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ARTICLE

Minjiwarra: archaeological evidence of human occupation of Australia's northern Kimberley by 50,000 BP

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ABSTRACT

Recent archaeological research in Australia's north-eastern Kimberley has luminescence dated a large red sedimentary feature, known as Minjiwarra, with artefacts in stratified contexts from the late Holocene to ∼50,000 years ago. This site is located on the Drysdale River, with preliminary excavations undertaken as part of an ARC Linkage Project. Deeply stratified sites in association with rockshelters are uncommon across the NE Kimberley and basal dates at open cultural deposits vary greatly. Most of them are mid-Holocene in age. However, Minjiwarra appears to cover the entire span of potential human occupation in this region, with associated lithic technology, reported on here.

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Aboriginal Archaeology; Australia; Kimberley; luminescence; Pleistocene

Introduction

Minjiwarra is an archaeological site complex located on the lower catchment of the Drysdale River in Australia's north-eastern Kimberley (Figure 1). Known colloquially as 'Big Red', but here named after its Kwini place name, Minjiwarra is a visually dominant, large sedimentary feature rising steeply from the western edge of the Drysdale River floodway (Figure 2). It rises to six metres in height from a carbonate pavement and extends horizontally for ∼1 km along the river (Figure 3).

The site was first described by Walsh (2000) as a dune and subsequently visited by geomorphologists and archaeologists such as Hammond, Morwood, Vita-Finzi, and Wyrwoll, who variously took samples for dating and artefacts for illustrating. No technical or site reports were produced. However, preliminary OSL results have been shared by Wyrwoll (pers. comm. 10 Aug 2017 and below). In July 2017 the site was sampled as part of the *Kimberley Visions: Rock Art Style Provinces of North Australia* ARC Linkage Project (LP150100490). Permits from the Kimberley Land Council, Balanggarra Aboriginal Corporation and Western Australian Department of Planning, Lands and Heritage were in place and Traditional Owners participated in the fieldwork and sampling. Minjiwarra is a site of continuing cultural significance to the Traditional Owners, the Waina family. We surveyed the stratified feature, took five sediment samples for optically stimulated luminescence (OSL) dating, and collected both *in situ* and surface artefacts, including stone axes. An OSL dating sequence was returned placing in situ artefacts from c. 7.7 ka back to c. 50 ka (Shfd17118, Shfd17119, Shfd17120, Shfd17121, and Shfd17122). These artefacts were underlain by sediments dating to 70 ka and capped by upper units dating to the terminal Pleistocene/Holocene transition. Ten stratigraphic units reveal a predominantly fluvial sequence, probably produced from episodes of overbank deposition. This first-stage site report provides the context for the stratified and surface artefacts at and near our sample area, the OSL ages and associations, and the significance of a 50 ka site from the north-eastern Kimberley. Minjiwarra is located at a key interstitial point on the archaeological landscape, which we now describe in greater contextual detail.

Minjiwarra site context

The Drysdale River drains a large catchment of ∼26,019 km^2 representing one of three catchments

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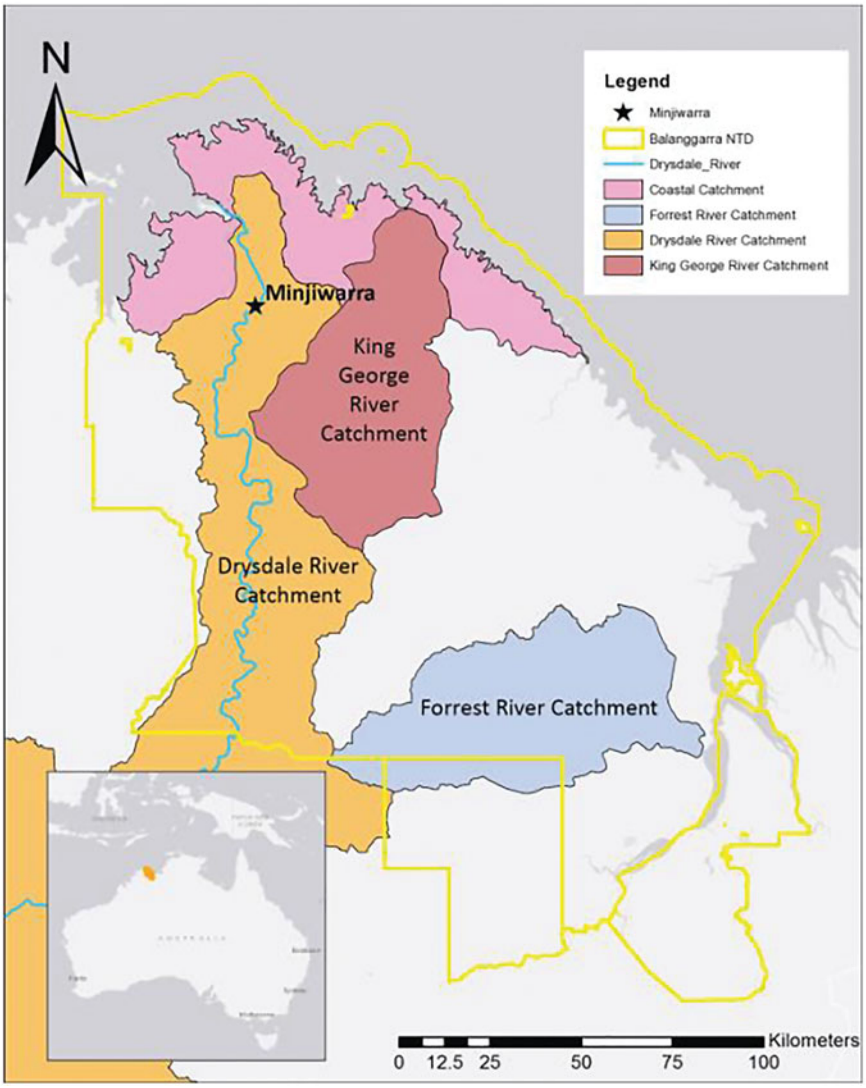

Figure 1. Location of Minjiwarra, northern Kimberley, Drysdale River, Australia.

