

GEOLOGY OF NELSON BAY CAVE, ROBBERG, SOUTH AFRICA

KARL W. BUTZER

Departments of Anthropology and Geography, the University of Chicago

Nelson Bay Cave is located on the southern face of the Robberg Peninsula on the south-eastern Cape coast of South Africa, near Plettenberg Bay. Co-ordinates are approximately 23° 22' 30" E and 34° 6' 10" S, and the mouth of the cave is at about 19–21 m above MSL. Systematic excavations were carried out in 1964–5 by R. R. Inskip (1965), and in 1970–1 by R. G. Klein (1972*a*, 1972*b*) and Inskip (this volume). The general geology and geomorphology of Robberg has already been studied by John Rogers (1966) and mapped at a scale of 1:7200. Rogers's meticulous work supersedes the cursory observations of the older literature and makes it unnecessary to outline the bedrock suite or structure, except in so far as they concern Nelson Bay Cave.

The present paper is based on field investigations in 1970 and 1971 followed up by laboratory analyses. The results are described in adequate detail since they are informative beyond the context of the archaeological sequence within Nelson Bay Cave. Most of the existing literature on cave sedimentology refers to limestones or dolomitic lithologies, whereas next to nothing has been published on quartz-sandstone and quartzite caves, of which Nelson Bay Cave provides an excellent example. Thus interpretation of this cave sequence poses a number of interesting and novel problems. Furthermore, the sediments of Nelson Bay Cave provide paleo-environmental information that is related to a relative and chronometric stratigraphy, and which is complemented by several categories of faunal analyses (Klein 1972*a*, 1972*b*) and oxygen isotope studies presently under way by N. J. Shackleton. These data complement the external sequence of geomorphological and pedological events (see Butzer & Helgren 1972), so contributing to an understanding of Quaternary palaeoclimates in the southern and south-eastern Cape Province of South Africa.

The Origins of the Cave

The cliffs of Robberg are punctuated with notches, caves and other erosional features that are primarily a direct result of wave-cutting at various times. However, the great majority of these features are closely related to lithological variation, bedding, and other structural features of the bedrock. This reservation also applies to the bulk of Rogers's inventory of possible indicators of former high sea-levels (Rogers 1966: Table 12), even though the great majority may well be relevant to various stages of wave erosion. Rogers's frequency graph (1966: fig. 17) singles out two levels of recurrent features that, also in view of their morphology, must be attributed to former sea-levels at about 30 m and again at about 15–18 m.

The two largest caves on the south face of Robberg,

namely Nelson Bay (or Wagenaar's) Cave and Hoffman's Cave (East Ghwanogat), were probably initiated by wave-cutting at about 15–20 m. However, both of these caves are developed in a breccia frequently found at the contact of the quartzite of the Silurian Table Mountain Series and the quartzitic sandstone of the Cretaceous Uitenhage Series. The age of this 'contact' breccia remains uncertain. At Hoffman's Cave the Table Mountain quartzite dips at 10° to N50°E, the overlying Contact Breccia at 27–25° to N70°E, and the Uitenhage Series above at 10° to N80°W. Comparable angular unconformities are evident at Nelson Bay Cave, except that the Contact Breccia dips at 6–9° to N50°–90°E. In each case the caves are almost exclusively cut into this breccia, in situations where the breccia is unusually thick and was fortuitously exposed in the cliff face in relation to a particular sea-level. Just as the Contact Breccia was prerequisite to the development of large caves at these particular sites, this same formation has remained the primary local source of mineral sediment.

The Contact Breccia at Nelson Bay Cave can be subdivided into three units:

(a) The *lower* bed, over 3 m thick, consists of coarse-to-cobble grade, subangular to angular quartzite rubble set in a silcrete, sandy loam matrix. Colours of the matrix vary from white to pale yellow and yellow (10 YR- 2,5 Y), depending on the degree of superficial weathering. Stratification of rubble limited, sorting moderate.

(b) The *intermediate* bed, about 1,5 m thick, has poorly sorted, fine-to-boulder grade detritus, sub-rounded to subangular, set in a comparable matrix. Marked stratification of pebbles.

(c) The *upper* unit, about 2 m thick, is comparable to the lower bed (a), except that stratification is more pronounced.

The intermediate and upper beds of the Contact Breccia have supplied most of the coarser detritus in the cave infilling. Superficially, the matrix of the Contact Breccia is oxidized by weathering or impregnated with some secondary carbonates. In the process of disintegration, slabs and splices peel off the roof along the bedding planes. This appears to be mainly in response to pressure releases, although weathering along fissures and cracks is indicated by superficial corrosion of the siliceous matrix, presumably through a combination of soil and rain waters, aided by sea-salt. The quartzite rubble within the Contact Breccia is another matter. It is jointed and fractured but, despite such potential lines of weakness, now seldom breaks up when detached from the intact breccia. Thus, whereas the matrix gradually disintegrates into fine-grained constituent parts or alteration products,

the quartzite rubble remains largely uncomminuted. Frost is practically unknown along the south-eastern Cape coast today, and only three of twelve climatic stations between George and Port Elizabeth have ever recorded subfreezing temperatures. In fact the mean lowest temperature of each year ranges from +1.4 to +5.3°C at these same stations (*Climate of South Africa*, 1954), and frost or frost-weathering must be totally absent in the far less extreme micro-environment of the cave. This does not, however, preclude the possibility of effective frost-weathering in the Pleistocene at times of cold, pleniglacial climate.

The formation of Nelson Bay Cave was initiated by wave-cutting at a time when relative sea-level stood at +15–20 m, judging by maximum roof elevation at +21 m and a floor rising from the back of the cave at +11 m to a rock threshold at +18–20 m. Wave-generated deposits are restricted to beach sands and spherical beach gravels in the rear of the cave to a maximum elevation of +12 m. This presupposes a low-level entrance, presumably a large fissure along the bedrock unconformity, that has long been filled with sediment but which once allowed storm waves to surge up into the back of the cave. These marine deposits at +12 m presumably reflect a part of the +5–12 m sea-level stage widely represented along the south-eastern Cape coast and which is most reasonably correlated with the Eem Interglacial (Butzer & Helgren 1972). In terms of C^{14} years the age is substantially greater than 40000 B.P. The correlation of the preceding +15–20 m stage remains conjectural, but an early Eemian age now seems very unlikely in view of more recent field-work (1973) at Klasies River Mouth and Swartklip.

The development and gradual enlargement of Nelson Bay Cave from the +15–20 m stage to the later phases of the +5–12 m stage presuppose a considerable span of time, no matter how indefinite. And the cavern is appropriately large, measuring 36 m long and 18 m wide on a trapezoidal plan, and ranging from 2 to 8 m in height. After the initial notch(es) was cut into the Contact Breccia, enlargement followed the relatively weak bedding planes of this breccia and both the north-easterly dip of the rock and the orientation of the cave axis reflect on this structural property. After the external shoreline dropped to below 10 m or so, the fissure at the back continued to serve as a conduit for rain and ground water—both to enter and drain away after heavy rains—and as a sluice for slow sediment removal. However, this exit has been ineffective for all but solubles and clays since waves ceased to flush it out. This can be deduced from the estimated 1 000 m³ of mineral sediment preserved, none of which appears to predate the +10–12 m beach deposit and a third of which is extraneous. Yet at least 3 000 m³ of Contact Breccia were destroyed during the course of cavern formation, so that a volume of as much as 2 500 m³ was removed prior to the time of the +10–12 m beach.

The Sediment Analyses

Excluding several suites from other sites on Robberg, a total of 31 sediment samples were collected in Nelson Bay Cave during the 1970 season, and 38 during the 1971 season. All of these were processed in preliminary fashion while in the field, including determination of colour (dry, from the *Munsell Color Charts*), structure, consolidation, stratification, any calcification or oxidation features, humus and other organic forms, and estimated texture.

