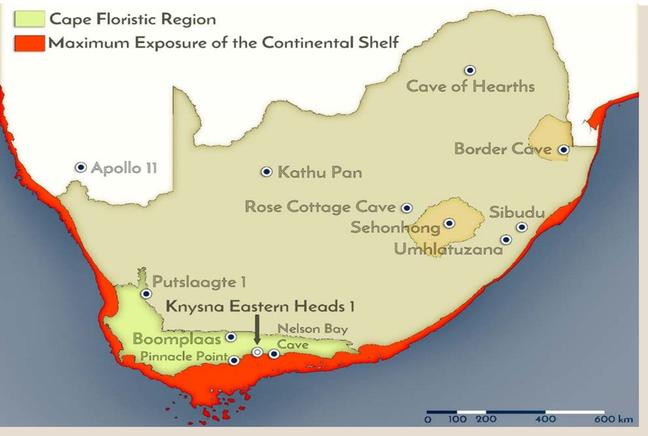
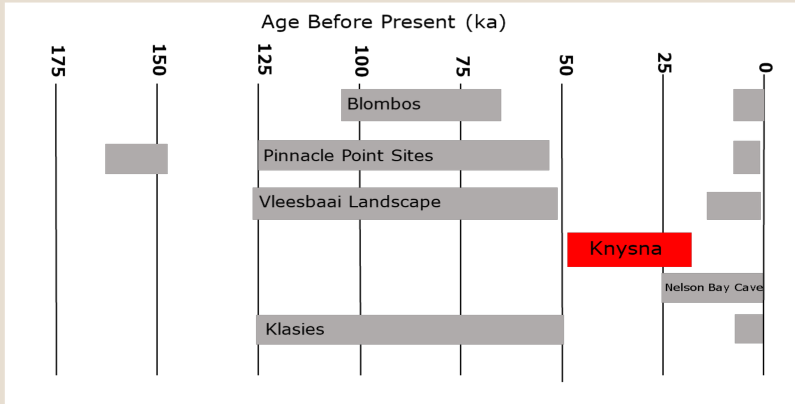


Assessing the development of societal complexity at the Middle to Later Stone Age transition in the context of the Economic Defensibility Model: Evidence from Knysna, coastal South Africa



Naomi E. Cleghorn[1], Hannah M. Keller[2], James R. McGrath[3], Christopher M. Shelton[4], Sara Watson[5], Benjamin J. Schoville[6], Daniel Peart[7], Nathan Bickerton[6], Irene Esteban[8]

1- Dept. of Sociology and Anthropology, University of Texas at Arlington, USA; 2 – Dept. of Anthropology, University of Colorado Denver, USA; 3 – Dept. of Anthropology, University of Iowa, USA; 4 – SWCA Environmental Consultants, USA; 5 – Dept. of Anthropology, University of California Davis, USA; 6 – Dept. of Anthropology, University of Queensland, Australia; 7 – Dept. of Anthropology, Ohio State University, USA; 8 – Evolutionary Studies Institute, University of the Witwatersrand, South Africa

ONE SITE, MANY LANDSCAPES – KNYSNA EASTERN HEADS CAVE 1 (KEH-1): The earliest coastal foraging groups documented along the southern coast of South Africa were early modern humans of the Middle Stone Age (MSA) that used coastal sites intensively (reflecting the dense, rich, and predictable nature of marine resources), but left more ephemeral and short-term occupation evidence when foraging in an inland biome[1–4]. Here we ask whether this pattern continues across the MSA to Later Stone Age (LSA) transition near the end of the Pleistocene or if there is evidence for a new pattern of landscape use, coinciding with this dramatic shift in forager lifeways.

