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A targeted drilling and dating campaign to identify Stone Age archaeological sites before excavation in west coast southern Africa

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ABSTRACT

Here we present the results of a targeted drilling campaign that facilitated a geochronological study with coarse sampling resolution inside a new cave site, Simons Cave, on the west coast of southern Africa. A combination of radiocarbon (^{14}C) dating and optically stimulated luminescence (OSL) dating was used as a range-finder. Results confirmed preservation of Holocene and late Pleistocene sediments up to 133 ± 35 ka, overlapping with the ages of Middle Stone Age (MSA) occupations of the broader west coast region. A subsequent, systematic test-excavation at the site then embarked on a second geochronological study with a higher sampling resolution. Ultimately, the comparative study confirmed the potential of Simons Cave as a new site for the exploration of hominin occupation through the later Pleistocene and Holocene, yet raised several issues concerning the direct comparability of information deriving from drilled sediment cores and actual archaeological excavation.

1. Introduction

Archaeological excavations are generally risky, requiring extensive planning and expense with respect to time, finances and expertise, while there is little to no guarantee that a significant scientific discovery will be made. Excavations are also invariably destructive in that their invasive impacts on *in situ* archaeological deposits cannot be reversed (Barker 1993; Roosevelt et al., 2015). Field projects also involve diverse teams of scientists and can be difficult to coordinate or justify in advance, in terms of prospective output and impact, particularly when a new project is initiated at a previously unexcavated site. It is therefore beneficial to explore the taphonomic integrity and geochronological suitability of a given deposit to a specific research question, prior to initiating a systematic excavation (Aitken 1974; Verhegge et al., 2016). Producing an initial chronology through sediment coring offers the potential to rapidly assess a site's suitability for excavation. The aim of this study is to test this proposition at Simons Cave on the west coast of South Africa, by obtaining and dating cores, then subsequently assessing the accuracy of the initial chronology with a more conventional test excavation and dating project. Two field seasons were undertaken at the site and the results from the two individual dating campaigns are comparatively presented here.

2. Archaeological significance

Recent discoveries suggest the majority of complex human behaviours (so-called 'modern human behaviours') such as the manufacture of elaborate tools, symbolic items, as well as wide social networks emerged in Africa a substantial period after our biological origins (Hublin et al., 2017; Richter et al., 2017; Schlebusch et al., 2017), and that the Marine Isotope Stage (MIS) 5-3 archaeological record of southern Africa documents this process across several regions (Henshilwood et al., 2004, 2011, 2018; d'Errico et al., 2005; Texier et al., 2010; Brown et al., 2012; Wadley, 2015). In several key archaeological sites, this period (~130-29 ka) is characterized by shifts in cultural behaviour that are critical to our understanding of later human behavioural evolution. The timing and

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geographic structure of these shifts, however, remain contentious (Jacobs et al., 2008; Guérin et al., 2013; Tribolo et al., 2013; Feathers 2015).

Aspects of this contention are well-reflected in the west coast archaeological record of South Africa (hereafter referred to as 'the west coast'), where some scientists argue for an earlier, more gradual evolution of key modern human behaviours, including the emergence of complex tool manufacture before these behaviours are documented in other sub-regions of southern Africa (Porraz et al., 2013; Texier et al., 2013). Further, it is argued that only later phases in the sequence of cultural change identified on the west coast are similarly reflected in Pleistocene occupations in other regions of southern Africa (Porraz et al., 2013; Texier et al., 2013; Douze et al., 2018 (but see Lukich et al., 2019)). This potential mismatch in the timing and geographic expression of key modern behaviours implies that the nature and timing of later *Homo sapiens* adaptation may have been spatially structured within southern Africa. If true, this raises the possibility that spatially variable ecological factors such as risk and/or demographic mechanisms may have been relevant in the emergence of complexity in southern Africa (Archer, 2021). A simpler explanation, however, is that some of the published geochronologies of key archaeological assemblages on the west coast may be problematic.

The west coast has a paucity of well-dated sites relative to the south-coast and near-coastal zones of southern Africa (Fig. 1). The farm of Steenbokfontein is located on the west coast, in relatively close proximity (~20 km) to the key sites of Elands Bay Cave (EBC) and Diepkloof Rockshelter (DRS). There are two sandstone caves at the site: the previously excavated Holocene sequence at Steenbokfontein Cave (Jerardino and Swanepoel 1999; Jerardino et al., 2000), and Simons Cave (Fig. 2a and b), an apparently deeper sequence, and the focal site of this study. Simons Cave has potential for the exploration of hominin occupation through the later Pleistocene and Holocene. This potential stems from i) the proximity of the site to the coast and the abundant marine resources available in the coastal zone, ii) the geological setting of the cave as a sizeable shelter with a clear depth of deposit and sediment trap, and iii) its proximity to two other important later Pleistocene west coast occupations (EBC and DRS).