The 1970 collection was subsequently analysed in the Paleo-Ecology Laboratory of the University of Chicago, including: (1) Hydrometer analyses, using a 5 per cent solution of sodium pyrophosphate as a peptizing agent, and subsequently passing the sand fraction through a set of standard sieves (63, 210, 595 and 2 000 microns). The samples were previously decalcified in 25 per cent hydrochloric acid after first removing all shell or bone fragments that did not pass the 2 mm sieve. Secondary ferric concretions were removed from the final residues and their weight subtracted from the original input. The resulting textures were classified according to the U.S. Soil Survey system, with sorting of fines as defined by Payne (1942). Sand percentages are given as the 63–200 micron fraction. (2) Calcium carbonate determinations by the Chittick gasometric apparatus. (3) pH and mV values, electrometrically, in distilled water. (4) Semi-quantitative estimates of sand grain micromorphology and composition, including degree rounding, frosting and the ratio of primary quartz to quartzite-derived sands. The great majority of the samples were further analysed by the Soils Department of the University of Wisconsin, under the supervision of E. E. Schulte, for: (5) Organic matter by the Walkley-Black method, which involves addition of sulphuric acid to a weighed sample with standard potassium dichromate; after reaction the excess chromate is backtitrated. (6) Available phosphorus, extracted with 3 per cent NH_4F in 10 per cent HCl. In alkaline sediments, such as those represented here, this method extracts mainly P_2 bound to carbonates and in various soluble organic forms. (7) Available potassium, mainly potassium salts, by the standard extraction method. (8) Free Fe_2O_3 , by reduction to ferrous iron by $Na_2S_2O_4$ in a sodium buffer.

Analysis of the 1971 collection was completed after submission of this paper (March, 1972) but the key results are included here.

Beyond the fine-sediment studies, 27 collections of crude detritus (greater than 1.5 cm) were studied by the various morphometric techniques, primarily modified after those of G. Lüttig, outlined by Butzer (1971: 166 ff): (a) ρ is the index of rounding; (b) CV of ρ is the coefficient of variation to express the uniformity of rounding properties; (c) E/L and E/l are ratios that provide indices of flattening, with L the major axis, l the minor axis, and E the height of the pebble. Finally some 4 600 pieces of 'non-artefactual' stone were lithologically classified.

The more important categories of analytical data

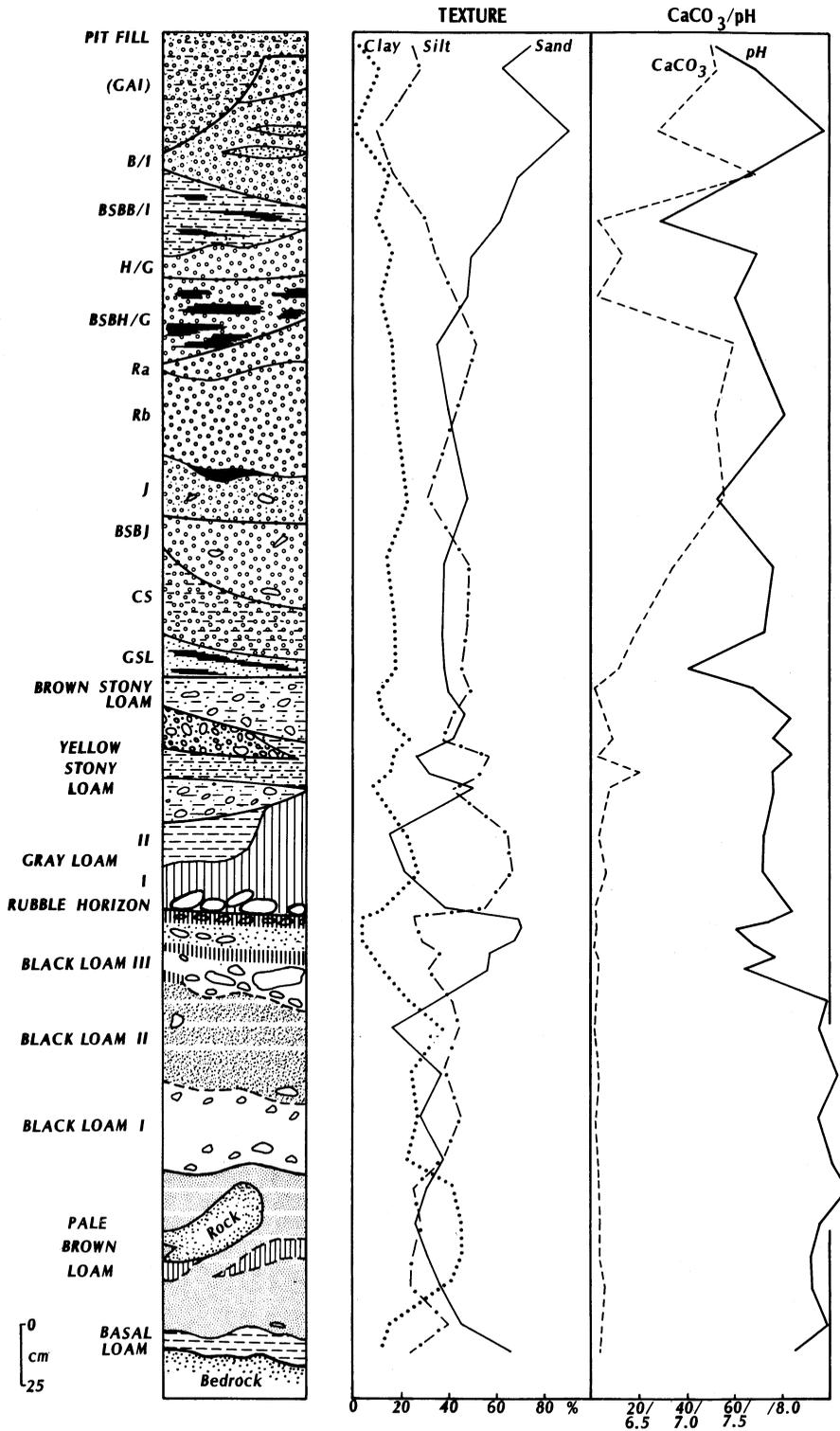


Fig. 1. Composite Sedimentary Profile of the Main Excavation, Nelson Bay Cave. Texture refers to matrix of non-carbonate residues under 2 mm.

are summarized in figures 1 and 2, and are incorporated into the subsequent sections describing and then interpreting the sedimentary units.

The Strata of the Main 1970–1 Excavation Area

The sedimentary units exposed by Klein's excavations in 1970–1 consist of a lower suite, primarily of natural origin, and an upper one that is primarily composed of cultural horizons and shell heaps. These are here described, beginning with the mineral sediment units, using the field nomenclature as a matter of convenience. Unless otherwise stated, units are uncemented and moderately compact, sorting poor, and contacts abrupt (0–2 cm) and straight or wavy. For discussion of radiocarbon dates see Fairhall & Young (1973) and Klein (1972a).

Basal Loam. 0–15 cm. Very pale brown (10 YR), sandy loam with coarse angular structure. Few, distinct yellow (10 YR) mottles, with limonite or pyrolusite staining of former organic impressions. Closely similar to weathered matrix of subjacent bedrock (Contact Breccia). Stratum dips 25–30° laterally to axis of cave.

Pale Brown Loam. 60–90 cm. Pale brown (10 YR) sediment very rich in organic colloids, grading upward from loam to clay and from weak medium, subangular blocky to strong, coarse angular blocky structure. Common, distinct yellow (10 YR) mottles in top 10 cm. Dispersed stone throughout, including several blocks of kaolinized and oxidized (yellow 10 YR) Contact Breccia from roof. Two samples showed abundant and varied organic impressions and all contain 5.5–9.0 per cent organic matter. Phosphorus levels vary from 25 to 150 p.p.m., potash 145 to 200 p.p.m. Three discontinuous lenses (less than 1 cm to 5–8 cm thick), rich in carbonaceous materials and charcoal fragments, are derived from hearths; they dip 18–30° towards cave axis. The stratum itself dips only 15–20°.

Black Loam I. 25–50 cm. Dark brown (10 YR), humic loam, with moderate, very coarse, angular blocky structure. Concentration of crude rock and a few, distinct yellow (10 YR) mottles in upper part, organic concentrations (? reworked hearth) at base. Organic matter varies from 4 to 8 per cent, phosphorus 100 to 175 p.p.m. and potash 240 to 300 p.p.m. Bed thins a little but remains horizontal towards back of cave, and dips an average of 19° towards centre.

Black Loam II. 30–60 cm. Brown (10 YR), highly humic loam to silt clay loam, with coarse subangular to angular blocky structure. Dispersed crude rock and a few, distinct yellow (10 YR) mottles. Artefacts and traces of fired, red (10 R) loam or rock record occupation, as do 7.5–10.0 per cent organic matter, 130–150 p.p.m. phosphorus and some 200 p.p.m. potash. Maintaining constant thickness, this bed dips 6–10° to back of cave; laterally, the base dips 19°, but upper boundary uncertain, possibly demarcated by undulating stone concentration.

