CHAPTER 4

HEAT RETAINER TECHNOLOGY

Fire-cracked rock is a world-wide archaeological phenomenon, widely recognised and little understood (Wandsnider 2000:118)

4.1 INTRODUCTION

The field description, excavation and analysis of mounded cultural deposits or 'mounds' located in widely separated areas of Australia suggests that the contents of many mounds are largely derived from the use of pit ovens or similar features that utilized baked clay, termite mound or stone heat retainers to cook food (Berryman & Frankel 1984, Coutts et al. 1979, Klaver 1998, Williams 1988, Martin 1996a, 1996b, 1996c). To understand the implications of this and provide a contextual background, an evaluation of the history of heat retainer use in North America, Europe, and the region of the Murray-Darling Basin including the Hay Plain, South-Eastern Australia is presented in this chapter. The first section briefly summarises the role of cooking on human history and biological and social evolution as: 'Identifying variations in hearth structures over time is ... fundamental for understanding the evolution of human social life' (Karkanas et al. 2004:513). The effects of heat retainer oven cooking on the physical and chemical properties of a range of foods is discussed. A summary of archaeological research into the chronology and development of heat retainer ovens, burnt rock middens and mounds in North America and Europe provides both details and broad scale trends to compare with Australia. Evidence of ethnohistorical use of heat retainer ovens and mounds in the Murray Darling Basin of Australia and archaeological research into the chronology and development of heat retainer ovens and mounds in the Basin of Australia is presented and analysed to establish both the similarities and differences with other areas of the globe.

4.2 HUMAN EVOLUTION AND COOKING

Wrangham & Conklin-Brittain make a convincing argument that humans have been cooking both meat and plant foods to aid in efficient nutrient uptake for a very long time and that humans are now only capable of living on raw food diets under unusual circumstances such as a relatively sedentary 'raw-foodist' lifestyle in a well-supported urban environment. They suggest that humans are not adapted to eating raw meat because of its inherent toughness and that much plant food has low digestibility unless it is cooked. They state that 'cooking has been practiced for long enough time to allow evolutionary adaptation' and 'although the adoption of cooked food imposed new dietary constraints, it created opportunities for humans to adapt by using diets of high calorific density more efficiently' (Wrangham & Conklin-Brittain 2003:37-41).

Following another line of evidence, the consistent trend of reduction in human tooth size at a rate of 1% every 2,000 years, beginning approximately 100,000 years ago, and accelerating in the Holocene to 1% every 1,000 years (Brace et al. 1987:705), has been interpreted as a consequence of new food processing techniques that made food easier to chew, digest and absorb. The trend may have started with the introduction of earth ovens or heat retainer hearths in the Late Pleistocene, which reduced selective pressure for large teeth and jaws, and in the Holocene included further developments such as cooking in ceramic vessels, pounding, milling and grinding (Brace et al. 1987: 715). Regional variation in tooth size reduction can be explained by regional variation in the adoption of cooking technologies (Brace 1995). Although Holocene tooth size reduction occurred in Australia at a similar rate to other areas, it is suggested that Middle Pleistocene tooth size was preserved in Australia until the end of the Pleistocene (Brace et al. 1987:713), which may have implications for the adoption of cooking technology such as heat retainer ovens in Australia. Wrangham & Conklin-Brittain suggest that cooking may have triggered biological changes such as the reduction in tooth and jaw size that accompanied the evolution of *Homo erectus* approximately 1.9 million years ago, and that the 100,000 year BP reduction may result from new cooking techniques (they suggest boiling). They also suggest that the differences in the human digestive system compared to that of other great apes can be explained by the adoption of cooking rather than the adoption of a high meat diet. Following this hypothesis increased meat eating would have followed the introduction of cooking, the most significant effect of cooking meat is tenderising, allowing high rate of intake (Wrangham & Conklin-Brittain 2003:40-42). It is also suggested

cooking may be linked to the eating of carbohydrate rich 'roots' or Underground Storage Organs (USOs) that occur at higher biomass in drier regions such as the African savannah because they store food and/or water during periods of climatic stress. The location of USOs makes them unavailable for most mammals, but available in quantity to humans with digging sticks (Wrangham et al. 1999:569).

Evidence about the use of fire by early populations is often open to question. However, the information is gradually building up for the case of early control of fire by humans. For example the strongly clustered distribution of burned seeds, wood and artefacts, in a stratified site dating from 790,000 BP on the shores of a palaeo-lake in Israel suggests that either *Homo erectus* or archaic *Homo sapiens* produced and controlled fire at this site (Goren-Inbar et al. 2004:725-727).

Regardless of the exact timing of the introduction of cooking and its effects on human biology, it has affected food supply by softening food, increasing food availability, and forcing human food distribution into predictable clumps around fires. Cooking also leads to an improvement in dietary quality and change in food distribution and availability, comparable to increased meat-eating, agriculture and animal domestication. The collection of food into food piles in preparation for, during and after cooking implies that cooking would have generated new forms of social behaviour to regulate the distribution of the food. It is also suggested that the early weaning of babies compared with other great apes may be explained by the supply of soft cooked food, and this resulted in shorter inter-birth intervals (Wrangham & Conklin-Brittain 2003 :41-42). The need to regulate cooked food distribution was 'responsible for the evolution of the unusual social system in which pair bonds are embedded within multifemale, multimale communities' (Wrangham et al. 1999:567). It is not the purpose of this thesis to assess the arguments about the antiquity of cooking or early hominin behaviour, I only seek to show that there are important relationships between cooking, biology and social organization, the principles of which also apply to the Australian case. It follows from this that different techniques of cooking may reflect elements of social structure and genetic diversity, aspects that are considered in later sections.

4.3 EFFECTS OF HEAT RETAINER COOKING ON PLANT AND ANIMAL FOODS

Cooking of plants foods has the following effects:(1) breaks down physical barriers such as thick skins or husks; (2) can burst cells making cell contents more easily available for digestion or absorption; (3) can modify the physical structure of molecules such as proteins or starches, into forms more accessible for digestion; (4) can reduce the chemical structure of indigestible molecules into smaller forms that can be fermented more rapidly; (5) can denature toxins or digestion-reducing compounds (Stahl 1984, Wrangham et al. 1999, Wrangham & Conklin-Brittain 2003:38). Cooking also has important effects on food by influencing palatability and the rate at which food can be chewed. Even very insoluble plant fibres such as cellulose will soften when cooked in the presence of heat and water, and there is evidence that dry heat will turn insoluble fibre into soluble fibre. The softening of fibres as well as gelatinization of starch due to heat results in cells separating more easily and the food becoming easier to bite and chew, increasing the rate of energy intake (Wrangham & Conklin-Brittain 2003:38).

Wandsnider (1997) considered the relationship between food chemistry and cooking by heat treatment, with emphasis on the effects of pit hearth (heat retainer oven) cooking such as that used on the Great Plains of North America, Polynesia and Melanesia. Heat treatment of foods may enhance digestion, kill food-borne bacteria and parasites, eliminate toxins, and increase the storage life of food by eliminating spoilage bacteria and water. Cooking may also include other non-heat processes such as mechanically grinding or pounding tissues to increase the surface area for the various physical or chemical processes of digestion to work on. It may also involve flushing or rinsing of plant tissues to eliminate toxins. Foods may be fermented or partially digested by bacteria breaking down components into smaller more digestible components, or food may be soaked in salty or acidic solutions to induce chemical changes. Dry heat treatment includes parching, broiling (grilling), spit-roasting, baking, and frying while moist heat treatment includes braising, stewing or boiling. The choice of cooking technique will be influenced by factors such as available fuel, the type of containers available, whether food is to be eaten immediately or stored,

time constraints, numbers of people to help cook and to be fed, maximization of nutrient value, or minimization of toxins (Wandsnider 1997:2). The paper then described in detail the physical and chemical effects of heat treatment on carbohydrates, proteins and lipids, relevant to the digestibility of foods. Different types of wild foods are considered and the ethnographically recorded strategies for cooking these, related back to the physical and chemical changes wrought by the different types of cooking (Wandsnider 1997:3-18).

Three general patterns for the cooking of meat emerged; firstly meat that is boiled is generally from species with low lipid/protein ratios or dried meat. Secondly both lean and less lean meat may be roasted in ash, coals, or hot sand for short amounts of time (10 minutes to 1 hour). Third, pit-roasting is carried out for species that have relatively high lipid/protein ratios. However, lean meat from rabbits and squirrels was also pit-roasted, which was contrary to expectations (Wandsnider 1997:13-14). Plants rich in starches tend to be boiled or dried for storage, whereas plants containing the complex carbohydrates fructan and inulin are processed in a variety of ways, probably depending on the degree of polymerisation. Plants containing inulin are eaten raw or pit-baked, eating of raw inulin rich plants may relate to seasonal conditions such as frost that decreases the degree of polymerization. Raw inulin may also provide good health by enhancing the activity of bifidobacteria in the colon. Pit-baking of inulin rich food results in an increase of up to 100% in the energy obtained as a result of hydrolysis to fructose and glucose, and can also denature secondary compounds that may have caused ill-effects. Pit-baked inulin rich foods often have a final processing involving shaping into loaves that were further dried for storage purposes, either in the pit oven or in the sun. It is clear from the ethnographic data that food processing generally appears consistent with what is expected from an analysis of food chemistry and human digestive physiology, but there were exceptions that may be related to cultural aspects, access to containers or fuel availability, or simply misunderstanding by the ethnographers (Wandsnider 1997:16-18).

Wandsnider considers 110 ethnographic accounts of pit-hearth food processing mainly from North America, but also including Africa, New Guinea, South America and two cases from Australia. Although cooking of fatty meats and inulin rich USOs dominated, as expected, complexities emerge. Cooking of buffalo meat demanded the use of heat retainers, layers of green leaves, sprinkling of water, the lot covered over with the paunch and then the hide, then gravel, and a fire on top. The fire was kept

going all day and night and the pieces of meat taken out the next morning (Wandsnider 1997:19). Although bison is not a fatty meat, the season and specific bison were targeted for highest fat content. The moist and lengthy cooking promoted collagen and lipid hydrolysis, and in accounts of pig roasting, fat was dispersed through the meat and sometimes onto the insulating leaves, which were often sucked (from Dwyer 1990:132). The data also indicates that for meat cooking, large animals or multiple small animals were pit-roasted, as it is a way of bulk processing meat, either when presented with a large amount or when hosting a feast. Only 37% of meat cooking in pit ovens used heat retainers, mainly for large animals, for the rest the sediment on the bottom and sides of the pit acted as a heat retainer. Cooking times varied from 10 minutes for lizards to 20 hours for bison. The hydrolysis of lipids to more digestible fatty polymers may be important for groups who rarely consume fatty foods, and the expressed fat may be shared more widely within the group than the fatty pieces of meat (Wandsnider 1997:20-21). Although Wandsnider concluded lean meat is not cooked in pit ovens, there were examples in her data such as rabbits and buffalo that may be classed as lean meat (Wandsnider 1997:28).

Wandsnider's data for plant foods shows that pit-hearths were predominantly used to cook and promote the hydrolysis of fructans. Fructan has a high degree of polymerisation and can have a branched structure, both features that make it difficult for people to digest. Inulin is an example of a complex fructan that is difficult to digest. Heat retainers are used to ensure long cooking at high temperatures needed for the hydrolysis of fructans to fructose and glucose, which are readily digestible. Other methods also used to promote hydrolysis in the pit oven include increasing moisture and alkalinity, by adding water or during cooking or adding salt rich plants such as *Suaeda* species to increase the alkalinity. Fructan or inulin rich plants cooked in pit-ovens discussed by Wandsnider include *Cordyline terminalis* (*ti* or palm lily, similar to the New Zealand *Cordyline australis* or Cabbage palm) used widely in Melanesia and Polynesia, and cholla buds, agave, mescal and camas bulbs of North America (Wandsnider 1997:22-23).

The length of cooking time has to do with the length of the fructan polymer (DP) and possibly also its structure (branching), for example Jerusalem artichokes only require boiling, but *Cordyline* (ti) and *Agave* with DP 15 and DP 32 branched structures respectively, require more energy for depolymerization and hydrolysis. In 61 of the 72 reports of pit cooking inulin bearing plants, heat retainers were used, and most

reported a fire built over the oven as well. In a description of cooking *Cordyline* or *ti* in Polynesia, a large hole was dug, a huge pile of firewood put in it and firestones placed on top. After the wood burnt down the firestones were packed to form a red hot pavement. Banana leaves were thrown over the rocks and the *ti* packed closely to prevent heat from escaping and the older roots were placed in the centre. More leaves covered this and then the oven was covered with three feet of earth and left for two days and nights. People marked their individual parcels of roots and were careful to take the right bundle (Gill 1880 quoted in Wandsnider 1997:23).

