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THE MOYJIL SITE, SOUTH-WEST VICTORIA, AUSTRALIA: EXCAVATION OF A LAST INTERGLACIAL CHARCOAL AND BURNT STONE FEATURE — IS IT A HEARTH?

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ABSTRACT: Claims for a human presence in Australia beyond 60,000 years ago must have a strong evidence base associated with rigorous methodology and intense scrutiny. In this light we present excavation results for Charcoal and Burnt Stone Feature #1 (CBS1) located within coastal dune sediments at Moyjil (Point Ritchie), Warrnambool, that independent geomorphic and OSL dating indicates is of Last Interglacial age (~120,000 years ago). While on plausibility grounds the cultural status of a feature of such great antiquity in Australia is unlikely, a cultural origin for CBS1 is less easily dismissed if assessed with an age-independent methodology. A broad range of macroscale discrimination criteria has been used to assess whether CBS1 is either a cultural hearth or a natural feature such as a burnt tree stump. On balance, evidence marginally supports a cultural origin over a natural origin. However, the absence of associated stone artefacts and faunal remains and the presence of burnt root wood precludes definitive statements on the cultural status of the feature. Our case study is methodologically instructive in terms of the potential complexities and issues of equifinality involved in the archaeological identification of ancient hearths.

Keywords: Aboriginal hearths, natural burning, taphonomy, Point Ritchie

INTRODUCTION

The oldest dates for human occupation of Sahul (Australia and New Guinea) based on radiocarbon dating are a little under 50 ka with 51–45 cal kBP at Carpenters Gap 1 in northern Western Australia (Maloney et al. 2018), ~48 cal kBP at Devil's Lair in southern Western Australia (Turney et al. 2011), 49.2–46.3 cal kBP at Warratyi in South Australia (Hamm et al. 2016), and 48.7–43.0 cal kBP in the Ivane valley in Papua New Guinea (Summerhayes et al. 2010). OSL/TL dating has provided older dates of c.50–60 ka at Malakunanja II and Nauwalabila I in Arnhem Land, Northern Territory (Roberts et al. 1990, 1994), 51.1–46.2 ka at Boodie Cave in Western Australia (Veth et al. 2017), and 50.1–45.7 ka at Lake Mungo in western New South Wales (Bowler et al. 2003). Recently, Clarkson et al. (2017) argued, based on re-excavation of Madjedbebe (aka Malakunanja II) and extensive OSL dating of cultural and pre-cultural sediments, that human occupation of the site, and by extension Sahul, began by at least 65,000 years ago. While a shorter and conservative chronology of 47,000 years as argued by O'Connell and Allen (2015) is secure and appealing to some (e.g. Stringer 2011: 237), a longer chronology of greater than 60,000 years has been considered plausible for over a decade by others (e.g. Bulbeck 2007; Chappell 2000: 88; O'Connor 2010: 51).

Clearly, a human site of Moyjil's antiquity in southern Australia with an age doubling recent views on the timing of the arrival of humans to Australia warranted further detailed investigation. The implications of evidence of humans in Australia before 100,000 years ago not only has important implications for understanding the deep human history of Australia but has profound implications for current understandings of the timing of the movement of modern humans out of Africa (Davidson 2010; O'Connell & Allen 1998; Rabett 2018). Controversy over reputed dates of >116,000 years ago at Jinmium in the Northern Territory reveal how claims of such antiquity can be discounted via follow-up analyses (Fullagar et al. 1996; Roberts et al. 1998). Similarly, fierce debate surrounding publication in *Nature* of archaeological evidence for humans in the Americas 130,000 years ago drives home the high evidential thresholds for such claims (Haynes 2017; Holen et al. 2017, 2018).

It is in this context that we present excavation results for a small deposit containing charcoal and darkened stones (some clearly burnt) at Moyjil (Point Ritchie headland), located at Warrnambool on the west coast of Victoria (Figure 1). Charcoal and Burnt Stone Feature #1 (CBS1) superficially looks like a hearth. What makes this hypothesis significant is that recent detailed geomorphic assessment and associated OSL dating of the headland indicates that the possible hearth dates to the Last Interglacial period (Carey et al. 2018; Sherwood et al. 2018a). The potential for Moyjil to re-write the early human history of Australia is not new, as claims have already been made that a marine shell deposit at the site dating to at least 60–80,000 years ago (since redated to 120–125,000 years old — see Sherwood et al. 2018a) could be cultural in origin (Sherwood et al. 1994; Nair & Sherwood 2007).

This paper rigorously tests the hypothesis that CBS1 is a hearth site of cultural origin. Yet as Berna and Goldberg (2007: 108) rightly noted, 'It turns out that recognizing remains of man-made fire in the past and the means to do so is not as straightforward as it might seem'. Furthermore, 'no clear archaeological definition of hearths' exists (Bentsen 2012: 95). 'Equifinality' (different processes having a similar result) is a key issue that has plagued hearth identification studies for years (Goldberg et al. 2017: S185; Mentzer 2014: 658; Thoms 2007: 487). It is for this reason that 'evidence for anthropogenic fire can be contextually variable and, in the case of the earliest examples, highly contentious' (Whitau et al. 2018: 740). It is now clear that differentiating cultural from natural burnt features requires weighing up multiple lines of macroscale and microscale evidence (e.g. Barbetti 1986: 779; Berna & Goldberg 2007: 108; Goldberg et al. 2017; James 1989: 9–10). Stahlschmidt et al. (2015: 182) remind us that 'the burden of proof rests on the archaeologists to demonstrate that the evidence for fire clearly represents human action, and not a natural process'. Using a range of diverse literature, this paper employs a broad range of macroscale, and to a lesser extent microscale, qualitative and quantitative discrimination criteria to determine whether or not, on balance, CBS1 is a cultural hearth or a natural feature such as a burnt tree stump.

GEOMORPHIC AND CHRONOLOGICAL SETTING

CBS1 is located near the top of the stepped cliff face of Moyjil on the west side of the mouth of the Hopkins River, Warrnambool, western Victoria (Figures 1 and 2). Detailed geological and geomorphic investigation of the headland by Sherwood et al. (1994) and most recently by Carey et al. (2018) and Sherwood et al. (2018a) indicates a complex sequence of loose and cemented aeolian dune sands dating to the Pleistocene and spanning at least the past 400,000 years. Of immediate concern for CBS1 are two calcrete layers (carbonate-cemented calcarenite sands) found across the upper sections of the headland: an 'upper calcrete' (unit Q2cs) up to 0.5 m thick and a 'lower calcrete' (unit Rcp) up to 1.25 m thick (Figure 3). The zone between