3. Methods

Two separate field seasons were undertaken at the Simons Cave site. During the 2018 field season a small team collected two cores from within the cave for preliminary sedimentological and archaeological investigations. Samples were collected from the cores for OSL and radiocarbon dating. The 2019 field season saw a systematic test excavation, with a larger scientific field team involved. Samples were collected for OSL dating and radiocarbon dating (Fig. 2c–e).

3.1. Percussion coring

Mechanical coring is a well-established method for archaeological prospection (Canti and Meddens 1998; Garrison 2016). At five locations within Simons Cave, cores were drilled down to a maximum 3 m depths using an Atlas Copco motor hammer and several 1 m corers. In each locality, a first continuous core was collected using an open gouge, for the purposes of assessing and describing the sedimentological sequence. A second core was collected alongside the first, ~30–50 cm away, using opaque core liners for the prospective dating campaign. The liners were plugged, packaged and sealed light-tight, and transported to the laboratory for processing. The core liners were split and opened in dim red light conditions at the Department of Physical Geography, Friedrich-Schiller-University, Jena. One side of the core was photographed under normal daylight conditions, whilst the opposite side was packaged and transported to the OSL laboratory at the Max Planck Institute for Evolutionary Anthropology where it was sampled for OSL and radiocarbon dating.

3.2. OSL dating

OSL samples were collected from the core liners retrieved at two coring positions approximately 8 m apart within the cave (field season 1, 2018) (Fig. 2b and c). Sampling took place in the laboratory under dim red light conditions, carefully avoiding the outer rim of the cores (Nelson et al., 2019). Equivalent dose (D_e) samples were collected from the unexposed half of the split core, whilst dosimetry samples were collected from the daylight-exposed half of the split core directly opposite the D_e sample location. During the excavation (field season 2,

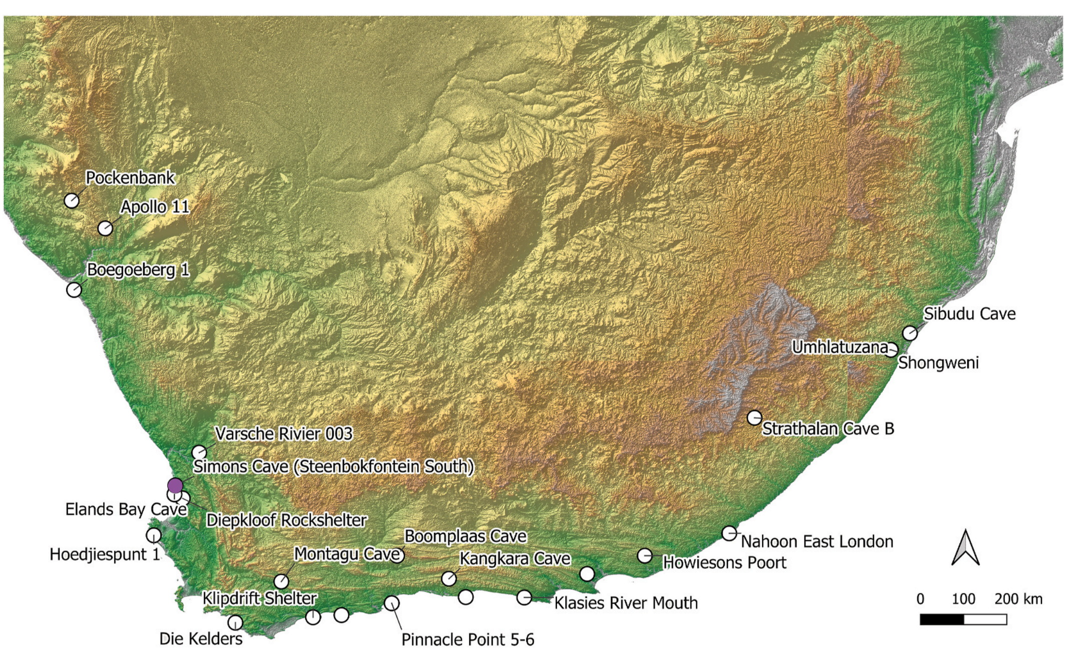

Fig. 1. Distribution of MIS5 and 4 sites along the coasts of southern Africa. Simons Cave at Steenbokfontein South is located on the west coast (shown as a filled circle).