Wandsnider discussed the use of pit ovens with heat retainers for the cooking of starch rich foods. The examples she used come from New Guinea and involve a mixture of foods such as pumpkin, choko, sweet potato, taro, sego [sic], as well as fish and pig. Water is sometimes added and cooking times vary from one to 3 hours or longer. Recent analysis of bush foods indicate that not all starchy foods are equally digestible. Relative portions of the two starch fractions, amylose and amylopectin, may be responsible for this variation, as amylose is more difficult to digest than amylopectin. Starchy foods may need exposure to moist heat for gelatinisation and pasting to occur and a higher heat for dextrinisation, and it is possible to mix meat and starchy foods in the one heat retainer pit. This type of cooking may have two layers of heat retainers, a lower layer upon which the meat is placed, and heated rocks scattered among the packets of starchy foods above (Wandsnider 1997:24-26).

Cooking is also used to eliminate or reduce toxins and to denature enzymes that affect digestion. Cyanogens in the cabbage family are oxidized when exposed to heat (Wandsnider 1997:4), and tannic acid found in acorns and millet is removed by the process of grinding, making dough and baking in a pit-oven (Wandsnider 1997:26). Cassava root, another common food, requires cooking to remove cyanogens some of which are removed via steam when boiled, but the rest remains in the cooking water (Ravi & Padmaja 1997:427). This suggests that pit oven cooking and boiling of cassava may have different effects on toxins, and the addition of water to the oven would be necessary to promote steam and remove the toxins. The acutely toxic and carcinogenic northern Australian food plant *Cycas* is processed using a variety of methods, some of which include roasting in pit ovens as one stage of the detoxifying process. In one ethnographic account kernels were 'roasted in an earth oven for up to one day' (Beck 1992:137). Pit-oven roasting is also used to reduce bitterness of nuts

and to denature the lipases that promote rancidity, thus extending storage life of nuts (Wandsnider 1997:26).

In summary, Wandsnider found pit oven cooking is associated with;

1) cooking high lipid meats at moderate temperatures for variable amounts of time depending on size of meat, from 1-3 hours for pig to 20 hours for buffalo (but lean meat examples such as rabbit are also included in her data)

2) cooking complex carbohydrates such as inulin at moderate to high temperature for a long period of time (but depending on the length and complexity of the polymer structure) - up to 48 hours for long branched polymers such as *Cordyline*

3) cooking hydrolysis resistant starch foods at moderate to high temperatures for average amounts of time - usually 1-3 hours

4) toxin oxidation or enzyme denaturization, which usually takes only moderate temperatures and short periods of time (but 12 hours for cycads, Beck (1992:137))

5) pit oven cooking can involve large amounts of food, for various reasons, such as to feed a large number of people, to introduce economy of scale, or to prepare food for storage (by dehydration after initial cooking).

Detailed analyses of plant carbohydrates are being carried out in many parts of the world, mainly by nutritionists, but this enables archaeologists to understand the potential for increasing digestibility and energy efficiency by various traditional cooking methods including baking and /or steaming in ground ovens. New Zealand flax (*Phormium spps*) for example, has complex branched fructan polymers resembling the fructans and fructo-oligosaccharides isolated from related food plant species such as *Agave vera cruz* and *Cordyine australis*, but is distinct from the linear structure of *Allium cepa* (onion) and *Asparagus officinalis* (Sims & Cairns 2001:661). This immediately tells us that the Flax, *Agave* and *Cordyline* will be potential candidates for prolonged baking in ground ovens, while onion and asparagus would not need such prolonged cooking. Very detailed research into the *Agave* genus in South West North America indicates that utilisation of these plants as food sources is extremely complex. *Agave* are adapted to arid and semi-arid regions through the use of crassulacean acid metabolism that involves reduced transpirational loss by opening the stoma at night in the cooler temperatures, the principal photosynthetic product

of this metabolism is fructan that is synthesised and stored in the stems. Fructan structures in *Agave* are variable and species dependant, some showing a complex mixture of highly branched fructans with an internal glucose and variable linkages (Lopez et al. 2003:7835). Thus the utilisation of the various stored complex carbohydrates from different species of *Agave*, often involving the prolonged baking in heat retainer ovens, is a significant development in the knowledge of plant use. This suggests that archaeologists need to understand the molecular structure of carbohydrates in plant resources before we can understand the archaeological record.

Most Australian plant food carbohydrates are yet to be analysed in detail and it is therefore difficult to fully understand the complexities of plant use and cooking. However, in traditional Australian and Pacific Island foods, the carbohydrate tends to be digested and absorbed much more slowly than that from typical 'western' foods (Thorburn et al. 1987:98). The results of this study also show that the Aboriginal bushfoods tested were on the whole digested much more slowly than the Pacific Island foods, and that there is variation in digestability within Aboriginal foods. The study suggested that bushfoods may contain a high proportion of amylose starch, which is difficult for humans to digest and absorb because of its compact linear structure (Thorburn et al. 1987:102). In fact some of the foods tested may contain other complex carbohydrates, as they have not been analysed in detail.

Gott tested *murnong* (*Microseris scapigera*) tubers, a staple food plant in Victoria and South-Eastern Australia for starch by using a simple iodine test, and got a negative result. Her botantical knowledge led her to suggest that the stored carbohydrate in *murnong* is inulin, which would have to be broken down by bacteria in the colon and would not supply the same amount of energy as starch. In the same article, however, Gott describes an ethnographic account of the 'sweet, dark-coloured juice' called '*minni*' that was produced by cooking *murnong* in an earth oven (Gott 1989:208-9). This indicates that it was cooked in an oven long enough for the inulin to be largely converted to sugars, thus maximising the amount of energy available. More detailed information about plants from the same family as *murnong* can tell us even more. Carbohydrates degrade or convert to lower molecular weight forms during winter or cold storage. In plants such as Jerusalem artichokes the fructan chain lengths are decreased during chilling until a stable pattern is established. Long chain fructans are degraded and the liberated fructose is recycled to sucrose, the number of chains increases at the expense of a decrease in chain lengths. In cold-stored chicory and

dandelion roots the degradation of fructans proceeds further than in Jerusalem artichoke tubers and fructose as well as oligofructans accumulate (Loewus & Tanner 1982:770- 773). This means that even within one plant family fructans will behave differently under certain conditions, and scientific research is only just beginning to document what hunter-gatherers had practical knowledge of for thousands of years. Jerusalem artichoke, and more particularly dandelion and chicory, are closely related to *murnong*, suggesting that *murnong* would be 'sweeter' in mid to late winter and supply more available energy then. This gives more insight into Gott's information that it was considered 'bitter' at certain times and was gathered in winter (Gott 1989:209). This example shows how knowledge of the molecular structure of plants is essential to understanding the sophistication of plant use by hunter-gatherers, and the beneficial effects of cooking and harvest timing.

4.4 HEAT RETAINER TECHNOLOGY RESEARCH IN NORTH AMERICA

4.4.1 Archaeological Research in North America

Research into heat retainer technology and cooking processes in general has gained momentum in the last few years. While many questions remain, it is evident that there is a world-wide pattern of adoption and abandonment of the various methods of cooking. Because the heat retainers (also variously described by archaeologists as fire cracked rock, thermally altered rock, burnt rock, burned rock, cookstones, clay balls, baked clay) and the actual cooking features such as pit ovens and mounds are often preserved and are dateable, they form a unique set of archaeological data that has often been overlooked in the past. A quote from Brink and Dawe (2003 :85) sums it up:

> Honesty requires admission that thermally altered stones recovered from archaeological contexts have, historically, been treated as the rubbish of the pre-contact record. Friends and colleagues have found the primary importance of these rocks to be: 1) backfilling excavations, 2) discouraging gophers from dig sites, 3) embellishing home rock gardens, and 4) weight for winter traction in vehicles. Although our hands are far from unsoiled in this disservice, we have been reborn.

North American studies have been focusing on the burnt rock middens or cookstone technology found across the continent but best exposed and preserved in the semi-

arid areas of Texas, New Mexico, Mexico and the Rockies. This research consists of archaeological survey and description of the features (Black et al. 1997, Sullivan et al. 2001, Smith & McNees 1999, Thoms 1998, Thoms 2003a & 2003b and others), ethnohistorical descriptions of what and how food was cooked using cookstones (Thoms 1998, 2003b), proton magnetometer investigation into burnt rock midden construction (Abbott & Frederick 1990), detailed research into fire cracked rock properties (Brink & Dawe 2003), and the evolution of cooking technology over the last 10,000 years (Thoms 2003a, Leach 2005). Most importantly however, this research has been linked with research into the physics and chemistry of cooking a range of foods, particularly food plants, in different types of heat retainer features and other styles of cooking such as boiling or cooking on the coals (Wandsnider 1997). This latter research asks questions about why people adopted, and in some cases abandoned, the use of a variety of heat retainer cooking methods and other methods such hot rock boiling and ceramic vessel boiling. This has led to the hypothesis that styles of cooking and focus on different foods can have a selective effect on the human genome resulting in regional variation in the genome, which reflects on the way populations cope with the sudden adoption of a modern western diet. Of relevance is the idea that long term dependence on complex and difficult to digest carbohydrates such as those commonly processed in pit ovens may directly affect the incidence of type II diabetes (NIDDM) in modern populations such as Native Americans (Wandsnider 1997:29-32), or indigenous Australians and Pacific Islanders (Thorburn et al. 1987:98-99). Recent research is focusing on calculating the energy returns from different styles of cooking a variety of foods, and then evaluating a range of complex reasons why people used 'low-ranked resources' such as agave stems and USOs or 'roots'(Dering 1999, Smith et al. 2001).

4.4.2 Chronological Trends in Cooking Styles in North America

Thoms has summarized trends in cookstone (heat retainer) technology in America during the Holocene and he relates the continent wide increases in use of rock heating elements to trans-global increases in broad spectrum foraging. He equates marked increases in the use of previously unused or underused food to resource-use intensification (as defined by Lourandos 1985). Cookstones in America were used for a variety of purposes, including roasting and steaming in earth ovens, in grills and hearths, and in stone boiling in a variety of containers (Thoms 2003a:87). Cookstone technology extends back to the beginning of the Holocene with ovens containing

charred plant remains dating back as early as 8,800 BP and distributed widely across the continent. The deeply stratified Richard Breen site in Texas gives view of cookstone evolution in one place, from a small containment hearth at 8,700 BP, small cookstone ovens from 8,200 to 7,600 BP, at 7,000 BP these continue but grill like cookstone hearths become more common, around 4,500 to 3,000 BP rockless basin-shaped ovens and small rock filled ovens predominated. Elsewhere in Texas small and large cookstone ovens continued to be used in the historic period and burned rock middens are characteristic of late Holocene sites. Stone boiling features are not common during the middle Holocene when the heated stones were placed in vessels such as animal skins and paunches, woven baskets, wooden vessels and bark-lined pits enabling water to be boiled. Stone boiling proliferated during the late Holocene that coincides with the period ceramic cooking vessels became prevalent 2,000 to 3,000 years ago. Initially cookstones (stone heat retainers) were used to boil liquid in the ceramic vessels, but in agriculture dominated areas ceramic vessels came to be used on their own as the primary heating element for boiling (Thoms 2003a:88-91). Wandsnider notes that pit ovens were also used for other purposes including firing ceramic vessels, for medicinal steam baths, for sweat baths, and for extraction of fibre from yucca (Wandsnider 1997:34-5).

Not all pit ovens used heat retainers. For example the starch-rich biscuit root (*Lomatium* spp.) ovens often had no rock heating elements except in typically fuel-poor places where 'use of rock heating elements may well be explained by the fuel-sparing capacity of cook stones' and the need to use brush due to lack of wood. However, camas (*Camassia quamash*) required prolonged cooking, the inulin rich bulbs were packed between layers of green plants rich in organic acids that facilitate hydrolysis, cooked for 48 hours in rock-heated earth ovens that 'transformed the tasteless, onion-shaped bulbs into sweet, fig-like morsels.' (Thoms 2003a:92).

Cook stones facilitate exploitation of a broad range of often more costly (defined by input of time versus output in kcal/hr) food resources in a range of environments, and 'integration of cook-stone technologies into land-use strategies affords an effective and efficient mean of utilizing more of a given landscape's food-resource potential' (Thoms 2003a:92). Cookstones or heat retainers are able to:

(1) maintain an adequate cooking temperature for longer periods of time than slow-burning wood or coals

(2) facilitate oven-cooking of foods, including many wild roots or USOs, that require cooking times in excess of 24 hours to render them digestible

(3) save fuel and rapidly capture and hold heat generated by scarce or fast burning wood

(4) facilitate steam-cooking foods in earth ovens

(5) assist water-boiling for stone boiling foods and rendering grease in a variety of containers.

The deeply stratified Wilson-Leonard site in Central Texas, ranges from the 11,500 BP Clovis period through to the Late Prehistoric period, and includes various burned rock features throughout the Holocene. Early Archaic occupations show continuity with Late Paleoindian in similarity of projectile point forms, use of small-medium hearths, and diverse subsistence base. The major discontinuity is the Early Archaic period introduction and focus on the use of rock-filled earth-ovens to cook USOs, most importantly camas bulbs. Preserved bulbs are dated as early as 8,250 ± 80 BP, and the oven cooking is seen as converting the non-digestible inulin rich bulbs to highly nutritious food through prolonged cooking in heat retainer ovens. This intensive bulk processing of plant foods using hot rock cooking suggest the large features were used to prepare large packets of food to increase efficiency. Research on understanding burned rock midden formation concluded that large earth ovens coalesce to form mounded cultural deposits termed 'burned rock middens', but that small discrete hearths with burned rock do not, and that these two different features represent different subsistence activities. Central Texas did not follow surrounding regions and adopt 'formative lifeways' (horticulture, ceramics, sedentism, non-domestic earthworks), an assessment of the reasons for this based on Wilson-Leonard does not support the idea such changes were a response to risk or stress, or climatic limitations, but that the occupants lacked the need or interest in adopting such patterns of behaviour (Collins et al. 1998 in Amick 2004:194-198). The Greater Edwards Plateau (West Central Texas) burned rock middens began to accumulate by around 9,000 BP, use intensified during the last 1,500 years and continued into the historic period when the indigenous occupants were forced to leave by the Spanish (Black et al. 1997 in Wandsnider 2000:117).