Figure 2. The 6 m high elevation of Minjiwarra looking north-west. The sediments are increasingly cemented with depth, with a large basal talus and carbonate pavement shown in the foreground. Artefacts are in situ in section with a near-continuous scatter of reworked and locally discarded artefacts lying on the pavement (Photo by Marine Benoit).

being surveyed by the *Kimberley Visions* project (Figure 1). Since 2016 the project team has located and recorded 1,087 archaeological sites including rock paintings, engravings, cupules and grooves, stone arrangements, quarries, stratified and open sites, as well as ethnographic sites. Minjiwarra is located at a transition between two rock art regions, with a lessening occurrence of Wanjina depictions eastwards, although still present sporadically and as far as the Cambridge Gulf. The area is defined by

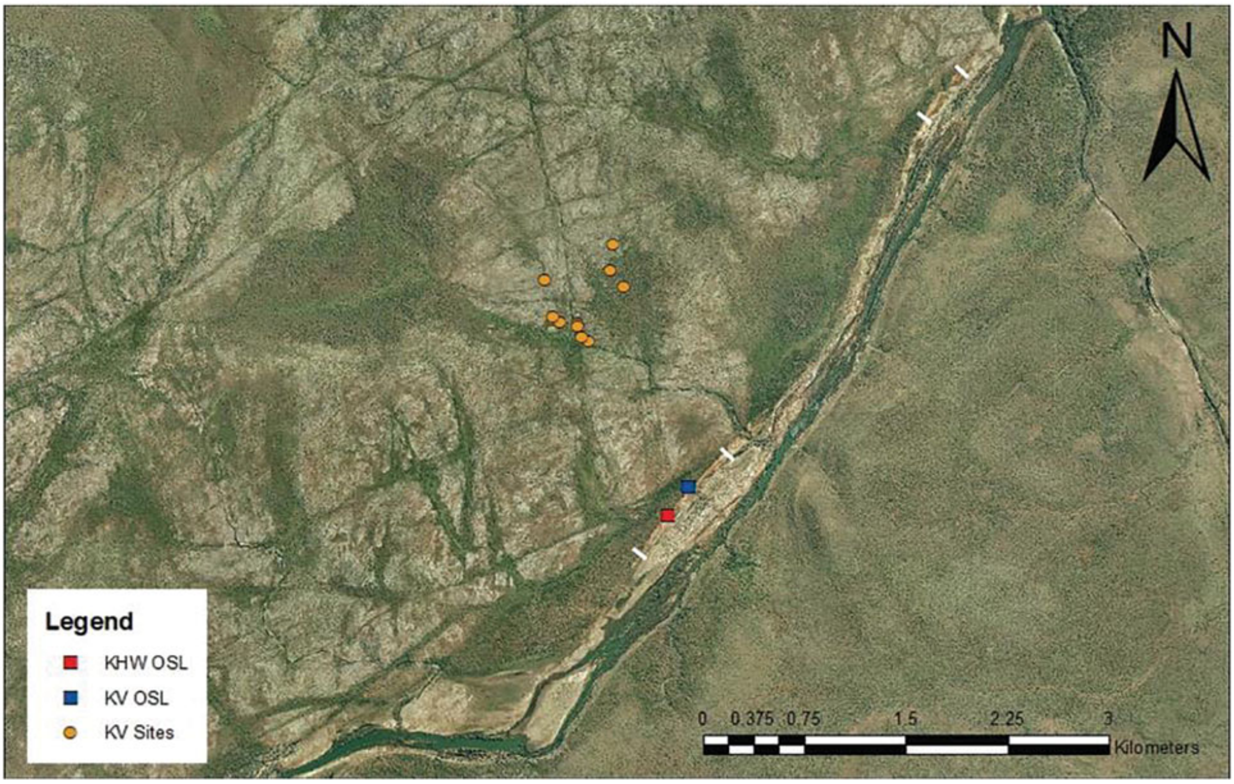

Figure 3. Aerial view of the extent of Minjiwarra along Drysdale River (white bars), location of OSL samples (red: earlier samples by Karl Heinz Wyrwoll; blue: Kimberley Visions 2017 samples), and rock art sites with Gwion Gwion and Wandjina motifs to the north-west (orange dots) (ArcMAP 10.5).

King Leopold sandstone that extends to the coast immediately west, and Warton sandstone comprising the inland Carson escarpment 4.5 km to the east. In the former region, we have recorded 30 rock art sites that contain both early Gwion Gwion (also 'Kira kiro') and more recent Wandjina phase rock art (Figure 4). In the latter region, we have recorded 390 rock art sites where all the known types of Kimberley rock art occur, including types yet to be fully described. We have also conducted nine excavations in addition to Minjiwarra in this region, the finds from which are currently being analysed as part of doctoral and other research. Most rock art sites have associated artefacts and living areas. However, rock shelter occupation sites seldom have deep, stratified deposits with all current excavations producing mid to late Holocene dates (Table 1). Some sites have metal, glass and other historic artefacts in upper units, and possess significance to current Traditional Owners and their immediate ancestors. Although deposits excavated are mid to late Holocene in age, several of the rock art traditions – such as cupules, Irregular Infill Animal and Gwion Gwion (Figure 4) are currently thought to be Pleistocene in age and are the subject of another ARC Project: *Dating the Aboriginal Rock Art Sequence of the Kimberley in North-West Australia* (LP170100155). We believe it is important to note the abundance and regional presence of what is thought to be earlier phase art and the concomitant lack of excavated Pleistocene-aged deposits (see Figure 4 and Table 1) compared to the Pleistocene deposits in limestone and sedimentary suites dominating the NW and SE Kimberley (see Maloney et al. 2018).

