The Monumental Earthworks of Palau, Micronesia: a landscape perspective

Volume II

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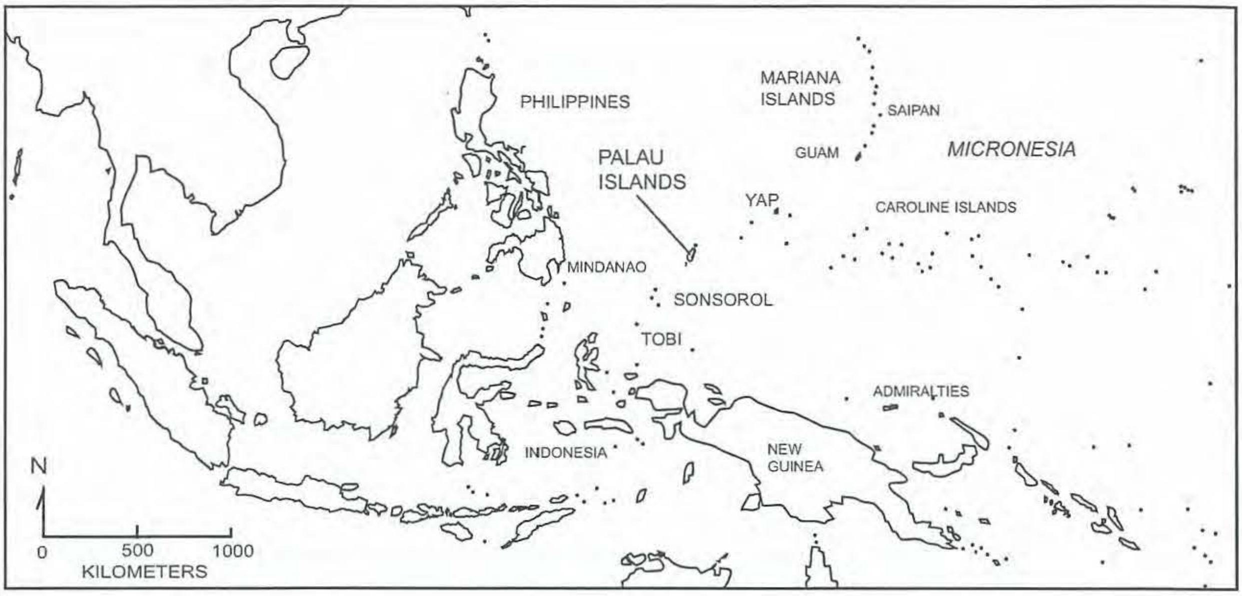

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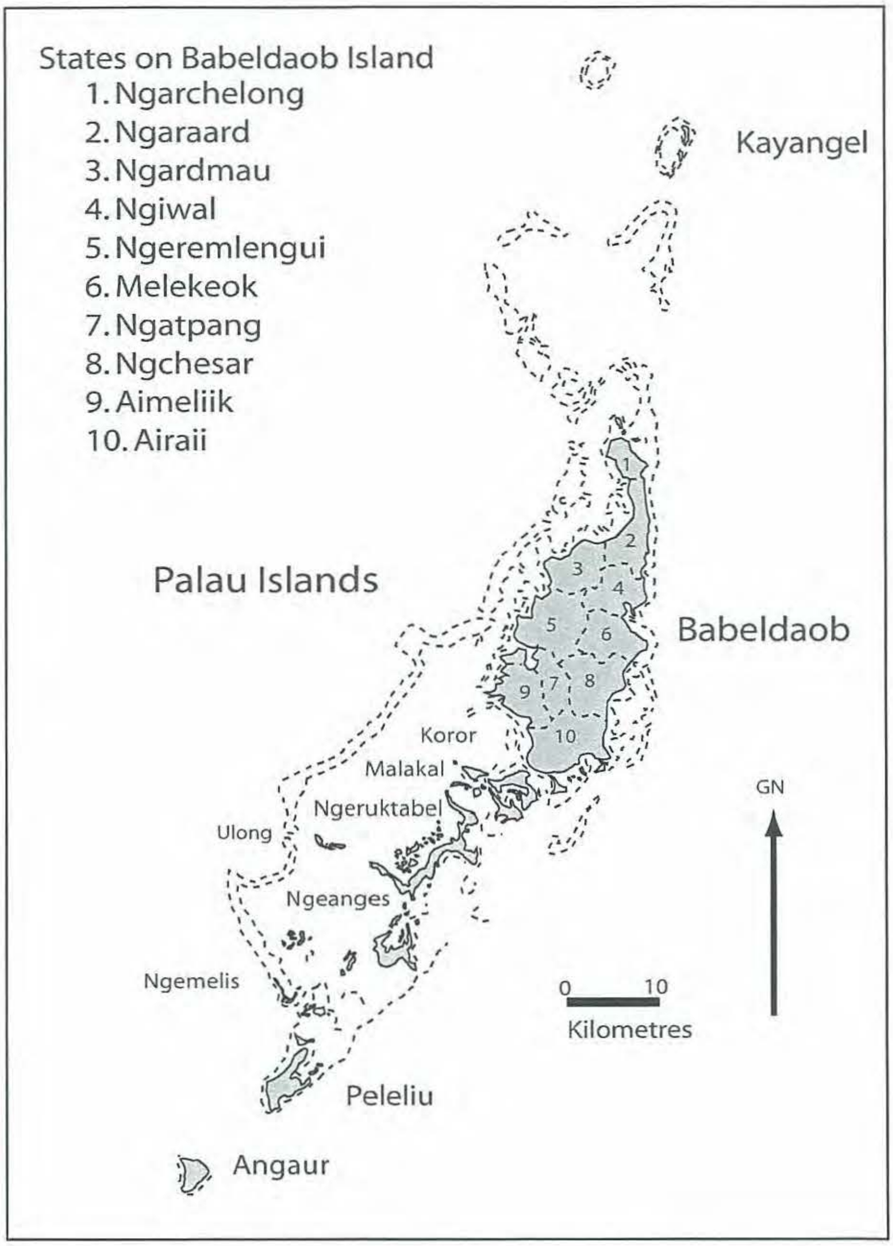

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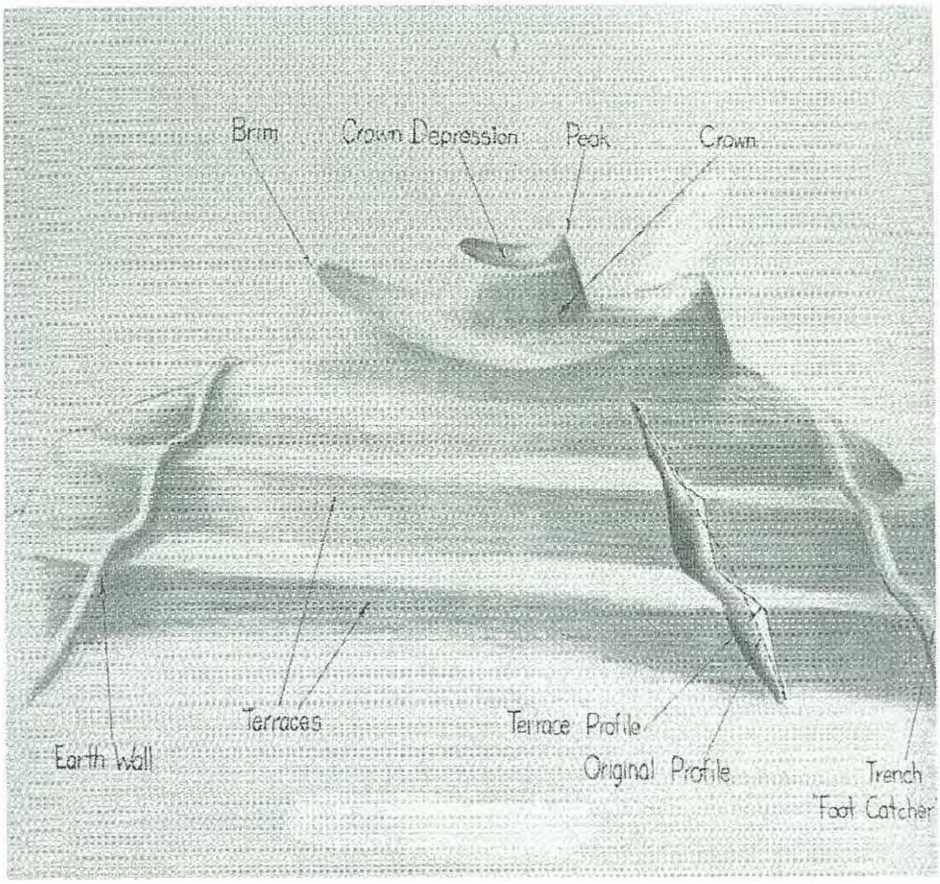

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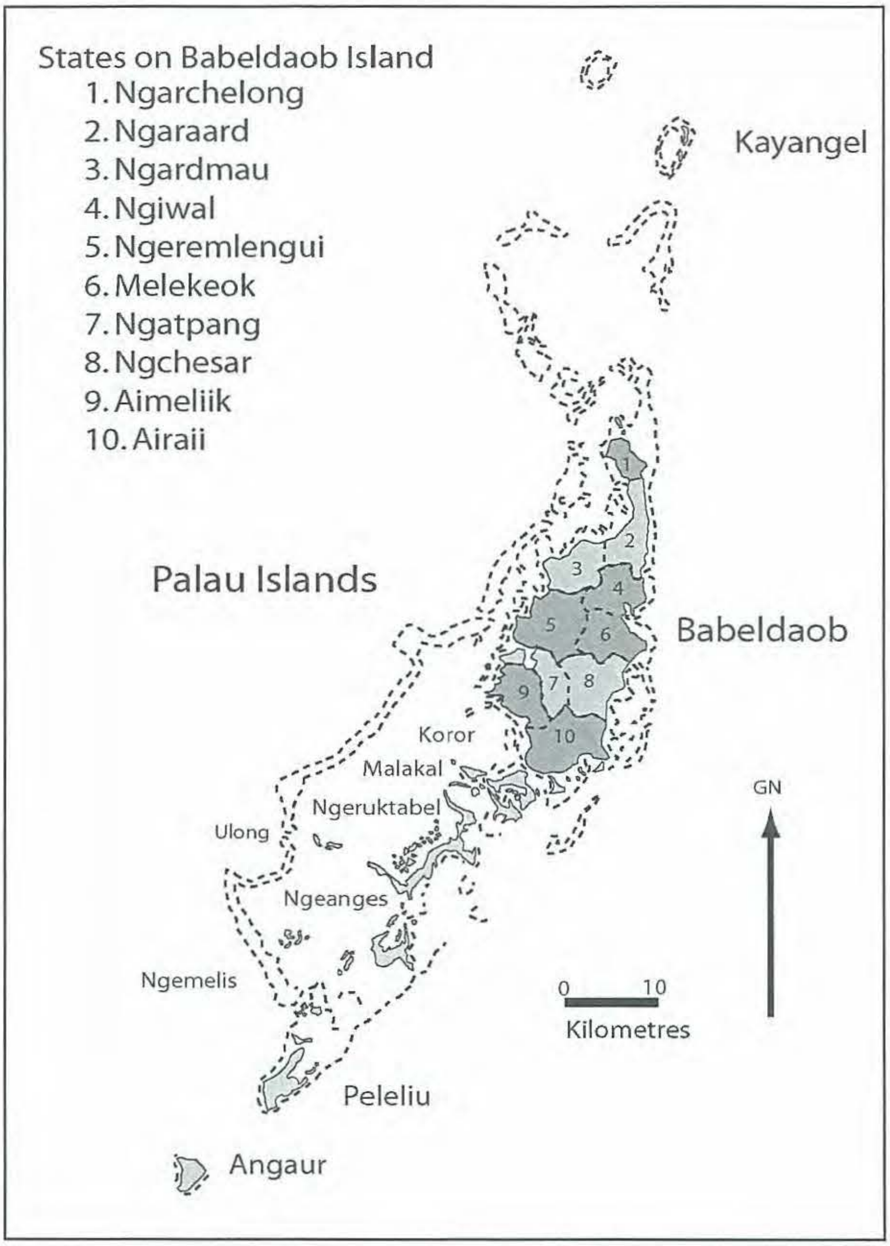

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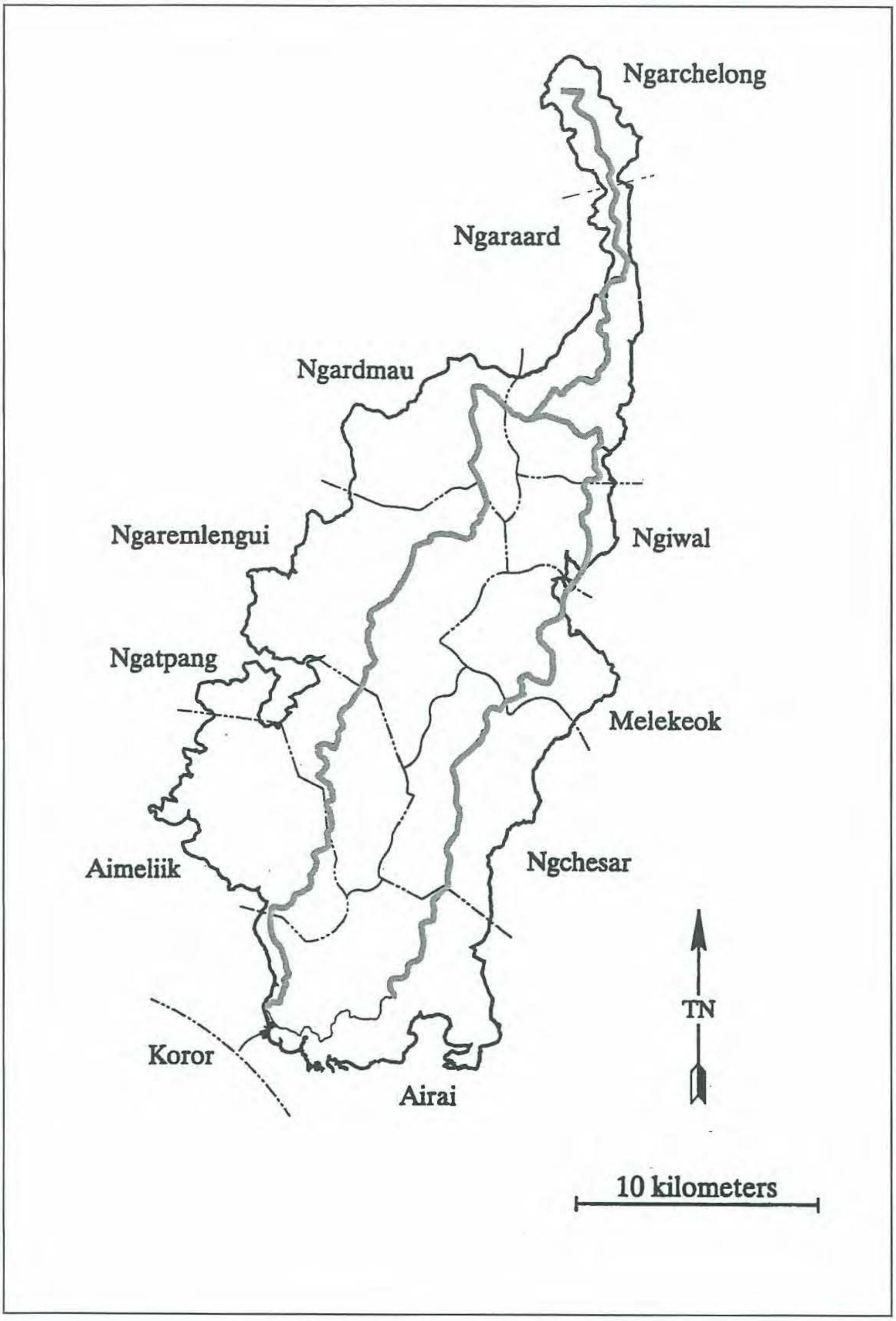

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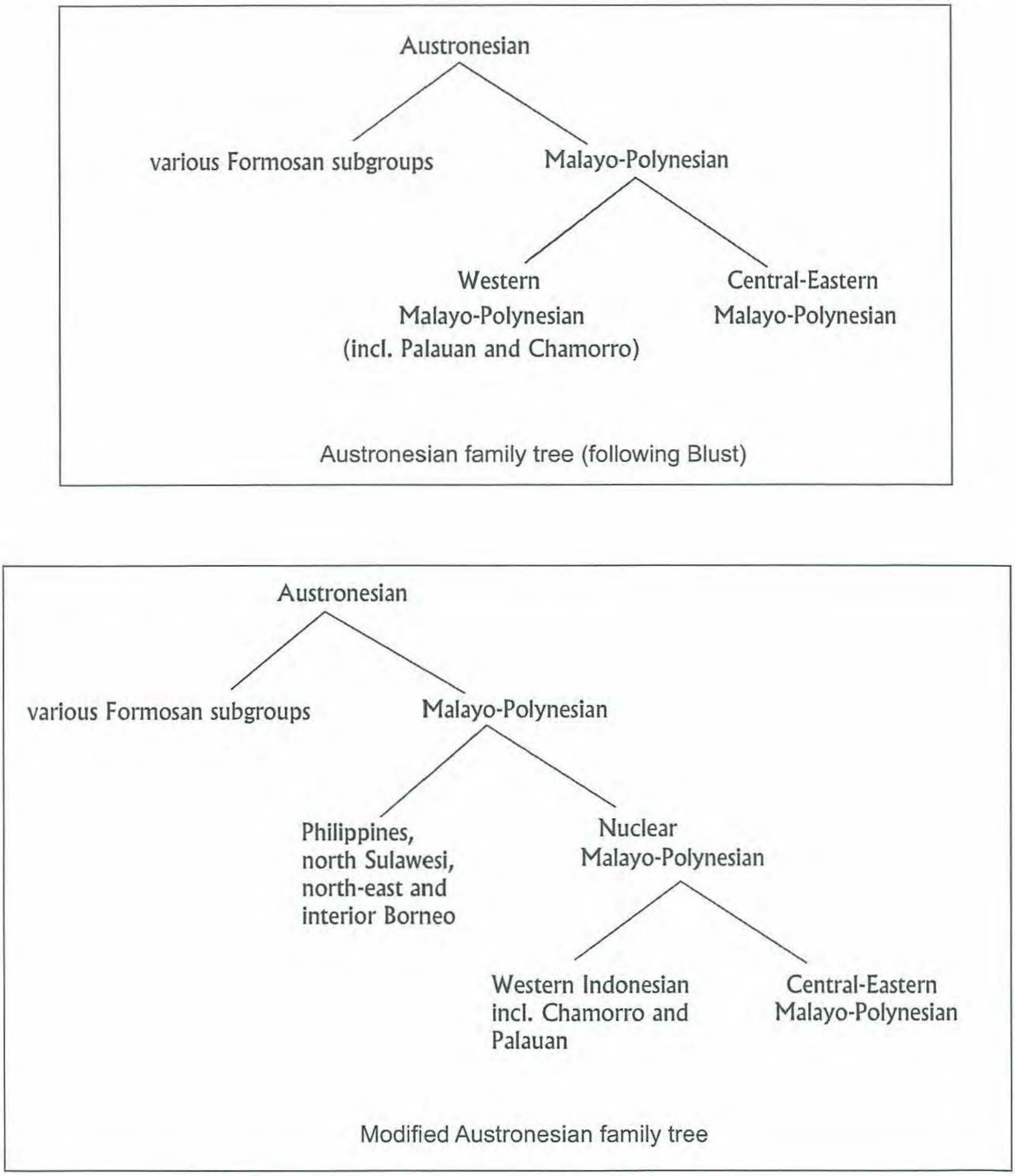

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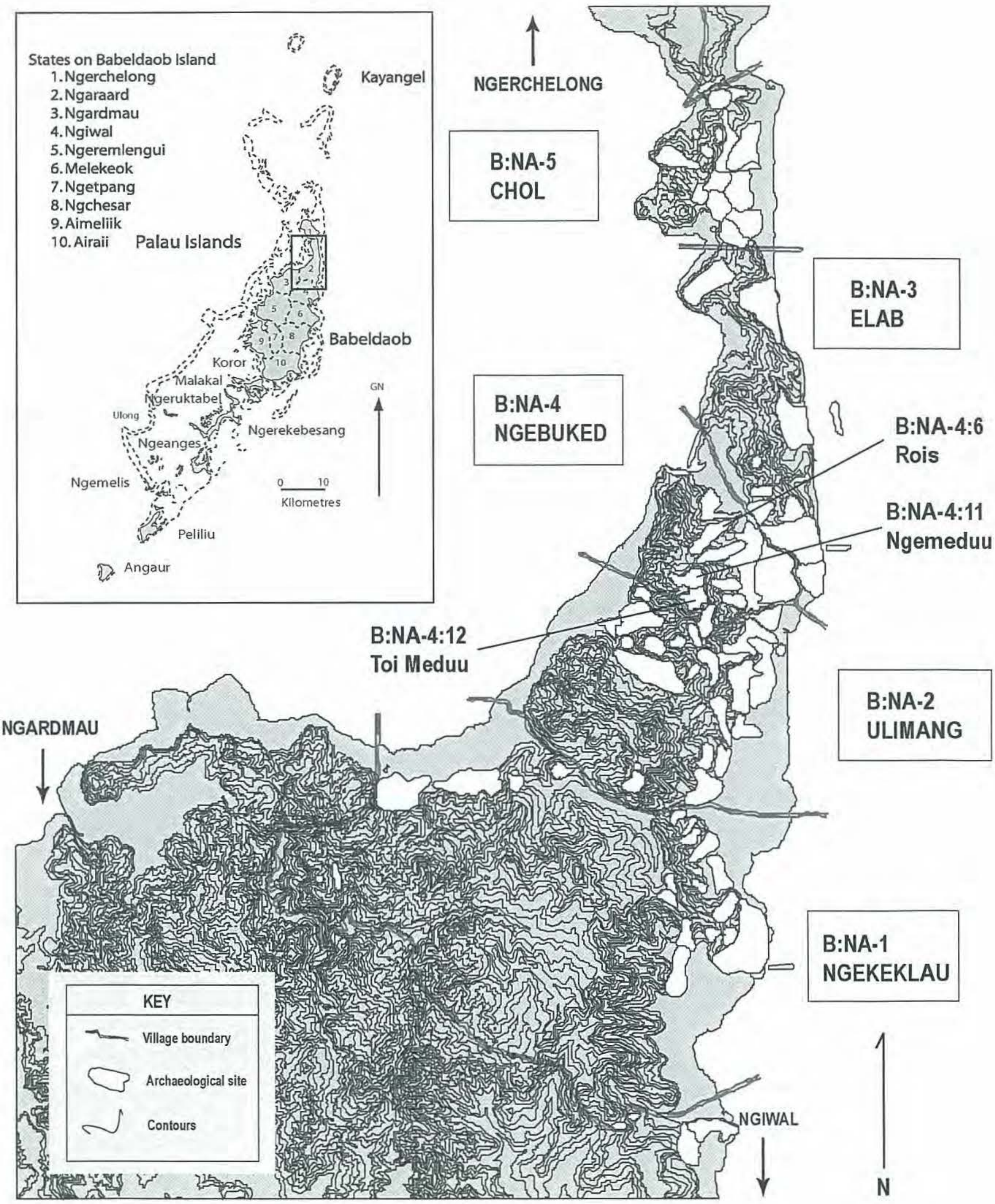


Figure 4.2 Map indicating location of Ngaraard, Babeldaob (inset), and the five village areas. It also illustrates the three sites investigated in this study. The map has been modified from the Bureau of Arts and Culture GIS database.

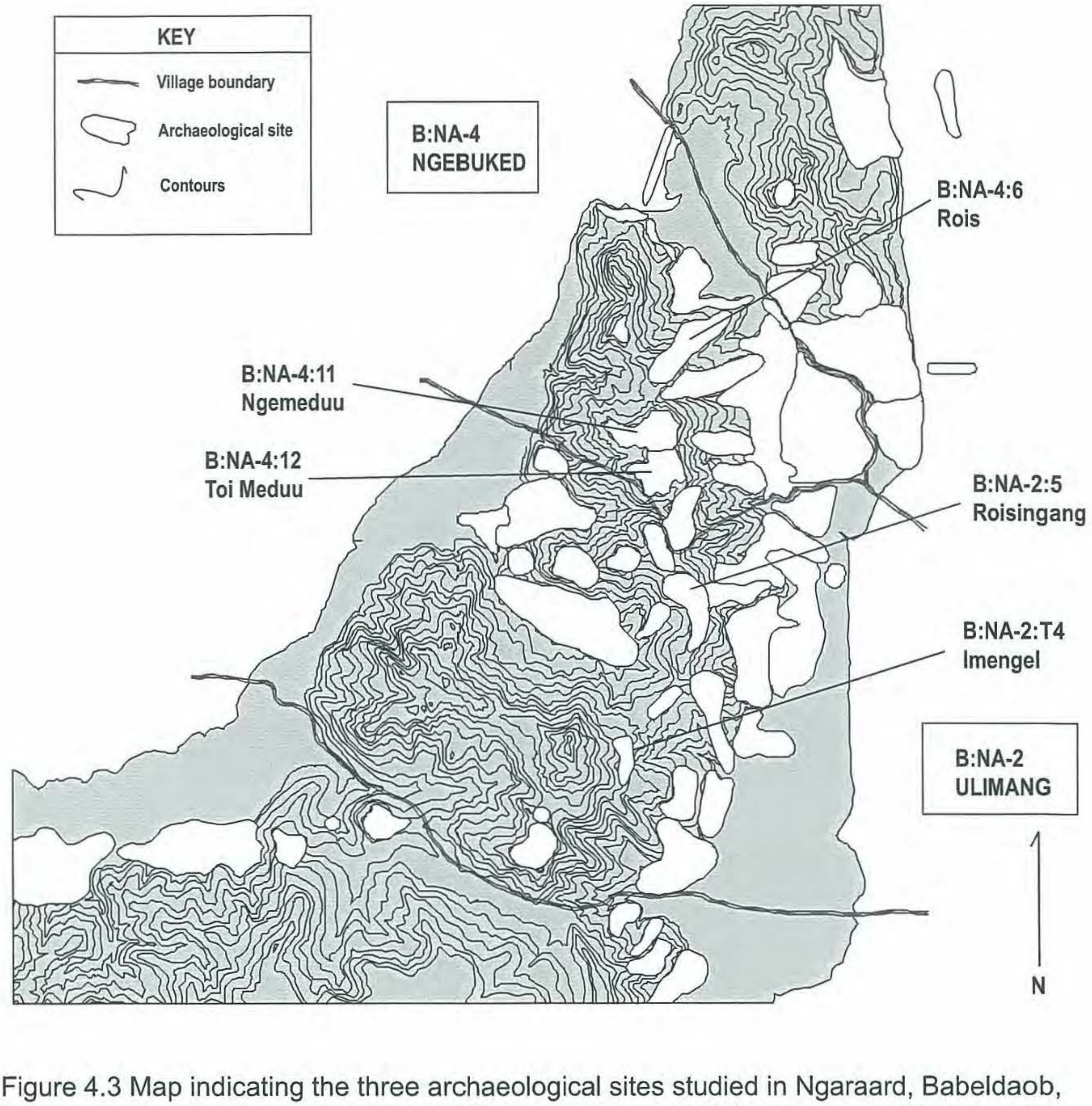


Figure 4.3 Map indicating the three archaeological sites studied in Ngaraard, Babeldaob, in Ulimang and Ngebuked Traditional Village areas.This map has been modified from the Bureau of Arts and Culture GIS database.

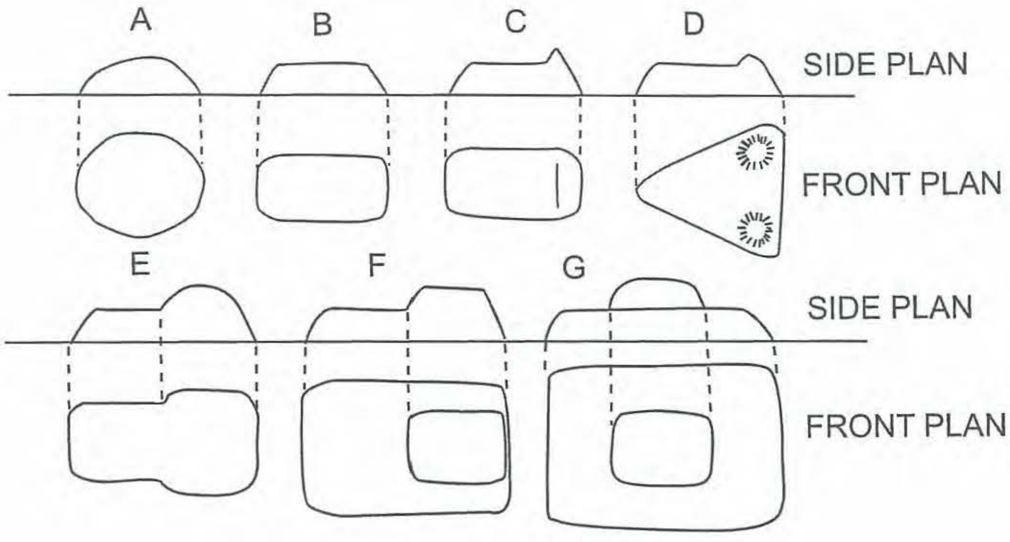


Figure 4.4 Example of *bukl*, from Hijikata (1993:59).

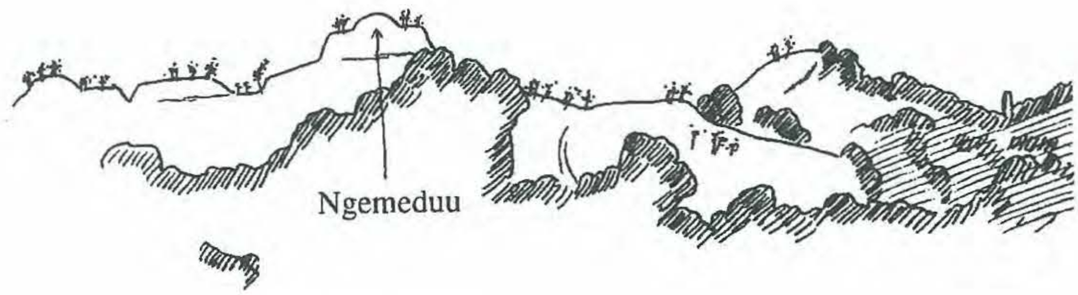


Figure 4.5 Hijikata' s drawing "The *ked* called Ngemeduu as seen from Cebtui" (Hijikata 1993:63). Toi Meduu is seen here immediately left of Ngemeduu.

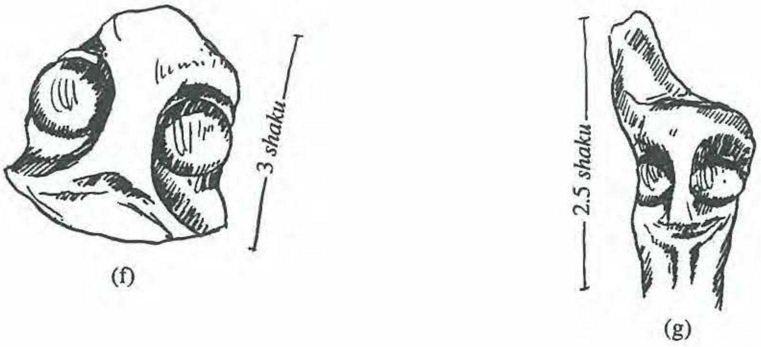


Figure 4.6 (a) Two carved monoliths located on the ridge by Toi Meduu and NgemedUu (Hijikata 1993:24-25).

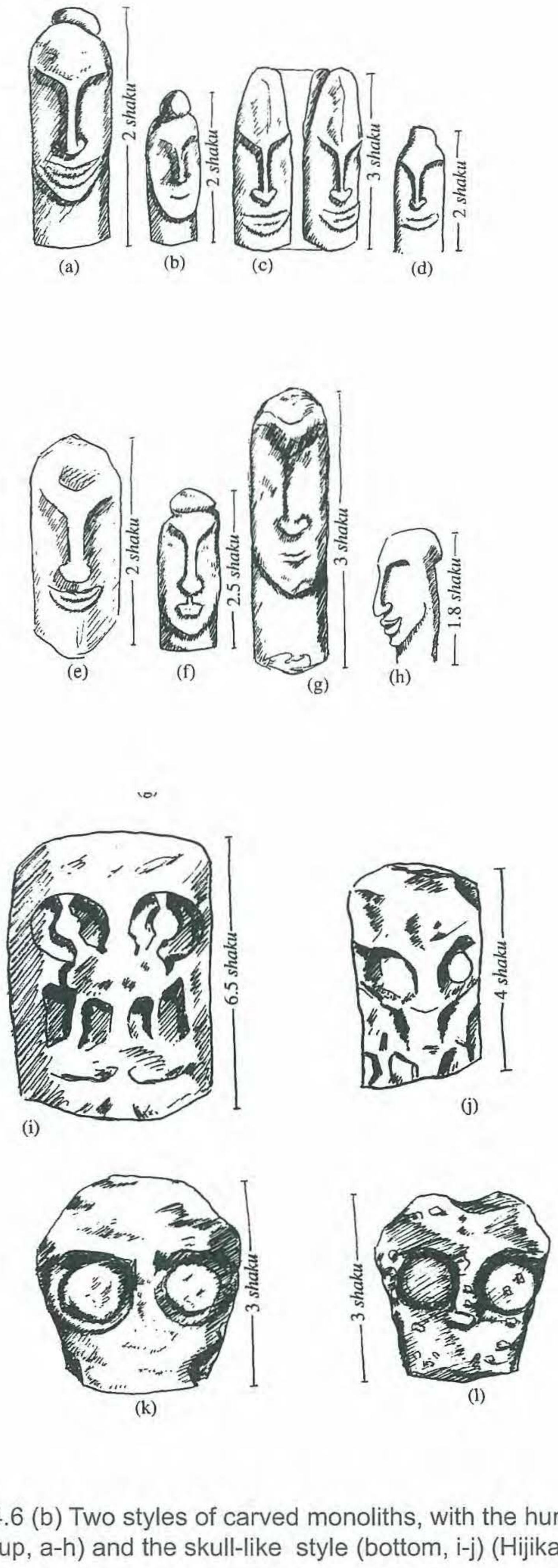


Figure 4.6 (b) Two styles of carved monoliths, with the human face style (top group, a-h) and the skull-like style (bottom, i-j) (Hijikata 1993:25-27).

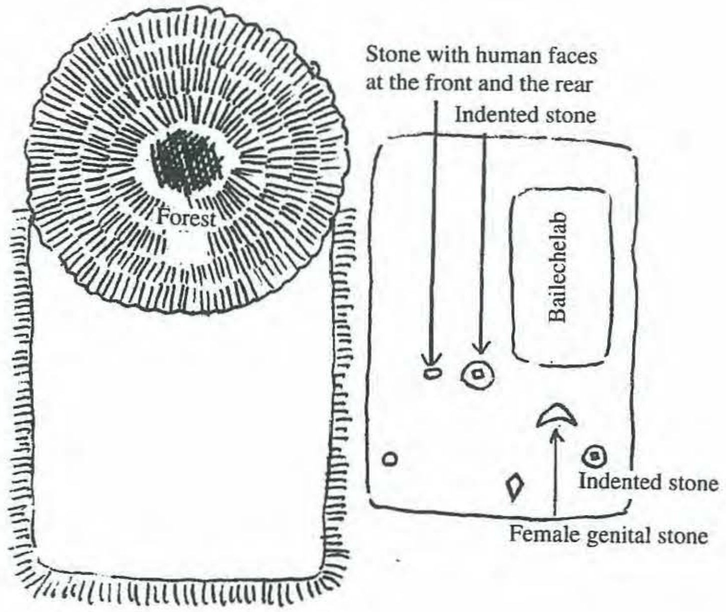
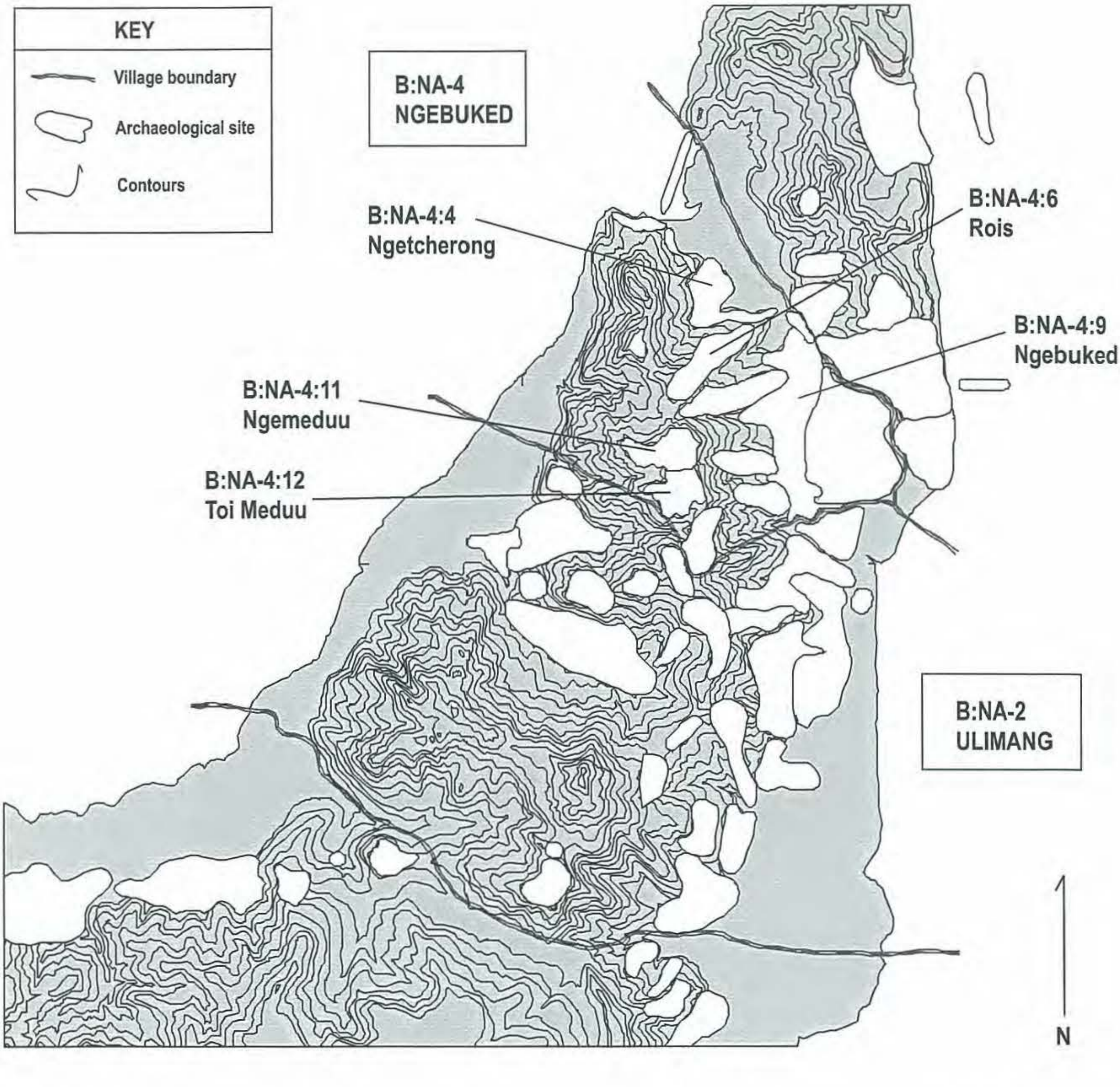


Figure 4.7 The front section of the hill called Roisang, indicating the position of the carved stone monoliths and the coral platform, *Bailechelab*. Identified by Hijikata (1993:69).



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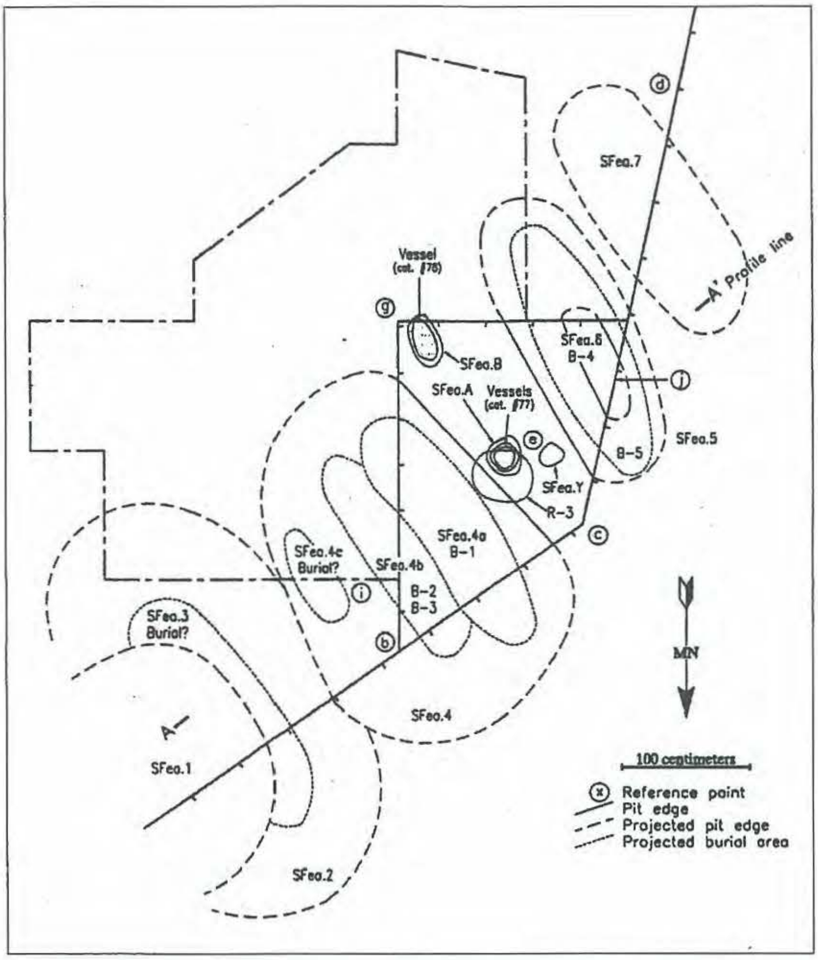


Figure 4.9 Plan of burials at Rois (B:NA-4:6), from the surface of Layer IV. Shows burial pit outlines and projected pit areas (hypothetical) (from Liston et al. 1998).

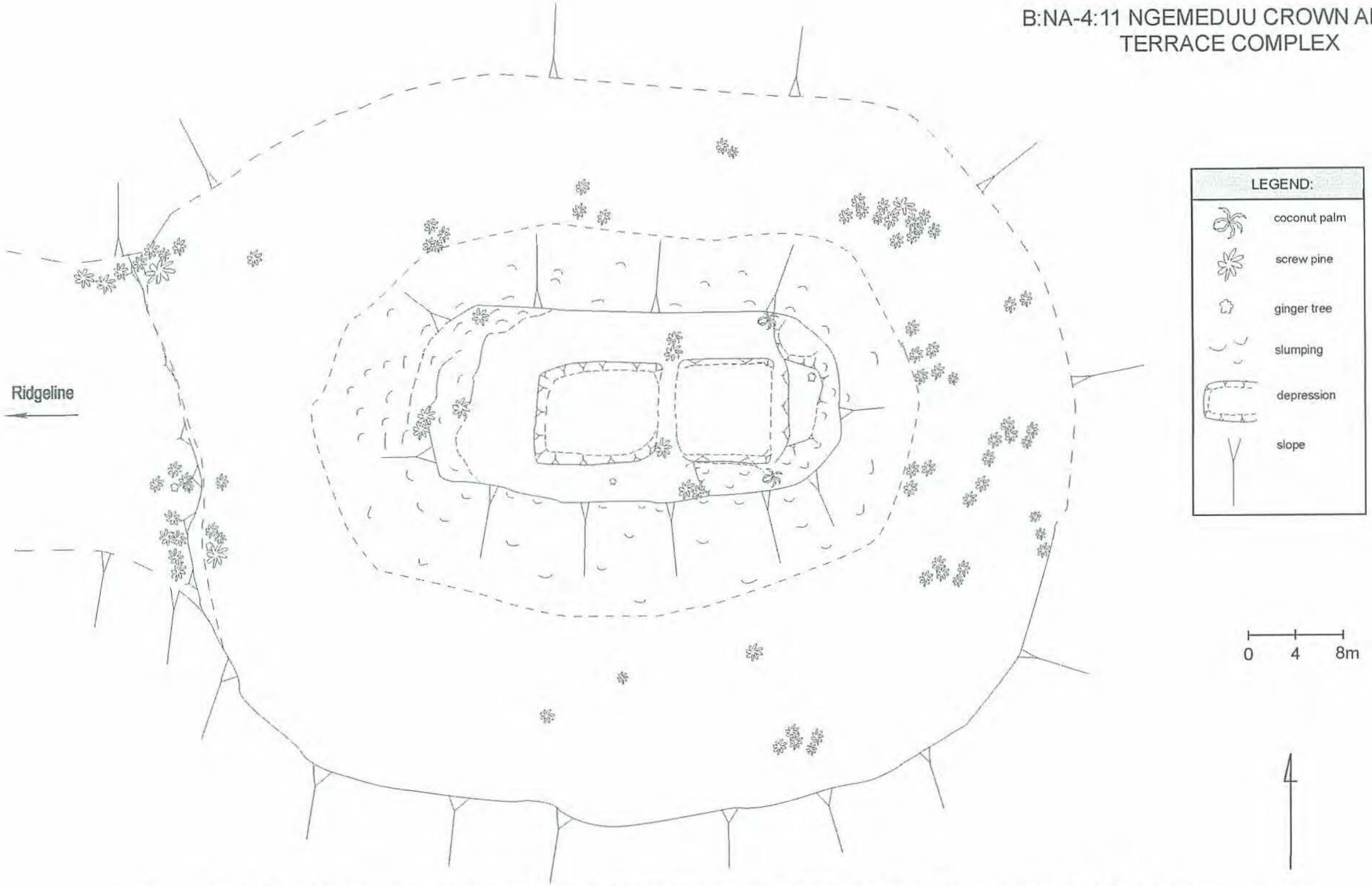


Figure 5.1 The Ngemeduu crown, with two depressions, and knoll on the eastern extent. Note also the berm or mounded edge of the encircling terrace.

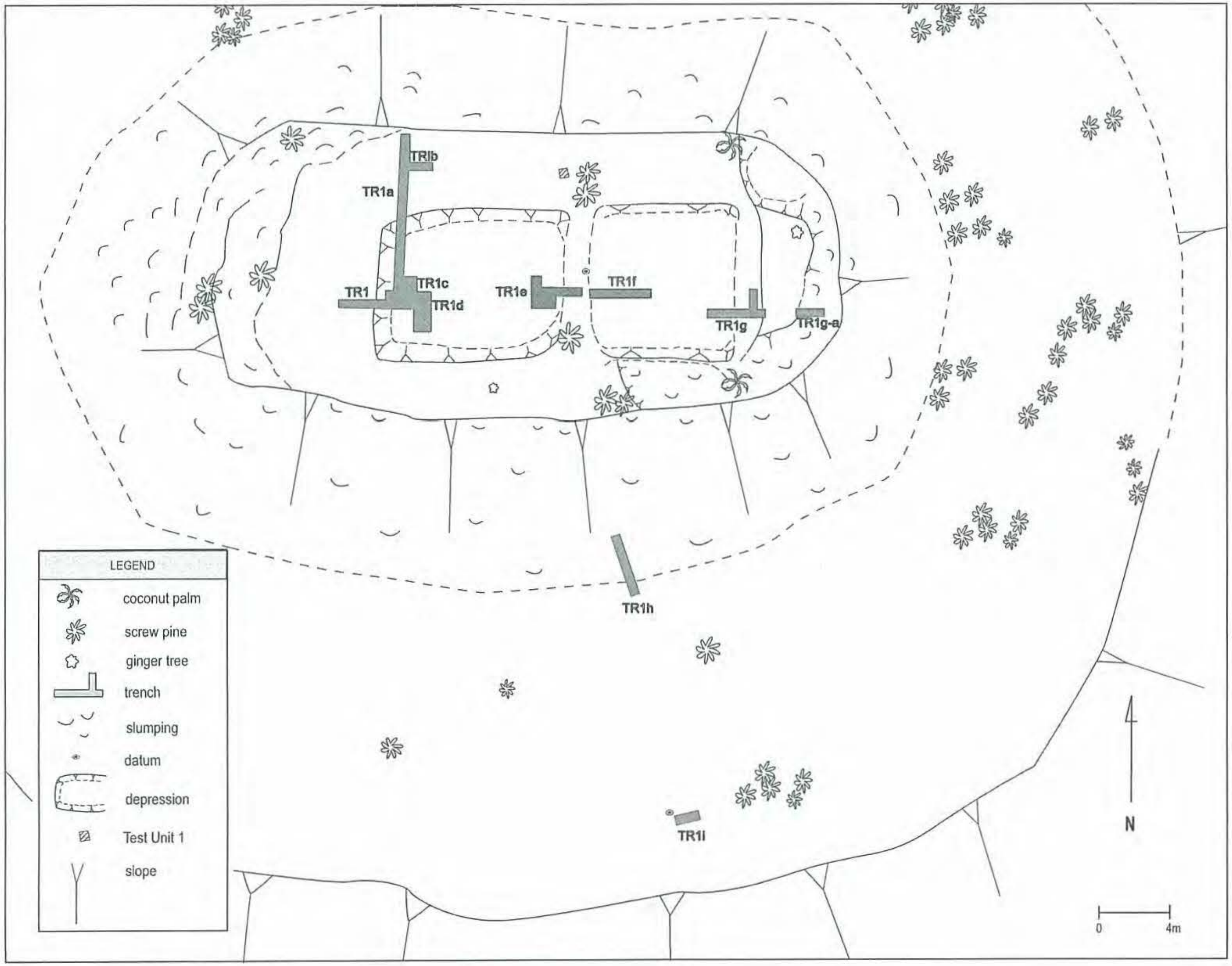


Figure 5.2 B:NA-4:11 Ngemeduu Crown and Terrace Complex. Map indicating trench locations on the crown and encircling terrace.

