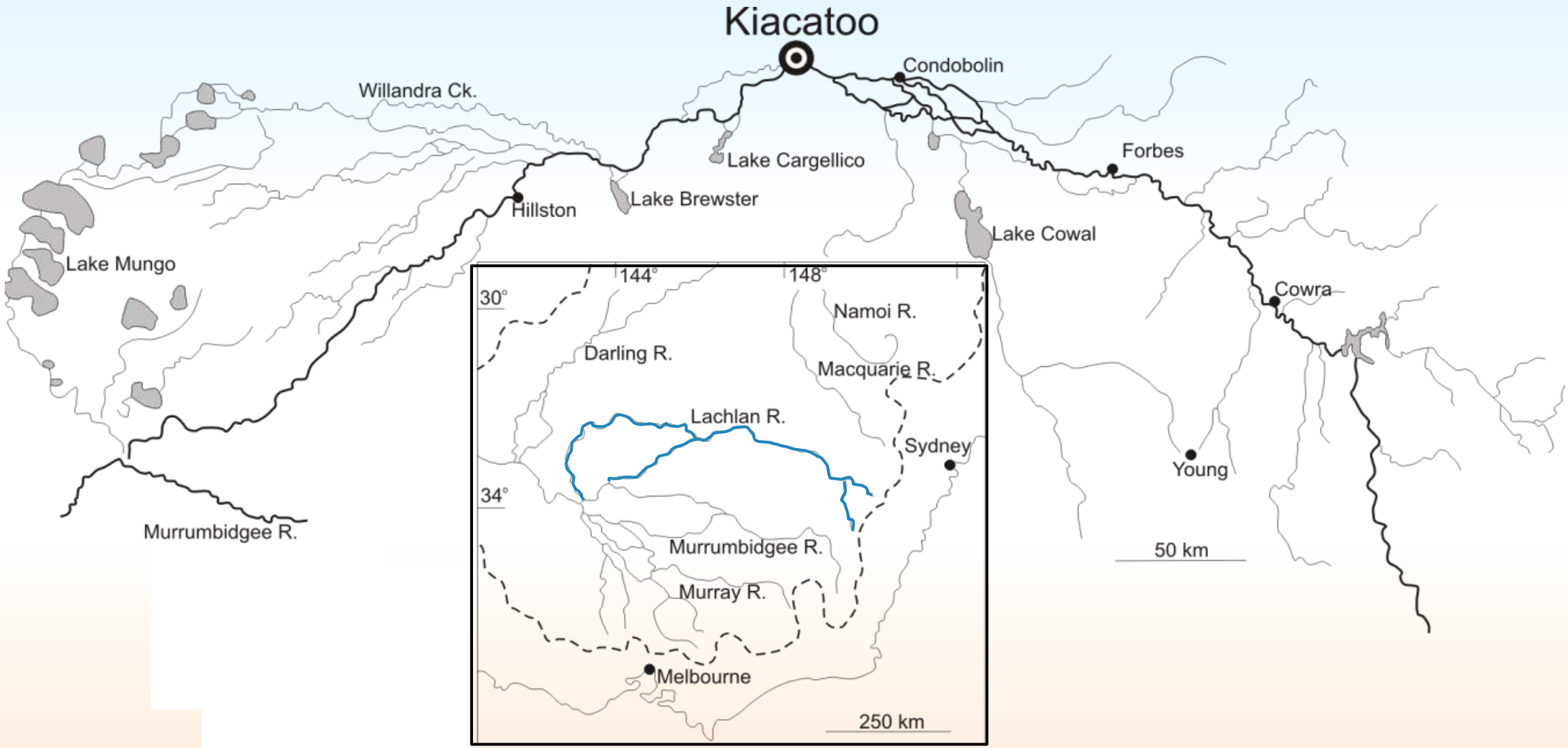
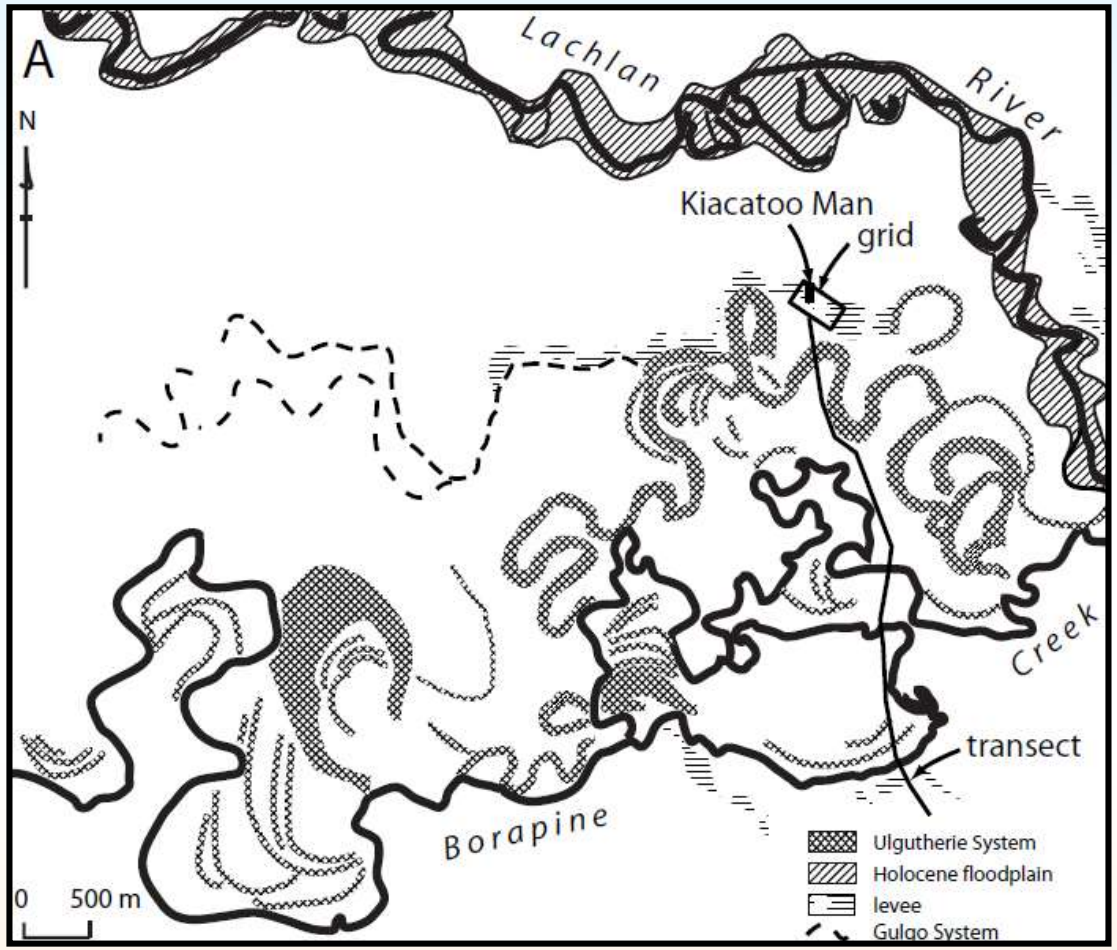
OSL and U-series dating of the burial site and skeleton of Kiacatoo Man