Black Loam III. 30–70 cm. Alternating ferruginized and non-ferruginous horizons in a high-variable

mass of humic sandy or silt loam with lines and concentrations of stratified crude rock. The approximate sequence of the deep pit is as follows: (a) The lowest ferruginous zone (*Oxidation Horizon Ia*) is a discontinuous level of stone concentrations in a matrix of brown (10 YR), loam with many, coarse and distinct mottles of reddish yellow (7.5 YR) colour. (b) 10–15 cm. Dark gray brown (10 YR), humic silt loam with coarse, angular blocky structure. Abundant hearth debris. (c) 5–8 cm. Partly cemented, yellow red (5 YR), stony sandy loam with dark red brown (5 YR), ferruginous laminae (*Oxidation Horizon Ib*). Abundant artefacts, some charcoal and fired, red (10 R) loam. (d) 15–20 cm. Dark gray brown (10 YR), humic, sandy loam with medium subangular blocky structure. Dispersed crude rock and many distinct coarse mottles of red yellow and yellow (7.5–10 YR) colour. Artefacts and common traces of fired, red (10 R-2.5 YR) loam. (e) 5–10 cm. Crude rock with a basic matrix of gray to dark gray brown (10 YR), humic sandy loam, and pockets of loamy sand. In large part ferruginized in bands of diffuse stains of prominent red yellow (7.5 YR) or dark red brown (5 YR) colour; surface semicemented and smoothly eroded (*Oxidation Horizon Ic*). Masses of stone artefacts, traces of bone and fired, red (10 R) loam, with organic matter ranging from 1.8 to 8.4 per cent, phosphorus only 35 to 85 p.p.m., potash 100 to 200 p.p.m. Despite basal irregularities, horizon is almost horizontal towards cave axis but dips 6–7° to back.

Rubble Horizon. 0–15 cm. Discontinuous level of crude rock, consisting entirely of quartzite with conspicuous corrosion of edges. Originally lacked fine materials with incomplete matrix derived from overlying bed. Morphology and random distribution comparable to modern, dry caves with very slow accumulation of rock.

Gray Loam I. 20–50 cm. Brown to dark gray brown (10 YR), silt loam, with structure ranging from weak, medium, subangular blocky to strong, very coarse angular blocky or prismatic. Dispersed crude rock near front of cave. High concentrations of phosphates and potash in back of cave, with low to moderate humus content (0.8–4.5 per cent), indicating organic compounds. Dips 3–12° (average 6°) to back of cave, with increasing evidence of oxidation in large pockets of common, distinct red yellow (7.5 YR) mottles, some ferruginous lenses, and pyrolusite on red faces (*Oxidation Horizon 2*). Upper contact very wavy, and clear to diffuse (2–10 cm).

Gray Loam II. 0–30 cm. Discontinuous bed of brown to pale brown (10 YR), silt loam, with coarse, subangular blocky structure. Rare, dispersed roof detritus. Top dips 1–8° to back of cave.

Yellow Stony Loam. 20–50 cm. Complex, inter-fingering lenses that allow local differentiation into as many as three subunits: (a) Basal 0–20 cm. Light yellow brown (10 YR), loam to silt loam with dispersed crude rock. (b) Intermediate 10–20 cm. Pale to very pale brown (10 YR), loam to silt loam, with local fossiliferous pockets of micro-fauna. (c) Top

10–20 cm. Light yellow to brown yellow (10 YR), silt loam, with dispersed crude rock, grit horizons or lenses of crude rock, including kaolinized slabs of Contact Breccia; locally with some phosphates and potash; fossiliferous pockets of micro-fauna; oxidation ranges from a few, distinct red yellow (7,5 YR) mottles to extensive yellow (10 YR) banding or general discoloration (*Oxidation Horizon 3*). All horizons include artefacts, some bone, and fragments of shell. Carbonaceous soil from the middle of the yellow Stony Loam gave a C^{14} age of 18100 B.P. (UW-175), possibly too young as a result of contamination by younger organic acids. A second date, of 18660 \pm 110 B.P. (GrN-5889) on shell (Vogel 1970), probably comes from this horizon. Overall dip is 2–5° to back of cave.

Brown Stony Loam. 10–30 cm. Gray to very pale brown (10 YR) loam, with dispersed crude rock and medium, subangular blocky structure. Contains artefacts, bone and some shell. Dips 2–5° to back of cave.

This completes the sequence of essentially natural sediments, and the overlying suite consists primarily of cultural strata. All contacts are abrupt and wavy, with most beds showing pronounced lenticular sorting into decalcified organic-mineral residues, hearths, or shell heaps, frequently with complex interdigitation. Abbreviated field designations (see Klein 1972*a*; 1972*b*) are utilized in the following description.

GSL. 10–15 cm. Occupation residues including conspicuous hearths, fired sediments (red to light brown, 7,5 R–2,5 YR) and decalcified shell ash. Highly variable in colour and composition, with texture generally that of an inhomogeneous loam with rare crude rock. C^{14} date on charcoal: 11950 \pm 150 B.P. (UW-177).

CS. 20–35 cm. Gray brown (10 YR), loam with abundant crushed shell and several hearth horizons with potash enrichment (250 p.p.m.). C^{14} dates on charcoal: 11540 \pm 110 B.P. (UW-162), 10285 \pm 85 B.P. (UW-164) and 10150 \pm 90 B.P. (Pta-392).

BSBJ. 25–35 cm. Loose shell, bone debris and hearths with matrix of light brown gray (10 YR), humic loam with rare crude rock and potash concentration (210 p.p.m.) C^{14} date on carbonaceous soil: 10540 \pm 110 B.P. (UW-178).

J. 20–25 cm. Loose shell debris, fired horizons and hearths with a matrix of light brown (10 YR), sandy clay loam with rare crude rock. C^{14} dates on charcoal and carbonaceous soil from hearths at contact between J and overlying bed Rb: 8990 \pm 80 B.P. (Pta-391) and 8120 \pm 240 B.P. (UW-181).

Rb/Rc/Rc/C. 30–50 cm. Loose, partially crushed shell and shell ash, with limited matrix of light brown gray (10 YR), loam. C^{14} date on marine shell: 8570 \pm 170 B.P. (UW-184).

Ra. 10–20 cm. Packed shell, with a little matrix of light brown gray (10 YR), loam. C^{14} date on shell: 9080 \pm 180 B.P. (UW-179), on charcoal: 6065 \pm 125 B.P. (UW-222).

BSBH/G 15–35 cm. Dark gray brown (10 YR),

humic loam, interbedded with very dark horizons of fine charcoal, phosphates (105 p.p.m.), and ash, as well as white shell ash. C^{14} date on carbonaceous soil: 5825 \pm 125 B.P. (UW-187).

H/G. 10–20 cm. Packed shell and hearths with some matrix of light brown gray (10 YR), humic loam.

BSBB/I. 10–35 cm. Gray brown (10 YR), humic sandy loam with hearths, phosphates (110 p.p.m.), bone and some corroded shell. C^{14} dates on carbonaceous soil: 6020 \pm 160 B.P. (UW-176) and 6050 \pm 80 B.P. (UW-186).

B/I. 10–55 cm. Packed shell and ash horizons with matrix of light brown gray (10 YR), moderately sorted, sandy loam. Interbedded with 2–5 cm lenticles of clean well-sorted, coarse sand of eolian origin. C^{14} date on shell: 5350 \pm 65 B.P. (UW-217).

GAI. 0–20 cm. Loose shell, shell ash and hearths with matrix of gray (10 YR), humic loamy sand.

Pit Fill. 0–50 cm. Mixed cultural debris, largely derived, with matrix of light brown gray (10 YR), humic, moderately sorted, loamy sand.

A suite of younger strata are exposed in the Inskeep excavations at the threshold of the cave. These remain to be studied, but this segment of the record is complemented by the fill of Hoffman's Cave, which shows eolian deposition continued unabated until 4200 B.P., with some stabilization thereafter (Butzer & Helgren 1972).

The Nelson Bay Cave strata below the Rubble Horizon include several variants of the Middle Stone Age. The Gray Loam lacks artefacts in the Main Excavation area, while the Yellow and Brown Stony Loams have a Late Stone Age industry, as yet unnamed (Klein 1972*a*, 1972*b*). Levels GSL through J have 'Pre-Wilton' (as used by Deacon 1969), levels Rb through GAI 'Climax Wilton', both Late Stone Age industries (Klein 1972*a*).

The Strata of the Sump Pit

The stratigraphic information from the Main Excavation area is complemented by that from the Sump Pit dug in 1971 to help lower the watertable in the cave. The strata are described below with reference to figure 2:

(a) Greater than 40 cm. Stratified, loose, clean, very pale brown (10 YR), sorted coarse sand as matrix to well-rounded beach gravel, subrounded crude rock from roof, and occasional waterworn artefacts. Upper contact gradual.