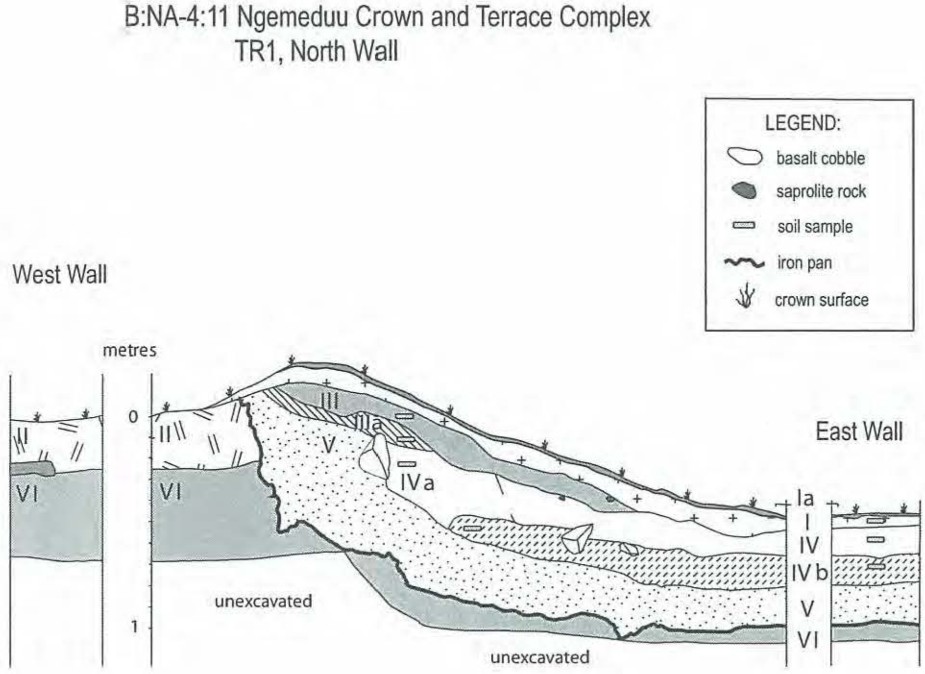


Figure 5.3 TR1 section diagram.

B:NA-4:11 Ngemeduu Crown and Terrace Complex

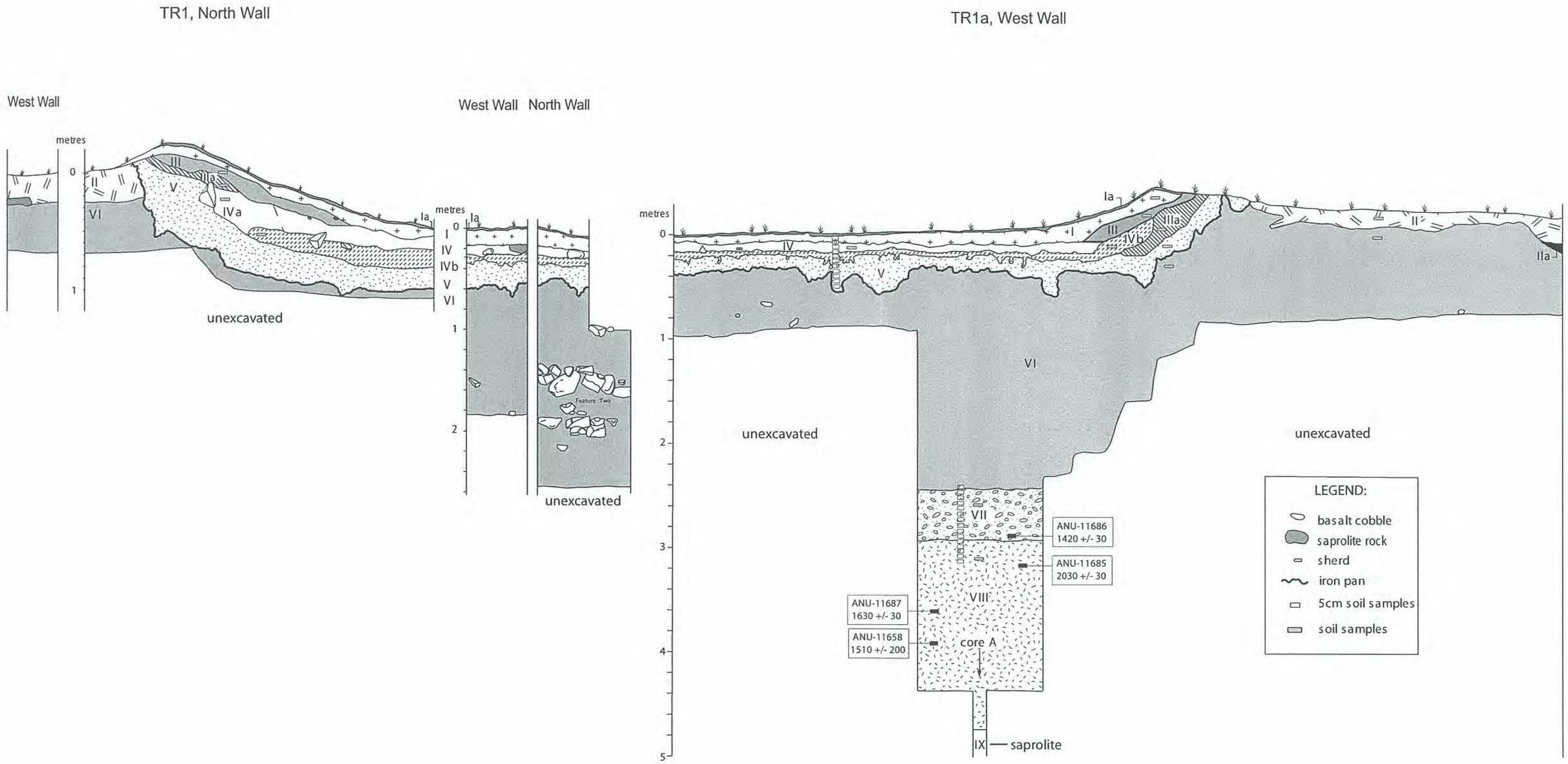


Figure 5.4 Section diagrams for TR1a and TR1, joined through the 'L' intersection (centre).

B:NA-4:11 Ngemeduu Crown and Terrace Complex
Feature One
Plan View

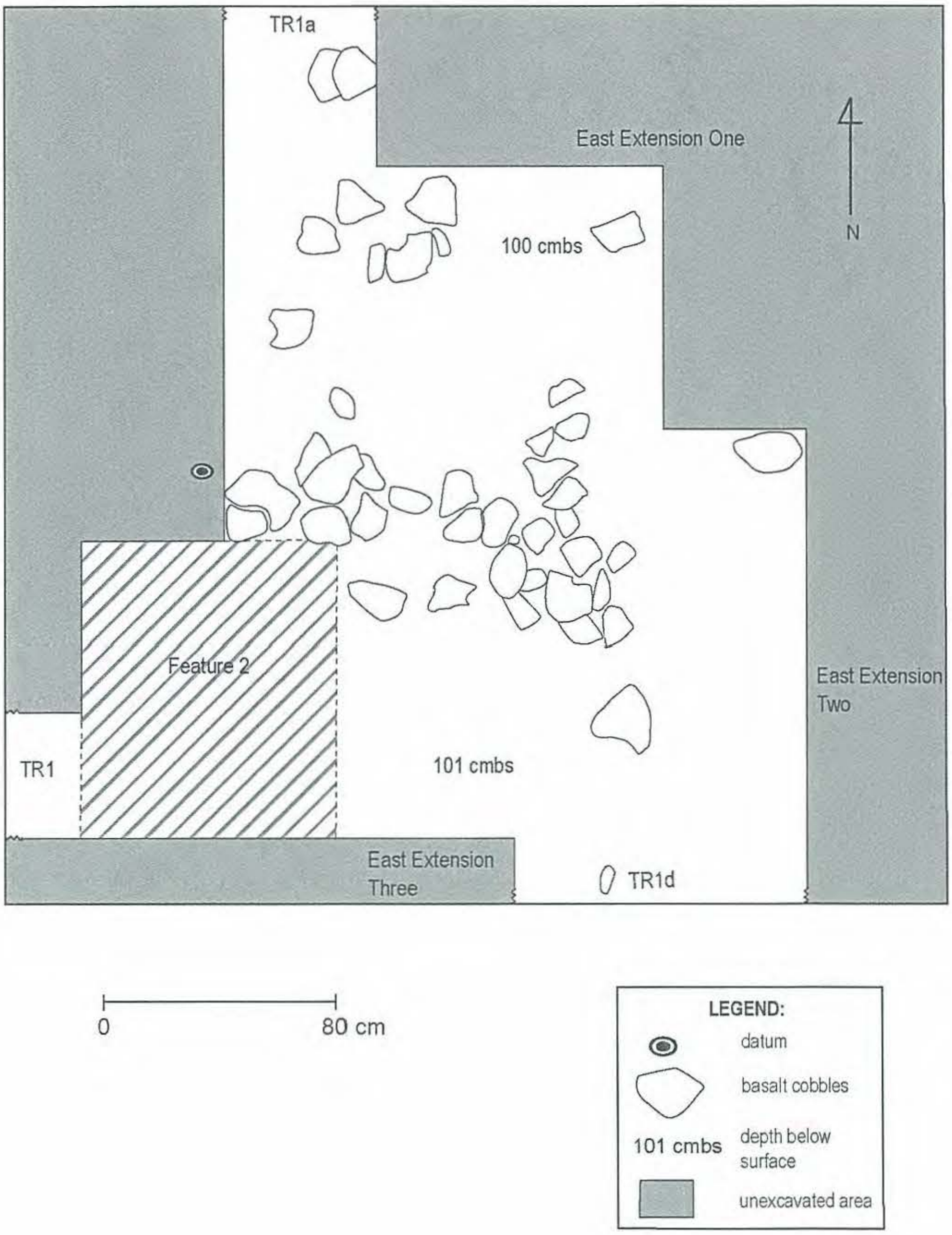


Figure 5.5 Plan view of Feature 1, TR1a.

B:NA-4:11 Ngemeduu Crown and Terrace Complex
Feature Two
Plan View One

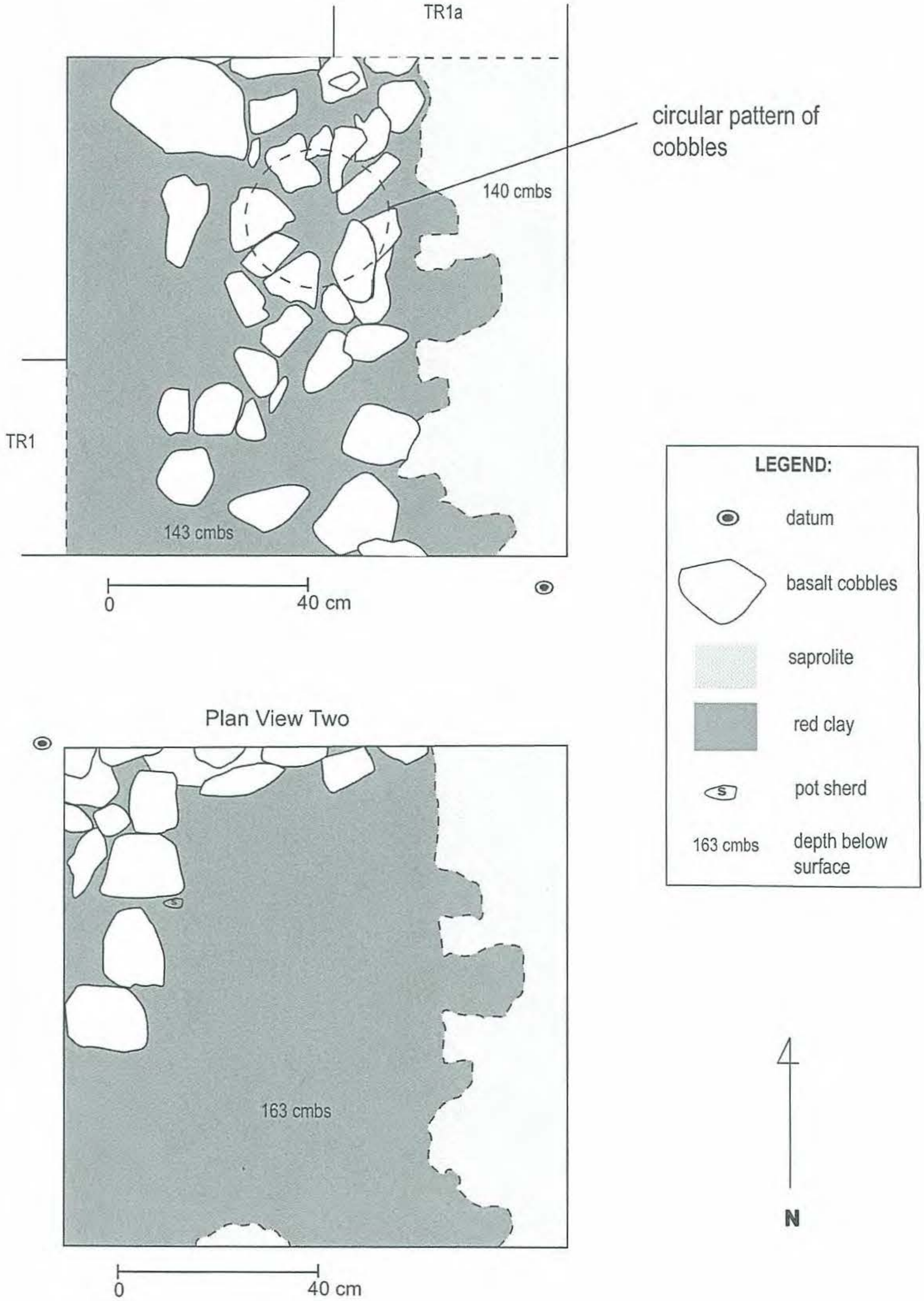


Figure 5.6 Plan views of Feature 2, TR1a. Note the circular pattern in Plan View One, and the differing clay fill materials in both.

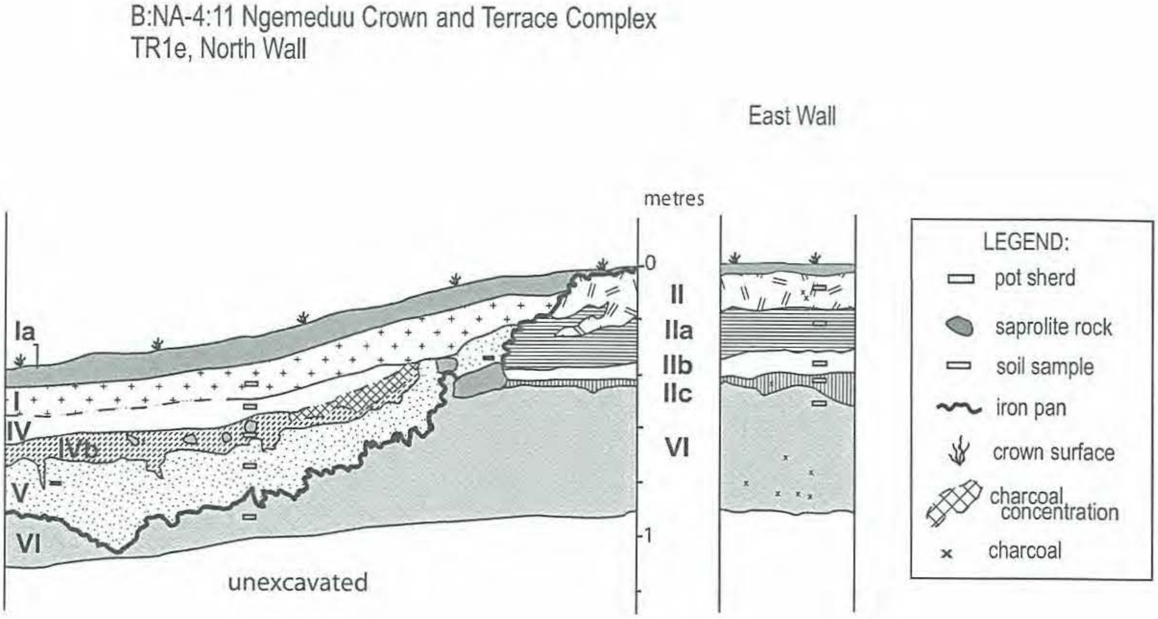


Figure 5.7 Section diagram for TR1e.

B:NA-4: 11 Feature 3 and Feature 3a
Plan View

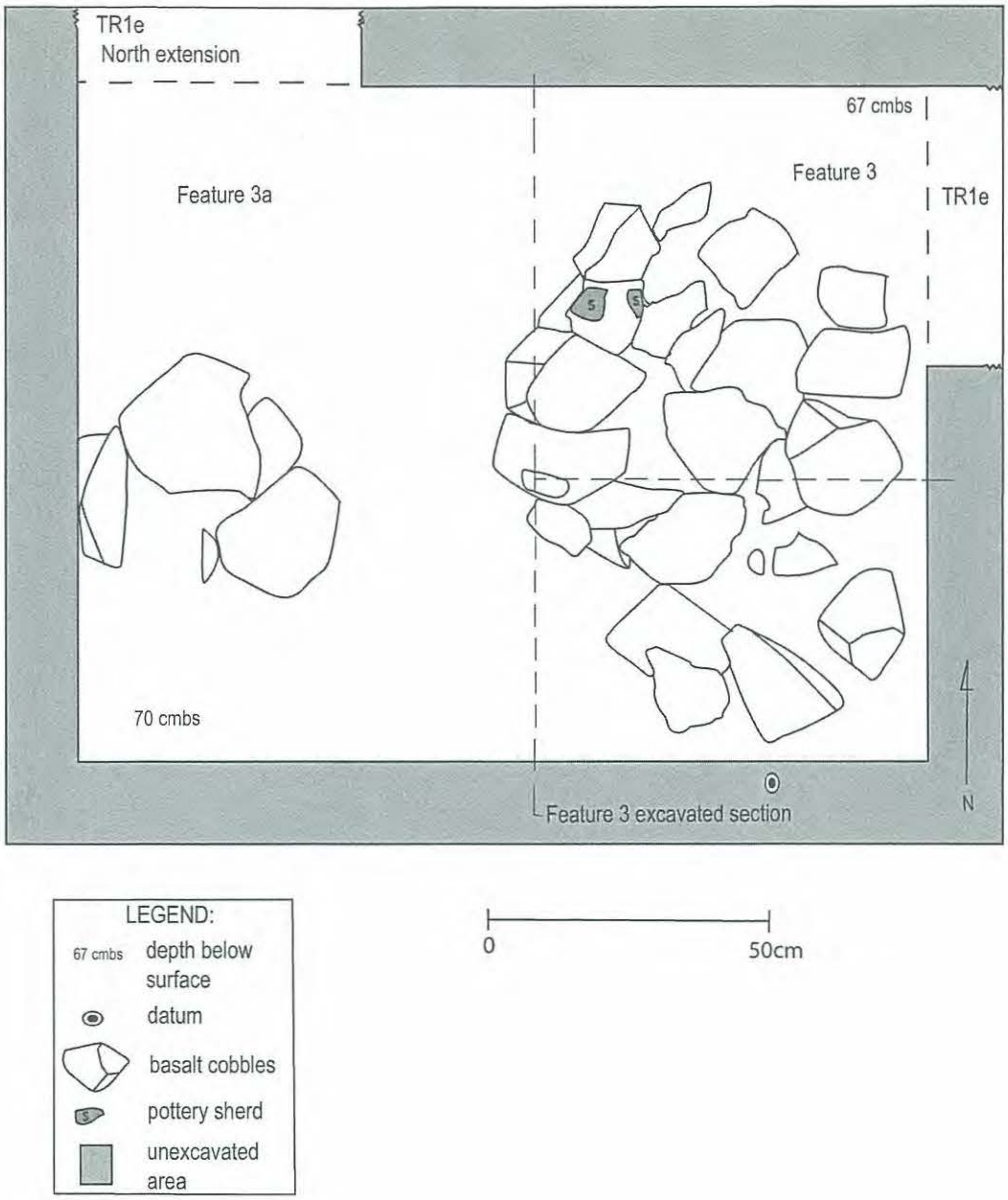


Figure 5.8 Plan view of Feature 3 and Feature 3a, TR1e.

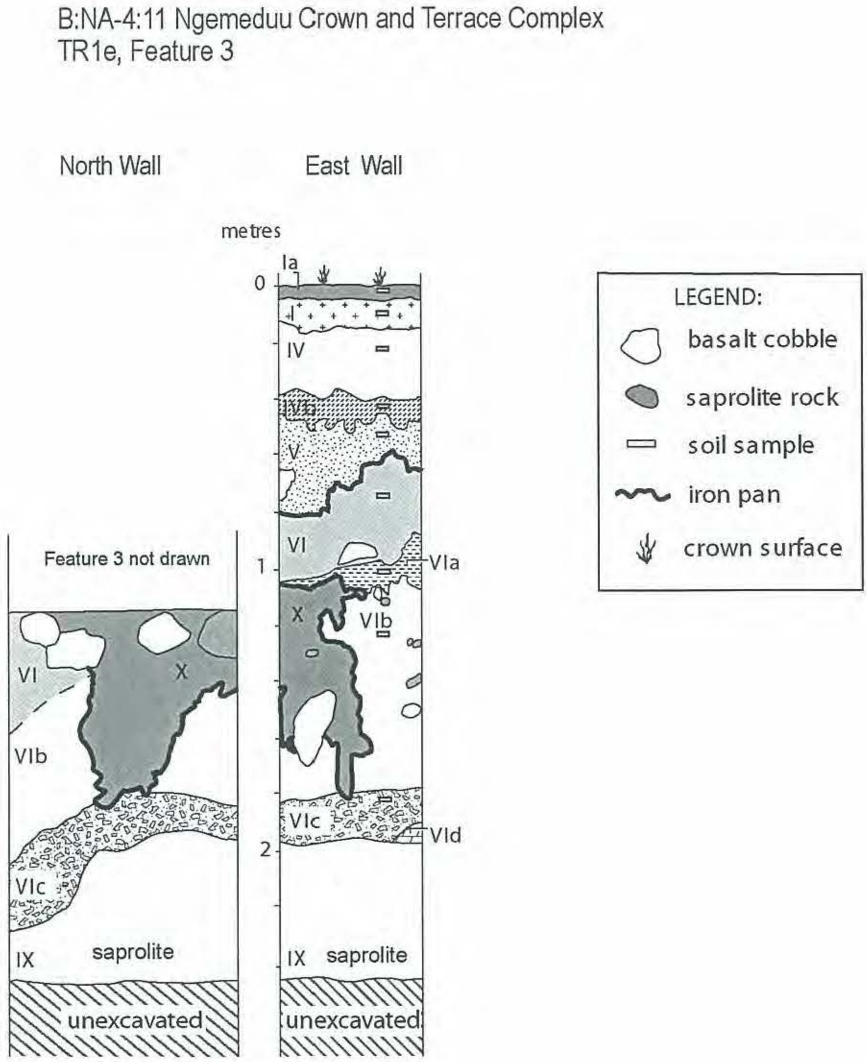
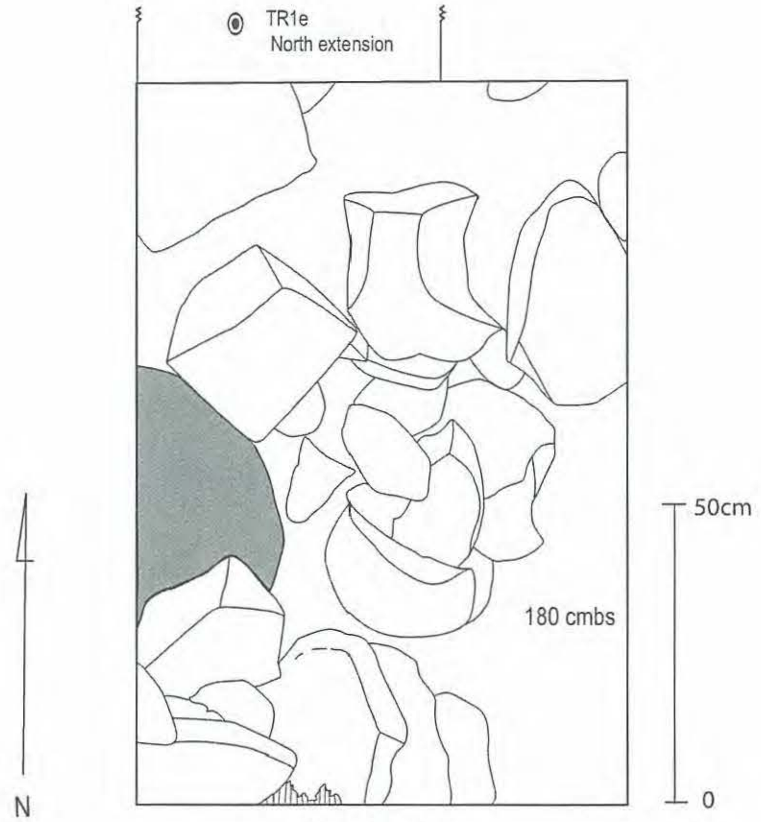
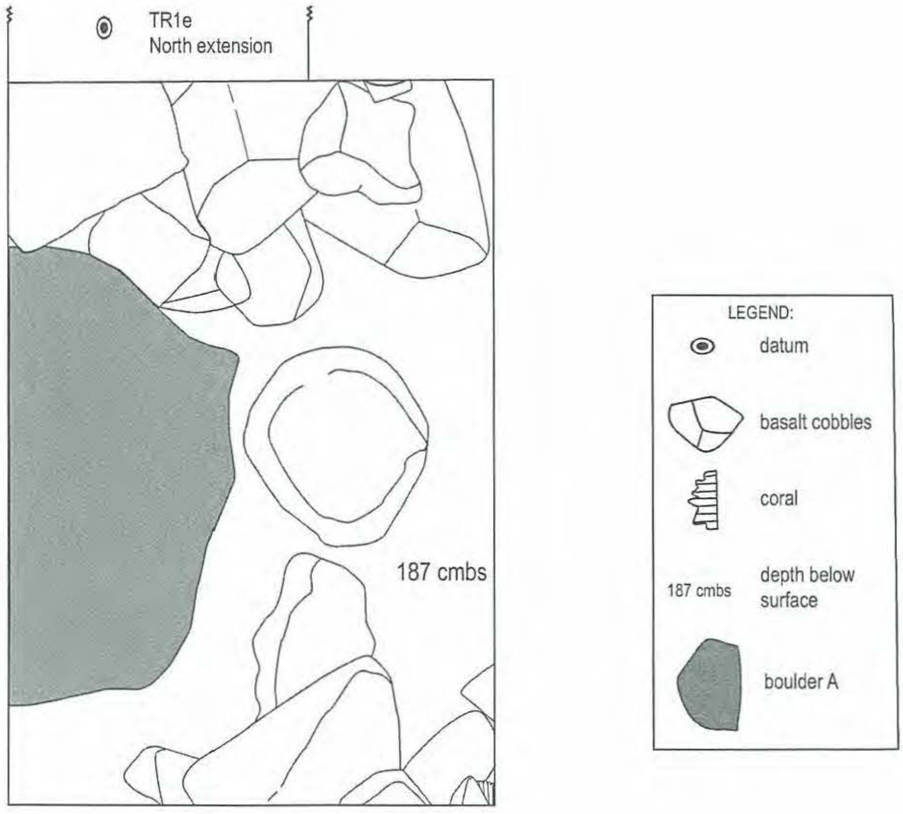


Figure 5.9 Section diagram for Feature 3, TR1e.

B:NA-4:11Ngemeduu Crown and Terrace Complex
Plan Views of Feature 3a, TR1e



Plan View 1



Plan View 2

Figure 5.10 Plan views of Feature 3a, TR1e, indicating large subsurface boulders, and coral.

B:NA-4:11 Ngemeduu Crown and Terrace Complex
TR1e, Feature 3a

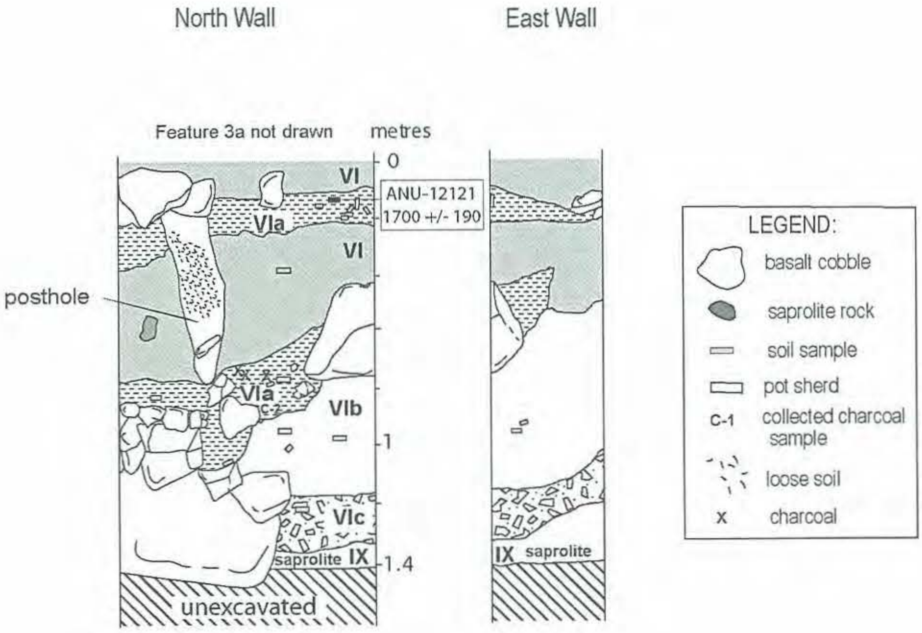


Figure 5.11 Section diagram of Feature 3a, TR1e, indicating the location of the posthole.

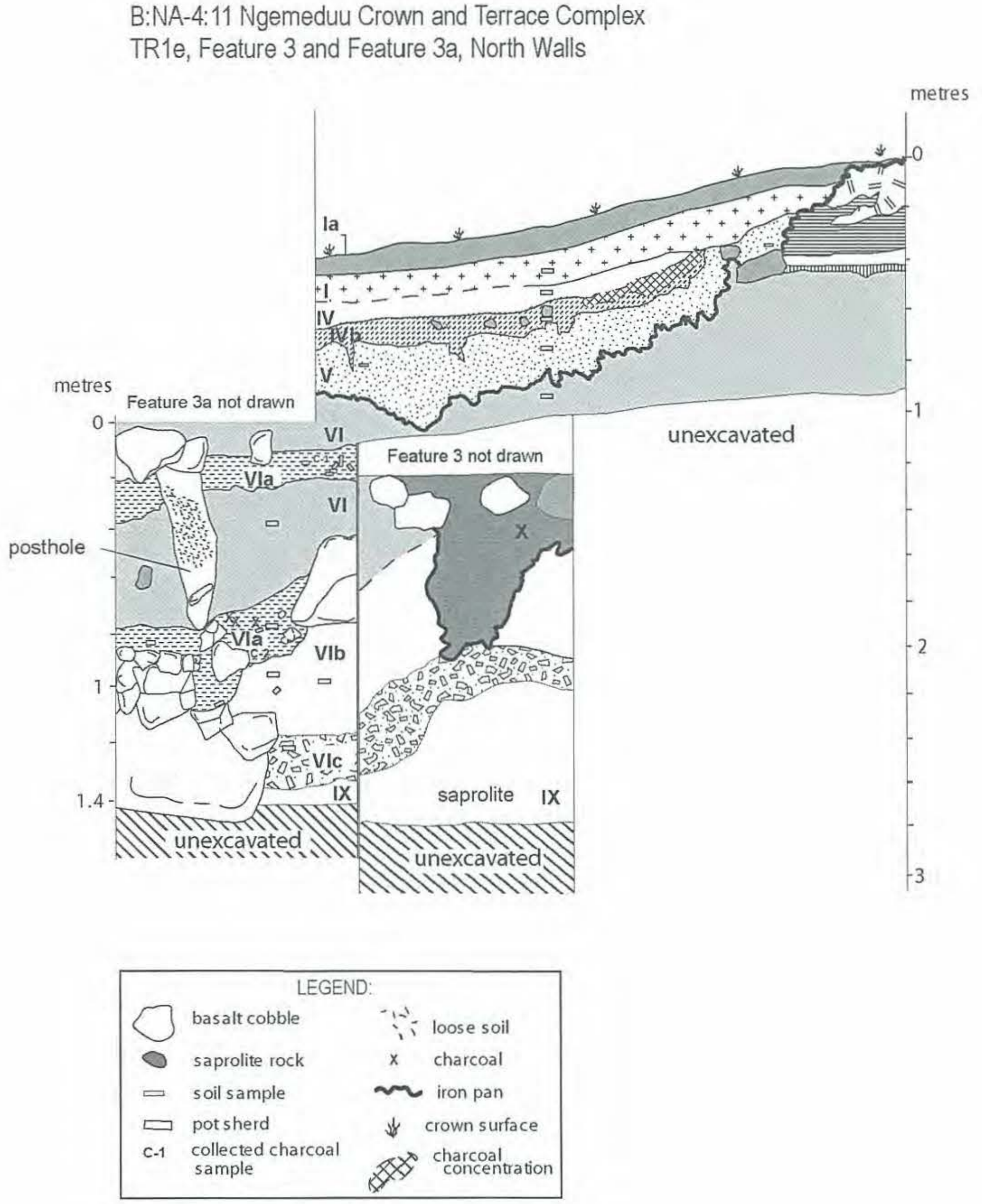


Figure 5.12 Joint section diagrams of TR1e, Feature 3 and Feature 3a. Note that both features are not drawn here.

B:NA-4:11 Ngemeduu Crown and Terrace Complex

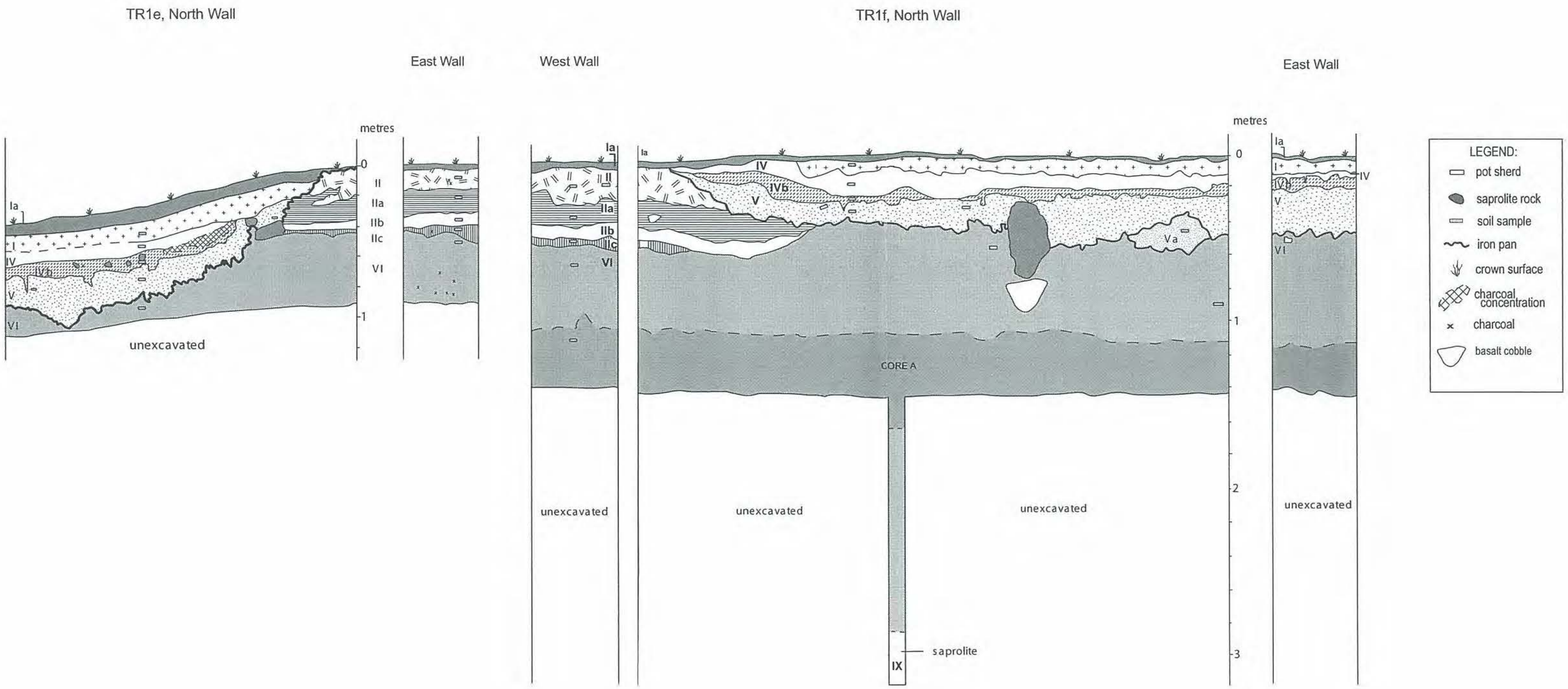


Figure 5.13 Section diagrams for TR1f, east depression, and TR1e, west depression, incorporating the strata of the baulk.

B:NA-4:11 Ngemeduu Crown and Terrace Complex
TR1g, South Wall

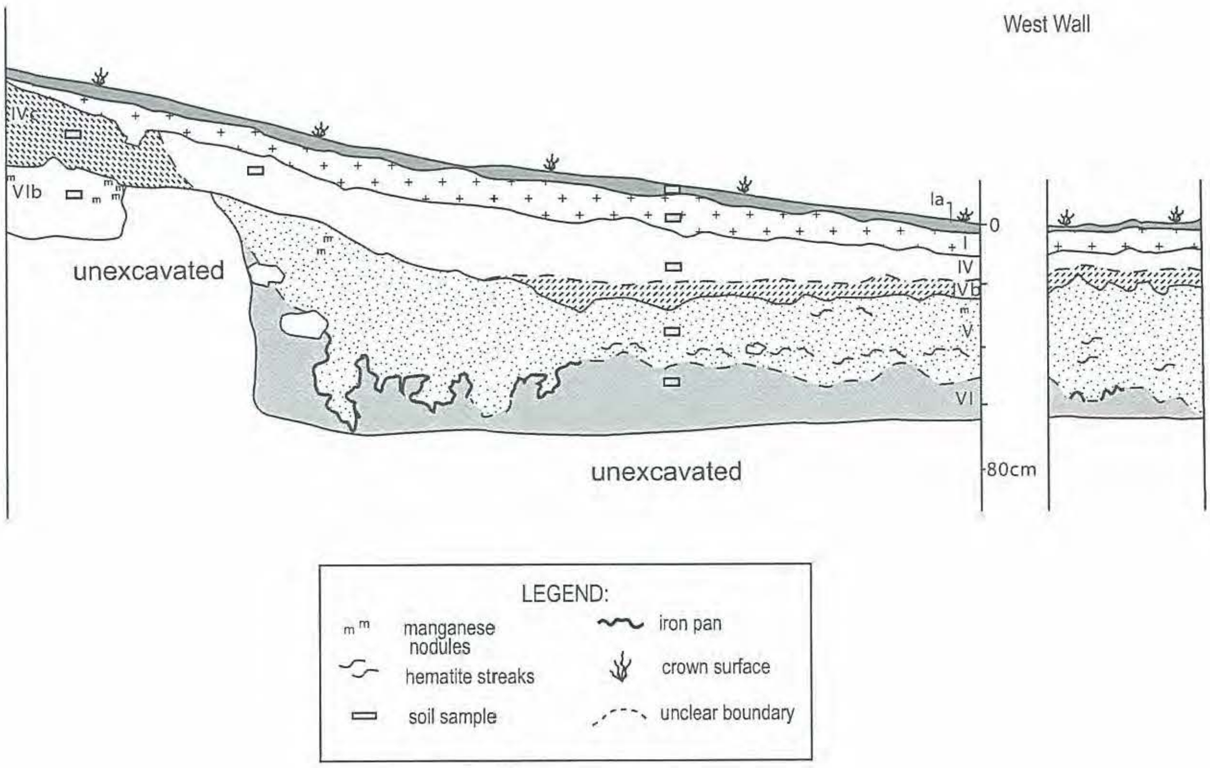


Figure 5.14 Section diagram for TR1g, illustrating the poorly developed iron pan.

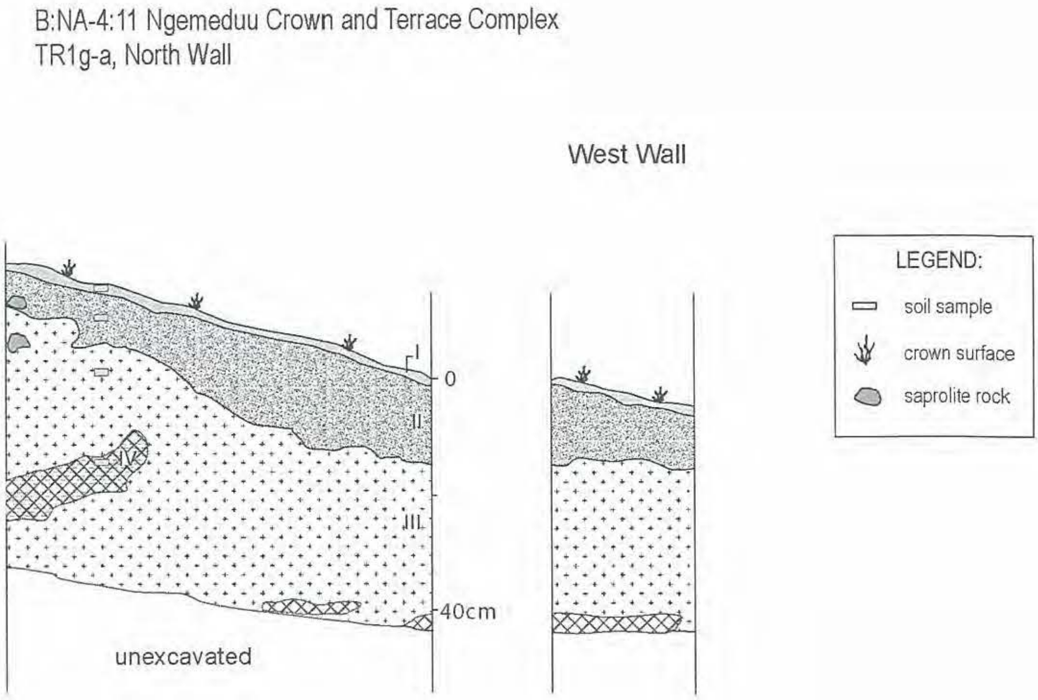


Figure 5.15 Section diagram for TR1g-a.

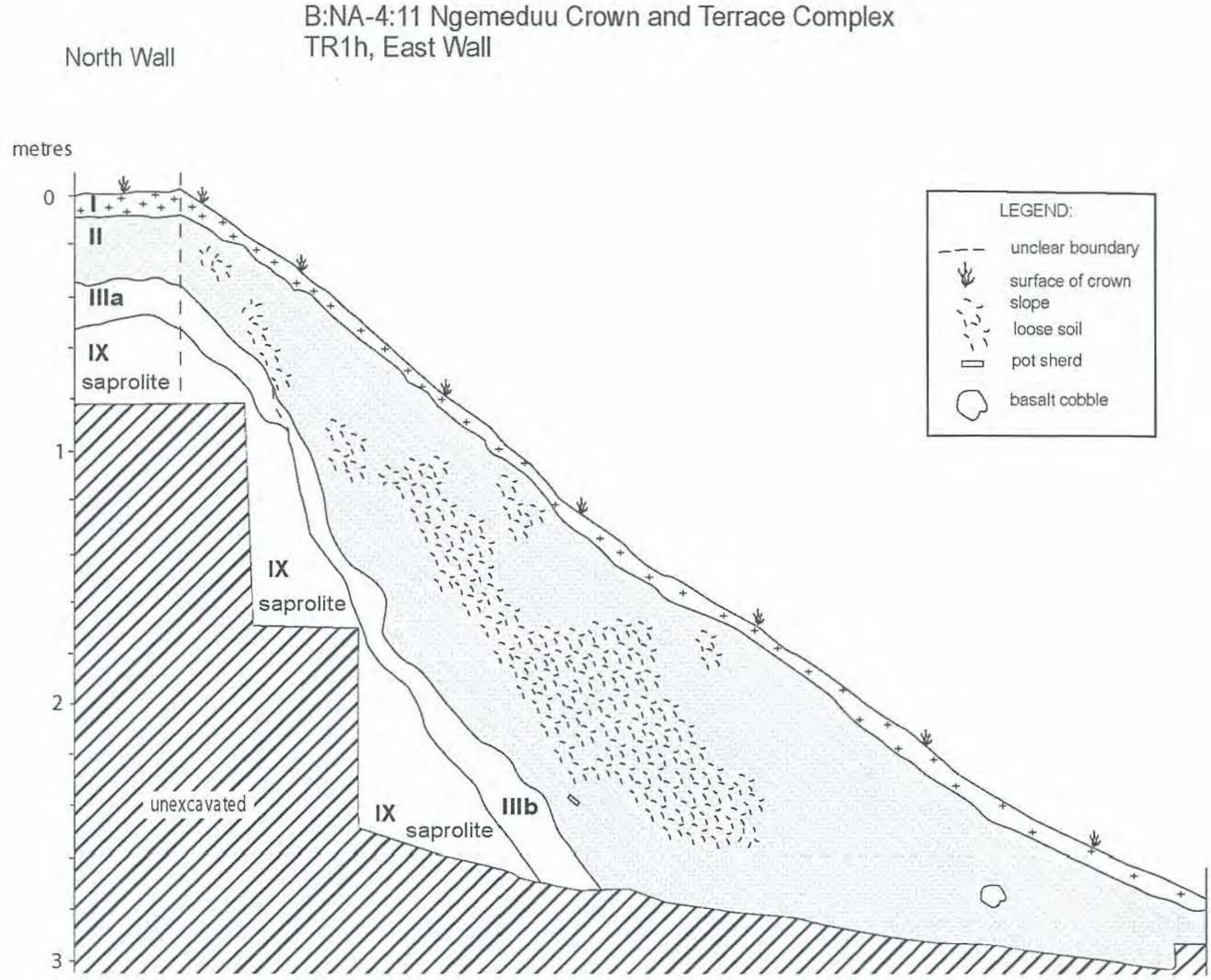


Figure 5.16 Section diagram for TR1h, southern slope of the crown.

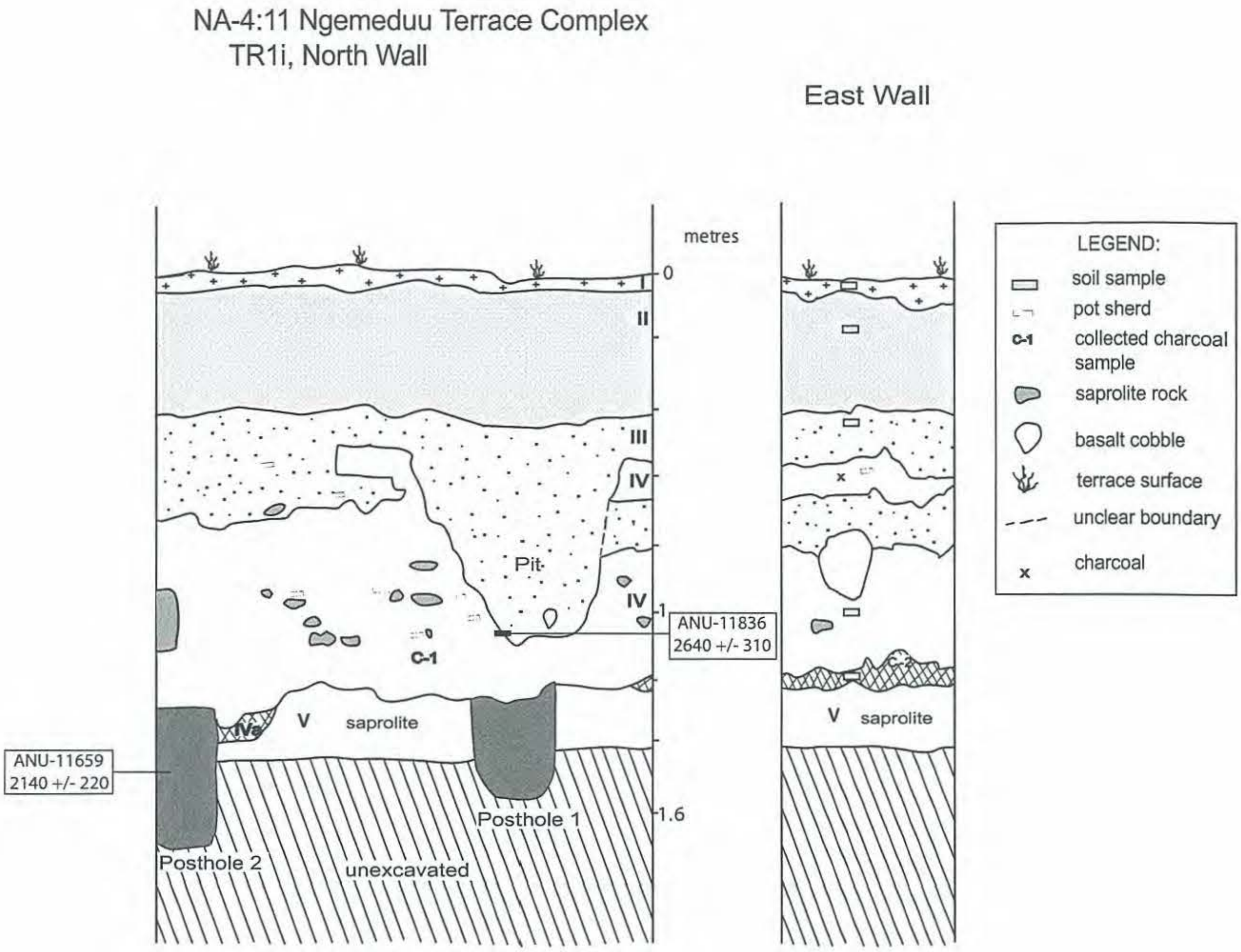


Figure 5.17 TR1i section diagram.