Leach has established that in the semi-arid Chihuahan Desert dating indicates a steady use of cookstone features beginning around 4,500 BP and a sharp increase in feature size and frequency around 1,250/1,300 BP. This sharp increase coincided with the appearance of the first settled villages and evidence of cultivated crops such as maize, beans and squash. He interprets this continuation of hunter-gatherer technology into the transitional agricultural period as showing the continued importance of wild plant foods in this marginal agricultural region. The cookstones are used in pit ovens to enable prolonged cooking of plant foods such as agave, sotol and cholla buds, to ensure the plants are less toxic and more energy rich. The increase in cookstone feature size and frequency is accompanied by a change from locations spread across the desert floor to clustering at alluvial fans along the mountains that had become the preferred locations for village settlements. The smaller early cookstone features would be inadequate for cooking many of the region's plants (especially those that require long cooking) and it is suggested that they may have been used to extend the use of fast burning wood, to cook animals, or to parch seeds (Leach 2005). In the Pinos Altos Mountain Range of southern New Mexico large earth ovens appear around AD 1,000 to AD 1,140 and appear to result from a strategy of residential mobility and alternative land use to cope with decreased arable land and population pressure brought about by drought and agricultural land degradation (Leach & Bradfute 2004). Again the large-scale use of wild foods such as agave and yucca that require long cooking in earth ovens to increase energy efficiency is seen as a buffering strategy for unreliable dry land agriculture.

Research projects also delineate regional variation in oven design and use patterns. Sandstone slab-lined cylindrical basins (ovens) associated with charcoal stained sediment in southwest Wyoming are apparently related to the harvesting, processing and cooking of a stable, predictable resource such as biscuit root (*Cymopterus bulbosus* -closely related to the previously mentioned *Lomatium spp.*). One study of these features attempts to define how people used the landscape over a longer period and how the infrastructure of the ovens affected occupation. The ovens were used from 4,830 ±100 BP for a period of approximately 2,000 years in defined patterns including: 1) periodic reuse of ovens over 500 year periods with sequences of short-term use alternating with more extended periods of non-use in estimated 100 year cycles; 2) repetitive use of some locations over 400-500 periods; and 3) use of some locations through the entire time span of 2,000 years. The periodic use is interpreted as relating to the depletion and regeneration of the resources within the locale.

Existing ovens were reused for up to 500 years or when the slabs deteriorated, after which new ovens could be constructed next to the old ones. Thus repetitive or periodic use of ovens, medium term or long term use of locales, and anticipated construction of ovens and abandonment of redundant ovens all occurred as aspects of the pattern of occupation (Smith & McNees 1999). Sullivan et al. (2001) report the intensive archaeological survey of upland conifer ecosystems in northern Arizona, where the recording of 126 fire-cracked-rock (FCR) piles and associated artefact scatters is 'unprecedented', or previously unknown from this ecosystem. Excavation and analysis indicates that the FCR piles were principally used to process wild plants in large quantities, with variable flaked stone manufacture, ground stone tool reuse and recycling, ceramic vessel fragment recycling, and minor animal carcass processing. Soil under the piles is orange-red and hardened, and the piles tend to have a round base but variable height.

In eastern North America the emphasis on archaeological research was focussed until recently on the monumental earthworks including platforms, mounds and concentric rings that characterize the pre-ceramic Poverty Point and the later ceramic producing and agricultural Mississippian and Eastern Woodlands cultures (Blitz 1999, Blitz & Livingood 2004, Knight 2004, Schroeder 2004, Trubitt 2000). However, there are mounds belonging to the Late Woodland period, one example dated to around AD 700-900, which are composed of earth, fire cracked rock, burials and artefacts that have been interpreted as burned rock middens related to the gathering and processing of nut mast in autumn and processing of tubers, roots or bulbs in spring (Hawley 2003). Recent dating has demonstrated the existence in the Lower Mississippi valley of an older pre-ceramic and pre-agricultural type of mound, possibly a precursor to Poverty Point, which has some similarities to the Hay Plain mounds. These are usually conical, and range in size from about 25m to 150m in diameter, and from 1m to 2.5m in height (but may be as high as 6m), often occurring in groups of two or three. Contents include sediment, clay cooking-balls, fire cracked rock, flake tools, debitage, cores, cobbles, and faunal remains. Some of these mounds have an earth platform at the base, may have several stages of building, and intact firepits with clay ball heat retainers. Dates indicate that these mounds have been initiated at least as early as 3,000 BC (calibrated) (Saunders & Allen 1994:472-473). The two Hedgepeth mounds are located on the banks of the Bayou D'Arbonne in north-central Louisiana. Mound A is 6m high and 50m in diameter, an excavation pit revealed that the mound was constructed in two stages and is composed of brown sandy clay

loam and sandy loam with 'basket loading' made visible in the wall sections by the colour variation of different basket loads. Features included a (non-fire) pit, a concentration of ash and charcoal, two rock clusters, and contents included artefacts, a bone fragment, specks of charcoal, and 'numerous fragments of burnt sandstone' (783 pieces from the upper 2A/2Eb horizon alone). The mound sits on a palaeosoil and the upper layers of the mound have formed distinct A, E, B and C horizons. A hearth pit immediately below the mound and associated with remains of either hickory or walnut, dates to 4,270± 100 BP (uncalibrated) or 2,888 BC (calibrated). Trenches cut into the top horizon of the palaeosoil adjacent to the mound recovered a high density of artefacts, principally burned rock, followed by grinding stones, debitage and microdebitage, suggesting extensive plant food processing and refurbishing of tools (Saunders & Allen 1994:476-486).

In north-east Louisiana the Watson Brake complex of 11 conical mounds with connecting ridges forming an enclosure, dates from between 5,400-5,000 BP. It is located on a terrace overlooking the Holocene floodplain of the Ouachita River, which between 7,000 - 4,800 BP consisted of a variety of stream channels and swamp and small stream habitats in back water areas near the mound complex. Mound contents include 'cooking stones' and fired earthen objects of unknown function. Fish are the most abundant food remains, in addition to freshwater mussel and snail, turtle and duck. Land mammal remains include deer, turkey, raccoon, opossum, squirrel, rabbit, dog, and rodent. Charred seeds indicate that weedy annuals including goosefoot (*Chenopodium*), knotweed (*Polygonum*) and possibly marshelder (*Iva annua*) were being exploited. As these plant species were later domesticated 'their presence may reflect the earlier development of ecological relationships that eventually lead to domestication' (Saunders et al. 1997:1797-1799). Thus in eastern North America earth mounds with fire cracked rock or baked clay began as early as around 4-5,000 BP and continued at least into the Late Woodland around 1,800 BP. They preceded and co-existed with the Poverty Point and then Mississippian monumental earth mounds, suggesting that the cooking mounds may have provided the initial template for the monuments (Sassaman 2005:342-344).

In summary, research in North America has elucidated the evolution of cooking with heat retainers, as well as the many reasons for cooking with heat retainers, variation in oven construction, range of foods cooked in ovens and patterns of use and reuse. Models of change in human behaviour that are derived from these studies include

the growing Holocene focus on a broad resource base and increased use of 'low-ranked' plant foods such as carbohydrate rich USOs and stems. Ethnography, archaeological research and phytochemistry all point to the importance of prolonged oven cooking with heat retainers in detoxifying and maximising energy return from carbohydrates stored in bulbs, corms, rhizomes, tubers or stems.

4.4.3 Heat Retainer Technology Experiments

Experimental cooking contributes an additional line of evidence about the use of heat retainer technology. In a complex experiment fatty acid residues extracted from burned rocks (heat retainers) and ground stones were compared with experimental burned rock residues produced by cooking a range of potential foods found in the south Texas region, including plants, mammal and fish (Quigg et al. 2001:283). Detailed research on the Wilson-Leonard site involved analyses of phytoliths, wood and food plant charcoal, stable isotopes, ostracods, diatoms, magnetic studies of burned rocks, magnetic susceptibility of sediments, dating, as well as detailed microfaunal (including egg shells) and stone analyses (Collins et al. 1998 in Amick 2004:194-198). In another example, the Head-Smashed-In Buffalo Jump site in Alberta includes many metric tonnes of thermally altered rock, or 'firebroken' rock, most of which had been transported several kilometres from the source. The analysis shows that the locally available sandstone was seldom used, while the imported river cobbles were conserved, cached, sorted and re-used as heat retainers. Boiling experiments indicated that sandstone was probably used in roasting pits, but was unsuitable for use in boiling pits as sand was introduced into the meat and fat (Brink & Dawe 2003).

Large numbers of pit ovens in the White River badlands of northwest Nebraska and southwest Dakota date from around 1,800 BP to 1,000 BP and have a particular design, cylindrical shape, about one metre deep and 75 cm in diameter, with a layer of rock near the base overlying a bed of charcoal. Experiments designed to determine the potential of these pits for cooking sego lily bulbs (*Calochortus nuttalli*), included the experimental gathering, preparation and cooking of sego lily bulbs in a pit oven using sagebrush for fuel, and the laboratory analysis of the cooked carbohydrate. This revealed that: 1) energy return rates for sego lily is relatively low at 207kcal/h: 2) this type of pit oven is designed for long-term moderate heat: 3) long-term moderate heat transformed the large complex polysaccharides into more digestible disaccharides and monosaccharides. The low return rates indicate that cooking of sego lily and other

similar plants at this time signals a widening of the diet, and that such food may have been an important source of carbohydrate in the nutritionally stressful spring season, and that low densities of plants and slow maturation rates would necessitate annual rotation from patch to patch. The Badlands were exploited by small groups, each pit representing a single occasion, and there is no evidence of large gatherings or intensive exploitation such as seen in other areas (Smith et al. 2001).

Another experiment utilised botanical analysis of Archaic period earth ovens in canyon zones of southwest Texas and adjacent Mexico, and experimental cooking in earth ovens to demonstrate that low-ranked high cost resources such as lechuguilla, prickly pear and sotol yield low calorific results but high refuse quantities. Both food plants and fuel would have been quickly depleted in the canyons, thus necessitating high mobility. It is suggested that the intensive use of such high cost plants, which need prolonged cooking in ovens, indicates subsistence stress in the Middle to Late Archaic periods. Such plants functioned as a low ranked resource regularly consumed as a carbohydrate source during periodic lows in resource abundance, and as a 'famine food' available when there was virtually no other food growing (Dering 1999).

These experiments indicate that heat retainer technology can be examined through a wide range of experimental techniques, from residue analysis to cooking experiments. Experiments tend to confirm that many of the plants cooked in ovens yield low kcal/hour returns, but that cooking in ovens maximises the energy return from these otherwise non-economic plants.

4.5 HEAT RETAINER TECHNOLOGY RESEARCH IN EUROPE

Dates of 34-32,000 BP have been obtained for baked clay basin shaped hearths within the stratified Klisoura Cave 1, southern Greece. These well preserved and superimposed features are made from clay brought into the cave, puddled and shaped, and contents included phytoliths of starches from seed grasses, suggesting that the structures were used for roasting wild grass seeds. The clay was not fired above 600 degrees C, indicating that coals were brought from the main fire to heat the clay enough to parch seeds. These hearths differ radically from the unstructured hearths, or layers of white ash and black charcoal rich material, belonging to the Middle Palaeolithic layers immediately below. It is suggested that these moulded clay

hearths signal significant social changes possibly related to 'setting up a memorable place' (Karkanas 2004:515, 522, 524).

England, Scotland and Ireland all contain large numbers of a type of 'burnt mound' composed of fire-cracked stones often forming a horseshoe shape and known by the Irish name '*fulachta fiadh*' (plural) These mounds tend to be located near water and include characteristic features such as clay-lined pits, wooden troughs or stone lined tanks, which are thought to relate to the boiling of water with heated stones (Buckley 1991:3). Debate over the actual origin of burnt mounds has focussed on whether they were used for cooking large amounts of meat, for hot baths (Gillespie 1991:69-70), or saunas (Barfield 1991:59), or for fulling (making woollen felt material) or other textile manufacture (Jeffery 1991:97). However, more recent work suggests that processing of plant foods may have been a factor in the formation of *fulachta fiadh*. An early mound dated to the Late Neolithic contains charred hazelnut shells and sloe stones, and the proximity of the mound to marshy ground suggests use of resources such as reeds that have left no record (Beamish & Ripper 2000:37). This ties in with a North American perspective that the geographical distribution of burnt mounds in Europe is consistent with the range of USOs similar to camas and glacier lily that are important staple foods of the Northern Rockies and cooked in ovens (Thoms 1989 quoted in Wandsnider 1997:34). Burnt mounds in Britain were initially thought to date from the Early Bronze Age through to the late medieval period, but recently Late Neolithic dates of around 2800 BC have been obtained from various locations (Anthony et al. 2001, Beamish & Ripper 2000).