As the only securely dated Late (post-50 ka) Marine Isotope Stage (MIS) 3 occupation on the southern coast of South Africa, Knysna Eastern Heads Cave 1 (KEH-1) provides a rare opportunity to examine the origins of the complex social systems of the LSA right at the MSA to LSA transition. This coastal cave sequence documents a significant occupation across a dramatically shifting landscape. During low sea stands, a broad coastal plain, likely supporting a large terrestrial faunal biomass[5], opened up before the cave. Our sequence also strongly suggests the presence of a short (possibly < 5k years), marine transgression, bringing the coast to within 10 km of the cave, coinciding with the appearance of coastal foragers at KEH-1. The shifting coastline would have directly impacted forager territory location and size. Here we present multiple proxies for changing site use from >46 k to ~18 k ya.

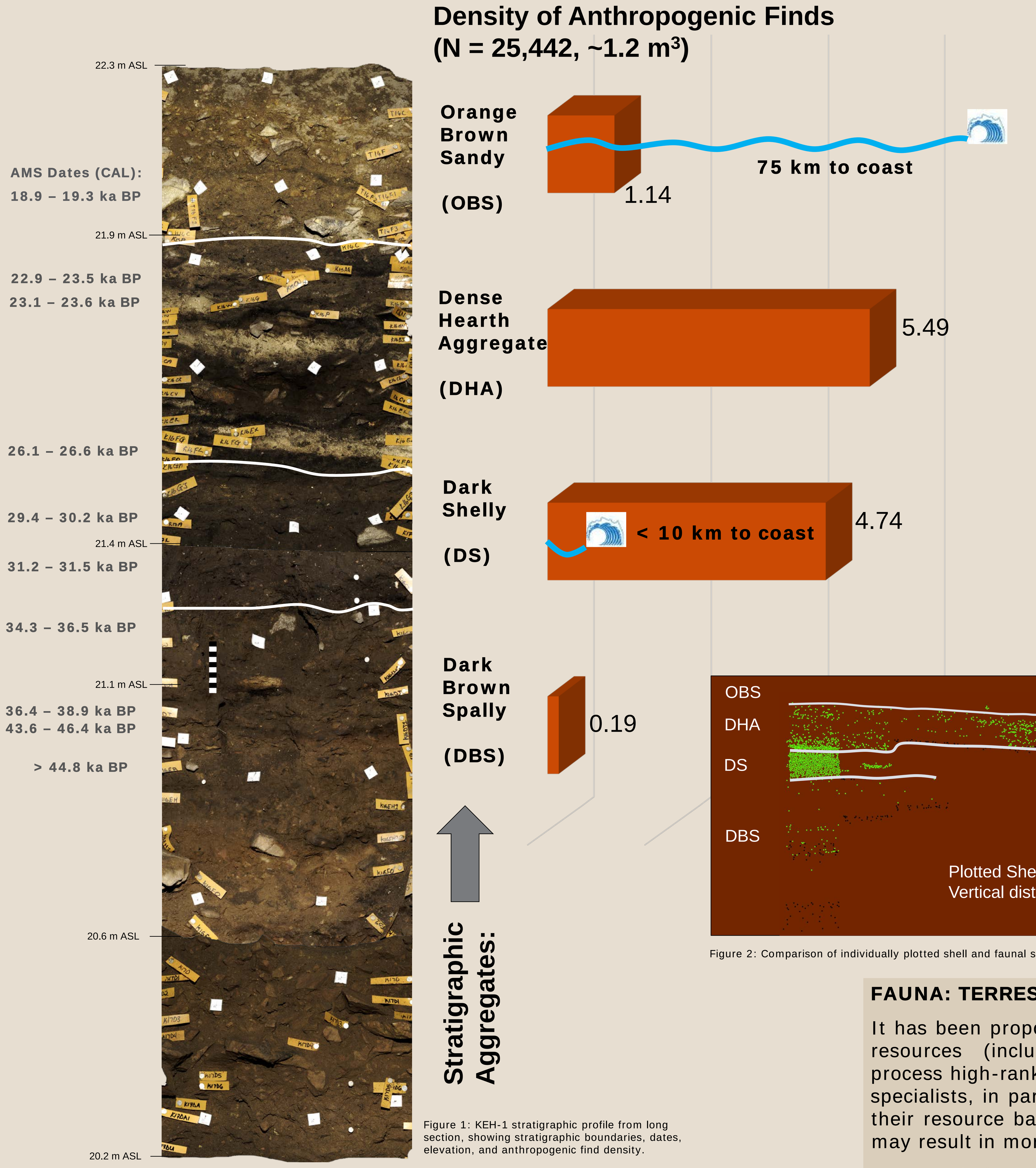


Figure 1: KEH-1 stratigraphic profile from long section, showing stratigraphic boundaries, dates, elevation, and anthropogenic find density.

ANTHROPOGENIC FINDS AND FEATURES:

The relative density of anthropogenic finds and features within different levels of the same site is a proxy for the intensity of human activity at a site. This "intensity" may correspond to the number of people using the site, the frequency with which they revisited it, the duration of occupation, or some combination of these. In all cases, though, intensive site use suggests the location is of some strategic significance to foragers.

At KEH-1 we have identified four major stratigraphic aggregates (Fig. 1, *sensu* Karkanas et al.[4]) dated by AMS on charcoal and shell. From the base of the excavation, these are the Dark Brown Spally (DBS) dating from > 46 ka to ~34 ka, the Dark Shelly (DS) dating from ~32 ka to ~29 ka, the Dense Hearth Aggregate (DHA) dating from ~26 ka to ~22 ka, and the Orange-Brown Sandy (OBS) dating to ~19 ka. Several of these dates are taken from within units, thus gaps between units do not necessarily indicate hiatuses.