Justine Kemp, Tim Pietsch, Jon Olley, Rainer Grün, Colin Pardoe, Rachel Wood

Griffith UNIVERSITY


Kiacatoo
Condobolin
Willandra Ck.
Forbes
Lake Cargellico
Hillston
Lake Brewster
Lake Cowal
Lake Mungo
Cowra
Young
Murrumbidgee R.
50 km
144°
148°
30°
34°
Namoi R.
Darling R.
Macquarie R.
Lachlan R.
Sydney
Murrumbidgee R.
Murray R.
Melbourne
250 km

Environmental setting



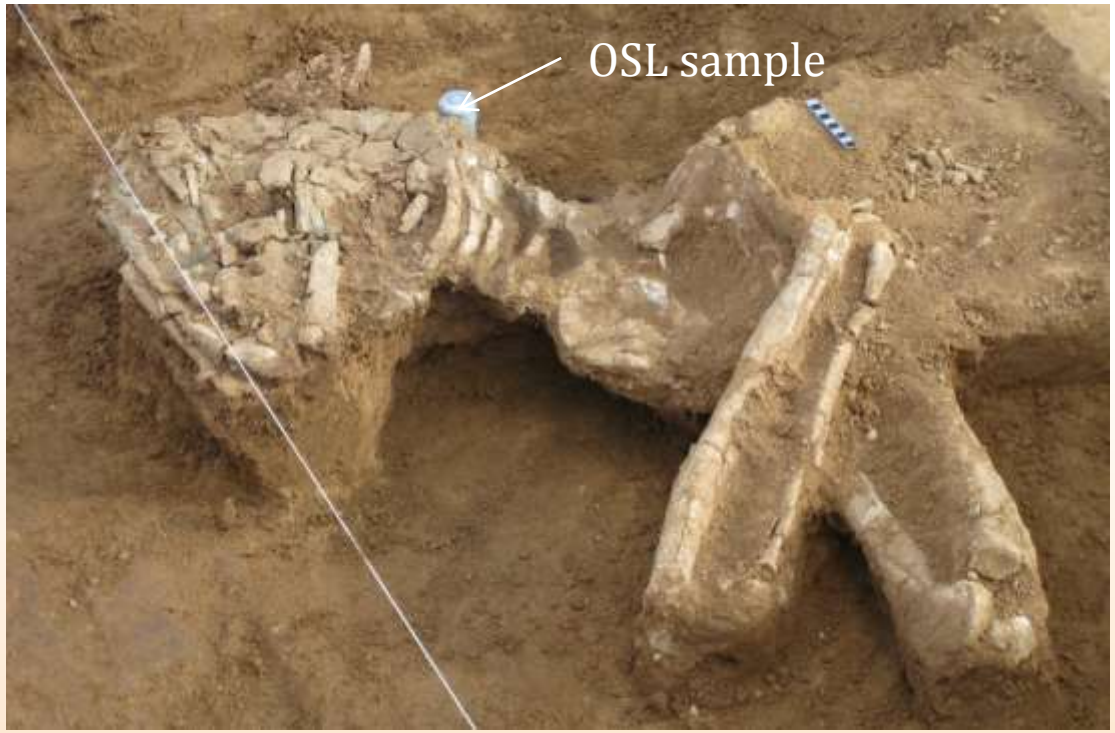
Anabranching riverine plains of the Lachlan upstream from Kiacatoo Weir

1. Large meandering Ulgutherie system south of the present river, now Borapine Creek.
2. Reduction in flow producing smaller channel, occasionally underfit. Active flood deposition on levee banks.
3. Channel avulsion to modern Lachlan floodplain
4. Lateral migration within the incised trough with palaeochannels acting as flood channels for the modern river.

Excavation

Colin Pardoe examining the emerging fossil

OSL samples were extracted from a trench above (3) and below (3) the grave base.



Excavated skeleton of Kiacatoo Man following removal of the cranium

Good preservation of bone, but many small fractures from soil movement and [as we now know] vehicle traffic

food remains or burial goods?

Larger right side indicates right-handedness

The (healed) finger was likely broken in a fight or accident.