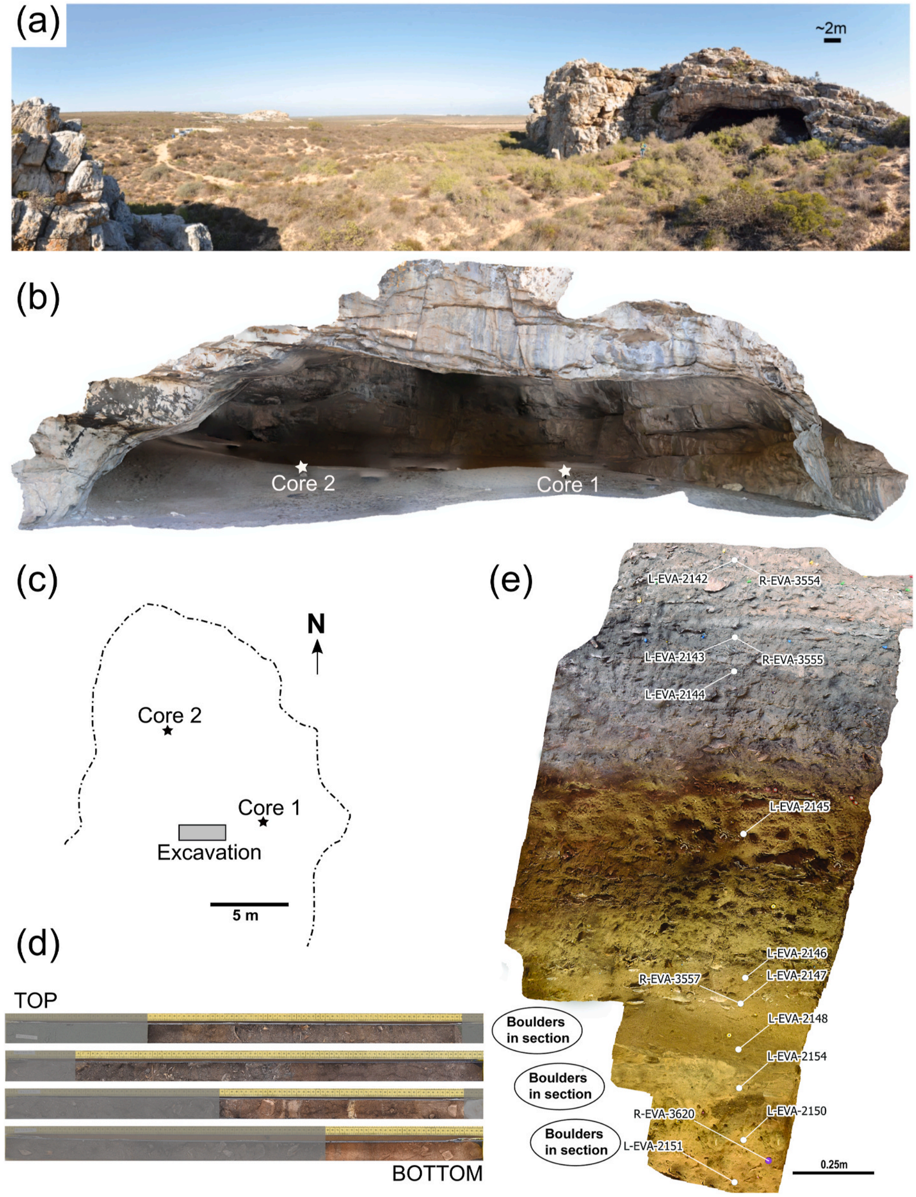

Fig. 2. a) The Simons Cave site, located on the west coast; b) view from the cave mouth; c) plan view of the cave showing the locations of Core 1, Core 2 and the test excavation; d) photo of Core 1, grey shaded areas denote infilling sediment displaced during the coring process; and e) profile of the test excavation showing the location of OSL samples (prefix L-EVA-) and ^{14}C samples (prefix R-EVA-). The profile shows ~1.9 m depth.

2019) samples were collected in opaque, light-tight bags under cover of a tarpaulin in dim red light, packaged light tight and transported to the laboratory. Laboratory preparation and measurement protocols (see Supplementary Section S1) were the same for both sample sets. Due to the location of the sampling site within a sandstone cave single grain measurements were used to avoid unbleached grains (see Roberts et al., 2015 and references therein). An example of the OSL signal and resulting dose response curve (DRC) for an individual grain, together with the equivalent dose distribution for the same sample is shown in Fig. 3. OSL ages and associated data are presented in Table 1.

3.3. Radiocarbon dating

Charcoal and bone samples were collected from the cores (obtained during field season 1, 2018) based on their size and preservation, rather than on their proximity to OSL sample locations. This was to ensure the two dating techniques were independent of one another during the first dating campaign, which used a coarse sampling resolution. Seven samples were collected from undisturbed *in-situ* sediments in the core liners, and three were collected from infilling sediments. Charcoal samples from the excavation (field season 2, 2019) were collected adjacent to OSL samples, except R-EVA-3620 as this sample was submitted for analysis later on, once it became evident that it was clearly associated with Middle Stone Age technologies. Collagen extraction from the bones was carried out in the Department of Human Evolution at the Max Planck Institute for Evolutionary Anthropology, according to the protocol described in Fewlass et al. (2019) for small sample sizes. All samples were dated using accelerator mass spectrometry (AMS) at the CEZA radiocarbon lab in Germany (see Supplementary Section S2 for further details). Radiocarbon ages and associated data are presented in Table 2.

