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13. Manuel Pinto's inland sea: Using palaeoenvironmental techniques to assess historical evidence from southwest Sulawesi

IAN CALDWELL

Department of East Asian Studies, University of Leeds, U.K.

MALCOLM LILLIE

Wetland Archaeology and Environments Research Centre, University of Hull, U.K.

1. INTRODUCTION

This paper outlines the results of combined geomorphological and historical analyses, alongside a re-evaluation of recent palaeoenvironmental studies in the Tempe depression on the southwestern peninsula of Sulawesi (southwest Sulawesi). Using previously published environmental analyses (Gremmen 1990), low-resolution borehole surveys were carried out in an attempt to define the likely areal extent of two freshwater lakes, Rawa Lampulung, to the east of Sengkang in the Cenrana River valley and Lake Tempe, which lies to the west of Sengkang in the Tempe depression (see Fig 1).

Two significant and inter-related research themes are considered here. Firstly, historical accounts of a great lake, or inland sea, located in southwest Sulawesi, and outlined in Pelras' (1981) study of the La Galigo texts, are evaluated against recent considerations of Gremmen's (1990) palaeoenvironmental work in this region (cf. Whitten et al. 1987). Secondly, and fully integrated within this assessment, is the evaluation of the age-altitude and sea level indices associated with Gremmen's (1990) study against historical and modern accounts of the potential dimensions of these lakes.

The borehole surveys undertaken by the present authors have determined that seasonal, as opposed to more permanent, fluctuations in Lake Tempe could conceivably account for the historically documented lake dimensions. Re-evaluation of Gremmen's (1990) borehole data suggests that a direct comparison between this data and the sea level curve of Whitten et al. (1987) is difficult to sustain on stratigraphical grounds. In addition, the relationship between the Lake Tempe and Rawa Lampulung cores relative to the evidence for saline influences is questioned, and we conclude that it is only with further high-resolution borehole surveys at both locations that these relationships can