More than 25k finds plotted by total station during excavation have been identified to type (i.e., ~ 69% of all plotted finds excavated). The frequency of each find type within the four major stratigraphic aggregates is given in Table 1. Charcoal plot frequency, provided on the table, is not included within the anthropogenic finds total, although it may also be indicative of intensity of site use. The Dark Shelly aggregate (~32 ka to ~29 ka), defined based on preliminary micromorpology[6], as a clayey, black sediment, largely comprised of microcharcoal from hearths based on preliminary micromorpology[6]. These microcharcoal fragments are too small to see or plot.

There is a clear trend from very low density of finds in the Dark Brown Spally (> 46 ka to ~34 ka), a jump in density in the Dark Shelly (by 32 ka), and peak density in the Dense Hearth Aggregate (~26 ka to ~22 ka) (Tables 2 and 3). The initial increase in density in the Dark Shelly is largely driven by an influx of shell fragments (Fig.2). Preliminary analysis of these by A. Jerardino demonstrates they are marine, and largely rocky intertidal in origin. Shell taphonomy and species suggests the coast was probably within 5 km of the site (Jerardino, pers. comm.), and certainly within a daily foraging radius of 10km. By contrast, terrestrial fauna and lithics drive the great increase in find density in the Dense Hearth Aggregate (Fig 2, Tables 1 -3). Terrestrial fauna and lithics are also significant components in the Orange-Brown Sandy (~19 ka), although overall find density falls precipitously. A small carnivore microfauna midden (identified by T. Matthews) in the Orange-Brown Sandy also attests to the lower intensity of site use during this period.

In addition to the density of individual finds, features such as hearths are a proxy for intensity of site use. To date, about 50 individual hearth features have been identified within the 0.46 m³ of the excavated Dense Hearth Aggregate level (Fig. 3). These hearths are densely stacked and occur horizontally across the full 3.5 m extent of the excavation. Most of the hearths are very well preserved, with distinct ash, carbonized, and sometimes rubified components, and many preserve a clear circular bowl shape. They vary from ~0.3 to 1 m in diameter. There are no identifiable hearths known from the Dark Shelly, although the matrix suggests they were present (X. Villagran, pers. comm.). There is one hearth currently known in the lowest unit – the Dark Brown Spally (visible in the section shown in Fig. 1).