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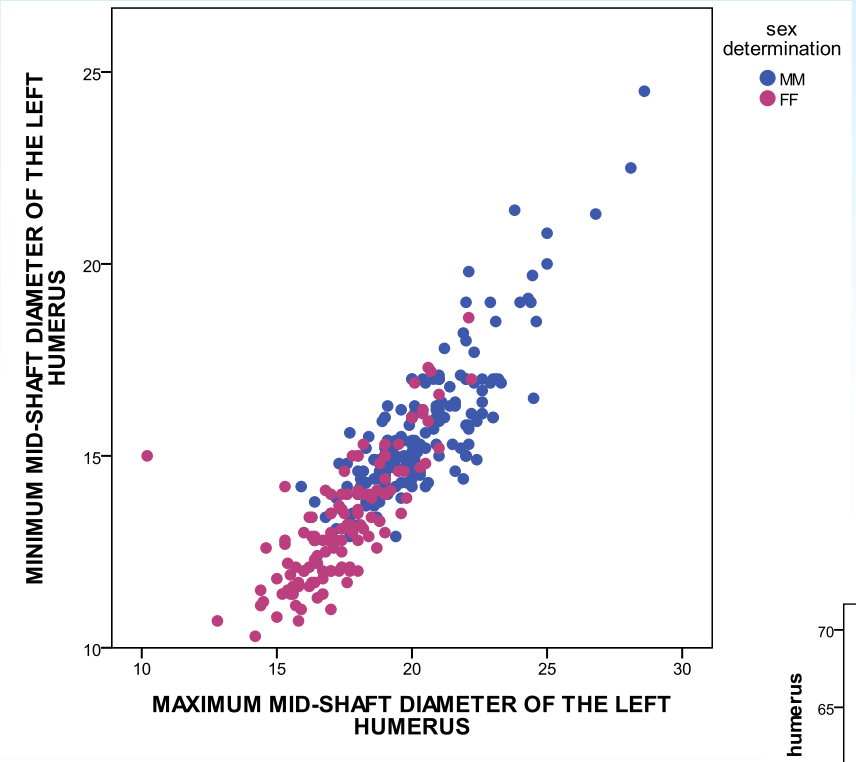
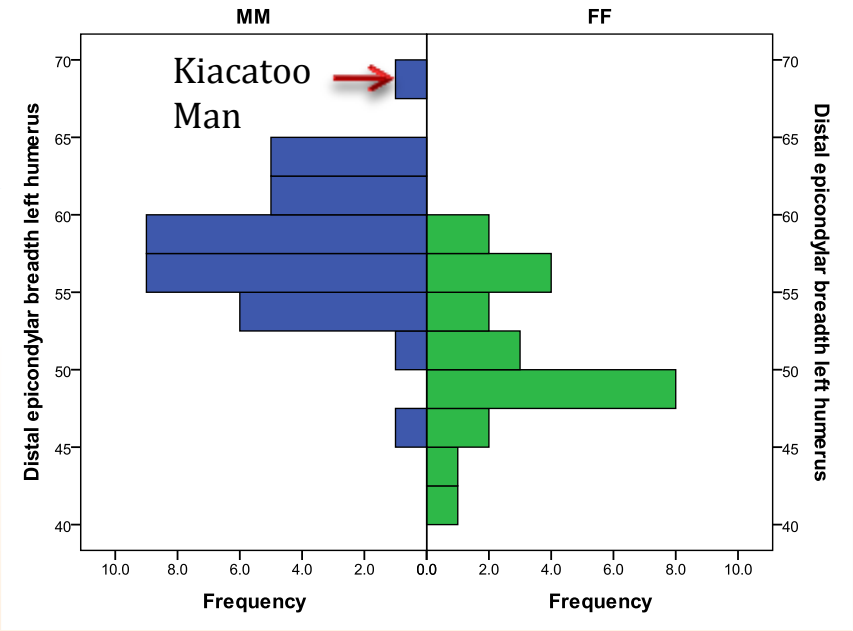
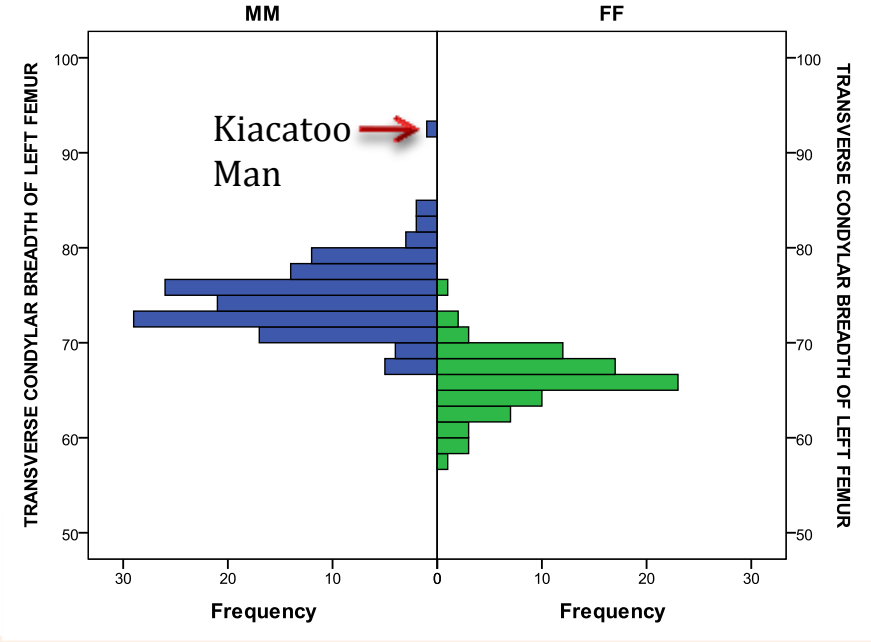
Large body size, “rugosity”, is typical of Pleistocene Australia