Heat retainer features found in Europe include pits containing burnt fragmented stones overlying a layer of charcoal that in Switzerland have been interpreted as 'cooking ovens' used for baking/steaming and similar to the Polynesian cooking ovens rather than the water boiling features recorded in Britain (Ramseyer 1991). Burnt mounds in east central Sweden, are described as heaps of burnt fire-cracked stones, charcoal, and sooty soil, but also variously pottery fragments, burnt clay, burnt cattle and sheep bones, hammerstones and grinding stone fragments, are interpreted as refuse dumps from nearby Bronze Age settlements. There is a correlation between the location of these settlements, burnt mounds, and 'damp clay basins' or 'natural wetlands' that are seen as being used for cattle and sheep pastoral production (Larsson 1991:142-149).

Clearly there has been less research into heat retainer features in Europe than in North America, although more recent work is focussing on a wider range of evidence. A priority is to fill in the time gap between the 34,000 BP Greek baked clay hearth and the younger *fulachta fiadh*. It is significant that both the Swedish and British burnt mounds tend to be located in wetland habitats, and recent evidence that Early Neolithic sites contain plant food remains suggest the beginnings of heat retainer use is closer to the North American model than previously thought. North American burned rock middens and early earth mounds with heat retainers have a similar chronological pattern to the British and north European burnt mounds, beginning around 4,500 BP and gaining momentum around 2,000BP.

4.6 HEAT RETAINER TECHNOLOGY IN THE MURRAY-DARLING RIVERINE BASIN

4.6.1 Ethnohistorical Evidence of Pit Oven Cooking on the Murray River and Murray Riverine Plain

Ethnohistorical sources provide detailed and varied evidence of the cooking of food in heat retainer ovens along the Murray River and its tributaries, some of which is summarised here. Eyre described the use of heat retainers and mentions cress (*Lepidium* spp. and similar plants), *Typha* spp. rhizome and *bellila* root *(Bolboschoenus* spp.*)* as staples of the Murray that were cooked in ovens (Eyre 1845 Vol II:254,269):

> The native oven is made by digging a circular hole in the ground, of a size corresponding to the quantity of food to be cooked. It is then lined with stones in the bottom, and a strong fire made over them, so as to heat them thoroughly, and dry the hole. As soon as the stones are judged to be sufficiently hot, the fire is removed, and a few of the stones taken, and put inside the animal to be roasted if it be a large one. A few leaves, or a handful of grass, are then sprinkled over the stones in the bottom of the oven, on which the animal is deposited generally whole, with hot stones, which had been kept for that purpose, laid on top of it, It is covered with grass, or leaves, and then thickly coated over with earth...bark is sometimes used to cover the meat...If the oven is required for steaming food, a process principally applied to vegetables and some kinds of fruits, the fire is in the same way removed from the heated stones, [and] wet grass or water weeds are spread over them. The vegetables tied up in small bundles are piled over this is the

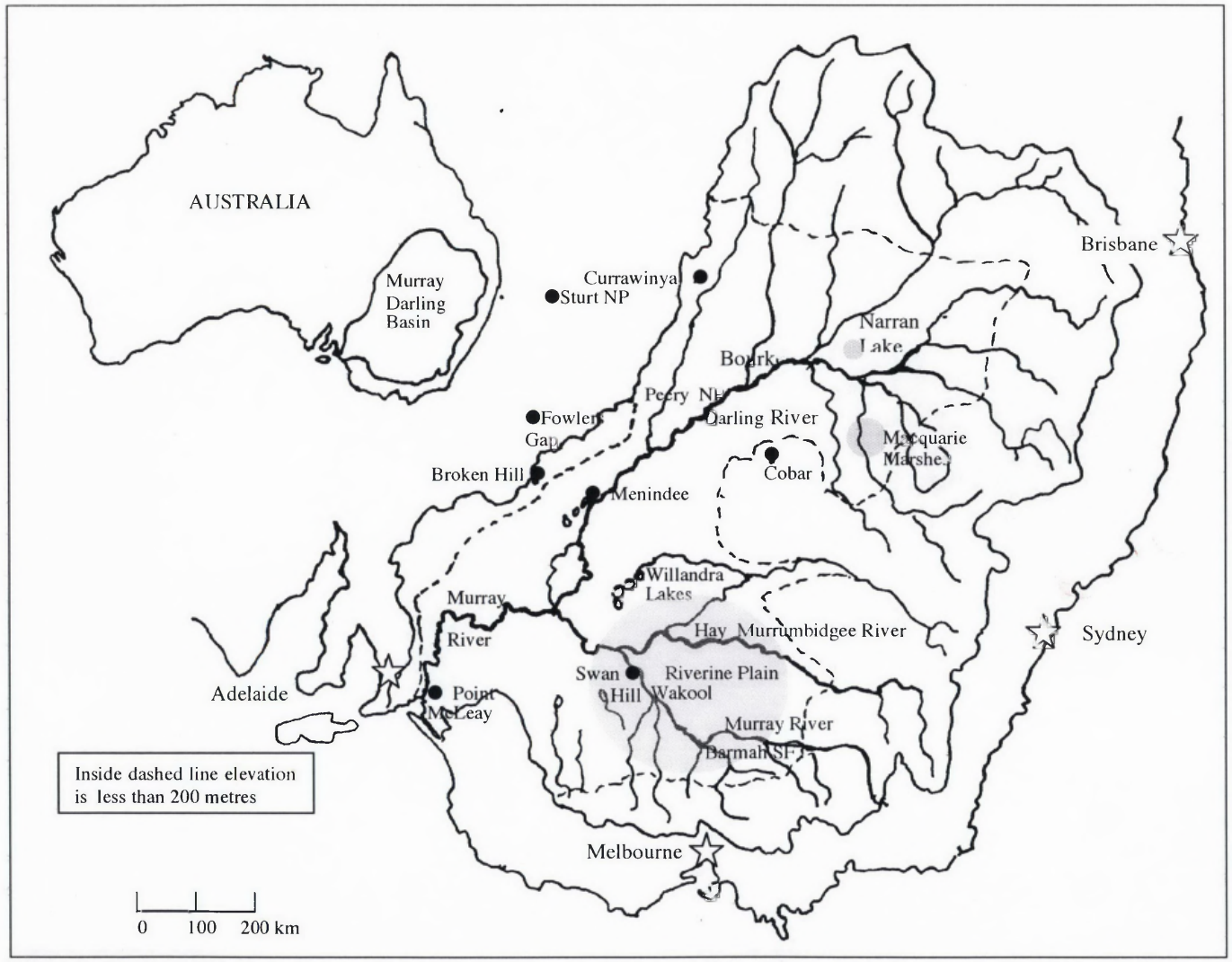
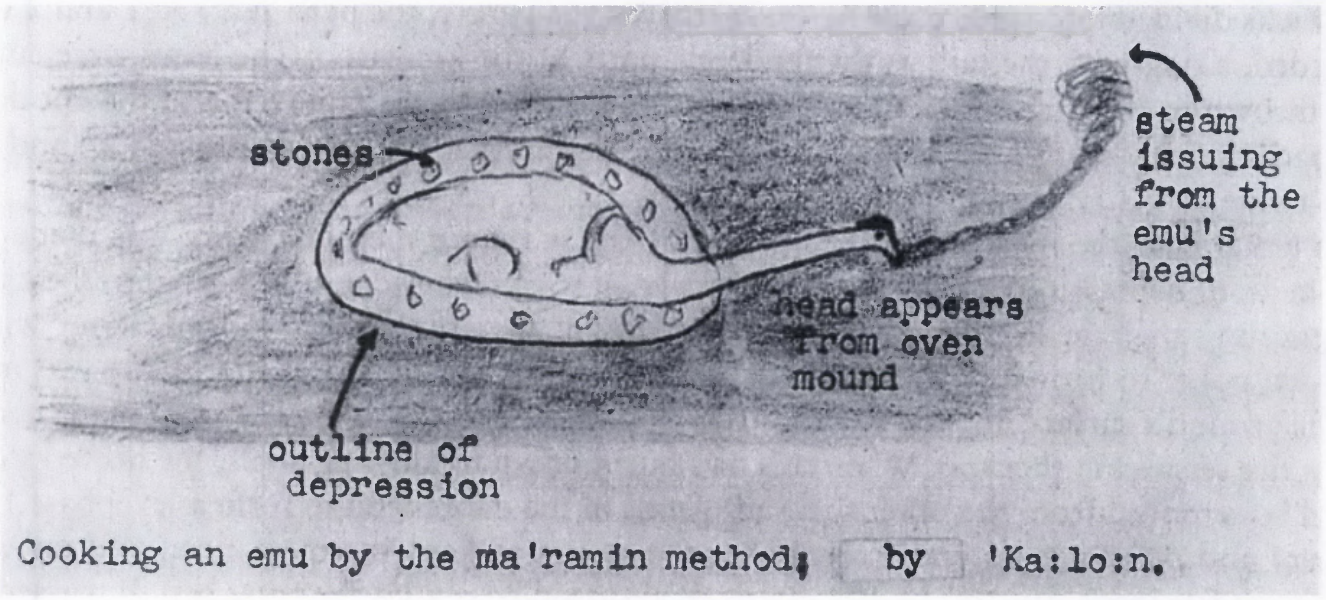


Figure 4.1: Map of the Murray Darling Basin showing places discussed in text, areas where mounds are concentrated shown in grey.

> central part of the oven, wet grass being placed above them again, dry grass or weeds above the wet, and earth over all. In putting the earth over the heap, the natives commence around the base, gradually filling it upwards. When about two-thirds covered up all round, they force a strong sharp-pointed stick in three or four different places through the whole mass of grass weeds and vegetables, to the bottom of the oven. Upon withdrawing the stick, water is poured through the holes thus made upon the hissing stones below, the top grass is hastily closed over the apertures and the whole pile as rapidly covered up as possible to keep in the steam ... In cooking vegetables, a single oven will suffice for three or four families, each woman receiving the same bundles of food when cooked, which she had put in (Eyre 1845 Vol II :289-291).

The Yaraldi man Albert Karloan, born in 1864 at Point McLeay on the Lower Murray River (Berndt and Berndt 1993:4), gives details in Yaraldi texts of the cooking of kangaroo and *Typha* rhizomes in pit ovens (Berndt & Berndt 1993: 345-347), and a pencil drawing of an emu cooking in a pit oven (Berndt & Berndt 1993:104)(Figure 4.1).

Figure 4.2 : Karloan's 1942 drawing of cooking emu in a pit oven with stone heat retainers (Berndt & Berndt 1993:104)



In what Karloan called the *maramin* style of cooking, a kangaroo was either dismembered or trimmed and trussed up. A fire was made in a pit and stones thrown in and heated, sometimes a large fire was also made near the pit and stones thrown in there and then moved into the pit when the fire died down. When the fire burnt down

the stones were moved about with a wooden poker to form a fairly level base. Special grasses were cut and thrown over the stones and the meat placed in this. Another grass then covered the meat, followed by skins and finally sand so that the heat of the oven would be retained. After a while a pointed stick was thrust through the sand down to the stone base then removed, and water poured down the hole to increase the intensity of steaming. If the kangaroo was whole it was important to increase the steam. When it was cooked the coverings were removed and the meat taken out and distributed according to the kinship obligations (Berndt & Berndt 1993:103-104). When cooking an emu the legs would be broken, doubled up and placed on the hot stones, or a bed of grass could be placed between the emu and the stones. Grass could be strewn over the bird and more stones placed on this, then covered up as for the kangaroo. The emu head was left sticking out of the coverings, and when steam was seen coming out of the beak the bird was regarded as cooked (Berndt & Berndt 1993:104-105). *Typha* or *manakuri* rhizomes were always steamed in the *maramin* style as were two kinds of cress and stinging nettle. Normally they took about an hour and a half to cook but the time could be shortened by making a hole and pouring water down into the centre to intensify the steaming (Berndt & Berndt 1993:107).

Along the Murray River and its anabranches the Wakool and Edwards, the use of pit ovens with heat retainers is remembered by older people: Margaret Tucker, born in 1904 and brought up at Moonacullah, remembered: 'On hunting trips ...I saw wild pigs, swans, emus and animals such as kangaroos cooked in a large hole in the ground, all specially prepared and wrapped in leaves, with hot rocks or mussel shell around it, to make it cook quickly' (Tucker 1977:41).

Gordon Kirby, born around 1919 on the Hay Plain at Oxley on the Lower Lachlan, told this story about cooking in ovens:

> When I was a kid, people mainly cooked out of doors. We'd get kangaroo and emu, goannas, possums, porcupines, and cook them in an earth oven. They'd dig a hole: fill it with wood and light a fire. When the wood was burned, they'd shovel all the coals out, put in the meat and cover over with leaves - maybe tips of gum leaves or sandalwood to give it a flavour - then fill in the top with earth and coals. With big animals like kangaroo or emu, they might put a hot stone in its stomach to help cook right through. Then after 2-3 hours, they'd open the oven. We weren't short of meat in those days.