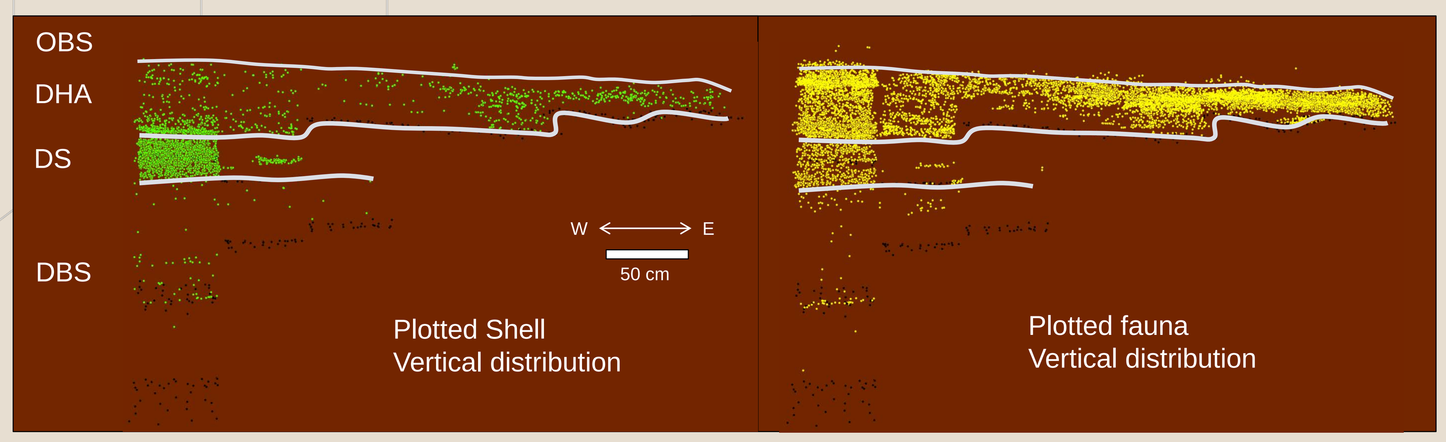


Figure 2: Comparison of individually plotted shell and faunal specimens relative to stratigraphic boundaries.

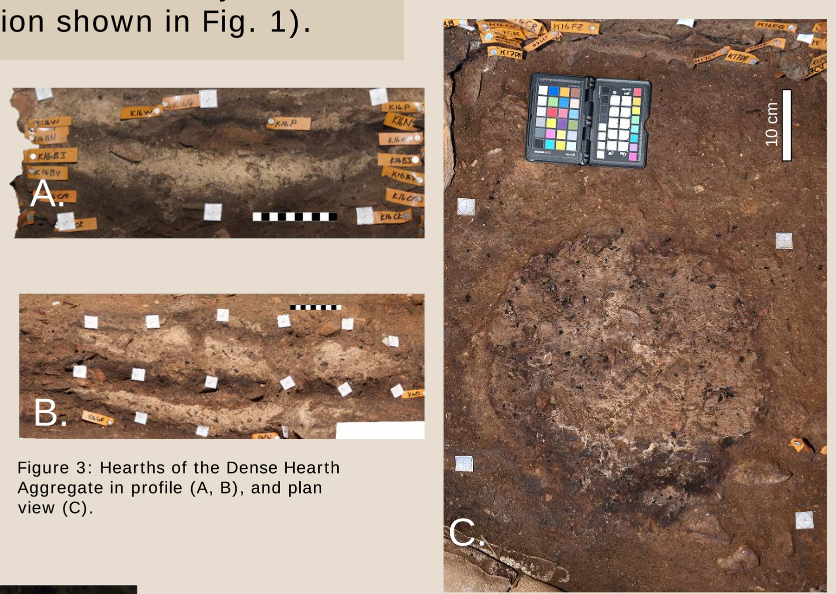


Figure 3: Hearths of the Dense Hearth Aggregate in profile (A, B), and plan view (C).