Body mass decreases by about 15% in the early Holocene

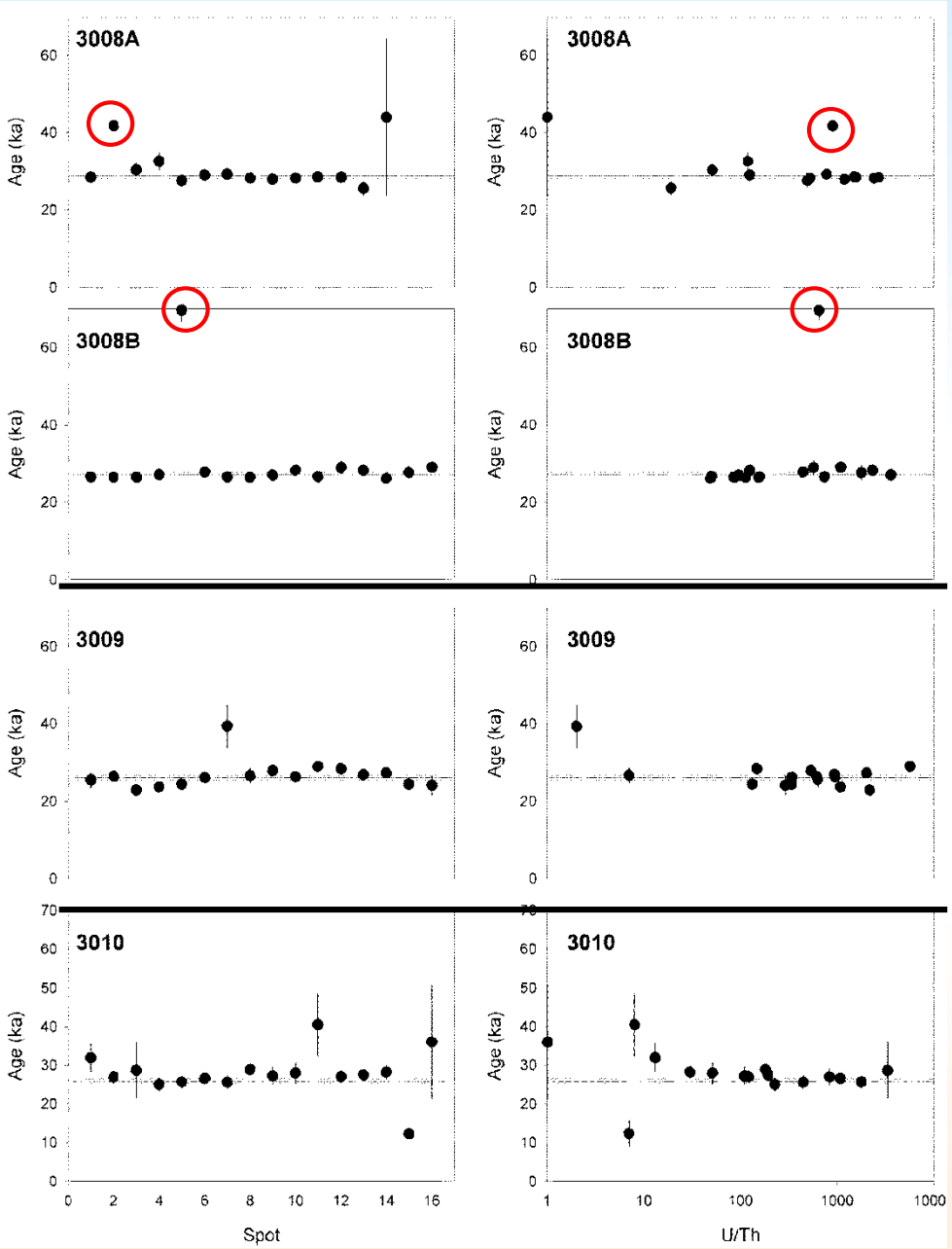


Upper arm shaft diameters indicate overall size.

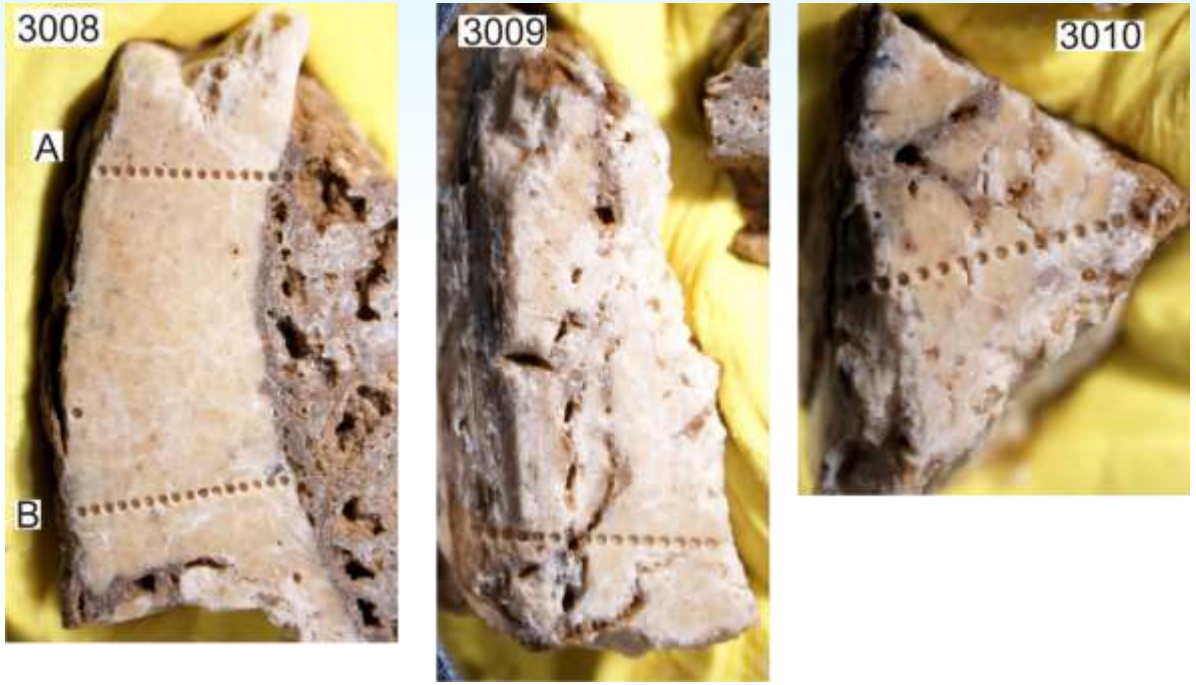




U-series results



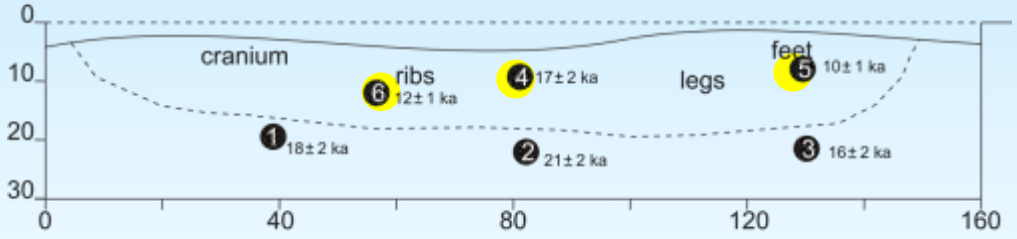
Calculated U-series age for each spot (left) and same data plotted against U/Th ratio. Solid line indicates weighted mean averages.



Weighted mean age of **27.4±0.4 ka** (minimum age)
No evidence for slow diffusion with depth into bone.
Therefore assumed fast diffusion-absorption model for U uptake.
Excludes U/Th<30 and two outliers.

7

OSL results (FMM)



Grave infill: 10-17 ka

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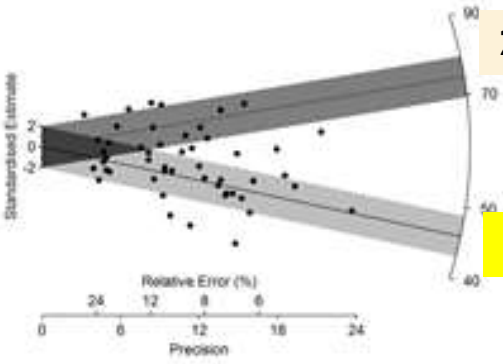

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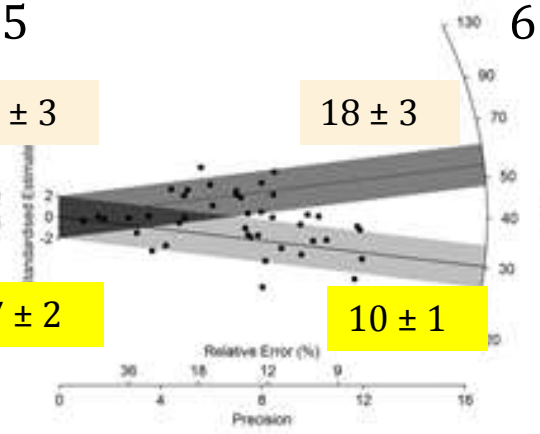