> Emu guts was a treat. They'd turn them inside out, wash them, put the emu fat in, pin up the ends and cook them in the earth oven. (Taylor & Undy 1994)

On the Central Murray River, Curr described oven use in the 1850's contact period;

> The way in which these ovens were used was as follows;-When there was food to be baked, the women, with their hands and yamsticks, scooped a hole in the mound; in doing so they came upon any lumps of clay (for there was no stone in those parts), they roughly lined the bottom of the hole with them. If none were met with, they quickly dug up a quantity for the purpose with their yamsticks, from somewhere near at hand. These lumps were about twice the size of a man's fist. The bottom of the whole being lined with them, a fire was made on top of them, and on the fire were thrown more lumps of clay. When the fire had burnt down, these last lumps were removed to one side, and the hot embers to the other. The hole being thus cleared of everything except its flooring of hot lumps of clay, the latter were strewn thinly with grass, or with leaves of a herb called pennyroyal, green if possible, and well damped with water. On this were laid, neatly packed, the animals or roots to be cooked; then came another coating of wet grass, next the remaining lumps of heated clay, and then the burning embers. These were often covered with a sheet of bark, and on top of all these was a quantity of earth. In an hour or two the food was taken out well-cooked and clean (Curr 1883:108-09).

4.6.2 Ethnohistorical Evidence of Cooking in Mounds on the Murray and its Tributaries

Sir Thomas Mitchell was the first European to describe mounds on his 1836 exploration of the Murray River system. Mitchell records the importance of *Typha* for food and fibre around the junction of the Lower Lachlan and Murrumbidgee Rivers, or 'Lowbidgee', particularly around the reed beds, lagoons and swamps, and the distinctive 'lofty mounds', which he said resulted from the cooking of *Typha* in 'kilns':

> [On] The Murrumbidgee ... One artificial feature, not observed by me in other places, distinguishes the localities principally frequented by the natives, and consists in the lofty mounds of burnt clay, or ashes used by them in cooking. The common process of natives in dressing their provisions, is to lay the food between layers of heated stones; but here, where there are no stones, the calcined clay seems to answer the same purpose, and becomes better or harder, the more it is used. Hence the accumulation of heaps resembling small hills. Some of them were so very ancient, as to be surrounded by circles of lofty trees ... I saw the first of these heaps, when near the end of the last day's journey along the Lachlan, where this river

> partook of the reedy character of the Murrumbidgee. I understood that the 'Balyan' or bulrush-root, which is the chief food of the natives there, is prepared in those kilns, when a family or tribe are together (Mitchell 1839 Vol II:80-81).

Beveridge, the first European pastoralist to occupy land in the 1850s on the Central Murray below Swan Hill, about 40 km south of the Hay Plain, described how ovens contributed to mounds:

> ...several families...select a site for their camp, where the abundance of game and other sources of food exist ... the *lyoores* [women] go off with their yamsticks... they begin with a will to excavate a hole three feet in diameter and eighteen inches deep. During the digging of the hole, any pieces of clay of about the size of cricket balls which are turned out are carefully placed on one side. When the hole has been dug sufficiently deep, it is swept or brushed out with some boughs, or a bunch of grass; it is then filled to the top with firewood (which the *lyoores* had previously collected for that purpose), upon which the selected pieces of clay are carefully placed. The wood is then ignited, and by the time it is all burned the clay nodules have become baked, until they are exactly similar to irregular sections of well-burnt brick; of course, they are red hot...
>
> After the hot clay is removed from the hole, the ashes are carefully swept out, and a thin layer of grass slightly moistened, placed over the bottom, and round the sides, upon which the prepared opossums are nicely packed, and then covered over with more damp grass. The hot clay nodules are then spread equally over the top of the grass, when the whole oven is then closed with the finer earth which originally came out of the excavation... Before the heat in the clay nodules, and the bottom of the hole has become exhausted, the opossums are beautifully cooked...
>
> When the cooking has been completed the covering is scraped off, and this debris, consisting of calcined clay, ashes, and burnt earth, becomes the nucleus of a blackfellow's oven. This process being repeated at short intervals, over a series of years, perhaps indeed for centuries, results in mounds, which are in reality blacks' ovens ... at least a barrowful of fresh clay is required every time the oven is heated to replace the unavoidable waste by crumbling,,, in consequence of the clay being used in an unwrought state, it will readily be seen how these mounds gradually, but surely increase. Bones, too, of the animals which they use for food, besides charcoal, etc., tend materially to hasten their growth (Beveridge 1889:32-34).

However, as Mitchell travelled south from the reed beds of the Murray, he describes another large mound or ash-hill, but this time associated with cooking of 'vegetables'

that he identifies as a species of Picris (probably a misidentification of *Microseris* or *murnong* , see Gott 1989):

> ...they had left their net bags containing stalks of a vegetable ... half boiled. Vegetables are thus cooked, I was told, by placing the root or plant between layers of hot embers, until it is heated and softened. The stalks found in the bag resembled those of the potatoe ... A very large ash-hill, raised no doubt by repeated use in such simple, culinary operations, and probably during the course of a great many years, was close to our camp.' (Mitchell 1839 Vol II :149).

In central and southern Victoria, mounds incorporated large oven structures designed for steaming *murnong* or *Microseris* tubers that used stone heat retainer and included one or more central large stones:

> This stone oven is usually slightly concave, or crater-like, with a central stone larger than those otherwise employed in the oven ... Such a central stone was obviously convenient for the process of cooking by steam... an opening was left or made for pouring water down upon the central heated stone (MacPherson 1885:51).

4.6.3 Use of Heat Retainer Ovens for Medicinal Purposes on the Murray Riverine Plain

On the Central Murray below Swan Hill, in the 1850-60s pit ovens were also used for medicinal steaming:

> For pulmonary affections and rheumatism, they make use of the vapour baths. This they construct after the fashion of their ovens, and the patient is walled up much in the same manner as a joint about to be cooked (Beveridge 1865:20).

In addition damp pine leaves were packed over the pit bottom, a possum skin cloak spread over the leaves and the person placed on this, another cloak over the top, and earth piled over the top cloak (Beveridge 1883:31). On the Lachlan River medicinal ovens were also used during childbirth:

> The expectant mother...takes herself to a secluded spot...The attendant's duty is to is to prepare a suitable place ... by digging out a bevelled hole in the ground, from a foot to eighteen inches deep in the centre, and about six feet in circumference. The hole is then filled with filled with light, dry wood, made ready to be fired as soon as the labour pains begin. As soon as the fire has burnt out, the coals are removed, and soft, dry grass or leaves put in their place. The woman is then placed

on the grass and covered with a 'possum rug... (Bowler 1901:147).

4.6.4 Use of Heat Retainer Ovens for Fibre Preparation on the Murray Riverine Plain

Krefft describes the preparation of *Typha* or '*Wongal*' rhizome around the Central Murray, lower Murrumbidgee and Lachlan; it was roasted in an oven and chewed vigorously, the residual lumps of fibre then made into nets and other domestic articles. These nets formed 'the staple article of barter between the tribes inhabiting the reed-beds and those parts where no *Wongal* was produced ... the possession of one of these nets has always been considered to be a sort of fortune to its owner' (Krefft 1866a:361). *Typha* fibre prepared on the Lower Murray was traded up the Murray and elsewhere together with skin cloaks and rugs, mats and baskets, oil and vegetables to be exchanged for stone axes, hardwood, weapons and shields (Berndt & Berndt 1993: 116-117). Beveridge describes in detail the preparation of fibre for twine and cord used extensively for lines, belts, carry bags and nets near Swan Hill 40 km south of the Hay Plain. Fibre making of all kinds included initial steaming in ovens:

> The *Kumpung* (*Typha* Muellera) root, furnishes the fibre most commonly employed .... After the root is cooked (it produces food as well as fibre), it is not cut up into short sections... each root is taken separately, the skin peeled off, and the remainder, consisting of both farina and fibre, is twisted up into a knot, often being larger than a good sized fist, and these knots are crammed into the mouths...the residue...the fibre is rejected in the shape of a small knot of beautiful white tow... carefully packed away...When about to make twine, these tow knots are steeped in water for twelve hours...teased out and scraped with mussel shells...tied up into small neat hanks...Two flax hanks ...are twisted into hard threads... The fibre Rush is the next plant from which they procure flax...[it is] cut as close to the ground as possible...tied into bundles....soaked in water for twenty four hours ... placed in an oven and baked for four hours....scraping [by] mussel shells ... dried ... from this fibre fishing lines and nets are made, as also nets for taking ducks. The next ...of their cord making plants is the giant mallow...fibre is much coarser...only employed for making very thick cord ... worked up into nets for capturing emus ... After the mallow is taken out of the oven it is well bruised with heavy clubs previous to its maceration and scraping. The emu nets ...are frequently from eighty to one hundred yards long (Beveridge 1889:70-74).

4.6.5 Ethnohistorical Evidence of Pit Oven Cooking on the Darling River and Hinterland

The Paakantyi people of the Darling River still cook in pit ovens, although they now only cook large animals such as emu or kangaroo in this style (pers. obs. from living with a Paakantyi hunter for over 20 years). Traditional plant foods are no longer cooked in pit ovens, reflecting plant resource degradation resulting from introduced land-use practices such as pastoralism and agriculture, and the cessation of Aboriginal land use practices including mosaic firing and semi-cultivation of USOs (Gott 1982, 1999b). The use of heat retainers in pit ovens is remembered by the older community members, but not considered necessary to cook an animal if there is plenty of good charcoal producing wood available and the soil is dry and clay rich. In this case the bottom and sides of the pit serve as a heat retainer, and the coals provide heat for the initial cooking. Modern Paakantyi people also use the certainty of cars and guns to ensure that any animal they cook 'in the hole' is young and fat (pers. obs.), a prime animal for pit roasting (Wandsnider 1997:14).

The early explorer Charles Sturt commented that in the relatively dry times of October 1844 the people at Menindee on the Darling River:

> subsisted on the *barilla* root, a species of rush which they pound and make into cakes, and some other vegetables; their greatest delicacy being the large caterpillar (*laabka*), producing the gum-tree moth, an insect they procure out of the ground at the foot of those trees, with long twigs like osiers, having a small hook at the end (Sturt 1849. :135).

Sturt noted on his return trip the same *barilla* root was again the staple at Menindee in December 1845 and around 1850 the first pastoralist in the area described people living:

> where plenty of flags and other aquatic plants having bulbous roots grew. These roots they baked and then pounded them between flat, water worn stones, and mixed the flour with water into a thick paste and baked, or ate it in the form of gruel. All day and night too, the sound of this pounding could be heard (Morey 1843-1908:103).

Sturt's *barilla* is almost definitely the same as Eyre's *belillah* rush that covered 'immense tracts of country on the flats of the Murray', the walnut sized tubers were roasted and pounded with stones into a thin cake (Eyre 1845Vol II:269).This plant has been identified as *Scirpus medianus*, and/or the similar *Scirpus caldwelli* (Gott 1982:61-62). *Scirpus caldwelli*, now called *Bolboschoenus caldwelli*, grows at

Menindee (Westbrooke, Kerr, and Leversha 2001) on shallow lake margins, lake inlet/outlet creeks and in the swampy areas on the floodplains between the lakes and the river. A member of Sturt's party suggests that *barilla* was baked in ovens at Menindee:

> The oven is a hole dug into which are placed stones; a fire is then made and when the stones are become sufficiently hot, whatever fibrous things they eat, or animal, is put into this oven and covered over and a fire made over it, when it soon gets cooked. (Brock 1988 [1844-6]:25)

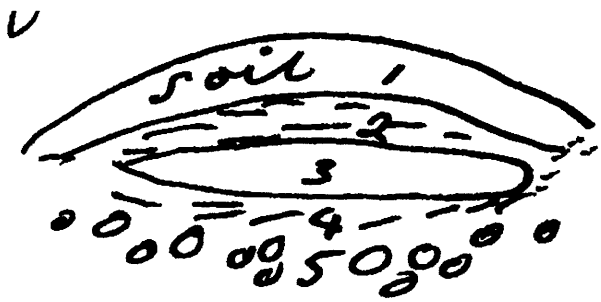
Pit ovens were also used for steaming leaves of *Trigonella suavissima* (trefoil or 'Menindee' clover) near Menindee in about 1850:

> women made their appearance and I noticed that some brought in from the east big bundles of clover which they steamed in ovens and then ate. This stained their teeth green and gave them a strong but not unpleasant odour; otherwise it appeared to be a healthful food (Morey 1843 -1908).

Frederic Bonney managed a pastoral station on the Darling River and its tributary the Paroo from around 1865 and within five years of occupation of the area by Europeans. He described the use of pit ovens mainly for cooking a range of vegetables including large amounts of 'cress' or *Lepidium* spp. (identified from a specimen he sent to the botanist von Mueller), and also kangaroo. Bonney describes the use of stone heat retainers in his notebook (Figure 4.3):

> Meat of all kinds is grilled on the ashes at their camp fires, and vegetables are cooked in their ground ovens (*windoo)* which are made thus, a hollow is scooped out of the ground and the bottom covered with hot stones, over the stones a layer of small boughs, often those of the eremophila (*Kultchia*), on the boughs the vegetable is placed and over it another layer of boughs and the whole covered with earth, which completes the oven. Moisture is added by removing a little of the covering and pouring water among the boughs - stones for this purpose have to be carried sometimes' (Bonney 1866-1915).

