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► **To cite this version:**

Lucinda Backwell, Francesco D'errico, Paloma de la Peña, Lyn Wadley. Border Cave, South Africa. Handbook of Pleistocene Archaeology of Africa. Hominin behavior, geography, and chronology, 1, Springer Cham, pp.1297-1310, 2023, 978-3-031-20289-6. 10.1007/978-3-031-20290-2_84. hal-04722241

HAL Id: hal-04722241

<https://hal.science/hal-04722241v1>

Submitted on 7 Oct 2024

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Border Cave, South Africa

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Location and excavation history

Border Cave is a large cavern situated in KwaZulu-Natal, 400 m from the Swaziland border (-27.0219444° (S, latitude) and 31.9900000° (E, longitude)). The site is 2 km north of the Ngwavuma River and 82 km west of the Indian Ocean (Fig. 1). Located just below the rim of an escarpment at an elevation of c. 600 m above sea level, it is accessible only by a small path from above or by walking a steep slope from below. Semi-circular in shape and approximately 50 m wide by 35 m long, the cave faces west (Fig. 1).

The cave deposit has experienced six excavation episodes, one of which was not archaeological. The first, which has remained unpublished, took place in 1934 when Raymond Dart dug a narrow East-West trench at the entrance (Fig. 1, EXC. 1). The second, conducted in 1940 by W. E. Horton to extract guano from the middle of the cave, uncovered archaeological and human remains that prompted controlled archaeological inquiry the following two years. During this third excavation episode (Fig. 1, EXC. 2), Cooke, Malan and Wells (1945) recovered additional human remains from Horton's dump that they attributed to the Middle Stone Age (MSA), and linked Dart's trench and Horton's pit, which led them to identify a long MSA and Early Later Stone Age (ELSA) sequence. They also report the discovery of an *in situ* infant burial with a *Conus* shell. The fourth excavation (Fig. 1, EXC. 3), carried out by Beaumont between 1970 and 1975, took place in two different areas (Fig. 1, EXC. 3A and 3B), and revealed Iron Age, ELSA, and MSA horizons (Beaumont 1973). The fifth excavation episode (Fig. 1, EXC. 4A and 4B), conducted in 1987 by Beaumont, Todd and Miller (Beaumont et al. 1992) significantly expanded excavation 3A. The sixth, and most recent excavations have been conducted by Backwell, Wadley and d'Errico (Backwell et al. 2018).

<INSERT Fig. 1>

The squares opened by the current team are all staggered along the North and South faces of Beaumont's Excavation 3A (Fig. 1), along lines N108, N109 and N103 (Beaumont's P, Q and U), thereby providing a good transverse profile of the deposit that includes the entire sequence, from the youngest layers near the back of the cave to bedrock towards the middle. We are doing fine resolution excavation in small areas to retrieve maximum archaeological information, which is studied using a number of microanalytical techniques.

Chronology and stratigraphic sequence

The site features a 4 m deep sedimentary sequence comprising 11 main alternating brown

sand (BS) and white ash (WA) deposits (Butzer et al. 1978). The sequence includes, from the bottom to the top: MSA 1/Pietersburg, MSA 2/Howiesons Poort (HP), MSA 3 (post-Howiesons Poort), and ELSA lithic assemblages (Table 1). The ELSA layers are overlain by a thick, virtually sterile deposit, capped by an Iron Age layer. The sedimentary sequence has been dated by electron spin resonance (ESR) (Grün and Beaumont 2001; Grün et al. 2003; Millard 2006), amino acid racemisation (Miller and Beaumont 1989; Miller et al. 1999), and radiocarbon methods (Beaumont and Vogel 1972; Beaumont 1980; Bird et al. 2003; d'Errico et al. 2012b; Vogel et al. 1986;), which have produced ages in broad agreement (Table 1). ESR results indicate that the MSA 1 layers (5 WA, 5 BS, 4 WA, 4 BS) span 227 ka to 77 ka, the Howiesons Poort layers (1 RGSB, 3 WA, 3 BS) range between 74 ka and 60 ka, and the MSA 3 (post-HP) layers (2 WA, 2 BS Lower C, B and A, 2 BS UP) fall between 60 ka and 39 ka. Inversions exist in the ESR ages for layers 4WA and 5BS. Forty radiocarbon ages have been generated for the post-HP, ELSA and more recent layers (2 BS Lower C, 2 BS Lower B and A, 2 BS UP, 1 WA 2 and UP, 1 BS Lower C, B and A), including five recently published ages for the ELSA (Backwell et al. 2018; d'Errico et al. 2012b; Villa et al. 2012). Age ranges could slightly change if the calibrations were done with INTCAL20. As part of the new round of excavations, Optically Stimulated Luminescence (OSL) dating is being applied to sediment, agate, mollusc and tooth enamel samples from throughout the sequence (Tribolo and Mercier in prep.).