Despite the absence of Pleistocene deposits in rock shelters (see Table 1), probably due to the slowly eroding nature of the Warton sandstone and different preservation of associated archaeological deposits, two open sites – of which Minjiwarra is the largest – have provided a chronological bridge into the Pleistocene. Table 1 shows basal dates obtained for 8 other sites excavated as part of the *Kimberley Visions* project. These show that Pleistocene deposits are rarely preserved in the area, both in open and rock shelter contexts. This clearly demonstrates the importance of Minjiwarra's Pleistocene sequence and the utility of under-researched open contexts in understanding the dynamics of human land use, especially in the earlier periods of human occupation of Sahul. Minjiwarra is situated immediately north (4.5 km) from the Warton Sandstone Carson River Escarpment – and a remarkable geological feature called 'The Finger', where 150 archaeological sites have currently been recorded within a 15 km radius (Figure 4). Some of these sites have potential archaeological deposits over 1 m in depth and are often heavily imprinted with multi-temporal rock art signatures dominated by Gwion

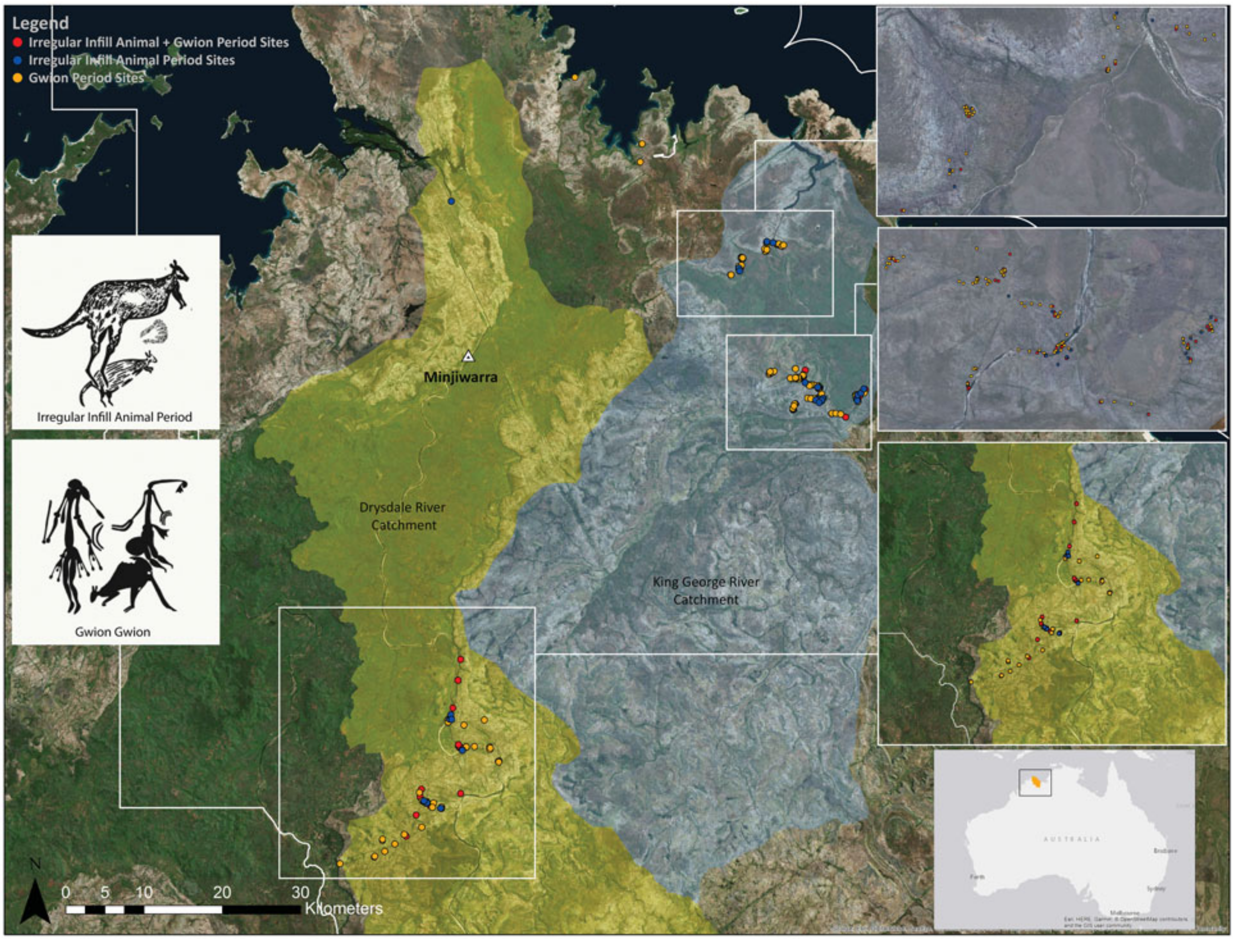

Figure 4. Location of Minjiwarra in relation to early phase rock art located in the Drysdale and King George River catchments.

Table 1. Sites and dates obtained from *Kimberley Visions* project excavations. Calibration was obtained using OxCal v4.3.2 with InterCal13 and SHCal13 calibration curves.