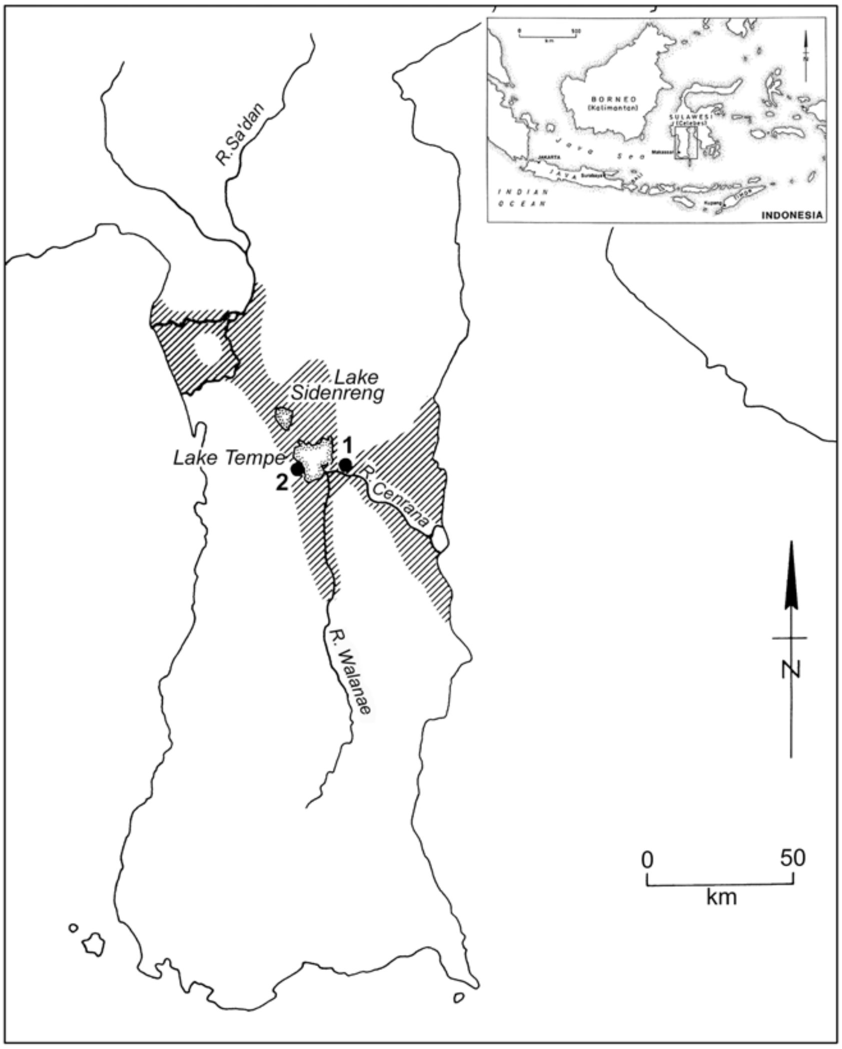

Figure 1. The approximate limits of inundated areas at the time of the trans-peninsula channel in southwest Sulawesi are shown by transverse lines (after Pelras 1981). 1. Groningen and the authors' boreholes at Rawa Lampulung. 2. The authors' boreholes at Padaelo.

be assessed. Finally, it is recognised that certain factors, such as the recent, exacerbated sediment infilling of Lake Tempe, and potential, as yet undetermined, tectonic activity in the region, may have a complicating influence on the studies carried out to date. The integration of the various strands of evidence presented below highlights the considerable potential that multi-disciplinary studies have for our understanding of Holocene landscape developments in the region, and how such studies can assist in the interpretation of more recent evidence, as obtained from the various historical sources considered.

2. SEA LEVEL CHANGES IN SOUTHWEST SULAWESI

There is a well-known tradition in southwest Sulawesi of an ancient waterway that once lay between the Gulf of Bone on the east coast and the Makassar Straits on the west coast of the peninsula. This channel, which ran from the mouth of the Cenrana River on the east coast to the harbour of Parepare on the west coast, made it possible (so the tradition states) to sail from one side of the peninsula to the other, via an 'inner sea' which occupied much of the Walanae depression. Based on the evidence of the La Galigo, an epic poem written in an archaic form of the Bugis language, Pelras (1981: 162) has published a map showing the approximate contours of the edges of this channel and the inner sea, superimposed on a map of the present day contours of southwest Sulawesi (see Fig. 1).

In his recent book, *The Bugis*, Pelras (1996: 62) sets out a description of the channel based on the La Galigo texts:

> 'At the mouth of the Cénrana river, instead of the present delta there seems to have been a wide estuary, narrowing into a first pass at Solo', then widening again into a vast, presumably brackish, lake into which water poured from what is now Lake Témpé through narrow straits, creating dangerous whirlpools. ... Beyond, where nowadays rich ricefields form a vast plain surrounding the shallow lakes Témpé and Sidénréng, an 'inner sea' covered most of the land as far as Soppéng to the south and the hills to the west which lead into the high cordillera running parallel to the western coast, with an outlet on this coast near Suppa'.'

Scientific research has confirmed that the water tables in the Cenrana valley and the region around Lake Tempe were significantly higher in the mid-Holocene than they are today. In their discussion of sea level changes, Whitten et al. (1987: 18, 20) state that:

> 'The most recent sea level maxima detected off the southwest peninsula were 4500 and 1600 years ago when sea level was 5 and 2.5 m higher respectively … the most marked effect on Sulawesi would have been the separation of the blocks of land either side of the Tempe depression. Evidence of this has been found in the vegetation record … and there are even stories among local people of a time when travellers did not have to sail round the southern tip of South Sulawesi but could instead sail from the Gulf of Bone through Lake Tempe and emerge in the Makassar Straits.'