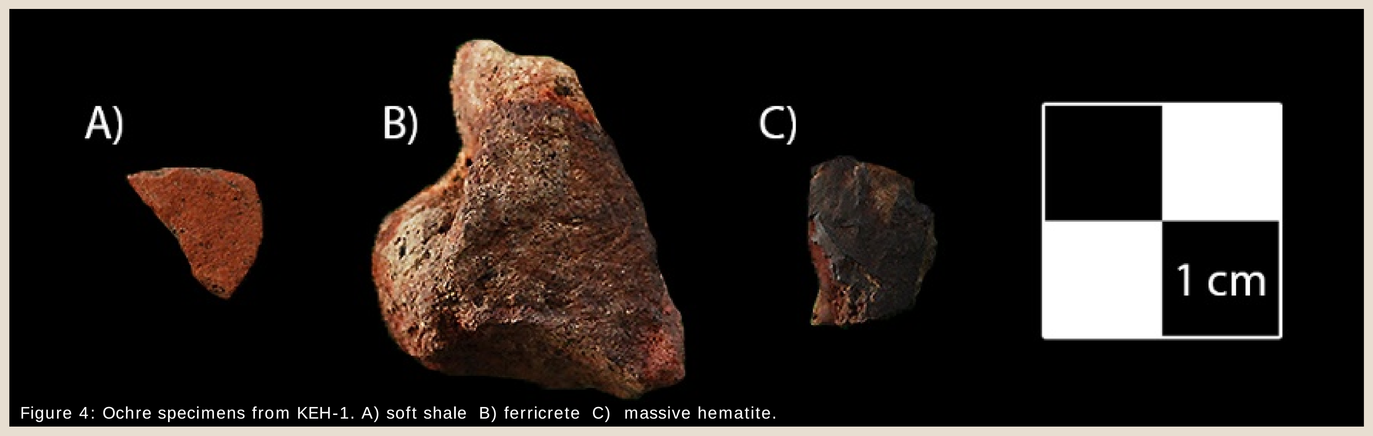


Figure 4: Ochre specimens from KEH-1. A) soft shale B) ferricrete C) massive hematite.

OCHRE

Ethnographic and experimental evidence demonstrates the importance of mineral pigments in visual social signals and as functionally important components of technologies such as adhesives and sunblock[7–10]. Here we use the term "ochre" to refer to any iron oxide-rich rocks or earth that produces a pigmented powder when applied to a streak plate. One of us (J.M.) analyzed 76 ochre nodules from KEH-1. By weight, 69% of specimens were soft, iron-rich shale, 23% were ferricretes, and 6% were massive hematite – all three geological types are common in south coast archaeological assemblages (Fig. 4). A survey (by J.M, C.S., and S.W.) of up to 47 km from KEH-1 identified multiple primary and secondary ochre deposits of the types of materials present in the archaeological assemblage. Further geochemical testing is needed to confirm these as the specific source locations, however, it is reasonable to assume that the occupants of KEH-1 accessed local deposits for these materials, the closest of which are 11 km away or less. Tables 1 through 3 show that there is a slight decrease in the absolute quantity of ochre from the Dark Brown Spally (>46 ka to ~34 ka) to the Dark Shelly (~32 ka to 29 ka), although it is more densely represented by volume in the latter. Thus, there may be a slight increase in ochre use from the Dark Brown Spally to the Dark Shelly. However, there is a dramatic increase in ochre density in the overlying Dense Hearth Aggregate (an example of yellow ochre from this aggregate shown in Fig. 5). In the Orange-Brown Sandy (~19 ka), representation falls back to a level comparable with the Dark Shelly.


Figure 5: Yellow ochre mass on an ashy hearth component in the Dense Hearth Aggregate (~23 ka).