Site code	Site type	Depth of the deposit	Radiocarbon dates	Calibration Curve
DRY007	Rock shelter	145 cm	3,390–3,230 cal. BP (Wk47580)	SHCal13
DRY025	Rock shelter	*ca.* 30 cm	1,710–1,560 cal. BP (Wk47582)	SHCal13
DRY104	Rock shelter	35 cm	5,299–5,038 cal. BP (Wk48208)	IntCal13
FOR001	Rock shelter	108 cm	730–670 cal. BP (Wk-44396)	IntCal13
FOR002	Rock shelter	125 cm	No dates available	-
KGR037	Open site	221 cm	12,710–12,570 cal. BP (Wk-44319)	IntCal13
KGR128	Open site	150 cm	1,120–980 cal. BP (Wk47579)	SHCal13
KGR010	Rock shelter	*ca.* 25 cm	490–320 cal. BP (Wk47574)	SHCal13

Gwion and Wandjina motifs, including hafted stone tool motifs. Wandjina motifs occur well to the east of most currently accepted Wandjina distributions in the Kimberley. Interestingly, these sites cluster on top of the Carson Escarpment rather than along the Drysdale river course, where most rock art sites are found. This unexpectedly rich site complex, together with the open sites and predominantly rock shelter derived occupational chronologies, show this human landscape to be enormously complex with distinct archaeological signatures that we are yet to fully disentangle. This complexity continues immediately west of Minjiwarra, where we are beginning to record a new suite of sites in the geologically and topographically distinct King Leopold sandstone which appears to have exceptional preservation of earlier phase art towards the coast (Figure 4).

Returning to Minjiwarra, we surveyed up and down the river, noting another similar but smaller heavily incised, steep landscape feature 2.5 km to the north. Figure 5 shows Minijiwarra in relationship to the larger creek system and escarpments. While brief mention of these features was made by previous researchers, none had positively identified in situ artefacts. OSL samples taken by Wyrwoll from a section 100 m to the SW of our 2017 target area (Figure 3) provided three OSL assays of 134 ka, 115 ka and 37 ka, between 1–6 m above the carbonate pavement (Karl-Heinz Wyrwoll pers. comm. 19 August 2017). Walsh (2000) and Morwood (unpublished notes) postulated that the feature is of considerable antiquity, noting an abundance of axe-making debris. Morwood collected six axes, one of which is illustrated in Figure 6, together with an axe

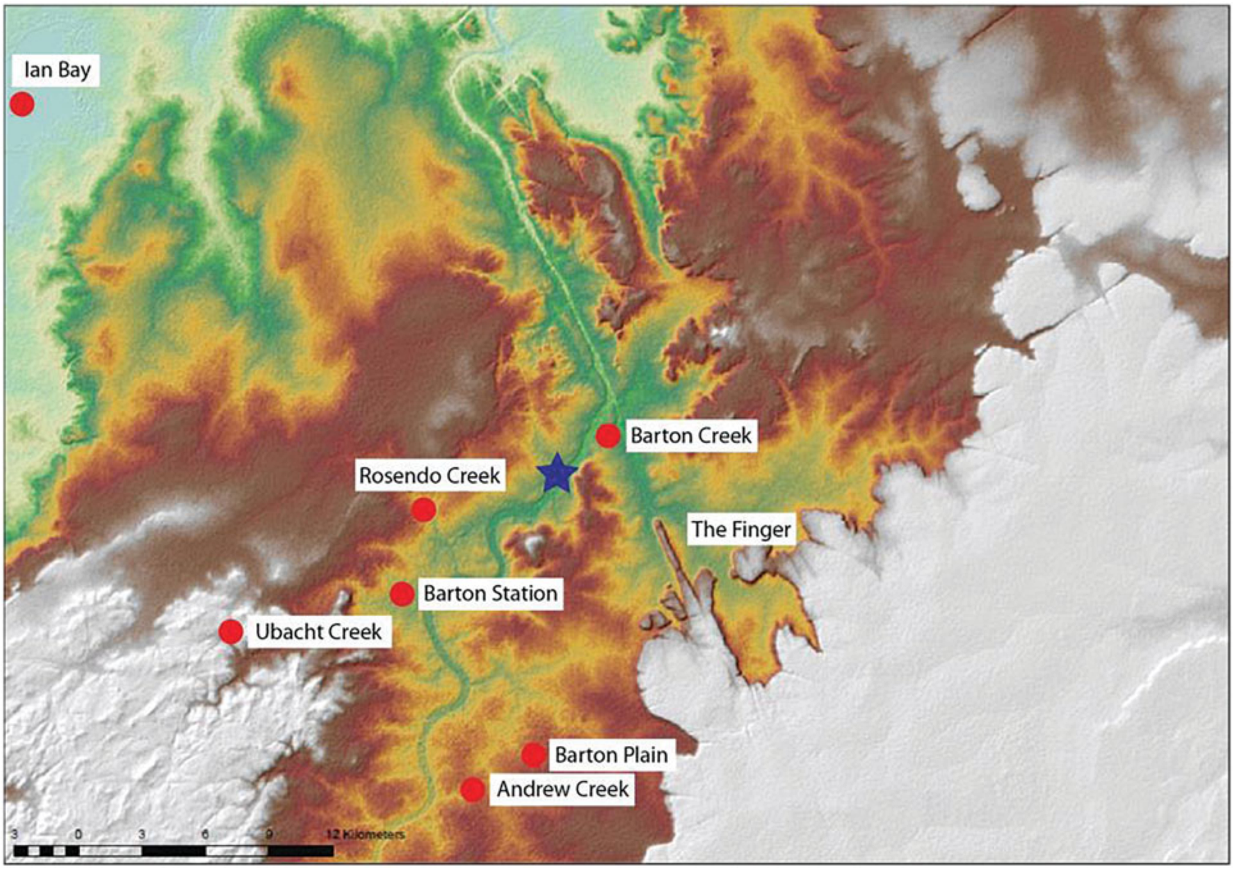

Figure 5. Digital elevation model with Minjiwarra marked by the blue star. The Drysdale River swings northwest along a fault line on the same axis as the uplands of the Warton sandstone escarpment that extends as 'The Finger' seen in the lower middle part of this figure. 30 m pixel resolution shading spans 100 m in elevation 20 to 120 m. (Figure compiled by Peter Veth and Ana Motta).