Figure 4.3 : Sketches traced from Bonney's notebooks c. 1865-1881 showing cooking in pit ovens with stone heat retainers. Layers in the top oven are 1. soil, 2. leaves 3. food 4. leaves 5. hot stones



During Sturt's 1845 exploration of the arid country to the north-west of the Darling River, the team doctor Browne, described the steaming of 'Vetch' roots [*Vigna lanceolata*?] in pit ovens near Milparinka. He did not describe the use of stone heat retainers in this naturally stony area, but the description of adding water to the oven indicates that they were used:

> The woman had collected a quantity of roots - a kind of Vetch. These they cooked in this way. They dug a hole in the ground and made a good fire in it. In about an hour they covered up the fire with earth out of the hole. On this they laid a quantity of grass and over this the roots, the quantity belonging to each individual being separated by a thin layer of grass. They put grass over the roots and then poured about 3 gallons of water over the whole and covered all up with sand. The roots were thus cooked by steam and in about an hour were well done. I tasted them and found them very good and full of starch. They must be very nutritious (Finnis 1966:42).

Another slightly later writer on the Darling describes the use of pit ovens for cooking 'large game', he does not mention heat retainers but they 'well heated' the pit and placed a fire on top:

> of old they used the oven (*wong-a*), a mere hole in the ground, for the cooking of large game. Having well heated it, they would place in it the carcase to be cooked, and, having 'topped-up' with a good fire, sit awaiting patiently the kindred cries, *nahtooko* (take it out!), *putta-puttako* (cut it up!) (Teulon 1886:193).

4.6.6 Ethnohistorical Evidence of Pit Oven Medicinal Steaming on the Darling River

On the Darling River heat retainer ovens with gum leaves were used to steam people for medicinal purposes:

> Aches, pains and swelling were dealt with in the following manner: a hole was scooped in the ground, a fire made in it, and by means of hot stones or hot ashes and gum leaves a steam bath was created; the patient laid down and was covered with leaves, and then more earth, until only his head protruded while he had a thorough steaming (Dunbar 1944:178).

4.6.7 Ethnohistorical Evidence of Pit Oven Plant Fibre Steaming on the Darling River System

The Menindee people steamed 'rushes' in a 'well heated' hole as part of the process of making cord for nets, in this case succulent salty plants are placed in with the rushes to add moisture and increase the alkalinity:

> Rushes, from which they make their twine with which they make birding nets, such as will go across the creek, and as the ducks are dashing on, they get stopped. Emu are also caught in nets made from strong twine. The rushes are put into a deep hole, which has been well heated. With the rushes are put in a salsolaceous plant, which contains a great quantity of moisture, the whole is then well covered in, and the steam arising from the plant saturates the rush, and after being thus subjected, it becomes extremely tough, and gets torn abroad, and is then twisted, which is done with the ball of the hand on the thigh. (Brock 1988 [1844-46]: 52).

4.6.8 Discussion of Ethnographic Accounts

Eyre comments on the lack of pottery or metal cooking utensils in Australia before European contact:

> Having no vessels capable of resisting the action of fire, the natives are unacquainted with the simple process of boiling. Their culinary operations are

> therefore confined to broiling on the hot coals, baking in hot ashes, and roasting, or steaming in ovens (Eyre 1845 Vol II:289).

While Murray Darling Basin people are generally accepted as not boiling food or using heat stones to boil food, there is the suggestion that the simmering of some foods occasionally took place. At Cumberland west of Sydney, holes in a rock platform were apparently used to boil food with heat stones, some of which were present (Mathews 1896:255-259). While there are no rock platforms on the riverine plain, the first European pastoralists on the Central Murray in the 1850's-1860's noted:

> They have a net also very nearly as fine in the mesh as coarse cheese cloth, with which during the spawning season they take millions of young fish, many of which are less than an inch in length... at the same time they catch immense numbers of young lobsters and shrimps, or prawns ... cooking ... consists merely in boiling them very slowly until the shrimps become red...[in an] elbow or knot of a tree scooped out (Beveridge 1889:84).

However, ethnographic accounts from the Murray Darling Basin indicate that pit ovens performed as well as 'the most perfect kitchen range extant' (Beveridge 1883:38) and were used to cook large animals, fibrous 'greens' and USOs or 'roots' such as rhizomes, corms, bulbs and tubers. Different plant species were cooked in different places but the technique varied only in minor detail. The ethnographic evidence also suggests that longer than usual pit oven cooking of USOs was a way of preserving these foods for several months, either for storage, ceremonies, travel or trade. This process included cooking then dehydration of the food to lengthen its storage life (Wandsnider 1997:24). The Yaraldi people collected large amounts of USOs that were then cooked in heat retainer ovens for longer than usual to preserve them for several months. They were cooked at length in ovens and half of the USOs would be kept to use when these plants were out of season, stored in small bundles, wrapped in skins, baskets or mats (Berndt & Berndt 1993:110). Bundles of preserved *Typha* rhizomes were used in trade, exchanged for native tobacco or pituri that was traded all the way from central Queensland, or traded to non-riverine neighbours in exchange for hardwood spears and points and gum dampers (Berndt & Berndt 1993:116-117).

On the Darling River and its semi-arid hinterland, heat retainer hearths in the form of pit ovens were commonly used for roasting/steaming larger animals such as kangaroo and emu, and leafy vegetables such as *Lepidium* (cress) and *Trigonella* (clover) and

many USOs were steamed in pit ovens. Some of the accounts detail the use of heat retainers, or just suggest the pit was 'well heated,' one account describes placing a fire on top of the oven, some describe adding water or succulent plants for steaming, and one account describes how each individual's USOs were separated by grass.

Pit oven steaming of plant fibre also provided efficiency in fibre processing facilitating the extensive use of nets that was an integral part of fishing, hunting and gathering in the Murray Darling Basin. *Typha* fibre was a by-product of steaming the rhizomes for food, a double saving in energy. Ethnographic descriptions emphasize the importance of the fibre and the amount of energy spent on preparing it. Steaming of plant material reduced the time and human energy needed for fibre preparation and resulted in better and longer lasting fibre for cords and nets. Intensive fibre and net manufacture for local use and/or trade suggests a high degree of sedentism was necessary for the manufacture and curation of such nets, and that they were very important trade items for the people who lived on the stone poor riverine plains (Krefft 1866a:361).

4.7 ARCHAEOLOGICAL EVIDENCE OF HEAT RETAINER TECHNOLOGY IN THE MURRAY DARLING BASIN

4.7.1 Archaeological Evidence of Heat Retainer Technology on the Murray Riverine Plain

1. Heat Retainer Hearths

Archaeological evidence of heat retainer hearths or pit ovens consists of buried, partly buried or exposed basin shaped tightly packed clusters of heat retainer, with a layer of charcoal beneath the heat retainers, and sometimes a fire-hardened pit bottom and sides. The clusters are usually circular or slightly elongated, and vary in size from 30 cm to 2 metres in maximum dimension. Heat retainer hearths apparently contribute large amounts of material to mounds and are found within mounds and in association with them (Coutts et al. 1979, Klaver 1998, Martin 1996a), but they are also located in areas of the riverine plain where there are no mounds (Martin 2000, Pardoe & Martin 2001). Interest shown by archaeologists in hearths on the riverine plain has been largely overshadowed by their interest in mounds.

The vast majority of heat retainer hearths on the Hay Plain contain baked clay heat retainers, however, areas on the northern and western edges of the Hay Plain also show a slight tendency to incorporate local pedogenic calcrete nodules as heat retainers (Martin 1996a).

2. Mounds

Mounds of the Murray Riverine Plain, which includes the Hay Plain, consist of deliberately mounded up cultural deposit that is usually circular or elliptical in plan and a domed outline. The deposit often has a dark grey to black colour due to the addition of ash, charcoal, baked clay heat retainers, and varying amounts of burnt animal bone. However, the deposit may be bleached to grey or grey-brown, or the finer deposit may be deflated leaving only baked clay and minor burnt animal bone or stone material as a lag. Mounds vary in size from length of 2 metres to 200 metres and range in height from ten centimetres up to two metres (Bonhomme 1990a, Klaver 1998, Martin 1996a, Paroe & Martin 2001).

There is overwhelming evidence of baked clay heat retainers in mounds on the Murray Riverine Plain, however Klaver found stone heat retainers in two mounds she recorded to the east of the Hay Plain on the margin of the Eastern Slopes where quartzite cobbles were common and she also noted mounds on the Murrumbidgee East contained quartzite grindstone fragments recycled as heat retainers (Klaver 1998:277).

A large number of mounds have been recorded along the Murray River near Swan Hill to Moama, and its anabranches the Edwards and Wakool Rivers and associated floodplain creeks, lagoons, river red gum forests and swamps. Mounds are located on levees, margins of lagoons and swamps, and on floodplain margin on the first break in slope above the floodplain (Berryman and Frankel 1984, Bonhomme 1990 a, Coutts et al. 1979, Craib 1991, Edmonds and Long 1998). Mounds found on the upper reaches of the southern tributaries of the Murray in temperate Central may not be as closely tied to wetland areas as a staple food plant of this area was the non-aquatic *murnong* or *Microseris* root. It proliferated in temperate meadows kept free of forest by the Aboriginal firing regime (Gott 1992, MacPherson 1885).

3. Non-Mounded Ashy Deposits

A separate category of non-mounded ashy deposits refers to sites with an ashy matrix, rich in heat retainer, similar to mounds. They are not deliberately mounded, and may have some height, be just exposed at ground level, or be buried and exposed in bank sections. These deposits also differ from mounds in that they tend not to be circular in outline, and may be linear or irregular in shape. Three areas of non-mounded ashy deposits were recorded on the Hay Plain on a lake inlet creek and river levees of the Lachlan River between Booligal and Oxley (Martin 1996a).

4.7.2 Heat Retainer Features on the Darling River and Hinterland

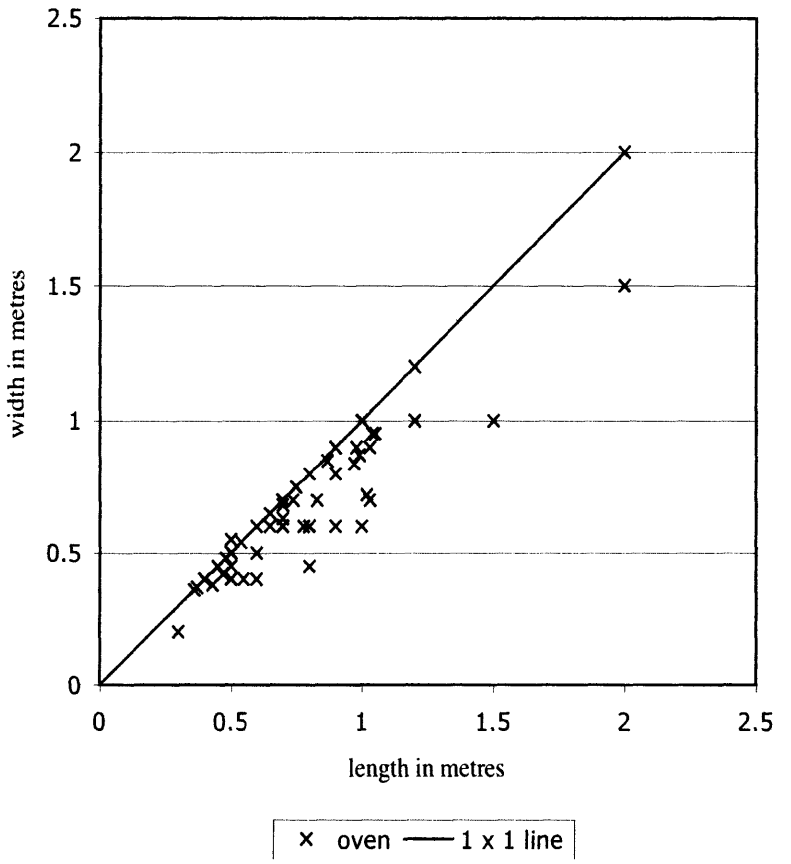
1. Heat Retainer Hearths

Archaeological research has tended to concentrate on the importance of grass seeds in the subsistence strategies of the semi-arid Darling River basin (Allen 1974, Balme 1995). However more recent work has concluded that the hard seeds of *Acacias* and other plants, together with a variety of USOs were also important plant foods of the region. Archaeological evidence for this wider range of plant foods includes sites with demonstrated equal numbers of mortars and pestles to soft seed grinding dishes and topstones, heavy usewear damage on mortars and pestles including ring cracks, and the prevalence of heat retainer hearths and large areas of ashy deposit consisting largely of heat retainer hearth material near habitats suitable for semi-aquatic USOs (Martin et al. 1994, Pardoe & Martin 2002).