The evidence of the vegetation record to which Whitten et al. (1987) refer is a set of two parallel cores taken from a swampy lake, Rawa Lampulung, by a Dutch-Indonesian research team in June 1980. These cores were analysed at the Biologisch-Archaeologisch Instituut in Groningen (hereafter, Groningen) and the results were published by Gremmen (1990). The pollen from the cores show that at least part of the area surrounding the freshwater lake Rawa Lampulung, which lies about four kilometres east of Sengkang, was covered with mangrove vegetation, and was thus inundated by the sea, from about 7100 to 2600 BC (Gremmen 1990: 129).

3. HISTORICAL REFERENCES TO A SINGLE GREAT LAKE

The earliest description of the lakes region of southwest Sulawesi is by Manuel Pinto[1], a Portuguese, who claimed in a letter written to the Bishop of Goa dated December 7, 1548, to have spent eight months as the guest of the 'emperor' of Sidenreng, the name of a Bugis kingdom and its eponymous palace centre on the northern edge of Lake Sidenreng (Schurhammer 1980: 628):

> 'His city is located on the shores of a lake on which there are many large and small *prahus* ['boat']. It has many types of fish in great abundance. Around about this lake there are many flourishing cities. This lake is about twenty leagues long and four or five leagues wide … A river flows from this lake towards the interior of the land and, after flowing for a month, empties in the east into the sea of Bamda in a city by the name of Maluvo … From this city called Semdre [Sidenreng] to that other called Malluvo[2] they sail in *prahus* for twenty days and a large *fusta* ['sail boat'] can sail up this river to this city of Semdre.'

It is not our intention here to inquire into whether Pinto actually visited Sidenreng, or whether he simply heard of the lake and its fertile surroundings during his stay at the west coast kingdom of Suppaq. The dimensions of the lake that he gives, if true, would require the inundation of much of the peninsula. They should be set against his description of the Cenrana River, which 'after flowing for a month, empties in the east into the sea of Bamda' (Schurhammer 1980: 628), but which in fact takes a single day to reach the sea (Brooke 1848: 85). The notion of a single waterway crossing the peninsula is found in Forrest (1792: 72), who writes: '*Chinrana*, the most considerable [river] takes its rise in the country of *Warjoo,* runs through *Bony,* and discharges by several mouths in the *Sewa* on its west coast.' A '*Laut-Sála* ['false sea'] or Fresh-water lake' is mentioned by Raffles (1817: clxxvii), and Crawfurd (1820: 149) writes that: 'The original country of [the Bugis] is the banks of the great fresh water lake *Tapara-karaja* in the south-western limb of Celebes'. James Brooke (later Raja of Sarawak) who to judge by his journals was an observant visitor, spent several days in the region, and stated that the *Taparke-raja* (Lake Tempe) and the Sarrow (Lake Sidenreng) 'evidently was one body of water originally [and] the greater part of the low alluvial plain between the lake and mountains, was [once] covered with water' (Brooke 1848: 105).

What these pre-twentieth century writers fail to mention is the remarkable annual expansion of lakes Tempe, Sidenreng and Buaya into a single, vast sheet of water during the rainy season from April to June, as shown in Figure 2. This phenomenon is so striking that Whitten et al. (1981: 255) refer to Lake Tempe as a *single* lake which, during the dry season, 'shrinks to become three separate but interconnected lakes: Tempe, Sidenreng and Buaya'. According to Table 4.1 in Whitten et al. (1981: 255), the area of this single lake varies from a maximum of 35,000 ha to a dry season minimum of 1000 ha, with a

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[1] Schurhammer (1980: 627) provides brief biographical details.

[2] Schurhammer (1980: 628) identifies Maluvo as Palima (sic: Palopo?) in Luwu. However, in the sixteenth century, the palace centre of Luwu lay at Malangke, on the central alluvial plain of the Gulf of Bone (Bulbeck & Caldwell 2000: 16).