(b) 30 cm. Well-stratified, weakly structured, light gray (10 YR), sandy loam as matrix to grit and coarse gravel that grades upwards from a beach facies to increasingly angular, crude rock with greater organic components organic matter 3,0 per cent, phosphorus 188 p.p.m. and potash 135 p.p.m. Artefacts and débitage not waterworn. Upper contact clear (2–5 cm).

(c) 50 cm. Well-stratified, packed, crude angular breccia of quartzite and kaolinized Contact Breccia. Incomplete matrix of gray brown (10 YR), humic (3,9 per cent organic matter) loam with crumb structure and many, prominent and large mottles

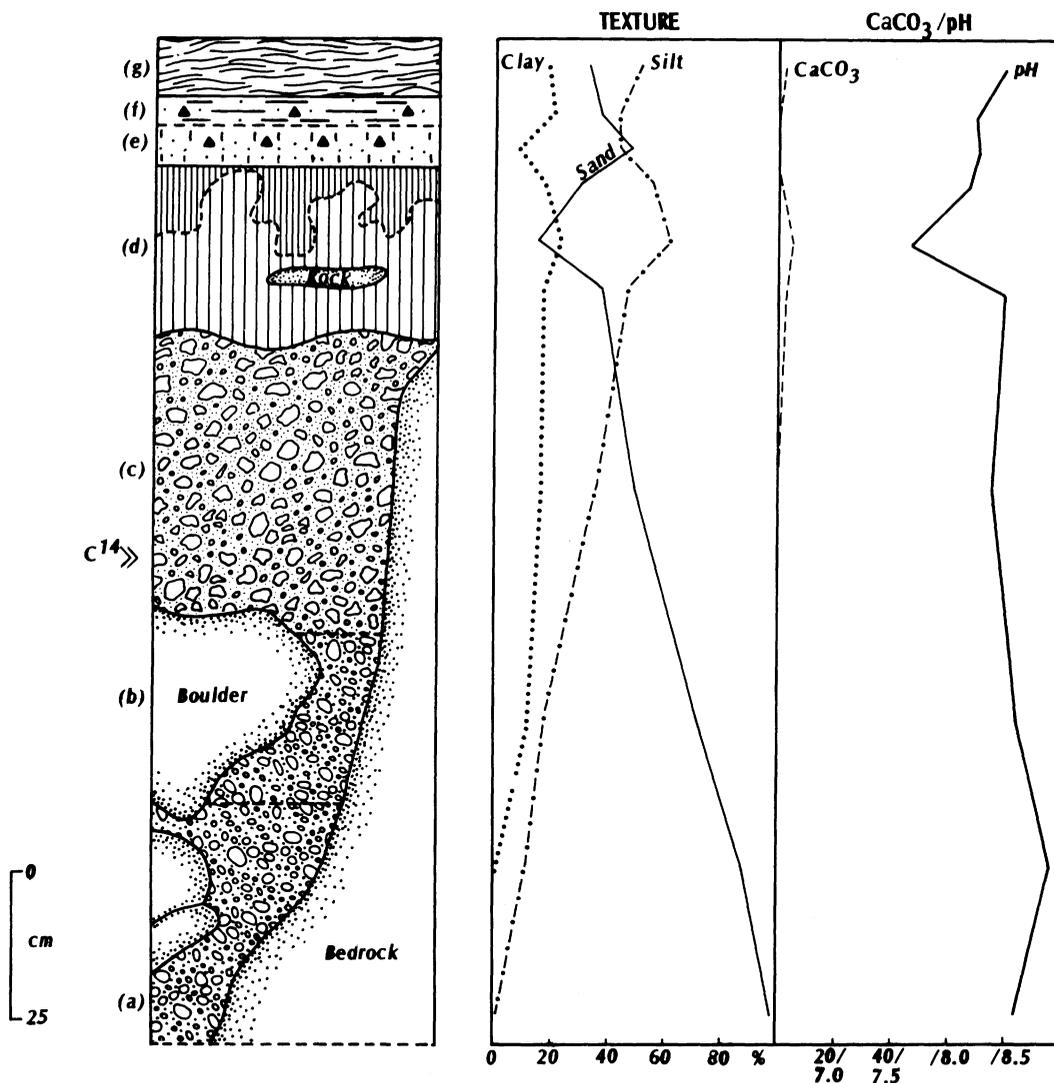


Fig. 2. Generalized Sedimentary Profile of Sump Pit, Nelson Bay Cave. Not to scale. Texture refers to non-carbonate matrix.

of red brown (2,5–5 YR) colour. Hearths and artefacts 175 p.p.m. phosphorus and 425 p.p.m. potash. C^{14} date pending on fine charcoal. Upper contact abrupt (0–2 cm) and wavy.

(d) 30 cm. Massive and compact, dark gray (10 YR), loam to silt loam with strong medium angular blocky to prismatic structure. Common, faint, yellow (10 YR) mottles in lower parts, but the top 0–15 cm show many, large and distinct mottles of red yellow (7,5 YR) colour in which ferric precipitates create a crumb structure. 4,5 per cent organic matter, 90 to over 250 p.p.m. phosphorus and 320–675

p.p.m. potash. Upper contact abrupt and straight.

(e) 7 cm. Weakly stratified, yellow brown (10 YR), silt loam with coarse angular blocky structure. Artefacts and ash traces. Upper contact abrupt and straight.

(f) 5 cm. Well-stratified, pale brown (10 YR), loam as matrix to occupation debris, with 2,4 per cent organic matter, 175 p.p.m. phosphorus and 260 p.p.m. potash; many, large and distinct mottles or bands of yellow (10 YR) colour. Upper contact abrupt and straight.

(g) 10 cm. Laminated, compact, brown to light

gray (10 YR), loam with occupation debris and fine lenticles of shell ash.

The artefacts from beds (*a*) through (*d*), although small in number, are of Middle Stone Age type, while those of (*e*) and (*f*) are too few to be diagnostic; unit (*g*) is probably Wilton (R. G. Klein, pers. comm.).

The Sump Pit section is separated from the Main Excavation by some 12 m, and there are no direct stratigraphic links. Although the beach deposit at the base of the Sump Pit is unique, other sedimentary properties are not. In particular, the three oxidation horizons (beds *c*, *d* and *f*) invite correlation with those of the Main Excavations. Next the breccia, bed (*c*), is lithologically comparable with Black Loam III, while the prismatic-structured, compact bed (*d*) is identical on all counts with Gray Loam I (23,5 per cent clay in Sump Pit compared with 27 per cent in Main Excavation, 14,5 per cent sand to 12 per cent, 5,0 per cent CaCO₃ to 3,4 per cent, 4,4 per cent organic matter to 3,7 per cent 675 p.p.m. potassium to 685 p.p.m., and both greater than 250 p.p.m. phosphorus). Since the sedimentary and oxidation-alteration criteria match, we have no hesitation in correlating as follows:

<i>Sump Pit</i>	<i>Main Excavation</i>
Beds (<i>e</i>) and (<i>f</i>)	Yellow Stony Loam (Oxidation Horizon 3)
Bed (<i>d</i>)	Gray Loam I (Oxidation Horizon 2)
Bed (<i>c</i>)	Black Loam III (Oxidation Horizon 1).

There is no direct correspondence for either the basal beach or bed (*g*). The top of the mixed beach-cave facies of bed (*b*) is at *c.* 12 m above MSL, which is the elevation of the lowest deposits of Black Loam I in the Main Excavation. It is therefore probable and lithologically reasonable that the Black Loam is broadly equivalent to the detrital bed (*c*) in the Sump Pit. This would imply that the beach proper is at least in part contemporary with the Pale Brown Loam. At the top of the column, bed (*g*) was deposited in standing waters, a facies also absent in the Main Excavation. The closest resemblance is with level GSL, or possibly, the Brown Stony Loam.

Interpretations of the Gravel Morphometry

The crude detritus in Nelson Bay Cave has been produced or modified by several agents that require some discussion.

(i) Spalling of the Contact Breccia of the cave roof is primarily a result of dilation and fracturing, in response to pressure release through active undermining of the cavern.

(ii) Accelerated spalling can result from frost-weathering, the products of which should be more angular and flatter as well as less oxidized or corroded than rubble due to the slower process of pressure release.

(iii) Thermoclastic weathering in response to fires in a cave will favour spalling by means of differential

heating and the creation of repeated intermineral stress. However, alternation of heating and cooling have proved of limited effectiveness in laboratory studies, while few of the major hearth horizons in Nelson Bay Cave have any crude roof rubble in them, so that this factor is of limited importance at best.