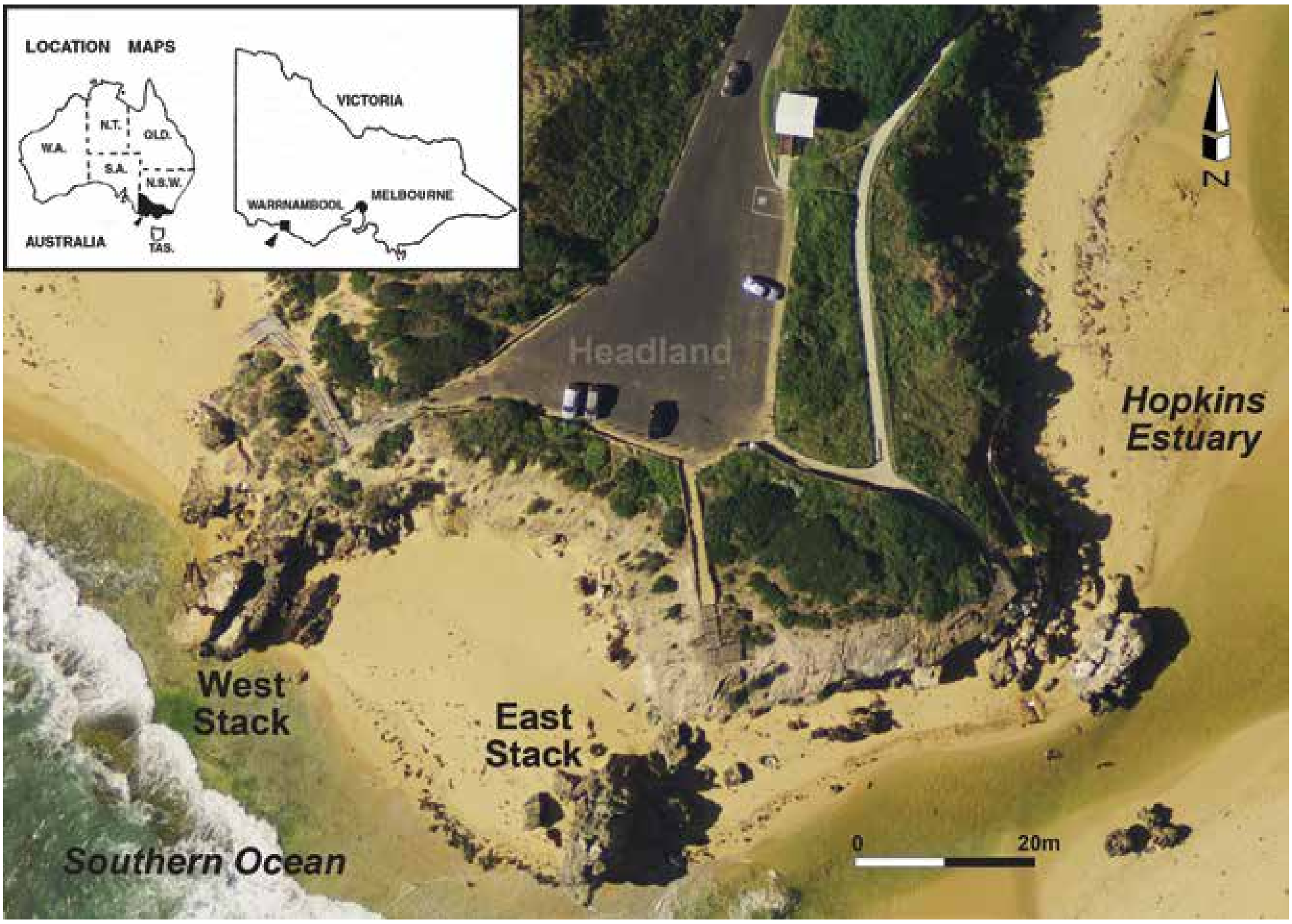

Figure 1: Study area.

Figure 2: Moyjil headland and West Stack, looking north-west, 15 July 2011. Jim Bowler standing on Gsα. Location of CBS1 is indicated by right arrow. Photograph: Ian J. McNiven.

the two calcrete layers varies in height between 0.5 and 2 m across the headland and contains mostly calcarenite (carbonate sands; unit Q2s) that has been infiltrated post-depositionally by plant roots, as shown by the presence of rhizomorphs. Sediments below the lower calcrete include couplets of calcarenite and *terra rossa* designated as units S (youngest at >240 ka), T, and V (oldest) by Carey et al. (2018). Sediments above the upper calcrete include a shallow layer of volcanic tuff (unit P) associated with eruption of Tower Hill volcano (located 15 km to the north-west) around 35,000 years ago (Sherwood et al. 2004) and a stiff brown soil capped by unconsolidated Holocene sands.

The upper surface of the lower calcrete layer (unit R) has been stripped back by recent erosion to create a 2–5 m wide pavement or bench designated Ground surface alpha (Gsα) by Carey et al. (2018) (Figures 2 and 3). CBS1 is embedded within the lower 15 cm of sands resting directly on the upper surface (Gsα) of the lower calcrete layer at an elevation of c.8 m above sea level (Figure 4). According to Carey et al. (2018), the basal 20–30 cm of calcarenite sands forming the matrix of CBS1 gained their reddish-brown colour as a result of oxidation and development of a reddish clay coating on grains through weathering and pedogenesis. Such oxidation is considered to have taken place elsewhere and not to represent *in situ* weathering and pedogenesis. The overlying 1–2 m of lighter coloured unit Q2 sands most likely represents rapid deposition, given the absence of darkened soil horizons. It is likely that a hiatus in deposition took place between deposition of the basal reddish-brown calcarenite sands and the overlying Q2 sands. As such, the upper sections of the darker-coloured basal sands probably represent a palaeo-land surface.

The formation of the overlying upper calcrete layer (unit Q2cs) is considered to have taken at least 20,000 years prior to capping by Tower Hill ash 35,000 years ago. As such, the residual deposit containing CBS1 is considered to be at least 50–60,000 years old on geomorphic grounds

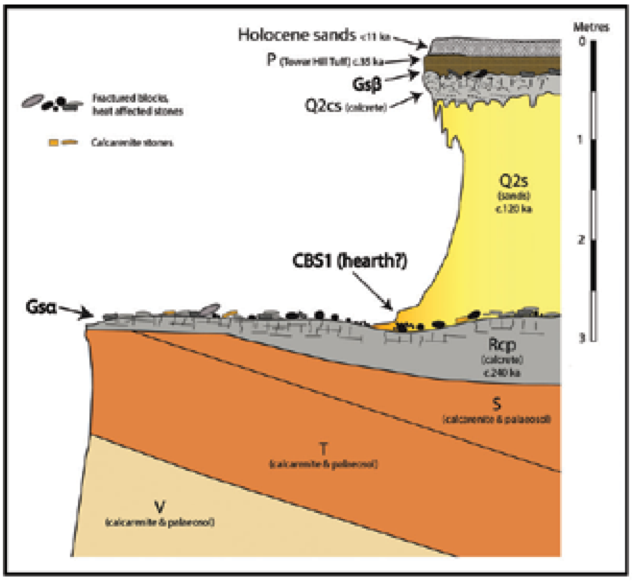

Figure 3: Composite stratigraphic column showing CBS1 and geochronological constraints (base drawing by Jim Bowler). Unit P consists of tuff or, as above CBS1, a brown pedified tuff (Carey et al. 2018).

(Carey et al. 2018). Broader stratigraphic and OSL dating interpretation of underlying sediments suggests strongly that unit Q sands, and by extension CBS1, dates to the Last Interglacial (~120,000 years ago) (see Carey et al. 2018; Sherwood et al. 2018a for details).

Unit Q2 sands contain scattered marine shell fragments (large and small) represented mostly by *Lunella undulata* (syn. *Turbo undulatus*) (Warrener) (both body shell and opercula), along with other rocky platform marine taxa such as *Haliotis rubra* (abalone*), Dicathais orbita* (dog winkle), Acmaeidae (limpet), and *Plaxiphora albida* (chiton) (Nair & Sherwood 2007; Sherwood et al. 2018b). This low-density shell deposit contrasts markedly with a high-density deposit of predominantly fragmented *L. undulata* shells located on top of West Stack opposite to CBS1 (Figures 1 and 2). West Stack has the same geomorphic context as CBS1 and both sites are considered to be of similar age (Carey et al. 2018). Nair and Sherwood (2007) argued for a cultural origin to both shell deposits. Habitat preferences for land snail species recovered from unit Q2 sands indicate 'a scrub or heathland in a dry and/or coastal region' similar to that seen today (Nair & Sherwood 2007: 72).

EXCAVATION OF CBS1

CBS1 was identified by JB as a likely cultural hearth feature in 2007. It had been partially uncovered by erosive retreat of unit Q2 at the western end of the headland (Figure 2). Cleaning up of the eroded and exposed surface of CBS1 by JB in 2007 revealed a concentrated area of charcoal and darkened sediment and what appeared to be burnt sediments and rocks consistent with a hearth. While neither faunal remains (bones and shells) nor stone artefacts were observed at CBS1, it was known that similar features designated hearths and dating to the Pleistocene have been recorded in South Australia and at Lake Mungo in western New South Wales (Clark & Barbetti 1982; Walshe 2012). To further test the hypothesis that CBS1 was indeed a hearth, additional excavations were led by IM over two weeks in November and December 2012 to obtain fine-grained stratigraphic, spatial and component data.

Excavation focused on the exposed southern half of the feature. The northern half of the feature remains buried under 40–60 cm of unit Q2 sands which were sectioned to create a vertical face (Figures 4, 5 and 6). The northern section was deliberately left unexcavated to allow for potential application of future detailed analyses. Excavation of southern feature sediments fronting the

Figure 4: CBS1 during excavation, 6 November 2012. Photograph: Ian J. McNiven.

Figure 5: CBS1 showing Square E (top left), D (top centre), L (top right), and C (front centre) after excavation and removal of sediments — looking north. The central depression in the basal calcrete is filled with dark brown sands containing charcoal fragments and burnt stones. Orange–brown sands (possible palaeosol) overlie CBS1 and grade into white dune sands. Red–white scale in 10 cm units. 17 December 2012. Photograph: Ian J. McNiven.

Figure 6: CBS1 showing Square E (top left), D (top centre), L (top right), and C (front centre) after excavation and removal of sediments — plan view. Dotted white line shows main area of CBS1. Red–white scale in 10 cm units. 17 December 2012. Photograph: Ian J. McNiven.

vertically cut section employed spits or excavation units (XUs) averaging 1.4 cm in thickness within a series of squares — Squares E, D and L (50 x 32 cm) and Squares B and C (50 x 50 cm). Squares E, D and L produced an E–W section through the feature while a N–S section was produced with Squares B, C and D (Figures 7 and 8). All observed charcoal fragments ≥2 mm in length were plotted in 3D and bagged separately. Excavated sediments were bulk bagged in the field and dry sieved through 2.1-mm mesh with total recovery of through-sieve sediments for further analysis. Sieve residues were subsequently re-sieved and washed through 2.1-mm mesh with freshwater in the laboratory. A total of 77.2 litres of deposit was excavated.