3.4. Archaeological excavation

Test excavation focused on excavating one square meter of deposit to bedrock, with two neighbouring squares excavated down ~30 cm in

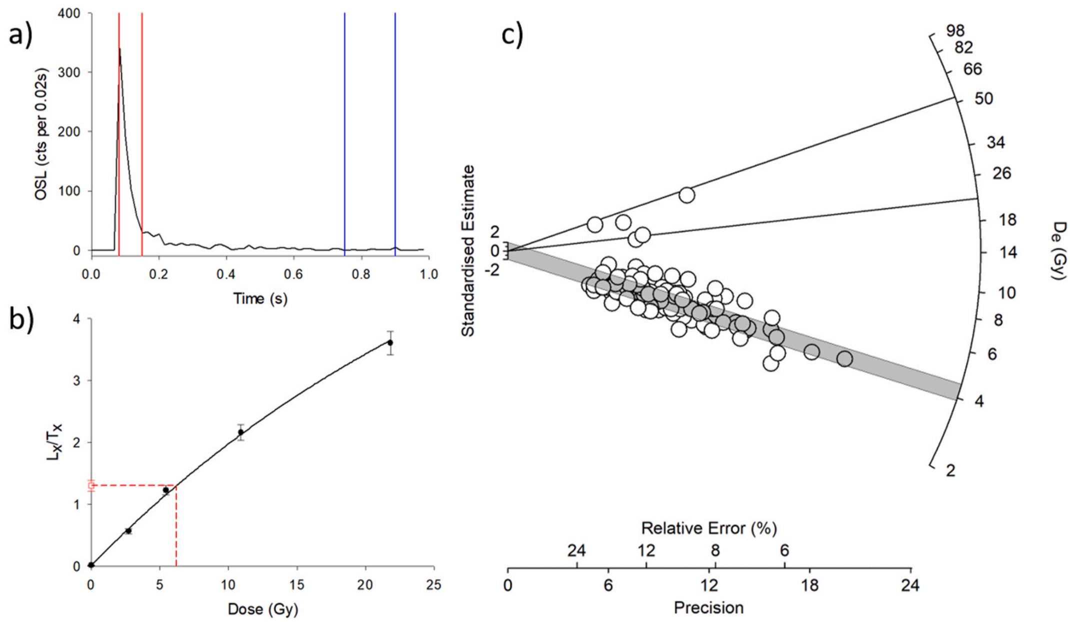

Fig. 3. Equivalent dose (D_e) data for excavated sample L-EVA-2145 showing examples of a) the signal decay from a single grain (signal integration shown in red and background integration in blue), b) the dose response curve (DRC) for the same grain, and c) a radial plot of the dose distribution and the components identified by the FMM.

depth, and supported with sandbags to strengthen the profiles of the main square. The excavation documented a relatively deep stratigraphic sequence of ~2 m in the main square before hitting fallen boulders. Excavation followed modern digital standards of recording which are best-practise in the discipline (see Supplementary Section S3). The deposits were systematically sampled for micromorphological analysis to investigate their formation and integrity. However, the processing and analysis of these block samples and recovered archaeological material is ongoing and will be presented in future publications.

4. Results

4.1. Field season 1: Initial investigation and coring

Preliminary inspection of the core sediments documented a ~3 m deep, well-bedded and -laminated stratigraphic sequence above the bedrock of the cave. It consists mostly of presumed aeolian sands with varying contents of organic matter, coarse-grained contributions (rock fall, shells, bones, charcoal) and diverse forms of iron oxidisation, implying pedogenic or thermogenic alterations (cf. Goldberg 2000; Jacobs et al., 2020). Preservation of several upper archaeological layers was good, documenting the presence of hearths, terrestrial and marine fauna and lithic remains, while preservation in the lower layers was less impressive in terms of the preservation of organic remains. A detailed stratigraphy was not compiled at this stage because the corers provided at most an 8 cm diameter view of a potentially complex stratigraphy, which makes it easy to miss details or exaggerate the significance of inclusions.

Geochronological data from the two cores was varied. Nine single grain quartz OSL ages are stratigraphically consistent, ranging from 5.03 ± 1.10 ka to 133 ± 35 ka. In contrast, the seven radiocarbon samples collected from the undisturbed sediments range from 4829 to 4582 cal BP (68.3% probability) between 0.18 and 0.75 m depth and 5306–4961 cal BP between 0.92 and 1.02 m depth below surface (Fig. 4a). The three ^{14}C dates from disturbed infilling sediments (refer Table 2 and Fig. 2d) perfectly agree with these ranges. Whereas the radiocarbon ages are all restricted to the Holocene, the OSL ages suggest overlap with key Pleistocene sites in the region. Specifically, the OSL ages of ~55 ka and ~43 ka at Simons Cave display a temporal overlap with the MIS5-3 ages of the layers at Diepkloof Rockshelter, coinciding with the later Howiesons Poort complex ages of Steele et al. (2016) and Tribolo et al. (2013) at sites in the broader region.