Figure 6. Left-hand side shows a bifacially flaked/edge-ground axe made from a river cobble recovered from the 'terrace mid-level deposits' of Minjiwarra by M. Morwood in 2004 (drawn by Mark Moore January 2005). Right-hand side is a heavily weathered and patinated, bifacially flaked, and edge-ground axe with an ovoid section stem from Minjiwarra that is similar to a small stemmed axe recovered from Phase 2 (c. 55 ka) at Madjedbebe (Clarkson et al. 2017). (Photo by Peter Veth).

we recovered here in 2017. The site was first described by Walsh (2000) as a dune, but, this was not supported in our subsequent inspections. While the top stratigraphical unit consists of homogenous aeolian sand, the remaining units are made of sand, silt, and clay. The compaction and composition of Units 2 to 10 show layered deposition of indurated and less compacted alluvial sediments, which is consistent with an overbank alluvial geological deposit (Boggs 2012). Indeed, Units 4, 5, and 7 (see Figure 7) show fine alternate beddings of silt and clay, typical of low energy over flooding deposition. The sediments have probably been intermittently deposited by floodwaters that have broken through or overtopped the banks of the Drysdale River, leading to different levels of preservation for the sedimentary and archaeological layers.

The erosion of some of Minjiwarra's archaeological layers has created a near-continuous scatter of larger igneous, mudstone, quartz, and

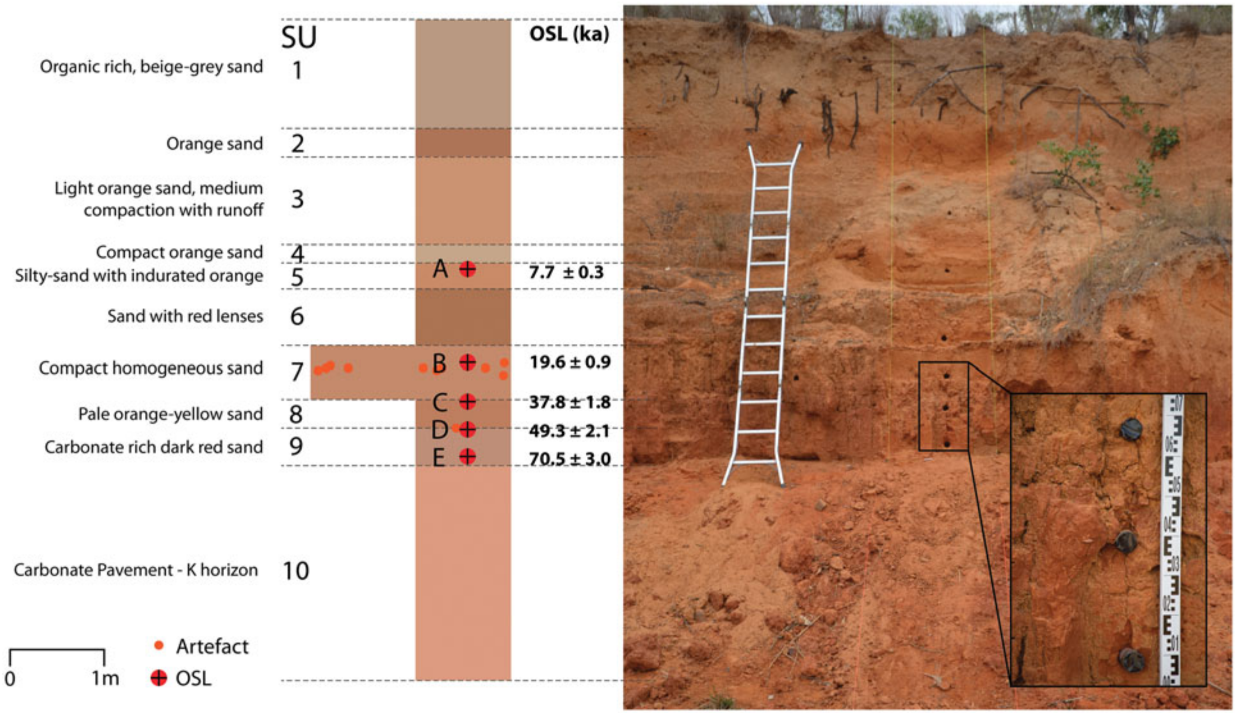

Figure 7. Location of five OSL sample points and results from the Minjiwarra section. The four samples in SUs 9, 8, and 7 are associated with in situ artefacts assumed to be Pleistocene, while the sample from SU5 is assessed as Holocene (photo by Marine Benoit).

silicified sandstone artefacts on the pavement and down into the river alluvium. This scatter occurs repeatedly in clusters for much of the 1 km length of Minjiwarra with variable assemblage density and composition. In the southwest section, minor rill and slope-wash erosion have exposed formal tools and debitage consistent with late Holocene artefacts, such as pressure-flaked Kimberley points and associated bifacial thinning flakes (see Maloney 2015; Moore 2015). In other sections of the site, pavement artefacts include unidirectional and multidirectional cores, flakes, unifacial points, knapped cobbles, and sandstone slabs with one or two flake removals.