<INSERT Table 1.>

Geology

The host bedrock belongs to Lower Jurassic-age (182.1 ± 2.9 Ma) felsic extrusive rocks of the Jozini Formation (Lebombo Group), which built most of the Lebombo Mountain in the area (Riley et al. 2004). Two volcanoclastic facies of the Jozini Formation can be identified in

the cave, and these are described as clast- and matrix-supported breccias. The clast-supported breccia facies dominates the roof and sides of the cave and features a very poorly sorted, ungraded, strongly lithified, massive breccia that has weakly to moderately defined, thickly to very thickly bedded layers that vary in thickness between 0.3 m and >1 m. The matrix-supported breccia facies is only exposed along the southern wall of the shelter. This ungraded, massive volcanoclastic breccia comprises fragments of rhyolite within a matrix of medium-grained, highly porous, silt- and clay-rich sandstone. It is proposed that Border Cave formed because of differential weathering of these two volcanoclastic deposits, of which the clast-supported breccia has been less susceptible to weathering than the more friable, porous matrix-supported breccia. Exposed blocks of sandstone within the clast-supported volcanoclastic breccia may also have been subjected to preferential weathering. Cave sediments that are not anthropogenic probably originate primarily from the physical weathering of the matrix-supported volcanoclastic breccia. This would explain the presence of medium-grained sand and roof spall made of rhyolite fragments in the excavated sediments.

Hominins

The remains of at least ten individuals have been recovered to date at Border Cave, all of them considered to be anatomically modern humans (Grün and Beaumont 2001; Rightmire 1989). An adult partial cranial vault and the shafts of two femora and tibiae, likely belonging to the same individual, and designated BC1, were recovered in 1940 by Horton while digging his pit, and by Basil Cooke, Barend Malan and Lawrence Wells (1945) when sorting W. E. Horton's dump in 1941 and 1942. The femora and tibiae have since been lost (de Villiers 1973). The dump also yielded a large number of human bone fragments representing more than one individual, including a partial adult mandible designated BC2. The stratigraphic provenance of the remains from the dump is uncertain. However, Member 4 WA and lower were not exposed when these remains were recovered, indicating that they can only derive

from younger layers, and matrix on the BC1 cranial fragments appeared most similar to that from the base of Member 4 BS (Table 1), previously called 1 GBS Lower (Beaumont et al. 1978; Beaumont 1980; Butzer et al. 1978).

BC3 is the skeleton of an infant from Member 1 RGS (Cooke et al. 1945). The four to six-month-old infant, found with a perforated *Conus* shell with traces of ochre (Fig. 2) in a pit excavated in HP layers dated to c. 74 ka, is considered the second oldest instance of modern human burial from Africa, and an early example of a deceased human interred with a personal ornament. The *Conus* shell shows that the use of marine gastropods as ornaments, already attested in the Still Bay, extended to the first phases of the HP (d'Errico and Backwell 2016). BC4, an Iron Age skeleton missing the skull, found in Member 1 BS Upper outside the grid area, and near the surface in the southern part of the cave, has been directly dated to 340 ± 45 (Pta 777) and 480 ± 45 (Pta 1318) (Beaumont et al. 1978; Beaumont 1980; Morris 1992; Vogel et al. 1986). BC5 is a nearly complete adult mandible, found by Powell and Beaumont in 1974 while collecting sediment samples. It comes from the South section of excavation 3A, just above the base of undisturbed 3 WA, in the Northwest corner of square T20 (Fig. 1). It was found close to a sub-circular shallow depression apparently dug into lower Member 4 BS. The most recent attempt to directly date BC5 (Grün et al. 2003) by applying ESR to a fragment of tooth enamel provided an age of 74 ± 4 ka, which is consistent with previous (Grün and Beaumont 2001) and more recent ages obtained for the sequence using the same technique.