4.2. Field season 2: Preliminary systematic excavation

Systematic excavation revealed the entire sequence to be archaeological, and to consist of variable beds and fine laminations of anthropogenic and geogenic sedimentary input that is typical of well-stratified sites in this region (Miller et al., 2013, 2016). The upper archaeological layers are well preserved, with the presence of abundant hearths as well as isolated evidence for burning, shell-fish remains, terrestrial and marine fauna, lithic remains and organic tools, as well as botanical remains. The lower layers - comprising characteristically MSA assemblages - contain substantially higher densities of lithics and less organic material with increasing depth, and evidence that a portion of encompassing sediment may have been lost over time through post-depositional processes. The sequence preserves discrete Later and Middle Stone Age technologies in what appear to be, in most layers, unmixed stratigraphic units, however, the chrono-cultural sequence of the site requires further investigation to be clarified.

Preliminary micromorphological analyses show that the deposits are dominantly composed of well sorted fine to medium sized quartz grains originating from the bedrock and from aeolian processes. Microscopic anthropogenic components include charcoal, shells, lithics and bones, but the latter are very rare and none were observed in the Pleistocene deposits. Hardly any bioturbation features are present and the clear stratification at the macro and micro scale further indicates good integrity of the layers.

Results from the dating of material excavated in field season 2, using a higher sampling resolution were encouraging (Fig. 4b). Thirteen OSL ages range from 5.22 ± 0.55 to 69.5 ± 6.2 ka, which span about half of the time frame (~5–145 ka) reported by the OSL ages from the cores. The radiocarbon dates from layers Afro and Ahmed range from 4826 to 4582 cal BP, and from layer Benny to 5439–5090 cal BP (1.32 m), in close agreement with the two age clusters seen in the core. A radiocarbon date for charcoal collected from layer Carl, potentially associated with a later Middle Stone Age lithic industry, returned an age of 34810–34510 cal BP (Tables 1 and 2).

Table 1
OSL data for sediments from the Simons Cave cores and excavation, including the CAM overdispersion (OD), equivalent dose (D_e), dose rate (D_r) and ages (±1 sigma uncertainty).

Sample ID	Location	Arch. layer	Depth (m)	OD (%)	D_e (Gy)[a]	D_r (Gy/ka)[b]	Age (ka)
L-EVA-1884	Core 2	–	0.46	27	2.31 ± 0.07	0.459 ± 0.099	5.03 ± 1.10
L-EVA-1885	Core 2	–	0.84	42	2.52 ± 0.06	0.353 ± 0.114	7.12 ± 2.32
L-EVA-1886	Core 2	–	1.34	59	2.66 ± 0.09	0.330 ± 0.105	8.06 ± 2.58
L-EVA-1887	Core 2	–	1.36	101	28.4 ± 0.37	0.513 ± 0.152	55.4 ± 16.5
L-EVA-1888	Core 1	–	0.61	50	2.37 ± 0.05	0.415 ± 0.084	5.72 ± 1.16
L-EVA-1889	Core 1	–	0.64	59	2.37 ± 0.06	0.325 ± 0.096	7.30 ± 2.16
L-EVA-1890	Core 1	–	0.76	51	2.29 ± 0.07	0.468 ± 0.104	4.89 ± 1.09
L-EVA-1891	Core 1	–	1.21	39	17.2 ± 2.29	0.397 ± 0.113	43.4 ± 13.7
L-EVA-1892	Core 1	–	2.15	80	72.8 ± 1.58	0.549 ± 0.145	133 ± 35
L-EVA-1893	Core 1	–	2.55	63	129 ± 10	0.893 ± 0.130	145 ± 24
L-EVA-2142	Front pit	Afro	0.08	45	2.34 ± 0.14	0.448 ± 0.039	5.22 ± 0.55
L-EVA-2143	Front pit	Ahmed	0.30	48	2.35 ± 0.09	0.407 ± 0.035	5.78 ± 0.55
L-EVA-2144	Front pit	AJ	0.39	37	2.74 ± 0.07	0.461 ± 0.049	5.95 ± 0.65
L-EVA-2145	Front pit	Allan	0.85	44	4.18 ± 0.07	0.716 ± 0.065	5.84 ± 0.54
L-EVA-2146	Front pit	Bart	1.25	41	3.65 ± 0.09	0.528 ± 0.066	6.92 ± 0.88
L-EVA-2147	Front pit	Benny	1.32	19	3.51 ± 0.09	0.489 ± 0.059	7.18 ± 0.89
L-EVA-2148	Front pit	Beryl	1.45	59	3.49 ± 0.09	0.530 ± 0.064	6.59 ± 0.82
L-EVA-2153	Front pit	Beryl	1.49	28	3.81 ± 0.11	0.477 ± 0.049	7.99 ± 0.85
L-EVA-2149	Front pit	Bevin	1.56	46	3.98 ± 0.10	0.517 ± 0.049	7.70 ± 0.75
L-EVA-2154	Front pit	Bevin	1.56	49	3.42 ± 0.16	0.529 ± 0.052	6.47 ± 0.70
L-EVA-2150	Front pit	Carl	1.70	43	22.5 ± 0.65	0.482 ± 0.053	46.8 ± 5.4
L-EVA-2151	Front pit	Carrie	1.82	43	32.0 ± 1.90	0.554 ± 0.052	57.9 ± 6.5
L-EVA-2152	Front pit	Catherine	1.98	38	45.4 ± 2.84	0.654 ± 0.041	69.5 ± 6.2