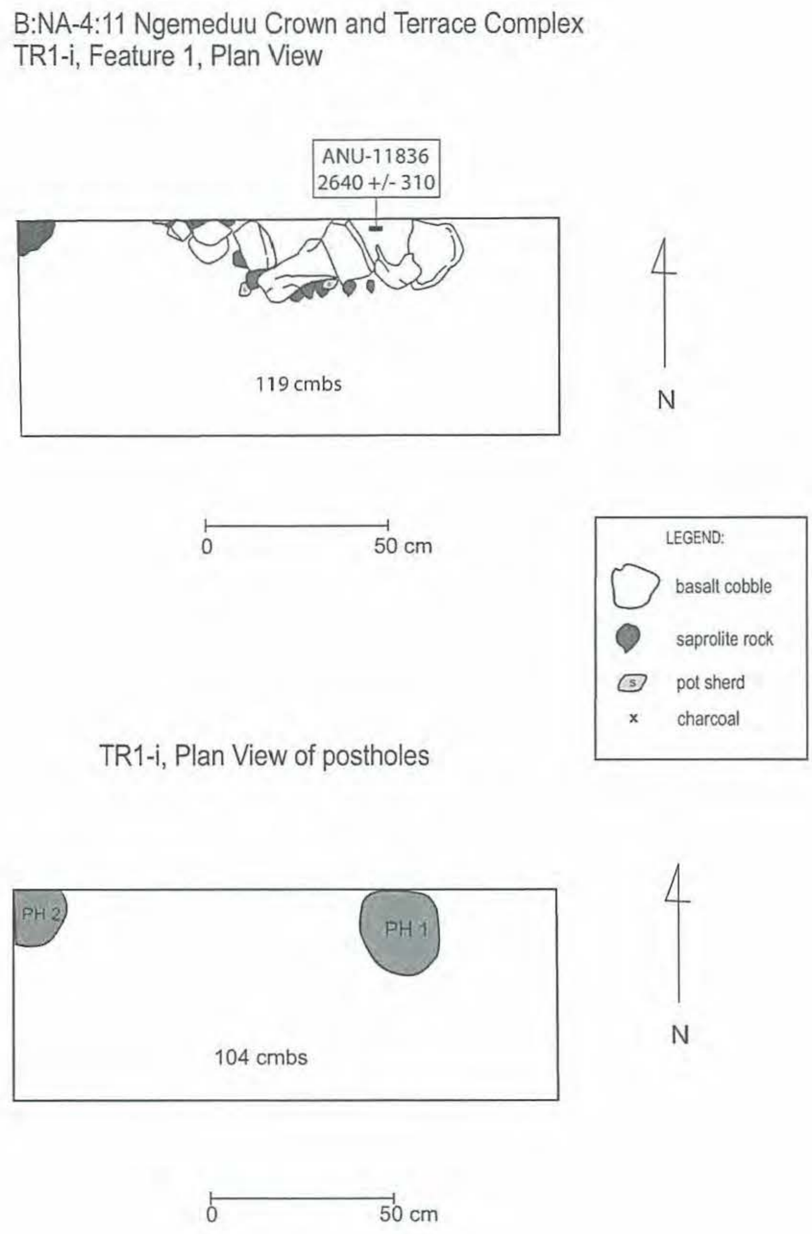


Figure 5.18 Plan views of Feature 1, and the two postholes of TR1i.

B:NA-4:11 Ngemeduu Crown and Terrace Complex
Test Unit One

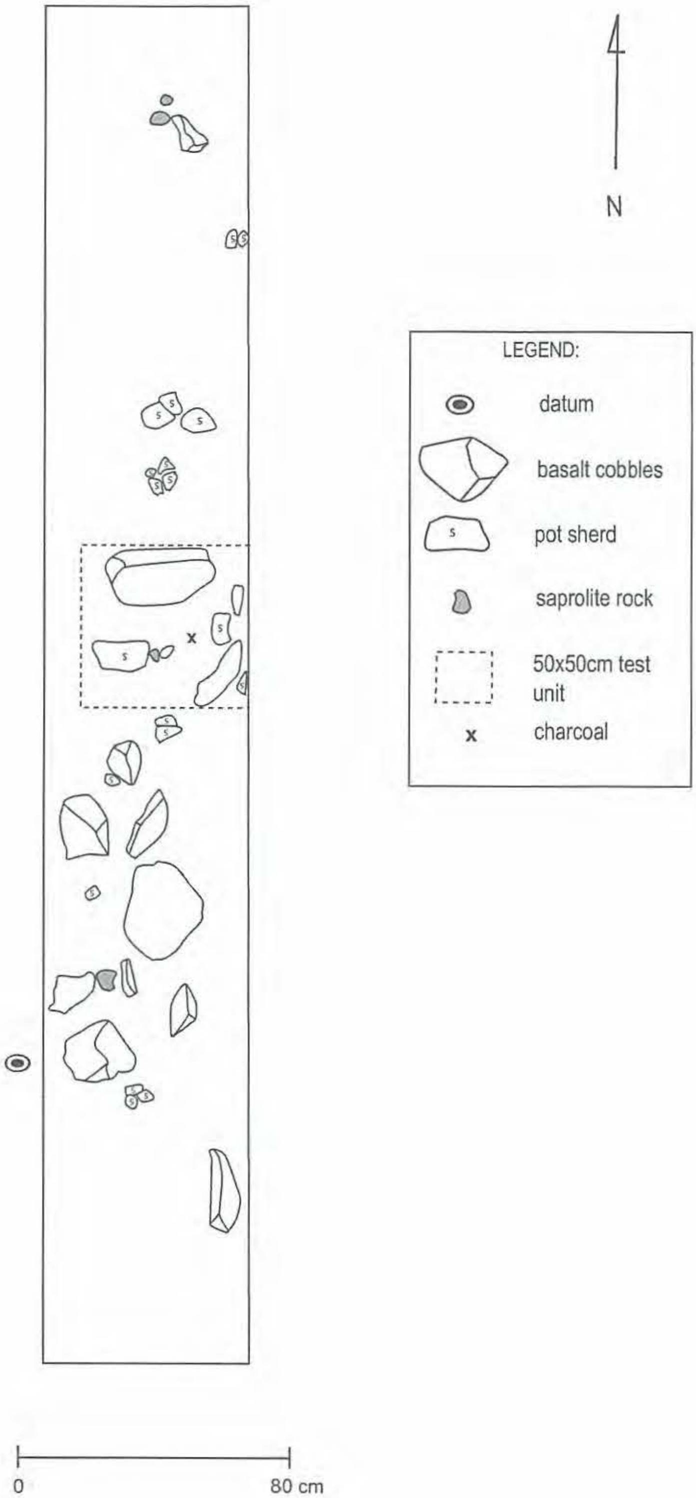


Figure 5.19 Test Unit One, Surface Plan View.

B:NA-4:11 Ngemeduu Crown and Terrace Complex
Test Unit One

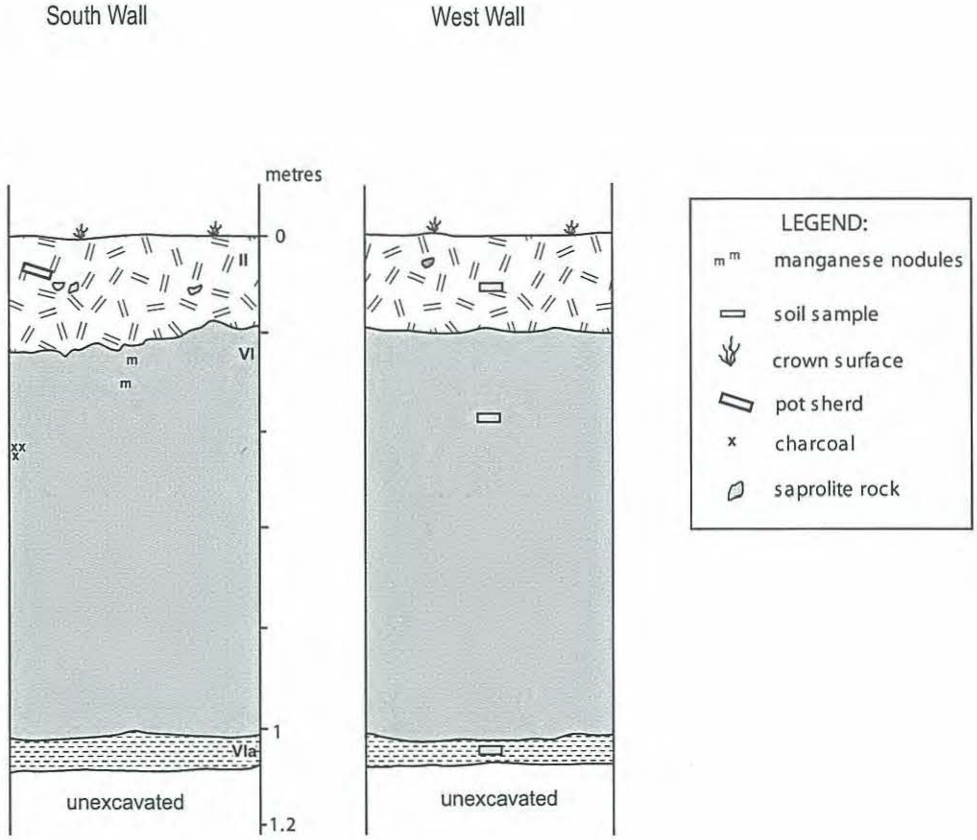


Figure 5.20 Section diagram for Test Unit One.

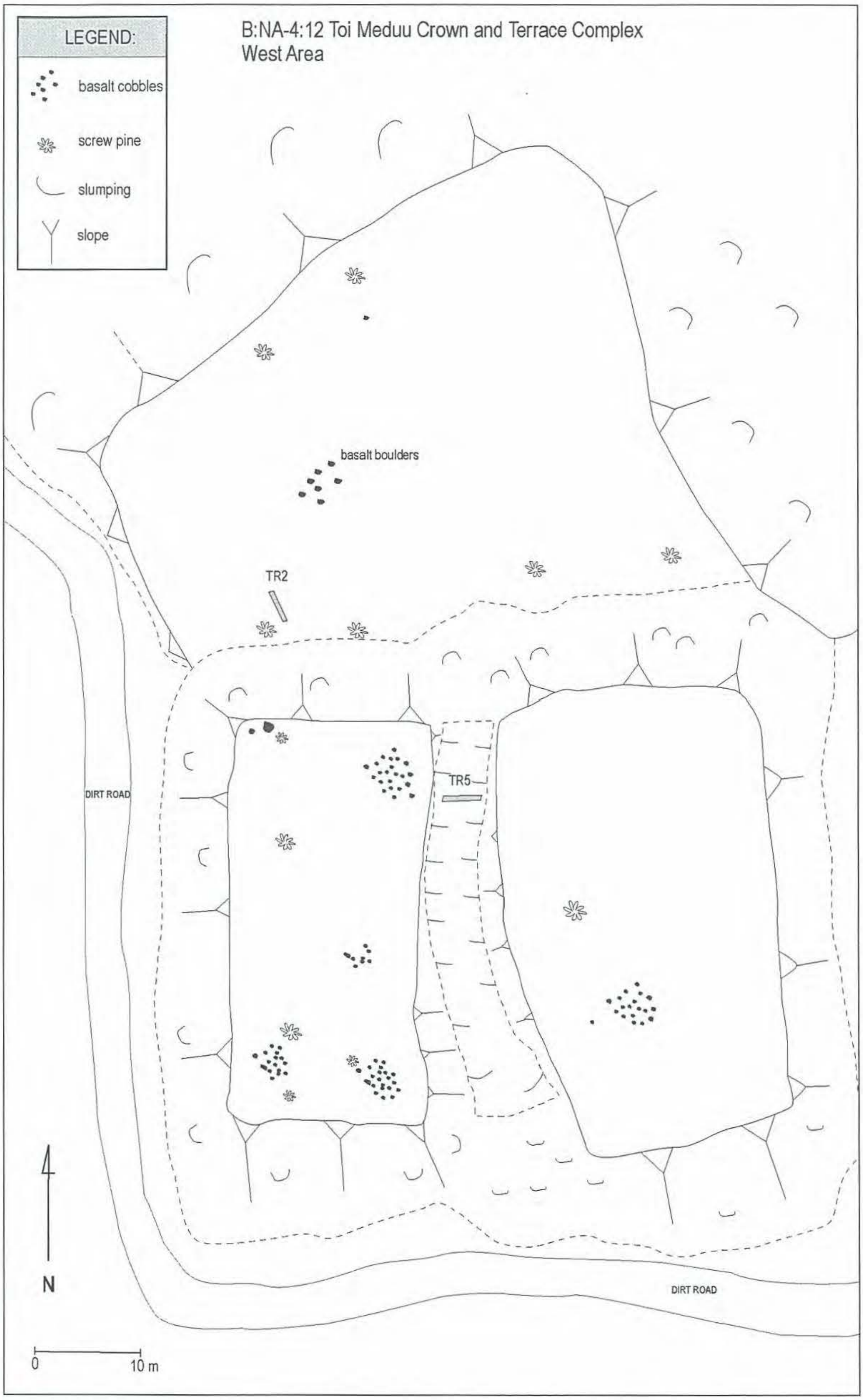


Figure 5.21 Map of Toi Meduu illustrating location of TR2 and TR5.

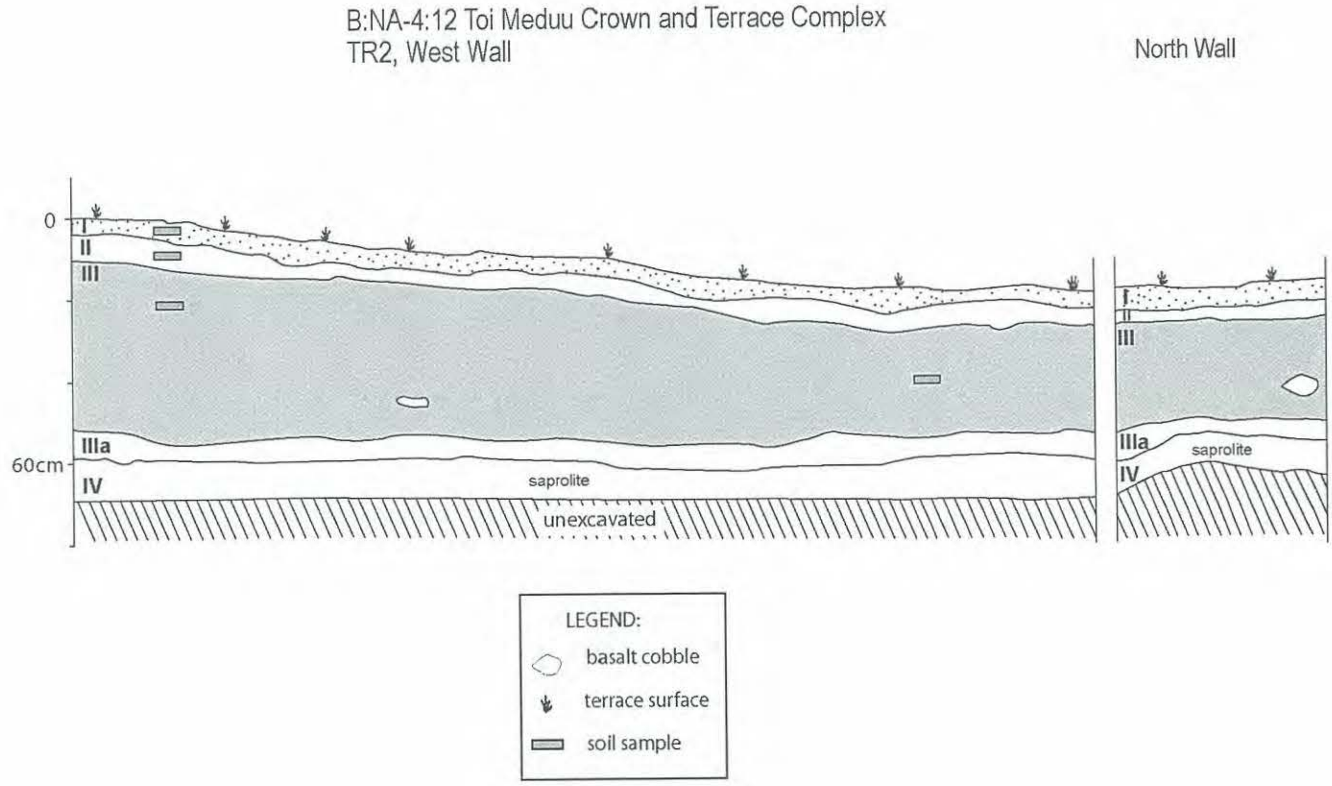


Figure 5.22 Section diagram for TR2.

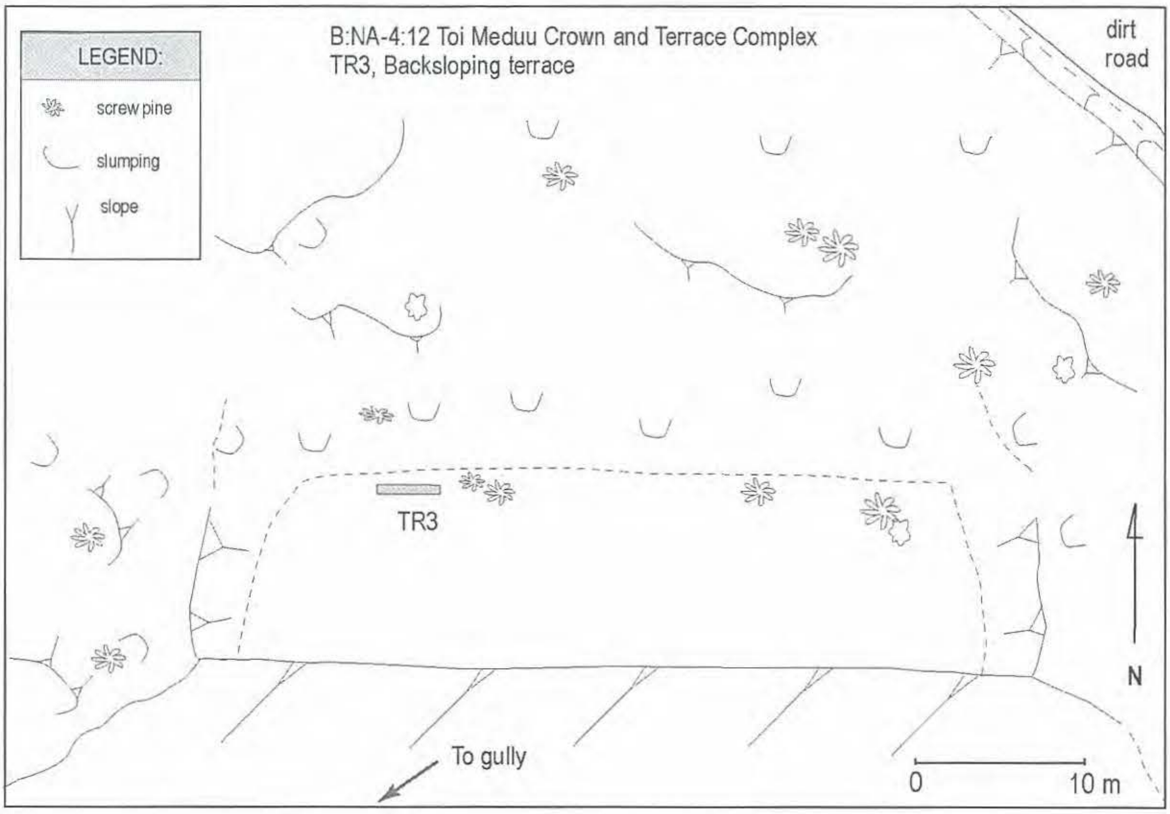


Figure 5.23 Map of the backsloping terrace on Toi Meduu's southern slopes, indicating location of TR3.

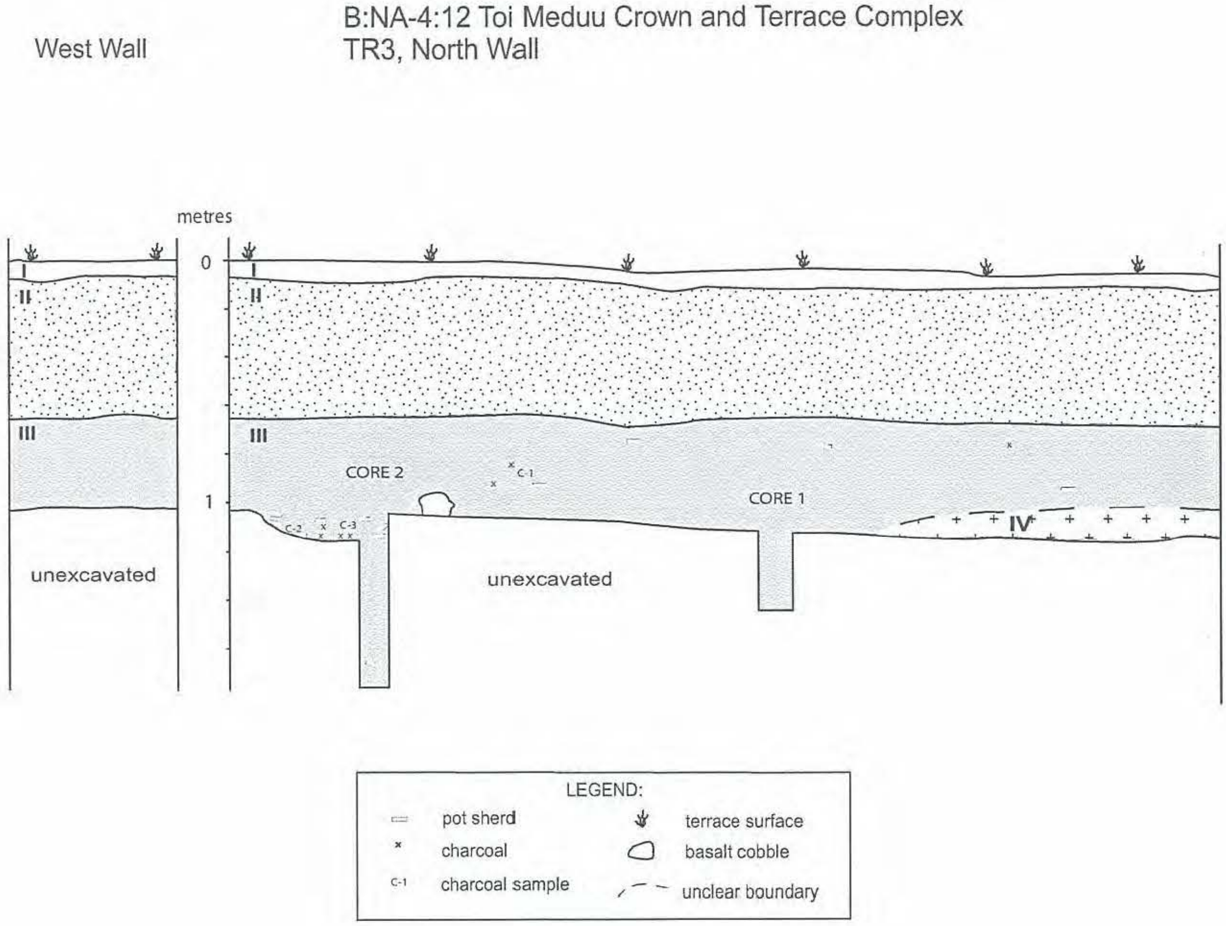


Figure 5.24 Section diagram for TR3.

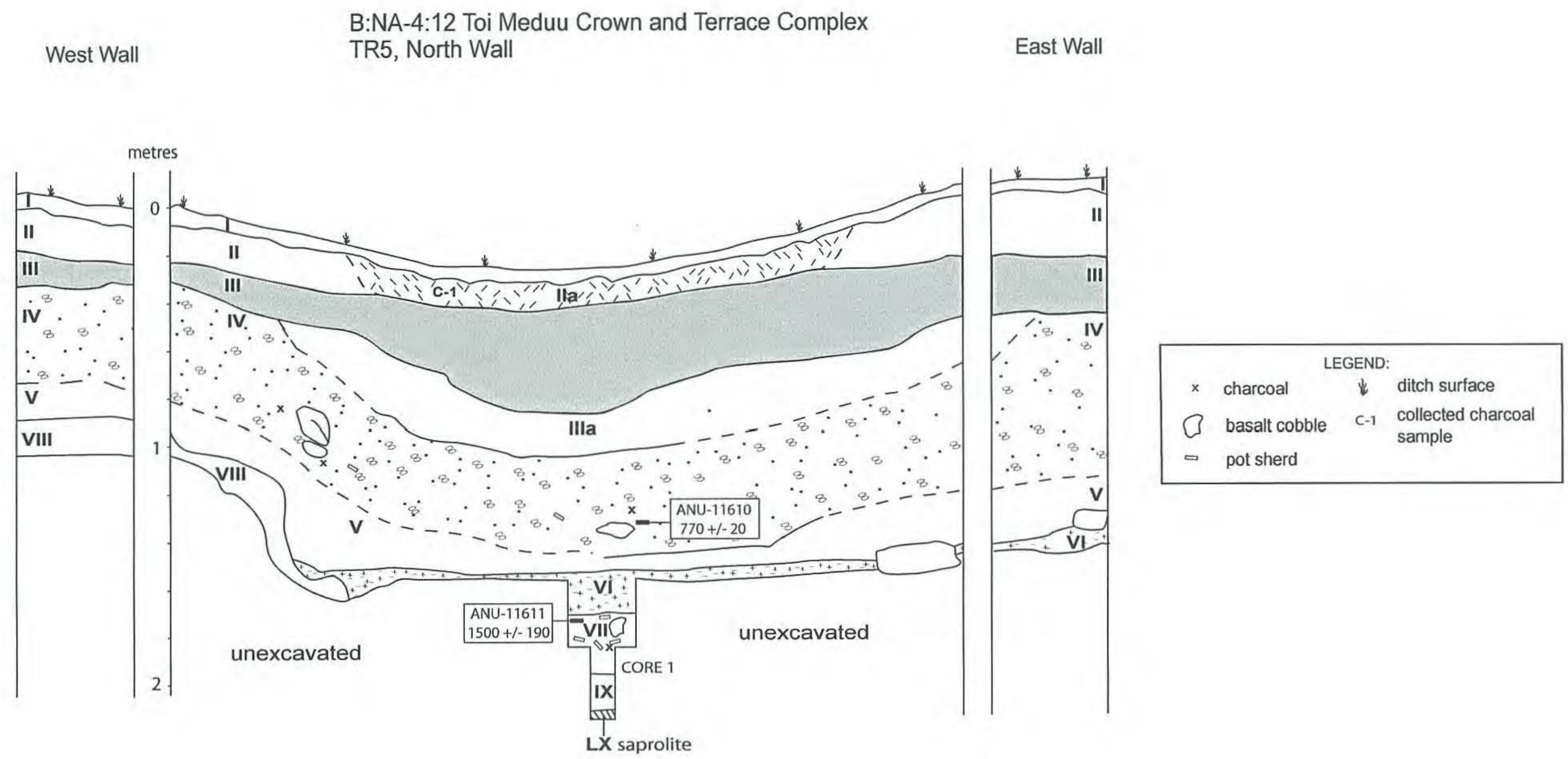
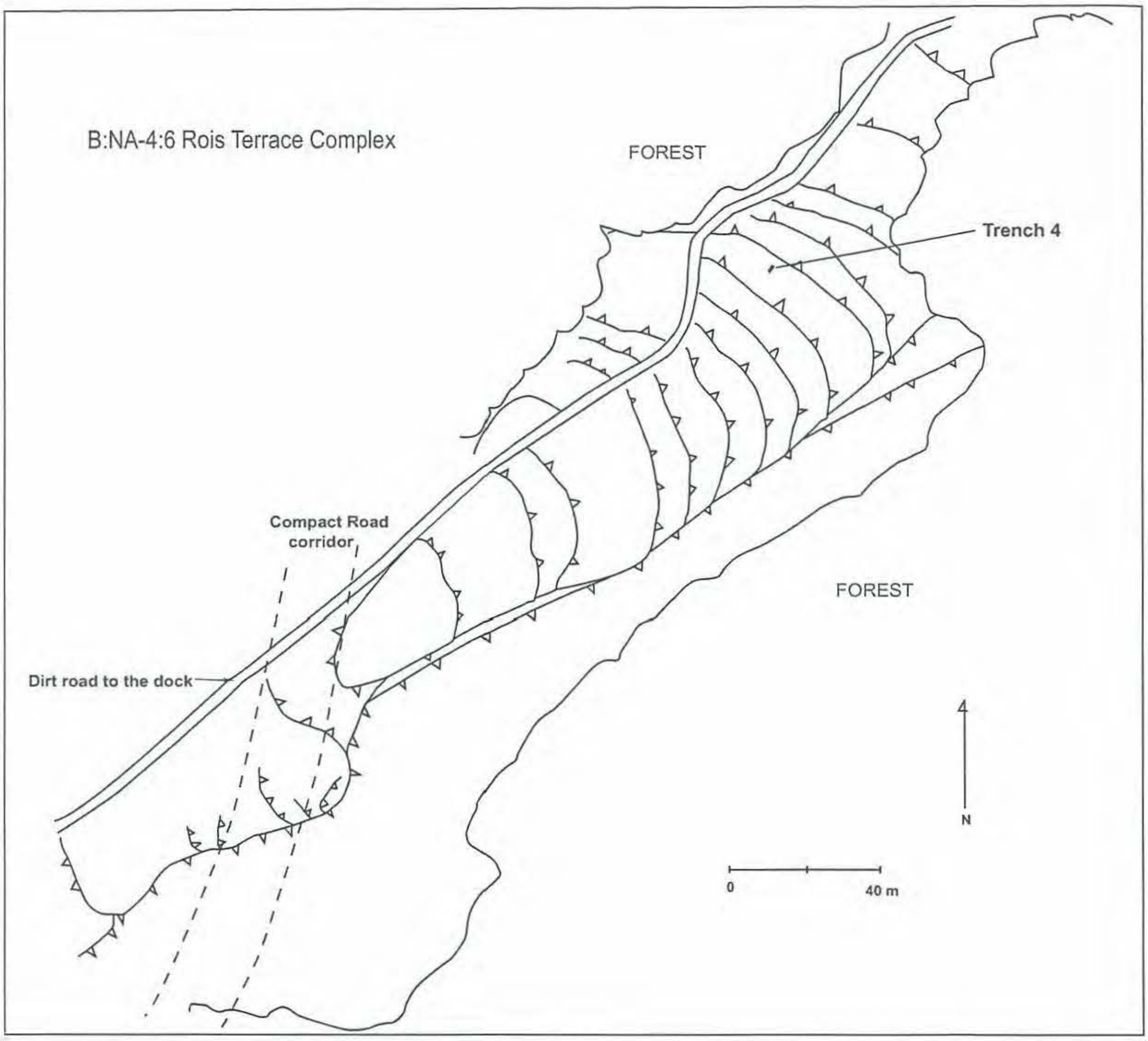


Figure 5.25 Section diagram for TR5.

Figure 5.26 Map of the Rois Terrace Complex illustrating the location of Trench 4. This map has been modified from Liston et al. (1998).



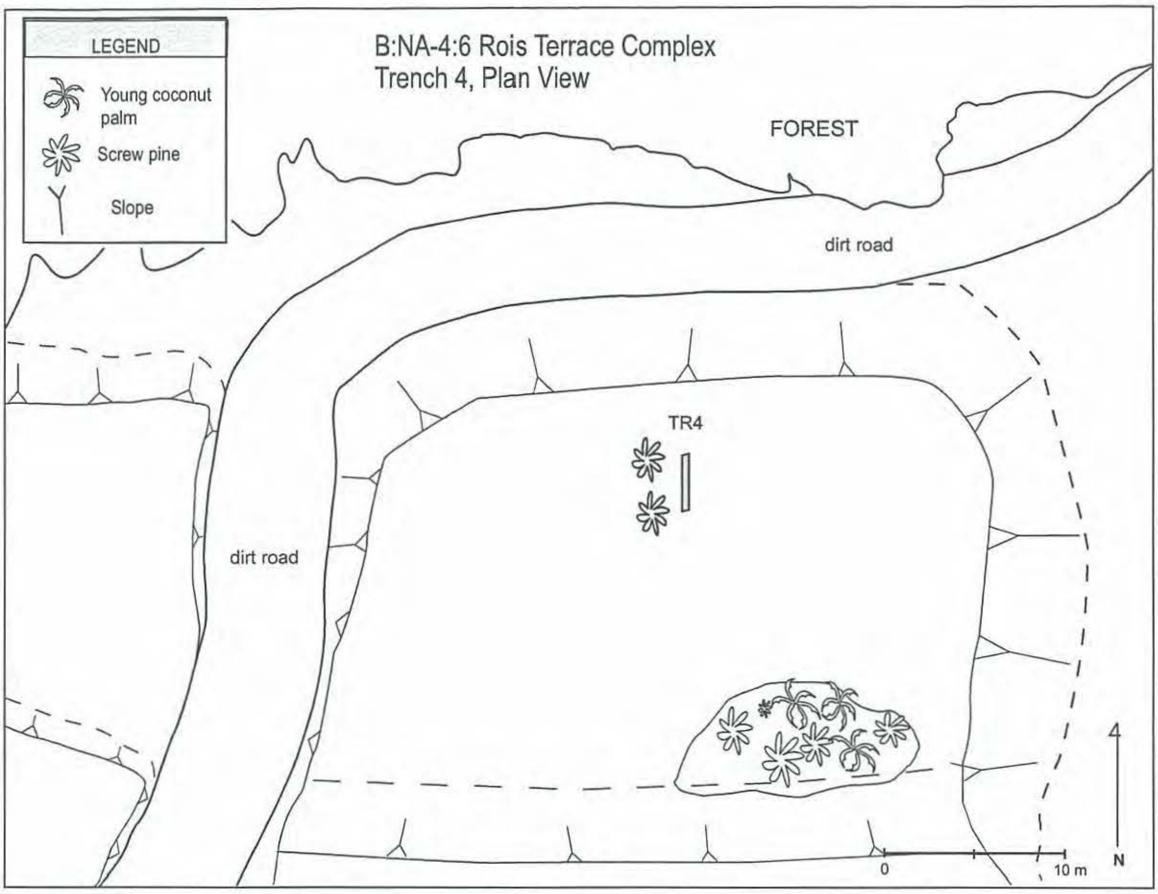


Figure 5.27 Map of the terrace excavated in the Rois Terrace Complex, and the location of TR4.

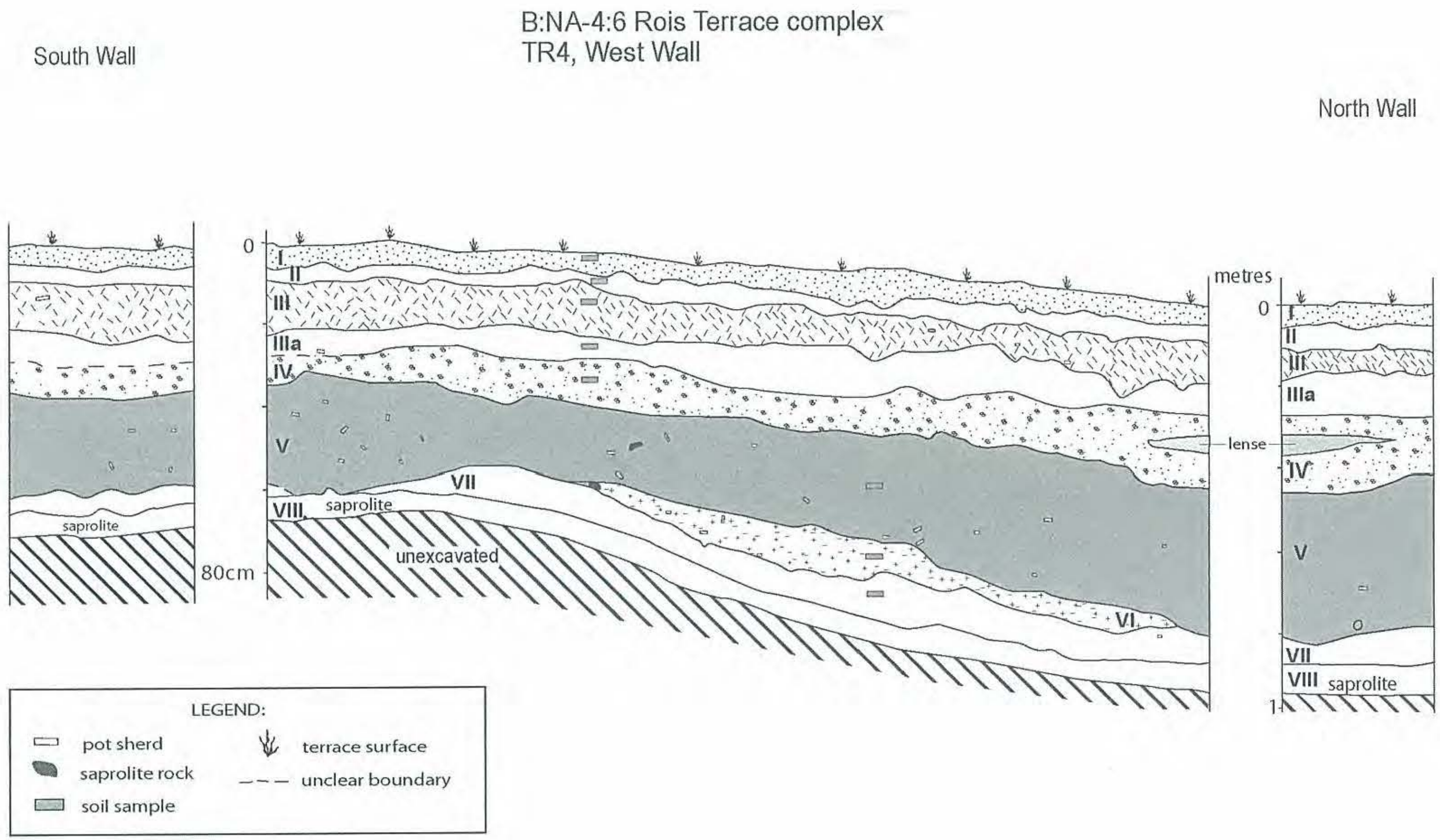


Figure 5.28 Section diagram for TR4.

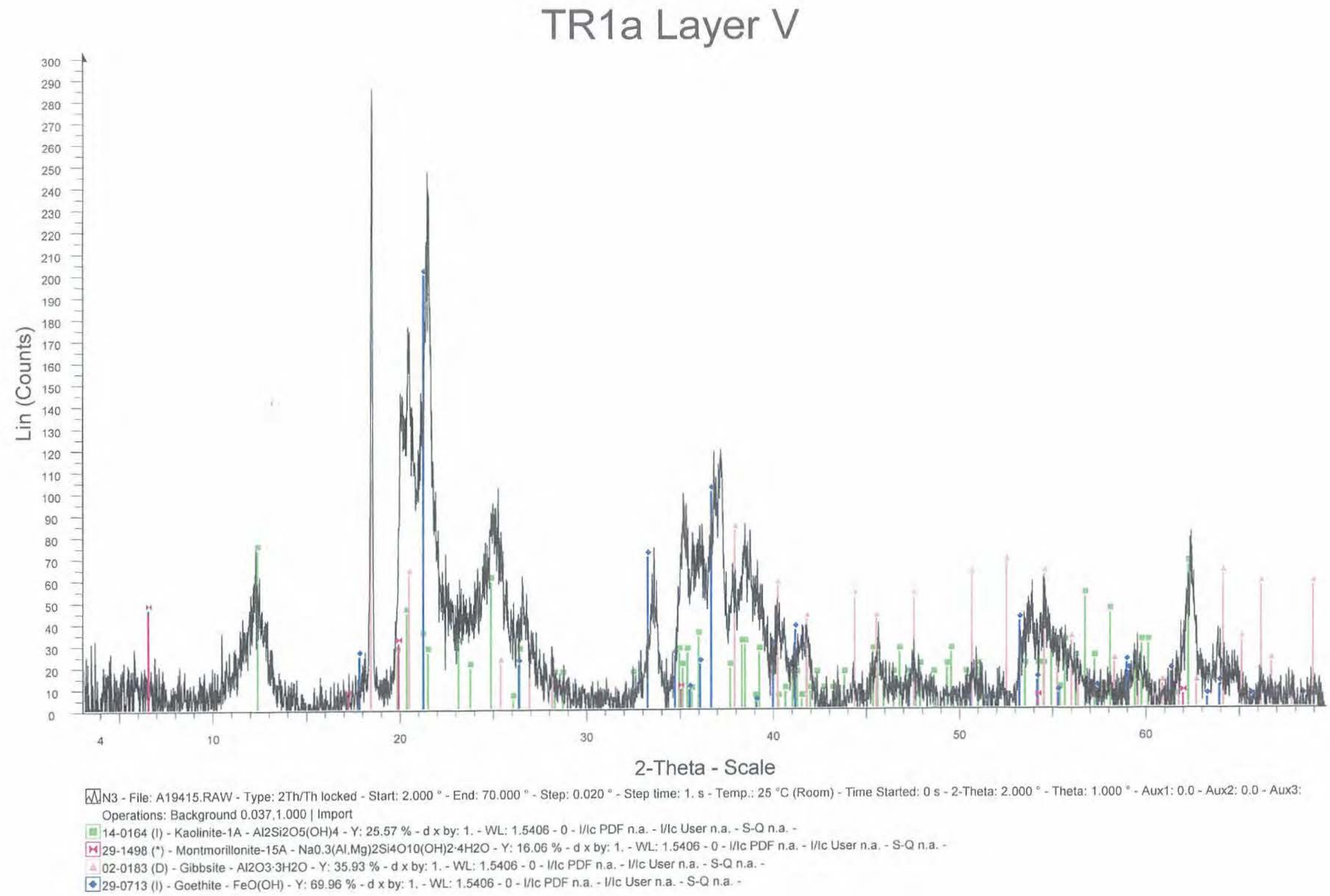


Figure 6.1 XRD diffractogram of LV.

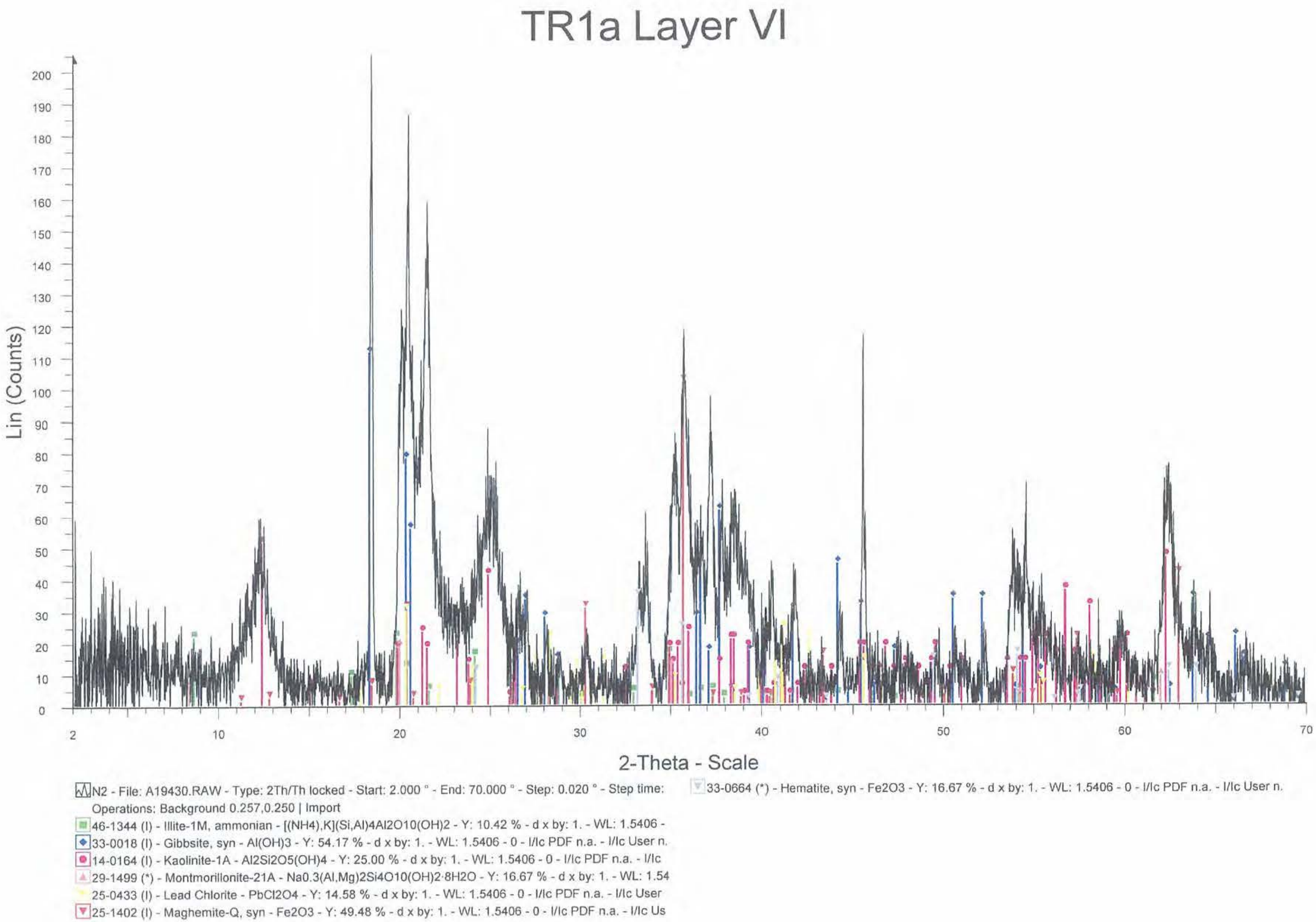


Figure 6.2 XRD diffractogram for Layer VI.

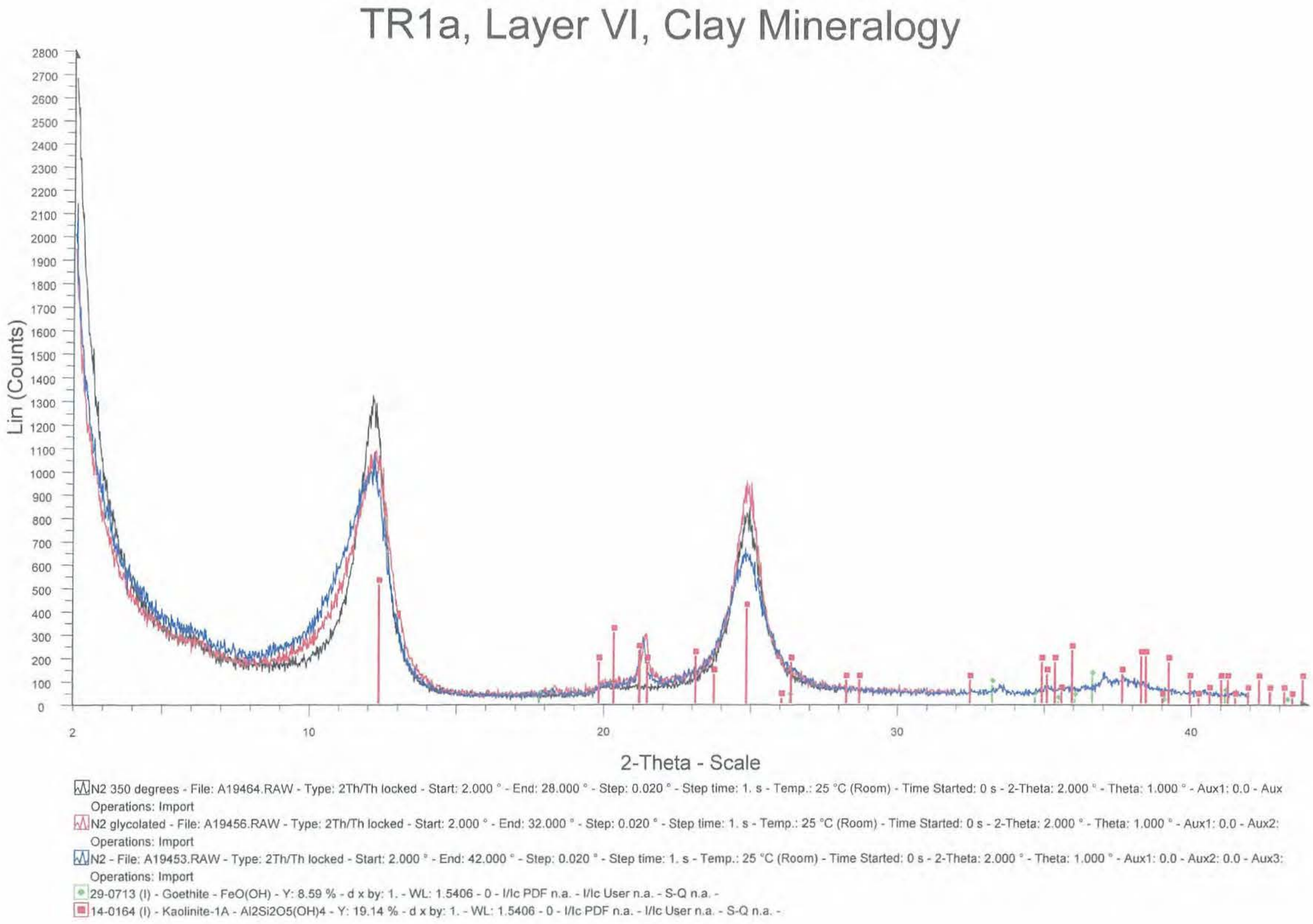


Figure 6.3 XRD diffractograms for the clay fraction of LVI.