OSL dating: samples and methods

Samples

In order to contextualise these finds chronologically, we identified ten stratigraphic units and took 5 OSL samples (see Figure 7). We planned our sampling so as to derive ages for (a) Stratigraphic Unit 5 and above, comprising lighter and less cemented sediments predicted to date to the Holocene, and (b) Stratigraphic Units 7–9, which contained visible insitu artefacts. The later units (8 to 10) are generally more compacted and cemented, with a deep red colour. Detailed description of the units can be found in Figure 7.

These five samples were submitted for dating with all luminescence work carried out at the Sheffield Luminescence Laboratory (Tables 2 and 3).

Methods

In order to derive an OSL age, both the palaeodose (De; Gy/ka) and the estimated radiation flux for the sedimentary bodies (Dose Rate; μGy/a-1) need to be determined. For the dose rate, the concentrations of potassium (K), thorium (Th), and uranium (U), the main contributors of dose to sedimentary quartz, were determined in the laboratory by inductively coupled plasma mass spectrometry (ICP) (ICP: Table 2). These were converted to annual dose rates taking into account attenuation factors relating to sediment grain size, density, and palaeo-moisture based on present-day values with a ± 3% error to incorporate fluctuations through time (Table 3). The contribution to dose rates from cosmic sources was calculated using the expression published in Prescott and Hutton (1994).

For palaeodose (De) determination, samples of quartz grains in the size range of 125–180 µm were extracted and cleaned as per Bateman and Catt (1996). Prepared grains were mounted as a 5 mm diameter monolayer on 9.6 mm diameter stainless steel disks. Samples were measured using a Risø DA-20 luminescence reader with stimulation provided by blue/green LEDs and luminescence

Table 2. Summary of dosimetry related data

Lab Code[a]	Field Ref	U (PPM)	Th (PPM)	K (%)	Dcosmic (μGy/a^{-1})	Moisture (%)	Dose rate (μGy/a^{-1})
Shfd17118	OSL A	1.68	4.4	0.4	139±7	0.8	1,278±49
Shfd17119	OSL B	2.10	7.3	0.5	126±6	3.5	1,629±62
Shfd17120	OSL C	1.90	5.7	0.5	119±6	2.7	1,475±57
Shfd17121	OSL D	2.11	6.9	0.6	114±6	7.5	1,613±63
Shfd17122	OSL E	1.78	5.0	0.5	107±5	3.3	1,376±54

[a]All samples: Latitude: 14°12′ (S); Longitude: 126°57′ (E); Altitude: 55 m.

Table 3. Summary of single grain palaeodose data and ages for Minjiwarra.

Lab Code	Field Ref	Sampling Depth	De (Gy)	Over-dispersion (%)	Age (ka)
Shfd17118	OSL A	2.8	9.85±0.11	5	**7.7±0.3**
Shfd17119	OSL B	3.6	31.9±0.86	15	**19.6±0.9**
Shfd17120	OSL C	4.0	55.8±1.67	15	**37.8±1.8**
Shfd17121	OSL D	4.4	79.4±1.24	21	**49.3±2.1**
Shfd17122	OSL E	4.9	69.9±1.61	7	**70.5±3.0**