The remains of heat retainer hearths are one of the most common archaeological features along the Darling River and hinterland areas to either side. A total of 2,754 were recorded in a large-scale survey of the Darling River and adjacent Menindee Lakes that covered an approximate sample area of 300km2 (Pardoe & Martin 2002). Archaeological evidence of heat retainer hearths consisted of buried, partly buried or exposed basin shaped tightly packed clusters of heat fractured rock or other kinds of heat retainers. The clusters are usually circular or slightly elongated, and vary in size from 30 cm to 2 metres in maximum dimension (Figure 4.4). The layer below the heat retainers, if it is still in-situ, contains charcoal pieces, and sometimes ash, from the original fire. A fire-hardened pit bottom may also be discernable, especially in clay rich sediments. The basin shape of the feature in cross section identifies the feature as a pit oven. At Menindee heat retainers used vary according to the nearest and most

suitable resource; broken up termite nest being by far the most common, but carbonate nodules from sandplain dunes, broken up grinding dishes and topstones, soft sandstone that occasionally outcrops in river banks, clay balls from the floodplain, or even baked mud wasp nest were used. Termite nest is the dominant material found in heat retainer hearths near the sand plains and linear dunes (photo 3), the habitat for this type of underground dwelling termite. Carbonate nodules (calcrete) are also used on the linear dunes and sand plains where it forms in the soil profiles and is exposed by erosion. Baked clay is commonly used in hearths next to the river, although termite nest is found where the sand plain comes in close to the river. River sandstone occurs where outcrops are found along the river edge. Heat retainer hearths are commonly located on the sandplain and linear dunefields, and on the clay rich floodplains are concentrated on slightly elevated features, such as lunettes, source bordering dunes, river levees and sand islands (Martin et al. 1994, Pardoe & Martin 2002, Martin 2003).

Figure 4.4 Sample of Menindee Oven Sizes (Length x Width in Metres, N=72)



At Currawinya Lakes further north Robins demonstrated that stone heat retainers were carried a maximum of 700 metres from the source before they were entirely replaced with clay. There is a zone of mixing with composite hearths, however, 88% of stone hearths occur within the first 300 metres from the source, and 96% of clay hearths occur after the first 300 metres (Robins 1996). Heat retainer hearths recorded at Fowlers Gap in stony country to the west of the Darling River contain mixtures of locally occurring stones including quartz, silcrete, quartzite and sandstone, with 6 hearths also containing broken grinding dish (Holdaway and Fanning 2003 a). Heat retainer hearths recorded at the Willandra Lakes to the east of the Darling River include a variety of heat retainers; including pieces of termite nest, carbonate nodules, baked indurated sandy sediment, baked clay, and silcrete (Clark and Barbetti 1982:146).

Witter's PhD research delineated the distribution of heat retainer hearths along a transect across NSW from the Tibooburra area to the Cobar Pediplain and to the southern highlands to the east of the study area (Witter 1992). Heat retainer features were most common on the Cobar Pediplain, with both Tibooburra and the highlands outside the most concentrated distribution of such features (Witter 1992). The density of such features was confirmed by a later survey on the Cobar Pediplain (Witter 2000). This indicated that heat retainer hearths are most common in semi-arid NSW, particularly along the Darling River and its tributaries, but becoming less frequent in the formerly forested highlands or the very marginal semi-arid country of Tibooburra. At Tibooburra heat retainer features are found in areas where water resources were concentrated by hydrological systems, such as the Thompsons Creek system (Holdaway et al. 1998). This distribution is similar to the Broken Hill areas where they are concentrated near creeks with soakages, springs, and semi-permanent waterholes, such as the Pine Creek area near the Pinnacles (Photo 2)(Martin 1998), and the Stephens Creek Gorge area (photo 1)(Martin & O'Donnell 1995).

2. Mounds

The only mound complex recorded on the Darling River system to date is located on a tributary, the Macquarie River, where it forms the extensive wetlands of the Macquarie Marshes. A group of 63 mounds was recorded in a survey area, with maximum density of 3 per hectare. They are circular to oval and range in maximum dimension from 5 metres to 75 metres, heights range from 15cm to 76 cm. The

mounds consist of dark grey fine sediments with charcoal and baked clay heat retainers, minor amounts of freshwater mussel shell and stone artefacts. The mounds are located on fluvial sediments, mostly near the main river channel, but above the areas that are seasonally flooded (Balme and Beck 1996:40).

3. Non- mounded Ashy Deposits

A total of 270 non-mounded ashy deposits were found during the large scale survey of the Menindee Lakes and adjacent Darling River (Pardoe and Martin 2002), bringing the total to 286 with addition of those recorded in previous surveys in the same area (Martin et al. 1994)). Ashy deposits have not been discussed elsewhere on the Darling River or its hinterland, but this may be a result of recording methods. Like the Murray Riverine Plain mounds they are composed of dark grey to paler grey or brown sediment with ash, charcoal and heat retainers, and fragmented and burnt faunal remains such a fish, mussel, yabby (freshwater crayfish), bird, and rarely larger mammals. The heat retainers are distributed through the deposit or clustered as individual heat retainer hearths (Photos 4 & 5). These deposits may be buried, or exposed at surface level, or built up above ground surface up to 40 cm, although averaging only 15-20 cm in depth even if they cover an extensive area (see Chapters 7 & 8).

4.7.3 Heat Retainer Experiments

Four examples of experimentation with heat retainer oven cooking in Australia were found in the literature review. At the Willandra Lakes, palaeomagnetic measurements indicated that hearths with termite nest heat retainers tend to show a single magnetism, acquired when the lumps were heated to above 500 degrees Celsius, suggesting the lumps were commonly in-situ and used only once. Other kinds of heat retainers tended to show movement during or after cooling (Clark & Barbetti 1982:146-7), suggesting they had been raked out of the pit ready for re-use. Also at the Willandra Lakes, lumps of termite nest were attached to thermocouples and placed in an experimental fire and the heating history recorded. The heat retainer surface reached 900degrees C within five minutes of the fire being lit, and internal temperatures reached 600 degrees C within 25 minutes. The core of the mass of heat retainers stabilized at 700 degrees C for 1.5 hours, while an outer heat retainer lost temperature from 600 degrees C to 150 degrees C in 1.5 hours. This confirmed that

heat retainers heat rapidly and cool slowly (even though these ones were not covered), and are very effective heat capacitors (Clark & Barbetti 1982:148).

Coutts et al. (1979:74-5) reported experimental firings of clay pellets collected from the base and perimeter of a mound, and the nearby Murray River banks. The experimental clay was then compared by thin section with archaeological samples. The archaeological samples were found to have about 10% more silica than the experimental ones, which led to the suggestion that the clay had been tempered by sand, or that an unknown source had been used. During the same field season on the Murray River, 'particularly successful attempts were made to follow the ethnographic descriptions for cooking food plants'. *Typha* was cooked in an oven with fired with clay heat retainers, grass packing and an earth covering. After half an hour the *Typha* rhizomes were removed and eaten; 'they proved delicious' (Coutts 1980: 37).

Amino-acid or fatty acid residues from pit ovens, particularly those dug into clay or utilising clay heat retainers, have the potential for identifying what was cooked in the ovens. This has not been carried out successfully in Australia as yet, but in New Zealand analysis of amino acids from large earth ovens indicate that they were used for cooking *Cordyline australis* (*ti* or cabbage palm) (Frankhauser 1993:13).

4.7.4. Chronology of Heat Retainer Technology in the Murray-Darling Basin

Heat retainer hearths have been dated to before the last glacial maximum at the Pleistocene Willandra Lakes including Lake Mungo, and provided some of the first hard evidence of the long antiquity of Aboriginal occupation of Australia. In 1972 Barbetti and Allen reported:

> The oldest fireplace ... is a typical Aboriginal oven – a shallow depression filled with ash and pieces of charcoal, with several lumps of baked clayey sand arranged on top (they were used as substitute cooking stones in the Lake Mungo region) ... Charcoal sealed underneath the ovenstones was collected...to give a reliable age of 30,780 ± 520 BP (ANU-680) (Barbetti and Allen 1972:48).

The date obtained from the Pleistocene Willandra heat retainer feature is similar to the series of moulded clay-lined basin shaped permanent hearth features from Klisoura Cave 1, Greece, which date from 34-32,000 BP. It is thus notable that at the Willandra Lakes at the same time but on the opposite side of the world Aboriginal

people were building specialized cooking places using baked clay heat retainers. Four other Pleistocene dates from Willandra Lakes heat retainer hearths range from around 27,530 to 19,420 BP (all dates are tabulated in Appendix 4). Another Pleistocene date was obtained from a heat retainer hearth to the west of the Darling River at Lake Yantara about 50 km southeast of Tibooburra. Charcoal from the feature gave a date of 26,200 ± 1100 BP (Dury & Langford-Smith 1970:73). Another feature dated from Lake Yantara gave a much younger age of 1,270 ± 140 BP (Barbetti & Polach 1973), but this does not contradict the earlier date as the area continued to be occupied into the recent period.

Another 18 Willandra Lakes heat retainer hearths (Appendix 4) are dated from around 4,000 BP to modern (Barbetti & Polach 1973). Clark and Barbetti compared dates for hearths with different kinds of heat retainers at the Willandra Lakes and found that baked termite nest heat retainers began to be used and were the most common type from about 4,500 BP onwards, and ovens older than about 19,000 BP were smaller, consisting of fewer lumps of baked clay-sand heat retainers (Clark and Barbetti 1982:144). The palaeomagnetic data indicates that the termite nest heat retainers tend to show less evidence of movement than other types of heat retainer material during or after cooling, which may result from a different style of cooking (Clark & Barbetti 1982:146-7). This appears to be the only study in Australia of temporal trends in heat retainer hearths. The absence of ceramics in Australia led to the early application of thermoluminescence (TL) dating to heat retainer hearths instead of, or in addition to, the more conventional Radiocarbon dating (Prescott 1982:262). This work was pioneered in the Murray Darling Basin and was crucial in understanding the need to calibrate radiocarbon dates. The comparison of Radiocarbon and TL dates from the Willandra Lakes showed that the TL dates were systematically older indicating that the RC dates were too young (Bell 1991:49) and needed calibration.

A research program focusing on the semi-arid hinterland to the west of the Darling River is using heat retainer hearths as a tool for dating landscape surfaces and associated archaeological material, and providing a chronology of occupation (Holdaway et al. 2005). Radiocarbon dates from 28 heat retainer hearths (Appendix 4) located in Sturt National Park, in the arid north-western corner of New South Wales, fall into two distinct phases of hearth construction separated by a period with no datable hearths. Phase 1 returned dates of between about 220 BP to 820 BP, and

phase 2 between about 1,170 BP to 1,630 BP (Holdaway et al. 2002a). Radiocarbon dates from 53 heat retainer hearths from the semi-arid ranges near Fowlers Gap gave a record from about 6,000 BP to modern, with variability in the length of the record at different places linked to geomorphic landscape change (Holdaway & Fanning 2003a). At Peery National Park nine heat retainer hearths have been dated so far ranging from about 1,800 BP to about 350 BP (Holdaway & Fanning 2003b). This work interprets increasing frequency of younger hearths as the result of more well-preserved recent surfaces and relative lack of older surfaces. The gaps in hearth dates from the three areas are analysed and interpreted as indicating that the region was periodically 'abandoned' during the Late Holocene (Holdaway et al. 2005:47). Other dates from the Darling River hinterland (Appendix 4) include two stone heat retainer hearths from the Broken Hill area dated to 5,830 ± 90 BP and 600 ± 50 BP (Martin and O'Donnell 1995:75). On the Cobar pediplain to the east of the Darling River heat retainer hearth dates include five dates ranging from 1,190 ± 50 BP to 430 ± 60 BP (Witter 2000), and four dates of between 3,830 ± 110 to 760 ± 70 BP (Bonhomme & Stanley 1985). Dates from six heat retainer hearths at Currawinya Lakes range from around 1,700 BP to 400 BP (Robins 1996).

Dates for heat retainer hearths (Appendix 4) from the Murray Riverine Plain are all younger than 3,000 BP, the lack of older dates reflects the few dates and the aggrading nature of this section of the alluvial basin and the general lack of deep erosion compared to the Darling River and Willandra Lakes areas. Two heat retainer pit ovens located to the south of the Murrumbidgee River returned dates of 1310 ± 50 BP and 440 ± 70 BP (Chapter 5) and three heat retainer hearths from a complex of mounds and ovens on an eastern tributary of the Murrumbidgee were all dated to around 3,000 BP (Klaver 1998). On the Murray River to the south of the Hay Plain heat retainer hearths returned dates of around 2,582 BP, 2,400 BP and 1,880 BP (Barbetti & Polach 1973, Downey & Frankel 1992).