FAUNA: TERRESTRIAL PREY PROCESSING

It has been proposed that foragers focused on low ranked resources (including shellfish) may more intensively process high-ranked terrestrial fauna[5]. For coastal foraging specialists, in particular, the relatively sedentary nature of their resource base constrains total foraging territory, and may result in more local depletion of terrestrial fauna.

Terrestrial fauna specimens are abundant, but highly fragmented throughout the KEH-1 sequence. Foragers targeted fauna ranging in size from small mammals including dassie (*Procavia capensis*), small and medium bovids, to large herbivores, including zebra and possibly giant buffalo (*Pelorovis*). A preliminary taphonomic analysis by H.K. and N.C. of more than 1400 specimens found that average fragment length in all stratigraphic aggregates is less than 2 cm. Burning and post-depositional (dry) fracture are relatively common throughout the sequence, and possibly related to each other. Although there is little difference in faunal processing from the ephemeral and presumably more mobile foragers of the Dark Brown Spally (>46 ka to ~34 ka) to the possibly more sedentary coastal foragers of the Dark Shelly (~32 ka to ~29 ka), the faunal specimens of the overlying Dense Hearth Aggregate (~26 ka to ~22 ka) and later OBS (~19 ka) are notably smaller and less identifiable to skeletal element.

In the pilot sample, there is no apparent positive relationship between intense faunal processing and coastal resource exploitation. Intense faunal processing and density-mediated destruction increase together with other proxies for increasingly intense of occupation. This could be the result of local depletion of the cave environs associated with either an increased group size or longer duration occupations.

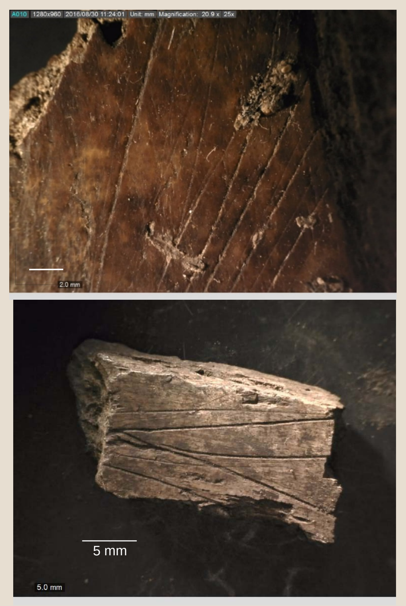


Figure 6: Cut marks on large mammal fragments.

PLANT PHYTOLITHS: RESOURCES & PALAEOENVIRONMENT

Well-preserved botanical remains at KEH-1 will provide a more complete picture of both the resources used by foragers and the local palaeoenvironment. One of us (I.E.), currently studying phytolith samples from the full archaeological sequence, provides a preliminary analysis of the Dark Shelly aggregate – the critical period when coastal foragers first appear. In this dark black level, there are very high phytolith concentrations and a high quantity of organic matter. A mix of C_3 and C_4 grasses are represented, but with a predominance of C_4 water-loving species. Sedges (*Cyperaceae*) and the phytoliths of leaves from trees and shrubs were also identified in high numbers – unusual in an archaeological site. Phytoliths from restios (*Restionaceae*), which are the defining feature of the Fynbos biome, were absent, with one single possible exception. From a palaeoenvironmental perspective, this phytolith assemblage is indicative of a landscape similar to the one occurs today in Knysna, where some sort of wetland vegetation might had occurred, together with a good source of trees and/or shrubs.

