BIOGEOCHEMICAL CONTRIBUTIONS TO THE MEGAFAUNAL EXTINCTION DEBATE

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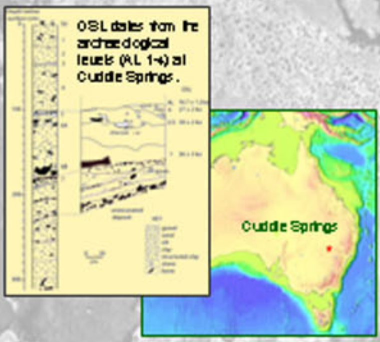
Diprotodon optatum, one of the megafaunal species found at Cuddie Springs. *D. optatum* is related to the modern-day wombat, and grew to the size of a rhinoceros (Drawing: Ann Musser, Australian Museum).

Climate Change, Human Impact & Megafaunal Extinctions

During the Late Pleistocene, over 20 genera of megafauna disappeared from the Australia-New Guinea landmass of Sahul.[1,2] These extinctions broadly coincided with projected dates of human arrival. Some researchers support a human-mediated extinction model where large-bodied animals were rapidly driven to extinction between 50ka to 40ka, via over-hunting and habitat modification.[3,4] Others point to climatic instability in the Late Pleistocene as a major driving force behind the megafaunal extinctions.[5] At Cuddie Springs, stone artefacts are found in association with the bones of now-extinct megafauna in sediments dated from ~36ka to ~30ka, representing a human-megafauna overlap of at least 16ka.[6]

Remains of *Sthenurus*, a short-faced kangaroo, have been found in the late Pleistocene sediments at Cuddie Springs (Drawing: Ann Musser, Australian Museum).



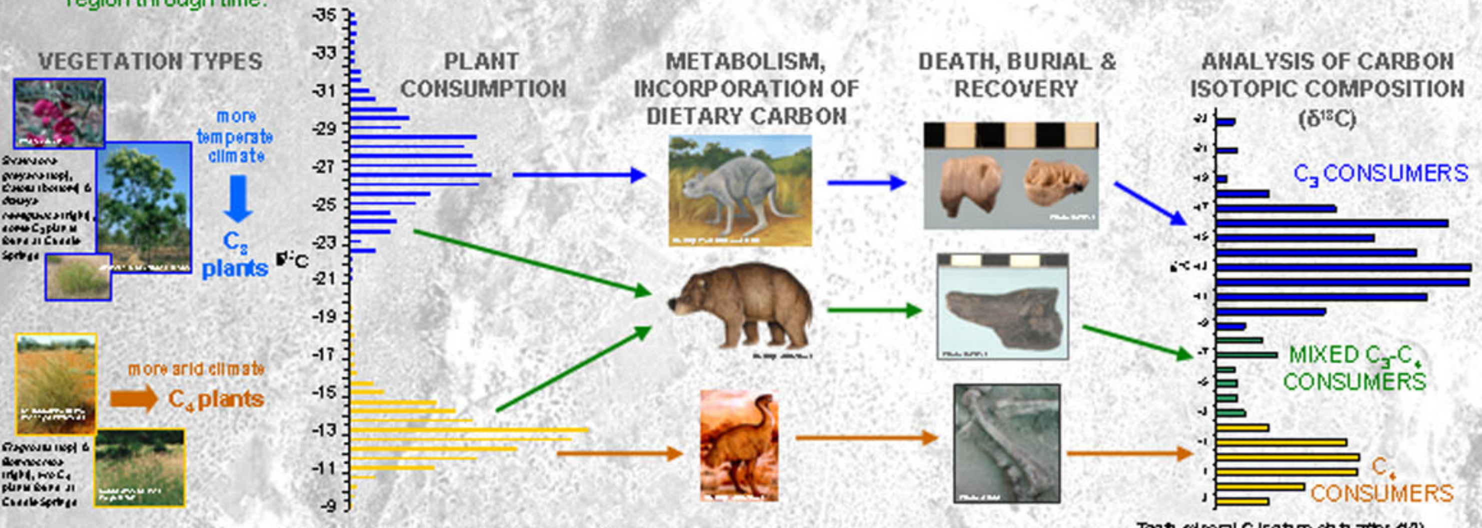
Assessing Environmental Change at Cuddie Springs