(iv) Chemical weathering can operate in initial rock disintegration as well as in subsequent, i.e. postdepositional, alteration. Exposed rock is generally covered with saline solutions or salt precipitates as a result of the saline 'sea mist' generated at times of high wave agitation. Such salts swell and contract in response to changes of moisture and temperature (see Evans 1970). In porous rock, such as the matrix of the Contact Breccia, salts can create intermineral stress, with granular disintegration as well as splicing off of superficial fragments by concentrated salt efflorescence or subflorescence. A second mode of chemical weathering is the slow corrosion of quartzose and silcrete matrices by percolating and condensation waters that are moderately alkaline as a result of the abundant sodium salts. As a consequence, roof rock is superficially impregnated with minute quantities of evaporite that react to hydrochloric acid, while the subcutaneous rock is abnormally porous and may even break down in acid. Furthermore, some parts of the roof show oxidation or secondary impregnation with iron oxides, as well as kaolinization. Finally, algae, fungi, lichens and bacteria are present in varying proportions and concentrations on rock surfaces or in fissures, contributing an uncertain component of biochemical and biomechanical changes and stresses. The impact of these complex chemical agencies is to aid in spalling or grain-by-grain disintegration of the matrix of the Contact Breccia, loosening out the quartzite rubble, which may be superficially corroded. Most of the fine detrital component is obtained in this way, while postdepositional alteration further breaks down the Contact Breccia matrix into kaolinized and/or oxidized material that ultimately returns to its component parts as a 'cave earth' with released quartzite rubble.

(v) Stone tool manufacture produces crude detritus that ranges a full spectrum from well-fashioned implements to incidental stone chips. Since almost all of the raw material used was quartzite, bulbless artefactual debris is difficult to distinguish from natural rock splices. It was consequently necessary to examine all crude detritus for percussion bulbs and, since these are poorly developed in fissured quartzite, the gravel analyses systematically excluded 'fresh' angular flakes with elongated, tapering shapes. All flakes or chunks of exotic rock, viz. chert, jasper, agate and vein quartz, were also rejected. In this way, *débitage* was excluded from the sample, although unmodified manuports in quartzite or quartzitic sandstone are next to impossible to recognize.

The many agencies capable of producing crude detritus in Nelson Bay Cave emphasize that the gravel morphometry is difficult to interpret. None of the

indices selected for analysis provides conclusive results, seen in isolation. Thus, all of the samples above the beach deposit are angular to subangular, heterogeneous in terms of rounding, highly detrital, and conspicuously flat (as opposed to spherical) in shape (fig. 3). Basically this reflects the fractured and inhomogeneous nature of the once strongly-jointed quartzite rubble embedded in the Contact Breccia. In other words, the primary morphological and morphometric traits are inherited. This is complicated by the presence of some primary changes in rubble morphometry among the quartzite rubble within different strata of the Contact Breccia. Samples from the Pale Brown and Black Loams are further skewed by their collection from 20 cm horizontal spits in what are, in part, dipping strata (fig. 3). The result has been to mix several of the samples near

stratigraphic boundaries, although the strong cementation of crude detritus into a few horizons minimizes the effect of 'smoothing' the overall curves. Finally, the samples were not uniformly selected from the Table Mountain Quartzite rubble released from the Contact Breccia: without careful microscopic examination it was often impossible to distinguish quartzitic sandstone or weathered quartzite of the Table Mountain Series from more quartzose samples of Breccia matrix or, possibly, from occasional pieces of quartzitic sandstone from the Uitenhage Series that may have been washed or carried into the cave. Although the samples measured were homogeneous in a purely lithological sense, within a reasonable spectrum of quartzite and quartzitic sandstone, a small and variable percentage of younger rock was unavoidable. These many caveats emphasize that the

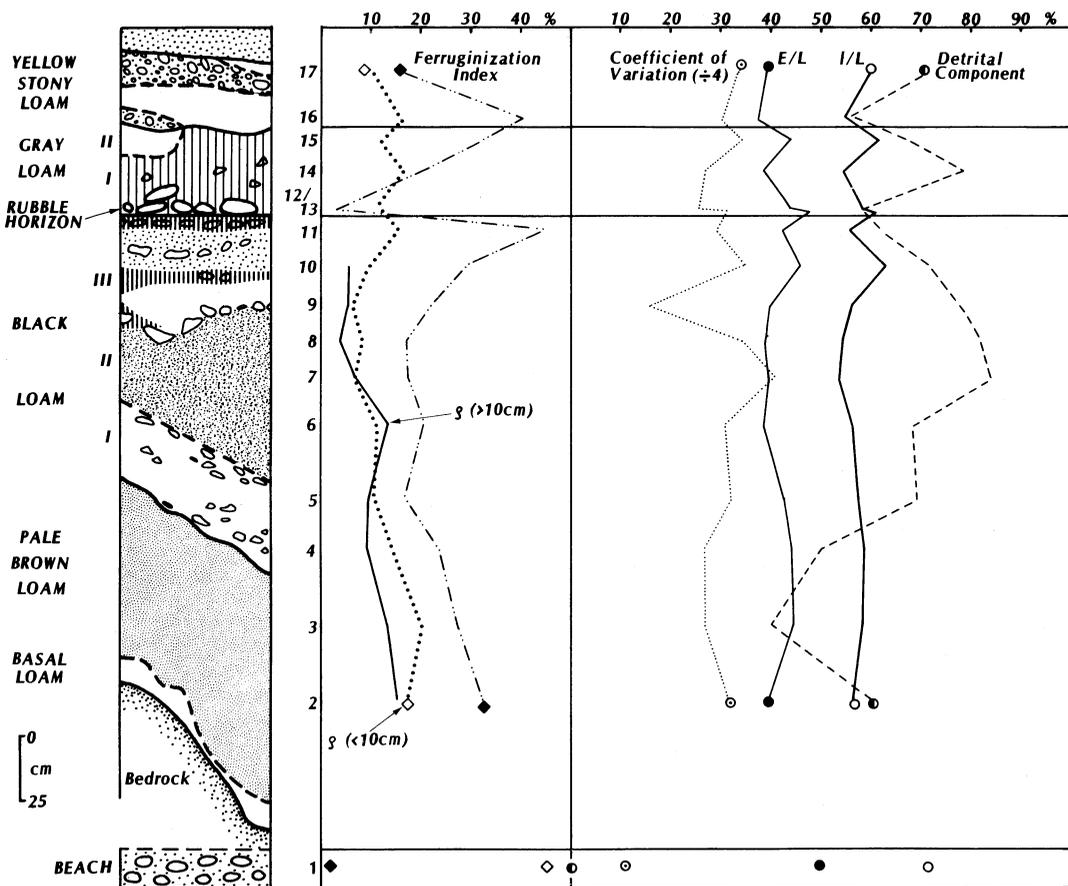


Fig. 3. Morphometric Gravel Analyses from Nelson Bay Cave. Index of rounding (ρ), indices of flattening (E/L and I/L, where E is thickness, L major axis, I minor axis), ferruginization index (per cent of rock fragments ferruginized and discoloured from total lithological sample), coefficient of variation of ρ (divided by 4), and detrital component (per cent $\rho \leq 8$ per cent). Restricted to pebbles 2–10 cm in length, except for one separate curve of ρ for pebbles longer than 10 cm.

graphic results of figure 3 cannot be interpreted mechanically. None the less, several of the convergent trends are both significant and diagnostic.

The beach gravel (no. 1, fig. 3) is quite unique in terms of a high mean rounding index and a relatively homogeneous degree of rounding, despite the presence of many subangular pieces of partly-modified roof debris. Unusually high sphericity is indicated by both the E/L and 1/L ratios. This must be attributed to a dominance of rolling over sliding motions in transport, presumably as pebbles were churned around in a confined space by indirect wave action. However, wave surges can 'pile up' at least 2 or 3 m in confined rock fissures during periods of high seas, so that beach pebbles to a maximum elevation of 12,5 m may have been generated with a MSL of no more than +9 or 10 m.

The gravel from the Basal and Pale Brown Loams (nos. 2 and 3, and the mixed sample 4, fig. 3) represents quartzite released from the Contact Breccia with little mechanical change. Some 24–33 per cent of the total lithological collection from these levels consists of oxidized matrix, in part attached to quartzite fragments, and in most cases in process of decomposition.

Within Black Loams I and II there is a notable increase in angular components (from 40–60 per cent to 70–85 per cent), a trend to increased mean angularity and heterogeneity, as well as reduced sphericity. In sample no. 9, mechanical fracturing is so ubiquitous that practically none of the quartzite rubble from the Contact Breccia remained unmodified; this subjective evaluation is verified by the unusually low coefficient of variation. Some 80 per cent of the related lithological samples consist of fresh, i.e. unoxidized and undecomposed, rock which, in view of the highly humic and otherwise fine nature of the basic sediments, must be attributed to accelerated spalling rates rather than to reduced chemical weathering. Finally, the subjective impression of the rubble in these strata is unequivocally that of fresh, cryoclastic debris—with marked comminution in size of the parent quartzite rubble into a striking proportion of highly angular rock splices, lacking any trace of edge-corrosion. *By all criteria the crude detritus of Black Loams I and II must be primarily attributed to accelerated spalling as a result of frost-weathering.* This is particularly so in the case of sample nos. 5, 7, 8, and 9, with the likelihood that sample 6 marks less extreme conditions.