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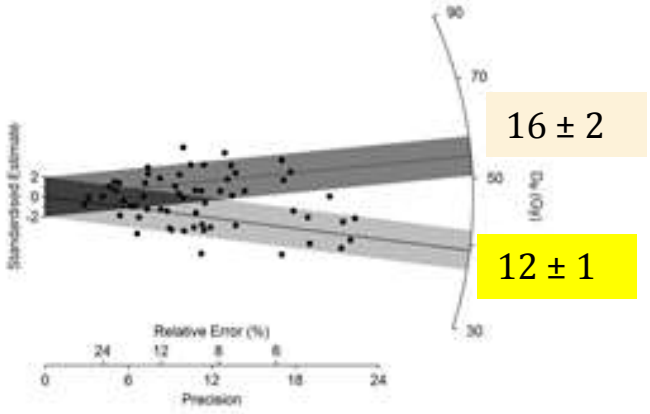
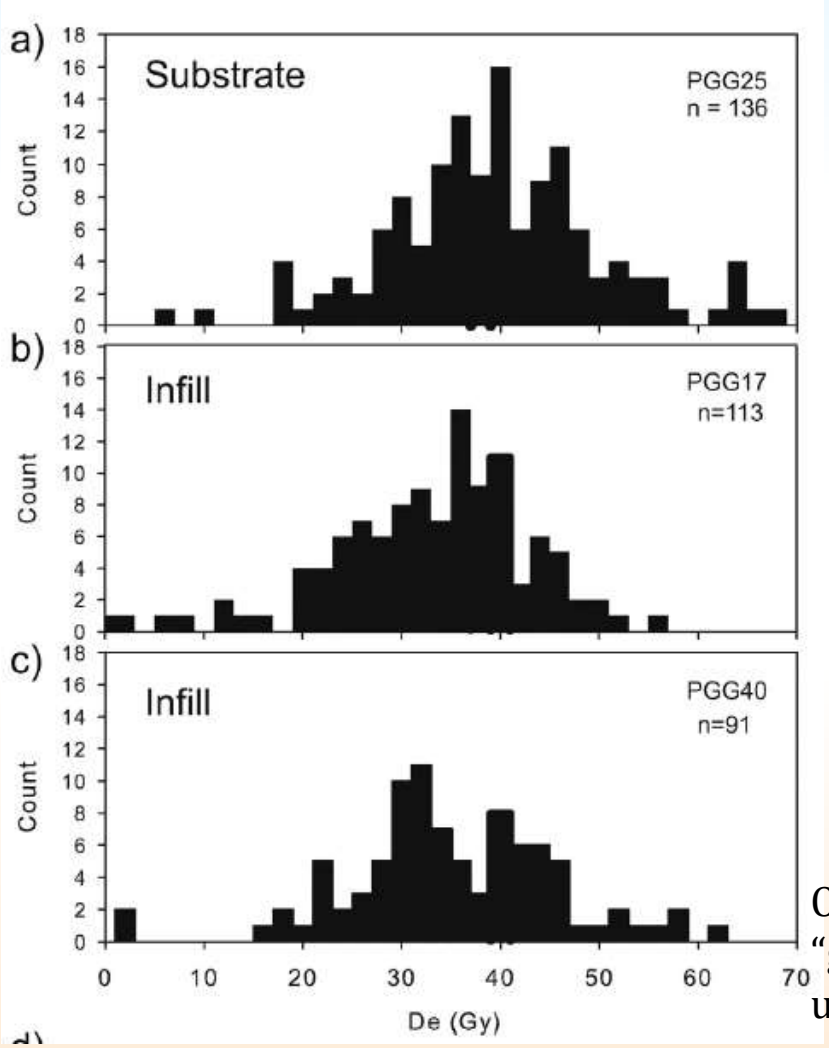


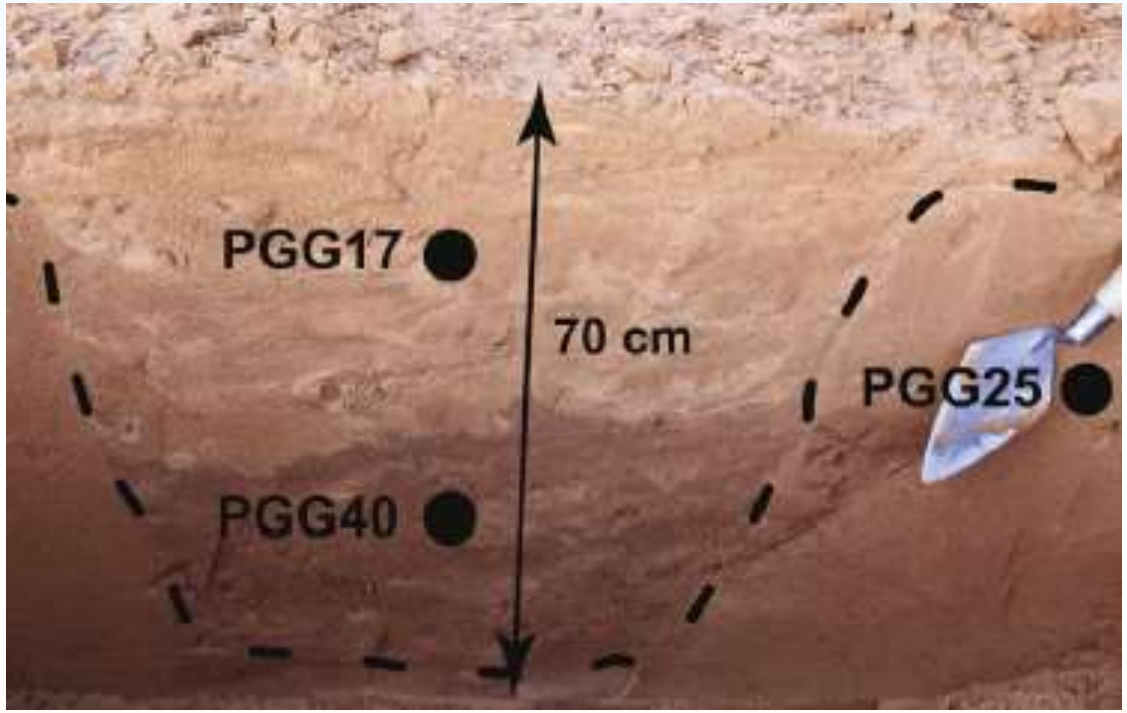
Dose rates 1.7-3.3 Gy/ka

Digging your own grave….