[a] All OSL D_e values calculated using the finite mixture model (FMM, Roberts et al., 2000) with σ_b of 0.20 for core samples and 0.15 for excavation samples based on dose recovery experiments. The one exception being L-EVA-1893 which is saturated, so the mean D_e was used to calculate a representative minimum age.

[b] Dose rates are comprised of an external beta- and gamma dose, corrected for grain size attenuation and a burial water content of 5 ± 2%, and a cosmic dose component.

5. Discussion

5.1. Geochronology from the coring campaign (field season 1)

Dating results from the Simons Cave cores were variable depending on the dating technique employed. The ^{14}C dating returned ages of ~4700 cal BP and ~5150 cal BP in Core 1 (Table 2), confirming the preservation of Holocene sediments within the cave. This result is reassuring given past excavations of Holocene occupation in nearby Steenbokfontein Cave (Jerardino and Yates 1996; Jerardino and Swanepoel 1999; Jerardino et al., 2000), but falls well short of the Late Pleistocene target. In contrast, the OSL dating gave an age range from 5.03 ± 1.10 ka to 133 ± 35 ka (Table 1), demonstrating consistent increase in age with depth and, importantly, overlap with the MSA layers at the nearby locality of Diepkloof Rockshelter (DRS). Feathers (2015) reported the quartz OSL signal at DRS was near saturation, however that is not the case at Simons Cave. Whilst the Simons Cave OSL samples have very low dose rates (~0.5 Gy/ka) similar to those at DRS, the only sample with a significant proportion of saturated grains was L-EVA-1893 (n = 158, 77% of the accepted dose distribution) thus the ~145 ka age is considered a minimum age for the lowest sediments sampled from Core 1 (Fig. 2d).

The limited range of the ^{14}C dates in comparison to the OSL ages collected from Core 1 is due simply to the difference in depth at which samples were collected, i.e. ^{14}C samples were collected from the upper 1.13 m of Core 1 (Fig. 4a, stars), whilst OSL samples were collected down to a depth of 2.55 m (Fig. 4a, blue circles). The core chronology (shown in Fig. 4a) potentially suggests an abrupt change in accumulation rate at ~1.2 m, with low accumulation rates towards the base of the excavation and increased accumulation rates at ~5 ka.

5.2. Geochronology from the excavation campaign (field season 2)

Comparison of the ^{14}C dates (layers Afro and Ahmed: 4826–4582 cal BP; layer Benny: 5439–5090 cal BP; layer Carl: 34810–34510 cal BP; 68.3% probability) and OSL ages (5.22 ± 0.55 to 69.5 ± 6.2 ka) that resulted from the systematic excavation show remarkably good agreement between the two techniques (Fig. 4b). The OSL ages are all slightly older than the ^{14}C dates. Minor recuperation of the OSL signal was observed to the order of <0.2 Gy, which could account for this difference in some of the younger samples. However, it cannot account for the difference between L-EVA-2150 (46.8 ± 5.4 ka) and R-EVA-3620 (34810-34510 cal BP) both of which were collected from excavated layer Carl. Thus, the difference between the OSL ages and ^{14}C dates is most likely due to the two different materials and events that are being dated by these techniques. Specifically, OSL provides a depositional age for the sediments encompassing the anthropogenic materials (contingent on bleaching of the OSL signal during sediment deposition), whereas conventional ^{14}C dating provides a date for the death of an organism. When anthropogenically derived (i.e., charcoal related to burning or bone associated with death of a prey animal), ^{14}C dating will therefore give a date directly linked to human behaviour. Another important result from the 2019 excavation dating campaign is the ^{14}C date for a piece of charcoal from layer Carl, potentially associated with a later Middle Stone Age lithic industry, which returned an age of 34810–34510 cal BP. This date is encouraging because it demonstrates that the material dated using the ^{14}C dating technique (i.e. charcoal and bone) was not all intruded at ~5 ka. Therefore, the limited ^{14}C date range represented in Core 1 was shown to be an effect of sampling

Table 2
Radiocarbon (^{14}C) dates and calibrated ranges for bone and charcoal samples from Simons Cave. Dates were calibrated in OxCal 4.4 (Bronk Ramsey, 2009) using the southern hemisphere calibration curve (SHCal 20; Hogg et al., 2020).