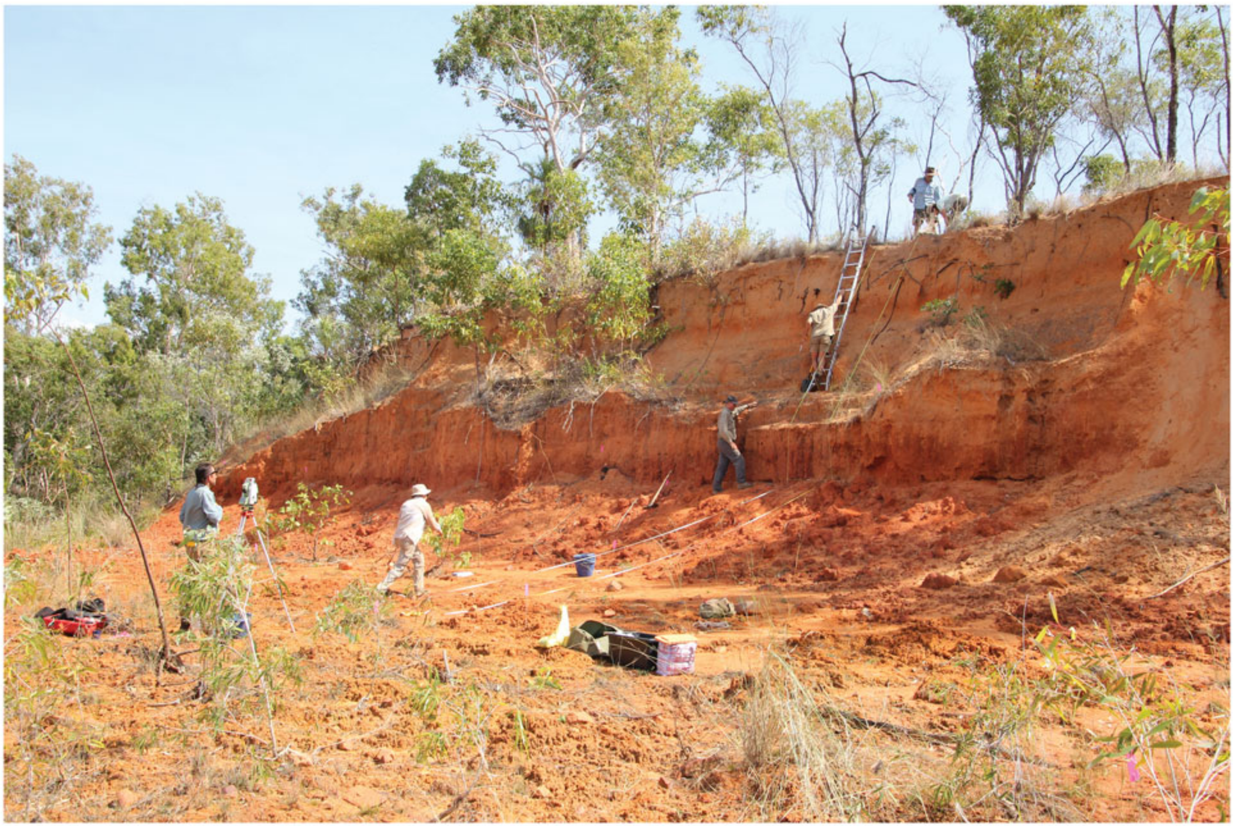

Figure 8. Preparing the column into the exposed section of Minjiwarra. In situ artefacts were recorded in the lower heavily cemented ped unit and eroding from the ledge above this (at chest height of PV standing next to ped bench). The ladder is secured on the next ledge above and to the apex of the feature (Photo by Sven Ouzman).

detection was through a Hoya U-340 filter. Samples were analysed for their De using the single aliquot regenerative (SAR) approach (Murray and Wintle 2003), with the preheat of 240 °C for 10 seconds optimised from a dose recovery preheat plateau test. Each sample possessed good luminescence characteristics with a rapid decay of OSL with stimulation and OSL signals dominated by a fast component.

The De replicate distributions of all samples were normally distributed with low levels of scattering (OD <20%; values given in Table 3). The data shows no indication that either partial bleaching or post-depositional disturbance (Bateman et al. 2003, 2007) has influenced the Minjiwarra samples and therefore the ages should reflect true burial ages. De values for age calculations were extracted using the Central Age or Common Age Models (CAM or COM) of Galbraith and Green (1990). Ages are quoted in years from the present day (2018; Table 3).

Stone artefacts and dating associations

A one metre wide column was cleaned back to reveal a clean section, utilising the steep erosion face of the feature and focussing on the largest aggregation of artefacts that were clearly in situ (Figure 8). Systematic surveying of the entire one kilometre long feature only located artefacts in primary context within a 30 m band centred on this column section. A significant number of artefacts (c. 50) were in secondary contexts along the lower faces of the alluvial feature often on small peds.

The preliminary Minjiwarra stone artefact assemblage described here only includes artefacts that were unequivocally in situ and associated with the OSL dates, as well as surface artefacts which have probably been reworked from the deposits onto the carbonate pavement. The assemblage is small ($n = 27$) and so only basic observations and metrics are reported here. The definitions for flake, core, and tool classes in Tables 4–6 follow Holdaway and Stern (2004). It should be noted that 'tools' in Table 4 are simply defined as artefacts that retain edge retouch or with evidence for use (i.e. use-wear). 'Complete tools' meet the definition for complete flakes (Holdaway and Stern 2004:111) but retain use-wear or retouch. The same is true for distal tools and so on (see Holdaway and Stern 2004). The tool types are detailed further in Table 5. The basic metric attributes for the Minjiwarra artefacts are displayed in Table 4, illustrating that most of the artefacts are large, particularly the silicified sandstone artefacts. This should come as little surprise since silicified sandstone is immediately available as sub-rounded river cobbles.

Table 4. Basic metric data for the Minjiwarra stone artefact assemblage. Maximum dimensions in millimetres and weight in grams.

		Max. length		Max. width		Max. thickness		Weight	
Raw material and flake class	No.	μ	σ	μ	σ	μ	σ	μ	σ
Crystal quartz									
core	1	82.0	–	48.0	–	45.4	–	170.7	–
Igneous									
Complete split flake	1	78.4	–	66.4	–	17.3	–	81.5	–
Complete tool	5	107.7	16.26	82.7	23.97	31.1	2.78	371.4	108.20
Mudstone									
Angular fragment	1	45.8	–	16.3	–	9.2	–	6.5	–
Broken flake	1	27.1	–	19.7	–	5.7	–	3.3	–
Complete flake	3	66.7	20.66	53.2	22.31	16.1	6.13	61.3	64.25
Complete tool	3	91.0	39.48	50.0	19.00	21.9	13.11	125.6	148.51
Core	4	110.4	23.41	87.2	23.00	55.8	13.59	794.6	653.96
Distal tool	1	82.6	–	68.2	–	24.1	–	144.9	–
Silicified sandstone									
Complete flake	1	121.6	–	92.9	–	24.6	–	283.9	–
Complete tool	1	188.3	–	157.1	–	37.1	–	1382.0	–
Core	3	136.2	21.52	105.9	9.56	64.8	18.87	1230.3	158.86
Core fragment	2	98.7	13.17	67.7	16.60	51.6	26.23	357.1	301.93

Table 5. The number of tools and core types at Minjiwarra. Test cores refer to cores with only one or two negative flake scars.

Tools and cores	Crystal quartz	Igneous	Mudstone	Silicified sandstone
Tools				
Bifacial tool	0	0	1	0
Nuclear tool (chopper)	0	1	0	1
Ground edge axe	0	3	0	0
Unifacial point	0	0	1	0
Scraper	0	1	2	0
Cores				
Core-tool	0	0	2	1
Multi-platform	1	0	1	1
Single platform	0	0	1	1
Test	0	0	0	2

Table 6. Depths of OSL samples and in situ artefacts.