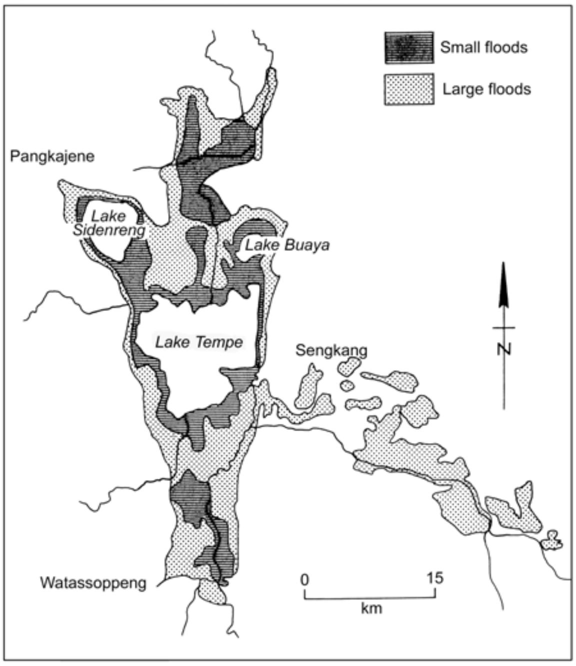

Figure 2. The lakes of the Tempe depression with the areas under water during small floods (diagonal lines) and large floods (hatched area) (after Anon. 1979, 1982).

corresponding seasonal variation in depth from 9.5 m to 1 m. In other words, during the dry season, the lake shrinks to one thirty-fifth of its wet season area, while its volume decreases to perhaps less than one-thousandth of its wet season volume[3].

4. THE BOREHOLES SURVEYS AT RAWA LAMPULUNG AND LAKE TEMPE

In this article we report the results of two borehole surveys conducted in 1999. In the first survey, two shallow cores were taken from the southern edge of Rawa Lampulung, a small freshwater lake about four kilometres east of Sengkang, which lies in a raised depression on the north side of the Cenrana River. A single, deeper, core was recovered during the second survey from a point less than one kilometre from the western edge of the much larger Lake Tempe, southeast of the settlement of Padaelo. The cores were sampled to identify the physical nature of the sediments adjacent to the two freshwater lakes as well as to assess their potential for palaeoenvironmental research. The borehole surveys were carried out as part of a research project on the landscape history of the upper Cenrana valley and the Tempe depression (the area around the central lakes) by

[3] Wichmann's (1890) sketch map of his journey from Parepare to the mouth of the Cenrana River shows the remarkable smallness of Lake Tempe in October 1888.

the Origin of Complex Society in Southwest Sulawesi (OXIS) project (Bulbeck & Caldwell 2000). In Bugis historical records, the upper Cenrana valley and the central lakes area are associated with accounts of agriculture and centralised political life as early as the thirteenth century AD (Caldwell 1995: 410).

The topographical maps used for this research were the 1:50,000 maps Sengkang-2111-43 and Batubatu 2011-64 published by the Indonesian National Coordination Agency for Surveys and Mapping (hereafter, Bakosurtanal n.d.). The Regional Physical Programme for Transmigration (hereafter, RePPProT 1998) was also consulted in order to gain insights into the physical and biological characteristics of the Walanae depression and the upper Cenrana valley. Overall, Sulawesi has about 90 recognised land systems over the total area of 188,487 km^2 (RePPProT 1998: 52). The land system upon which the regional capital Sengkang is located, and which forms the molasse ridge which separates the two areas of study, is classified as undulating tuffaceous sedimentary plains (31-Watampone [WTE]; RePPProT 1998). The Cenrana River, which in the wet season drains the lake, dissects this ridge, and is flanked by a series of wetland areas comprising both coalescent estuarine/riverine plains (05-Kahayan [KYH]) and permanent waterlogged peaty floodplains (13-Klaru [KLR]), bordered by undulating tuffaceous sedimentary plains (31-Watampone [WTE]; Sengkang 2111-43 [Bakosurtanal n.d.]). Small areas of open water occur throughout the region east of the molasse ridge, fed by a series of small streams that flow off the ridge. A number of swamps are mapped throughout the areas adjacent to the main water courses (Sengkang 2111-43 [Bakosurtanal n.d.]).