Sample ID	Location	Arch. layer	Depth (m)	Material	Sampled (mg)	Collagen (%)	C %	N %	C: N	AMS lab code	^{14}C age ±1SD (BP)	68.3% cal BP	95.4% cal BP
R-EVA-3249	Core 1	–	0.18	Charcoal	287.6	–	46.0	–	–	MAMS-40808	4178 ± 20	4815–4582	4825–4533
R-EVA-3253	Core 1	–	0.28	Charcoal	56.6	–	63.2	–	–	MAMS-40810	4217 ± 20	4829–4647	4837–4582
R-EVA 3251	Core 1	–	0.32	Bone	165.0	10.9	41.1	15.2	3.2	MAMS-44870	4191 ± 21	4820–4620	4828–4576
R-EVA-3252	Core 1	–	0.48	Charcoal	173.7	–	36.9	–	–	MAMS-40809	4223 ± 21	4830–4650	4839–4584
R-EVA 3257	Core 1	–	0.75	Bone	196.9	11.5	42.1	15.9	3.1	MAMS-44871	4197 ± 22	4822–4623	4829–4578
R-EVA-3255	Core 1	–	0.92	Charcoal	31.5	–	37.2	–	–	MAMS-40812	4472 ± 27	5270–4961	5281–4875
R-EVA-3256	Core 1	–	1.02	Charcoal	139.7	–	24.0	–	–	MAMS-40813	4563 ± 22	5306–5056	5312–5050
R-EVA 3254	Core 1[a]	–	–	Charcoal		–	58.3	–	–	MAMS-40811	4214 ± 21	4828–4646	4836–4581
R-EVA 3258	Core 1[a]	–	–	Bone	364.6	11.6	44.8	15.8	3.3	MAMS-44867	4170 ± 21	4809–4579	4822–4530
R-EVA 3259	Core 1[a]	–	–	Bone	379.2	14.0	45.1	15.6	3.4	MAMS-44868	4518 ± 22	5280–5047	5294–4979
R-EVA-3554	Front pit	Afro	0.08	Charcoal	45.1	–	58.5	–	–	MAMS-46954	4177 ± 21	4814–4582	4825–4532
R-EVA-3555	Front pit	Ahmed	0.30	Charcoal	109.5	–	63.7	–	–	MAMS-46955	4206 ± 22	4826–4629	4833–4580
R-EVA-3557	Front pit	Benny	1.32	Charcoal	19.7	–	65.4	–	–	MAMS-46957	4617 ± 23	5439–5090	5447–5054
R-EVA-3620	Front pit	Carl	1.76	Charcoal	106.8	–	41.3	–	–	MAMS-49057	30360 ± 110	34810-34510	35130-34440

[a] Sample from infill sediment.

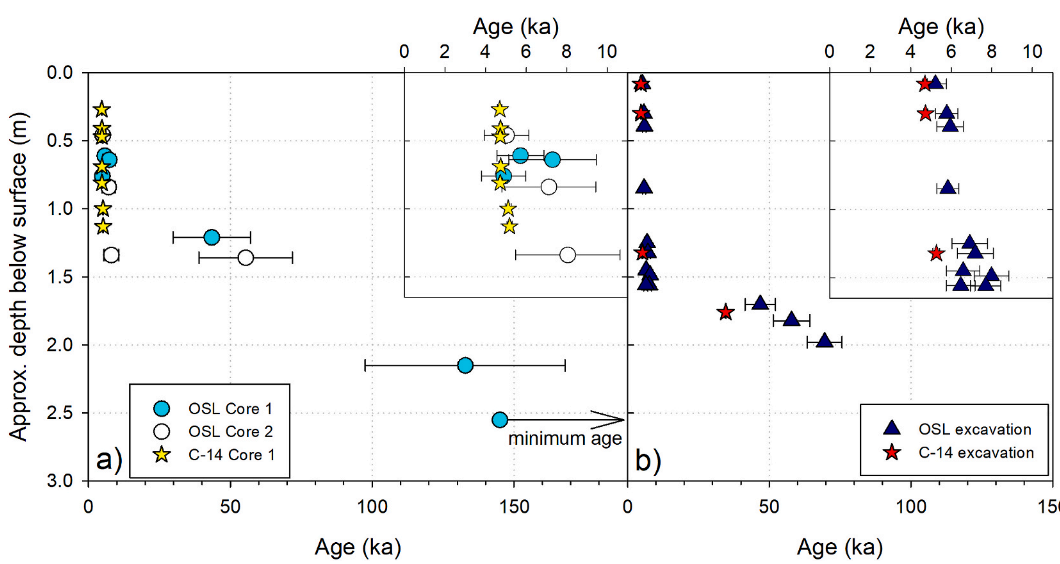

Fig. 4. Comparison of OSL ages and calibrated ^{14}C dates (68.3% probability) from a) cores collected during field season 1 and b) the systematic excavation undertaken during field season 2. *Insets:* Holocene ages shown on an expanded axis. Error bars for ^{14}C dates are obscured by the symbols.