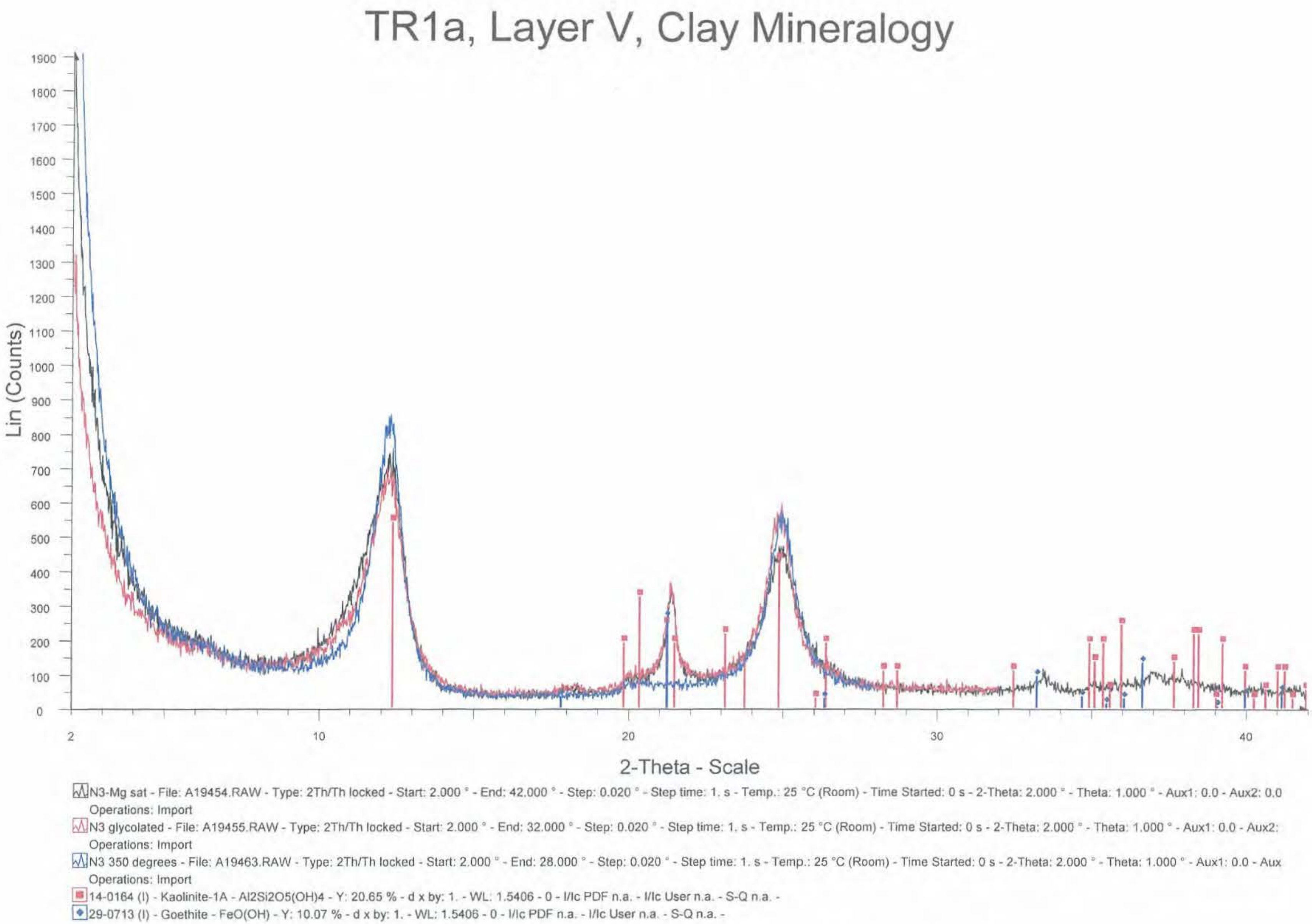


Figure 6.4 XRD diffractograms for the clay fraction of LV.

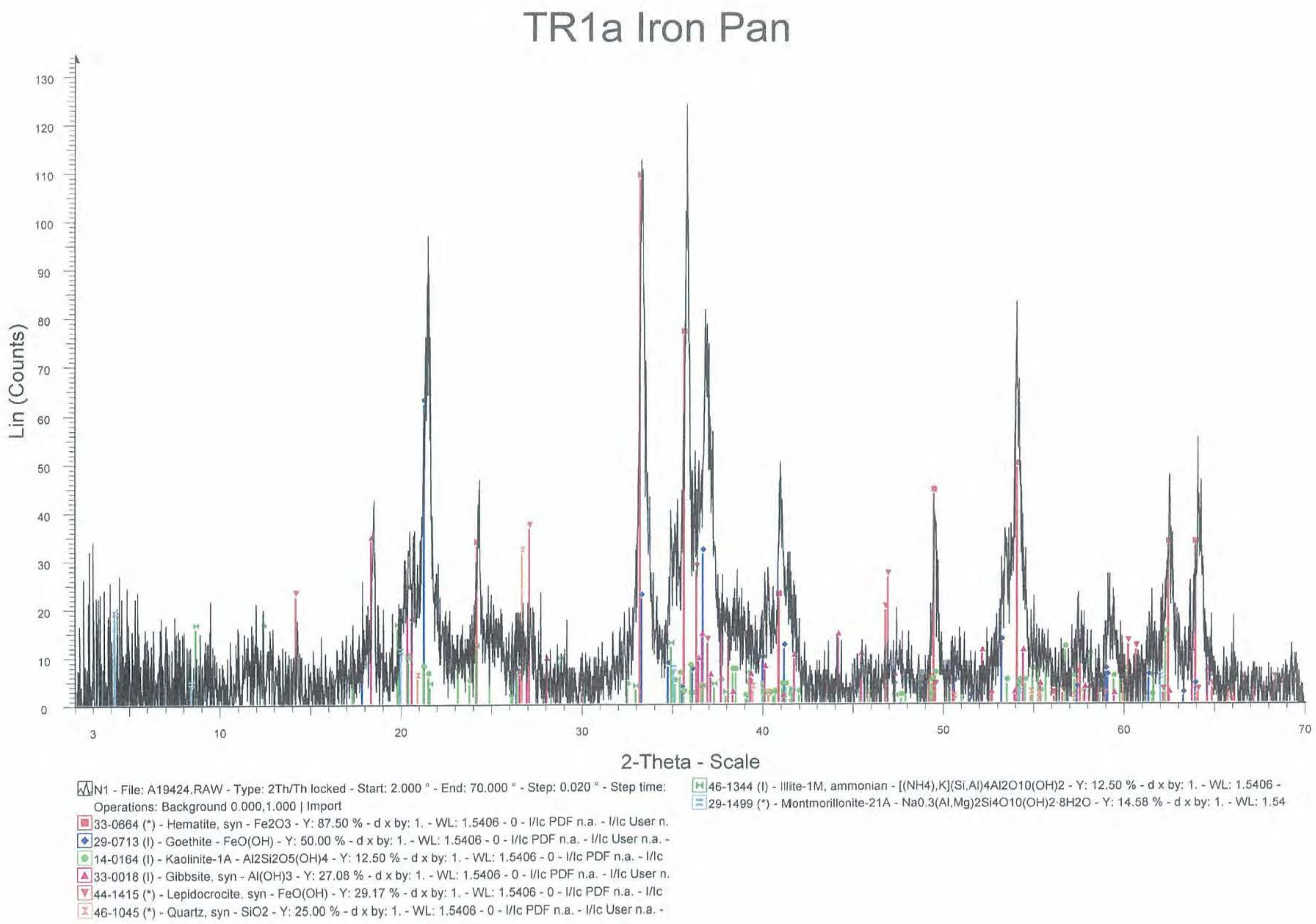


Figure 6.5 XRD diffractogram for the iron pan.

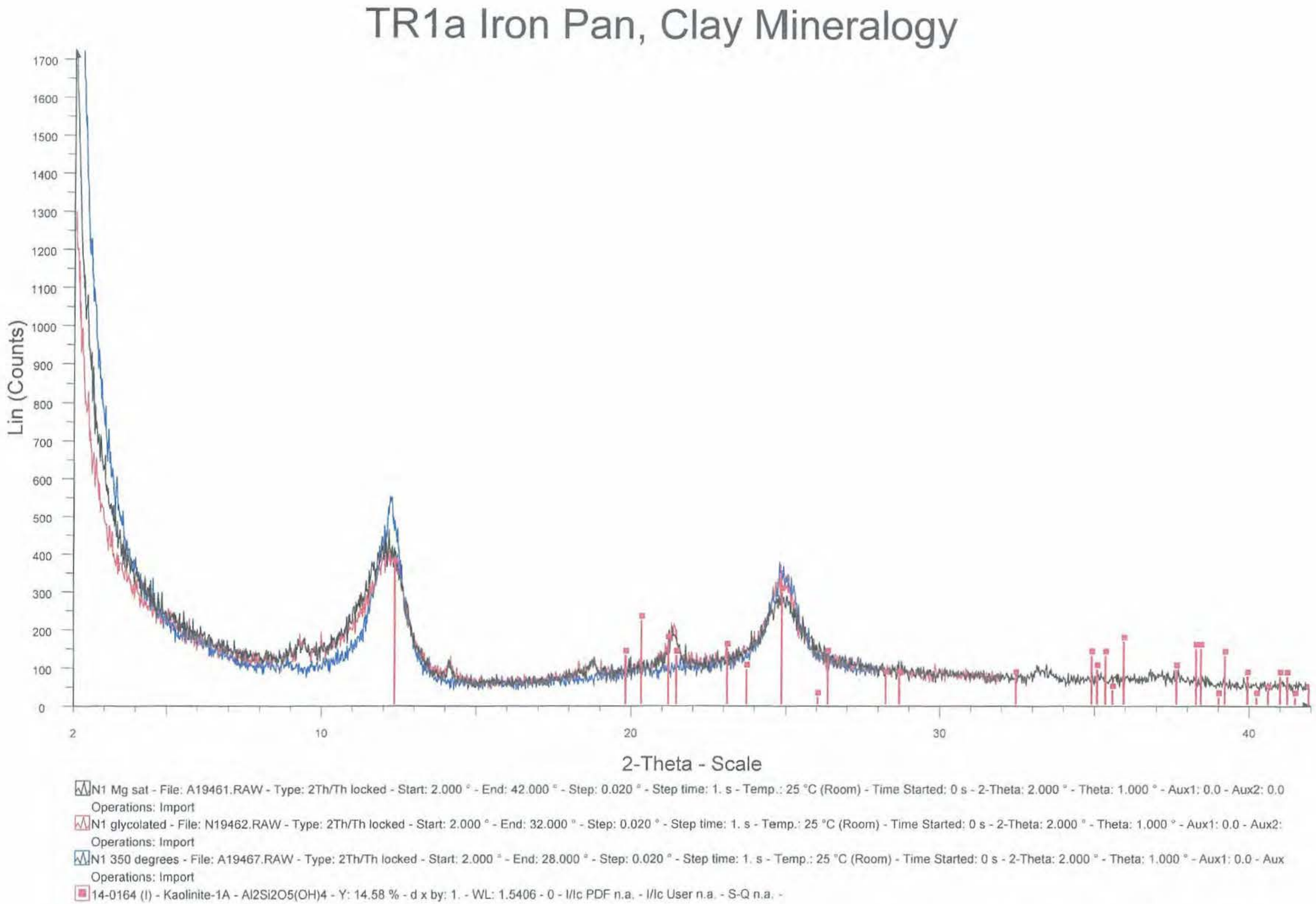


Figure 6.6 XRD diffractograms for the clay fraction of the iron pan.

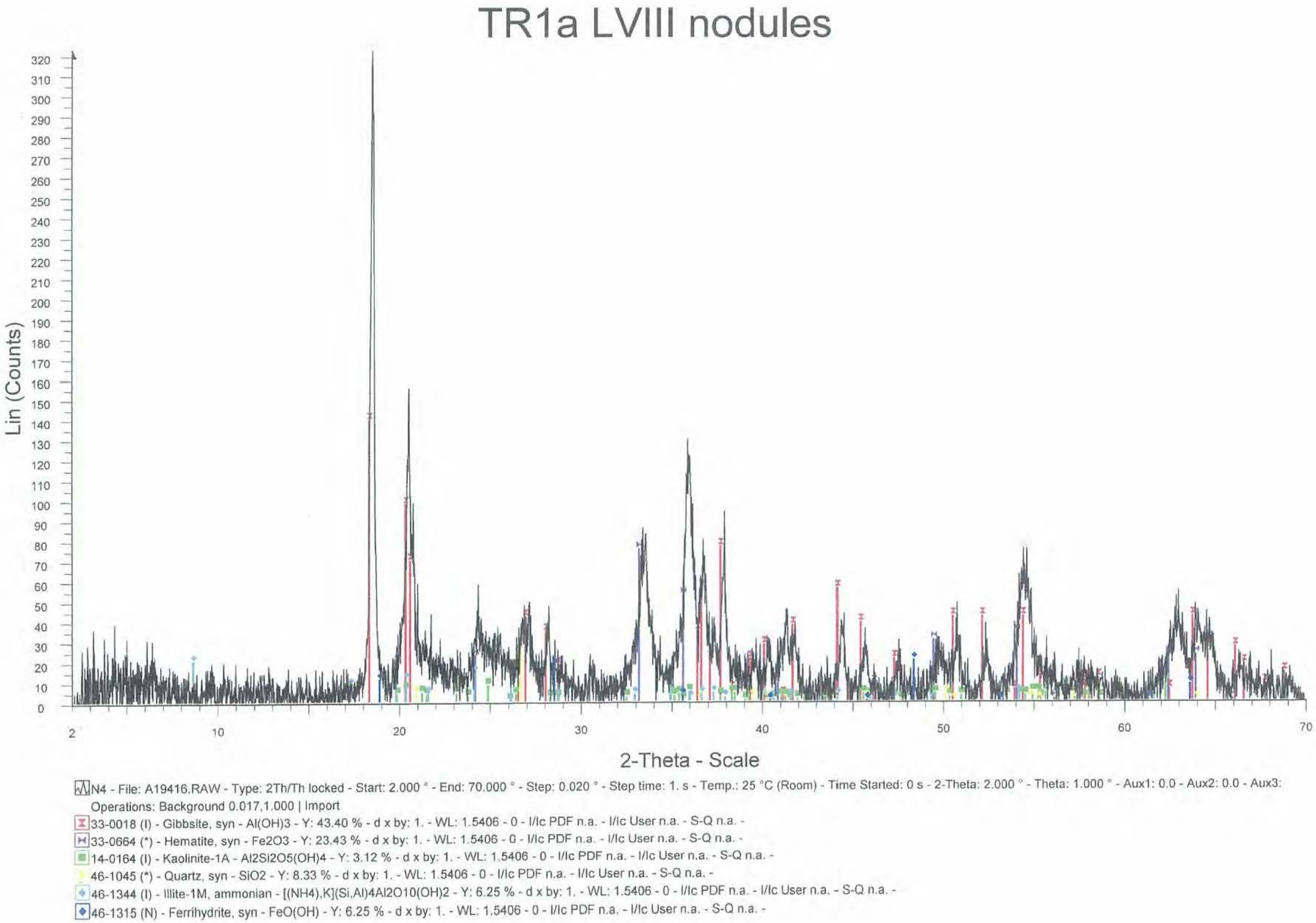


Figure 6.7 XRD diffractogram of the nodules from LVIII.

B:NA-4:11 Ngemeduu Crown and Terrace Complex

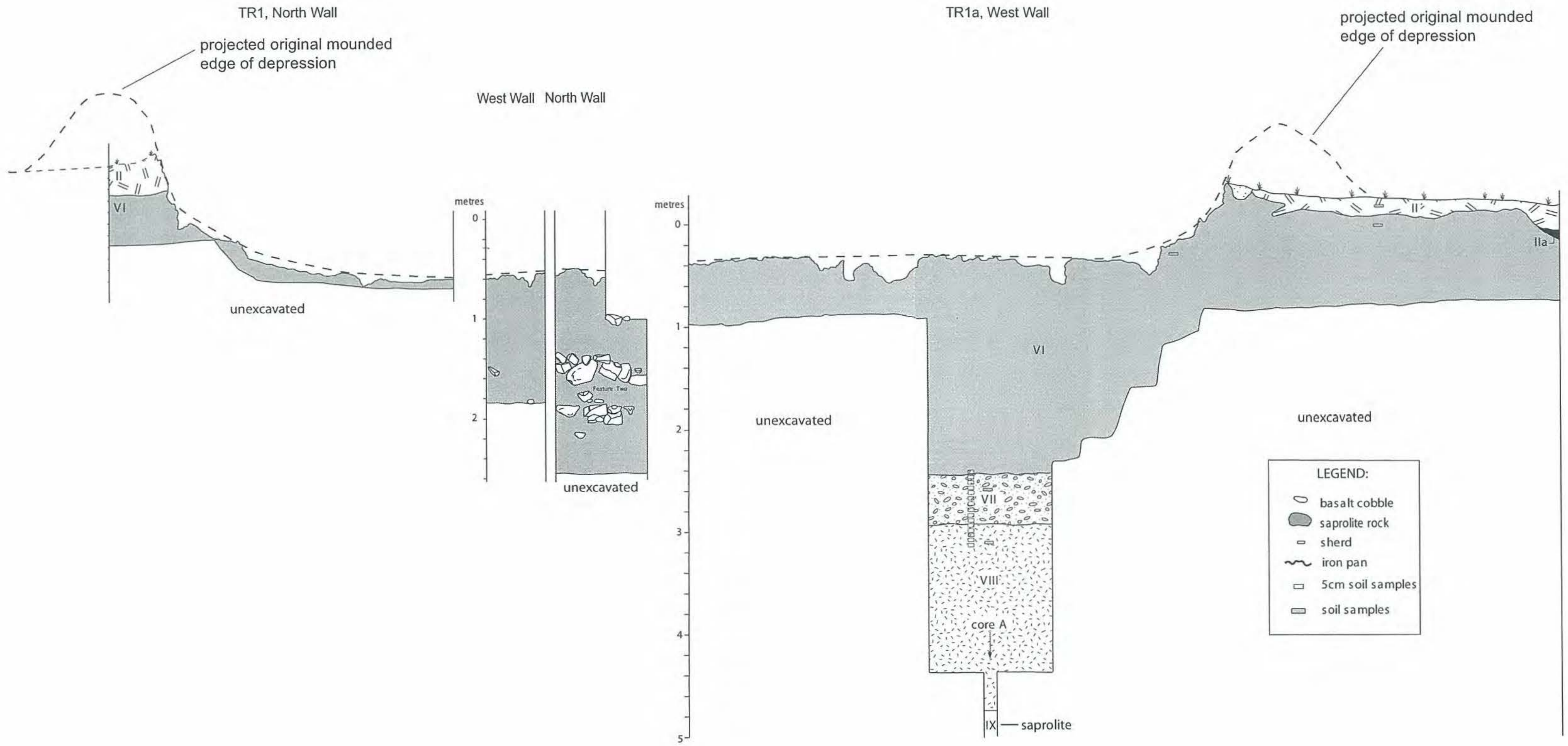
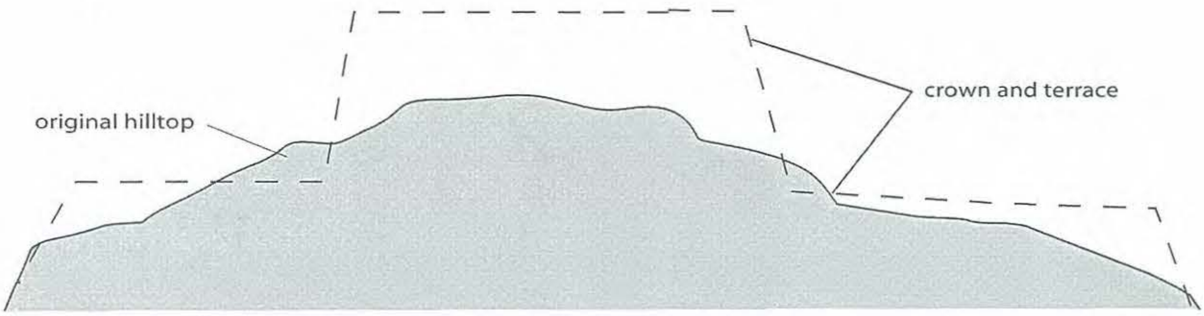


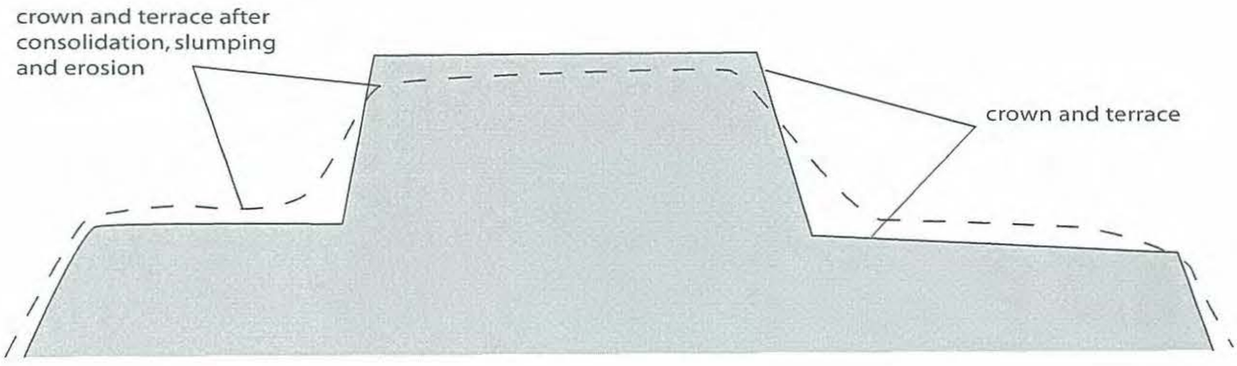
Figure 6.8 Reconstruction of the projected original base of the west depression, inlcuding the projected mounded edges.

Figure 6.9 Sketch profiles of Ngemeduu, a. the original hilltop illustrating the bounds of the constructed crown and terrace, and b. the change in structure of the crown and terrace through post-depositional processes (not to scale).

A.



B.



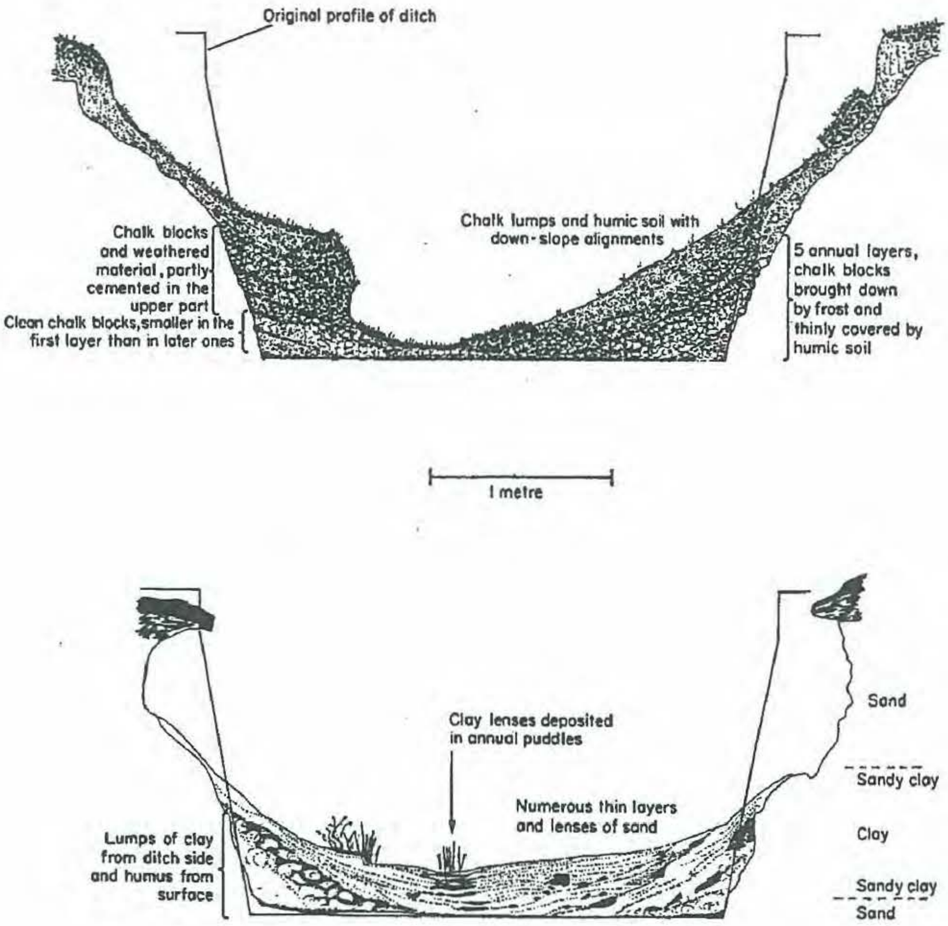


Figure 6.10 Sections of ditches from experimental earthworks, indicating the effects of weathering (taken from Limbrey 1975:291).

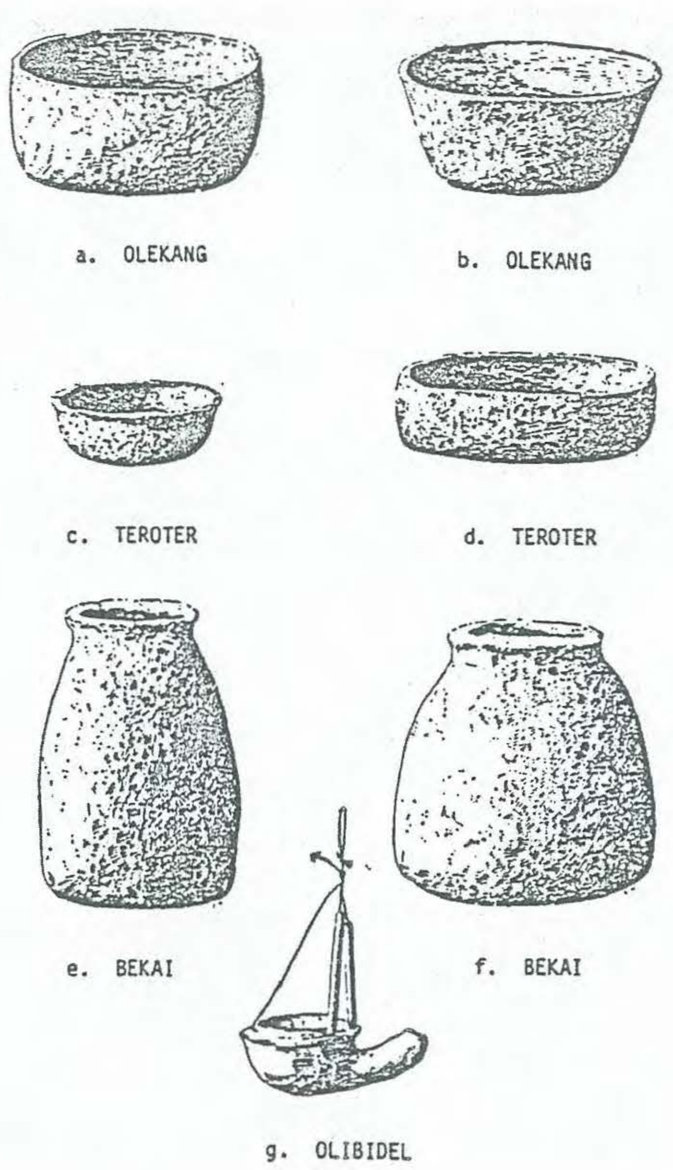
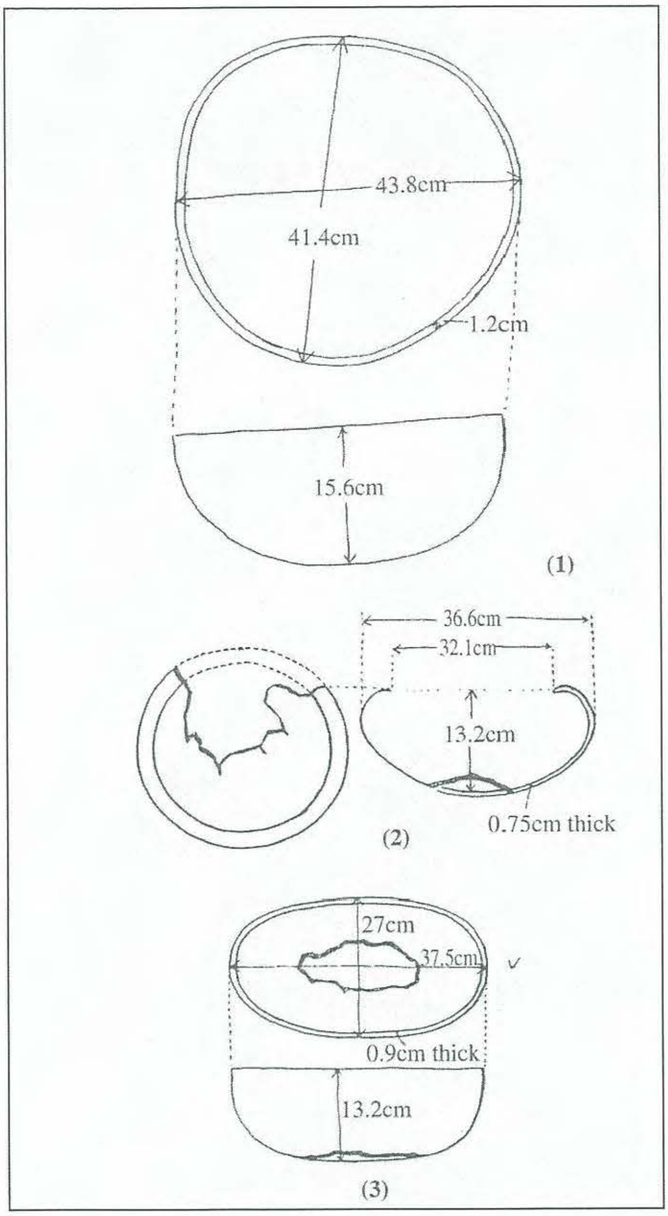


Figure 8.1a Illustrations of vessel types observed by Krämer (1926:135).



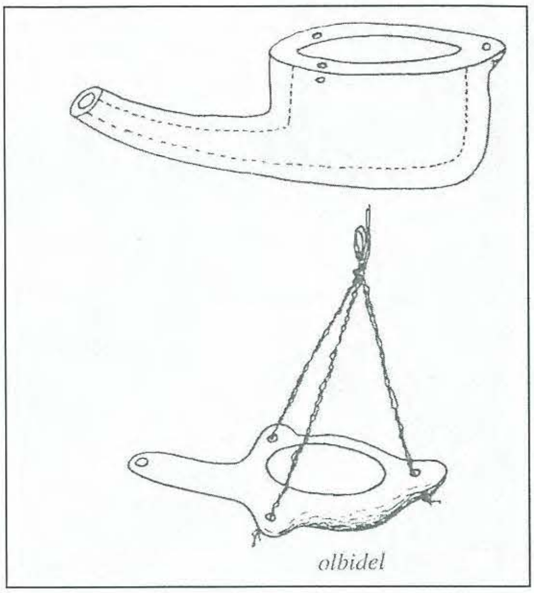
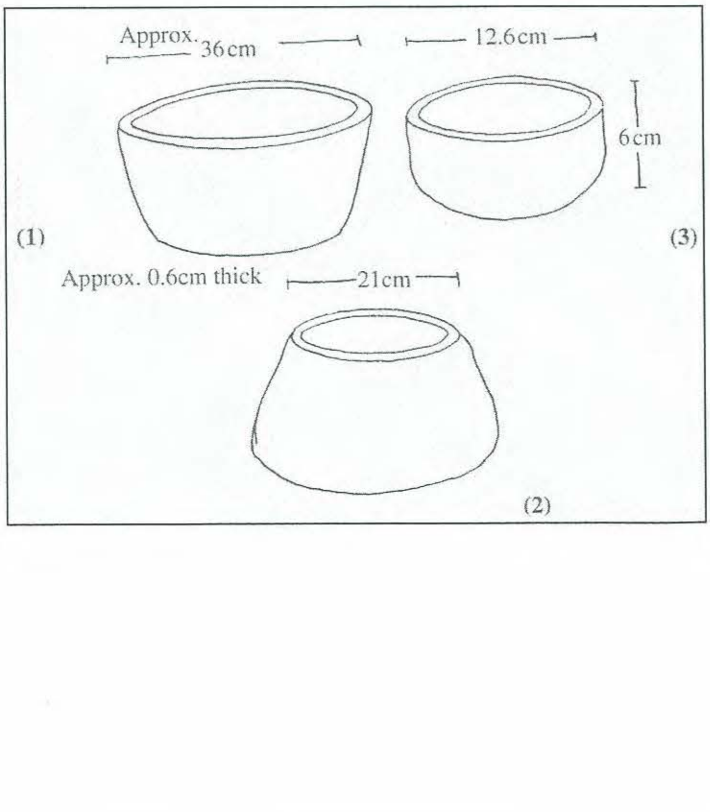


Figure 8.1b Examples of *Olikang* collected by Hijikata (above and right). Clay lamps were also recorded (upper right) (Hijikata 1995:258-263).



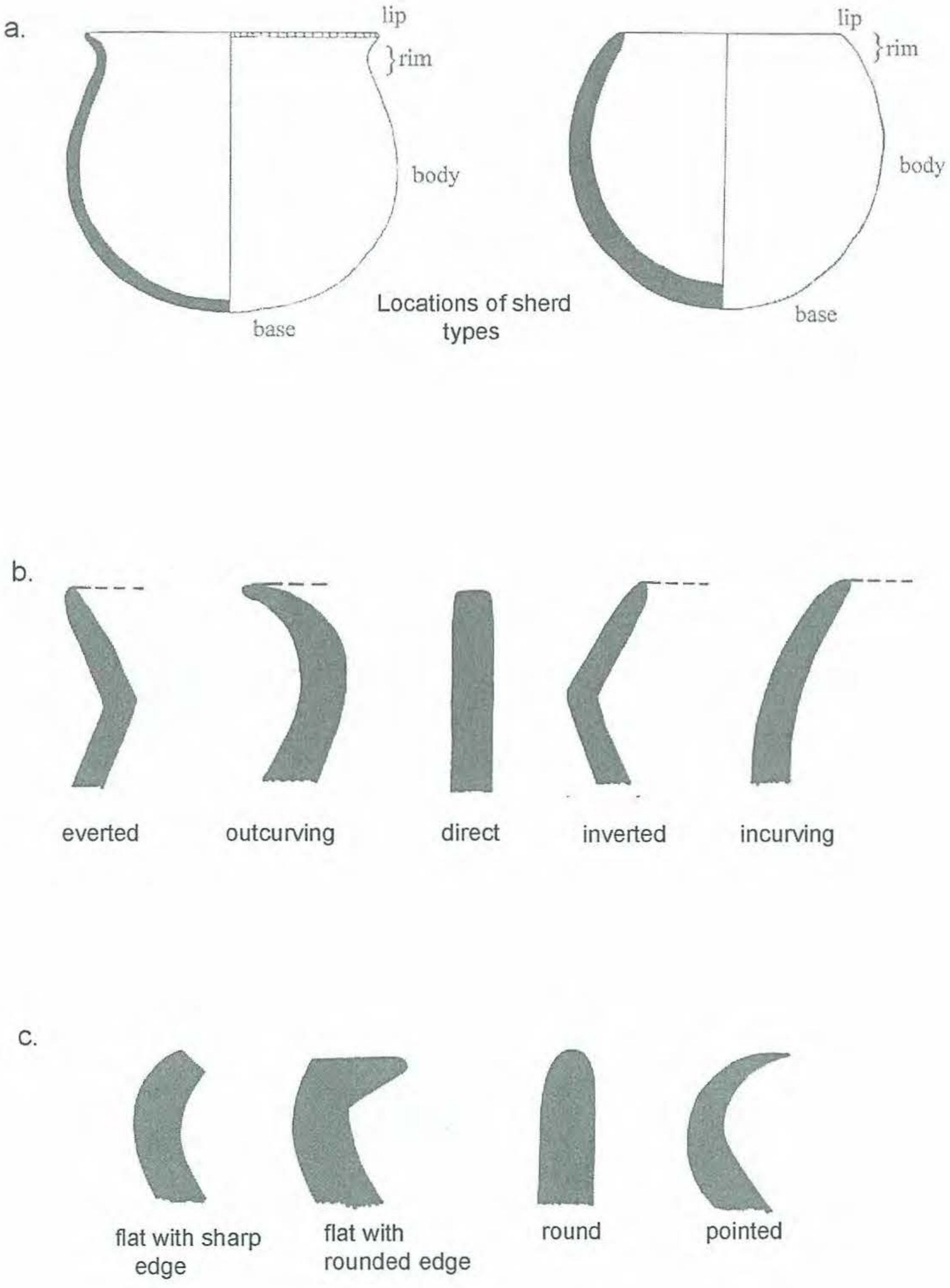


Figure 8.2a Illustrating the location of different types of sherds on a vessel; b, the different rim orientations and c, different lip profiles (modified from Bedford 2000).

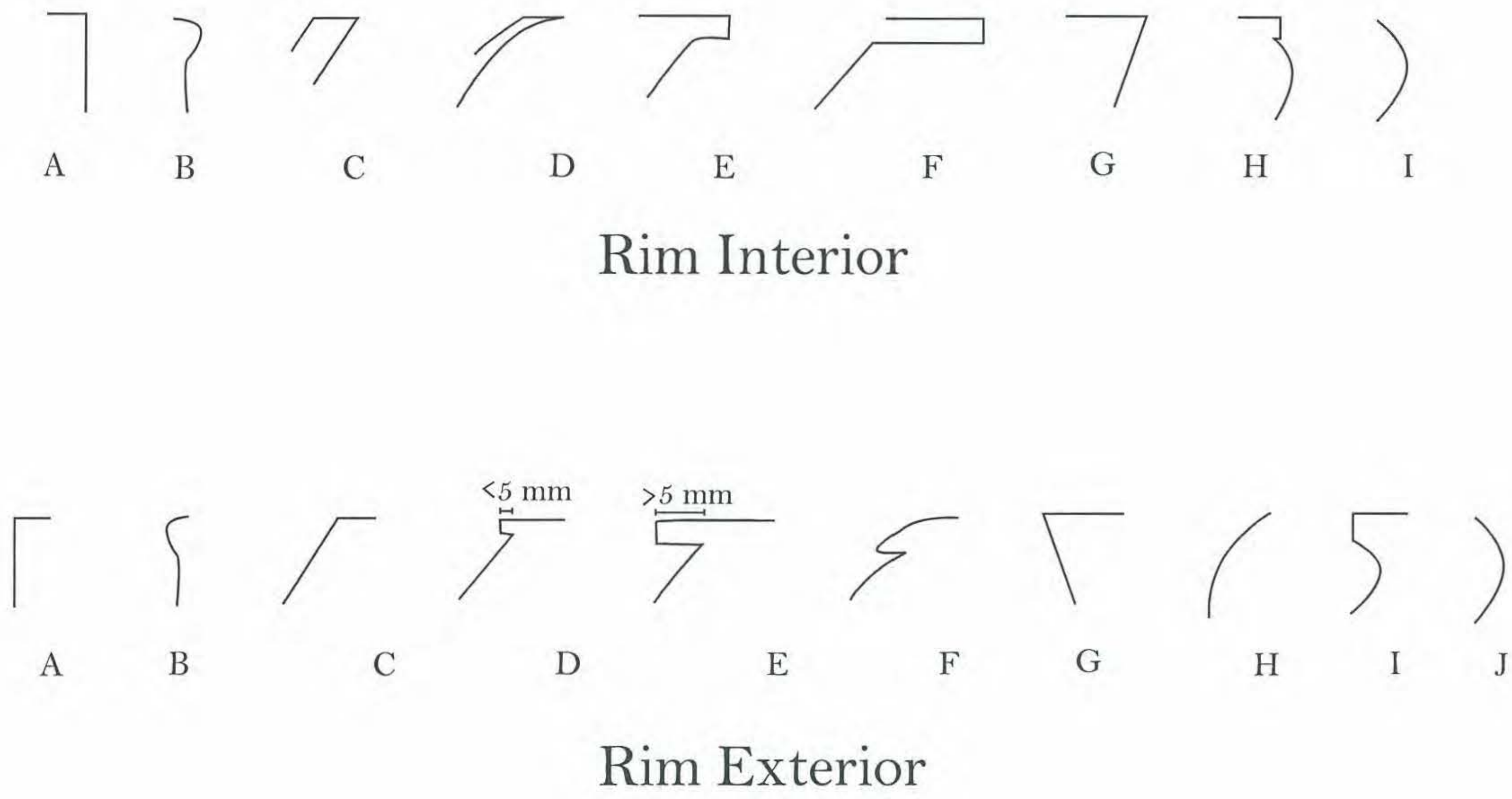
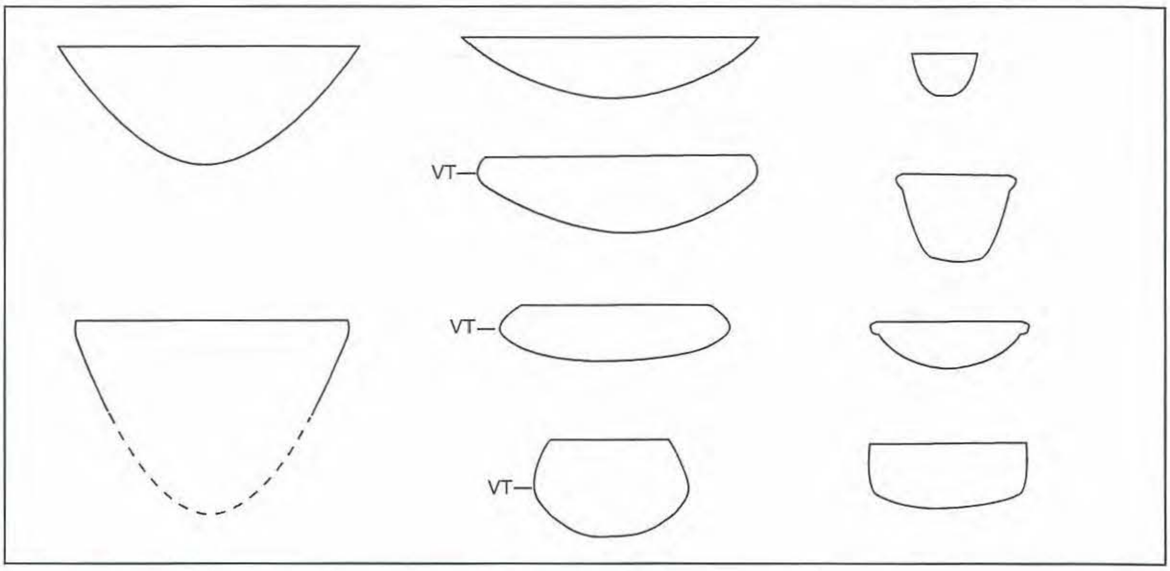
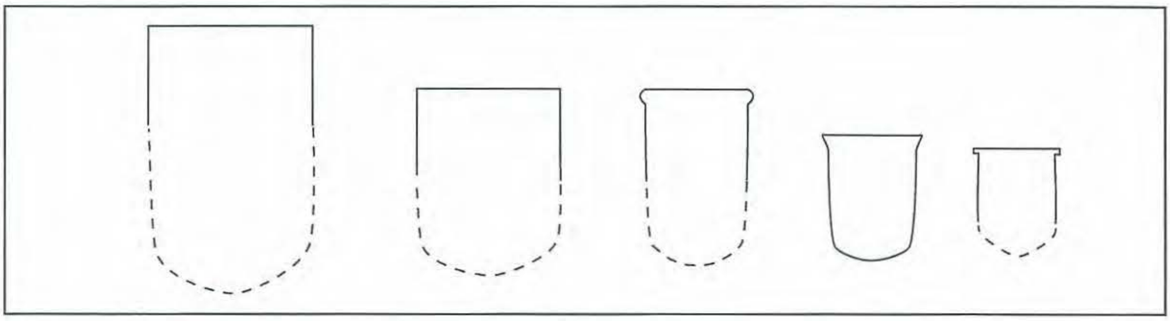
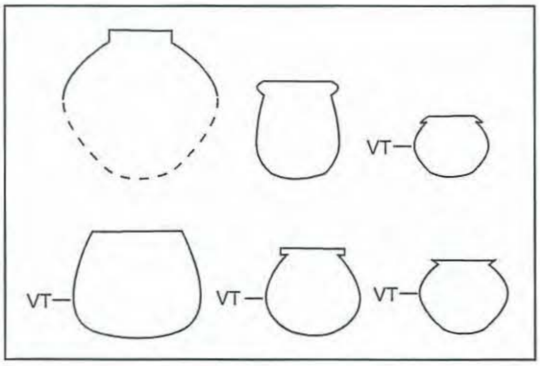


Figure 8.3 Interior and exterior rim shapes (modified from Desilets, et al. 1999).

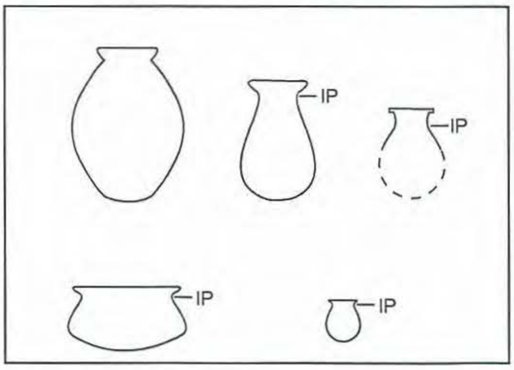


Vessel Form I


Vessel Form II



Vessel Form III



Vessel Form IV

Figure 8.4 Vessel Forms in the assemblage. The dotted line iilustrates the projected base of vessels where the complete shape is not known.

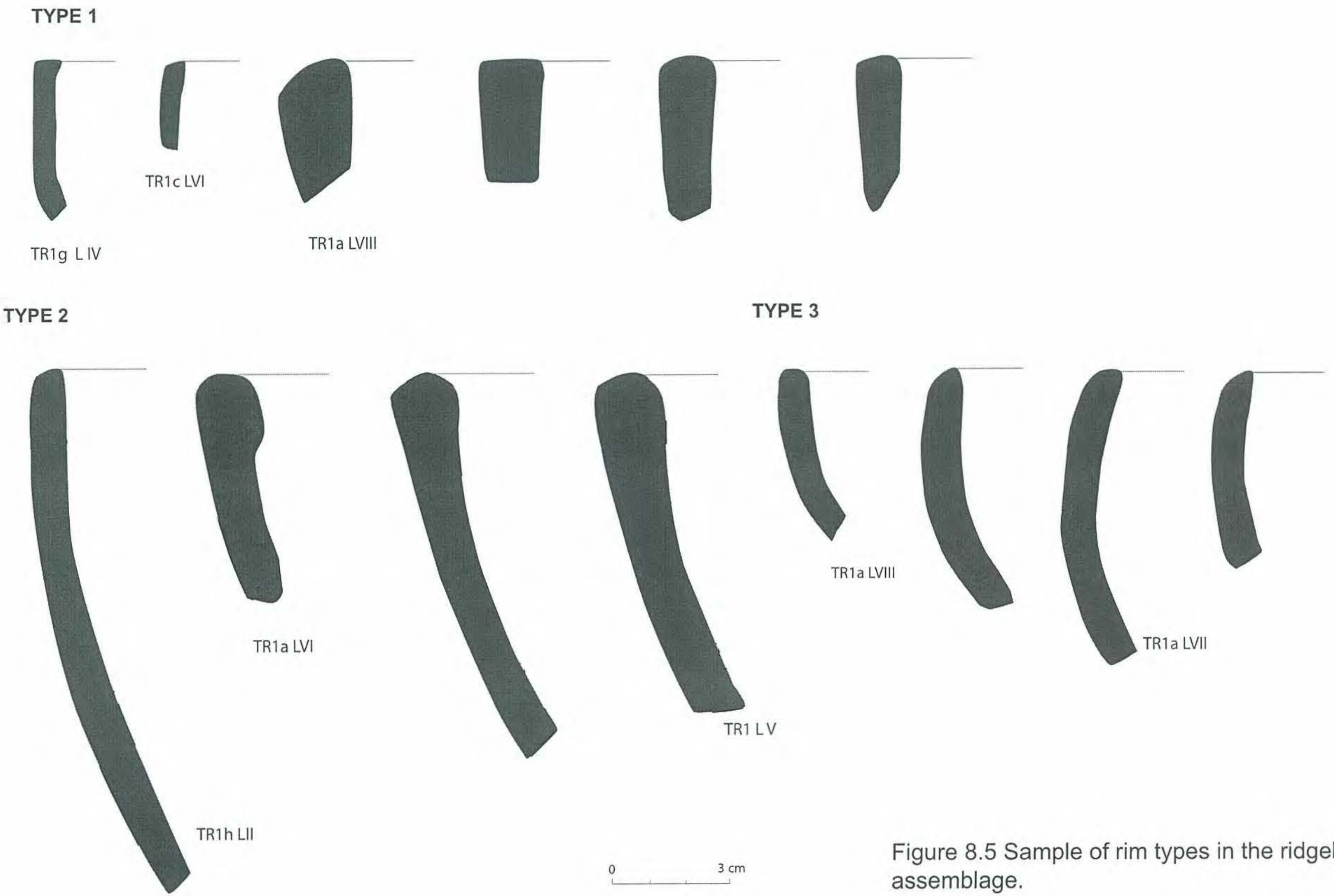


Figure 8.5 Sample of rim types in the ridgeline assemblage.