CBS1 DEPOSIT

The deposit forming CBS1 comprises a stratified sequence with a sandy loam matrix containing scattered fragments of charcoal and numerous locally derived angular to sub-rounded stones and carbonate concretions. Square D revealed the central and deepest sections of CBS1 in the form of a basin-shaped layer of brown sands containing numerous charcoal fragments and discoloured (dark-grey to grey) stones within a depression in the basal calcrete (unit Rcp). This basin-shaped feature has a maximum diameter of around 70 cm and depth of around 15 cm. Squares E, L and C adjoining Square D revealed the western, eastern and southern edges of the feature respectively. Severe erosion had stripped sediments in Square B to shallow (<2 cm) remnant pockets of sediment and exposed areas of basal calcrete. Superficially, CBS1 looks like the remains of a cultural combustion feature with hearth stones that functioned as a hearth and possibly a ground oven.

Stratigraphy

Five major stratigraphic units were identified (Figures 7 and 8; Table 1). Brown to dark-brown sandy loam represents Stratigraphic Unit 4 (SU4) and the major part of CBS1. It is overlain by brown to dark-brown loamy sand (SU3) that may be an old land surface. Above SU3 is SU2 representing partly consolidated pale-brown sand containing carbonate concretions. SU1 represents loose to mildly consolidated wind-blown sands and deflated stones and modern bottle-glass fragments that have accumulated recently on newly exposed and wind-eroded Pleistocene sands represented by SU3 and SU4. SU5 is brown sand to loamy sand associated

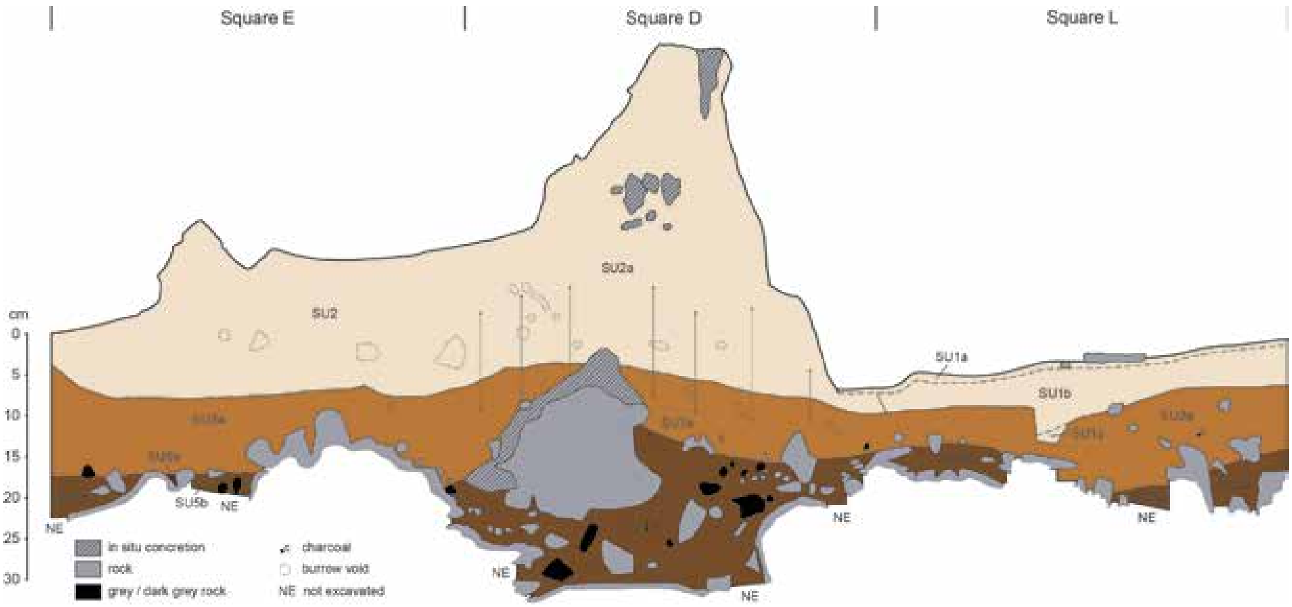

Figure 7: East–West section of CBS1 exposed in the north walls of Squares E, D and L.

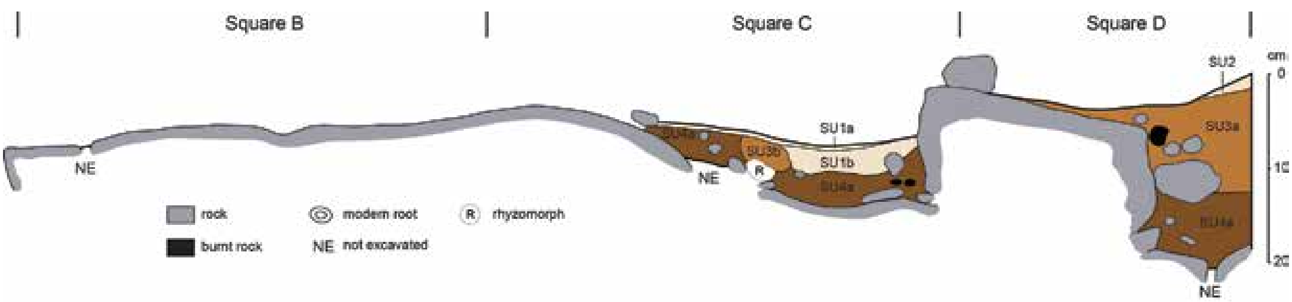

Figure 8: North–South section of CBS1 exposed in the west walls of Squares C and D.

Table 1: Stratigraphic unit descriptions for CBS1.

SU	Description
1	SU1 is sub-divided into SU1a, SU1b and SU1c, and comprises recent wind-blown sands that have been deposited on top of eroded and exposed Pleistocene sands. SU1a comprises loose, light brown (7.5YR 6/4) sand up to 1 cm thick sitting on top of SU1b. It has numerous stone inclusions. SU1b is mildly consolidated light brown (7.5YR 6/3; 6/4) to brown (7.5YR 4/4; 5/4; 4/4) to pink (YR7R 7/3) sand to loamy sand with scattered fibrous roots. SU1c is loose brown (7.5YR 4/4) sand with a restricted location at the base of a small pit feature filled with SU1 sediments in Square L. This pit feature is associated with exploratory excavations by Jim Bowler in 2007.
2	SU2 comprises partly consolidated light brown (10YR 6/4) sand with areas of sandstone concretion.
3	SU3 is subdivided into SU3a and SU3b. SU3a grades from dark brown (7.5YR 3/4) to brown (7.5YR 4/4; 4/3; 5/4) to strong brown (7.5YR 4/6) with depth. It ranges from mostly loamy sand in Squares E and D to mostly sand in Square L. SU3b is sandy loam that appears to be sediments partly altered by carbonates associated with formation of an underlying rhizomorph in Square D.
4	SU4 is subdivided into SU4a and SU4b. SU4a comprises brown (7.5YR 4/3; 4/4) to dark brown (7.5YR 3/3; 3/4) partly consolidated sandy loam with numerous inclusions of charcoal fragments and stones. The basal 2–3 cm of SU4a consists of silty loam sediments resting on calcrete and is slightly lighter in colour from infiltration of carbonates from weathering of underlying calcrete. SU4a represents the bulk of sediments forming the CBS feature. Many of the stones in it are rounded and have a grey colour postulated to be due to exposure to strong heat. SU4b is sand to loamy sand with a brown (7.5YR 4/3) colour and is restricted to a small area of Square L.
5	SU5 is subdivided into SU5a and SU5b. SU5a comprises brown (7.5YR 4/4) slightly compacted sand. It is easily differentiated from overlying SU3a sediments which are noticeably less compacted. It is located across the base of the excavation trench on the eastern side of the CBS feature in Square L and in some places rests directly on calcrete bedrock. SU5b is brown (7.5YR 4/4) loamy sand located across the base of the excavation trench to the west of the CBS feature in Square E and similarly sits upon basal calcrete bedrock.

with ancient sandstone concretions possibly pre-dating CBS1 formation. The apparent absence of SU5 sands and sandstone concretions underlying CBS1 suggest that they never developed within the depression feature or that they had been removed prior to CBS1 formation by natural erosion. The smooth and rounded surfaces of the calcrete depression are consistent with water erosion.