KEH-1 AND THE ECONOMIC DEFENSIBILITY MODEL

The Economic Defensibility model[11] posits increases in social and technological complexity in populations with access to rich, dense, and predictable resources. The model is therefore relevant to the appearance and evolution of complex forager strategies during the Late Pleistocene, and ultimately to the diversification of human adaptations, the biogeographic expansion of the global population, and the increased ratcheting of cultural technology that now define the human population. Archaeological evidence provides a means to assess the degree to which models such as Economic Defensibility and others successfully explain the development of complexity within forager society. On the southern coast of South Africa, shifts in coastal position of 75 km or more would have impacted foraging territory location, potentially bringing groups into conflict. The juxtaposition of groups committed to different foraging strategies is a source of potential tension and social complexity (in terms of exchange of people and information). Thus, shifting coastlines would have shaped the evolution of the larger social landscape, possibly stimulating the growth of territory management and defense within early modern humans.

At KEH-1, we note a large increase in anthropogenic materials coincident with the appearance of coastal foraging in the Dark Shelly aggregate (~32 ka to 29 ka).This is consistent with the pattern observed in earlier MSA sites on this coast. In the later Dense Hearth Aggregate (~26 ka to 22 ka), the decrease in the absolute and relative frequency of shell, together with a significant rise in the density of terrestrial mammal remains is the expected pattern for a receding coastline. However, at KEH-1 this also coincides with a dramatic increase in every measure of site use intensity. In this case, the dense, predictable resource (shellfish) is apparently decreasing in importance as site use is ramping up. This is a departure from the MSA pattern, and may thus be an important development of the early LSA.

So why do people come to this particular site more often (and / or in larger groups / for a longer duration)? One possibility is that the compression of foraging area associated with coastal transgression of the Dark Shelly stimulated a new approach to territoriality. That is, the site itself may have become a culturally important location during the Dark Shelly, and then later maintained this status within the territory of coastal foraging groups – possibly as these groups increased in size. We could test this first by examining mobility across this landscape, and by developing a better understanding of the relationship between the Dark Shelly and Dense Hearth Aggregate populations. Finally, we need to compare the assemblages from these layers with local inland sites like Boomplaas, that chronologically overlap with KEH-1.

Table 1: Plotted Finds and Sediment Volume

Stratigraphic Aggregate	Sediment volume cubic cm	Fauna	Lithic	Ostrich eggshell (OES))	Ochre	Shell	Water worn stone (WWS)	Total Anthropogenic Finds	Charcoal
OBS (~19 ka)	194655.8	900	1161	71	28	56	3	2219	551
OBS/DHA	1489.516	70	28	0	1	4	0	103	27
DHA (~26 - ~22 ka)	328172.5	9299	7167	292	301	935	32	18026	1912
DHA/DS	29913.92	288	80	1	1	260	1	631	121
DS (~32 to 29 ka)	72559.45	688	730	0	12	1909	102	3441	60
DBS (>46 to ~34 ka)	535514.5	101	739	0	41	69	72	1022	1664
Total	1162306	11346	9905	364	384	3233	210	25442	4335

Table 2: Frequency of Finds and volume of Excavation by Stratigraphic Aggregate

Stratigraphic Aggregate	Sediment volume	Fauna	Lithic	OES	Ochre	Shell	WWS	Total Anthropogenic Finds	Charcoal
OBS (~19 ka)	16.7%	7.9%	11.7%	19.5%	7.3%	1.7%	1.4%	8.7%	12.7%
OBS/DHA	0.1%	0.6%	0.3%	0.0%	0.3%	0.1%	0.0%	0.4%	0.6%
DHA (~26 - ~22 ka)	28.2%	82.0%	72.4%	80.2%	78.4%	28.9%	15.2%	70.9%	44.1%
DHA/DS	2.6%	2.5%	0.8%	0.3%	0.3%	8.0%	0.5%	2.5%	2.8%
DS (~32 to 29 ka)	6.2%	6.1%	7.4%	0.0%	3.1%	59.0%	48.6%	13.5%	1.4%
DBS (>46 to ~34 ka)	46.1%	0.9%	7.5%	0.0%	10.7%	2.1%	34.3%	4.0%	38.4%
Total	1	1	1	1	1	1	1	5	1

Table 3: Density of Finds by Volume -- 100 * (n of find / sediment volume)