ID	Age (ka)	Type	Material	Depth	Comment
OSL_A	7.7±0.3	–	–	2.80	–
OSL_B	19.6±0.9	–	–	3.60	–
ART_1_12	–	Broken flake	Mudstone	3.67	–
ART_1_4	–	Angular fragment	Mudstone	3.68	–
ART_1_5	–	Core	Sil. Sandstone	3.69	Test core
ART_1_6	–	Complete tool	Igneous	3.71	Ground-edge axe
OSL_C	37.8±1.8	–	–	4.00	–
ART_1_13	–	Complete tool	Mudstone	4.27	Scraper
ART_1_11	–	–	–	4.29	–
OSL_D	49.3±2.1	Complete flake	Mudstone	4.40	–
OSL_E	70.5±3.0	–	–	4.90	–

Figure 9. In situ ground edge axe (ART_1_6). Note grinding striations on the polished surface (upper right lateral margin).

Large flakes, tools, and cores could be easily produced from these cobbles for expedient use at Minjiwarra. Both the crystal quartz and igneous artefacts, while few, are also large and their source locations are currently unknown. The same is true for mudstone but, interestingly, there is more variation in the size of these artefacts (Table 4).

Table 5 shows tool and core type counts for Minjiwarra. Tools are almost exclusively manufactured using igneous and mudstone material while cores are almost exclusively represented by mudstone and silicified sandstone. A wide variety of cores are present, with little patterning. Igneous tools retain a large proportion of volume (e.g. ground edge axes and nuclear tools) while mudstone tools generally have a larger proportion of surface area and cutting edge (e.g. points and other bifacial tools; see also Table 4). This probably derives from raw material selection where specific qualities (e.g. toughness versus edge sharpness) required for anticipated tasks were targeted. The tools and cores are not dissimilar to those found throughout the Kimberley where both Pleistocene edge-ground axe and Holocene point technology is well established (Hiscock et al. 2016; Maloney et al. 2018). It is worth noting that some of these specimens are very weathered and patinated (e.g. Figure 6), which may be an indication of considerable antiquity.

Table 6 shows the depth of the in situ artefacts recovered from Minjiwarra within and immediately adjacent to the 1 m wide section (see Figure 7) and their associated OSL ages. The table demonstrates a clear association between the onset of artefact deposition and OSL samples, suggesting occupation of Minjiwarra and the surrounding landscape from c. 50 ka (49.3 ± 2.1 ka). Two mudstone artefacts and a scraper occur within c. 10 cm from OSL D dated to 49.3 ka. The complete edge-ground axe is worthy of note. Occurring in association with sample OSL C (37.8 ± 1.8 ka), it clearly demonstrates the presence of this technology in the Kimberley at this time and is consistent with the 44–49 ka date for a small flake from a similar axe found in the south-west Kimberley (Hiscock et al. 2016). The Minjiwarra complete edge-ground axe specimen is depicted in Figure 9.

Discussion and conclusions

The Warton and King Leopold sandstones of the north Kimberley are slow weathering which, combined with the dominant shelter morphologies, may be a factor in the generally shallow deposits noted.

Despite concerted attempts since 2016 to locate deeply stratified sites, these have proved to be uncommon in shelter contexts. Deposits in most of the 9 excavations are relatively shallow – less than 1 m – and have returned post-LGM dates, mostly in the mid to late Holocene range. The exception of greater than 2 m is the large open site of Oomarri on the King George River (KGR037, Table 1).

This is a valuable record of Holocene and recent occupation but does not generally extend into the Early Holocene and Pleistocene. Fortunately, the *Kimberley Visions* project has also located several large and stratified open sites. At least one of these sites, located on the King George River some 40 km east of Minjiwarra, has several metres of deposit and has returned a late Pleistocene date, and is the focus of Benoit's doctoral research. Minjiwarra is several orders of magnitude larger than these open sites.

A conservative reading of the age of the artefacts recovered from Minjiwarra sees the onset of occupation with whole tools and debitage from 51.4 ka–47.2 ka. This is a remarkably similar age range, and indeed overlaps with the modelled ages for earliest occupation of Kimberley sites such as Carpenter's Gap 1 and Riwi in the Devonian Reef system (Wood et al. 2016), and Parnkupirti at Lake Gregory on the Kimberley-desert edge (Veth et al. 2009). It also overlaps with the first dates for occupation at Boodie Cave in Australia's north-west arid coastal zone (Veth et al. 2017), Nawarla Gabarnmang in the Northern Territory (David et al. 2018) and Warratayi from the Flinders Ranges of South Australia (Hamm 2016). Researchers have used a combination of complementary dating techniques on these sites and also integrated genetic sequences from different global laboratories to reach remarkably similar dates for the first occupation of the continent (O'Connell et al. 2018; Tobler et al. 2017; Veth 2017). The Northern Territory site of Madjedbebe (Clarkson et al. 2017) at 65 ka is currently the only outlier in this group and has recently been subjected to critiques on different fronts (O'Connell et al. 2018; Veth 2017; response by Clarkson et al. 2018). Traditional rock shelter-based research thus must be broadened to include large fluvial-derived features such as Minjiwarra in the sandstone provinces, as they appear to cover the entire span of potential human occupation. The continued investigation of large open sites in the Kimberley, which necessarily provide a different kind of human occupational record to discrete and geologically constrained shelters, may help flesh out the full record of human occupation for early settlement.

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