Sediments

The character of sediments was assessed for selected XU sediment samples from Square D. Samples were selected to construct a continuous vertical sequence. Sediment acidity (pH) was measured on a soil–water ratio of 1:5 (Rayment & Higginson 1992). The samples (1:5 water suspension) were mechanically shaken (end-over-end shaker) for one hour. A pH meter, HACH Sension156, standardised against buffer solutions of known pH, was used. Results indicate alkaline sediments ranging subtly from 8.93 to 8.25 with depth (Figure 9). This alkalinity reflects the high carbonate content of the surrounding limestone geology. The subtle decrease in alkalinity with depth possibly reflects increasing influence of the downward percolation (and possible pooling) of rainwater with higher acidity. It is probable that these high pH values also existed around the time of deposition indicating that sediment acidity levels conducive to the preservation of organic (e.g. shell and bone) remains have existed at the site since the LIG.

Sediments from 16 XUs used for the pH sequence were also subjected to particle size analysis. Ten grams of air-dried sediment and approximately 100 ml of 5% tetra sodium pyrophosphate ($Na_4P_2O_7$) were placed in a 250 ml beaker and left overnight to disperse at room temperature. The following day the beakers were placed on a hot plate and boiled for approximately 60 minutes, then cooled to room temperature. Sediments were not decalcified. The samples were wet sieved at 1000 microns (the size limit of the analyser). The particles retained on the sieve were transferred to pre-weighed petri dishes, air-dried to constant weight, and weighed (particles >1000 microns). The soil water suspension (particles <1000 microns) was analysed using the Backman Coulter LS 100 instrument. The particle size distribution was classified using the Standard Association of Australia scheme (McDonald et al. 1998). The size fractions are defined as sand (63–2000 microns), silt (2–63 microns), and clay (<2 microns). The sand-size fraction (total sand) is a sum of coarse sand (2000–600 microns), medium sand (600–212 microns) and fine sand (212–63 microns).

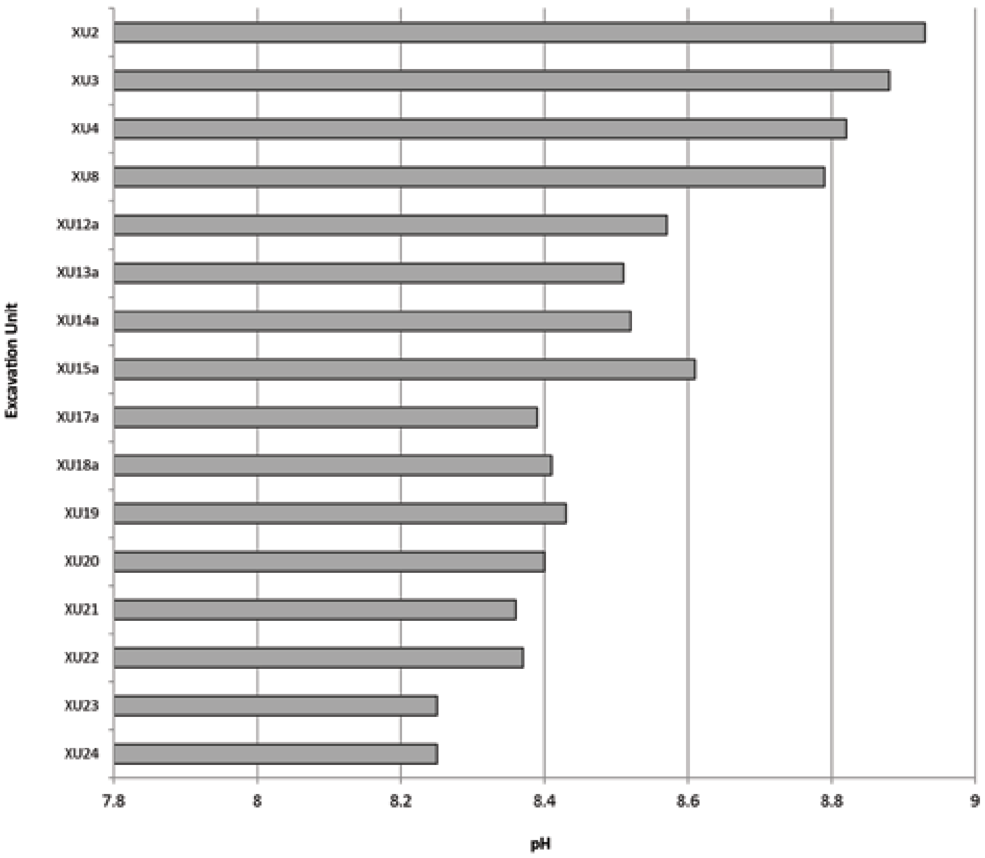

Figure 9: CBS1 pH values, Square D.

Particle size analysis reveals that sediments gradually become finer with depth with the proportion of fine sand, silt and clay increasing relative to coarse and medium sands from the top to the bottom of the sequence (Figure 10). No major change in the proportion of sand, silt and clay is seen across the SU3a–SU4a interface (i.e. between XU14 and XU15). Fining of sediments with depth is consistent with illuviation and the gradual and selective downward translocation of finer sediments as a result of downward percolation of water (Phillips 2007). Illuviation is limited to sediments with a pH of >6.5, which is consistent with the alkaline sediments of CBS1 (Quénard et al. 2011: 136). The presence of rhizomorphs and carbonate concretions is consistent with sustained post-depositional water percolation through CBS1 sediments.

Thus, both the pH and particle-size analyses point to long-term water percolation and fine-sediment mobilisation through the sequence producing small-scale, depth-dependent patterning. As such, these patterns are considered to be the long-term cumulative result of post-depositional processes. It is likely that most if not all of the water-percolation occurred prior to upper calcrete formation at least 50,000 years ago (Carey et al. 2018). No macroscopic evidence for clay-enriched lamellae (commonly 6–22 mm in thickness) of pedologic origin through illuviation and/or geologic origin through deposition (e.g. fluvial in-wash) was observed macroscopically in sediments during excavation or within wall sections (e.g. Bockheim & Hartemink 2013; Schaetzl 2001). The presence of an *in situ* fire-cracked rock within CBS1 further demonstrates that the feature is not a fluvial in-wash deposit (see below).

Rhizomorphs

A complex network of carbonate concretions has infiltrated the unit Q2 sands in which CBS1 is located. These concretions form as a result of percolation of rainwater carrying dissolved carbonates that eventually precipitate. To what extent concretions are in their original depositional context or have moved as a result of post-depositional disturbance is unknown. In many cases, concretions form as amorphous lumps within sands. Examples of these lumps were encountered in SU2a and SU3a (Figure 7). In other cases, carbonate concretions known as rhizomorphs or rhizoliths form moulds around roots, which can subsequently be in-filled with further carbonate materials to form solid root casts (Gill 1975; Klappa 1980; Semeniuk 1986). A rhizomorph cast with a diameter of around 3 cm was uncovered in the western part of Square C (Figures 8, 11, 12). This rhizomorph appears to have formed *in situ* and possibly represents a post-depositional intrusion into CBS1 by a root from a shrub growing around 2 m above the developing upper calcrete layer at least 50,000 years ago (see Carey et al. 2018).