Stratigraphic Aggregate	Fauna	Lithic	OES	Ochre	Shell	WWS	Total Anthropogenic Finds	Charcoal
OBS (~19 ka)	0.462	0.596	0.036	0.014	0.029	0.002	1.140	0.283
OBS/DHA	4.700	1.880	0.000	0.067	0.269	0.000	6.915	1.813
DHA (~26 - ~22 ka)	2.834	2.184	0.089	0.092	0.285	0.010	5.493	0.583
DHA/DS	0.963	0.267	0.003	0.003	0.869	0.003	2.109	0.404
DS (~32 to 29 ka)	0.948	1.006	0.000	0.017	2.631	0.141	4.742	0.083
DBS (>46 to ~34 ka)	0.019	0.138	0.000	0.008	0.013	0.013	0.191	0.311
Total	9.925	6.072	0.129	0.201	4.095	0.169	20.590	3.476

Acknowledgments: This work was made possible through the generous support of the L.S.B. Leakey Foundation, the National Science Foundation (grant number 1523986), the John Templeton Foundation, the University of Texas at Arlington, and the Albrecht Family. We also thank Heritage Western Cape, the South African Heritage Resources Agency; Dr. Thalassa Matthews, Dr. Curtis Marean, Dr. Claudine G. Miguel, Dr. Erich Fisher, MAPCRM, the SAC P4 project, the Woodbourne Trust, the Knysna Municipality, the Richardson Family, and Mrs. Barbara Clark.

REFERENCES
1.Deacon, H. J. & Wurz, S. A Late Pleistocene archive of life at the coast, Klasies River. in *African Archaeology* 130–149 (Blackwell Publishing, 2005).
2.Jerardino, A. & Marean, C. W. Shellfish gathering, marine paleoecology and modern human behavior: perspectives from cave PP13B, Pinnacle Point, South Africa. *J. Hum. Evol.* **59,** 412–424 (2010).
3.Langejans, G. H., van Niekerk, K. L., Dusseldorp, G. L. & Thackeray, Jf. Middle Stone Age shellfish exploitation: Potential indications for mass collecting and resource intensification at Blombos Cave and Klasies River, South Africa. *Quat. Int.* **270,** 80–94 (2012).
4.Karkanas, P., Brown, K. S., Fisher, E. C., Jacobs, Z. & Marean, C. W. Interpreting human behavior from depositional rates and combustion features through the study of sedimentary microfacies at site Pinnacle Point 5-6, South Africa. *J. Hum. Evol.* **85,** 1–21 (2015).
5.Marean, C. W. *et al.* Stone age people in a changing South African greater Cape Floristic Region. *Fynbos Ecol. Evol. Conserv. Megadiverse Reg. Oxf. Univ. Press Oxf.* 164–199 (2014).
6.Cleghorn, N. E., Villagran, X. S., Schoville, B. J., Peart, D. & Keller, H. M. Hearth Features at Knysna Eastern Heads Cave 1, Southern Coast of South Africa. in (2017).
7.Rifkin, R. F. Processing ochre in the Middle Stone Age: Testing the inference of prehistoric behaviours from actualistically derived experimental data. *J. Anthropol. Archaeol.* **31,** 174–195 (2012).
8.Wadley, L. Putting ochre to the test: replication studies of adhesives that may have been used for hafting tools in the Middle Stone Age. *J. Hum. Evol.* **49,** 587–601 (2005).
9.Lombard, M. The gripping nature of ochre: The association of ochre with Howiesons Poort adhesives and Later Stone Age mastics from South Africa. *J. Hum. Evol.* **53,** 406–419 (2007).
10.Watts, I. Pigments. in *Encyclopedia of Geoarchaeology* (ed. Gilbert, A. S.) (Springer, 2017).
11.Marean, C. W. The transition to foraging for dense and predictable resources and its impact on the evolution of modern humans. *Phil Trans R Soc B* **371,** 20150239 (2016).