Black Loam III shows declining angularity, an increase in unmodified quartzite chunks, an irregular but none the less conspicuous increase in sphericity, and a high percentage of oxidized rock specimens in the total lithological sample—the last property due in large part to postdepositional ferricretion. The suite of samples 9 through 11 can best be interpreted by a decline in frost effectiveness and, by implication, a warming trend. This is compatible with the other sedimentary properties, viz. sorting by running water, post depositional ferricretion and, ultimately, a very

slow rate of sedimentation.

The Rubble Horizon is a selective quartzite residue, with 86 per cent of the lithological spectrum (264 pieces identified) quartzite, compared with ranges of 47–73 per cent in the underlying and overlying stratigraphic units. Only 1,1 per cent of the quartzite retained adhering matrix, as compared with 2,8–16,2 per cent in the other levels. Another 1,1 per cent of this sample consisted of oxidized matrix, compared with 4,6–29,8 per cent in the other levels. The remaining 11,4 per cent consisted of quartzose matrix. Thus, the lithological composition of the Rubble Horizon is unique. A second characteristic of this level is that 60,3 per cent of the rubble (greater than 2,0 cm in major axis) falls into the size class over 10 cm, compared with only 15,4–49,9 per cent in the other horizons. Furthermore, the extreme size grades of 20 to over 35 cm are not even represented elsewhere in the sequence. This, and the relatively high sphericity, suggest no comminution of the quartzite rubble released from the Contact Breccia. The last hallmark is a conspicuous, yet very superficial corrosion on the edges of most pieces, a phenomenon present in the modern crude detritus that litters the floor of Nelson Bay Cave and other Robberg shelters. However, this edge-corrosion is insufficient to modify the index of rounding appreciably.

Altogether the Rubble Horizon, which is just as distinctive as the beach gravel, must be attributed to weathering agents and rates similar to those of today. The modern counterparts are also similar in respect to quartzite concentration, large calibre, and absence of fine matrix. The single problem of interpretation surrounds the lack of fine matrix, since the selective nature of the quartzite residue can only be explained by total disintegration or decomposition of almost all of the less resistant Contact Breccia matrix. The best explanation is very slow breakdown, allowing fine weathering products to be removed by erosion about as rapidly as they formed. It is therefore highly probable that the Rubble Horizon marks a protracted period of very slow weathering, certainly without frost, and presumably in relation to a temperate or warm external environment.

Interpretation of the gravel data from the Gray Loam and Yellow Stony Loam (nos. 14–17) is difficult and somewhat equivocal because of a number of minor contradictions between the trends of the different indices. For the lower Gray Loam and the upper Yellow Stony Loam, there is a reasonable but inconclusive case for some frost-weathering and colder climatic conditions. The overall subangular class of rounding is partly due to the presence of unmodified roof quartzites—many of these subrounded—in all of the samples, and in the case of Gray Loam I is accentuated by evidence of edge-corrosion, possibly as a result of slow sedimentation rates. The writer feels that the Gray Loam I and upper Yellow Stony Loam fall well outside of the range of variation of either the Pale Brown Loam or the Rubble Horizon, and that they suggest weathering

environments intermediate between those responsible for the Pale Brown Loam and the indisputably cryoclastic Black Loam. However, the sum of fracturing evident in these upper strata *could* have been a result of weathering agencies other than frost. This only serves to emphasize how anomalous the cold climate of Black Loam II must have been.

The crude rubble of the cultural horizons post-dating 12000 B.P. was far too limited for systematic study, and probably was overwhelmingly disturbed or imported by man.

General Interpretation of the Sediment Suite

Following the description of the sedimentary units and the specific interpretation of the gravel analyses, it is now possible to attempt a more general explanation of the depositional history of Nelson Bay Cave.

The Basal Loam is quite similar to weathered Contact Breccia, and the shallow, irregular development suggests a residual product derived in substantial part from weathering of the cave floor, rather than disintegration of roof materials. A relatively damp and probably temperate microclimate can be inferred. The presence of a few artefacts and admixed, diffuse organic matter—in limited but discernible quantity—speaks for cave occupation at this early stage, quite possibly preceding accumulation of the beach deposit at the back of the cave.

The Pale Brown Loam is a thick deposit containing unusually high proportions of organic colloids and clay, with low proportions of crude rock. This suggests that much of the finer sediment is extraneous, rather than derived from disintegration of Contact Breccia. The high frequency of rounded quartz grains among the angular, quartzite-derived sand indicates that beach sands were introduced in some quantity. It is likely that short-distance eolian transport, from a beach near the cave entrance, was a significant depositional agent during the later stages of accumulation. This would be a reasonable interpretation in conjunction with the beach deposit at the base of the Sump Pit, assuming that the two facies overlap in time. However, the concentration of beach sands within the upper Pale Brown Loam could just as well reflect on a younger transgression to a level considerably below +10 m. Finally, all of these deductions must be considered as tentative since the Pale Brown Loam is reworked, as indicated by its steep, wavy bedding. In view of the oxidized nature of the crude detritus, conditions in the cave appear to have been damp and roof spalling relatively slow during primary accumulation, or during redeposition, or both. The organic matter, phosphorus and clay are best explained by organic residues introduced by cave animals and man. Several discrete occupations by Middle Stone Age groups are indicated by the disturbed but none the less clear hearth horizons; bone is unfortunately not preserved.

Black Loam I is also redeposited, while preserving basic stratigraphic order. The sand fraction is dominated by the angular grains derived from disintegrated

quartzitic sandstone, and there is little positive evidence of beach sands except at the base. Finally, as discussed above, the crude detritus indicates accelerated roof spalling with frost-weathering.

In Black Loam II the record of human and animal occupation is even more intensive, with significant organic residues. Sands are essentially autochthonous in origin, although rounded, extraneous quartz is present in the upper half of the bed. Frost-weathering attained a maximum. This unit fills in the persistent hollow along the axis of the cave and bedding has not been appreciably disturbed. By the time sedimentation came to a close, the cave floor was almost level but with a distinct, general dip towards the back. The reasons for the steep lateral dips and apparent slumping of the preceding strata are obscure, but undermining by erosion is a good possibility.

Deposition of Black Loam III initially continued the trends evident in Black Loam II. Considering the substantially lower levels of organic matter and phosphorus, and the great abundance of artefacts, man was now directly or indirectly responsible for most or all of the organic residues. In fact the irregular stone horizon at the base may demarcate a number of shallow pits, so that future excavation of this important Middle Stone Age horizon may well reveal the presence of archaeological features. Unfortunately, the watertable during the 1971 excavations was so high that it was impossible to maintain such close vertical and horizontal control. The later units of Black Loam III coincide with lines of crude detritus with increasingly coarse and better-sorted interstitial materials. Since these sands show no eolian or beach properties, it is most probable that these terminal sediments reflect on selective sorting by running water. Wet conditions are also implicit from the post-depositional ferruginization.

Oxidation Horizon 1 dips 5° or more from the front to the back of the cave, with ferruginization in close proximity, i.e. 30–40 cm, of the former surface. This and the lack of systematic mottling at depth both indicate impregnation by iron-rich surface percolation or lateral seepage waters, rather than oxidation at the watertable. It is possible that such impregnation began during the last phases of sedimentation of Black Loam III, and that these mineralizing solutions are responsible for the local preservation of fragmentary bone. In any event, ferruginization continued for a protracted period after sediment removal had begun to exceed local sediment supply. The presence of abundant, percolating waters rich in sesquioxides presupposes an unusually wet, external climate with more active chelation than is evident today. However, the dominance of anhydrous forms of iron suggests marked seasonality of cave moisture or, otherwise, a subsequent period of quite dry microclimate. No record of prehistoric occupation is preserved from this long interval of non-deposition, and the crust-like surface was scoured clean by running water before or during accumulation of the Rubble Horizon.