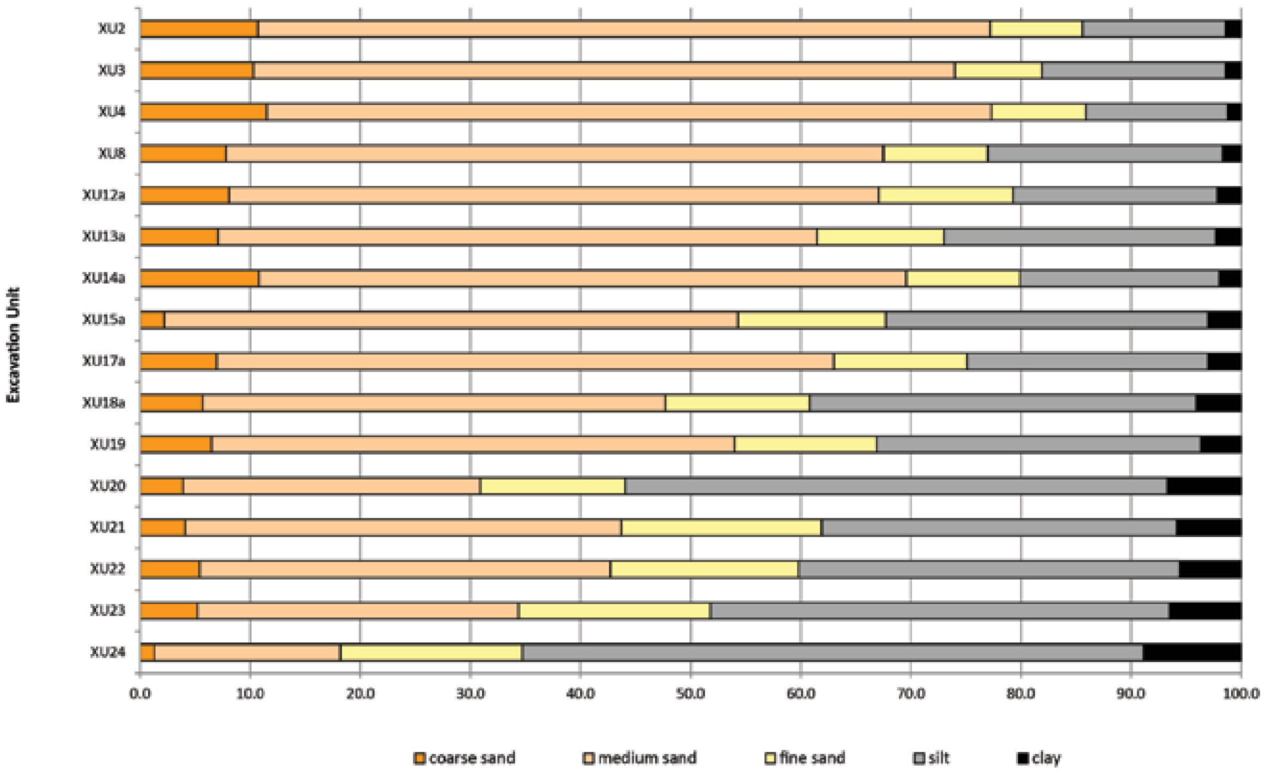

Figure 10: CBS1 sediment particle sizes, Square D.

Figure 11: CBS1 during excavation of upper level of feature with large fragments of charcoal surrounded by charcoal-stained sediments (Square C) and darkened (dark-grey to grey) stones (Square D) exposed at the end of XU4 (Square C) and XU12 (Square D). Note blackened (burnt?) mark on end of stone (S1) (arrowed). Photograph: Ian J. McNiven.

Bioturbation

It is likely that bioturbation (e.g. root penetration) took place during the formation of the overlying calcrete layer dated to over 50,000 years ago (see Carey et al. 2018). That some form of bioturbation may have taken place when CBS1 was located close to the ground surface is indicated by upward mobilisation of darker SU3a sediments into lighter-coloured SU2a (Figures 5 and 7). This zone of mixing across the lower sections of SU2a also corresponds to a zone of recent insect burrows into the exposed erosion face (Figure 7). As such, it is possible that palaeo-bioturbation may have disaggregated, dispersed, and over-printed depositional lamellae that were once present (Johnson et al. 2008). It is unlikely that burrowing insect activity contributed to sediment grain-size patterns noted above, as ants and termites tend to move fine sediments upwards and not downwards (McBrearty 1990; Van Nest 2002). Apart from root (rhizomorph) penetration, no other major palaeo-bioturbation processes are evident within CBS1 sediments. None of the stone inclusions within CSB1 sediments reveal evidence of rearrangement into stone-lines indicative of major bioturbation within a biomantle (e.g. Balek 2002). Indeed, some fired-cracked stones show little evidence of post-depositional movement (see below).

Land snails

Land snail analysis was undertaken by one of us (J. Stanisic). Most shells were reasonably preserved and identifiable to genus, with some shells ‘indeterminate’ due to the state of preservation, and others identified only as land snails. Of the 80 individual snail shells recovered, and 12 taxa identified, the majority of shells were *Elsothera* spp. (n=58, 73%) (Table 2). However, the modern-day fauna of this region remains poorly known and more detailed categorisation is not possible at this stage. The land snails recovered are referable to modern-day taxa existing in the coastal wooded areas of southern Victoria. *Elsothera* are ground surface-dwelling (i.e. non-burrowing) snails found within a wide range of habitats, ranging from leaf litter and under decaying logs in coastal heath, woodland and rainforest, to under rocks in drier areas of limestone cliffs (Smith & Kershaw 1979: 157–160; Stanisic et al. 2010: 190–194). As the depth of loose, sandy sediments at CBS1 was limited to less than 25 cm by the underlying calcrete when inhabited by surface-dwelling snails such as *Elsothera*, it is probable that the site only supported shallow-rooted plants such as grass and low shrubs.

Four specimens of ‘Land snail A’ were recovered from loose, recent (SU1) sediments. These fragments

Figure 12: CBS1 during excavation of Squares C (left) and D (right) looking west. The image shows the emerging basal calcrete (unit Rcp) and the middle level of the feature with darkened (dark-grey to grey) stones, an *in situ* stone (thermally?) fractured into three pieces (x), and charcoal (arrowed) exposed at the end of XU7 (Square C) and XU15 (Square D). Note darkened sediments surrounding concentration of darkened stones on right. Cemented onto the upper surface of a large calcrete stone (S1) is a small stone (S2) of *terra rossa*. A rhizomorph (fossil root cast) (R) exposed in Square C penetrates the southern sections of CBS1 and formed well after feature formation. Photograph: Ian J. McNiven.

Table 2: Land snails, CBS1.

SQ	XU	SU	Elsothera A	Elsothera B	Elsothera C	Elsothera D	Camaenid A	Charopid A	Charopid B	Succineid A	Scelidoropa A	Austro-chloritis	Magilaoma	Land snail A	Indeter-minent	Marine
C	1	1a	1													
	2	1b		1										1		
	10	4a			1										3 frags	
	11	4a					1									
	14	4a			1											
D	1	1a			1							1				
	2	3a											1			1
	4	3a			1											
	5	1a/b			2											
	6	1a/b											1			
	8	3a			1											
	12a	3a			1											
	13b	3a			4											
	14a	3a	1		1											
	14b	3a			2											
	15b	3a			1											
	19	4a			1											
	20	4a													6 frags	
	23	4a										1				
E	4	2			1											
	5	2			2											
	7	3a			3											
	8	3a			1											
	9	3a						1								
	10a	3a				4									1 frag	
	11b	3a			1											
	11c	3a											1			
	12b	3a				1										
	13b	3a				1										
	14b	4a				2										
	15b	4a	1												1 frag	
	16b	4a			1											
	17b	4a	1													
L	1	1a,b	3						1				1	1		
	2	1b	1						1				1	1	1	1
	3	1b				2			1	1		1	1	1		1
	4	3a			1			1		1					4 frags	
	6	3a			2											
	7b	3a					2 frags									
	7c	1b				3			1			1				
	8b	3a			2											
	8c	1c											1			
	9a	4b			1											
	9c	1b									1					
	10b	3a			2											
	10c	1b														1
	11b	3a			2											

appear to belong to the post-European introduced species *Prietocella barbara* (Fam. Cochlicellidae). This Mediterranean species, native to Europe, the Middle East and North Africa, is common across southern Australia and numerically abundant in coastal areas of Victoria, including dune habitats (Stanisic et al. 2010: 526). There were also four tiny marine snails recovered from recently disturbed sediments (SU1) (see below).

Charcoal and darkened stones

A total of 62 charcoal samples was plotted in 3D from XUs dominated by SU3 and SU4. For SUs 3, 4 and 5, most charcoal was recovered from Square C (16.40 g), followed by Square D (0.94 g), Square L (0.34 g) and Square E (0.02 g). In terms of charcoal density (expressed as grams per litre of deposit), counts are 20 times higher in SU4 (0.61 g/L) compared to SU3 (0.03 g/L) and SU5 (0.03 g/L). Clearly, SU4 within Squares C and D represents the core of CBS1.

Hundreds of mostly pebble-sized stones (all locally available headland calcrete) weighing 6524.24 g were recovered from XUs dominated by SUs 3, 4 and 5 in Squares C, D, E and L. Local calcrete is white to pale-brown in colour, yet 47.8% (3117.29 g) of stones recovered from CBS1 have been discoloured (burnt?) dark-grey to grey. In terms of the relative proportion of these darkened stones, highest counts were found in SU4 (50.8%, 2110.77 g), followed by SU3 (42.7%, 1003.49 g) and SU5 (16.5%, 3.03 g). Again, SU4 within Squares C and D represents the core of CBS1.

Artefacts and faunal remains

CBS1 revealed no evidence for original depositional association with stone artefacts or faunal remains (apart from tiny land snails). Essentially all artefacts and faunal remains (including introduced land snail species and tiny marine snails) were obtained from recently deposited loose aeolian sediments forming SU1. Tiny chips of basalt were recovered from recent SU1 sediments and probably derive from the adjacent roadway or paths. SU1 also contained fragments of bottle glass and rusty metal of modern origin, with one glass fragment (0.05 g) penetrating 2 cm into the surface level of SU3a in Square D. All of the 12 fragments of larger marine shells (1.76 g) were similarly recovered from SU1. Five marine shell fragments exhibit rounded edges indicative of wind/water erosion. The marine shells (large fragments and tiny snails) most likely derive from either the adjacent beach (through wind action) or late Holocene Aboriginal middens located within dunes immediately inland.