<INSERT Fig. 2.>

BC6 (humerus), BC7 (proximal ulna), and BC8a and BC8b (two metatarsals) were recovered from disturbed deposits (Grün and Beaumont 2001). However, the very low nitrogen content of BC6 and BC7 compared to that of faunal remains throughout the sequence (Grün et al. 2003; Sillen and Morris 1996) suggests that they were originally

incorporated in layers older than 1WA (>43 ka). An MSA attribution of BC3 and BC5 has been called into question by Sillen and Morris (1996) based on the comparison between Infrared Splitting Factors (IR SF) and Nitrogen (N) content in fauna and human remains. However, reappraisal of these results by Grün and colleagues (2003) shows that, with the exception of the Iron Age skeleton BC4, N values for hominin remains support an MSA age, and lower IR SF in BC2, BC3 and BC5 may have resulted from rapid burial.

Fauna

A study of the larger mammals by Klein (1977) from Members 1 GBS (later renamed 4 BS by Beaumont, Miller and Vogel [1992]) through to Member 1 BS (that is, from the youngest MSA 1 assemblage to the Iron Age) suggests that the vegetation mosaic in the area was broadly similar to the one at present, at least from about 77 ka through to the final MSA, about 45 thousand years ago. This tends to support Avery's (1992) environmental conclusions for the period based on micromammals. Nonetheless, Klein thought that Member 1 GBS (4 BS) (uppermost MSA 1/Pietersburg) represented different climatic conditions from today, with more bush than the grassier conditions of Members 2 WA and 2 BS (post-HP). *Syncerus caffer* (Cape buffalo), *Equus quagga* (plain's zebra), Alcelaphines, and *Potamochoerus porcus* (bushpig), as well as a variety of antelope were present throughout the sequence in low frequencies (Klein 1977). Butzer and colleagues (1978: 338) suggest that the alternating frequencies of grazers and browsers through time imply that Member 1 GBS (4 BS) (MSA 1/Pietersburg) had a woodland-savanna habitat mosaic whereas 2 BS Lower, 2 WA (post-HP) and 3 BS Upper (HP) had grassland/savanna habitats.

Lithics

A preliminary analysis of the lithics from the 2015 and 2016 excavation seasons and a small sample from 2017 (3 BS only [HP]) has been published by Backwell and colleagues (2018).

The lithic analysis included 1,218 blanks larger than 2 cm and 3,527 chips. The main rock and mineral types knapped at the site are rhyolite, quartzite, agate, chalcedony, hyaline quartz and dacite. Rhyolite is the most dominant rock type throughout the members. The highest frequencies of blades and blade fragments have been found in Member 4 WA (MSA 1) and to a slightly lesser extent also in 5 BS (MSA 1) and 2 BS Lower (post-HP). Members 1 BS Lower C and 1 WA (ELSA) yielded large flakes, probably from multifacial cores. In Member 2 BS Lower (post-HP) there is a *Levallois* reduction sequence for flakes and blades. Elongated and pointed *Levallois* blanks are quite frequent and sometimes retouched (Fig. 3). Large flakes, sometimes over 5 cm in breadth and length, are also present in this member, demonstrating a flake-based production. In previous publications by Beaumont this industry was placed in MSA 3 (post-HP). In Member 3 BS (HP) there are several *Levallois* cores, and only two pieces with backed retouch have been documented so far. Members 5 BS and 4 WA (MSA 1) also have *Levallois* reduction strategies for flakes and blades. Some of the layers recently excavated in these members have clear bladelet production, which is contrary to Mason's (1962) expectation that a MSA 1/Pietersburg Industry should have large blade production. In the basal layers of Member 4 WA and in the top ones of Member 5 BS, *Levallois* points are the most characteristic technological feature (Fig. 4).

<INSERT Fig. 3.>

<INSERT Fig. 4.>

Organic remains

Our millimetre scale approach to excavations and use of sophisticated analytical instruments is yielding illuminating results. The new excavations have yielded the oldest evidence of cooked starchy rhizomes (*Hypoxis angustifolia*) at 170 ka (Wadley et al. 2020a). Fifty-five rhizomes were recovered from Members 5 Brown Sand (5 BS) and 4 White Ash (4 WA). The

rhizomes have preserved because they are charred, and presumably because they were lost while roasting them in ashes, which is where they were found. The pan-African and Near East distribution of the species would have provided a familiar food source for mobile groups within and out of Africa. Grass bedding occurs throughout the sequence. Analysis of the bedding and sequence of hearths shows that from about 200 thousand years ago, people could produce fire at will, and used fire, ash, and aromatic plants to maintain clean, pest-free camps (Wadley et al. 2020b). The organic remains found in Early Later Stone Age layers are described by d'Errico and colleagues (2012). In sum, at around 44,000 years ago, the people at Border Cave were using digging sticks probably weighted with perforated stones. A perforated stone is amongst the ELSA artefacts from Border Cave (Villa et al. 2012), and regional rock art depicts weighted digging sticks (Lewis-Williams and Dowson 1989). They adorned themselves with ostrich egg and marine shell beads, and crafted fine bone points for use as awls and poisoned arrowheads (Fig. 5). One point is decorated with a spiral groove filled with red ochre, which closely parallels similar marks that the San people make to identify their arrowheads when hunting.