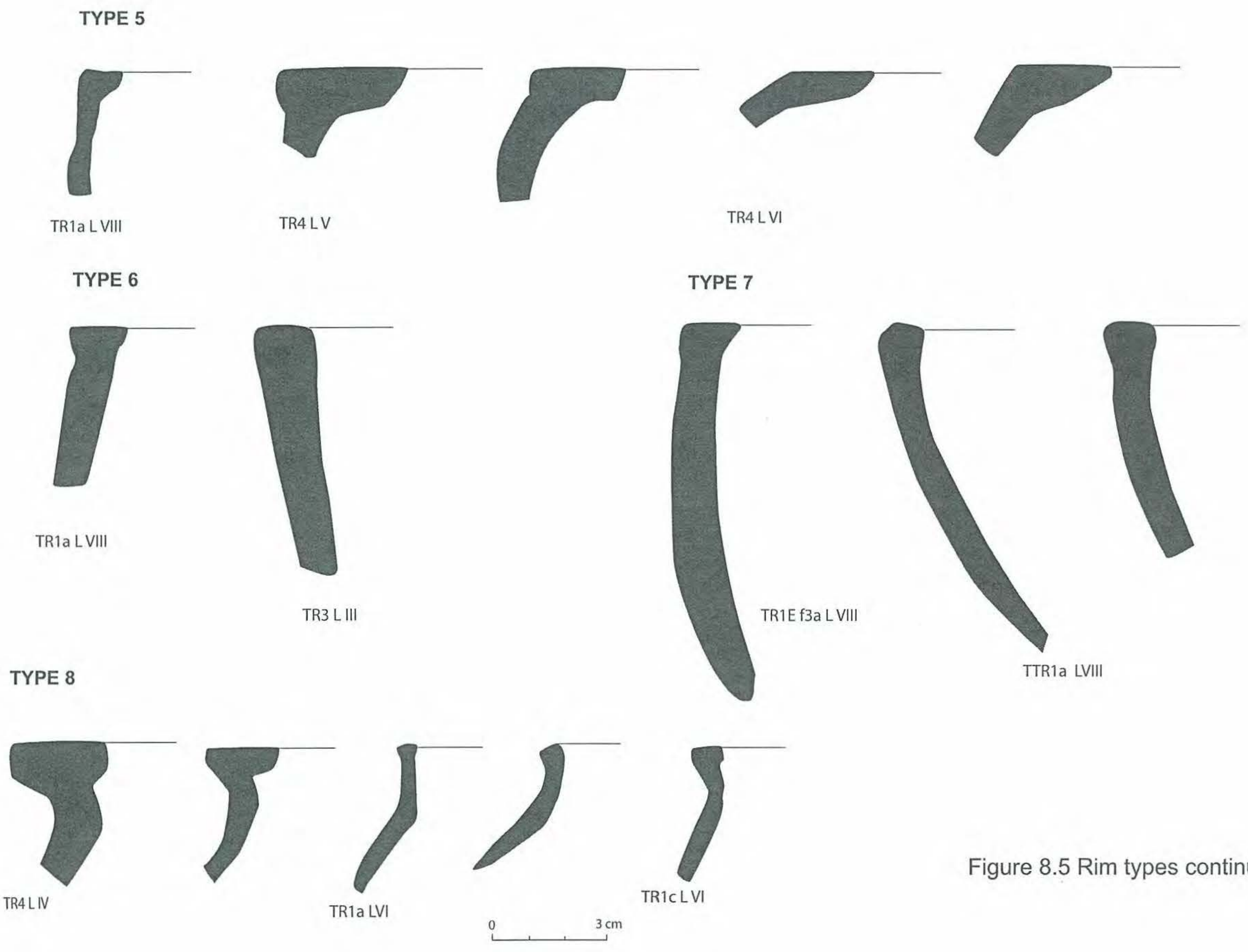


Figure 8.5 Rim types continued.

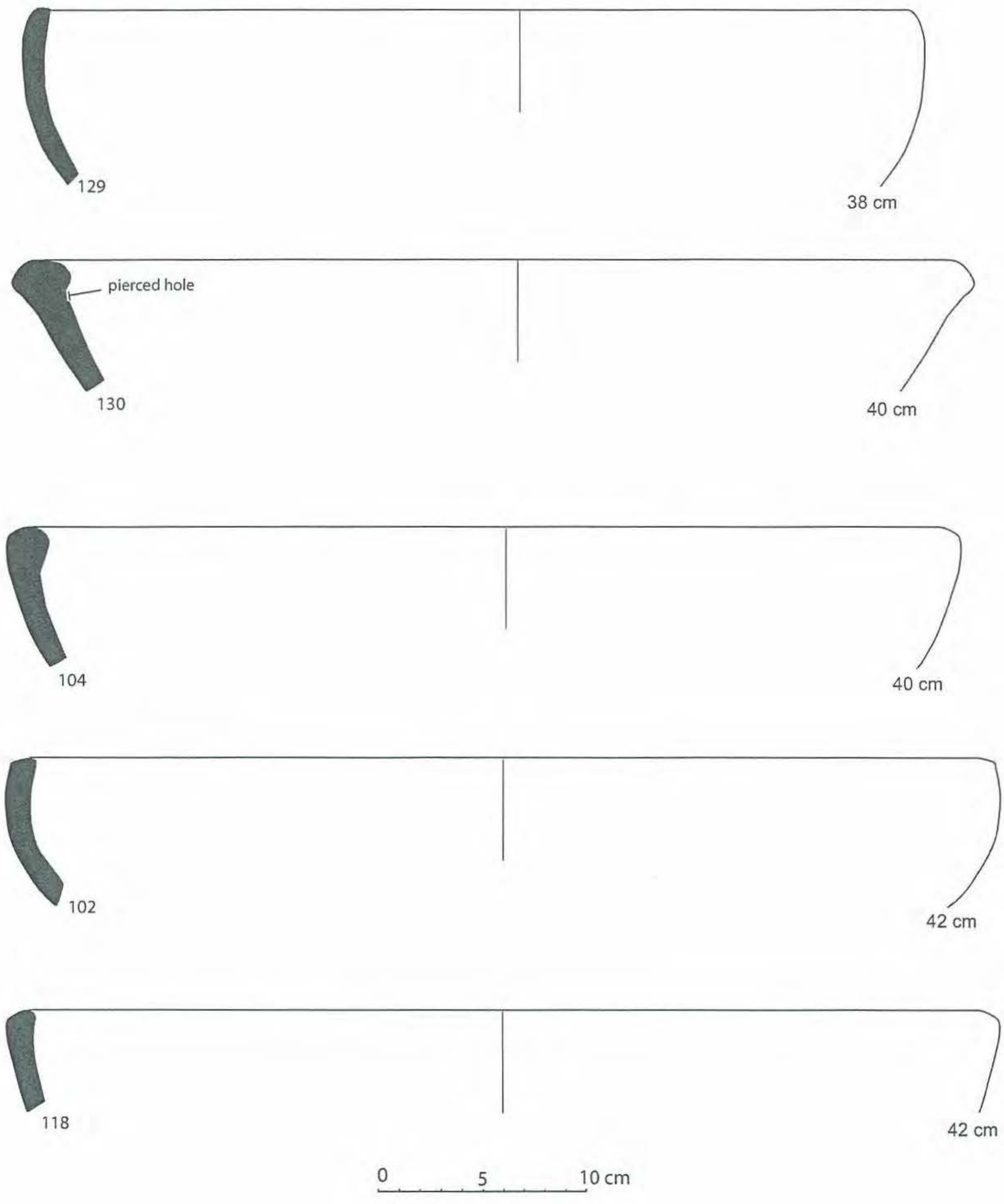


Figure 8.6a Rim sherds of Vessel Form I, orifice diameters 38-48 cm, continued.

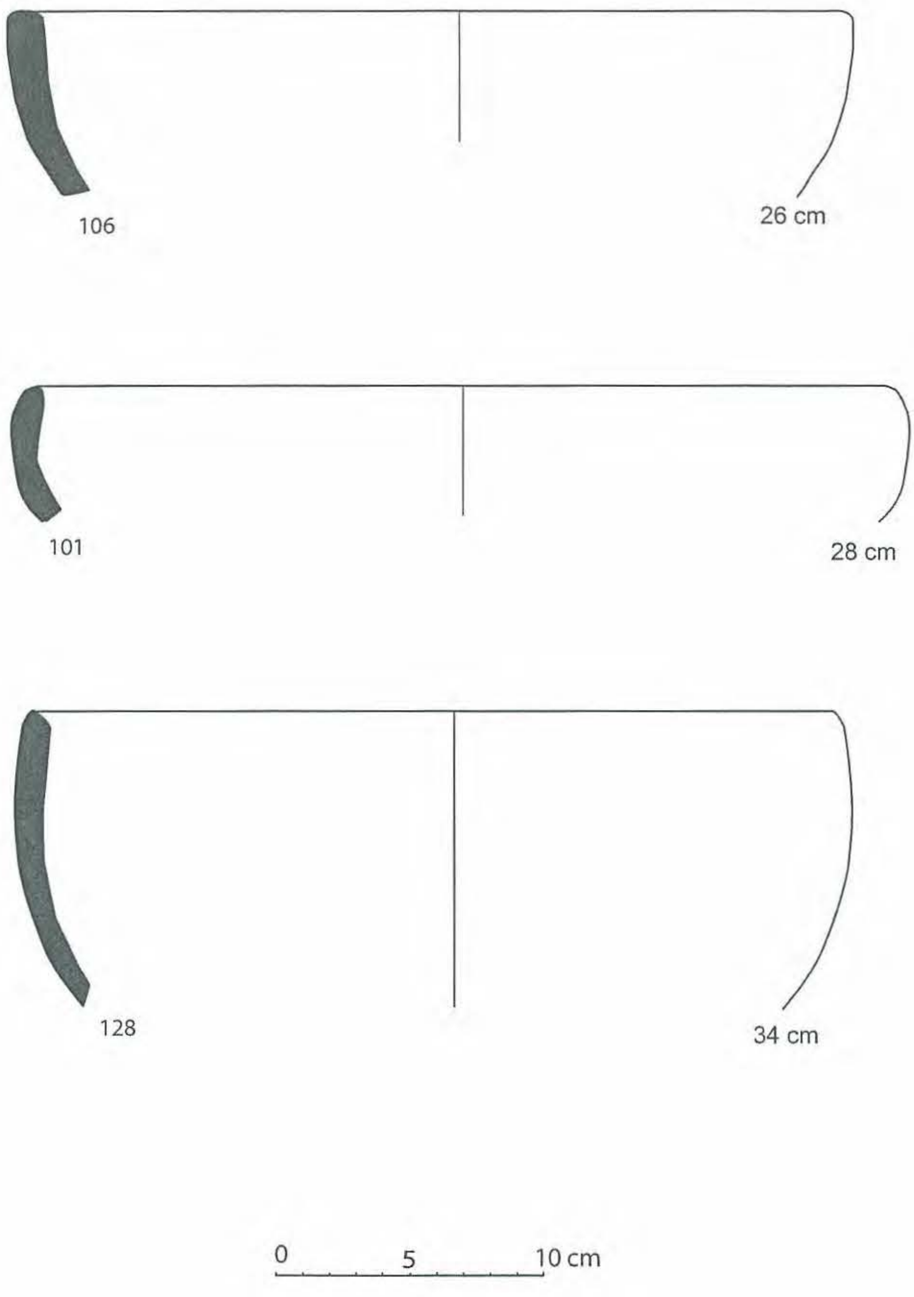


Figure 8.6b Rim sherds of Vessel Form I, orifice diameters 26-34 cm.

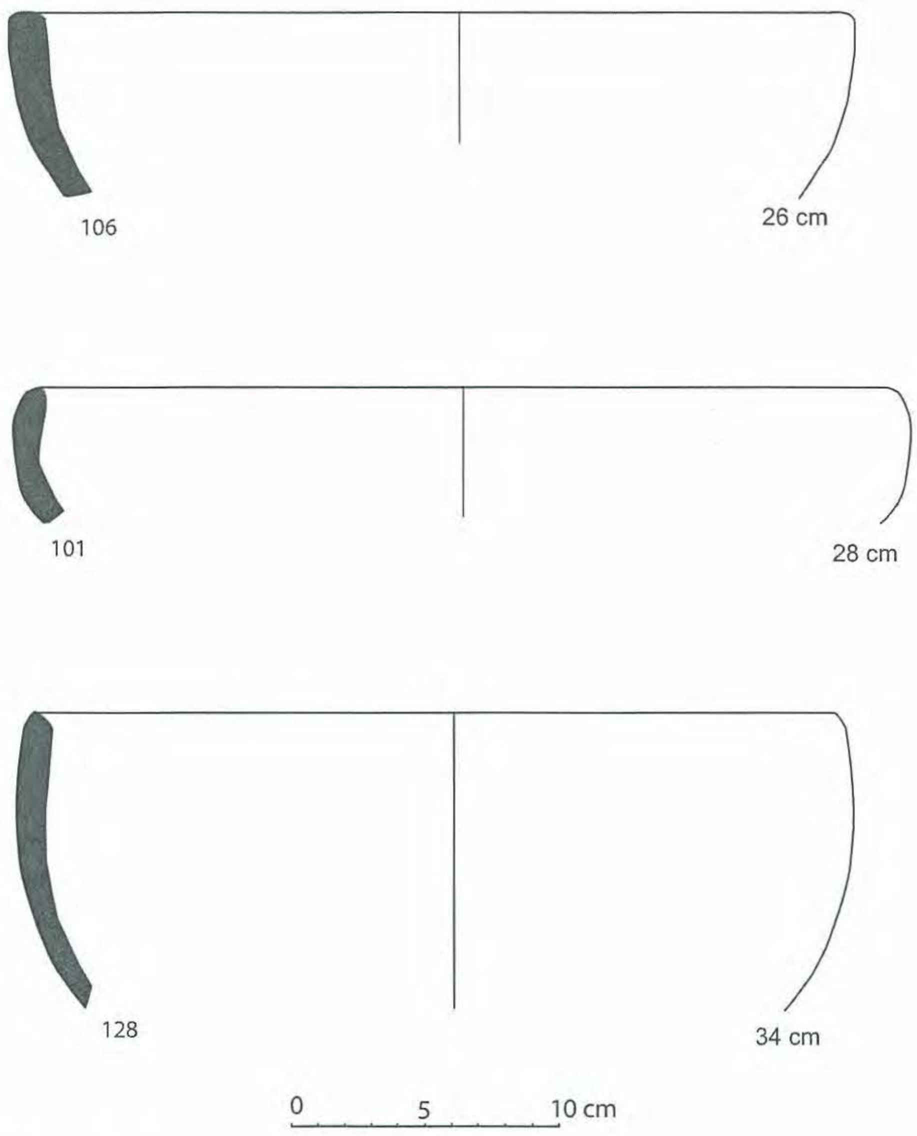


Figure 8.6b Rim sherds of Vessel Form I, orifice diameters 26-34 cm.

Figure 8.6c Vessel Form I, oval vessel (#48), with a. rim orientation as a lid, and b. rim orientation as a plate.

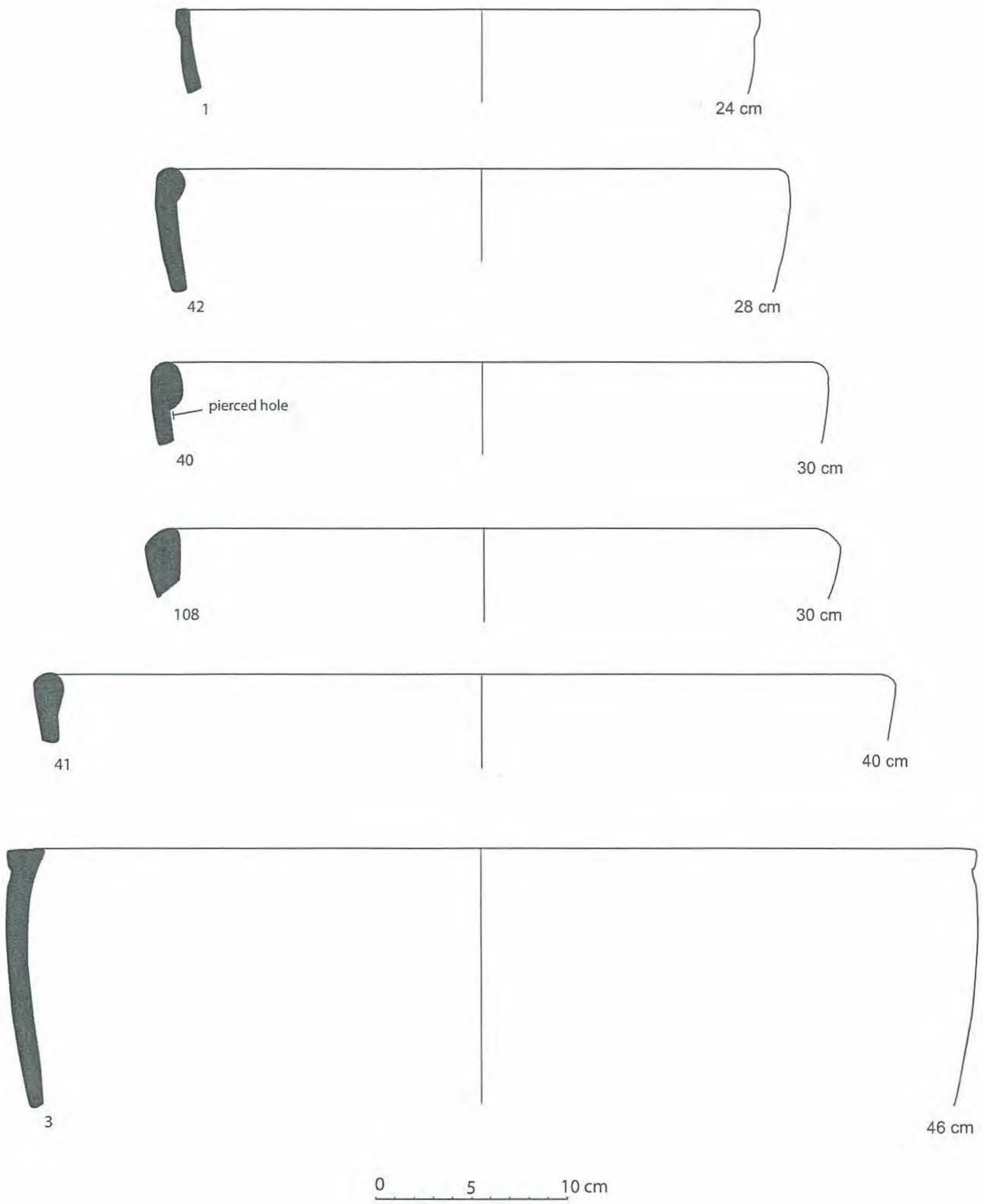


Figure 8.6d Rim sherds of Vessel Form II, orifice diameters 24-46 cm.

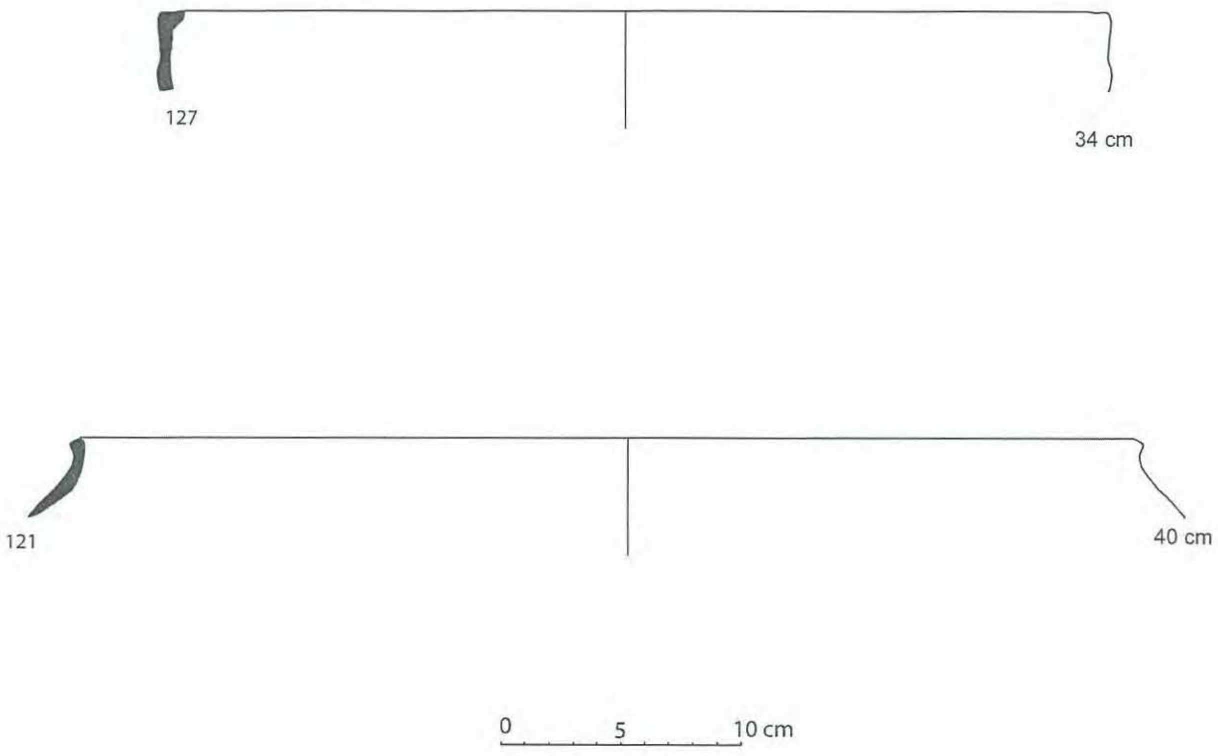
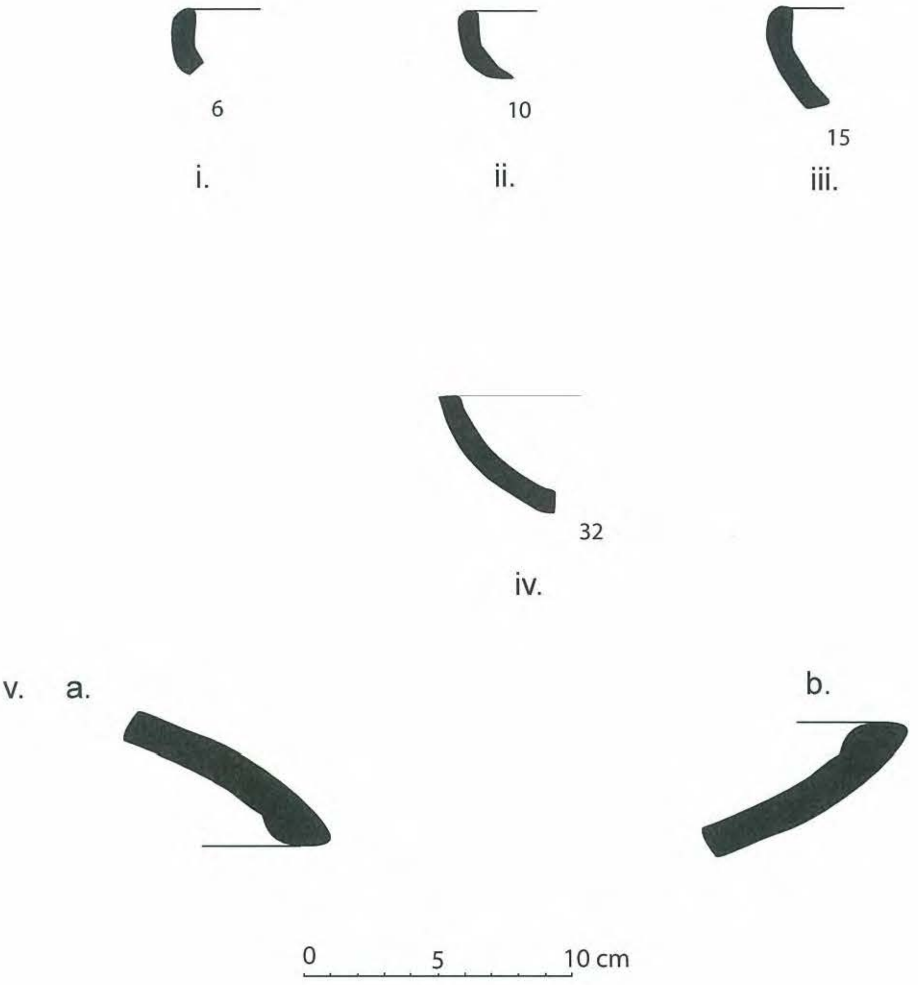


Figure 8.6e Rim sherds of Vessel Form III (upper), and Vessel Form IV (lower).



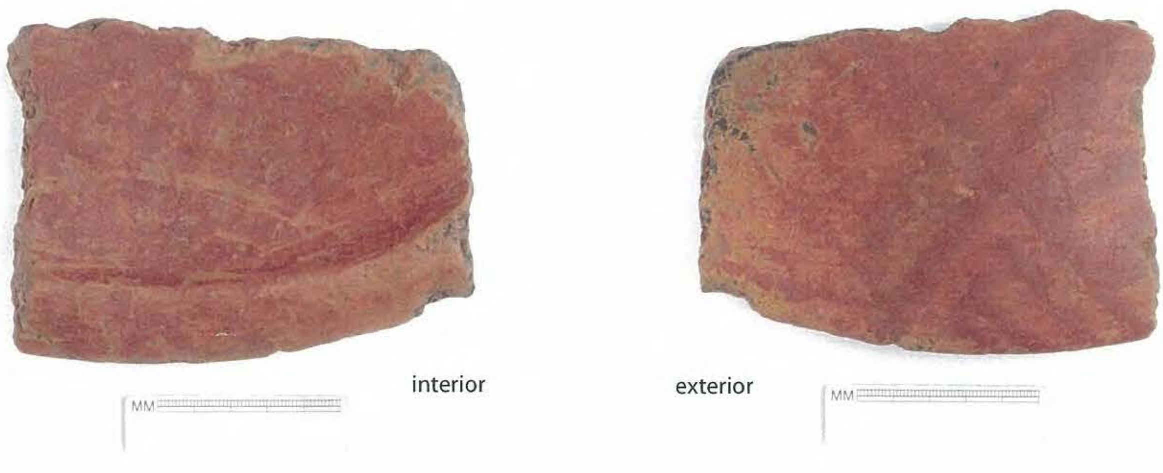


Figure 8.7a i-iii Block painted rim sherds of Vessel Form I; iv. rim with painted block and pattern and v. rim sherd (a. as a lid, b. as a plate) with painted block on the interior surface, and triangular pattern on the exterior surface.

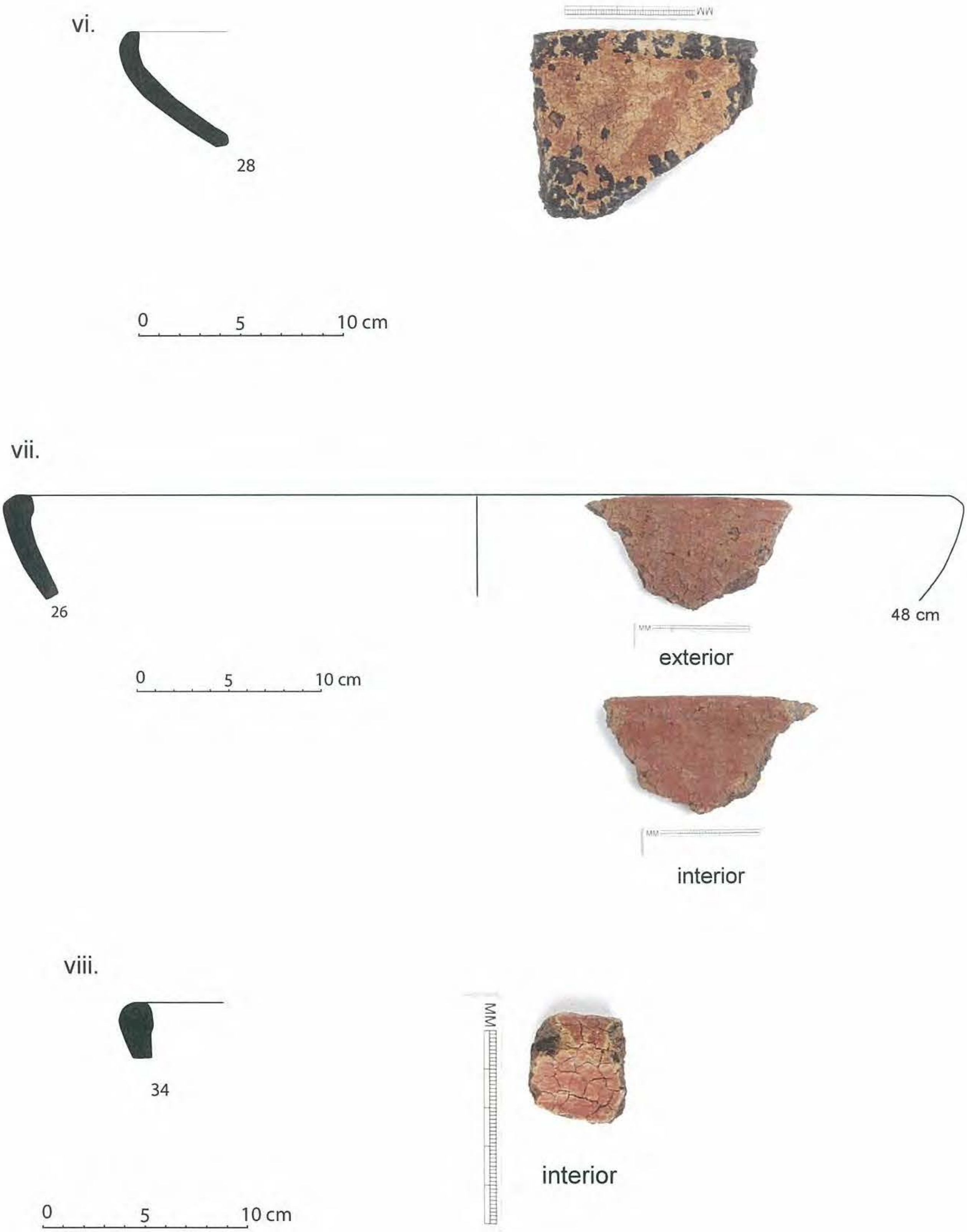
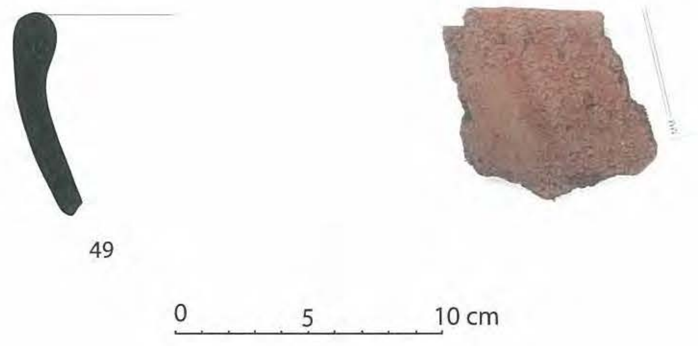
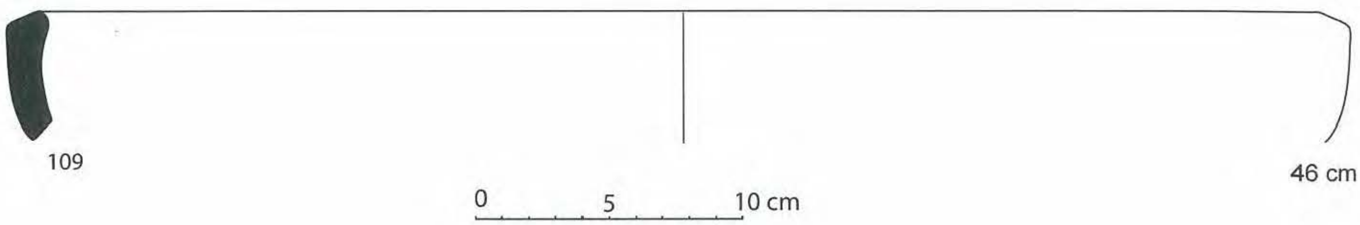


Figure 8.7a vi-viii Vessel Form I painted rims; vi. rim with pattern and possible block painting; vii. painted pattern with slip, exterior surface has diagonal stripes, interior a striped design; viii. painted block with slip.

ix.



x.



xi.

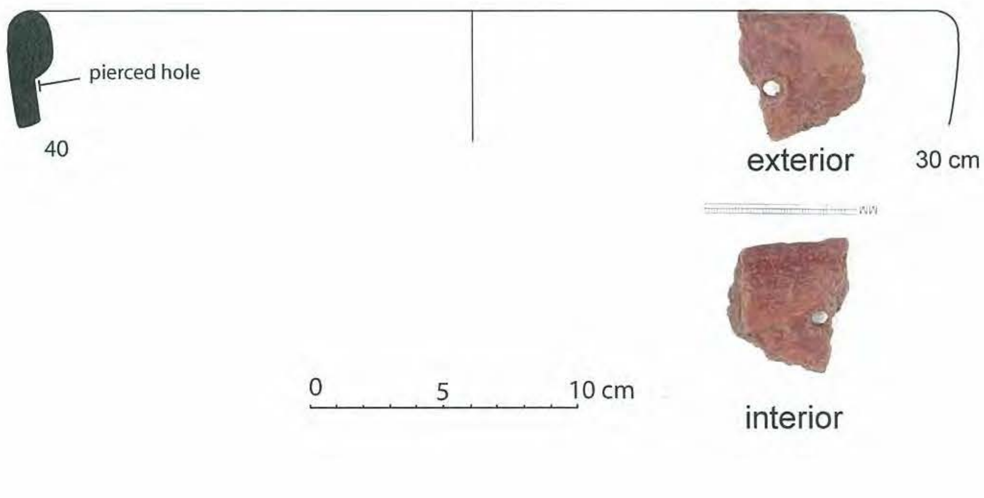


Figure 8.7a ix-xi Rim sherds of Vessel Form I; ix. pattern (stripes) on exterior surface, and slip; x. pattern and slip; xi. block painted, slip, and piercing.

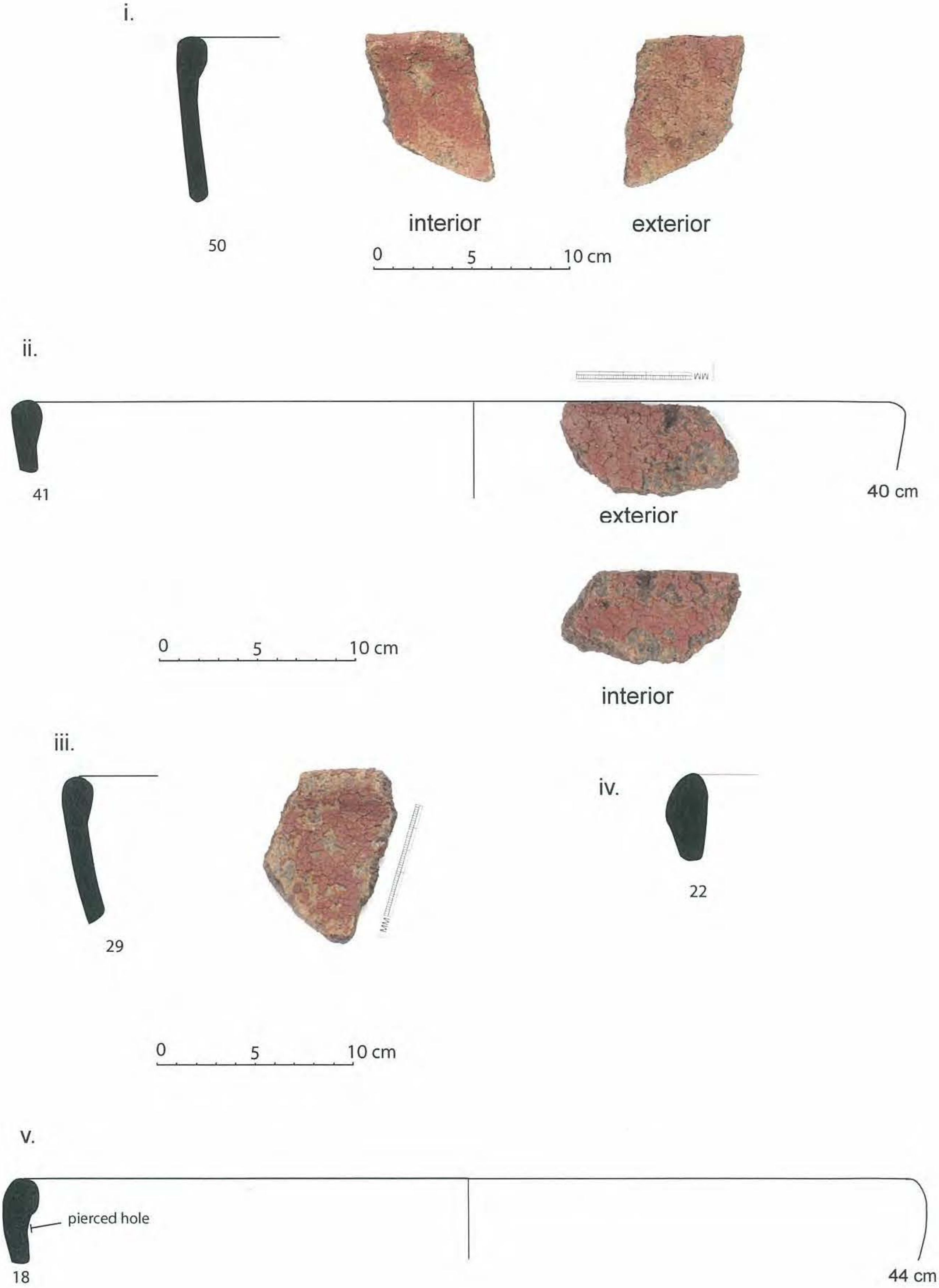


Figure 8.7b i-v Rim sherds of Vessel Form II; i. pattern 'leaf-like' on interior and stripes on exterior surface; ii. pattern on exterior, block on interior, and slip; iii. pattern and slip; iv. block painting; v. painted pattern, block and pierced.

11

0 5 10 cm

Figure 8.7c Rim sherd of Vessel Form III, painted in block colour.

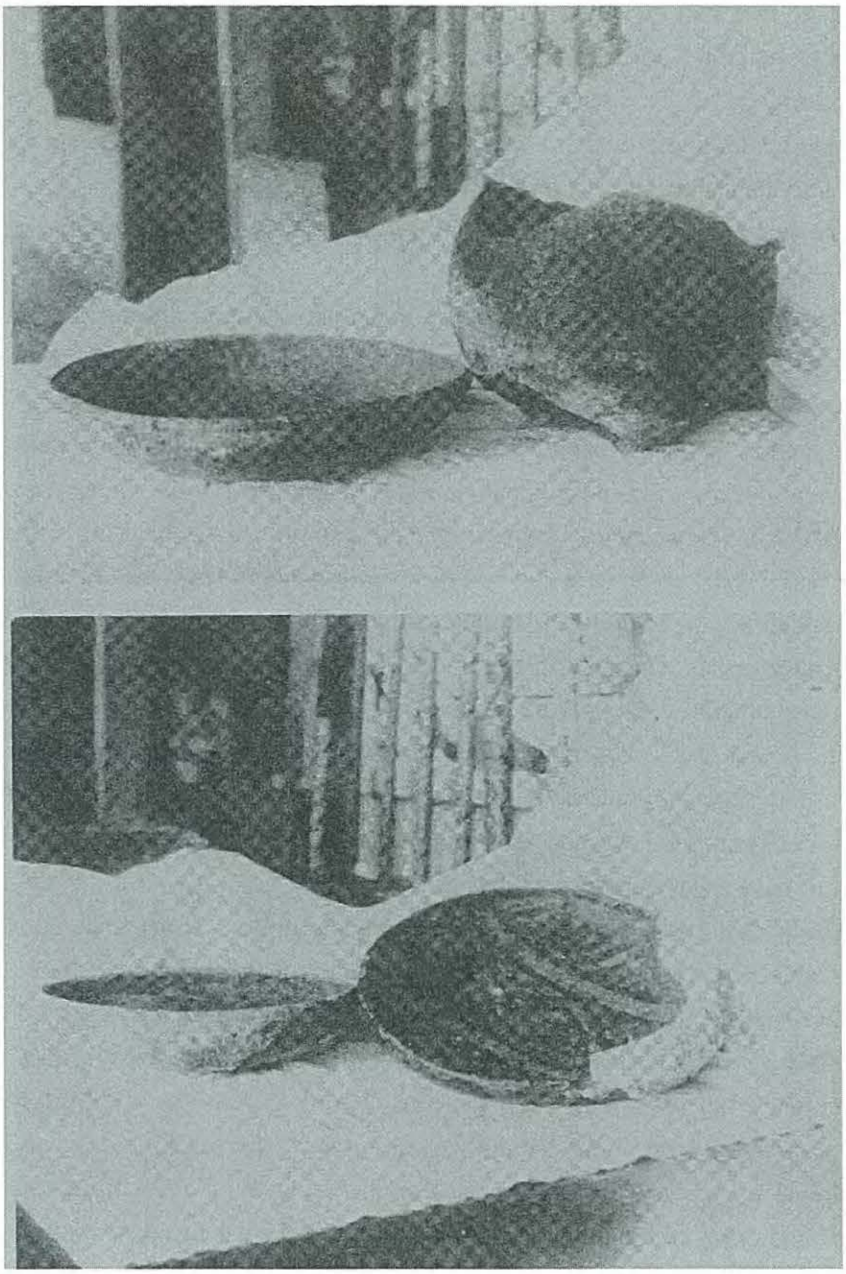


Figure 8.8a *Olekang* plate-like vessels painted with red pigment, with the lower picture illustrating geometric designs (Hijikata 1995:261-262).

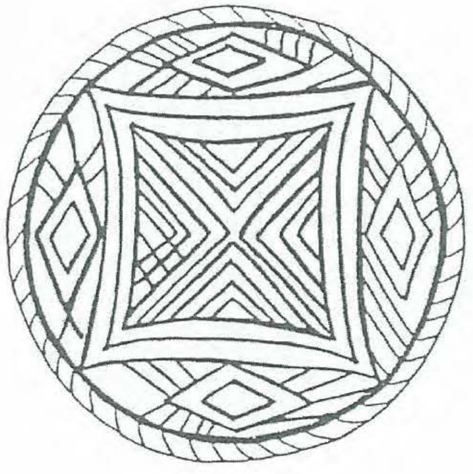


Figure 8.8b Reconstructed red painted pattern on the exterior of Bowl B from the Palau Museum (Osborne 1979:291).

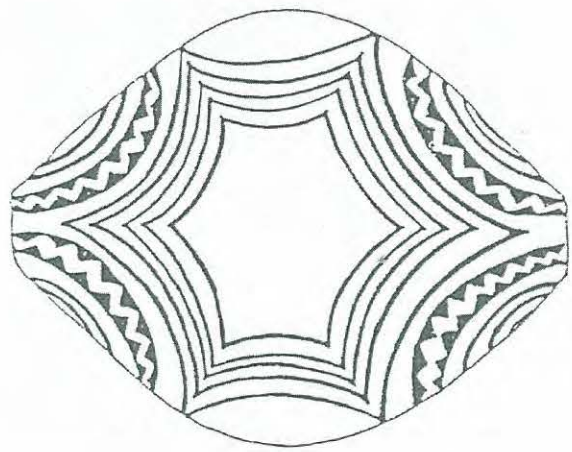


Figure 8.8c Reconstructed red painted pattern on the exterior of Bowl 13 from the Palau Museum (Osborne 1979:291).

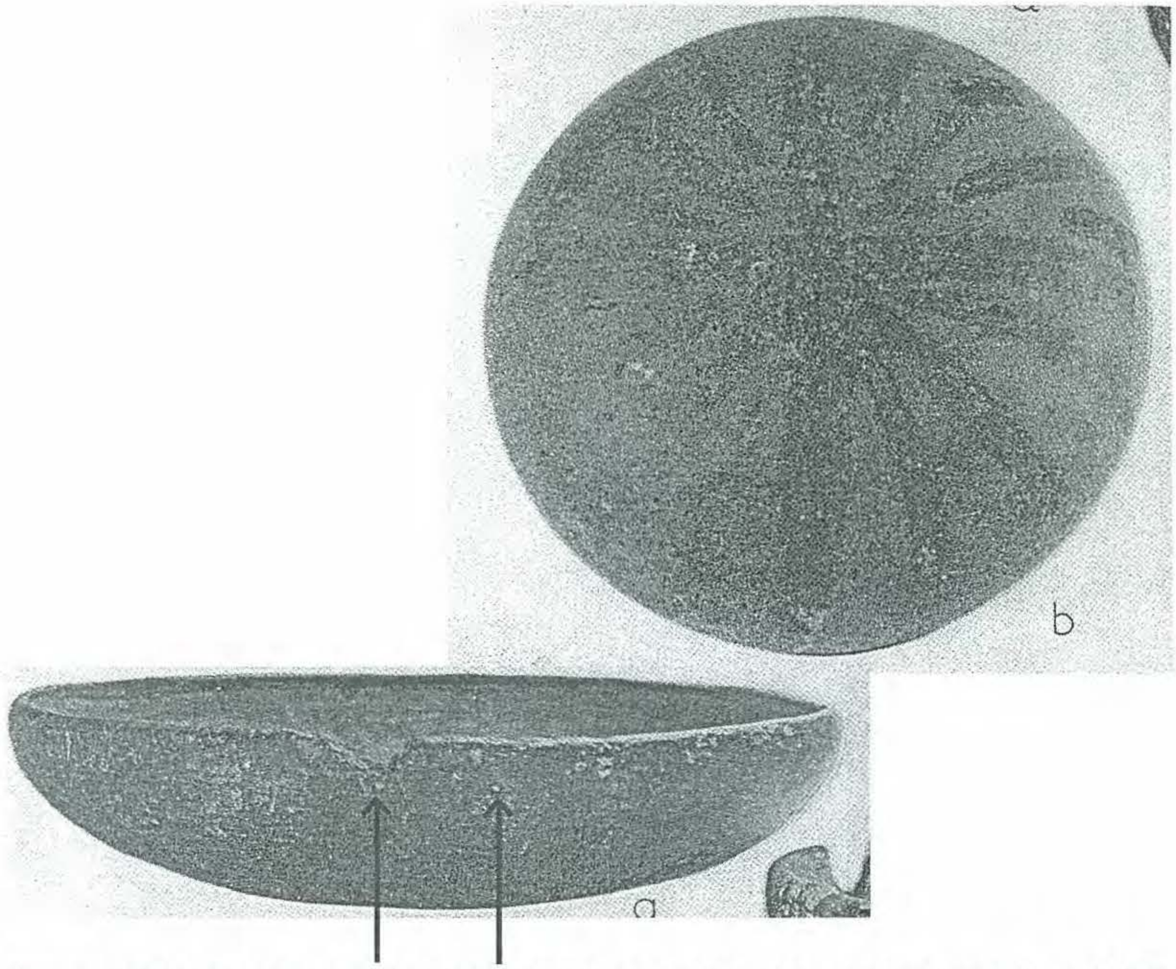


Figure 8.8d Vessel with red striped design on its exterior surface (upper), and the two arrows indicate the location of two pierced holes (above) (Osborne 1966:79).

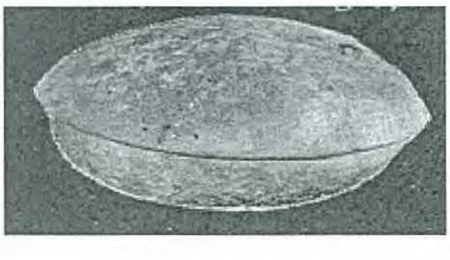
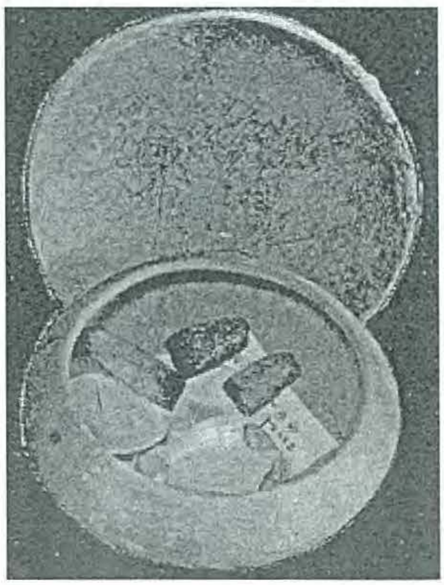


Figure 8.8e The two bowls collected by Prof. Kanaseki (above). Inside was a collection of stone adzes and shell artefacts (right) (Osborne 1966:65).



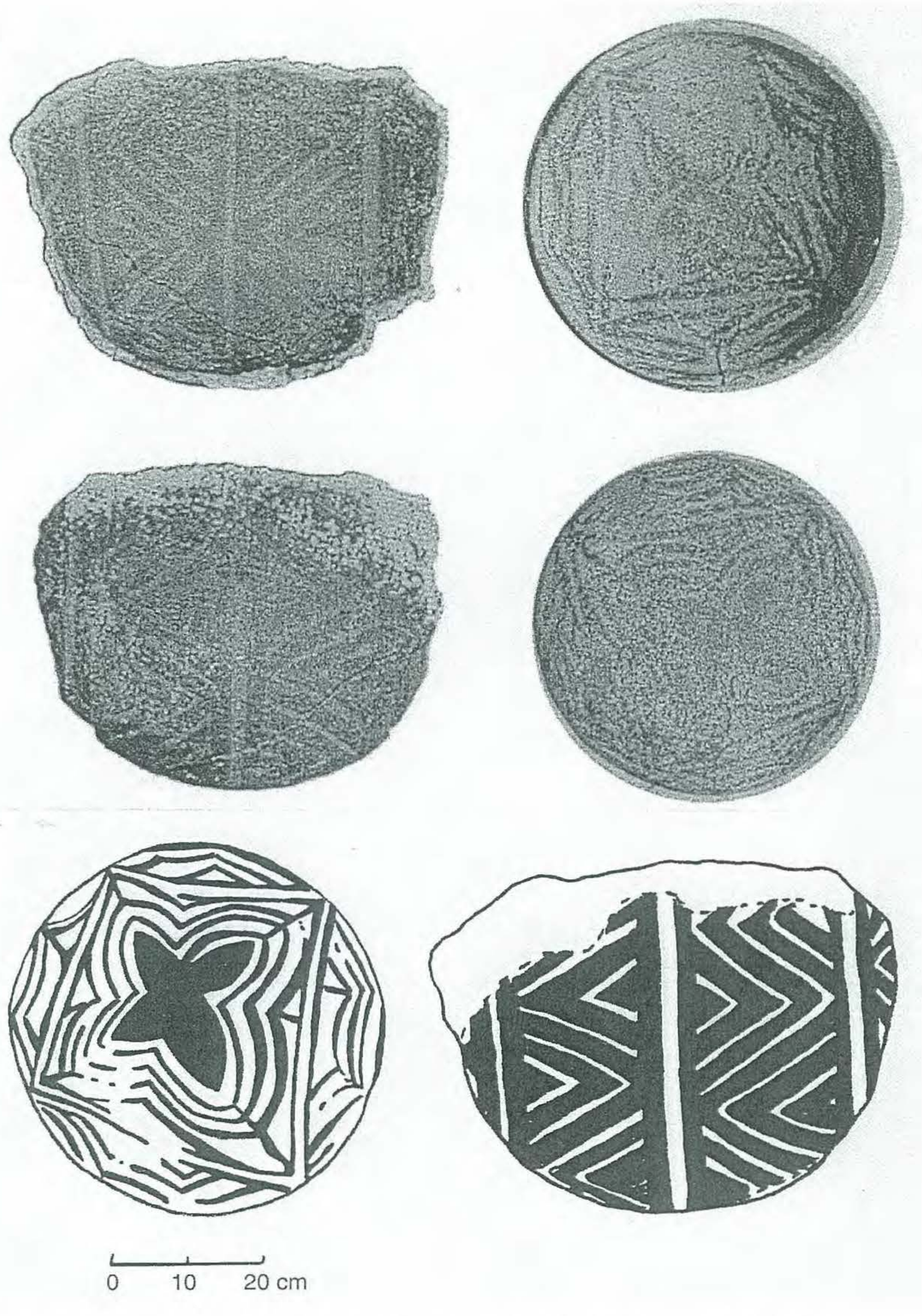


Figure 8.8f Painted vessels removed from Sengall Ridge burial cave. The bottom depictions are reconstructions of the exterior surfaces of each vessel (Beardsley and Basilius 2002:149).