DETERMINING THE HEARTH STATUS OF CBS1

Three issues (linked to discrimination criteria) are associated with determining whether or not CBS1 is a hearth:

1. Does it represent *in situ* burning (as opposed to in-washed sediments)?
2. Does it represent features inconsistent with natural burning (e.g. burnt tree/shrub stump/roots)?
3. Does it exhibit features consistent with known hearth features (e.g. stratified lens- or basin-shaped deposit associated with burnt wood (charcoal), burnt sediments, burnt stones (hearthstones), artefacts, and food remains)?

These criteria are explored in detail below.

In situ burning?

CBS1 revealed a number of characteristics consistent with *in situ* burning and an *in situ* combustion feature. First, the feature contained macro-fragments of charcoal in the context of discoloured (dark-grey to grey) stones suggestive of burning (see below) (Figures 11 and 12). Second, a large calcrete stone (S1) located on the south-west margin of the feature (a possible windbreak stone — see below) exhibits a blackened mark on a protuberance on its northern end (Figures 8 and 11). This black mark looks nothing like blackening associated with lichen growth across other parts of the upper surface of the rock exposed by recent wind erosion to sunlight. Third, the area of blackening on S1 stone is located directly adjacent to an identical patch of blackening on an adjacent smaller stone (S3) (Figures 8, 12 and 13). We interpret this evidence to mean both stones were in their current positions when blackening, produced by fire, took place. Fourth, the upper third of the feature exhibits at least one large stone that has been fractured into three large fragments with only minimal subsequent movement of each fragment (i.e. they remain in 'jigsaw' fit; Figures 12 and 14). Similar fracturing of partly blackened and possibly burnt stones has been recorded elsewhere on Gsα at Moyjil (Bowler et al. 2018). The fact that the fractured stone remained largely *in situ* indicates that it has moved little since fracturing, which we attribute to the effects of fire (see Backhouse & Johnson 2007; Petraglia 2002: 254). Additionally, this stone and the scorch marks found on nearby stones negate the possibility of the feature representing a secondary deposit of relocated and dumped hearth materials (Miller et al. 2010). Furthermore, this stone, plus the lack of macroscopic evidence of fine laminae associated with fluviatile deposits, is inconsistent with infill by secondary deposition of in-washed burnt sediments from further afield (Goldberg et al. 2001).

Figure 13: Calcrete rock (S3) with area of blackening (possibly from burning), CBS1. White patch in middle of blackened area reflects removal of surface blackening and exposure of underlying 'fresh' calcrete during the excavation process. Scale in cm units. Photograph: Ian J. McNiven.

Figure 14: Stone showing *in situ* (thermal?) fracturing and darkening probably from burning (XU17, Square D) CBS1. Scale in cm units. Photograph: Ian J. McNiven.

Natural burning?

Two natural processes are potentially responsible for creation of CBS1 — lightning strike and bushfires.

Lightning strike? It is highly unlikely the deposit was created by direct lightning strike given the absence of diagnostic fulgurites (straw-like glass tubes formed by lightning-induced fusion of quartz sand grains) and explosively blasted large pit features (Clark & Harris 1985: 18; Knight & Grab 2014; Mahaney & Krinsley 2012; Melson & Potts 2002: 312; Pasek et al. 2012). Alternatively, bushfires can create burnt sediments with superficial similarities to CBS1 in three ways: scorching the ground surface (e.g. grass fires), burning of shallow sediments (e.g. area under a burning fallen tree trunk), and burning of deep sediments (e.g. burnt-out tree stump).

Passing bushfire? The clear presence of non-burnt areas surrounding the concentrated and contained nature of burning suggested by CBS1 is inconsistent with bushfire activity, in that such an activity would result in broad-scale burning of the ground surface (Bentsen 2012: 96). Furthermore, the depth of sediments containing charcoal and darkened stones (~15 cm) is much greater than the <3 cm depth of topsoil burning associated with natural bushfires of high severity (Humphreys & Craig 1981; Neary et al. 1999; Oster et al. 2012; Wright & Clarke 2008; see also March et al. 2014: figs 5a, 13), let alone the superficial burning (<1 cm) associated with low intensity fires such as grass fires (Bellomo 1993: 533). Chandler et al. (1983: 173) reported that 'even the most intense forest fire will rarely have a direct heating effect on the soil at depths below 7 to 10 cm' (see also Beadle 1940). Thus bushfires, especially those moving quickly through a lightly vegetated dune environment as once existed at the site, are unlikely to create the sustained high temperatures necessary to comprehensively burn and fracture stones such as those recovered from CBS1 (see also Bellomo 1993: 533).

Burning under a fallen tree trunk? Sediments exposed to sustained burning under fallen tree trunks can exhibit burnt (reddened) sediments down to a depth of 8 cm, with an underlying burnt (blackened) layer 1–15 cm in thickness, in circumstances where soils have high organic content (Ulery & Graham 1993). This scenario is unlikely for CBS1, given the probable absence of trees as part of the Pleistocene vegetation on the thin dune sands and the low organic content of the dune sands.

Burnt tree stump? CBS1 revealed evidence that is both consistent and inconsistent with the burnt tree stump hypothesis. For example, the absence of reddened sediments within the feature is ambiguous given that burnt tree stumps can produce oxidisation (reddening) of sediments with intense burning (Thoms 2008: 455) or little or no oxidisation for low intensity burnt tree stumps (Bellomo 1993: 533). Evidence considered inconsistent with the burnt tree stump hypothesis includes:

1. Burnt-out tree stumps tend to create pit voids ('tree well' — Thoms 2007) that subsequently fill with in-washed non-burnt sediments and not lens- or basin-shaped features filled with charcoal and darkened stones as seen at CBS1 (Bellomo 1993: 533, 545, 547; Connor & Cannon 1991: 10; Thoms 2007: 480).
2. In cases where a burnt-out tree stump exhibits considerable charcoal, the charcoal tends to form a dense deposit at the base of the pit (Johnson 2004: 5, fig. 5) — such a basal concentration of charcoal was not observed at CBS1.

3. None of the numerous charcoal fragments recovered from CBS1 were in linear arrangements suggestive of *in situ* burnt roots (Gowlett et al. 2017: S211, S214: Thoms 2007: 480).

However, the type of wood that formed the charcoal within CBS1 is consistent with the burnt tree stump hypothesis. Hearths tend to contain above-ground wood as fuel and often from a range of species (e.g. Barbetti 1986: 779; Byrne et al. 2013; Smith et al. 1995; Whitau et al. 2018). Most collected firewood is dry deadwood, especially branches, but may also include roots from fallen trees (Gelabert et al. 2011: 381). In marked contrast, natural charcoal deposits such as burnt-out tree stumps feature large and small burnt roots from an individual plant and hence species. In some cases, hearths can carbonise underlying rootlets (Mallol et al. 2007: 2039, 2045).

Detailed analysis for the presence of root-wood charcoal within CBS1 was undertaken by one of us (ND) using an Olympus metallurgical microscope with transmitted incidental light mostly using ×100 magnification (range: ×50 to ×500). Analysis was limited to 30 3D-plotted and three sieve-recovered charcoal specimens (each weighing >0.01 g) from SU3 and SU4 in Squares C and D. Transverse, radial, and tangential surfaces were examined for diagnostic structures. Identification of root wood was based largely on a high density of vessels (xylem) that transfer water up into the main plant structure above ground. Most if not all specimens were considered to represent burnt wood from hardwood angiosperms (flowering plants). Only 16 of the 30 3-D-plotted specimens were diagnostic to allow an assessment of root vs above-ground wood. Of these, the likelihood of a correct designation as root wood ranged from definite (n=2), probable (n=11), to possible (n=3). The two definite designation specimens had tiny root hairs protruding from their surface strongly suggestive of underground burning within a protective sediment matrix. Of the thirteen definite and probable specimens, ten were considered to be from the same taxon and seven specimens provided an estimate of original root diameter (1.5–4 cm, n=6; 10 cm, n=1). As such, just under half of the identified charcoal specimens examined were either definitely or probably root wood (nearly all of these came from the same taxon) and none were identified as above-ground wood.