<INSERT Fig. 5.>

Chemical analysis of residue on a wooden stick decorated with incisions, and very similar to a San poison applicator, revealed that it contains poisonous ricinoleic acid. A lump of beeswax, mixed with the resin of toxic *Euphorbia*, and possibly egg, was wrapped in vegetal twine made from the inner bark of a woody plant. This complex compound used for hafting arrowheads or tools, directly dated to 40,000 years, is the oldest known evidence of the use of beeswax. Warthog tusks were shaped into awls and possibly spear heads, and a baboon fibula was notched to store numerical information (Fig. 5). The use of microliths to arm hunting weapons is confirmed by the discovery of resin residue still clinging to some of the tools (Villa et al. 2012).

Significance

The timing of the emergence of our species and of key cultural innovations reflecting modern cognition is the subject of ongoing debate. In Africa, early evidence of complex behaviour and symbolism is found at a handful of sites, mostly dotted on opposite ends of the continent from about 100 kya in the form of intense pigment use, complex bone technology, beads, and burials. Border Cave is the only African cave site containing a sedimentary sequence that documents the emergence of these and other innovations over the critical time span of ~227 ka to 24 kya. The site is remarkable for the preservation of organic material, including cooked starchy rhizomes from 170 kya, a suite of grass bedding layers, the oldest of which dates to 200 thousand years ago, 40-thousand-year-old wooden tools, hafting with vegetal resin, and modified bees wax. An original bone technology emerges at 60 ka and is applied at 40 kya to the production of the earliest known device to store numerical information. Border Cave is the only African site that associates such a unique archaeological record with the discovery of human remains, including the burial in a pit of an infant with a personal ornament dated to ~74 ka. The site has the potential to produce a high-resolution multi-proxy record of climate change and human adaptation extending from MIS 7 (243 ka) to MIS 2 (29 ka) that can substantially contribute to our understanding of the impact of climate change on subsistence strategies and cultural change in this region.

Acknowledgements

We thank Deborah Olszewski, Amanuel Beyin and David Wright for useful suggestions that improved the text. This research was funded by a National Geographic Explorer grant (NGS-54810R-19) and DSI-NRF Centre of Excellence in Palaeosciences grant (CEOOP2020-1) to LB. We are grateful to Amafa aKwaZulu-Natali (Heritage KwaZulu-Natal) and the South

African Heritage Resource Agency (SAHRA) for granting us an excavation permit (SAH15/7645). FdE acknowledges support from the Research Council of Norway through its Centre's of Excellence funding scheme (SFF Centre for Early Sapiens Behaviour –SapienCE- project number 262618), the Talents programme of the University of Bordeaux IdEx, and the ERC project QUANTA (grant 951388).

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Figure legends

Fig. 1. Location of Border Cave and a plan of the site marking the position of the various excavations from 1934 to 2019.

Fig. 2. a: Schematic representation of the upper layers of Border Cave stratigraphy with 14C and mean ESR ages. (1-5): directly dated artefacts, 1: poison applicator, 2: digging stick, 3: resin on a microlith, 4: OES bead, 5: beeswax. b: Bayesian model of radiocarbon ages from the Border Cave upper layers performed using OxCal 4.1. Figures in brackets next to the laboratory numbers denote outlier probabilities (posterior: prior). Modified after d'Errico et al. 2012.

Fig. 3. *Conus* shell with ochre residue found in the pit with the infant BC3.

Fig. 4. A-F: Border Cave, Member 2 BS Lower, *Levallois* elongated blanks. Scale bars = 10 mm.

Fig. 5. A-F: Border Cave, Member 5 BS, *Levallois* points. Scale bars = 10 mm.

Fig. 6. Organic remains from the Early Later Stone Age layers at Border Cave. Bone awls and points (1-7), ostrich eggshells beads (8-21), *Nassarius kraussianus* beads (22, 23), lump

of organic material bound with vegetal fibres (24), digging stick (25), poison applicator (26), possible spearhead made on warthog or bushpig lower canine (27), and notched bones (28-30). Scale bars = 10 mm.

Table 1. Chronology of the Border Cave stratigraphic sequence.