Kemp et al. (2014) *Journal of Human Evolution*

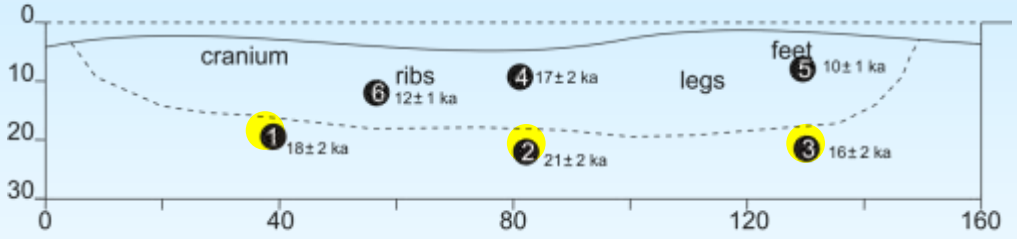


OSL results for "grave fill" and undisturbed substrate



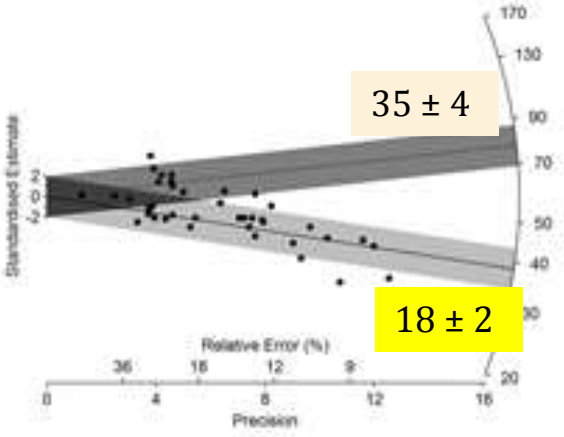
Experimental grave digging at Lake Golgolo, Willandra Lakes. Outline of the "grave" is clearly visible.

OSL results (FMM)



Underlying substrate: 16-21 ka

1



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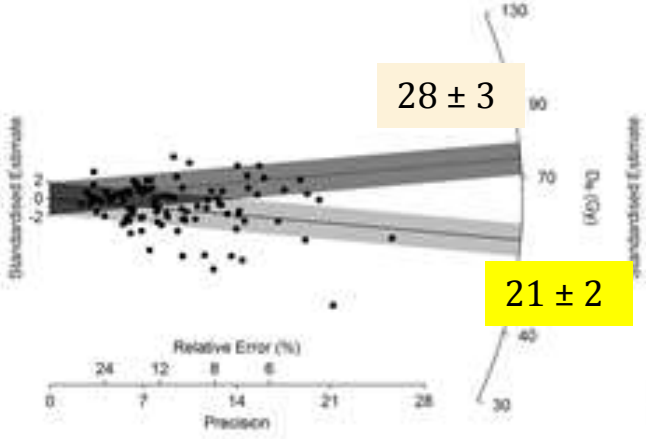

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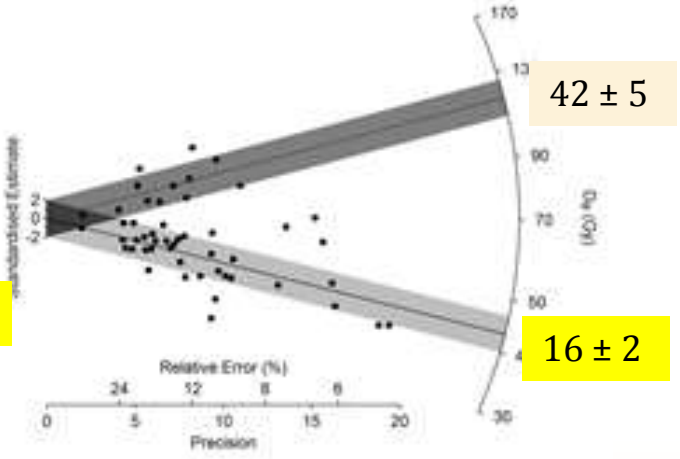

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Quantifying processes of pedogenesis using optically stimulated luminescence

U. Stockmann[a], B. Minasny[a], T. J. Pietsch[b] & A. B. McBratney[a]

[a]*Department of Environmental Sciences, The University of Sydney, Biomedical Building C81, 1 Central Avenue, Australian Technology Park, Eveleigh, NSW 2015, Australia, and* [b]*Australian Rivers Institute, Griffith University, Nathan Campus, 170 Kessels Road, Nathan, QLD 4111, Australia*

Summary

New analytical techniques have opened up the possibility of addressing rates of soil processes quantitatively. Here, we present the results of an investigation into the use of single-grain optically stimulated luminescence (OSL) dating to derive rates of soil mixing in the top 50 cm of soil profiles from two toposequences situated in the Werrikimbe National Park in Australia. Of 500 single grains analysed from each sampled depth increment, less than 25% provided a finite age, with the rest of the grains either non-responsive or dose-saturated. This proportion of finite-age grains tended to decrease with soil depth. Median ages of quartz grains increased down the soil profile, with topsoil ages of up to 500 years and subsoil ages of up to 5000 years. Few 'younger' grains were found deeper in the profile and few 'older' grains near the soil surface. These trends suggest that pedoturbation is resulting in vertical transport of grains through the profile, but that there is a distribution of transport distances, with a poor probability of large transport distances from surface to subsoil or *vice versa* compared with a more frequent movement of grains to and from the surface in the uppermost 10–35 cm. The calculation of a single age for each soil horizon was unachievable as each horizon contained a heterogeneous mixture of grains with varying histories of transport to and from the soil surface. Soil mixing was confirmed along both toposequences studied. However, the occurrence of minor mixing rates did not lead to a homogenization of the topsoil and adjacent horizons. We postulated that mixing velocities were mostly related to flora at our study site. Vertical soil mixing rates of 0.5 and 0.2 mm year^{-1} were calculated from the distribution of finite single-grain ages.

Introduction

Soils are complex natural systems composed of a variety of interconnected physical, biological and chemical components. To understand their complexity it is important to investigate soil formation processes quantitatively, addressing questions such as 'at what rate does soil evolve over time?' and 'how fast are the rates of soil turnover occurring in the profile and how does this influence pedogenesis?' (Minasny *et al.*, 2008). Recently, there has been a growing interest in quantifying the rate of soil formation and improving our understanding of pedogenesis (Minasny *et al.*, 2008). While some work has focussed on mechanistic modelling of soil formation (Salvador-Blanes *et al.*, 2007; Finke & Hutson, 2008; Sommer *et al.*, 2008), direct measurement of soil-forming processes is required (Bockheim & Gennadiyev, 2009) to validate and improve the models.