The data from the wood structure analysis strongly suggest that nearly half of all the identifiable charcoal excavated from CBS1 represents roots from a single taxon. These findings are consistent with an *in situ* underground burning of plant roots. However, the overall representativeness of the identified roots is difficult to assess given that nearly half of the charcoal specimens could not be diagnosed as either root or above-ground wood. Furthermore, the thermal impact of these burning roots is unlikely to have extended more than a few centimetres into surrounding sediments and certainly would not have been capable of subsurface burning and blackening of stones and thermal fracturing of the large stone in Square D XU17. Thus, CBS1 is considered to reflect two types of combustion processes — first, an open fire to allow burning and fracturing of stones (consistent with a hearth), and second, post-depositional intrusion of burnt shrub roots (consistent with a natural bushfire).

Burnt stones?

All stones within SU3 and SU4 sediments are calcrete, a rock type used effectively and extensively as hearthstones elsewhere (e.g. Backhouse et al. 2005; Backhouse & Johnson 2007). Thousands of similar stones of varying size and shape (i.e. angular to sub-rounded) were located across the exposed and eroded surface of the ‘lower calcrete’ bench (Gsα). Unlike CBS1, large areas of exposed stones became cemented to the ‘lower calcrete’ surface after burial by Q2 sands. Small patches of blackened stones similar to those recovered from CBS1 were found in a number of areas, albeit cemented to the underlying calcrete. But is the darkening of stones recovered from CBS1 a result of burning? As is well known, burnt hearthstones used as heat retainers are a feature of many hearths. Diagnostic traits include colour change (e.g. blackening and reddening), thermal cracking and spalling (Backhouse & Johnson 2007; Gur-Arieh et al. 2012; Pagoulatos 2005).

Blackened stones. The darkened colour of 48% (by weight) of stones within CBS1 differs from white to pale-brown calcrete exposed across the headland. Many of the dark-grey stones were almost black in colour when excavated due to moisture content (e.g. Figure 14). As pale colours characterise calcrete outcropping at Moyjil, it is clear that the darkened stones have been modified in some way. Darkening and blackening of calcretes within coastal contexts is a well-known phenomenon and results from a range of natural processes such as mineral deposition (e.g. iron sulphides, manganese oxides), organic impregnation and organic (root) infiltration and calcification, and natural and/or cultural processes of carbonisation through fires. Mineral and organic surficial impregnation of calcretes is associated with decayed vegetal matter (e.g. algae) in anoxic marine/freshwater micro-environments (Strasser 1984). In marked contrast, the darkening of CBS1 stones usually extended well below the surface and in most cases where stones were freshly cracked in half during excavation the darkening penetrated to the centre. For example, the large stone from XU9c (Square L) revealed a dark-grey to black outer layer and grey core (Figure 15). Bowler et al. (2018) attribute such colouration of stones at Moyjil to burning.

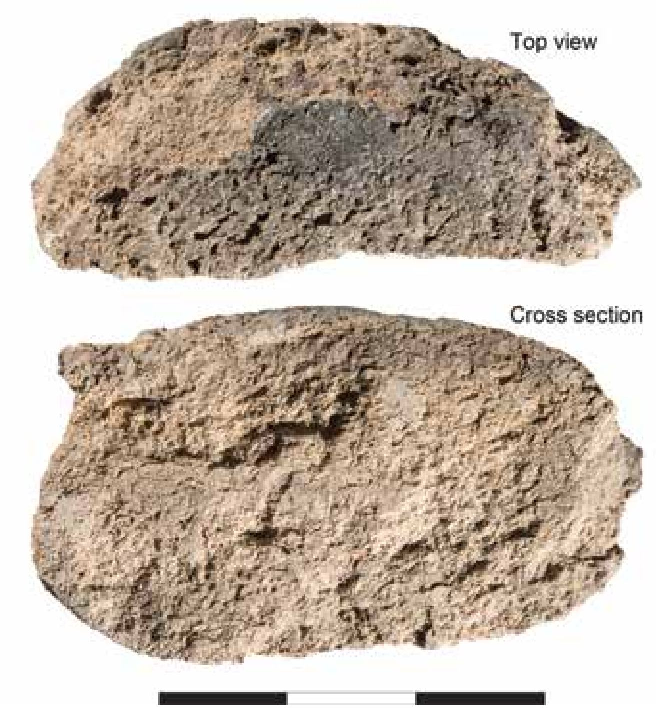

Figure 15: Stone (fractured post-excavation) revealing black to dark-grey surface and grey core from XU9c, Square L, CBS1. Scale in cm units. Photographs: Steve Morton.

The organic (root) calcification hypothesis is most relevant to CBS1, as stones naturally blackened by fossil organic inclusions have been documented for southern Australia coastal calcretes (Miller et al. 2013; see also Shinn & Lidz 1988). Miller et al. (2013) argued that such blackened stones form in small (20–120 cm diameter) and shallow (5–10 cm) depressions in limestone. Detailed chemical analyses revealed 'a direct exponential correlation between the weight percent carbon and the degree of black coloration' (Miller et al. 2013: 346). The carbon is argued to be the fossil (calcified) remains of roots of overlying plants. Blackened stones are further argued to result from the calcification of buried root mats in small shallow depressions that eventually break-up into small plate-like angular fragments. It is possible that some of the blackened stones within CBS1 are discoloured by incorporation of calcified (fossil) roots. However, if present, such darkened stones must have formed elsewhere as the calcrete depression containing CBS1 exhibited no diagnostic evidence of a residual calcified root mat in the form of blackened platy stones cemented to its surface.

It seems clear that some of the stones within CBS1 were darkened through a process of burning. Backhouse et al.'s (2005: 706) experimental burning of caliche (a form of calcrete) hearthstones at temperatures averaging 280–370°C (max. = 670°C) produced near-identical colour changes such that 'a general trend from color designations dominated by white, pink and pale hues prior to burning is replaced by designations dominated by browns and greys after burning' (see also Lintz 1989). Indeed, 'the post-burn assemblage is dominated by high frequencies of gray and dark gray nodules' (Backhouse et al. 2005: 706). Nearly all darkened stones from CBS1 were discoloured over the entire surface. Such comprehensive discolouration is more a feature of sustained burning in hearths, whereas 'confinement of discoloration to one area of a cobble is prime evidence of natural burning' (Lintz 1989: 344; Pagoulatos 2005). Backhouse et al. (2005: 710) noted further that comprehensive subsurface discolouration reflected exposure to sustained high temperatures such as occurs in hearth contexts in contrast to the short and intense heat of bushfires. Experimental burning of fragments of Moyjil calcrete by one of us (JB) found that comprehensive blackening occurred after an hour of immersion within an open fireplace reaching temperatures estimated to be 350–500°C (Bowler et al. 2018).

Non-blackened stones. Just over half of all stones recovered (52% by weight) revealed no signs of darkening. In marked contrast, experimental burning of calcrete in open fireplaces resulted in near complete darkening of stones (Backhouse et al. 2005: table 5). As such, Backhouse et al. (2005: 710) suggested that unburnt stones found mixed with burnt stones in archaeological hearth sites represented 'post-depositional inclusions'. However, other experimental studies found that not all heated stones within open hearths evidenced colour change and soot blackening (Gur-Arieh et al. 2012: 127, 130). Significantly, burning of limestone within experimental hearths by Pagoulatos (2005: 311–312) revealed that long-term burning and re-use of hearths resulted in whitening in 38% of hearthstones and that blackening 'tended to be uncommon'. Similar experiments using limestone hearthstones by Homsey (2009: 109–110) produced subtle, thermally induced colour changes of bluish grey or white. Significantly, Bowler's experimental burning of Moyjil calcrete similarly resulted in some blackened surfaces eventually turning to white due to 'reduction to lime by loss of carbon dioxide at highest temperature' (see Bowler et al. 2018 for details). These experimental studies reveal that darkened stones may only represent a subset of thermally-impacted stones within hearths. As such, many of the non-darkened stones recovered from CBS1 may also have been thermally altered.

Fracturing. As noted above, a large burnt stone that had been fractured *in situ* into three conjoinable pieces was uncovered fully in XU17 (Square D) within the upper half of SU4 (Figures 12 and 14). It is unlikely that this tough stone fractured simply as a result of application of pressure from overlying sands. Alternatively, the curvilinear fractures are more consistent with thermal fracturing. Catastrophic

Figure 16: Dorsal surface (left) and ventral surface (right) views of two possibly thermally fractured spalls from CBS1. Left: XU13 (Square C), right: XU22 (Square D). Scales in cm units. Photographs: Steve Morton.

thermal fracturing of stones indicates elevation of core nodule temperature to high levels from sustained application of heat (Backhouse et al. 2005; Backhouse & Johnson 2007: 1372). Lack of obvious potlid depressions (produced by removal of small cone-shaped spalls through rapid heating) probably reflects that limestone-based rocks tend not to potlid with thermal impact (Homsey 2009; Pagoulatos 2005; cf. Barbetti 1986: 780).