Mounds on the Wakool River, an anabranch of the Murray River just to the south of the Hay Plain, are dated from around 3,000 BP to modern. The earliest date appears to be an oven rather than a mound from its description, but it may be an incipient mound given the high density of mounds in the area (Berryman & Frankel 1984:26). Three Radiocarbon dates from a clay heat retainer hearth on the Murray River gave an age range of 2,753-2,612 CAL BP, which compared with the TL date of 2,651 ± 275 BP from the same material demonstrated the value of TL dating of clay heat

retainers (Downey and Frankel 1992:35). Another seven mounds dated from this area range in age from around 2,059 BP to 250 BP (Coutts et al. 1979, Godfrey et al.1996, Johnston 2004). A burial closely associated with a mound complex on the Hay Plain southwest was dated at approximately 5,000 BP (Pardoe 1995), which corroborates the dates of over 4,000 BP from the nearby Ravensworth 3 and Tchelery 1 mounds (Chapter 5). A single date of 1,050 ± 90 BP was obtained for a mound in the Macquarie Marshes (Balme & Beck 1996. Klaver obtained 27 dates from Cooey Point Lagoon on the Murrumbidgee (eastern edge of Hay Plain) and Columbo Creek (South Eastern Slopes, to the east of the Hay Plain), for a series of mounds, ovens and a midden (Appendix 4). Cooey Point Lagoon 82 mound has a series of 10 dates ranging from about 400 BP to 2,660 BP. However, the early date is not necessarily related to mound construction , as it comes from a small, disturbed, water rounded heat retainer feature at the base of only part of a younger mound, with a 2,000 hiatus between the two features. The Cooey Point Lagoon sites, including 4 mounds and a midden all range from about 1,000BP to 400 BP, except for the one older date mentioned above. The Colombo Creek mound is dated at approximately 2,500 BP, similar to the dates from nearby ovens (Klaver 1998:191-208).

There are not enough dates from mounds on the Hay Plain or Murray Riverine Plain for a statistical analysis, However, it is interesting to combine Hay Plain dates (this study and Klaver 1998), with the dates from the Murray just to the south of the Hay Plain (Table 4.1). I have left out Klaver's problematic dates from test pit 3 of Cooey Point Lagoon 82, and just included the dates from test pit CP 82/4. A total of 16 dated mounds give basal dates ranging from approximately 4,300 BP to 650 BP, an average of 1,825 BP, with a breakdown of 6 younger than 1,000 years BP, 4 between 1-2,000 BP, 4 between 2-3,000 BP, none between 3-4,000 BP and 2 older than 4,000 BP. Given the ability of mounds to resist erosion (Chapters 5-6) and the aggrading rather than eroding nature of the riverine plain, the dates suggests mound building started between 4-5,000 BP and increased over the last 3,000 years. The top and bottom dates for the 12 mounds with multiple dates suggest that mounds can take anything from 50 to 1,200 years to be constructed, an average of about 500 years.

Table 4.1 Dates and Mound Construction Period for Combined Hay Plain and Murray Riverine Plain Mounds

Location	Descript.	Top & bottom dates	Approx. period of mound construction	Reference
Murray/Wakool	Mound	2990 ± 100 BP	n/a	Berryman & Frankel 1984:26}.
Murray/Wakool	Mound	2250 ± 105 BP	n/a	Berryman & Frankel 1984:26.
Murray/Wakool	Mound	2490 ±60 BP	n/a	Berryman & Frankel 1984:26.
Central Murray	mound	800 ± 100 BP 1610 ± 90 BP	400	Godfrey et al 1996
Central Murray	mound	250 ± 80 BP 1470 ± 90 BP	1200	Godfrey et al 1996
Central Murray	mound	950 ± 80 BP 1000 ± 80 BP	50	Godfrey et al 1996
Central Murray	mound	1180 ±150 BP	n/a	Godfrey et al 1996
Central Murray	mound	260 ± 70 BP 1000 ± 90 BP	740	Godfrey et al 1996
Central Murray -Nyah Forest Vic	mound	960 ± 80 BP 1375 ±30 BP	400	Coutts et al 1979 (site DP/1)
Central Murray-Loddon River, Lake Boort, Vic	mound	775 ± 47 BP 2059 ± 46 BP	1280	Johnston 2004 Boort Swamp 2
Hay Plain Tchelery 1	mound	3730 +-240 4340+-160	600	Martin this thesis
Hay Plain Ravensworth 3	mound	3820 ± 36 BP 4109 ± 55 BP	300	Martin this thesis
Murrumbidgee CP 59/4/a & b	Low mound	440 ± 70 BP 650 ±70 BP	200	Klaver 1998
Murrumbidgee CP 79	Low mound	680 + 60 BP 750 + 60 BP	70	Klaver 1998
Murrumbidgee CP 116/D4/	Mound	450 ± 60 BP 970 ±70 BP	500	Klaver 1998
Murrumbidgee CP 82/4/1-2-3/C	mound	390 ± 70 BP 960 ± 170 BP	600	Klaver 1998
Average build up period			c. 528 years	
Average basal date		c. 1825 BP		

4.8 UNDERSTANDING HEAT RETAINER TECHNOLOGY

The introduction of cooking, and the various kinds of cooking technology including heat retainer cooking, has been of major significance to both the human genome and human history (Brace et al. 1987, Wrangham & Conklin-Brittain 2003) The use of heat retainers for cooking is a world wide phenomena of emerging significance, however

many aspects are poorly understood (Wandsnider 2000:118).

Some general patterns emerge regarding the use of heat retainer hearths or ovens in the Murray-Darling Basin. They have been used in the Basin over a very long period of time from at least 31,000 BP until the contact period, and a form of pit oven is still in use among Paakantyi people of the Darling River today. They are widespread both in space and time are found both in the Darling and Murray riverine systems and in the semi-arid non-riverine landforms either side. Issues of preservation and sampling need to be addressed before any increase in the use of individual heat retainer ovens can be defined. In contrast non-mounded ashy deposits and mounds are much more restricted, both in space and time, and are found only in specific parts of the riverine systems. Mounds appear in the archaeological record around 4,300 BP (Chapter 5), but the majority of dated mounds are younger than 2,000 BP. Mounds are concentrated on the Murray Riverine Plain (which includes Hay Plain), and also in the Macquarie Marshes. The non-mounded ashy deposits are concentrated at specific landforms on the Darling River but have also been recorded on the Lachlan River on the northern side of the Hay Plain, and it is probable that they occur in areas that have not been investigated in detail.

The chronology suggests that heat retainer cooking began to contribute to the formation of mounds and non-mounded ashy deposits in the mid to late Holocene. Other chronological trends suggest that mid to late Holocene ovens are bigger than Pleistocene ovens, and that termite mound became the heat retainer of choice in sandplain areas of the Basin after around 4,500 BP (Clark & Barbetti 1982:144). However, this research was based on small samples, and termite mound may have only gradually become a usable resource after the post-glacial regeneration of mallee in the 17.000-13,000 BP period (Bowler 1998). The adoption of baked clay heat retainers in hearths, mounds and ashy deposits, is concentrated on stoneless alluvial landforms (which are also unsuitable habitats for the right kind of underground termite), such as sections of the modern Darling and Murray Rivers and their tributaries including the Murrumbidgee and Lachlan of the Hay Plain.

In the non-riverine Darling River hinterland, heat retainer cooking of USOs and fibrous vegetables may have enabled people to stay in semi-arid areas during long dry periods. The most significant effect of cooking meat is tenderising thus allowing a high rate of intake (Wandsnider 1997:40), nevertheless the hydrolysis of fats may

have also been most significant effect for people on fat-poor diets in the semi-arid non-riverine areas. Wandsnider concluded that fatty meat was cooked in ovens and others also state that meat has low energy value during periods of climatic stress, and is therefore unlikely to be a fall back food (Wrangham et al. 1999:571 after Speth 1989). However, Wandsnider noted there were exceptions to her fatty meat rule, and ethnography from the Darling River area indicates that an important drought food was oven cooked lean meat such as kangaroo. Bonney indicates that droughts in the Darling hinterland could last for 18-22 months, and during such times people existed on 'half-starved' and 'weak' animals forced to go to springs or waterholes and killed easily (Bonney 1884:123). Mitchell describes a similar situation on the Darling River at Bourke (Mitchell 1839 Vol II:293).

Many ethnographic accounts from the Darling and its hinterland and present day practice suggests that heat retainer stones, termite mound or baked clay is not always necessary to cook emu and kangaroo, but that the sides and bottom of the pit retain sufficient heat to cook the animal if it is 'fat' (which means tender). So what is the origin of the many individual heat retainer hearths found in the Darling River hinterland? Where they used to cook 'roots' and 'greens', or were they used to cook kangaroo and emu, or both? Another description from the same area as Bonney describes cooking kangaroo in an oven with heat retainer. 'If the steam is not sufficient to cook the flesh properly, holes are made and water is poured in. The skin is left on, in order to preserve the juices of the meat' (Brough Smyth Vol I:187). The evidence suggests that lean drought-affected meat may have been steam/baked inside intact skins ('foil') in ovens with heat retainer and for a long time to enable the hydrolysis of lipids and collagen, including the bone marrow and fat attached to the skin which are important source of fats for Aboriginal people (personal observation). Steam/baking of USOs may have provided the carbohydrate to balance the meat and fats. It is thus more likely that the many individual heat retainer hearths result from the cooking of lean animals rather than fat animals, as well as 'greens' and USOs, that is the food that required steam/baking with heat retainers for several hours. It follows from this that periods of time in the Late Holocene when heat retainer ovens were not built in the semi-arid refuge type areas of Darling River hinterland, detected by Holdaway et al. (2005), may represent a period of better than usual climate when people could move around more in their ranges and eat a more varied diet, and were cooking fat animals in ovens without added heat retainers. Thus the supposed forced

'abandonment' of Darling River hinterland during periods without heat retainer hearths (Holdaway et al. 2005), can be reinterpreted as periods of plenty.

In North America the burned rock middens of the west and earth mounds with clay heat retainers in the east were introduced around 4,500 BP, almost exactly the same time as the earliest burnt mounds of Britain, and Chapter 5 shows that this is very similar to the earlier dates for earth mounds in South-Eastern Australia. The North American research is significant because of the numerous deeply stratified open sites and rockshelter sites that have provided detailed evidence of heat retainer use over long periods of time in numerous regions. Thus in North America trends over time can be clearly delineated, unlike Australia where the paucity of deeply stratified sites has resulted in the site preservation versus intensification debate (Chapter 2). In both continents larger heat retainer oven features such as burnt rock middens, mounds and ashy deposits appeared around 4,500BP and then became more common around 2,000 BP.

Heat retainers were used globally, including in Australia, for a range of purposes, for cooking meat (particularly large animals and fatty meats), cooking a range of plant foods particularly those that contain complex carbohydrates of various kinds, to increase storage life of foods by dehydration and denaturing enzymes that promote rancidity, for medicinal uses and saunas, detoxifying poisonous compounds in plants, fuel saving, for processing plant fibre, for large scale cooking to cater for large groups of people including those gathered for ceremonies. Ethnographic descriptions of heat retainer use indicate that people in varying regions and continents using different species used similar processes to obtain the best results from heat retainer use, even down to minute details such as packing food between salt rich plants to change the pH of the cooking environment, or using tongs to move the heat retainers into position. Wandsnider was able to develop a set of 'rules' to predict why and how people used heat retainers, based on food physics and chemistry. The rapidly developing research into the molecular structure of food plants enables archaeologists to understand for the first time the complexity of knowledge held by heat retainer using peoples about carbohydrate structure, cooking methods, fuel, energy maximisation, denaturing of enzymes and toxins in foods, dehydration for storage, and much more. This extraordinary knowledge was/is equally advanced in agricultural and non-agricultural societies, and by studying the cooking methods used for the various plant species archaeologists can for the first time establish the level of knowledge people had

about plant foods, a level often assumed to have belonged only to agricultural societies.

In comparing the use of heat retainer ovens in North America and Australia, it is apparent that they were used in a similar way and for similar reasons and with similar mid to late Holocene trends to larger features such as mounds and burnt rock middens, and complex oven structures. The only significant difference between oven use in North America and Australia is that prolonged cooking for 36-48 hours of long branched polymers, particularly those of the *Agave* genus, was not necessary for most Australian foods cooked in ovens. In Australia many starch rich USOs are cooked in ovens, probably rich in amylose starch that needs extra cooking to increase digestibility. Some Australian inulin sources, such as *Microseris*, appear to have a less complex structure than the inulin in *Agave* for example, and therefore require less cooking. The similar susceptibility to diabetes among indigenous people in North America, Oceania and Australia, suggests they are all genetically attuned to eating difficult to digest and absorb carbohydrates such as amylose starches, fructans and inulin

In North America cooking in ovens can be seen as part of an overarching process of increasing focus on a broad range of plant foods what were previously little used or under-utilised (such as toxic and/or complex carbohydrate foods), or new foods (such as maize). In summary;

> By the early to middle Holocene, there is ample archaeological evidence in the form of pit hearths, grinding technology, and ceramics, as well as the floral and faunal remains themselves, indicating that people were drawing from a very extensive larder. And, throughout the rest of the Holocene, the archaeological record is dominated by evidence that people are resorting to increasingly costly food processing practices to detoxify and maximize the energy value of foods (Wandsnider 1997:35).

In addition the increased use of heat retainer ovens in the mid to late Holocene co-evolved with changing relationships between people and foods cooked in ovens, including management of food plant crops. Both the aspects of intensified focus on foods that were previously under-utilised and required prolonged cooking in ovens to detoxify and/or maximise energy value, and the closer relationships between people and these species, is applicable to the mid to late Holocene of Australia.