The Rubble Horizon, whose genesis has been discussed already, was ultimately buried by Gray Loam I, in many ways similar to Black Loam I. Strong organic components are indicated by well over 250 p.p.m. phosphorus and 600–700 p.p.m. potassium, although organic matter in the restricted sense ranges from 3.5 to 4.5 per cent only. Artefacts are lacking in the Main Excavation area, although there are traces of charcoal and of partly-corroded shell fragments (recognizable microscopically). Phosphates in a quartzite cave must be attributed primarily to faecal residues or bone derivatives, while the bulk of the potash can only be ascribed to wood ash. Although the phosphates, in isolation, could be attributed to decomposed owl pellets or to the faeces of undetermined mammals, the presence of abundant wood ash and shell fragments points indisputably to human occupancy, as of an intensity unrivalled thereafter. The restriction of artefactual remains, of Middle Stone Age type (Klein, pers. comm.), to the back of the cave as exposed in the Sump Pit is therefore enigmatic.

Ferruginization of the topmost Gray Loam I proceeded with respect to a surface dipping an average of 6°. However, Oxidation Horizon 2 is morphologically distinct from the banded, partly-indurated ferric precipitates of Black Loam III. This may reflect on the more impermeable nature of Gray Loam I, which is poorly sorted and rich in silt. The strong prismatic structure of the surface of this bed near the back of the cave, where Gray Loam II is absent, suggests a long hiatus during which the cave floor was alternately very wet and relatively dry. Impregnation by percolating, ferric solutions and a dominance of anhydrous iron are best associated with this period of seasonal soaking.

Grey Loam II suggests a similar origin to that of Grey Loam I, but there is considerably less diffuse humus. Despite the continued absence of artefacts, there also are traces of charcoal and shell fragments.

The Yellow Stony Loam records two or more intervals of accelerated roof spalling, and high proportions of the sands and grit reflect on disintegrating Contact Breccia. Particularly interesting is the preservation and abundance of bone, including pockets of rich micro-faunal remains, and of horizons of shell fragments and artefacts. This would imply that the pH has remained relatively high since the time of deposition, and that man and owls alternated in their use of the cave.

Roof spall near the cave entrance shows a high incidence of oxidized Contact Breccia (see fig. 3), not necessarily embedded in an oxidized sediment matrix. This would suggest that much of the sesquioxide in this stratum first accumulated during weathering of the cave roof. However, the typical mottling of the upper units (Oxidation Horizon 3) militate for at least some postdepositional alteration. The superficial nature of the oxidation level, the 2–5° dip, and the presence of shell all argue against a high, perched watertable. Instead, the shallow

limonitic zones suggest a slow impregnation of surface sediment by water dripping from the ceiling and, since the pH was high, ferric solutions would have been precipitated almost immediately. The presence of hydrated iron—in contrast to the dominance of anhydrous forms in earlier oxidation horizons—indicates that the cave environment was perennially moist at the time of impregnation, and that the subsoil has remained moist ever since. The final oxidation horizon(s) finds a parallel evolution of humic soils on nearby coastal sands, terminating a little before 16000 B.P. (Butzer & Helgren 1972).

The Brown Stony Loam appears to represent the mineral residue remaining after almost complete decomposition of shell and other organic refuse, intermixed with natural sediment derived primarily from the cave roof. Compared with the youngest cave strata, the nature of the humification and compaction, as well as the decalcification, suggest a relatively damp microclimate.

The thick complex of hearths and middens that comprises strata GSL through GAI are primarily 'cultural' sediments. They provide fascinating examples of accelerated sedimentation, periods of non-deposition, complex interdigitation, and periodic leaching—all related directly to human occupancy. The C¹⁴ dates indicate that the time interval from 12000 to 5000 B.P. is represented by a discontinuous suite of beds.

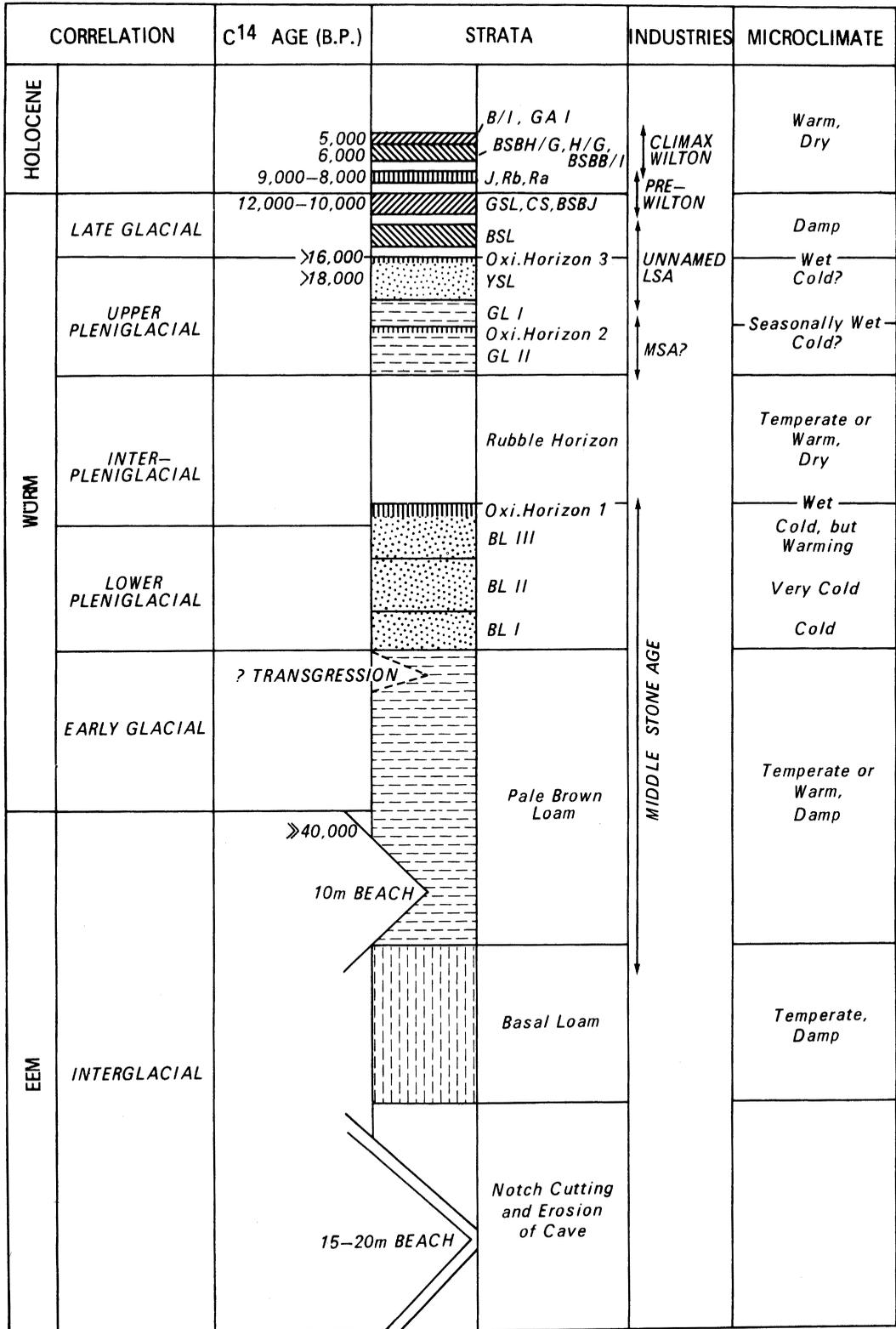
Several points of interest can be summarized:

(a) The three lowest beds (GSL, CS, BSBJ) are decalcified and the mineral spectrum is still broadly comparable to that of the Brown Stony Loam. These horizons were deposited with few major temporal breaks between about 12000 and 10000 B.P. The condition of these deposits suggests a damper microclimate than that coeval with accumulation of the overlying strata. Such an interpretation is corroborated (either for the Brown Stony Loam or GSL) by the subaqueous deposit (*g*) of the Sump Pit.

(b) Beginning with level J, rounded quartz sands become conspicuous and, except for the midden Ra, sands remain the leading size component of the loose, mineral matrix (see fig. 1). With level B/I the sand component becomes typically eolian with a strong grade-size maximum near 100 microns, improved sorting, and with rounded quartz far outweighing quartzite-derived sand of local provenance. Primary lenticles of eolian sand occur in the midden complex B/I and sand grains frequently show typical micropitting or 'frosting' (but see reservations in Butzer & Gladfelter 1968: 473 ff. on the implications of frosting). The inconsistent C¹⁴ dates appear to indicate that the complex of beds J, Rb and Ra were deposited with few major interruptions c. 9000–8000 B.P. The appearance of eolian, littoral sands is consonant with the increasing significance of fish remains and marine birds (Klein 1972a).