Spalling. Seven burnt (dark-grey to grey) large spalls with a distinctive concave/convex ventral surface and undulating outer stone (dorsal) surface were recovered from Squares C and D (Figure 16). The presence of such spalls is indicative of rapid and intense heating of stones from direct application of fire such that a major temperature differential occurred between surface and core nodule temperature (Backhouse & Johnson 2007: 1372; McParland 1977; Neubauer 2018: 684–685; Ng 2004: 38–39; Pagoulatos 2005; see also Lintz 1989: 336, 340).

Hearth structure?

Structurally, the area of burning (charcoal and burnt stones) forming CBS1 is basin-shaped due to location within a natural depression within the calcrete bedrock. Use of natural concavities for hearths is rare (Vallverdú et al. 2012; but see Aldeias et al. 2012; Meignen et al. 2007). Bellomo (1993: 550) argued that a basin-shaped profile over a vertical distance of up to 15 cm is a primary distinguishing feature of human hearths. The recessed position of CBS1 would have provided protection for a fireplace and helped insulate and constrain heat to a restricted area. Furthermore, two stones (S1 and S3), and possibly a third stone (S4), located at the western margins of CBS1 are of a size and location that would have provided an effective windbreak from southerly winds (Figure 12). Significantly, S1 is surmounted by a fragment of naturally pink-coloured *terra rossa* sandstone (S2) that has cemented to S1 via subsequent deposition of carbonate (Figure 8). Bowler et al. (2018) argue that S2 was placed upon the top of S1 through human agency, as movement by natural processes is less likely. S2 also has a small thermal spall on its east side cemented in place (Figures 11 and 12).

Hearths are known to have a basic stratification of ash-rich deposits often overlying a charcoal-rich layer with a basal layer of burnt sediments (Bentsen 2012: 95; Mallol et al. 2007; Robins 1996; Petraglia 2002). While basal sediments are often rubified — i.e. reddish in colour from heat-induced oxidation of iron-rich minerals (Bellomo 1993) — other experimental research suggests basal 'reddening of the soil happens only rarely' in humic soils (Canti & Linford 2000: 385, 392; see also Aldeias et al. 2016: 73–74; Mentzer 2014). No obvious diagnostic reddening was macroscopically visible within SU4 sediments across the base of CBS1. Absence of basal reddened sediments is known to be characteristic of small pit hearths where 'rapid filling of the depression by a layer of charcoal and ashes raises the centre of combustion, thus acting as an insulator rather than a fuel' (March et al. 2014; see also Canti & Linford 2000: 386). Furthermore, controlled experimental research by Aldeias et al. (2016: 71, 73) revealed that 'limestone sands' (comparable to the calcium-rich sediments within CBS1) tend not to rubify, probably due to 'mineralogy and the lower conductivity of carbonates'. It is also possible that long-term illuviation has overprinted any reddish basal layer.

The ~15 cm maximum thickness of CBS1 is consistent with the thickness of thermally altered sediments in

Aboriginal archaeological hearth sites in Australia (Robins 1996: 34; Wallis et al. 2004) and elsewhere (e.g. Sievers & Wadley 2008: 2910), and is also consistent with experimentally-produced hearths (Bellomo 1993: 533; Bentsen 2012: table 3). However, the existence of darkened stones (at least some of which appear to have been burnt) over a depth of ~15 cm suggests some form of mixing of sediments has taken place given that experimental hearth research reveals that the depth of burning within sediments only takes place within ~5 cm of the fireplace (Sievers & Wadley 2008; Werts & Jahren 2007). Whether such mixing took place during hearth use (e.g. heaping of heated stones and associated sediments around food to aid cooking, cf. ground oven), during hearth re-use (e.g. pushing previously heated stones and associated sediments to the side to create a new fire-pit hollow), and/or post-depositionally (e.g. bioturbation), is unknown (Bellomo 1993: 533; Isaacs 1989: 51–57; Thoms 2007, 2008). Such mixing may also account for inclusion of non-burnt stones. In this connection, the *in situ* heat-fractured stone in XU17 (Figures 12 and 14) suggests strongly that the upper half of the feature has undergone little disturbance during what may have been the final phase of hearth use.

CONCLUSIONS

Table 3 summarises the detailed discussion of discrimination criteria used to distinguish cultural hearths from naturally burnt features. A majority of hearth discrimination criteria produced positive evidence while the majority of natural feature discrimination criteria produced negative evidence. While discrimination criteria could not demonstrate conclusively that CBS1 is a hearth, they also could not demonstrate that it is

Table 3: Summary of cultural and natural discrimination attributes for CBS1.

General combustion feature attributes	**Present**	**Equivocal**	**Absent**
1. primary (*in situ*) combustion deposit	x		
2. charcoal	x		
3. thermally fractured stones (spalls)	x		
4. thermally fractured stones (angular fragments)		x	
5. thermally altered stones (darkened)		x	
6. thermally altered sediments		x	
Hearth attributes			
1. lens- or basin-shaped cross-section	x		
2. peripheral windbreak stones	x		
3. exotic (introduced) stones	x		
4. moderately deep (~15 cm) thermally altered deposit	x		
5. subcircular plan view	x		
6. reddened basal sediments		x	
7. non-root wood charcoal		x	
8. multiple charcoal taxa		x	
9. stone artefacts			x
10. faunal remains			x
Burnt tree trunk attributes			
1. root wood charcoal	x		
2. single charcoal taxon		x	
3. linear charcoal (root) features			x
4. in-filled pit void ('tree well')			x
5. basal charcoal deposit			x
Burnt fallen tree/branch attributes			
1. linear burnt sediment zone			x
2. shallow (<5 cm) burnt sediments			x
Lightning strike attribute			
1. fused sand (e.g. fulgurites)			x
2. explosively-blasted large pit feature			x

exclusively a natural feature. On balance, the broad range of discrimination criteria marginally point more towards CBS1 representing a cultural hearth and not exclusively a naturally burnt feature. As such, some evidence exists for CBS1 representing a ~120,000 year old hearth. However, the evidence for CBS1 as a hearth must be definitive and irrefutable for such a substantial claim to be considered credible, given the significant implications that this would have for world history. At this juncture, CBS1 does not meet this high level evidential threshold.

Arguably the biggest limitations on demonstrating the cultural status of CBS1 are the absence of stone artefacts and faunal remains, the presence of burnt roots, and ambiguity over processes responsible for blackening of many stones. Yet the absence of definite cultural materials cannot be considered to negate the hearth hypothesis. Many known hearth and ground-oven sites contain no stone artefacts or faunal remains, especially those associated with cooking plant foods and not animal foods (Bang-Andersen 2015: 86; Black & Thoms 2014). Indeed, parallels can be drawn with recent Aboriginal plant food cooking hearths in western Victoria and nearby south-east South Australia (Godfrey 1983: 57; Luebbers 1978: 102; Witter 1977: 57).

The complex nature of hearth sites, coupled with numerous morphological overlaps with naturally burnt features, often results in analyses plagued by issues of equifinality. This issue of identification and differentiation is particularly relevant for ancient hearths that have been subject to long-term taphonomic processes and post-depositional modification. This paper brings together a wide range of macroscopic and to a lesser extent microscopic methods to develop a series of discrimination criteria and multiple lines of evidence to assess the cultural status of CBS1 at Moyjil. Although our resulting 'on balance' conclusion is not conclusive in terms of the substantive question of cultural versus natural origins, methodologically our approach is instructive in terms of the broad range of issues and complexities that need to be considered in hearth identification.

This paper has presented the results, albeit equivocal, of the first phase of research on CBS1 at Moyjil using mostly macroscale (macroscopic and macromorphological) evidence. Further research is required to strengthen conclusions on the feature's origin, given its age and potential cultural significance. In this connection, three interrelated lines of microscale (microscopic and micromorphological) evidence would be informative. First, testing for the presence of burnt sediments and associated mineral transformations diagnosed through Fourier Transform Infrared Spectroscopy (FTIR) (e.g. Berna et al. 2007, 2102; Shahack-Gross et al. 2014; Stahlschmidt et al. 2015); magnetic transformations diagnosed through magnetic susceptibility (Bellomo 1993; Dalan 2008; Fanning et al. 2009; Gose 2000; Maki et al. 2006; Weston 2002); and TL dating (Brodard et al. 2012; Rengers et al. 2017). Second, testing for the presence of specific types of plant remains (especially in ash) via microfossils such as phytoliths (e.g. Albert & Marean 2012; Thoms et al. 2015) and calcitic crystalline structures (e.g. Canti 2003; Mentzer 2014: 625–629; Schiegl et al. 1996). Third, identification of microfeatures and components, and depositional and taphonomic processes, through micromorphologic analysis of resin-impregnated block sediment samples (e.g. Goldberg et al. 2001, 2017; Mentzer 2014: 651–656; Stahlschmidt et al. 2015).

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