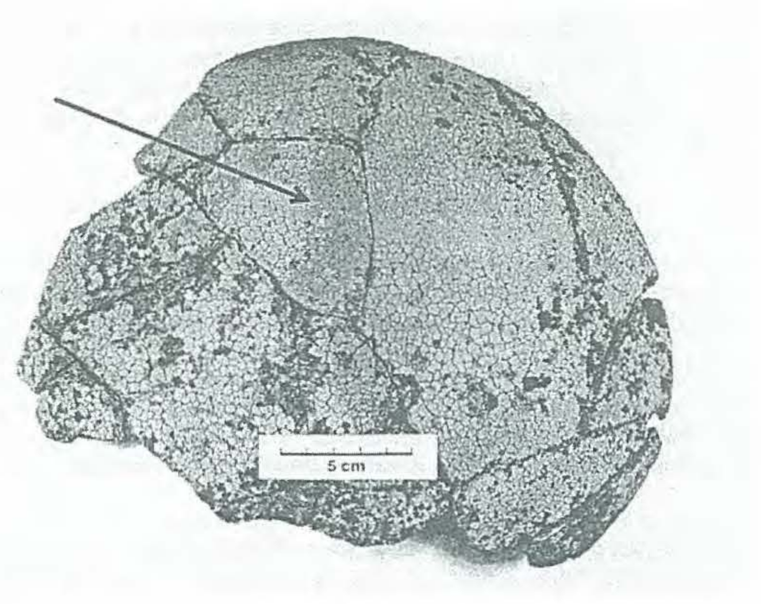


Figure 8.8g Reconstructed bowl with red painted striped design on its exterior surface (from Desilets, et al. 1999:200).

DATE	Osborne (1966)	Masse (1989)	Wickler et al. (1998)	CRDR (Liston 1999)
2500 BC	Exploration and Early Settlement			Period I
2000				
1500				
1000	Archaic			Period II
500			Early Settlement Period *Colonisation Phase*	
AD 1	Early LOWER	Colonisation	*Expansion Phase*	Period III
500				Period IV *Phase A*
	MIDDLE	Resource Intensification EARLY	Terrace Period EARLY	*Phase B*
1000	UPPER	LATE	LATE	
		Rock Island Village	Village Period EARLY	Period V *Phase A*
1500	Late LOWER	Transition	INTERMEDIATE	*Phase B*
	MIDDLE	Traditional *PROTOHISTORIC*	LATE	
		INITIAL CONTACT		
2000	UPPER	*HISTORIC* Modern	HISTORIC	HISTORIC

Table 2.1 Proposed cultural sequences for Palau (after Liston 1999).

Lab number	Provenance	Dating Method	Material	CRA bp	d14C%	δ13C%	D14C%	Cal. 2 sigma BP
B:NA-4:12 Toi Meduu								
ANU-11610	TR5, ditch, LIV, late-secondary fill layer	AMS	charcoal	770 +/- 20	-76.8 +/- 2.1	-17.0 +/- 0.2 measured	-91.6 +/- 2.1	730 (680) 670
ANU-11611	TR5, ditch, LVII, first secondary fill layer	conventional	charcoal	1500 +/- 190	-176.6 +/- 18.9	-28.9 +/- 0.2 measured	-170.2 +/- 19.1	1820 (1390,1360,1350) 990
B:NA-4:11 Ngemeduu								
ANU-11685	TRla, crown, LVIII, original hilltop surface prior to crown construction	conventional	charcoal	2030 +/- 30	-225.5 +/- 2.2	-26.2 +/- 0.2 measured	-223.7 +/- 2.2	2060 (1990,1970,1980,1960,1950) 1900
ANU-11687	TR1a, crown, LVIII, original hilltop surface prior to crown construction	AMS	charcoal	1630 +/- 30	-189.0 +/- 2.2	-28.7 +/- 0.2 measured	-184.0 +/- 2.2	1610 (1530) 1420
ANU-11658	TR1a, crown, LVIII, original hilltop surface prior to crown construction	conventional	charcoal	1510+/- 200	-169 +/- 19.4	-24.0 +/- 2.0 estimated	-171.5 +/- 19.6	1870 (1400, 1400,1390) 990
ANU-11686	TR1a, crown, LVII, hill surface layer	AMS	charcoal	1420 +/- 30	-166.9 +/- 2.2	-27.8 +/- 0.2 measured	-162.2 +/- 2.2	1350 (1310) 1290
ANU-11641-2	TR1, crown, LVI, fill layer	AMS	charcoal	1960 +/- 40	-214.9 +/- 0.9	-24.0 +/- 2.0 estimated	-216.5 +/- 3.3	1993 (1919,1912,1897) 1822
ANU-12121	TR1e, crown, LVI, underneath Feature 3a.	AMS	charcoal	1700 +/- 190	-190 +/- 18.0	-24.0 +/- 2.0 estimated	-190.8 +/- 18.3	2041 (1606,1580,1571) 1265
ANU-11659	TR1i, terrace encircling crown, Posthole 2.	conventional	charcoal	1770 +/- 210	-232.3 +/- 19.8	-24.0 +/- 2.0 estimated	-233.8 +/- 20.0	2300 (1710,1640,1640) 1290
ANU-11836	TR1i, interface of Feature 1(LIII) and the pit (LIV)	AMS	charcoal	2640 +/- 310	-279 +/- 26.4	-24 +/- 2.0 estimated	-280.3 +/- 26.5	3471 (2753) 1951

Table 3.1 Radiocarbon determinations from Toi Meduu and Ngemeduu.

Ngemeduu (B:NA-4:11)
Trench 1 (TR1)

LAYER Ia	Organic A horizon, top 2cm, located only in the depression, many roots.
LAYER I	7.5YR 4/2 Brown clay loam, average thickness 10cm, friable, subangular-blocky, many roots all sizes, begins just before mound on west side and extends into depression.
LAYER II	5YR 5/4 Reddish brown clay, average thickness 30cm, subangular blocky, roots common fine to coarse, quite friable, present at the west end of the trench only, before the mound and depression.
LAYER III	7.5YR 4/4 Brown silty clay, average thickness 12cm, firm, roots common, fine to medium in size, many fine charcoal flecks, only present on mound, discontinuous.
LAYER IIIa	7.4YR 4/4 Brown silty clay, average thickness 7cm, subangular blocky, firm, very few roots micro sized, no charcoal or cultural material, only present of the 'hump' of the mound – discontinuous.
LAYER IV	10YR 4/2 Dark greyish brown clay silt, average thickness 20cm, subangular blocky, firm, abundance of fine charcoal flecks.
LAYER IVa	7.5YR 4/6 Strong brown clay, average thickness 25cm, mix of layer IV and V, subangular blocky, few roots at micro size, two basalt cobbles are present.
LAYER IVb	10YR 5/4 Yellowish brown silty clay, average thickness 18cm, subangular blocky, quite firm, roots common fine to medium sized, many fine charcoal flecks, two basalt cobbles present in this layer.
LAYER V	7.5YR 6/8 Reddish yellow clay, average thickness 35cm, quite firm, although structureless, few roots at micro sizes, few charcoal flecks, very distinct iron pan on lower boundary, one rim sherd.
LAYER VI	2.5YR 4/3 Reddish brown clay mottled with yellow, pink and white saprolite, subangular blocky, small rootlets, saprolite quite friable, one rim sherd found and < 1mm sized charcoal sample, iron pan forms upper boundary in depression.

Table 5.1 Trench 1 stratigraphic descriptions.

Ngemeduu (B:NA-4:11)

Trench 1a (TR1a)

LAYER I	7.5YR 4/4 Brown clay loam, average thickness 10cm, friable, many roots all sizes, begins just outside of depression edge, discontinuous.
LAYER Ia	Organic A horizon, top 2cm, located only in the depression, many roots.
LAYER II	5YR 4/4 Reddish brown clay, average thickness 30cm, subangular blocky, roots common fine to coarse, quite friable, discontinuous.
LAYER III	10YR 4/4 Dark yellowish brown silty clay, average thickness 12cm, firm, roots common medium sized, >1mm sized charcoal flecks, discontinuous.
LAYER IIIa	7.5YR 5/8 Strong brown with grey flecks silty clay, average thickness 10cm, subangular blocky, firm, few roots micro sized, discontinuous.
LAYER IV	10YR 4/3 Brown clay silt, average thickness 12cm, subangular blocky, firm, abundant >1mm sized charcoal flecks, discontinuous.
LAYER IVb	10YR 6/6 Brownish yellow silty clay, average thickness 10cm, subangular blocky, quite firm, roots common fine to medium sized, many >1mm charcoal flecks.
LAYER V	7.5YR 5/8 Strong brown clay, average thickness 25cm, firm though structureless, few roots micro sized, few charcoal flecks, lower boundary defined by iron pan, some sherds.
LAYER VI	2.5YR 3/3 Dark reddish brown clay with white and pink mottles of saprolite, average thickness 2m, many sherds and charcoal, mixed with degrading more friable saprolite present in clasts and brown rather structureless clay, micro sized roots, upper boundary defined by iron pan in depression only.
LAYER VII	5YR 4/4 Reddish brown clay, average thickness 30cm, plastic but firm, abundant charcoal flecking with some larger charcoal samples present, subangular blocky, consistent boundary, highly eroded bauxite nodules, some micro sized roots, small basalt pebbles, abundant sherds.
LAYER VIII	5YR 4/3 Reddish brown clay, average thickness 1.5m, subangular blocky, charcoal flecking frequent with larger samples present, small saprolite clasts and some slight mixing with basal saprolite at boundary, many sherds though frequency decreases with depth, a few bauxite pebbles.
LAYER IX	C Horizon, Saprolite.

Table 5.2 Trench 1a stratigraphic descriptions.

Ngemeduu (B:NA-4:11)
Trench 1e (TR1e)

LAYER I	7.5YR 4/4 Brown clay loam, average thickness 20cm, friable, many roots, present in depression only.
LAYER Ia	Top 7cm of soil, mainly root layer.
LAYER II	5YR 4/3 Reddish brown clay, average thickness 20 cm, subangular blocky, roots common, quite friable, present in baulk only, many small charcoal flecks.
LAYER IIa	2.5YR 4/3 Reddish Brown clay mottled with yellow and pink saprolite; average thickness 18cm, roots of various size; subangular blocky, quite friable, clear boundary, in baulk.
LAYER IIb	5YR 4/4 Reddish brown clay, average thickness 10cm, subangular blocky, quite firm, some charcoal, some various sized roots, in baulk.
LAYER IIc	5YR 4/4 Reddish brown clay with black mottled saprolite, average thickness 5cm, firm, some charcoal, roots of various sizes, in baulk.
LAYER IV	10YR 4/4 Dark yellowish brown clay silt, average thickness 10cm subangular blocky, firm, some >1mm sized charcoal samples, discontinuous.
LAYER IVb	10YR 4/6 Dark Yellowish brown silty clay, average thickness 12cm, subangular blocky, firm, may roots fine to medium sized, large charcoal concentration on eastern boundary, many small saprolite rocks/clasts.
LAYER V	10YR 5/8 Yellowish brown clay, average thickness 25cm, firm though structureless, few roots micro sized, few charcoal flecks, lower boundary defined by iron pan.
LAYER VI	2.5YR 4.3 Reddish brown clay mottled with yellow and pink saprolite, many sherds an charcoal, mixed of clay and friable saprolite present as clasts, micro sized roots, medium to large sized charcoal fragments, upper boundary defined by iron pan in depression only.

Table 5.3 Trench 1e stratigraphic descriptions.

Ngemeduu (B:NA-4:11)
Trench 1e Feature 3 (TR1e F3)

LAYER I	10YR 4/4 Dark yellowish brow n clay, average thickness 10cm, many roots all sizes, within the depression only.
LAYER Ia	Top 7cm of loamy clay, root mat.
LAYER IV	10YR 4/4 Dark yellowish brown clay, average thickness 25cm, subangular blocky, firm, >1mm charcoal fragments present, discontinuous.
LAYER IVb	10YR 4/4 & 6/6 Dark yellowish brown and brownish yellow clay silt, average thickness 10cm, subangular blocky, quite firm, roots common, fine to medium sized.
LAYER V	7.5YR 5/8 Strong brown clay, average thickness 15cm, firm though structureless, few roots micro sized, few charcoal flecks, lower boundary defined by iron pan, one basalt cobble.
LAYER VI	2.5YR 4/3 Reddish brown clay with black, white and pink mottled saprolite, average thickness 30cm, mixed with friable saprolite clasts, micro sized roots, one basalt cobble present.
LAYER VIa	5YR 4/4 Reddish brown clay, average thickness 10cm, subangular blocky; firm, no roots, some saprolite flecking, clear upper boundary; discontinuous – lense, some sherds in south wall.
LAYER VIb	7.5YR 4/4 Brown clay, average thickness 75cm, very loose and friable clay saprolite mix, some large roots, clear boundary, continuous, some saprolite and basalt cobbles.
LAYER VIc	5YR 4/4 Reddish brown clay with some saprolite flecking, average thickness 12cm, micro sized roots, firm in places though friable in others, subangular blocky, uneven boundary indicating possible 'gouge' marks, fill layer over saprolite.
LAYER VId	7.5YR 4/4 Brown clay lense, average thickness 5cm, discontinuous, very friable, clear boundary.
LAYER X	7.5YR 5/6 Strong brown clay with black & yellow mottled saprolite, only found within boundary of the F3, framed by the iron pan which extends beneath the feature, quite firm, subangular blocky, some small micro roots, clear boundary.
LAYER IX	C Horizon, Saprolite

Table 5.4 Trench 1e F3 stratigraphic descriptions.

Ngemeduu (B:NA-4:11)
Trench 1e Feature 3a (TR1e F3a)

LAYER VI	10R 4/3 Weak red clay with grey, yellow and pink mottles, average thickness 42cm, mixed with degraded saprolite, some hematite clasts visible and manganese veins, micro-sized roots, some saprolite rocks and clasts.
LAYER VIa	2.5YR 3/4 Dark reddish brown clay, average thickness 12cm, subangular blocky, firm, no roots, clear upper boundary, many sherds and charcoal, all sizes, second lense (vertically) more friable than the first, basalt cobbles concentrated in this layer.
LAYER VIb	5YR 4/4 Reddish brown clay with pink, white and yellow mottles, average thickness 40cm, friable, frequent saprolite clasts with manganese veins, some sherds, some roots all sizes, clear boundary.
LAYER VIc	5YR 4/ 4 Reddish brown clay with a few white and yellow mottles, average thickness 17cm, firm in places and friable in others, some saprolite flecking, subangular blocky.
LAYER IX	C Horizon, Saprolite.

Table 5.5 Trench 1e F3a stratigraphic descriptions.

Ngemeduu (B:NA-4:11)
Trench 1f (TR1f)

LAYER I	10YR 4/4 Dark yellowish brown clay, a verage thickness 9cm, many roots all sizes, within the depression only.
LAYER Ia	Top 7cm of loamy clay, root mat.
LAYER II	7.5YR 4/4 Brown silty clay, average thickness 20 cm, subangular blocky, roots common, quite friable, present in baulk only, many small charcoal flecks.
LAYER IIa	2.5YR 4/3 Reddish brown clay mottled with yellow and pink saprolite, average thickness 18cm, roots of various sizes, subangular blocky, quite friable, clear boundary, in baulk only.
LAYER IIb	5YR 4/4 Reddish brown clay, aver age thickness 10cm, subangular blocky, quite firm, some charcoal, some various sized roots, in baulk only.
LAYER IIc	5YR 4/4 Reddish brown clay with black mottled saprolite, average thickness 5cm, firm, some charcoal, roots of various sizes, in baulk only.
LAYER IV	10YR 4/4 Dark yellowish brown clay, average thickness 18cm, subangular blocky, firm, present only in depréssion, discontinuous.
LAYER IVb	7.5YR 5/6 & 4/6 Strong brown clay silt, average thickness 5cm, subangular blocky, quite firm, roots common, fine to medium sized.
LAYER V	7.5YR 5/6 Strong brown clay, average thickness 30cm, firm though structureless although many orange-red haematite 'smudges' present, lower boundary defined by iron pan, a few sherds and a large yellow saprolite rock.
LAYER Va	5YR 4/4 Reddish brown clay mixed with pink and yellow saprolite, average thickness 11cm, an enclosed gulf within LV.
LAYER VI	2.5YR 4/3 Reddish brown clay with white and yellow mottles, average thickness 2.4m, mixed with friable saprolite clasts, micro sized roots, one basalt cobble, colour slightly lighter in central area, although very purple-red saprolite breccia dominates.
LAYER IX	C Horizon, Saprolite.

Table 5.6 Trench 1f stratigraphic descriptions.

Ngemeduu (B:NA-4:11)
Trench 1g (TR1g)

LAYER Ia	7.5R 3/4 Dark brown top organic A horizon, heavy root mat.
LAYER I	7.5YR 3/4 and 3/3 Brown and dark brown clay, average thickness 10cm, similar to TR1f though not as developed, many roots all sizes.
LAYER IV	7.5YR 4/6 Strong brown clay, average thickness 20cm, becomes much thicker as it extends up the knob and the boundary between LIVc is not clear, subangular blocky, some roots, boundary unclear with LIVb.
LAYER IVb	7.5YR 5/6 & 4/6 Strong brown clay silt, average thickness 5cm, subangular blocky, unclear upper boundary, roots common, fine to medium sized, uneven lower boundary.
LAYER IVc	5YR 4/4 Reddish brown clay, average thickness 20cm, subangular blocky, firm, some charcoal flecking but predominantly small black flecks of manganese, many roots, all size classes, some saprolite clasts also remaining, B horizon formation, present only on knoll, unclear boundary with LIV.
LAYER V	7.5YR 5/6 Strong brown clay, average thickness 25cm, firm though structureless, some micro sized roots, many small manganese veins and hematite 'smudges', colour grades darker and depth is deeper as the layer extends west, not present on the knoll at basalt interface, poorly developed iron pan at interface with LVI.
LAYER VI	7.5YR 4/6 Strong brown clay and saprolite mix, depth not known, iron pan at interface between this layer and LV is not clearly formed, though the boundary is clear, friable saprolite clasts mixed with red clay, micro sized roots, some basalt cobbles at knoll interface.
LAYER VIb	5YR 4/4 Reddish brown clay silt with pink saprolite mixing, average thickness 18cm, quite loose, many clasts of saprolite and manganese veins, only present on the knoll underlying LIVb, many basalt pebbles at interface between LVI.

Table 5.7 Trench 1g stratigraphic descriptions.

Ngemeduu (B:NA-4:11) Trench 1g-a (TR1g-a)	
LAYER I	7.5YR 3/4 Dark brown clay, top 3 -4cm organic root mat – humic layer.
LAYER II	7.5YR 4/4 Brown clay with many saprolite clasts, average thickness 15cm, main erosional layer with an increase in depth as the layer extends west, some small charcoal flecks and manganese veins, friable, many roots of medium to small size.
LAYER III	7.5YR 4/4 Brown clay with pink, white and yellow mottled saprolite, average thickness 32cm, friable, mix between layers IVc and VI b in trench TR1g - erosional, one sherd and sporadic micro charcoal samples.
LAYER IV	5YR 4/3 Reddish brown with yellow mottled saprolite lenses, potential remnants of LVI when crown was initially built, firm.

Table 5.8 Trench 1g-a stratigraphic descriptions.

Ngemeduu (B:NA-4:11) Trench 1h (TR1h)	
LAYER I	5YR 4/3 Reddish brown loamy clay, average thickness 7cm, micro roots common, friable, subangular blocky, very sparse small pebbles, nor charcoal or sherds, recent A horizon.
LAYER II	5YR 4/4 Reddish brown silty clay, average thickness 1.1m, subangular blocky, varies between very loose and compact, some saprolite clasts throughout, presence of manganese veins, few sherds, some rocks at the base of deposit on terrace surface.
LAYER IIIa	5YR 4/4 Reddish brown clay with grey and black mottled saprolite, average thickness10cm, mix of LII and IV with LII more common, manganese veins mixed throughout.
LAYER IIIb	7.5YR 5/4 AND 4/3 Brown clay with white and yellow mottle saprolite, average thickness 10cm, mix of LII and IV with LIV more common, very loose.
LAYER IV	C Horizon, Saprolite.

Table 5.9 Trench 1h stratigraphic descriptions.

Ngemeduu (B:NA-4:11) Trench 1i (TR1i)	
LAYER I	7.5YR 4/4 Brown clay, A horizon, average thickness 5cm, man y roots of all sizes, firm, humic layer.
LAYER II	5YR 4/4 Reddish brown silty clay, average thickness 40cm, friable, some > 1mm sized charcoal samples, many roots all sizes, saprolite clasts mixed throughout, same erosional layer as TR1h.
LAYER III	5YR 4/4 Reddish brown clay mixed with pink saprolite, average thickness 25cm, friable and loose, many small saprolite clasts and manganese nodules spread throughout, roots predominantly small to micro sized, some sherds and charcoal, some basalt cobbles part of Feature1.
LAYER IV	5YR 4/4 Reddish brown clay with some pink saprolite flecking, average thickness 50cm, compact, subangular blocky, roots of small sizes, many small saprolite clasts and 2-5cm sized saprolite rocks, some sherds and charcoal flecks, many manganese nodules, leveling layer.
LAYER IVa	7.5YR 4/4 Brown clay mixed with saprolite breccia, average thickness 6cm, likely formation of B horizon in progress.
LAYER V	C Horizon, Saprolite.

Table 5.10 Trench 1i stratigraphic descriptions.

Ngemeduu (B:NA-4:11)
Test unit 1 (TU1)

LAYER Ia	5YR 3/3 Dark reddish brown loamy clay, upper humic horizon.
LAYER II	2.5YR 4/3 Reddish brown silty clay, average thickness 20cm, subangular blocky, roots common, quite friable, many small charcoal flecks, some pot sherds and saprolite rocks.
LAYER VI	10R Weak red clay, heavily mottled with white, black, yellow and pink saprolite, average thickness 80cm, friable saprolite clasts mixed with red clay, micro sized roots, small charcoal samples, and some manganese veins.
LAYER VIa	5YR 4/4 Reddish brown, heavily mottled with yellow, pink, black and white saprolite, a lense of fill material, subangular blocky, no roots. firm.

Table 5.11 Test unit 1 stratigraphic descriptions.

Toi Meduu (B:NA-4:12) Trench 2 (TR2)	
LAYER I	5YR 4/3 Reddish brown silty loam, organic A horizon, average thickness 5cm, clear lower boundary, smooth, moderate subangular blocky medium sized peds, some charcoal flecking, friable, many roots, all diameters.
LAYER II	5YR 4/4 Reddish brown clay, average thickness 5cm, clear lower boundary, smooth, medium blocky peds, common roots, fine to medium sized, loose, two sherds.
LAYER III	5YR 5/6 Yellowish red clay with some pink, white and yellow mottling (saprolite), average thickness 40cm, clear smooth boundary, weak subangular-blocky medium sized peds, some charcoal flecks, common fine roots, firm.
LAYER IV	C Horizon, Saprolite .

Table 5.12 Trench 2 stratigraphic descriptions.

Toi Meduu (B:NA-4:11) Trench 3 (TR3)	
LAYER I	7.5YR 3/3 Dark brown silty loam, organic A horizon, average thickness 6cm, clear lower boundary, smooth, moderate subangular blocky, friable, very common, rootlets.
LAYER II	7.5YR 4/4 Brown silty clay, average thickness 42cm, firm and compact, few roots, less than 1mm in size, indistinct boundary grades into Layer III.
LAYER III	7.5YR 5/6 Strong brown silty clay, average thickness indeterminate, firm and compact, few roots, many scattered sherds and charcoal flecks, saprolite and basalt cobbles.
LAYER IV	7.5YR 5/6 Strong brown silty clay with 'chunks' of saprolite, 3-3cm in diameter. This layer is only present on the eastern side of the trench, possibly a soil lense.

Table 5.13 Trench 3 stratigraphic descriptions.

Toi Meduu (B:NA-4:11) Trench 5 (TR5)	
LAYER I	10YR 3/2 Very dark greyish brown silty loam, organic A horizon, average thickness 8cm, clear lower boundary, friable, many tiny rootlets.
LAYER II	10YR 4/2 Dark greyish brown silty loam, average thickness 20cm, friable, many rootlets, flecked throughout with red, orange black and white saprolite specks.
LAYER IIa	7.5YR 3/4 Dark brown silty clay, average thickness 15cm, east and west boundary clear, most likely a lense caused by water concentration.
LAYER III	7.5YR 4/4 Brown silty clay, average thickness 40cm, firm subangular blocky, a few less than 1mm roots, sparse charcoal, a few small to medium cobbles, abundant saprolite flecks with a loamy texture.
LAYER IIIa	7.5YR 4/6 Strong brown clay, average thickness 21cm, very similar to LIII with less saprolite flecks and a darker colour, some less than 1mm roots, similar formation as Layer IIa.
LAYER IV	7.5YR 4/4 Brown silty clay, average thickness 50cm, similar to Layer III, but with more cobbles and charcoal flecks, some sherds also, less than 1mm roots, some saprolite flecks and loamy texture.
LAYER V	7.5YR 4/6 Strong brown silty clay, average thickness 25cm, firm, less saprolite flecking and a higher clay content, faintly mottled with orange/yellowish matrix indicative of B horizon formation, scattered subangular medium sized cobbles, scattered sherds, less than 1mm roots, occasional charcoal chunks.
LAYER VI	7.5YR 4/6 and 5/6 Strong brown silty clay, average thickness 20cm, heavily mottled with the orange/yellow clay indicative of B horizon formation, very sparse tiny rootlets, one large cobble.
LAYER VII	7.5YR 4/4 Brown silty clay, average thickness 20cm, firm, occasional 2-3cm saprolite clasts, scattered sherds and charcoal, occasional medium cobbles.
LAYER VIII	10YR 3/4 Dark yellowish brown with heavy black and yellow mottles, clay, dominated by saprolite mottling.
LAYER IX	7.5YR 4/4 and 5/6 Brown and strong brown mixed silty clay, very moist.
LAYER X	C Horizon, Saprolite.

Table 5.14 Trench 5 stratigraphic descriptions.

Rois Terrace Complex (B:NA-4:6)
Trench 4 (TR4)

LAYER I	7.5YR 4/4 Brown clay, average thickness 6cm, clear lower boundary, wavy, angular blocky, many roots, all sizes.
LAYER II	5YR 4/4 Reddish brown silty clay, average thickness 7cm, clear smooth boundary, weak subangular blocky, quite friable, many roots, medium to coarse, some charcoal flecking.
LAYER III	5YR 5/6 Yellowish red silty clay, average thickness10cm, clear wavy boundary, weak subangular blocky, common fine roots, firm, a few sherds.
LAYER IIIa	5YR 5/4 Reddish brown with white and pink saprolite mottled silty clay, average thickness 12cm, wavy boundary, weak subangular blocky, firm, few fine roots, a few sherds.
LAYER IV	Pink and yellow flecked saprolite dominates with a little 5YR 5/4 Reddish brown clay, average thickness 14cm, abrupt lower boundary, a few roots. The saprolite is denser at northern end of the trench and less dense at southern end.
LAYER V	5YR 4/4 Reddish brown silty clay, average thickness 40cm, clear smooth boundary, weak subangular blocky, firm, very few fine roots, many sherds, concentrated at southern end of trench.
LAYER VI	5YR 5/6 Yellowish red silty clay, average thickness 12cm, broken boundary, angular blocky, no roots or charcoal, some sherds, firm.
LAYER VII	7.4YR 5/4 Brown silty clay, average thickness 14cm, clear smooth boundary, subangular blocky, some micro roots, firm, no charcoal or pottery.
LAYER VIII	C Horizon, Saprolite.

Table 5.15 Trench 4 stratigraphic descriptions.

B:NA-4:11	LAYER	pH		LAYER	pH		LAYER	pH		LAYER	pH	B:NA-4:12	LAYER	pH
TR1	I	6	TR1e F3	I	5	TR1g	I	5	TR1i	I	6	TR2	I	5.5
	II	5		Ia	6		Ia	6		II	5		II	5.5
	III	5		IV	5		IV	5		III	5 WEAK		III	5
	IIIa	5		IVb	5		IVc	6		IV	5			
	IV	5		V	5 WEAK		V	5 WEAK		IVa	5			
	IVa	5		VI	5 WEAK		VI	6		posthole 1	5			
	IVb	5		VIa	5		Vib	5		posthole 2	5			
	V	5		VIb	5									
	Iron pan	6		VIc	6									
				X	5									
TR1a	I	6	TR1e F3A	VI	5 WEAK	TR1g-a	Ia	6	B:NA-4:6			TR3	I	5.5
	II	5.5		VIa	5 WEAK		II	5	TR4	I	5.5-6		II	5
	III	5.5		VIb	5 WEAK		VI	5		II	5.5		III	5.5
	IIIa	5		VIc	5.5-6		VIc	5		III	5.5		IV	no sample
	IV	5.5-6								IIIa	5			
	IVb	5								IV	5.5			
	V	5								V	5			
	VI	5 WEAK								VI	5.5			
	VII	5								VII	5			
	VIII	5												
TR1e	I	6	TR1F	I	5.5	TR1h	I	6.5				TR5	I	5.5
	II	5		II	5 WEAK		II	5					IIa	5.5
	IIa	5		IIc	5 WEAK		IIIa	5					IIb	5
	IIb	5		IV	5		IIIb	5 WEAK					III	5
	IIc	5 WEAK		IVb	5		IV	5 WEAK					IV	5.5
	IId	5		V	5 WEAK								V	5
	IV	5.5		Va	5 WEAK								VI	5.5
	IVb	5		VI	5 WEAK								VII	6
	V	5 WEAK											VIII	5.5
	VI	5 WEAK											IX	5.5
													X	5

Table 6.1 pH readings for all three sites.

Table 6.2 Munsell Colour descriptions

SITE	TRENCH	LAYER	MUNSELL COLOUR
B:NA-4:11	TR1	I	7.5YR 4/2 BROWN
		II	5YR 5/4 REDDISH BROWN
		III	7.5YR 4/4 BROWN
		IIIa	7.4YR 4/4 BROWN
		IV	10YR 4/2 DARK GREYISH BROWN
		IVa	7.5YR 4/6 STRONG BROWN
		IVb	10YR 5/4 YELLOWISH BROWN
		V	7.5YR 6/8 REDDISH YELLOW
	TR1a	I	7.5YR 4/4 BROWN
		II	5YR 4/4 REDDISH BROWN
		III	10YR 4/4 DARK YELLOWISH BROWN
		IIIa	7.5YR 5/8 STRONG BROWN WITH SOME GREY SPECKS
		IV	10YR 4/3 BROWN
		IVb	10YR 6/6 BROWNISH YELLOW
		V	7.5YR 5/8 STRONG BROWN
		VI	2.5YR 3/3 DARK REDDISH BROWN WITH WHITE AND PINK MOTTLES
		VII	5YR 4/4 REDDISH BROWN
		VIII	5YR 4/3 REDDISH BROWN
	TR1e	I	7.5YR 4/4 BROWN
		II	5YR 4/3 REDDISH BROWN
		IIa	2.5YR 4/3 REDDISH BROWN MOTTLED WITH YELLOW AND PINK
		IIb	5YR 4/4 REDDISH BROWN
		IIc	5YR 4/4 REDDISH BROWN WITH BLACK MOTTLES
		IV	10YR 4/4 DARK YELLOWISH BROWN
		IVb	10YR 4/6 DARK YELLOWISH BROWN
		V	10YR 5/8 YELLOWISH BROWN
		VI	2.5YR 4/3 REDDISH BROWN MOTTLED WITH YELLOW AND PINK
	TR1e F3	I	10YR 4/4 DARK YELLOWISH BROWN
		IV	10YR 4/4 DARK YELLOWISH BROWN
		IVb	10YR 4/4 AND 6/6, DARK YELLOWISH BROWN AND BROWNISH YELLOW
		V	7.5YR 5/8 STRONG BROWN
		VI	2.5YR 4/3 REDDISH BROWN WITH BLACK, WHITE, AND PINK MOTTLES
		VIa	5YR 4/4 REDDISH BROWN
		VIb	7.5YR 4/4 BROWN
		VIc	5YR 4/4 REDDISH BROWN
		VId	7.5YR 4/4 BROWN
		X	7.5YR 5/6 STRONG BROWN WITH BLACK AND YELLOW MOTTLES
	TR1e F3a	VI	10R 4/3 WEAK RED WITH GREY, YELLOW AND PINK MOTTLES
		VIa	2.5YR 3/4 DARK REDDISH BROWN
		VIb	5YR 4/4 REDDISH BROWN WITH PINK, WHITE AND YELLOW MOTTLES
		VIc	5YR 4/4 REDDISH BROWN WITH A FEW WHITE AND YELLOW MOTTLES
	TRIf	I	10YR 4/4 DARK YELLOWISH BROWN
		II	7.5YR 4/4 BROWN
		IIa	2.5YR 4/3 REDDISH BROWN
		IIb	5YR 4/4 REDDISH BROWN
		IIc	5YR 4/4 REDDISH BROWN
		IV	10YR 4/4 DARK YELLOWISH BROWN
		IVb	7.5YR 5/6 AND 4/6, STRONG BROWN
		V	7.5YR 5/6 STRONG BROWN
		Va	5YR 4/4 REDDISH BROWN
		VI	2.5YR 4/3 REDDISH BROWN WITH WHITE AND YELLOW MOTTLES

Table 6.2 Munsell Colour descriptions cont...

SITE	TRENCH	LAYER	MUNSELL COLOUR
B:NA-4:11	TR1g	I	7.5YR 3/4 DARK BROWN
		IV	7.5YR 4/6 STRONG BROWN
		IVb	7.5YR 5/6 & 4/6 STRONG BROWN
		IVc	5YR 4/4 REDDISH BROWN
		V	7.5YR 5/6 STRONG BROWN
		VI	7.5YR 4/6 STRONG BROWN
		VIb	5YR 4/4 REDDISH BROWN
	TR1g-a	I	7.5YR 3/4 DARK BROWN
		II	7.5YR 4/4 BROWN
		III	7.5YR 4/4 BROWN WITH PINK, WHITE AND YELLOW MOTTLES
		IV	5YR 4/3 REDDISH BROWN, SOME YELLOW MOTTLES
	TR1h	I	5YR 4/3 REDDISH BROWN
		II	5YR 4/4 REDDISH BROWN
		IIIa	5YR 4/4 REDDISH BROWN WITH GREY AND BLACK MOTTLES
		IIIb	7.5YR 5/4 AND 4/3, BROWN, WITH WHITE AND YELLOW MOTTLES
	TR1i	I	7.5YR 4/4 BROWN
		II	5YR 4/4 REDDISH BROWN
		III	5YR 4/4 REDDISH BROWN
		IV	5YR 4/4 REDDISH BROWN
		IVa	7.5YR 4/4 BROWN
		posthole 1	7.5YR 4/4 BROWN WITH YELLOW AND PINK MOTTLES
		posthole 2	5YR 4/4 REDDISH BROWN
	F4	II	2.5YR 4/3 REDDISH BROWN
		VI	10R 4/3 WEAK RED, HEAVILY MOTTLED WITH WHITE, BLACK, YELLOW AND PINK
		VIa	5YR 4/4 REDDISH BROWN, HEAVILY MOTTLED WITH YELLOW, PINK, BLACK AND WHITE
B:NA-4:12	TR2	I	5YR 4/3 REDDISH BROWN
		II	5YR 4/4 REDDISH BROWN
		III	5YR 5/6 YELLOWISH RED
	TR3	I	7.5YR 3/3 DARK BROWN
		II	7.5YR 4/4 BROWN
		III	7.5YR 5/6 STRONG BROWN
		IV	7.5YR 5/6 STRONG BROWN
	TR5	I	10YR 3/2 VERY DARK GREYISH BROWN
		II	10YR 4/2 DARK GREYISH BROWN
		IIa	7.5YR 3/4 DARK BROWN
		III	7.5YR 4/4 BROWN
		IIIa	7.5YR 4/6 STRONG BROWN
		IV	7.5YR 4/6 STRONG BROWN
		V	7.5YR 4/4 BROWN
		VI	7.5YR 4/6 STRONG BROWN
		VII	7.5YR 4/4 BROWN
		VIII	10YR 3/4 DARK YELLOWISH BROWN WITH HEAVY BLACK AND YELLOW MOTTLES
		IX	7.5YR 4/6 AND 5/6, STRONG BROWN
B:NA-4:6	TR4	I	7.5YR 4/4 BROWN
		II	5YR 4/4 REDDISH BROWN
		III	5YR 5/6 YELLOWISH RED
		IIIa	5YR 5/4 REDDISH BROWN WITH WHITE AND PINK FLECKS
		IV	PINK AND YELLOW FLECKED AND A LITTLE 5YR 5/4 REDDISH BROWN
		V	5YR 4/4 REDDISH BROWN
		VI	5YR 5/6 YELLOWISH RED
		VII	7.4YR 5/4 BROWN

SOIL MICROMORPHOLOGY APPLICATION

Soil micromorphology has been applied to many issues in archaeology. The most common uses of this method are:

- on-site spatial analysis – usually on settlement sites, dealing with micro-distributions of materials and use of space (e.g. micro-studies of dwellings re. trampling, microartifacts, material accumulations etc.). These may be compared to modern ethnographic/experimental findings.
- on-site site formation processes – using microscopic methods to study site formation processes, especially re. post-depositional natural and cultural influences on site materials
- on-site palaeoenvironmental reconstruction – focusing on remnants of soils especially, within feature fills/studying buried soils on site – local/immediate environment around the site, as well as site formation processes and use of space
- landscape scale – palaeoenvironmental reconstruction – focusing on soils and sediments, usually looking for buried materials, or studying pedogenetic changes to access ancient climate, geomorphological processes, indicators of biota etc.
- landscape scale – land use studies – focusing on soils and sediments from soils (e.g. colluvium) to look at ancient land uses re. clearance, agriculture etc. Often with modern ethnographic/experimental component
- feature scale – studying archaeological features regarding identification of ancient activities, processes and events; also learning to identify archaeological remains at a microscopic level when no clear macroscopic features are seen. Often has an experimental component

These types of applications are interconnected, and all can be studied at once in any given situation, as any micromorphological sample can provide some information on all of these issues. Most important is working between the macroscopic field remains and the microscopic in order to deal with identification of processes and materials, as well as integration of standard archaeological methods and interpretative scenarios with microscopic evidence and interpretative procedures.

Table 6.3 The various uses of soil micromorphology in archaeological investigations (taken from H. Lewis "Geoarchaeological and Archaeological Science Practicals 2000-2001").

EARLY WEATHERING STAGES:	INTERMEDIATE WEATHERING STAGES:	ADVANCED WEATHERING STAGES:
Gypsum	Quartz	Kaolinite
Calcite	Hydrous mica (illite)	Aluminium oxides (gibbsite)
Olivine	Vermiculite and mixed layer minerals	Iron oxides (goethite, hematite)
Pyroxene	Chlorite	Titanium oxides (anatase, rutile, ilmenite)
Hornblende (amphibole)	Montmorillonite	
Biotite (mica)		
Na-Feldspars		

Table 6.4 Stages in the weathering of minerals, in < 2mm fraction of soils (table modified after White 1987).

TR1 LV	Kaolinite Gibbsite Goethite Chlorite (minor)	**TR1 Iron Pan**	Kaolinite Gibbsite Goethite Interlayered clay
TR3 LIII	Kaolinite Gibbsite Goethite Smectite (minor) Interlayered clay (minor)	**TR4 LVII**	Kaolinite Gibbsite Goethite Smectite Interlayered clay (minor)
TR5 LVII	Kaolinite Goethite Smectite Interlayered clay Chlorite (minor) Gibbsite (minor)	**TR5 LIX**	Kaolinite Goethite Smectite Gibbsite (minor) Interlayered clay (minor)

NB. Interlayered clays most likely smectite/kaolinite

Table 6.5 XRD results (not quantified)

Iron Pan	**GLOBAL CHI^2**	2.33	
		WEIGHT %	**ERROR**
	Goethite	44.8	0.8
	Hematite	24.5	0.54
	Illite	14.1	1.16
	Gibbsite	7.2	0.58
	Kaolinite	4.1	0.54
	Lepidocrocite	1.2	0.17
		99.9	
LAYER V	**GLOBAL CHI^2**	3.36	
		WEIGHT %	**ERROR**
	Kaolinite	67	1.47
	Goethite	15.8	0.51
	Illite	8.8	1.77
	Gibbsite	6.9	0.35
	Montmorillonite	1.5	0.39
		100	
LAYER VI	**GLOBAL CHI^2**	3.16	
		WEIGHT %	**ERROR**
	Kaolinite	62.4	1.92
	Goethite	12.6	0.81
	Gibbsite	11.7	1.14
	Illite	6	1.9
	Hematite	2.9	0.37
	Montmorillonite	2.6	1.17
	Maghemite-C	1.7	0.38
		100.1	
LAYER VIII Nodules	**GLOBAL CHI^2**	2.59	
		WEIGHT %	**ERROR**
	Gibbsite	33.9	1.3
	Hematite	33.8	1.28
	Geothite	19.4	1.35
	Illite	8.6	2.49
	Kaolinite	4.3	1.22
		100	

Table 6.6 Quantified XRD results for Trench 1a

SITE	TRENCH	LAYER	DEPTH (CM)	Phytolith: CHARCOAL COUNT	Pollen: CHARCOAL COUNT
B:NA-4:11	TR1	II	8	64	36
		IV	17	22	41
		IVb	50	26	60
		V	75	20	21
	TR1a	VII	285	64	60
			300	40	N/A
			315	49	N/A
		VIII	330	92	129
			340	46	N/A
B:NA-4:12	TR2	III	25	3	58
	TR3	III	80	0	82
	TR5	VI	140	13	24
		VII	160	53	54
B:NA-4:6	TR4	III	20	1	70
		V	75	15	93

Table 7.1 Phytolith charcoal counts and comparable pollen charcoal counts.

Microfossil	**TR1/LI**	TR1/LII	TR1/LIV	TR1/LIVb	TR1/LV	TR1a/LVII	TR1a/LVIII	TR1i/LIII	TR1/LIV
Pollen identified:									
Pandanus sp.	23.8	17.0	27.5	26.2	37.4	0.0	2.1	10.4	0.0
Trilete spores	12.6	7.5	17.4	35.4	33.0	15.3	31.9	8.3	3.3
Monolete spores	3.8	35.8	3.6	1.2	18.7	81.4	48.9	43.8	94.4
Poaceae	46.4	5.7	38.1	17.7	3.3	0.0	2.1	10.4	2.2
Polypodiaceae	2.5	22.6	0.4	1.2	1.1	0.0	1.1	2.1	0.0
Asteraceae	1.3	0.0	1.6	11.6	1.1	0.0	2.1	2.1	0.0
Macaranga sp.	0.4	0.0	0.8	0.0	2.2	0.0	0.0	0.0	0.0
Casuarina	1.3	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0
Polygonum	2.1	0.0	0.0	4.3	0.0	0.0	0.0	8.3	0.0
Total pollen Sum#	239.0	53.0	247.0	164.0	91.0	59.0	94.0	48.0	90.0
Charcoal concentrations on pollen slides##	12.03	0.30	2.89	4.80	1.51	0.63	10.30	0.41	3.32
Phytoliths identified:									
Andaintaceae			X						
Arecaceae			X		X				
Areistolachaeae			X						
Compositae			X						
Cyperaceae			X						
Liliaceae			X						
Magnoliaceae									
Marantaceae		X							
Moraceae			X						
Musaceae		X							
Pandanaceae					X				
Poaceae		X	X	X					
Urticaceae			X						
Diatoms									
Starch		X							
Charcoalon phytolith slides###		**	*	*	*	**	***		
Charred Phytoliths		X	X	X	X				

includes sum of all pollen and spores counted in sample
point count method (cm2/cm3)
abundance of charcoal to phytolith counts
[grey shading] not analysed

Table 7.1a Illustrates the pollen percentages and charcoal concentrations (top), and phytolith and charcoal abundance (bottom) for Ngemeduu (B:NA-4:11)

Microfossil	TR2/LII	TR2/LIII	TR3/LIII	TR5/LVI	TR5/LVII
Pollen identified:					
Pandanus sp.	51.5	17.5	6.2	0.0	1.8
Trilete spores	11.8	52.5	13.2	10.9	8.9
Monolete spores	5.1	6.3	66.0	81.8	89.3
Poaceae	14.7	5.0	0.7	0.0	0.0
Polypodiaceae	0.0	0.0	0.0	3.6	0.0
Asteraceae	0.0	0.0	0.0	0.0	0.0
Macaranga sp.	1.5	0.0	0.0	1.8	0.0
Casuarina	0.0	0.0	0.0	0.0	0.0
Polygonum	7.4	15.0	12.5	1.8	0.0
Total pollen Sum#	136.0	80.0	144.0	55.0	56.0
Charcoal concentrations on pollen slides##	6.46	1.48	3.55	0.60	1.32
Phytoliths identified:					
Andaintaceae					
Arecaceae					
Areistolachaeae					
Compositae					
Cyperaceae					
Liliaceae					
Magnoliaceae					
Marantaceae					
Moraceae					
Musaceae					
Pandanaceae					
Poaceae					
Urticaeae					
Diatoms		X	X		
Starch				*	**
Charcoalon phytolith slides###		*			
Charred Phytoliths					

Table 7.1b Illustrates the pollen percentages and charcoal concentraitons (top), and phytolith and charcoal abundance (bottom) for Toi Meduu (B:NA-4:12).

Microfossil	TR4/LI	TR4/LII	TR4/LIII	TR4/LIIIa	TR4/LIV	TR4/LV	TR4/LVI
Pollen identified:							
Pandanus sp.	15.2	11.5	13.9	7.1	8.8	4.9	13.6
Trilete spores	35.4	38.9	47.4	38.7	40.4	12.3	16.9
Monolete spores	8.3	11.8	10.2	35.7	42.1	67.9	50.8
Poaceae	32.3	18.2	13.9	8.3	7.0	6.2	13.6
Polypodiaceae	0.2	0.3	0.0	0.0	0.0	0.0	0.8
Asteraceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macaranga sp.	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Casuarina	0.0	0.0	0.0	0.6	0.0	0.0	0.8
Polygonum	6.3	16.9	12.4	8.9	0.0	6.2	0.0
Total pollen Sum#	480.0	296.0	137.0	168.0	57.0	81.0	118.0
Charcoal concentrations on pollen slides##	13.02	6.74	3.87	4.08	1.05	4.72	1.49
Phytoliths identified:							
Andaintaceae							
Arecaceae							
Areistolachaeae							
Compositae							
Cyperaceae							
Liliaceae							
Magnoliaceae			X				
Marantaceae							
Moraceae							
Musaceae							
Pandanaceae							
Poaceae			X				
Urticaeae							
Diatoms							
Starch							
Charcoalon phytolith slides###			*			*	
Charred Phytoliths			X				

Table 7.1c Illustrates the pollen percentages and charcoal concentrations (top), and phytolith and charcoal abundance (bottom) for Rois (B:NA-4:6).

RIM SHAPES AND DEFINITIONS			
	1. Interior rim shape		2. Exterior rim shape
A	straight-sided; vertical orientation; no thickening	A	straight-sided; vertical orientation; no thickening
B	straight-sided; vertical or slightly angled orientation (usually inverted); distinctly rounded lip with coil apparent	B	straight-sided; vertical or slightly angled orientation; distinctly rounded lip with coil apparent
C	straight-sided; angled orientation (usually inverted); no thickening	C	straight-sided; angled orientation (usually inverted); no thickening
D	curved inward	D	top forms acute angle with exterior body; lip overhangs body by less than 5mm; usually inverted
E	flanged; rim oriented perpendicular to central axis of body; articulated to vessel wall with a curve; rim overhanging vessel usually not more than ~2cm	E	top forms acute angle with exterior body; lip overhangs body by more than 5mm; usually inverted
F	flanged; rim oriented perpendicular to central axis of body; articulated to vessel wall with a sharp, obtuse angle; rim substantially overhangs vessel interior	F	round lip that is concentric with inwardly curved body; overhangs body slightly; usually inverted
G	interior thickening; top forms acute angle with interior body	G	exterior thckinening; top forms acute angle with exterior body
H	flanged;articulated to vessel wall with distinct outward-curve; rim slightly overhangs vessel interior	H	curved inward
I	distinct outward curve, some interior thickening of lip, lip generally rounded-flat	I	top overhangs outcurving body by less than 5mm
		J	curved outward

Table 8.1 Set of interior and exterior rim shapes. Modified after Desilets, et al. (1999).

RIM TYPES AND DEFINITIONS				
Rim Type	Interior Rim	Exterior Rim	Definition	Vessel Forms
1	A A A A B B	A B D C A B	Generally straight-sided on both interior and exterior; generally vertical orientation; occasionally very slight thickening in form of interior or exterior coil or lip overhanging exterior body by less than 5mm.	II
2	C C C B B	C B D C D	Generally straight-sided on both interior and exterior; generally angled orientation; occasionally slight interior/exterior thickening by coil of lip overhanging exterior body less than 5 mm.	I
3	D C D D	H H C A	Pronounced curvature in vessel; no thickening of lip.	I
4	F F F F	C A D H	Flanged interior; flange articulated to vessel wall with a sharp, obtuse angle; flange is generally substantial; angled orientation; occasionally exterior of vessel has small overhanging lip.	III
5	E E E E E E	A C D F E H	Flanged interior; flange set off from vessel wall by a curve; generally shorter flange than "F"; generally angled orientation; exterior of vessel either straight or with small overhanging lip.	III
6	G G G G G C A	A B G D C G G	Interior and/or exterior acute angle thickening with opposing side occasionally thickened with small coil or lip; vertical or angled orientation.	II
7	D D D D B G	D F G B H H	Pronounced curvature in vessel; exterior and/or interior thickened by coil, lip, or acute angle thickening.	I
8	I I I H	B I J I	Pronounced back-curvature in vessel; occasional thickening of both interior and exterior lip by small coil thickening and flange; lips normally flat-rounded or rounded.	IV

Table 8.2 Eight rim types based on rim shape groupings, with the Vessel Forms illustrated in the right-hand column. Modified after Desilets, et al. (1999).