(c) After another break, the sedimentary data indicate a major phase of habitation during the accumulation of the horizontal complex BSBH/G,

NELSON BAY CAVE



H/G and BSBB/I, c. 6000 B.P. This is demonstrated by marked decalcification, leaching, an increase in organic matter and, above all, by high phosphate levels.

(d) The unleached shell middens all have a low density and include little mineral sediment. That component which is smaller than 2 mm in size already includes 55–65 per cent calcium carbonate and for bulk samples the non-carbonate residue appears to average between 10 and 20 per cent. This implies that a metre of loose, organic midden ultimately weathers and compacts to no more than 20 per cent residue by mass and possibly to as little as 5 cm in thickness.

Although comparative details are beyond the scope of this paper, the sedimentological conclusions are complemented by and find corroboration in the biological record of the cave strata, beginning with the Yellow Stony Loam: mammalian faunas (Klein 1972*b*), fish and mollusca (Klein 1972*a*), and oxygen isotopic temperatures on mollusca (N. J. Schackleton, pers. comm.).

Stratigraphic and Paleoclimatic Conclusions

The previous information can now be integrated into a broader scheme of cave evolution through time and in response to different climatic settings. A tentative attempt in this direction is made in figure 4. The external time-stratigraphic framework of the correlation column is adapted from Van der Hammen *et al.* (1967). It must be emphasized that a synthetic chart of this type is an author's interpretation of the best of the available hypotheses. In this particular instance the major weaknesses lie in (a) the lack of detailed radiocarbon resolution of the strata older than 20 000 years, and (b) the uncertainties of internal and external correlations for the Basal and Pale Brown Loams. Consequently, apart from the Rubble Horizon, next to nothing is known about intervals of non-deposition prior to the Yellow Stony Loam. It is equally important to note that stratigraphic resolution prior to the Black Loam is minimal.

Despite these reservations, the Nelson Bay Cave sequence provides a remarkably complete record of the Upper Pleistocene and Holocene, yielding valuable information on microclimatic variation and, by implication, for external environmental change as well. Together with the sedimentary sequences from Amanzi Springs (Butzer 1973*a*), Montagu Cave (Butzer 1973*b*), Klasies River Mouth (Butzer, in preparation), and Hoffman's Cave (Butzer & Helgren 1972), the Nelson Bay Cave profile contributes towards an understanding of the mid to late Quaternary records of man and his environment in the southern and south-eastern Cape Province. Perhaps the most striking implication at the moment is the

geological verification of the growing body of radiocarbon data to the effect that the Middle Stone Age extends back to beyond 50000 B.P. (Vogel & Marais 1971; Vogel 1970; Klein 1970; John Wymer, pers. comm.). In fact, the beginnings of the MSA can now be demonstrated during the last, i.e. Eem Interglacial, so that the earliest MSA appears to be at least 50 000 years older than it was assumed to be in the mid-1960s. In other words, the roots of the MSA are no younger than those of the European Mousterian, although the South African MSA may have persisted somewhat longer.

Acknowledgements

Field and laboratory work were supported by National Science Foundation (Washington, D.C.) grant GS-3013 (to R. G. Klein and K. W. Butzer). D. M. Helgren (Chicago) collaborated in the field during the 1970 season and, together with John Piccininni (Chicago), assisted in the sedimentological analyses carried out in the Paleo-Ecology Laboratory of the University of Chicago. Further determinations by the University of Wisconsin Department of Soils were made possible through the courtesy of E. E. Schulte. H. J. Deacon (Stellenbosch) provided valuable critical comments on a preliminary draft of the manuscript, while John Rogers (Cape Town) provided discussion in the field. The diagrams were drawn by Christopher Mueller-Wille.

References

- BUTZER, K. W. 1971. *Environment and archeology: an ecological approach to prehistory*. Chicago: Aldine-Atherton; London: Methuen.
- . 1973*a*. Spring sediments from the Acheulian site of Amanzi (Uitenhage District, South Africa). *Quaternaria* 16: in press.
- . 1973*b*. A provisional interpretation of the sedimentary sequence from Montagu Cave (Cape Province), South Africa. In C. M. Keller, *Archaeology of Montagu Cave*. Univ. Calif. Publ. Arch: in press.
- DEACON, H. J. 1969. Melkhoutboom Cave, Alexandria District, Cape Province, a report on the 1967 investigation. *Ann. Cape Prov. Mus. Nat. Hist.* 6: 141–69.
- BUTZER, K. W. & HELGREN, D. M. 1972. Late Cenozoic evolution of the Cape coast between Knysna and Cape St. Francis, South Africa. *Quaternary Research* 2: 143–169.
- Climate of South Africa*. 1954. Part I: Climate statistics. Pretoria: South African Weather Bureau.
- EVANS, I. S. 1970. Salt crystallization and rock weathering: a review. *Rev. Géomorph. dyn.* 19: 153–77.

← Fig. 4. A tentative Stratigraphic and Paleoclimatic Interpretation of Nelson Bay Cave. Time-stratigraphic units after Van der Hammen *et al.* (1967).

- FAIRHALL, A. W. & Young, A. W. 1973. Radiocarbon dates from Nelson Bay Cave. *S. Afr. Archeol. Bull.* 28.
- INSKEEP, R. R. 1965. University of Cape Town excavations at Plettenberg Bay. *Scientific South Africa* 2: 575-7.
- KLEIN, R. G. 1970. Problems in the study of the Middle Stone Age of South Africa. *S. Afr. Archaeol. Bull.* 25: 127-35.
- . 1972a Preliminary report on the 1970 excavations at Nelson Bay Cave (Plettenberg Bay, South Africa). *Palaeoecology of Africa* 6: 177-208.
- . 1972b. The late Quaternary mammalian fauna of Nelson Bay Cave (Cape Province, South Africa). *Quaternary Research* 2: 135-142.
- PAYNE, T. G. 1942. Stratigraphical analysis and environmental reconstruction. *Bull. Amer. Assoc. Petrol Geol.* 26: 1697-770.
- ROGERS, J. 1966. *The geology of Robberg, Plettenberg Bay*. Unpubl. Honours Project, University of Cape Town.
- VAN DER HAMMEN, T., MAARLEVELD, G. C., VOGEL, J. C. & ZAGWIJN, W. H. 1967. Stratigraphy, climatic succession and radiocarbon dating of the Last Glacial in the Netherlands. *Geol. Mijnbouw* 46: 79-95.
- VOGEL, J. C. 1970. Groningen radiocarbon dates IX. *Radiocarbon* 14: 444-71.
- VOGEL, J. C. & Marais, M. 1971. Pretoria radiocarbon dates I. *Radiocarbon*. 13: 387-94.

REVIEW

Flora of Lesotho by Amy Jacot Guillarmod. Published by Verlag von J. Cramer, Germany, 1971. 474 pp. No illustrations. Price in South Africa approx. R50.

The bulk of this book is a check list of Lesotho flora, but, fortunately for the archaeologist and the ethnographer, the contents are not limited to this purely taxonomic aspect. In addition to a brief but comprehensive history of Lesotho, with useful sections on topography, climate, ecology, land tenure and land usage, there is also a Sotho glossary of plant names and an invaluable section on the uses made of particular plants with special emphasis on domestic usage. This type of information is of immense practical value to the archaeologist, especially to those concerned with the Iron and Later Stone Ages of the highveld areas of southern Africa. The identification of plant remains in excavations, instead of remaining as a dry list appended to the site report, can be interpreted in human terms; we can reconstruct, with relative confidence, the seasonal uses of various plants in the diet, in the household, as materials for the construction of artefacts and buildings, or as medicinal, spiritual, or decorative adjuncts to daily living.

There is one snag to the use of this book in the field; no common names of plants are included.

Take a practical example; you find a piece of plaited fibre in association with Later Stone Age artefacts in the surface layers of a Lesotho rock shelter, and you subsequently see a Mosotho woman tying up headloads of brushwood with a similar-looking fibre rope. You ask what it is made of, and the woman answers, 'Leloele'. So you look up *Leloele* in Guillarmod's book and find it could be *Crytanthus lutescens* or any of a number of *Kniphofia* species. Unless you happen to be botanically informed you are probably none the wiser and will have to wait until you can consult C. A. Smith's *Common Names of South African Plants* (Botanical Survey Memoir No. 35, Government Printer, Pretoria, 1966). You will then discover that the plants in question are Ifafa Lily and Red Hot Poker, which means a little more to most of us. But this is a criticism which is readily overcome by the combined use of the two books cited.

Dr Guillarmod has made a substantial contribution not only to the botany of Lesotho, where some plant species are becoming extinct through overgrazing and erosion, but also to ethnography and the recording of traditions, which are likewise undergoing radical and rapid changes. We urgently need this sort of record before it is too late.

PATRICIA VINNICOMBE