Correspondence: U. Stockmann. E-mail: uta.stockmann@sydney.edu.au

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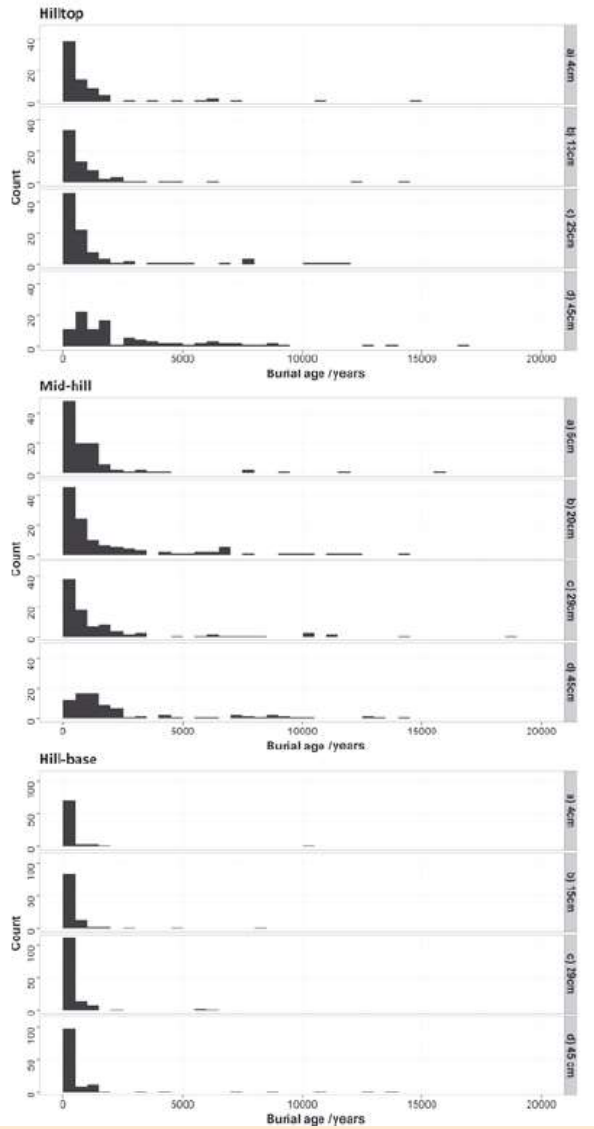
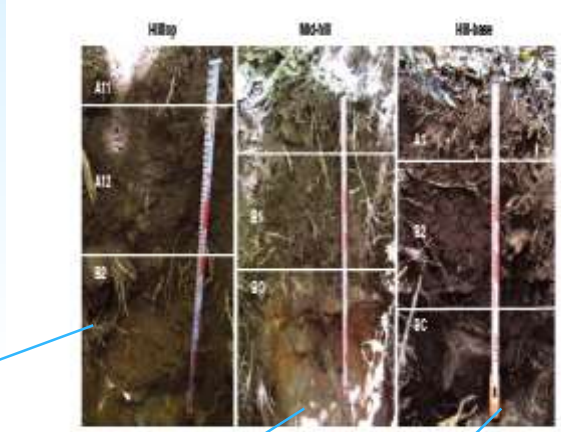
Here, we study the application of single-grain optically stimulated luminescence (OSL) for deriving rates of soil mixing and for potentially determining the age of soil horizons. This allows us to examine the changing periodicity of transport with depth. It is assumed that rates of allocation of single grains from and to the soil surface decrease down the soil profile.

Background to the application of OSL in soil science

Optically stimulated luminescence is a dating method that is based on determining the time elapsed since crystalline materials were last exposed to sunlight. For dating sediments, this exposure is assumed to occur during transport prior to deposition, whereas within soils the exposure mechanism of primary interest is the movement of grains, usually sand-sized grains of quartz, to and from the surface by pedoturbation, including bioturbation. When buried, quartz grains acquire a radiation dose, because they are exposed to ionizing radiation emitted by radionuclides in the surrounding material, as well as cosmic radiation. The radiation dose

Dr Uta Stockmann
(SSSA NSW)





OSL results (CAM)

Levee and floodplain sediments

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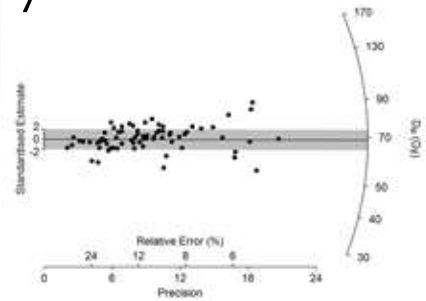

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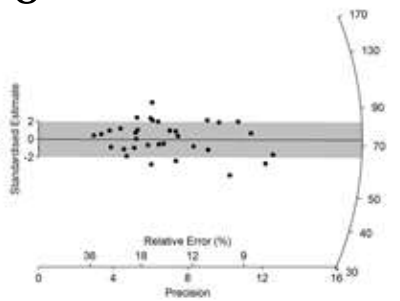