Ngemeduu B:NA-4:11	Layer	Non-DIAG	DIAG	TOTAL sherds (per site)	DIAG % (per site)	DIAG Rim	DIAG Body	DIAG with surface treatment	% DIAG with surface treatment	PLAIN body	TOTAL body
Test Unit 1	surface		3		2.0	3		1	0.6		
	Ia	18	3		2.0		3	3	1.7	18	21
	II		2		1.3	2					
	VI	12	5		3.4	5				12	12
	VIa	3	1		0.7	1				3	3
TR1	IVb	1								1	1
	V		1		0.7	1					
TR1a	NK	4								4	4
	IVb	1								1	1
	VI	25	28		18.8	13	15	23	13.3	25	40
	VII	14	10		6.7	5	5	8	4.6	14	19
	VIII	31	72		48.3	32	40	67	38.7	31	71
F2	VI	1	2		1.3		2	2	1.2	1	3
TR1c	VI	4	4		2.7	2	2	2	1.2	4	6
TR1d	VI	2	3		2.0	2	1	2	1.2	2	3
TR1e F3	V	1								1	1
	VI	1								1	1
F3a	VI		1		0.7		1	1	0.6		1
	VIa	4	1		0.7		1	1	0.6	4	5
	VIb		5		3.4	3	2	4	2.3		2
TR1f	VI	6	4		2.7	3	1	1	0.6	6	7
TR1g	I		1		0.7	1					
	V		1		0.7	1					
	VI	1								1	1
TR1h	II		1		0.7	1		1	0.6		
TR1i	IV	4								4	4
TR1i F1	IV	1	1		0.7		1	1	0.6	1	2
GRAND TOTAL:		**134**	**149**	**283**	**100.0**	**75**	**74**	**117**	**67.6**	**134**	**208**
Rois B:NA-4:6											
TR4	III	15								15	15
	V	11	7		58.3	6	1	1	0.6	11	12
	VI	49	5		41.7	5				49	49
GRAND TOTAL:		**75**	**12**	**87**	**100.0**	**11**	**1**	**1**	**0.6**	**75**	**76**
Toi Meduu B:NA-4:12											
TR2	III	2	1		8.3		1	1	0.6	2	3
TR3	III	31	7		58.3	1	6	6	3.5	31	37
TR5	IV	2	1		8.3	1				2	2
	V	7	1		8.3	1				7	7
	VII	13	2		16.7	2				13	13
GRAND TOTAL:		**55**	**12**	**67**	**100.0**	**5**	**7**	**7**	**4.0**	**55**	**62**
TOTAL of assemblage		**264**	**173**	**437**		**91**	**82**	**125**		**264**	**346**
% TOTAL of assemblage		**60.4**	**39.6**			**52.6**	**47.4**		**72.0**	**60.4**	**79.2**

Table 8.3 Non-diagnostic and diagnostic sherd counts and percentages for the ridgeline assemblage.

Ngemeduu B:NA-4:11	Layer	DIAG Rim	Weight (gm)	DIAG Body	Weight (gm)	TOTAL DIAG sherds	TOTAL WGT (gm) DIAG sherds (assemblage)
Test Unit 1	surface	3	257				
	Ia			3	74.4		
	II	2	14.31				
	VI	5	25.9				
	VIa	1	10.1				
TR1	V	1	122.6				
TR1a	VI	13	595.1	15	541.1		
	VII	5	691.9	5	129.2		
	VIII	32	1845.9	40	720.8		
F2	VI			2	46.7		
TR1c	VI	2	13.9	2	71.3		
TR1d	VI	2	25.1	1	15		
TR1e F3a	VI			1	107.6		
	VIa			1	16.6		
	VIb	3	442.7	2	50.5		
TR1f	VI	3	177.5	1	56.7		
TR1g	I	1	15				
	V	1	1.9				
TR1h	II	1	115.5				
TR1i F1	IV			1	18.9		
TOTAL:		75	4354.41	74	1848.8		6203.21
Rois B:NA 4:6							
TR4	V	6	140.6	1	2.3		
	VI	5	69.8				
TOTAL:		11	210.4	1	2.3		212.7
Toi Meduu B:NA-4:12							
TR2	III			1	45.9		
TR3	III	1	68	6	93.2		
TR5	IV	1	53				
	V	1	32				
	VII	2	4				
TOTAL:		5	156.5	7	139.1		295.6
Assemblage TOTAL		**91**	**4721.3**	**82**	**1990.2**	**173**	**6711.5 gm**

Table 8.4 Diagnostic rim and body sherds and their associated weights.

	Ngemeduu B:NA-4:11									Toi Meduu B:NA-4:12				Rois B:NA-4:6		
	Test Unit 1	TR1a	TR1a, F2	TR1c	TR1d	TR1f	TRle,F3a	TOTAL:	% diag body	TR2	TR3	TOTAL:	% diag body	TR4	TOTAL:	% diag body
DIAG Body: thickness	2	44	2	2	1	1	3	**55**		1	6	**7**		1	**1**	
1-5 mm		3						3	**5.5**		3	3	42.9	1	1	**100**
6-10 mm		17	2	2	1		1	23	**41.8**		3	3	42.9			
11-15 mm	2	22					2	26	**47.3**	1		1	**14.3**			
16-20 mm		2				1		3	**5.5**							
% diag body (per site)	**3.6**	**80.0**	**3.6**	**3.6**	**1.8**	**1.8**	**5.5**			**14.3**	**85.7**			**100.0**		

Table 8.5a Thickness measurements for the diagnostic body sherds.

DATED DIAG Body: TR1a LVIII	1530 cal. BP	1970 cal. BP	total:	**% per thickness**
1-5 mm				
6-10 mm	1	9	10	**37.0**
11-15 mm	4	12	16	**59.3**
16-20 mm	1		1	**3.7**
total:	6	**21**	27*	

Table 8.5b Association of diagnostic body sherds in TR1a LVIII to radiocarbon dates.

NGEMEDUU RIMS: thickness	lip thickness	%	below rim	%	C(mm) body	%
1-5 mm	0	**0**	1	**5**	1	**5.0**
6-10 mm	3	**15**	4	**20**	11	**55.0**
11-15 mm	8	**40**	13	**65**	7	**35.0**
16-20 mm	9	**45**	2	**10**	1	**5.0**
total:	20		20		20	

Table 8.5c Thickness measurements from rim sherds, including lip (A), below rim (B), and body (C) measurements.

	rim type	1	2	3	4	5	6	7	8			
	rim orientation	DIRECT	DIRECT	INCURVING, INVERTED		DIRECT	DIRECT	INCURVING	OUTCURVING	Total:	% lip per site	% lip assemblage
B:NA-4:11 Ngemeduu	lip profile:											
	flat, sharp		1							1	1.4	1.1
	flat, rounded	11	4	9			4	6	3	37	50.7	42.5
	rounded	6	10	5				1		22	30.1	25.3
	pointed	2		7		2		2		13	17.8	14.9
	Total:	19	15	21		2	4	9	3	73		
B:NA-4:6 Rois	flat, rounded	2				1			1	4	44.4	4.6
	rounded	1							1	2	22.2	2.3
	pointed					3				3	33.3	3.4
	Total:	3				4			2	9		
B:NA-4:12 Toi Meduu	flat, rounded	1					3			4	80	4.6
	rounded								1	1	20	1.1
	Total:	1					3		1	5		

Table 8.6 Counts of rim types, orientation and lip profiles.

B:NA-4:11 Nqemeduu rim shapes	interior rim	rim types / exterior rim	1	2	3	5	6	7	8	**Total:**
ALL UNITS	A	A	8							8
		B	3							3
	B	A	6							6
		B	2							2
		C		9						9
		H						5		5
	C	B		1						1
		C		5						5
		H			8					8
	D	B						2		2
		H			13					13
	E	A				1				1
		H				1				1
	G	A					2			2
		B					1			1
		G					1			1
		H						2		2
	I	I							2	2
		J							1	1
	Total:		19	15	21	2	4	9	3	**73**
B:NA-4:12 Toi Meduu			1	2	3	5	6	7	8	**Total:**
TR3	G	G					1			1
TR5	A	B	1							1
	C	G					1			1
	G	G					1			1
	I	B							1	1
	Total:		1				3		1	**5**
B:NA-4:6 Rois			1	2	3	5	6	7	8	**Total:**
TR4	A	A	3							3
	E	C				2				2
		D				2				2
		E								
	H	I							2	2
	Total:		3			4			2	**9**

Table 8.7 Combinations of interior and exterior rim shapes in specific rim type categories.

B:NA-4:11 Ngemeduu	vessel form	I			II		III	IV	Total:
	rim type	2	3	7	1	6	5	8	
Test Unit 1	surface			2		1			3
	II		1						1
	VI		1		4				5
	VIa				1				1
TR1	V	1							1
TR1a	VI	7	2		1		1	2	13
	VII		5						5
	VIII	6	10	6	9		1		32
TR1c	VI		1		1				2
TR1d	VI				1			1	2
TR1f	VI				1	1			2
TR1g	I				1				1
	V		1						1
TR1h	II	1							1
TRle,F3a	VIb			1		2			3
	Total:	15	21	9	19	4	2	3	
	Total per vessel form	45			23		2	3	**73**
	% vessel form per site	**61.6**			**31.5**		**2.7**	**4.1**	
B:NA-4:12 Toi Meduu	vessel form	I			II		III	IV	**Total:**
	rim type	2	3	7	1	6	5	8	
TR3	III					1			1
TR5	IV					1			1
	V					1			1
	VII				1			1	2
	Total:				1	3		1	
	Total per vessel form				4			1	**5**
	% vessel form per site				**80.0**			**20.0**	
B:NA-4:6 Rois	vessel form	I			II		III	IV	**Total:**
	rim type	2	3	7	1	6	5	8	
TR4	V						3	1	4
	VI				3		1	1	5
	Total:				3		4	2	
	Total per vessel form				3		4	2	**9**
	% vessel form per site				**33.3**		**44.5**	**22.2**	
	total % vessel form assemblage	**51.7**			**34.5**		**7.0**	**6.8**	

Table 8.8 Frequency of Vessel Form and their related rim types for the assemblage.

B:NA-4:11 Ngemeduu	orifice diameter (cm)	Vessel form: I	II	III	IV	total:
	24		1			1
	26	2				2
	28	1	1			2
	30		2			2
	32					0
	34	2		1		3
	36					0
	38	1				1
	40	2	1		1	4
	42	2				2
	44	2				2
	46	2	1			3
	48	2				2
	oval	1				1
	total:	17	6	1	1	**25**

Table 8.9 Vessel Form and orifice diameter measurements for rims from Ngemeduu.

B:NA-4:11 Ngemeduu						
A (mm)	B (mm)	Vessel form	Layer VIb	VI	VIII	Total:
12	11	I			1	1
13	12	I		1		1
15	14	I			2	2
16	14	I			1	1
17	13	I			1	1
20	15	I			1	1
28	19	I		1		1
12	9	I		1		1
16	11	I,II		1	2	3
14	11	II	1			1
15	8	II			1	1
18	15	II			1	1
18	14	II	1			1
14	10	II			1	1
7	9	III		1		1
8	12	III			1	1
6	5	IV		1		1
		Total:	2	6	12	**20**

Table 8.10 Lip and rim thickness measurements for Ngemeduu rim sherds.

Ngemeduu B:NA-4:11																Toi Meduu B:NA-4:12					Rois B:NA-4:6		
Surface Treatment: Technique	Test Unit 1	TR1	TR1a	TR1a, F2	TR1c	TR1d	TR1e, F3	TR1f	TR1g	TR1h	TR1i	TR1i, F1	TRle,F 3a	Grand Total	% ST assem. (per site)	TR2	TR3	TR5	Grand Total	% ST total assem.	TR4	Grand Total	% ST total assem.
wiping			2									1	1	4	3.4								
exterior ribbing	1													1	0.9								
painted -block			13											13	11.1								
painted block?			1											1	0.9								
painted - pattern			7											7	6.0								
slip	1		24	2	2			1		1			3	34	29.1	1	6		7	100	1	1	100
slip/wiping	2		21										1	24	20.5								
slip/exterior ribbing						1							1	2	1.7								
slip/piercing			1											1	0.9								
painted block/slip			4											4	3.4								
painted block/ slip/piercing			1											1	0.9								
painted block/ pattern/slip			1											1	0.9								
painted block/ pattern			4											4	3.4								
painted block/ pattern?			1											1	0.9								
painted block/ pattern/ piercing			1											1	0.9								
painted pattern/ block?			1											1	0.9								
painted pattern/slip			15			1								16	13.7								
painted pattern / slip/piercing			1											1	0.9								
TOTAL:	4	0	98	2	2	2	0	1	0	1	0	1	6	117		1	6	0	7		1	1	
insufficient surface	16	2	41		3	1		9	3		4	1	5	85	29.8		19	26	45	67.2	56	56	64.4
no surface treatment	27		46	1	3	2	2							81	28.6	2	13		15	22.4	30	30	34.5
GRAND TOTAL:	47	2	185	3	8	5	2	10	3	1	4	2	11	283		3	38	26	67		87	87	

Table 8.11 Counts of various surface treatment techniques and combinations recorded in the ridgeline assemblage.

Ngemeduu B:NA-4:11 TR1a							
Occurence of technique:						Total	
wiping						23	
painted - block						25	
painted - pattern						34	
slip						68	
piercing						4	
Actual occurence of technique: in combinations	Layer IVb	Layer VI	Layer VII	Layer VIII	Layer NK	**Total**	**% ST**
wiping		2				2	**2.0**
painted - block		1		12		13	**13.3**
painted block?				1		1	**1.0**
painted - pattern		1		6		7	**7.1**
slip		13	4	7		24	**24.5**
slip/wiping		1	2	18		21	**21.4**
slip/piercing		1				1	**1.0**
painted block/slip		2	1	1		4	**4.1**
painted block/slip/piercing				1		1	**1.0**
painted block/pattern/slip				1		1	**1.0**
painted block/pattern/piercing				1		1	**1.0**
painted block/pattern				4		4	**4.1**
painted block/pattern?				1		1	**1.0**
painted pattern/block?				1		1	**1.0**
painted pattern/slip		1	1	13		15	**15.3**
painted pattern/slip/piercing		1				1	**1.0**
TOTAL:	0	23	8	67	0	**98**	**100.0**
% ST	**0**	**23.5**	**8.2**	**68.4**	**0**		
insufficient surface		11	8	19	3	41	**41.8**
no surface treatment	1	19	8	17	1	46	**49.0**
GRAND TOTAL	**1**	**53**	**24**	**103**	**4**	**185**	

Table 8.12 Occurence of surface treatment techniques and combinations of sherds from TR1a, Ngemeduu.

TR1a Location of Surface Treatment	outside rim	inside rim	outside rim/inside rim	inside rim/outside rim?	inside body	outside body	body - side indistinguishable	inside body/outside body	inside body/outside body?	inside body ?	lip/outside rim	lip/outside rim/inside rim	lip/inside rim	lip/inside rim/outside rim/outside body	**TOTAL:**
TR1a Surface Treatment: technique															
wiping					2										2
painted - block		1			2			4 (30.7)		2		3 (23)	1		13
painted block?									1						1
painted - pattern		1			3 (42.8)*			2 (28.6)				1			7
slip	1	1			13 (54.1)	4 (16.7)	2					3			24
slip/wiping		4			7 (33.3)			4				6 (28.6)			21
slip/piercing			1												1
painted block/slip		1	1					1					1		4
painted block/slip/piercing												1			1
painted block/pattern/slip												1			1
painted block/pattern/piercing												1			1
painted block/pattern			1					2				1			4
painted block/pattern?				1											1
painted pattern/block?								1							1
painted pattern/slip		1			5 (33.3)	2	1	2			1	3			15
painted pattern/slip/piercing														1	1
TOTAL:	1	9	3	1	32	6	3	16	1	2	1	20	2	1	98
% ST Location:	1.0	9.2	3.1	1.0	32.7	6.1	3.1	16.3	1.0	2.0	1.0	20.4	2.0	1.0	

* number in brackets indicates percentage

Table 8.13 Cross tabulation of surface treatment techniques and surface treatment locations for Tr1a, Ngemeduu.

B:NA-4:11 Ngemeduu TR1a	COLOURS													
Surface Treatment: Technique	red	dark red	yellow-white	orange-red	orange	brown	pink	yellow-orange	yellow-grey	grey	white	smudging*	TOTAL:	% ST:
painted - block	14	11											25	**19.7**
painted - pattern	21	12		1									34	**26.8**
slip	10	2	13	8	3	5	4	9	8	5	1	5	73	**53.5**
TOTAL:	45	25	13	9	3	5	4	9	8	5	1	5	127 (132)*	
% ST:	**35.4**	**19.7**	**10.2**	**7.1**	**2.4**	**3.9**	**3.1**	**7.1**	**6.3**	**3.9**	**0.8**	**-**		
Application time														% ST:
pre-firing	14	4	10		1	3	3	8	8	5	1	-	57	**44.9**
post-firing	22	14				1						-	37	**29.1**
pre-post firing	9	7	3	9	2	1	1	1				-	33	**26.0**
TOTAL:	45	25	13	9	3	5	4	9	8	5	1	-	127	

* smudging is created during firing so is not a 'colour. As such it is not inlcluded in the total except in brackets, and is not relevant for the 'application time' section.

Table 8.14 Frequency and percentage distribution of colours recorded for the sherds from TR1a, Ngemeduu.

ST technique	Vessel form I	II	III	Total:
Date range:	1400-1970 cal. BP	1400-1970 cal. BP	1400 cal. BP	
painted - block	3	1	1	5
painted - pattern		1		1
slip	1			1
slip/wiping	6	2		8
painted block/pattern	2			2
painted pattern/block?	1			1
painted block/pattern/piercing	1			1
painted block/pattern/slip		1		1
painted block/slip	1			1
painted block/slip/piercing		1		1
painted pattern/slip	3	2		5
Total:	18	8	1	**27**
% ST per vessel	**66.7**	**29.6**	**3.7**	
Fabric:				% fabric
grog	12	4		**59.3**
grog and volcanics	5	4	1	**37.0**
none visible	1			**3.7**
Total:	18	8	1	
Total painted (not inlcuding exclusive slips):	11	6	1	
% of painted rims	**61.1**	**33.3**	**5.6**	

Table 8.15a Vessel Forms, surface treatment techniques,and fabric groups recorded for rim sherds in LVIII, along with the associated radiocarbon determinations.

Rim types and vessel forms of 18 painted rims:

vessel form:	rim type: 1	2	3	5	7	**Total:**
I		4	5		2	11
II	6					6
III				1		1
Total:	6	4	5	1	2	18

Table 8.15b Distribution of rim types and Vessel Forms for the 18 painted rim sherds in TR1a, LVIII.

Table 227-1. Classification of grog tempers in 16 Palau painted (p) and associated unpainted (u) pottery sherds (Types A-C after Fitzpatrick et al., 2003)

Type A	Type B	Type C
PPP-10 (p)	PPP-34 (p)	PPP-22 (p)
PPP-11 (p)	PPP-48 (p)	PPP-106 (u)
PPP-18 (p)	PPP-50 (p)	
PPP-26 (p)	PPP-108 (u)	
PPP-28 (p)	PPP-112 (u)	
PPP-32 (p)		
PPP-41 (p)		
PPP-113 (u)		
PPP_117 (u)		

Table 8.16 Fabric groupings of painted and plain sherds from TR1a, LVIII, based on petrographic analysis (table by W. R. Dickinson, see Appendix D).

Table 227-2. Net frequency percentages of terrigenous grain types in Palauan sherds containing composite tempers (mixed grog particles and terrigenous grains); data for sherds studied previously from Fitzpatrick et al., 2003 (with std dev added from raw data)

grain type	Type C-D Published[1] [20 sherds; 345 grains]	Type B-C this report[1] [7 sherds; 152 grains]
quartz grains	11 ± 2	9 ± 2
plagioclase feldspar grains	26 ± 2	22 ± 3
clinopyroxene grains	3 ± 1	6 ± 2
felsitic volcanic rock fragments	22 ± 2	21 ± 3
microlitic volcanic rock fragments	5 ± 1	5 ± 2
hypabyssal igneous rock fragments	3 ± 1	3 ± 1
opaque iron oxide grains	30 ± 2	33 ± 4
weathered biotite flakes	?	1

[1] Percentages plus or minus standard deviations of counting errors, calculated from the expression $[p(100-p)/n]^{1/2}$, where p is the reported percentage of a given grain type and n is the total number of grains in the counted population (345 or 152)

Table 8.17 Net frequency percentages of terrigenous grain types in Palauan sherds that contain composite tempers.

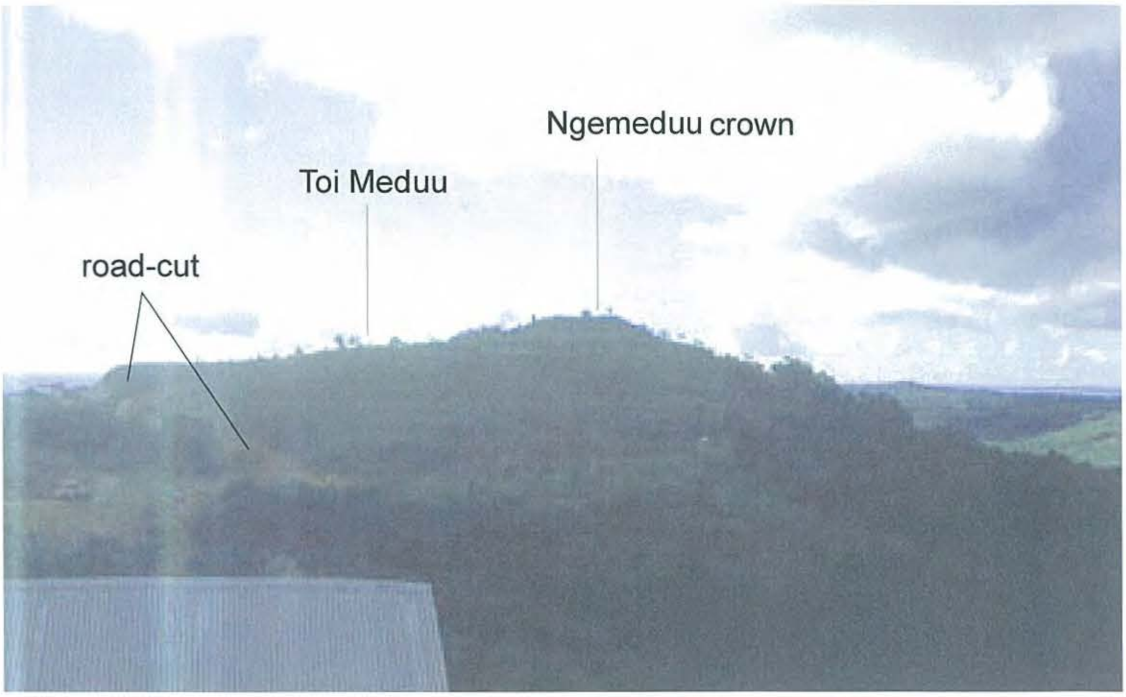
Sherd number:	Hematite Fe2O3	Quartz SiO2	Goethite Fe+O(OH)	Ilmenite Fe+2TiO3	Calcite CaCO3
10 red	X	X			
11 red	X	X	X		
18 red	X	X			
26 red	X	X			
28 red	X	X		X	
32 red	X	X			
40 red	X	X			
40 orange	X	X			
41red	X	X			X
48 red	X				
48 orange	X	X			
50 red	X	X			
51 red	X	X			
51 orange	X	X			

Table 8.18 Mineralogical identifications of red pigments using GADDS analysis. Note the highlighted section illustrating pigment of pure hematite.

Plate 5.1 B:NA-4:11 Ngemeduu Crown and Terrace Complex. Photo taken from the north-east.

Plate 5.2 Excavations for the Compact Road, a. cutting through the north-west extent of Ngemeduu, and b. cutting through the western ridge of Ngemeduu, and Toi Meduu, as seen from Roisingang.

a.



b.

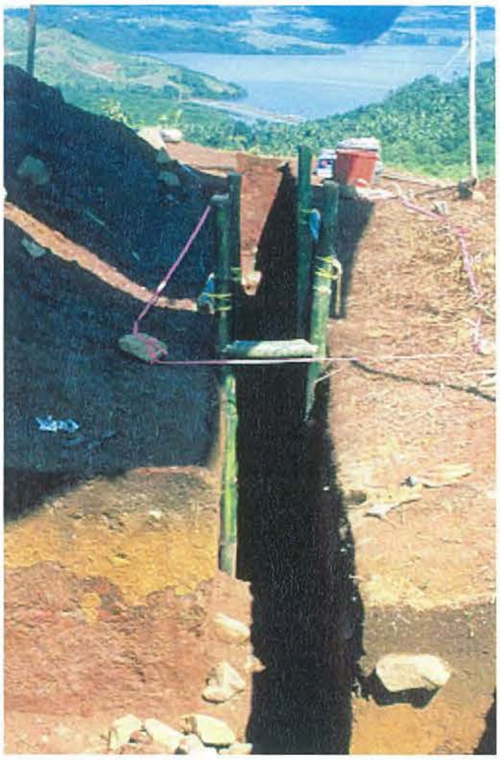


Plate 5.3 Bamboo brace built to support TR1a, with the north east coast in the background.

Plate 5.4 The photo illustrates the stratigraphy of TR1a and TR1 (at the rear). Figures (left to right): John Chappell, Sarah Phear and Jolie Liston.

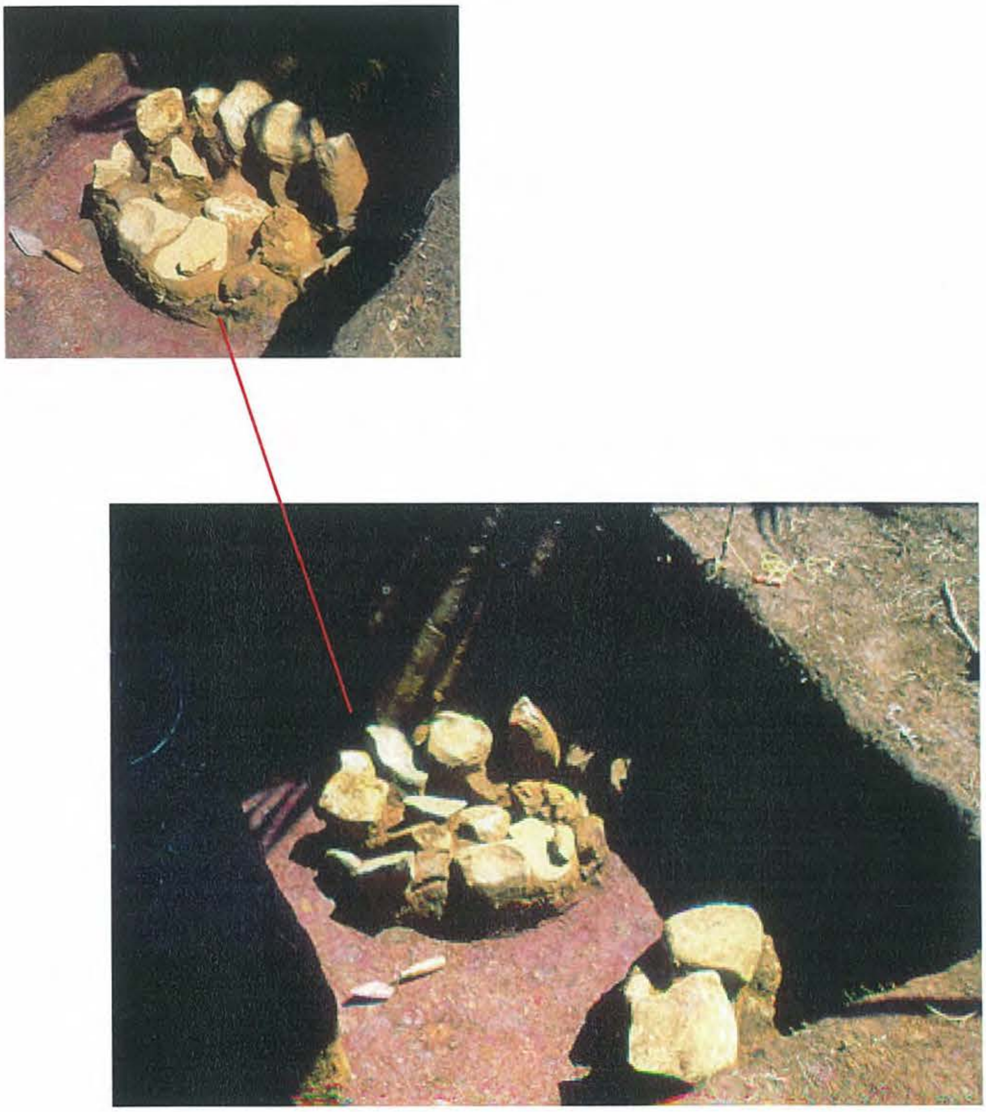


Plate 5.5 Feature 3 (expanded above) and Feature 3a, TR1e. Layer V has been removed here, exposing Layer VI.

Plate 5.6 Piece of coral removed from Feature 3, TR1e.

Plate 5.7 Basalt cobbles beneath Feature 3a (removed). The black plastic marks the base of the excavation.

Plate 5.8 Trench 1g-a. Background: Jenny in TR1g, TR1f, and TT1e.

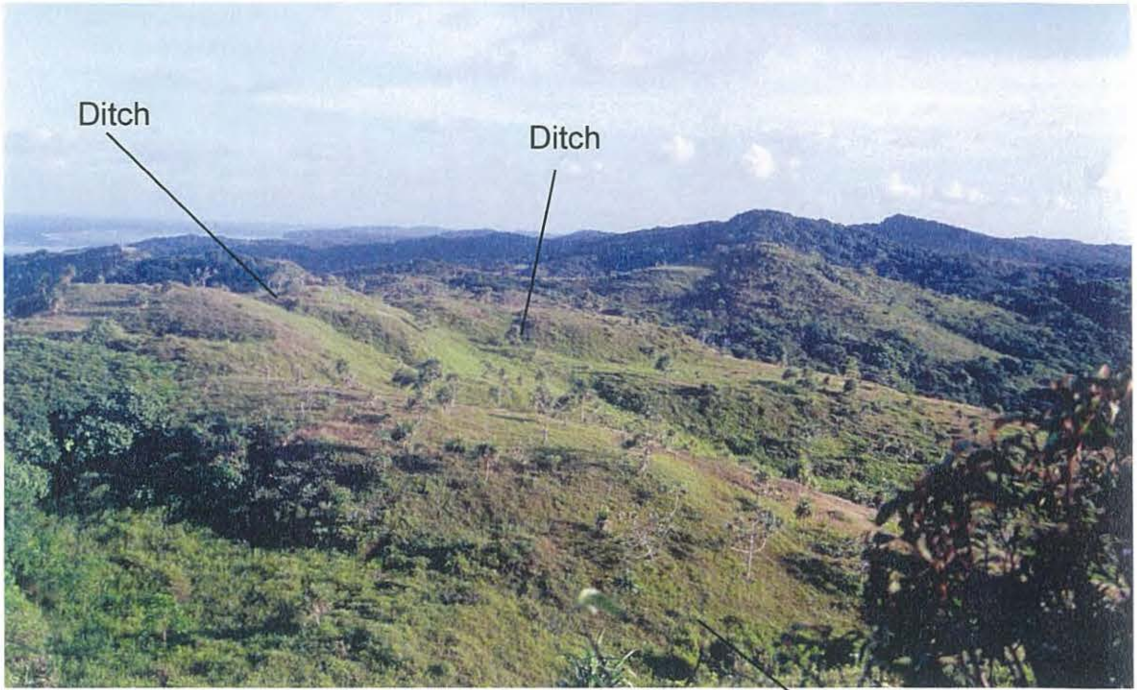
Plate 5.9 Rocky within Trench 1h.

Plate 5.10 Current slumping on the Southeast surface of Ngemeduu. Note the Compact Road cut through Toi Meduu in the background.

Plate 5.11 Slumped wall excavated for the Compact Road Project.
Located 500m Northwest of Ngemeduu.

Plate 5.12 Surface of Test Unit One, next to a screw pine (*Pandanus tectorius*) tree.

Plate 5.13 Toi Meduu, a. with the three ditches indicated, south-west facing, and b. north-west facing with a Compact Road cut through Ngemeduu in the foreground.



A.

Ditch called Toi Meduu

B.

Plate 5.14 Possible basalt platform on the Northwest terrace, adjoined to the West crown of Toi Meduu. Rocky is standing next to TR2.

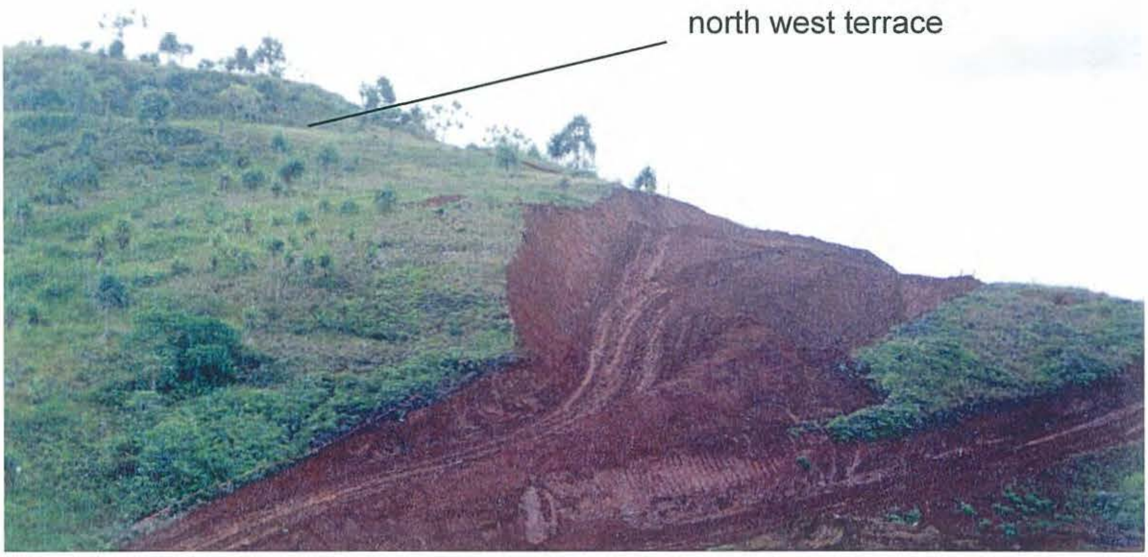


Plate 5.15 Excavations for the Compact Road cutting through the west extent of Toi Meduu.

Plate 5.16 West crown of Toi Meduu. Stonework in the south west corner of the crown.

Plate 5.17 Ditch between crowns where TR5 was placed. Note its current shallow appearance and dense vegetation.

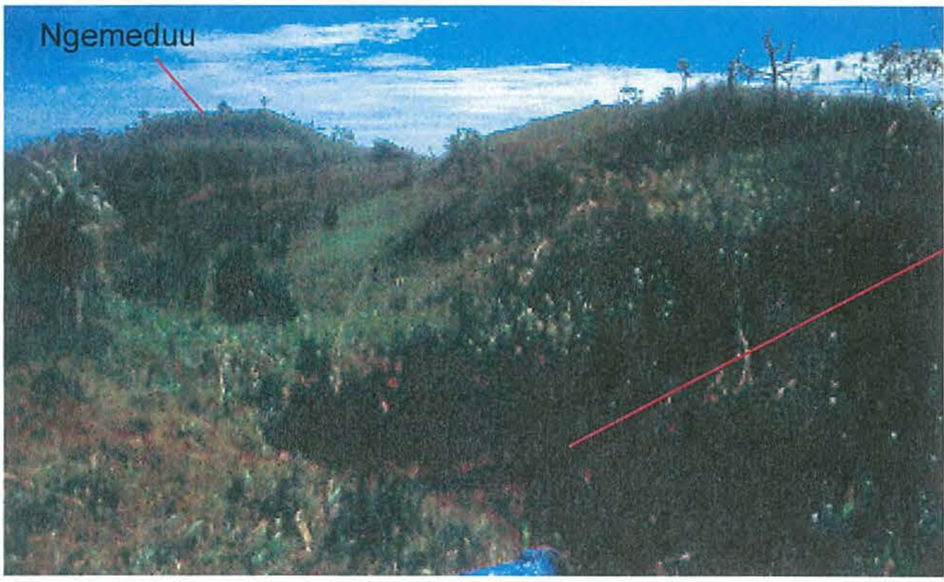


Plate 5.18 Trench 5 with Ngemduu in the background.

Plate 5.19 Lower terraces in the Rois Terrace complex. The lowest terrace is currently cultivated with tapioca.

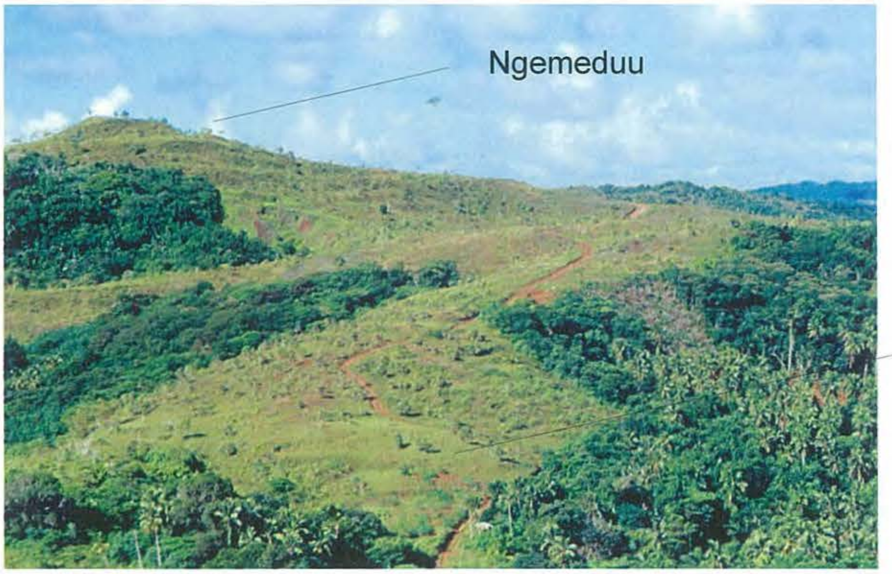


Plate 5.20 Vegetation conditions on the ridgeline, Ngemeduu, and Rois Terrace Complex. This photo was taken prior to the excavation of the Compact Road.

Plate 6.1 Photo of Ngemeduu crown after it had been cleared of vegetation, indicating the 'lip' of the southern edge of the west depression. Note also the angle of the slope extending into the depression.

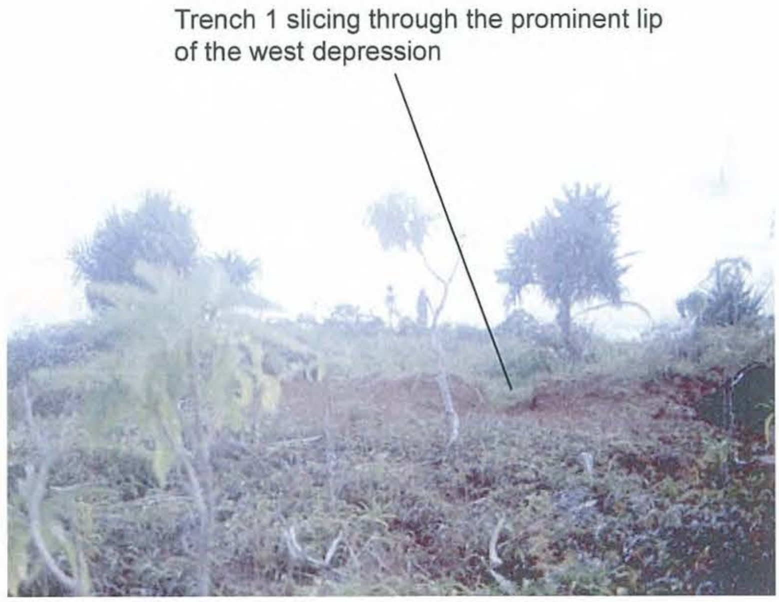


Plate 6.2 Photo of Ngemeduu crown when still covered in vegetation, indicating the 'lip' of the west edge of the depression.

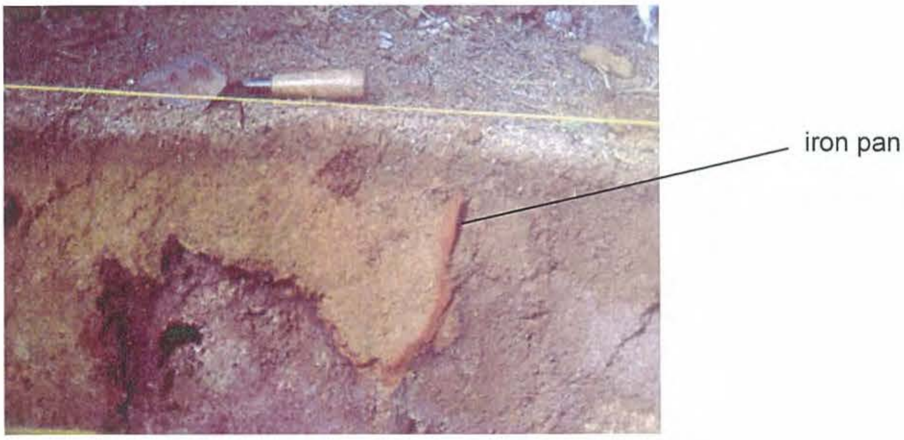


Plate 6.3 This image illustrates the uneven distribution of hematite (orange) in the iron pan between Layer V and Layer VI.

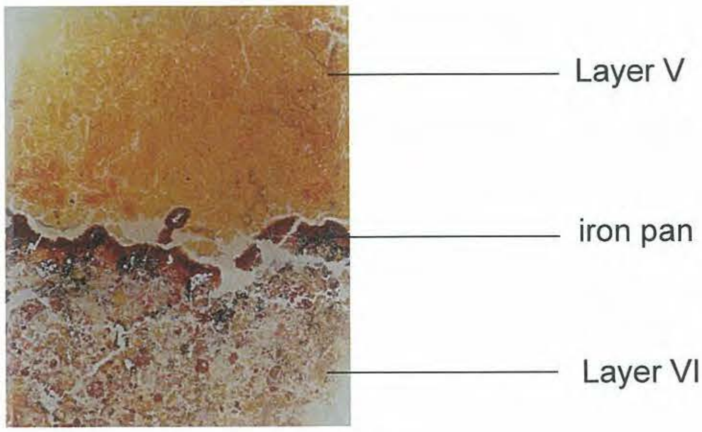


Plate 6.4 Scanned image of the thin section analysed by Hart (2004), showing the location of the two soil layers and the iron pan.

Plate 6.5 Photo of the backsloping terrace on the southern extent of Toi Meduu.

Plate 6.6 Photo of Trench 3 illustrating the level of curvature at the rear of the terrace, caused by the settling of eroded sediments.

Plate 7.1 Dense fern growth on either side of the ditch in an earthwork site in Ngatpang State.

Plate 8.1b Close-up of rim showing the relatively smooth, firm sherd underneath the flaking original surface.

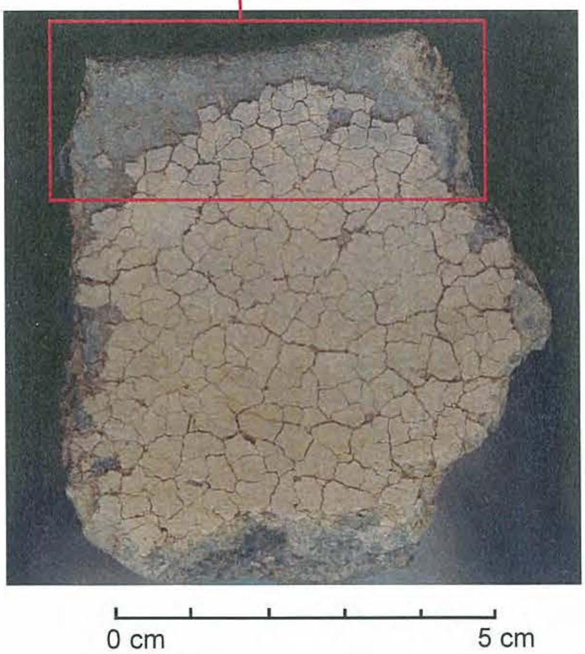


Plate 8.1a Rim sherd illustrating the cracked and flaking orignal surface.

0 cm 1 cm

Plate 8.2 Charred fibre in the fabric of a sherd.

36

#37

47

47

51

51

Plate 8.3 Selection of painted body sherds from TR1a, Ngemeduu.

APPENDIX A

Micromorphology Analysis and Report of Thin Section Monolith 12 from Palau in Micronesia

March 2004

By
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Micromorphology Analysis and Report of Thin Section Monolith 12 from Palau in Micronesia, March 2004

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Introduction

The thin section analysed is taken across two distinct clay layers separated by an iron pan. The sample was collected from one of the two deliberately cut rectangular depressions from the crown of a purposefully constructed terrace complex. The thin section is described in two parts distinguishing between the clay layers and follows the labels provided from field observations: Layer V (LV; yellow-brown clay) and Layer VI (LVI; purple-red clay). The description follows Stoops (2003) and Bullock *et al* (1985). This report will first give a brief summary of the thin section description, followed by a more detailed format of the description and will conclude with a brief interpretation of the sample under analysis.

Summary of Description

The upper layer, LV, is an iron-rich clay horizon with distinctive angular peds and accommodating planar voids with 25% porosity. This horizon contains many fresh roots as evidenced by the presence of both lignified and parenchymatic tissues. The groundmass is strongly masked by iron oxide and consequently it is difficult to identify more delicate features such as phytoliths and pollen. Strongly impregnated iron nodules with diffuse boundaries are dominant throughout this horizon as are clay nodules. Clay coatings are present on grains and aggregates but do not line pore walls.

The lower layer, LVI, has a definite crumby structure with many vughy and partially accommodating channel voids with 40% porosity. This horizon has an extremely high quantity of charcoal throughout the horizon, more so than LV. The groundmass is also masked by iron oxide but it is clear that this layer is heavily organic. LV is far more compact in structure than LVI and LVI has a higher frequency of calcium carbonate crystals replacing organic material. LVI also has very little fresh organic material in relation to LV. Clay nodules with sharp boundaries are frequent and clay coatings on grains and aggregates are dominant as are clay coatings lining pore walls.

Palau 12

This thin section is described as two separate layers, **Layer V** (LV) and **Layer VI** (LVI). It is a vertical thin section of 7.5cm x 5cm in size and a thickness of 25-30μm.

Abbreviations: ms: medium sand size; fs: fine sand size; vfs: very fine sand size; ss: silt size; c/f: coarse/fine; OIL: oblique incident light; PPL: plane polarized light; XPL: cross polarized light

Layer V

Microsructure

Separated and well developed subangular to angular blocky microstructure with accommodating peds ranging in size from 0.5cm to 1.5cm. Well developed and moderately separated angular blocky intrapedal structure with accommodating peds (0.3mm-2mm).

Porosity

~ 20% of LV

Very dominant accommodating planar voids, frequent partially accommodating channel voids and common chamber and mamillated vughs

Groundmass

$c/f_{20\mu m}$ ratio:1:2

c/f related distribution: double spaced porphyric

sand/silt/clay: 1:2:2

Mineral Component

Coarse Material:

~ 20% of LV

Nature: frequent smooth subrounded rock fragments (300μm-80μm); frequent smooth subrounded to subangular monocrystalline quartz grains (200μm-20μm)

Size Frequency: ms: 5%; fs: 5%; vfs: 10%; ss: 30%; clay: 50%

Sorting: poorly sorted

Fine Material:

~ 50% of LV

Nature: iron rich clay with fine amorphous organic punctuations

Clay to silt ratio: 5:3

Colour: red-orange (OIL and XPL); brown (PPL)

Limpidity: cloudy, dotted iron rich clay

b-fabric: undifferentiated – masked by iron but where visible some grano-striation is present

Organic Material

~ 10% of LV

- Frequent to dominant fresh organic material including parenchymatic (700μm-150μm) and lignified tissues (6mm)
- Frequent charcoal (800μm-100μm)
- Common amorphous organic punctuations
- Common amorphous organic residue, usually highly deteriorated
- Very few plectenchyma (sclerotia) 50μm

Pedofeatures

- Dominant calcium carbonate coatings (20μm) lining pore walls and infillings
- Dominant replacement of plant cells by calcium carbonate
- Dominant dusty unlaminated clay coatings of minerals and aggregates
- Dominant typic mamillated strongly impregnated iron nodules with diffuse boundaries (50μm-500μm)
- Frequent pure dusty clay nodules with sharp boundaries
- Frequent dusty clay unlaminated infillings of pores (100μm)

Layer VI

Microsructure

Weakly to moderately separated and moderately developed subangular blocky microstructure with partially to well accommodating peds ranging in size from 1cm to 3cm. Crumby intrapedal structure with complex packing voids.