strategy rather than site depositional processes. Ultimately, agreement between the OSL ages and ^{14}C dates from the excavation (Fig. 4b) shows rapid deposition of a thick Holocene sediment package, with an abrupt transition to the underlying late Pleistocene sediments at ~1.6 m depth.

5.3. Comparison of the geochronologies from the coring campaign and the excavation campaign

The OSL ages from the excavation do not extend as far back in time as those from the cores, 69.5 ± 6.2 ka and 133 ± 35 ka respectively (Table 1; Fig. 4 circles and triangles). However, both sets of OSL ages overlap with the early and intermediate Howiesons Poort at DRS. The OSL age datasets are also offset with respect to depth below surface, for example both OSL datasets include ages around ~45–55 ka, but at ~1.3 m depth in the cores and ~1.7 m depth in the excavation. This age offset with depth could be due to sediment compaction during the coring process, but may also be attributed to a complex stratigraphy and fluctuating/non-horizontal layer boundaries across the cave. Although sample depths in the cores were corrected following the method of Canti and Meddens (1998), the vertical offset in ages cannot be fully accounted for and would imply that the reason there are no ages >100 ka in the excavation OSL dataset, is because these sediments were simply not sampled.

The OSL excavation ages also have improved precision compared to the core ages, likely due to sediment mixing during the coring process. Smearing of grains can occur along the outside of the core (Nelson et al., 2019) and a plausible explanation may be that our OSL sampling strategy was not stringent enough, and these grains were incorporated into the samples used for dating. Introducing these young, variably bleached grains into the OSL samples would affect the equivalent dose estimation, resulting in larger uncertainties on the ages (as evident here). Furthermore, due to the sandy, unconsolidated nature of the sediments in Simons Cave, care had to be taken to exclude the disturbed infilling sediments (Fig. 2d, grey shading) from the core during the sampling process in the laboratory, which may have been variably successful.

Considering both ^{14}C datasets, there are two clusters in the Holocene ^{14}C dates (~4700 cal BP and ~5150 cal BP) in addition to the lowermost sample from the excavation which produced an age of ~34660 cal BP. The ^{14}C dates from the core (Fig. 4a, yellow stars) correspond well with the dates from the excavation (Fig. 4b, red stars), and fit well within the broader geochronological framework (i.e. considering both ^{14}C dates and OSL ages) produced by the excavation.

The ultimate goal of the 2018 coring campaign was to establish the potential of Simons Cave as a new west coast Stone Age site. Based solely on the Holocene ^{14}C core dates, a systematic excavation campaign targeting MSA layers would not have been pursued. Conversely, the situation would be reversed if the OSL core ages provided the sole chronological framework. However, it must be noted that both techniques worked successfully as a range-finder in this regard, and the reason that the cored ^{14}C samples all returned Holocene ages was because they were collected from above the hiatus revealed by systematic excavation (at ~1.6 m depth below surface). The results from the 2019 excavation showed the true geochronological record through a combination of the two dating techniques, which highlights the importance of using multiple techniques when feasible. Ultimately, the geochronology from the targeted coring campaign with its coarse sampling resolution was successful in identifying the potential of the site for excavation, without the need for a detailed stratigraphy to account for potential complexities and differing layer thicknesses within the cave.

6. Conclusion

Coring inside the cave proved challenging logistically, i.e. the location was influenced by available overhead space to enable removal of the core liners and unconsolidated dry sediment falling into the core hole. Furthermore, our sampling strategy was perhaps not stringent enough, which led to the incorporation of young grains into the OSL samples and collection of ^{14}C samples from only the upper Holocene layers present in Core 1. These factors introduced additional uncertainties into the core geochronology. However, the resolution of the core geochronology proved to be a sufficient range finder to recommend further excavation of Simons Cave as a promising new locality on the west coast of southern Africa. Subsequent systematic excavation at the site improved the geochronological resolution and confirmed the sites potential to add to the debate on the timing of behavioural evolution on the west coast. A more detailed investigation of the Simons Cave locality is ongoing, but the results presented here show the value of geochronological prospection using coarse sampling resolution in identifying potential archaeological cave sites for excavation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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