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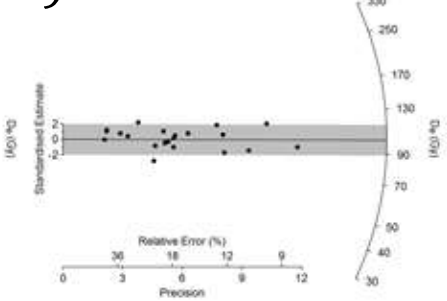
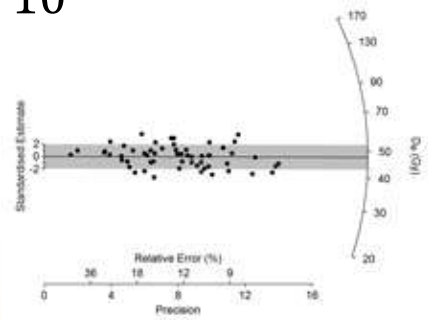
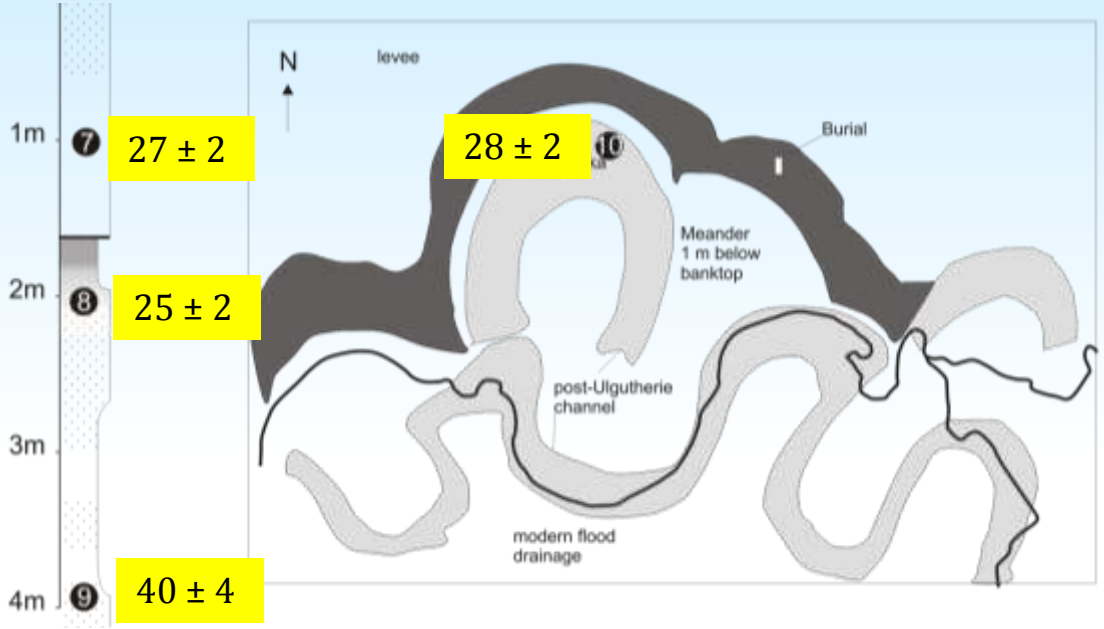


channel bed sediments

10





OD<20%

Maximum age of 27 ± 2

U-series Minimum age of 27.4 ± 0.4

= 27 ka

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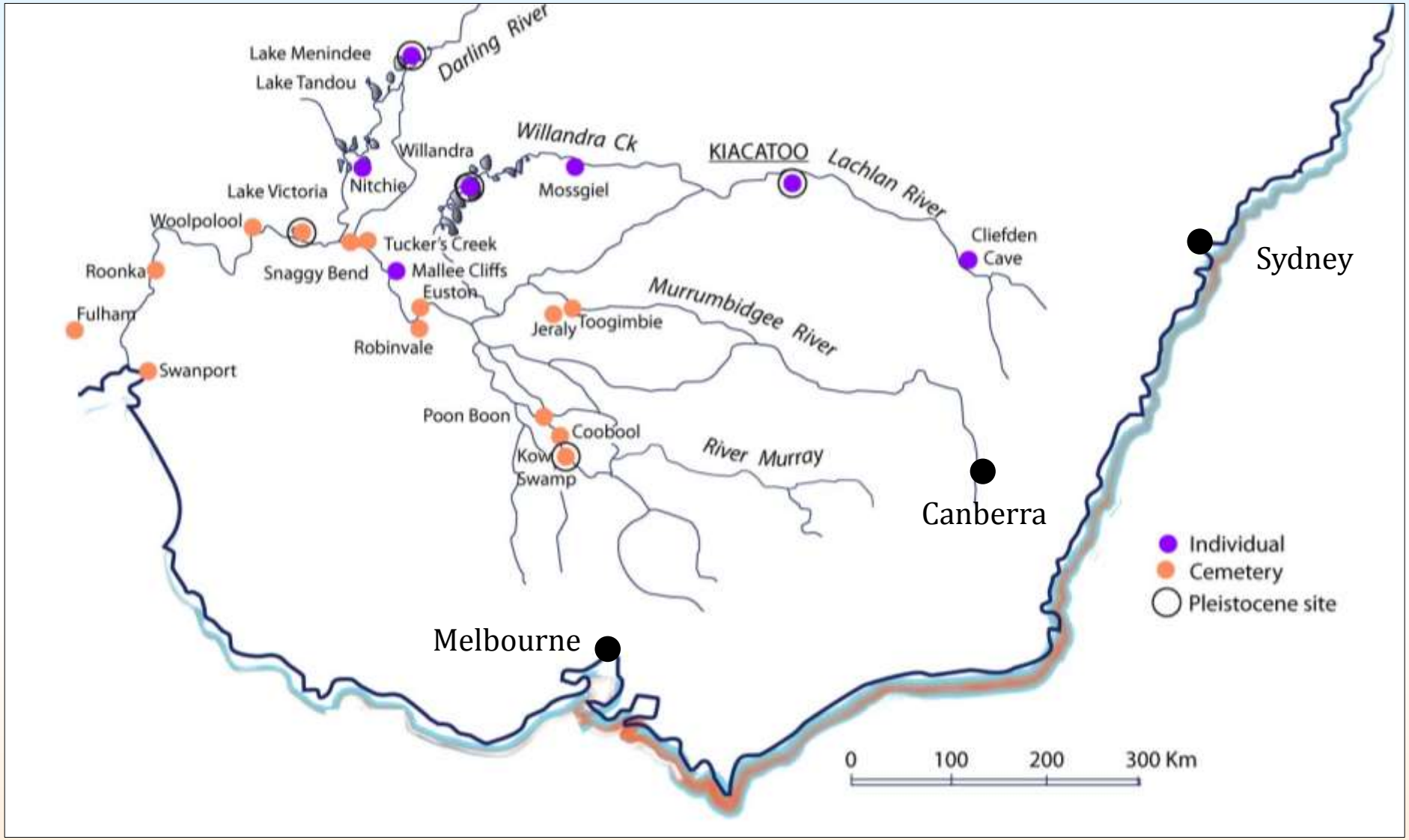

Locations of Pleistocene and Holocene burial grounds and cemeteries in the lower Murray-Darling Basin.
After Pardoe (1995)

Summary

- More than one age method is required for significant human fossils.
- Kiacatoo Man is largest Pleistocene individual yet discovered in Australia, and possibly the most robust.
- Further evidence that “rugosity” or “robusticity” corresponds to the LGM, at least in the eastern tribes. Lithe, gracile desert people inhabited the lower Lachlan, Darling and Murray during the same period.
- Kiacatoo Man provides the first direct evidence for a Pleistocene human presence on any of the riverine corridors upstream of Willandra Lakes.
- But extensive searches have not been made. Sandy source-bordering dunes and levees may hold the key to understanding the distribution of people during the LGM, whether they ranged widely or retreated to the river systems as the lakes dried.