Porosity

~ 40% of LVI

Dominant mamillated vughs and frequent partially to well accommodating channel and planar voids

Groundmass

c/$f_{20\mu m}$ ratio:1:3

c/f related distribution: enaulic

sand/silt/clay: 1:3:5

Mineral Component

Coarse Material:

~ 10% of LVI

Nature: few smooth subrounded rock fragments (250μm-50μm); few smooth subrounded to subangular monocrystalline quartz grains (50μm-20μm)

Size Frequency: ms: 1%; fs: 2%; vfs: 17%; ss: 30%; clay: 50%

Sorting: poorly to moderately sorted

Fine Material:

~ 30% of LVI

Nature: iron and charcoal rich clay with calcium carbonate and fine amorphous organic punctuations

Clay to silt ratio: 5:3

Colour: red-orange (OIL); dark brown (PPL); brown-red-orange (XPL)

Limpidity: dotted (PPL) and cloudy (XPL) iron rich clay

b-fabric: undifferentiated – masked by iron but where visible, some random striation and some crystallitic. Also poro- and grano-striation is present around voids, aggregates, minerals and charcoal

Organic Material

~ 20% of LV

- Dominant charcoal ranging from specks (<2μm) to 1mm
- Dominant amorphous organic punctuations
- Very few lignified fresh tissues (300μm)

Pedofeatures

- Dominant calcium carbonate coatings (20μm) lining pore walls
- Dominant calcium carbonate infillings
- Dominant replacement of plant cells by calcium carbonate
- Dominant dirty unlaminated clay coatings of minerals, aggregates and pores
- Dominant dirty clay unlaminated infillings of pores
- Frequent typic mamillated strongly to moderately impregnated iron rich clay nodules with sharp boundaries (2mm-20μm) – varying stages of deterioration – often speckled with charcoal

Figure 5. Fresh organic material from LV (2mm; XPL).

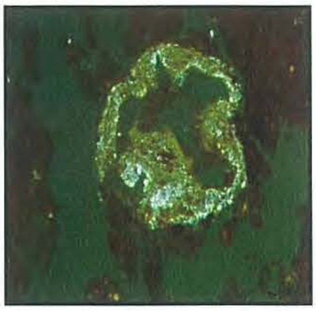


Figure 6. Replacement of organic material by calcium carbonate in LV (2mm; XPL).

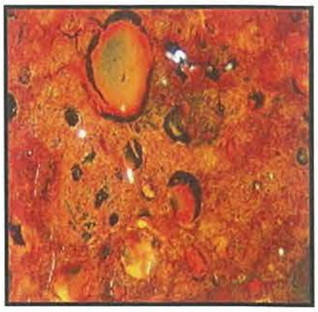


Figure 7. Iron pan between LV and LVI (6mm; OIL).

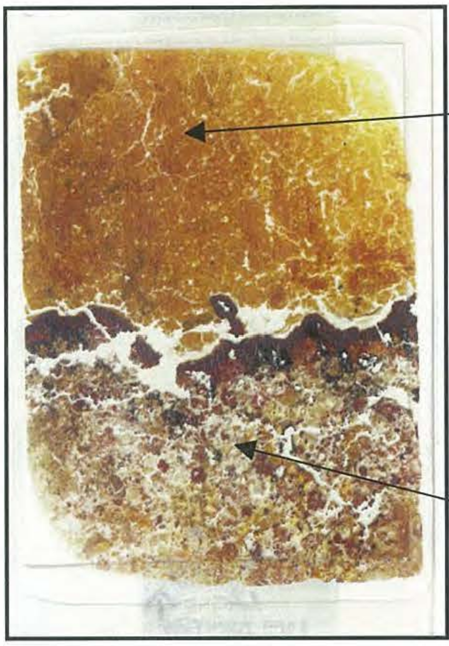
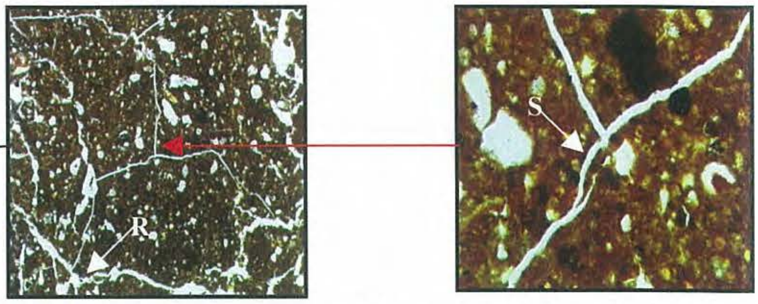


Figure 1. Palau 12 thin section.



Figures 2 and 2a. Angular blocky microstructure of LV showing two types of planar voids (R & S) taken in PPL. Figure 2 is 6mm wide and figure 2a is 2mm wide.

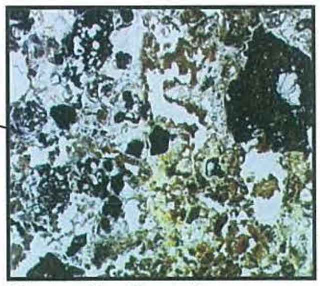


Figure 3. Crumby microstructure of LVI in PPL; 6mm wide.

Figure 4. Planar void through a ped in LVI – evidence of compaction (1cm; PPL).

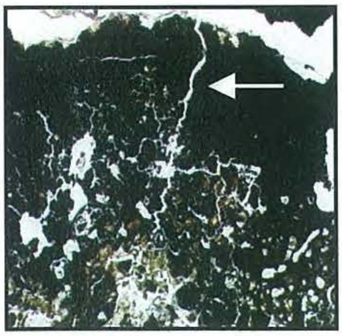


Figure 8. Planar void through rim – evidence of compaction post formation of iron pan (6mm; PPL).

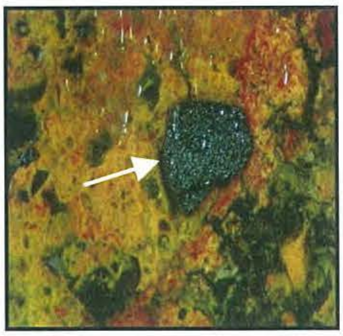


Figure 9. Charcoal in iron rich clay from LVI (2mm; OIL).

Figure 10. Replacement of organic material by calcium carbonate in LVI (1mm; XPL).

Interpretation

Palau 12 is likely to belong to the major soil grouping of Oxisols. These soils contain oxic and kandic horizons and have more than 40% clay (Bridges, 1997). The microstructure of layer V suggests contains two types of void structures which are indicative of compaction (and possible trampling). The first type of void is most likely compaction as the result of the terrace construction and the second type is likely to be the result of compaction after the terrace construction. These voids are evident in figures 2 and 2a. The outline of the larger ped (R) is marked by accommodating planar voids with rough edges. This may be the result of initial compaction but due to weathering by the hydrological environment the edges of the peds are worn. Within and crossing these peds are smaller, smoother accommodating planar voids (S) which suggest more recent compaction most likely occurring post terrace construction.

The microstructure of layer VI is very different from layer V. Layer VI has a crumby structure (figure 3) which is indicative of high levels of disturbance throughout the profile. Although in some of the peds closer to the iron-manganese "boundary" or pan there is evidence of planar voids crossing through the peds suggesting some level of compaction (figure 4). In addition planar voids are also evident through the iron-manganese pan (figure 8) which is also suggestive of compaction occurring post iron pan formation. This compaction could either be the result of the weight of the terrace itself or by activity carried out on the surface of the terrace.

In studies carried out by researchers in Denmark, iron pans have been known to form within weeks of anaerobic conditions being present (Breuning-Madsen and Holst, 1992; Breuning-Madsen and Holst, 1998; Breuning-Madsen *et al.*, 2001). These conditions can be formed by an abrupt change in texture between soil horizons where one horizon is more impermeable than the other. As layer V and layer VI have distinctly different microstructures the formation of the iron-manganese pan on the border of these two horizons may be the result of this impermeability of layer V. This may also explain why the pan continues to the surface of the soil profile, following the horizon border. The compaction of layer V during the construction of the terrace is most likely the cause of the increased impermeability of layer V, resulting in the pan formation on the border of layer V and layer VI. Such formations have also been noted in Denmark where iron pans have formed between the core and mantle of burial mounds as a result of tighter compaction of the core during the mound construction (Breuning-Madsen and Holst, 1992; Breuning-Madsen and Holst, 1998; Breuning-Madsen *et al.*, 2001).

The replacement of organic material present in both layers (more so in layer VI) by calcium carbonate (figures 6 and 10) can only have formed within alkaline conditions which are favourable for this type of formation. This would suggest that the profile has been fed by a base-rich water source and this microclimate has been maintained for some time. This water source may also be the cause of translocation of iron needed to occur for the formation of the iron-manganese pan.

Charcoal is present throughout the profile and is more prominent in layer VI (figure 9). Although charcoal can occur naturally in a soil profile, the extreme disturbance in layer VI and the high quantity (20-30%) of charcoal present suggests that it may be the result of anthropogenic activity on the land surface prior to the terrace construction. The presence of dirty unlaminated clay coatings and infillings of voids in layer VI is also indicative of disturbance.

The indicators of disturbance in layer VI may have been caused by faunal activity. However, the high quantity of iron present throughout the profile acts as a masking agent and it is therefore difficult to identify any signs of faunal activity in terms of excremental remains. Further, other evidence of human activity apart from high quantities of charcoal and indicators of soil disturbance, have not been identified due to the iron oxide present in the profile. In addition, the general morphology of the border between layers V and VI is not consistent with natural deposition but is more likely to be the result of anthropogenic activity, perhaps the preparation of the land surface prior to terrace construction.

References

Breuning-Madsen, H. and M. K. Holst (1992). "Genesis of iron pans in Bronze Age mounds in Denmark." Journal of Danish Archaeology **11**: 80-86.

Breuning-Madsen, H. and M. K. Holst (1998). "Recent studies on the formation of iron pans around the oaken log coffins of the Bronze Age burial mounds of Denmark." Journal of Archaeological Science **25**: 1103-1110.

Breuning-Madsen, H., M. K. Holst and M. Rasmussen (2001). "The chemical environment in a burial mound shortly after construction - an archaeological-pedological experiment." Journal of Archaeological Science **28**(7): 691-97.

Bridges, E. M. (1997). World Soils. Cambridge, Cambridge University Press.

Bullock, P., N. Fedoroff, A. Jongerius, G. Stoops and T. Tursina (1985). Handbook for Soil Thin Section Description. Wolverhampton, Waine Research Publications.

Stoops, G. (2003). Guidelines for Analysis and Description of Soil and Regolith Thin Sections. Madison, Wisconsin, Soil Science Society of America, Inc.

APPENDIX B

Pollen identified:	TR1/LI	TR1/LII	TR1/LIV	TR1/LIVb	TR1/LV	TR1a/LVII	TR1a/LVIII	TR1i/LIII	TR1i/LIV	TR2/LII	TR2/LIII
Lycopodium added	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Charcoal present	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Pandanus sp.	57	9	68	43	34	0	2	5	0	70	14
Trilete spores	30	4	43	58	30	9	30	4	3	16	42
Monolete spores	9	19	9	2	17	48	46	21	85	7	5
Poaceae	111	3	94	29	3	0	2	5	2	20	4
Polypodiaceae	6	12	1	2	1	0	1	1	0	0	0
Rubiaceae ?	0	0	1	0	0	0	0	0	0	0	0
Asteraceae	3	0	4	19	1	0	2	1	0	0	0
Macaranga sp.	1	0	2	0	2	0	0	0	0	2	0
Unknown pollen	0	1	0	0	0	0	3	0	0	0	0
Unknown 3CP	4	2	17	3	3	0	1	3	0	8	2
Unknown 3P	1	1	2	0	0	0	0	0	0	0	1
Restio-like	1	2	2	0	0	0	0	0	0	0	0
Damaged pollen	4	0	3	0	0	2	2	0	0	0	0
Myrtaceae	0	0	0	1	0	0	1	0	0	0	0
Podocarpaceae	0	0	0	0	0	0	0	0	0	0	1
Polgalaceae	0	0	0	0	0	0	0	0	0	2	0
Unknown 3C	1	0	0	0	0	0	1	0	0	0	0
Euphorbiaceae	3	0	1	0	0	0	0	1	0	0	0
Periporate	0	0	0	0	0	0	0	0	0	0	0
Casuarina	3	0	0	0	0	0	1	0	0	0	0
Rhamnaceae ?	0	0	0	0	0	0	0	1	0	0	0
unk 3CP Type 2	0	0	0	0	0	0	0	2	0	1	0
2 Porate,fine patt	0	0	0	0	0	0	0	0	0	0	0
Dacrycarpus	0	0	0	0	0	0	0	0	0	0	0
unk Colpate	0	0	0	0	0	0	0	0	0	0	0
Amaranthaceae	0	0	0	0	0	0	0	0	0	0	0
Polygonum	5	0	0	7	0	0	0	4	0	10	12
Anacardiaceae/Rutaceae	0	0	0	0	0	0	0	0	0	1	0
Palm/Liliaceae	0	0	0	0	0	0	0	0	0	1	0
Celtis/Engelhardtia	0	0	0	0	0	0	0	0	0	1	0
Apiaceae?	0	0	0	0	0	0	0	0	0	2	0
Malvaceae	0	0	0	0	0	0	1	0	0	0	0
Apocynaceae	0	0	0	0	0	0	1	0	0	0	0

Table 1 Raw counts from the pollen analysis.

Pollen Identified:	TR3/LIII	TR4/LI	TR4/LII	TR4/LIII	TR4/LIIIa	TR4/LIV	TR4/LV	TR4/LVI	TR5/LVI	TR5/LVII
Lycopodium added	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Charcoal present	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Pandanus sp.	9	73	34	19	12	5	4	16	0	1
Trilete spores	19	170	115	65	65	23	10	20	6	5
Monolete spores	95	40	35	14	60	24	55	60	45	50
Poaceae	1	155	54	19	14	4	5	16	0	0
Polypodiaceae	0	1	1	0	0	0	0	1	2	0
Rubiaceae ?	0	0	1	0	0	0	1	0	0	0
Asteraceae	0	0	0	0	0	0	0	0	0	0
Macaranga sp.	0	4	0	0	0	0	0	0	1	0
Unknown pollen	0	0	0	0	0	0	0	0	0	0
Unknown 3CP	0	3	3	1	0	0	0	0	0	0
Unknown 3P	0	0	0	0	0	0	0	1	0	0
Restio-like	0	0	0	0	0	0	0	0	0	0
Damaged pollen	0	0	0	0	0	0	1	0	0	0
Myrtaceae	0	0	0	0	0	0	0	0	0	0
Podocarpaceae	0	0	0	0	0	0	0	1	0	1
Polygalaceae	0	0	0	0	0	0	0	0	0	0
Unknown 3C	0	0	1	1	0	0	0	3	0	0
Euphorbiaceae	0	3	1	1	0	1	0	0	0	0
Periporate	0	0	0	0	1	0	0	0	0	0
Casuarina	0	0	0	0	1	0	0	1	0	0
Rhamnaceae ?	0	0	0	0	0	0	0	0	0	0
unk 3CP Type 2	0	0	0	0	0	0	0	0	0	0
2 Porate,fine patt	0	0	0	0	0	0	0	0	0	0
Dacrycarpus	0	0	0	0	0	0	0	0	0	0
unk Colpate	0	0	0	0	0	0	0	0	0	0
Amaranthaceae	0	0	0	0	0	0	0	0	0	0
Polygonum	18	30	50	17	15	0	5	0	1	0
Celtis/Engelhardtia	1	1	1	0	0	0	0	0	0	0
Caryophyllaceae	1	0	0	0	0	0	0	0	0	0

Table 1 Raw counts from the pollen analysis, continued.

Spit number	charcoal ©	no.of pts (n)	P value (c/n)	area of sample (Ap) cm2	Area A (PxAp)	Susp.vol (Vs) ml	Slide vol.(Vp) ml	Org.vol.(V) ml	Conc.(Ac) = (AxVs)/(VpxV)cm2/cm3
TR1/LI	89	3905	0.0227912	8.8	0.2005625	0.15	0.01	2.5	1.203375
TR1/LII	36	4290	0.0083916	8.8	0.073846	0.01	0.01	2.5	0.0295384
TR1/LIV	41	4994	0.0082098	8.8	0.0722462	0.1	0.01	2.5	0.2889848
TR1/LV	21	3421	0.0061385	8.8	0.0540188	0.07	0.01	2.5	0.1512526
TR1/LVI	60	4400	0.0136363	8.8	0.1199994	0.1	0.01	2.5	0.4799976
TR1/LVII	80	4103	0.0194979	8.8	0.1715815	0.07	0.01	2.5	0.4804282
TR1a/LVIII	60	3377	0.0177672	8.8	0.1563513	0.01	0.01	2.5	0.0625405
TR1a/LIX	129	4312	0.0292207	8.8	0.2571421	0.1	0.01	2.5	1.03
TR1i/LIII	32	2772	0.011544	8.8	0.1015872	0.01	0.01	2.5	0.0406348
TR1i/LIV	104	3311	0.0314104	8.8	0.2764115	0.03	0.01	2.5	0.3316938
TR2/LII	91	4961	0.018343	8.8	0.1614184	0.1	0.01	2.5	0.6456736
TR2/LIII	58	4125	0.0140606	8.8	0.1237332	0.03	0.01	2.5	0.1484798
TR3/LIII	82	4070	0.0201474	8.8	0.1772971	0.05	0.01	2.5	0.3545942
TR4/LI	99	4015	0.0246575	8.8	0.216986	0.15	0.01	2.5	1.301916
TR4/LII	71	3707	0.0191529	8.8	0.1685455	0.1	0.01	2.5	0.674182
TR4/LIII	70	4455	0.0157126	8.8	0.1382708	0.07	0.01	2.5	0.3871582
TR4/LIV	20	3344	0.0059808	8.8	0.052631	0.01	0.01	2.5	0.105262
TR4/LIVa	86	3707	0.0231993	8.8	0.2041538	0.05	0.01	2.5	0.4083076
TR4/LV	93	3465	0.0268398	8.8	0.2361902	0.05	0.01	2.5	0.4723804
TR4/LVI	61	2882	0.0211658	8.8	0.186259	0.02	0.01	2.5	0.1490072
TR5/LVII	24	2805	0.0085561	8.8	0.0752936	0.02	0.01	2.5	0.0602348
TR5/LVIII	54	2882	0.0187369	8.8	0.1648847	0.02	0.01	2.5	0.1319077

Table 2 Charcoal counts made during the pollen analysis.

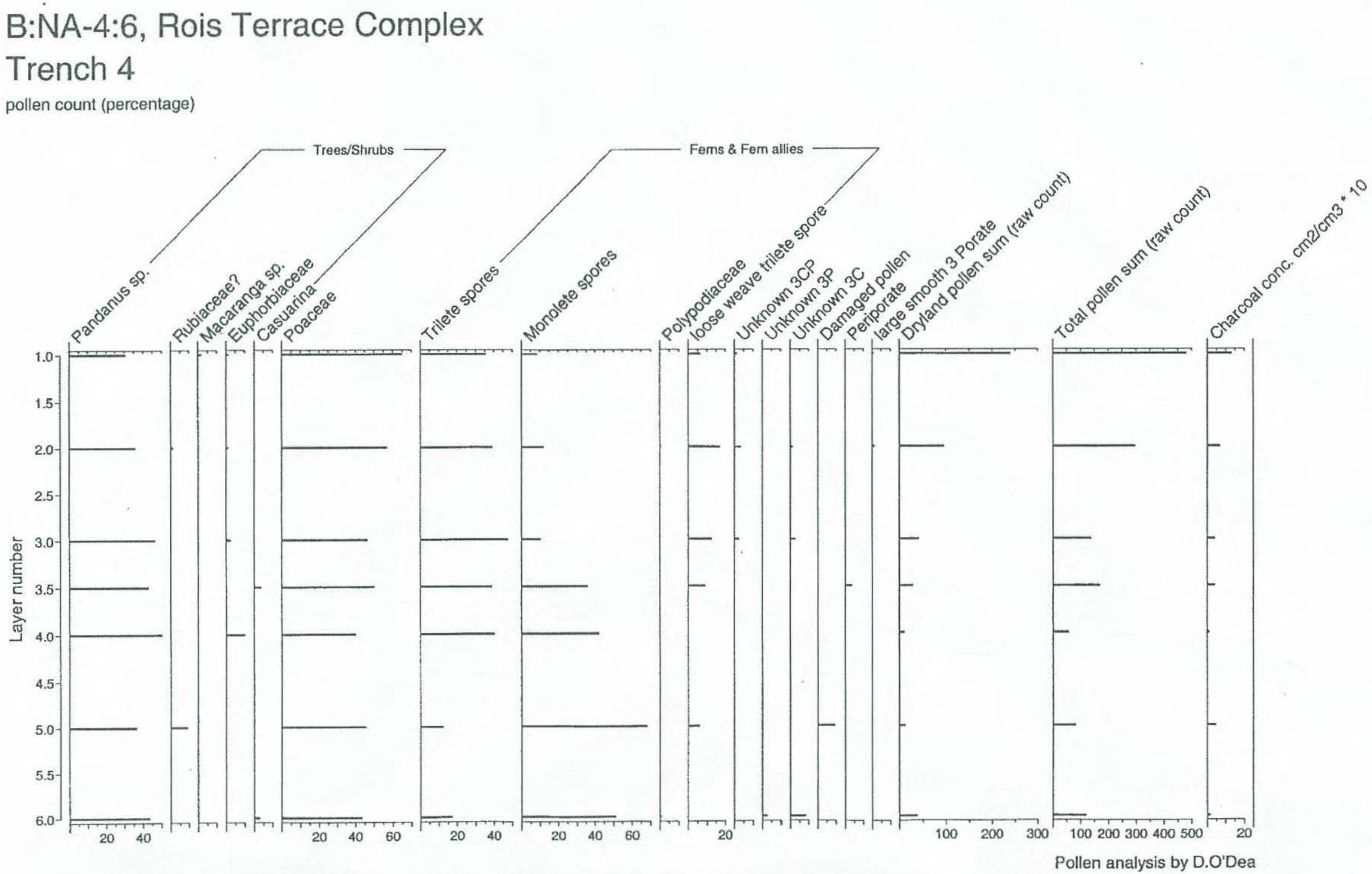


Figure 1 Tilia graph illustrating pollen count percentages from TR4, Rois.

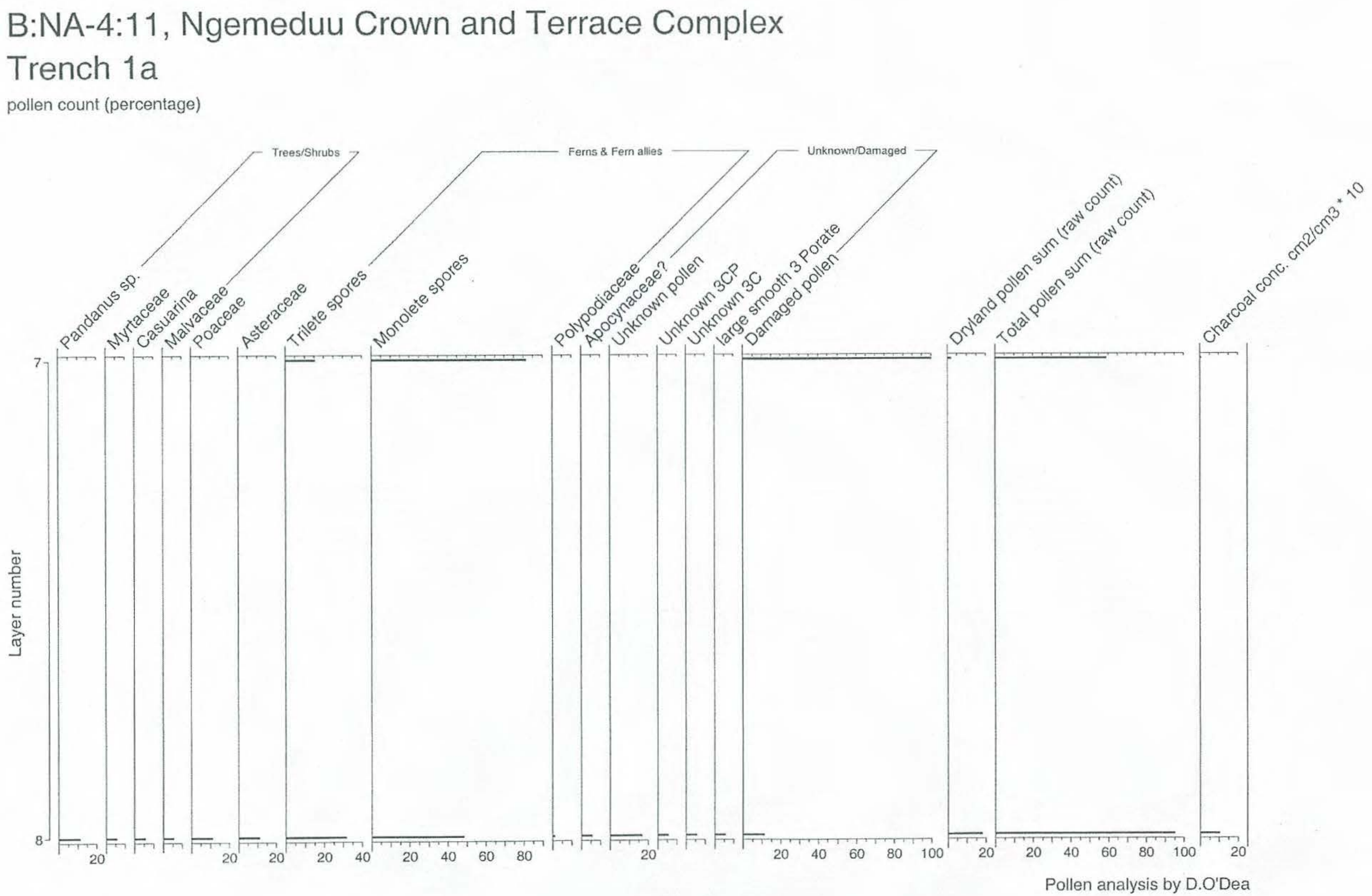


Figure 2 Tilia graph illustrating pollen count percentages from TR1a, Ngemeduu.

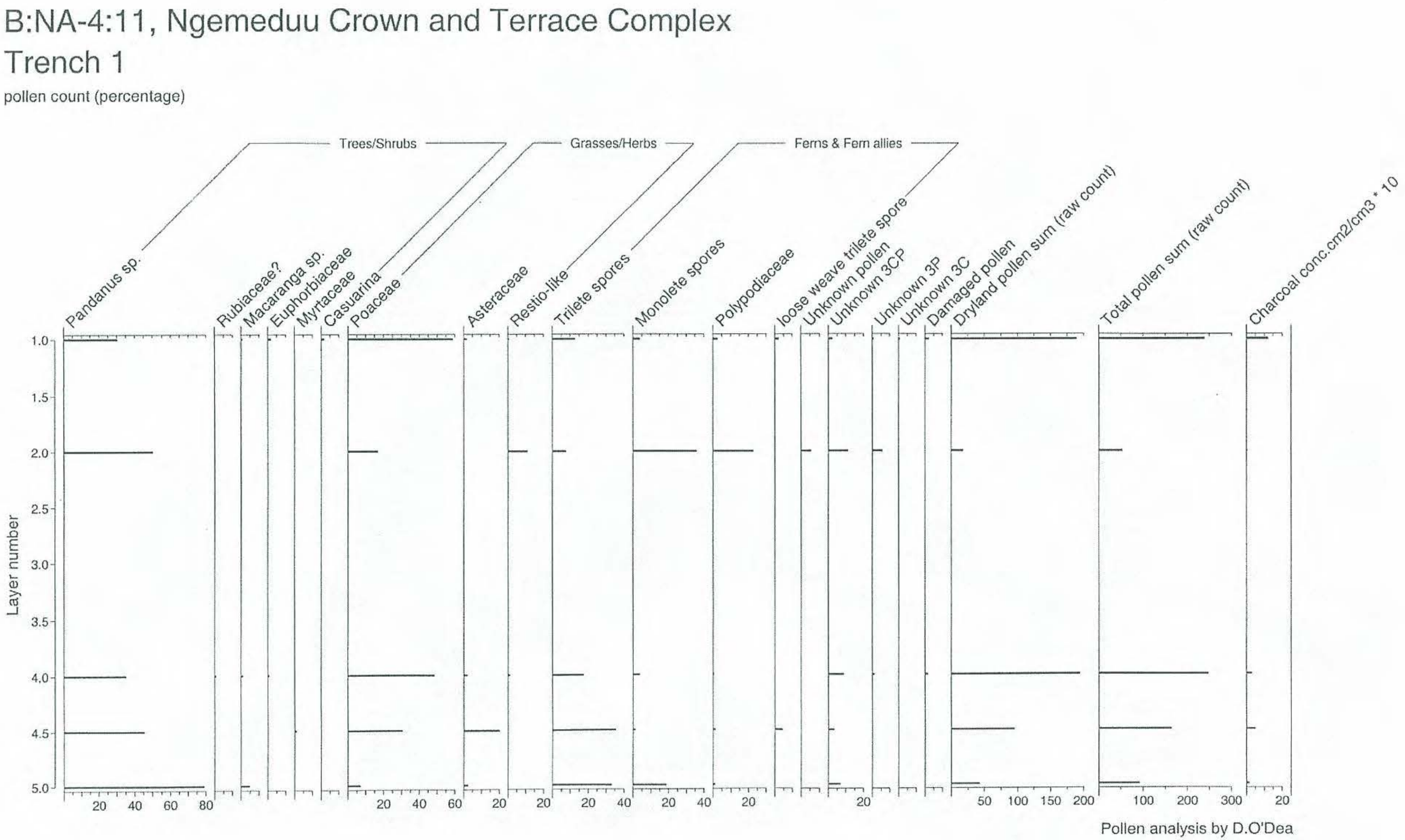


Figure 3 Tilia graph illustrating pollen count percentages from TR1, Ngemeduu.

APPENDIX C

Report on phytolith analysis

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Outline

This short report provides the results of a small phytolith study undertaken on behalf of Sarah Phear of the Australian National University. There is currently no phytolith database for Palau and the immediate neighboring areas of the Asia pacific. In view of this all identifications in this study are tentative and based on morphological comparisons made with phytolith types of modern species databases from outside the study area.

Methods

A Perkin - Elmer Multiwave Microwave Sample Preparation system was used for phytolith and starch grain extraction from palaeosols (Parr 2002). Phytoliths extracted from each sample were weighed, mounted onto microscope slides and scanned at 400x magnification on an Olympus BH2 microscope. All phytoliths encounted during three transects of a microscope slide were counted.

Fossil phytolith types were compared to those stored in a modern phytolith digital-image database of around ~200 species from regionally applicable flora of Papua New Guinea and Australia. Other databases used included the Runge (1996) CD-ROM and Kealhofer and Piperno (1998). Phytolith sizes were gauged using an ocular micrometer and the individual scale bars on each digital-image.

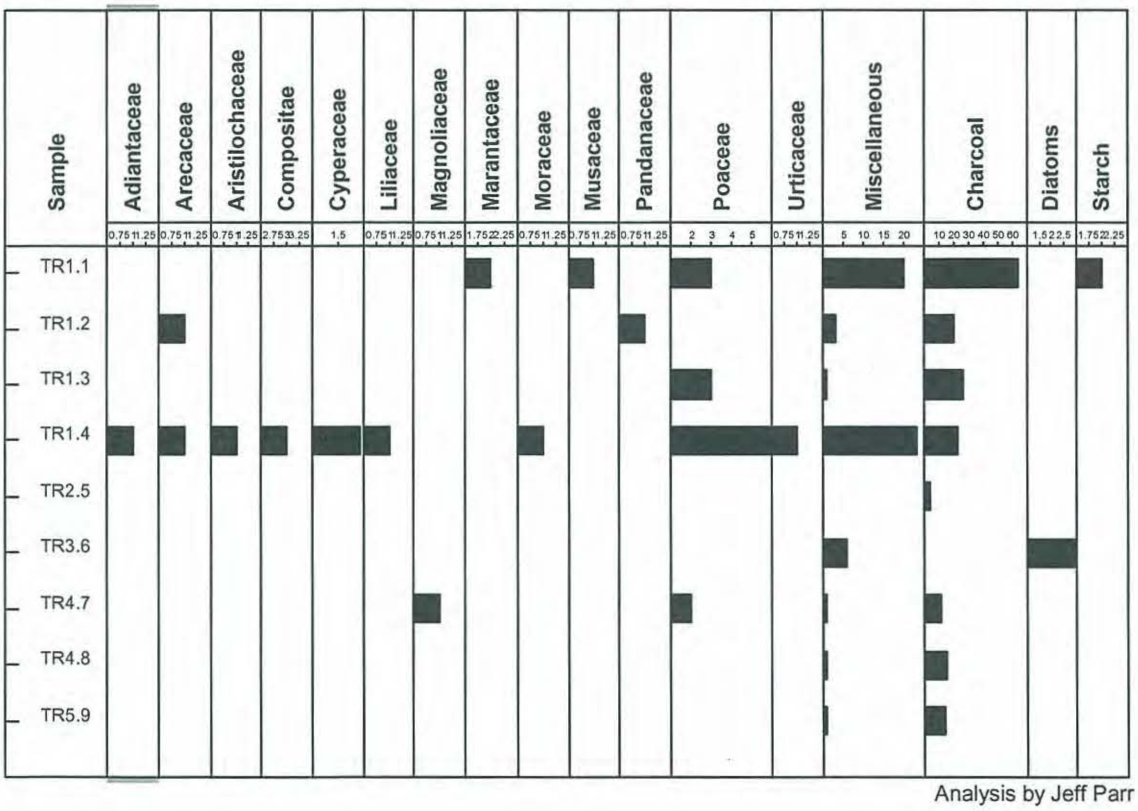


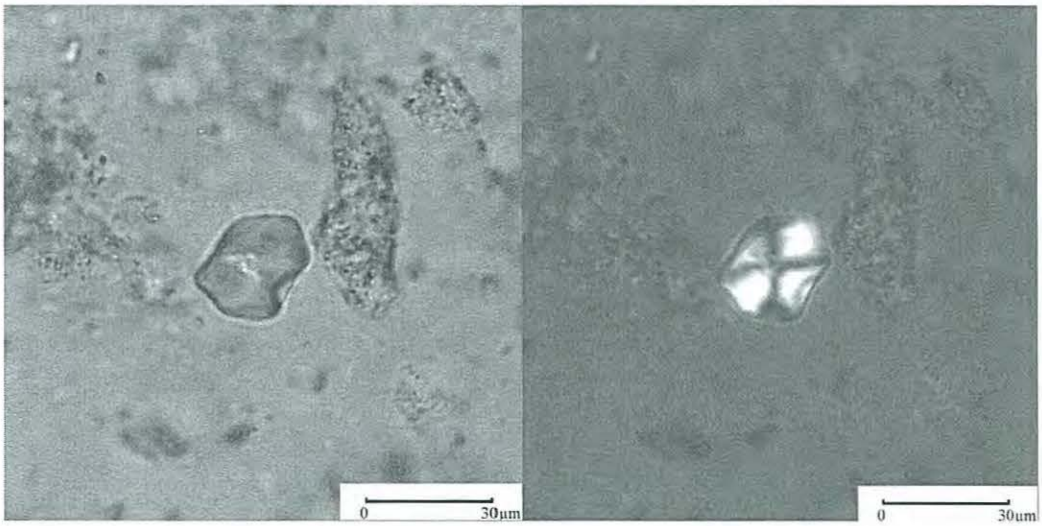
Figure 1. Summary of samples, counts for indicated plant families based on phytolith morphology, microscopic charcoal particles, diatoms and starch.

Results, Discussion and Conclusion

All samples were phytolith deficient due mainly, to the strongly weathered condition of palaeosols. Nevertheless, odd phytoliths do occur in some samples that may lend some tentative assistance to the possible vegetation types present in each sample.

Sample TR1.1

The sample TR1.1 has a total of 26 phytoliths. Some of the phytolith types that were recovered resemble those of *Donax Canniformis* (Marantaceae) found in damp swampy conditions, Musaceae that may occur in forests or garden areas and grasses (Poaceae). There was also a 20 phytoliths that did not resemble any of those types represented in the database material. In addition, this sample contained two large unidentified starch grains



Plates 1. Starch grain from sample TR1.1 left in bright-field at 400x magnification and using crossed polarized light right.

(Plate 1) and 64 charcoal particles and odd charred phytoliths, which is significantly high in comparison to all other samples (Figure 1).

Sample TR1.2

A total of 7 phytoliths were counted in sample TR1.2. Phytoliths occurring in sample TR1.2 resemble those types found in palms (Arecaceae) that occur in a variety of habitats including forest, woodland, foreshore areas and gardens. Types such as those found in Pandanaceae associated with open grasslands are also present. The sample TR1.2 has no starch grains, around 20 charcoal particles and 3 charred phytoliths including 1 from a palm type.

Sample TR1.3

The sample TR1.3 has a total of 4 phytoliths present, of these 3 are types found in grasses and 1 of these is charred. This sample also has 26 charcoal particles (Figure 1).

Sample TR1.4

A total of 40 phytoliths were counted in the sample TR1.4 including types that resemble those found in Adiantaceae, ferns often associated with rock outcrops and hill slopes in the tropics, palms, a widespread vine type such as those found in *Aristolochia tagala* (Aristolochiaceae), Compositeae that include many garden plants and weeds, Cyperaceae found in open areas, *Cordyline sp.* (Liliaceae) of secondary forests, figs (Moraceae) and grasses (Figure 1). Charred material included 20 charcoal particles and 2 charred phytoliths.

Sample TR2.5

No phytoliths or starch grains were recorded in the samples TR2.5, however, a single *Synedra ulna* fresh water diatom was recovered and 3 charcoal particles were counted (Figure 1).

Sample TR3.6

The sample TR3.6 has 6 unidentified phytoliths and 3 *Synedra ulna* fresh water diatoms (Figure 1). This sample has no charred material or starch grains.

Sample TR4.7

A total of 7 phytoliths were recorded in this sample including types such as those observed in Magnoliaceae and grasses 1 of the grass types was charred. In addition 11 charcoal particles were counted (Figure 1).

Samples TR4.8 and TR5.9

A single unidentified phytolith was recorded in each of the samples TR4.8 and TR5.9 (Figure 1.). Sample TR4.8 had 15 charcoal particles and the sample TR5.9 13 particles.

Summary

Although soil pH conditions were optimal for preservation all samples examined were found to be phytolith deficient. The abundance of rounded quartz particles in the samples suggests that the low levels of phytolith preservation are probably due to the strong weathering of palaeosols. However, phytoliths are present in some samples, in particular, the samples TR1.1 and TR1.4. Results from previous studies indicate that the greater abundance of phytoliths in buried soil horizons may be indicative of cultural activity (Rovner 1983). Given the lack of phytoliths in all but two samples the results from Rovner's (1983) study offers a possible explanation. For the sample TR1.1 in particular, the presence of starch grains and the greater number of charcoal particles counted may further support this type of explanation. An alternative view is that the sterile layers are representative of ongoing disturbance as a result of anthropogenic or natural processes allowing little time for the recovery of vegetation. In such a situation the samples that are comparatively more abundant in phytoliths than other samples may actually indicate fallow periods or soil stability allowing the re-emergence of vegetation. All mention of phytolith descriptions in this study are at best tentative, as they relate to morphological likeness (not identification) based on digital image databases not specific to the study area.

References Cited

Kealhofer, L. and Piperno, D. R. (1998). Opal Phytoliths in Southeast Asian Flora Smithsonian Contributions to Botany. Washington DC, Vol 88 pp1.39,

Parr, J. F. (2002). "A comparison of heavy liquid floatation and microwave digestion techniques for the extraction of fossil phytoliths from sediments." Review of Palaeobotany and Palynology **120 (3-4)**: 315-336.

Rovner, I. (1983). Plant opal phytolith analysis: major advances in archaeobotanical research. Schiffer, M. B. e. (eds.). *Advances in Archaeological Method and Theory*. Academic Press, London Vol.6 pp225-66.

Runge, F. (1996). Leaf phytoliths and silica skeletons from east African plants. CD-Rom Database. Dept. of Physical Geography, University of Paderborn, Germany.

APPENDIX D

Petro Rpt WRD-227 (5 April 2003) [revised 25 May 2003]

Petrography of Painted and Unpainted Sherds from Palau

Eleven (11) sherds of painted pottery (and 5 plain unpainted sherds) from Palau were sent by Sarah Phear for examination in thin section to establish the nature of their tempers. The sherds were given simplified numbers (in thin section) of the form PPP-n, where n is the last of the numbers assigned to each sherd (other numbers presumably apply to the site or locality for each). One additional sherd (PPP-31) was too crumbly for preparation of a thin section.

All the sherds contain variants of grog (broken pottery) temper similar to tempers present in 90% of the sherds examined to date in thin section from Babeldoab and neighboring islets in Palau (Fitzpatrick et al., 2003). Table 227-1 indicates the assignment of the sherds to four previously established types of grog-tempered Palauan sherds:

A, exclusively grog temper with essentially no terrigenous grains;

B, dominantly grog temper with sparse terrigenous grains;

C, composite tempers of mixed grog particles and terrigenous grains but with grog particles more abundant than terrigenous grains.

None of the sherds contain representatives of rare type D composite tempers (with grog particles less abundant than terrigenous grains).

Neither from the sherd numeration, nor from the typology (painted vs unpainted), is there any discernible system to the distribution of A-B-C tempers in the collection. Proportions of A-B-C tempers (56-31-13) are not significantly different from the proportions (63-23-14) in 156 other grog-tempered Palauan sherds containing A-B-C tempers (Fitzpatrick et al., 2003). As the A-B-C tempers form a gradational spectrum of temper variation, the distribution of variants is probably essentially random.

The net percentages of terrigenous grain types present in type B-C tempers of the sherds were determined by frequency count (n=152), and are compared in Table 227-2 with comparable data generated previously for type C-D tempers in other Palauan sherds (Fitzpatrick et al., 2003). The results are statistically indistinguishable, and leave no doubt that both painted and unpainted pottery is native Palauan ware made on Babeldaob or a nearby bedrock islet where volcanic rock is exposed. The characteristic Palauan grog temper could not derive from outside Palau, and no other islands in Palau could yield the kind of volcanic detritus represented by the terrigenous grains.

The grog particles are clearly manually added temper, but the terrigenous sand grains are probably natural temper that was imbedded, together with finer silt particles, in the clay bodies as collected. This inference is drawn from the generally angular nature of the terrigenous grains, their weathered character, and the wide variation in their grain size, which ranges downward into the silt range. The volcanic nature of the terrigenous detritus reflects derivation of the clay, with its component of natural temper, from Babeldaob or a neighboring bedrock islet (Arakabesan, Koror, Malakal).

The prevalence of grog temper in the painted sherds raises anew the question of Palauan pottery technology. It is impossible to know from petrography whether grog was obtained by breakage of disused pottery, or by breakage of some form of prefired ceramic objects fabricated specifically to yield grog particles. It is perhaps even conceivable that ancient potters simply sun-dried clay until it was firm enough to break up into clots usable as grog temper. Some distinction between the potential sources of grog particles might be made on the basis of archaeological investigations if unfamiliar ceramic objects or odd clay clumps are present at any sites.

In six of the sherds (PPP-18, 22, 32, 41, 106, 112; four painted and two unpainted), selected grog particles internally contain pre-existing grog particles, or at least one margin of a pre-existing grog particle, and these occurrences favor breakage of grog-tempered pottery to obtain more grog. In general, however, the instances where this evidence of multiple generations of grog can be clearly seen in thin section seems low, at least intuitively, given the ubiquity of grog particles in the finished wares. The whole issue needs more thought, as it bears upon the most characteristic feature of Palauan wares, as opposed to other prehistoric Oceanian pottery. Inquiry into ethnographic accounts of modern peoples, if there be such, who make earthenware with grog temper might repay the time spent to seek them out. My own knowledge of grog usage is almost nil, and I feel a lack of fundamental insight that might be required to address the question effectively

Reference Cited

Fitzpatrick, S.M., W.R. Dickinson, and G. Clark, 2003, A petrographic analysis of ceramics from Palau, Micronesia: Journal of Archaeological Science, in press.

Table 227-1. Classification of grog tempers in 16 Palau painted (p) and associated unpainted (u) pottery sherds (Types A-C after Fitzpatrick et al., 2003)

Type A	Type B	Type C
PPP-10 (p)	PPP-34 (p)	PPP-22 (p)
PPP-11 (p)	PPP-48 (p)	PPP-106 (u)
PPP-18 (p)	PPP-50 (p)	
PPP-26 (p)	PPP-108 (u)	
PPP-28 (p)	PPP-112 (u)	
PPP-32 (p)		
PPP-41 (p)		
PPP-113 (u)		
PPP_117 (u)		

Table 227-2. Net frequency percentages of terrigenous grain types in Palauan sherds containing composite tempers (mixed grog particles and terrigenous grains); data for sherds studied previously from Fitzpatrick et al., 2003 (with std dev added from raw data)

grain type	Type C-D Published[1]	Type B-C this

		report[1]
	[20 sherds; 345 grains]	[7 sherds; 152 grains]
quartz grains	11 ± 2	9 ± 2
plagioclase feldspar grains	26 ± 2	22 ± 3
clinopyroxene grains	3 ± 1	6 ± 2
felsitic volcanic rock fragments	22 ± 2	21 ± 3
microlitic volcanic rock fragments	5 ± 1	5 ± 2
hypabyssal igneous rock fragments	3 ± 1	3 ± 1
opaque iron oxide grains	30 ± 2	33 ± 4
weathered biotite flakes	?	1

[1] Percentages plus or minus standard deviations of counting errors, calculated from the expression $[p(100-p)/n]^{1/2}$, where p is the reported percentage of a given grain type and n is the total number of grains in the counted population (345 or 152)

APPENDIX E

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SUBJECT OF REPORT

GADDS Analysis

Requested by: Sarah Phear	Date:3/7/03
Written by:Alan Chappell	Job No:5623-03
Checked by:Dr Kevin Blake	emailed
Approved by:Dr Kevin Blake	Unit:GADDS

1. **PROCEDURE:**
Nine (9) pottery samples were received into the X-ray Unit of the Advanced Analytical Centre (AAC).

AAC personnel did not participate in any sampling procedures.

2. **AIM**

Identification of mineral phases present in paint on pottery sherds by micro-X-ray diffraction (μ-XRD) using the General Area Detector Diffraction System (GADDS)

3. **METHOD**

3.1 Preparation

No sample preparation was required.

3.2 Instrumentation

Samples were analysed on a General Area Detector Diffraction System (GADDS) made by Bruker AXS. Frames of diffraction rings are collected and integrated to produce conventional XRD patterns (2theta v intensity). Analysis is by standard XRD methods.

Samples were analysed on a General Area Detector Diffraction System (GADDS) made by Bruker AXS. This instrument uses Copper Ka_1 radiation (λ = 1.5405Å) generated at 40kV and 52mA. The samples are mounted on a platform that has travel in the X, Y and Z directions: collimation of the X-ray beam is by selection of a suitably-sized pin-hole collimator. Collimation can range from 800 μm to 50 μm.

The GADDS instrument is shown in Figure 1.

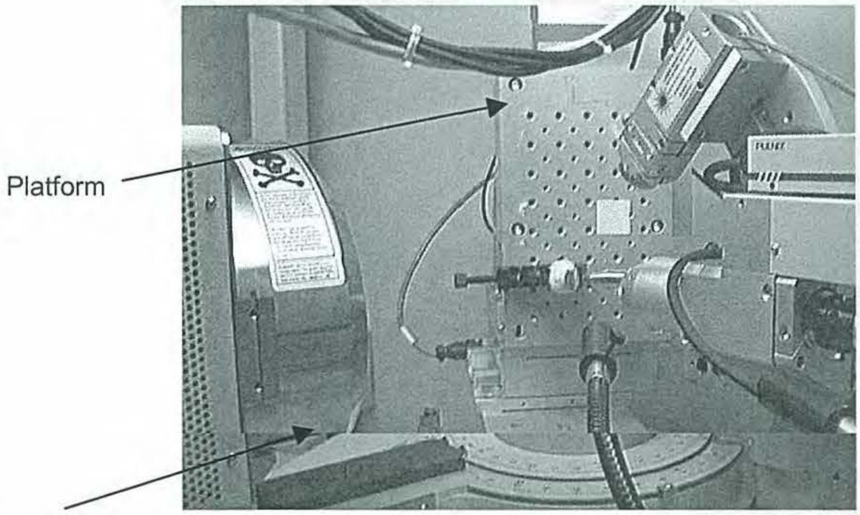

Figure 1. The GADDS showing the XYZ platform.

All samples were analysed with a 200 µm collimator and X-ray diffraction (XRD) patterns were collected at steps of 0.2mm. The collimation system of the instrument is shown in Figure 2. Data were collected at 300seconds per step.

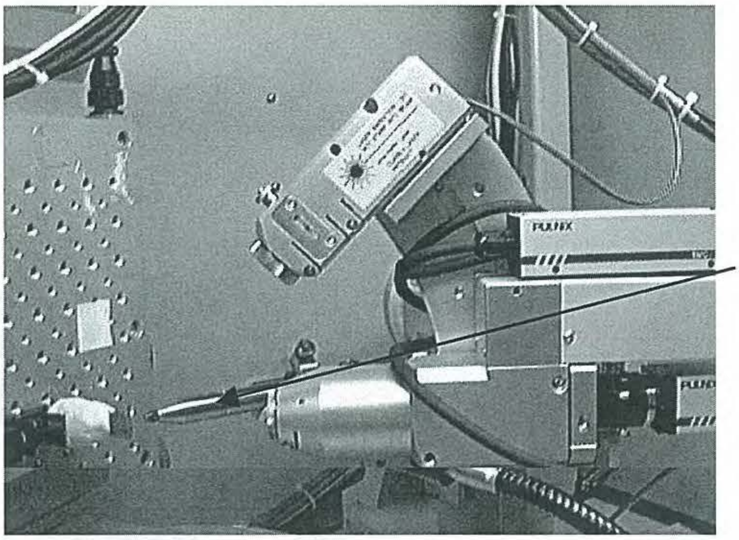

Figure 2. The collimation system of the GADDS.

3. Results

Sherd 10

Hematite	Fe_2O_3
Quartz	SiO_2

Sherd 11

Hematite	Fe_2O_3
Quartz	SiO_2
Goethite	Fe+3O(OH)

Sherd 18

Hematite	Fe_2O_3
Quartz	SiO_2

Sherd 26

Hematite	Fe_2O_3
Quartz	SiO_2

Sherd 28

Hematite	Fe_2O_3
Quartz	SiO_2

Ilmenite Fe+2TiO3

Sherd 32

Hematite Fe2O3
Quartz SiO2

Sherd 41

Hematite Fe2O3
Quartz, SiO2
Calcite CaCO3

Sherd 48-Orange

Hematite Fe2O3
Quartz SiO2

Sherd 48-Red

Hematite Fe2O3

Sherd 50

Hematite Fe2O3
Quartz, SiO2