The prolonged co-existence of humans and megafauna at Cuddie Springs highlights the need to investigate the possible role of climate change in the decline of the Australian megafauna. The palynological evidence suggests that the phase of megafaunal decline and eventual disappearance from the fossil record (~30ka) coincided with the onset of a period of ephemeral lake conditions and increased grassland cover, followed by a period of pronounced aridity and extended dry lake conditions.[7] The biochemical analysis of megafaunal bones and teeth from Cuddie Springs can provide us with further information about the environment in which these animals lived.

Mandible of a *Protemnodon* cf. *brehus* (above) & a *Diprotodon optatum* molar (left) from Cuddie Springs (Photos: K. Privat)

Stable Isotope Analysis of Megafaunal Bones & Teeth: A Palaeoenvironmental Indicator

When an animal feeds on a plant, the carbon in the plant is partially incorporated into the animal's body, e.g., into bone and tooth mineral. The carbon isotopic composition of each animal reflects that individual's dietary carbon intake.[8] Plants adapted to more arid, summer rainfall-dominant climates have a different carbon stable isotopic composition (i.e., ratio of carbon-13 to carbon-12, or $\delta^{13}C$) than plants adapted to more temperate, winter rainfall-dominant climates. Arid-adapted plants, which include most tropical grasses, are called 'C_4.' Temperate-adapted plants, such as most trees, herbs and temperate grasses are called 'C_3.' As climatic conditions change, the relative abundances of C_3 and C_4 plants change, altering the overall carbon profile of the food available to animals in the region. Since the average carbon isotopic signature present in the plants consumed is preserved in the tissues of the consumer, we can use the carbon isotopic composition of megafaunal bones and teeth from various archaeological levels to work backwards and reconstruct climatic shifts reflected in the change (or lack thereof) in relative proportions of C_3 and C_4 plants in the Cuddie Springs region through time.



C3 & C4 plant C isotope distributions after (9).

Tooth mineral C isotope data after (10).

Analyses In Progress

Data obtained from modern Australian vegetation and fauna indicate that the climatically-induced variability in overall plant carbon isotope values is reflected in the isotope values of Australian herbivores.[11,12,13] We are obtaining carbon isotope data from 13 tooth and 51 bone samples of extinct and extant megafauna from the archaeological and pre-archaeological strata (SU6+) at Cuddie Springs in order to investigate the degree of climatic change leading up to and including the period of megafaunal decline. Carbon isotopic transects along the growth lines of Vombatid and Diprotodontid fossil teeth from Cuddie Springs will provide further insight into the degree of seasonal climatic variability at the site.[13]

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References

1. O'Connell JF & Allen J 2004. Journal of Archaeological Science 31:835–853; 2. Flannery TF & Roberts RG 1999. In Extinctions in Near Time, RDE MacPhee, ed. New York: Kluwer Academic/Plenum Publishers, pp. 239–255; 3. Martin PS 1984. In Quaternary Extinctions: A Prehistoric Revolution, PS Martin & RG Klein, eds. Tucson: University of Arizona Press, pp. 354–403; 4. Flannery TF 1994. The Future Eaters. New York: Braziller; 5. Vickers-Rich P & Hewitt Rich T 1993. Wildlife of Gondwana. Chatswood, NSW: Reed; 6. Field J, Fullagar R & Lord G 2001. Antiquity 75:696–702; 7. Field J, Dodson J & Prosser I 2002. Quaternary Science Reviews 21:1005–1019; 8. See DeNiro MJ 1987. American Scientist 75:182–191 for a background of isotopes in ecosystem studies; 9. O'Leary MH 1988. BioScience 38:328–336; 10. Cerling TE et al. 1997. Nature 389:153–158; 11. Pate FD et al. 1998. Quaternary Australasia 16:3–6; 12. Pate FD & Noble AH 2000. Australian Journal of Botany 48:203–207; 13. Rebecca Fraser (RSES, ANU), unpublished data.