4.1. *The borehole sequence at Rawa Lampulung: sedimentological and radiocarbon evidence*

The first of the two sites considered, Rawa Lampulung, was chosen to evaluate and to attempt to replicate, as far as practicable, the research reported in Gremmen (1990). In 1980, Rawa Lampulung was a shallow lake, as opposed to the swamp area shown on the 1:50,000 Bakosurtanal (n.d.) map Sengkang-2111-43 (Gremmen 1990: 125). The present authors also found this to be so, and observed that the lake is a local source of freshwater fish. At the time of the Groningen study, the lake was approximately 2.4 m deep and the excavated boreholes were taken from a fixed platform on the lake at a distance of about 300 m from the shore (Gremmen 1990).

The sedimentological sequence recovered by the Groningen team in 1980 is described by Gremmen (1990) as comprising 9.31 m of lake and lake infill deposits, with sediment occurring from a depth of 2.4 m below the lake surface at the time of the coring. A sequence of unoxidised clay on to peaty clay at 4.95 m depth gave way to organic-rich clays at 5.8 m depth. The frequency of the contained organics reduced with depth to about 7.73 m, at which point a thin horizon of clayey peat was encountered between 7.73 to 8.45 m depth. The basal part of the sequence between 8.45 and 9.31 m produced inorganic sandy clays (Gremmen 1990).

The Rawa Lampulung sequences have been dated to between 2610 ± 50 BP (GrN-12540) and 7100 ± 70 BP (GrN-10514). These radiocarbon determinations have produced calibrated ranges of 6088 - 5811 BC and 843 - 766 BC at the two sigma level using the Oxcal calibration program (Stuiver & Reimer 1993). The lower radiocarbon determination was recovered from the base of this lower peat horizon at c. 8.45 m and marks the shift from freshwater to salt water influences in the area's hydrology.

In relation to this freshwater to salt water shift, Whitten et al. (1987: 29) state that 'The rise in sea level needed to produce this effect is about 5 m which matches the palaeo-climate information' (namely the 5 m rise in sea level 4500 years ago referred to previously). If we accept that the mapped contour heights on the Bakosurtanal (n.d.) maps are correct, then the base of the Rawa Lampulung sequence at 7100 ± 70 BP (c. 6000 BC), which reflects the onset of mangrove vegetation, is at an approximate height above sea level of 6.55 m. This would be approximately 1.55 m above the 5 m sea level maximum dated to 4500 years ago in the sea level curve shown in Whitten et al. (1987; see Fig. 3). Given these data, clear inconsistencies exist between the Groningen altitude/age data and the general sea level curve from southwest Sulawesi. The Groningen evidence would suggest an earlier and stratigraphically higher sea level than has hitherto been proposed. Further complications occur when we examine the evidence obtained from Lake Tempe (Gremmen 1990: 129-130), which is considered below.

The saline influences occurring at c. 7100 ± 70 BP resulted in the development of mangrove vegetation (see above). According to Gremmen (1990: 129), this phase of vegetation development is abruptly curtailed during his pollen zone RL3, to be replaced by open vegetation dominated by grasses and sedges. The upper sampling depth for the cessation of mangroves is not stated, but is probably at 4.95 m depth [10.05 m real height on the basis of the Bakosurtanal (n.d.) map] at the transition between the upper inorganic clays and the peaty clays, which is dated to 2610 ± 50 BP (see above). This would suggest that the intervening c. 3.5 m of sediment relating to the saline mangrove vegetation was deposited between c. 6000 and c. 800 BC, with the upper freshwater lake sedimentation occurring after c. 800 BC.

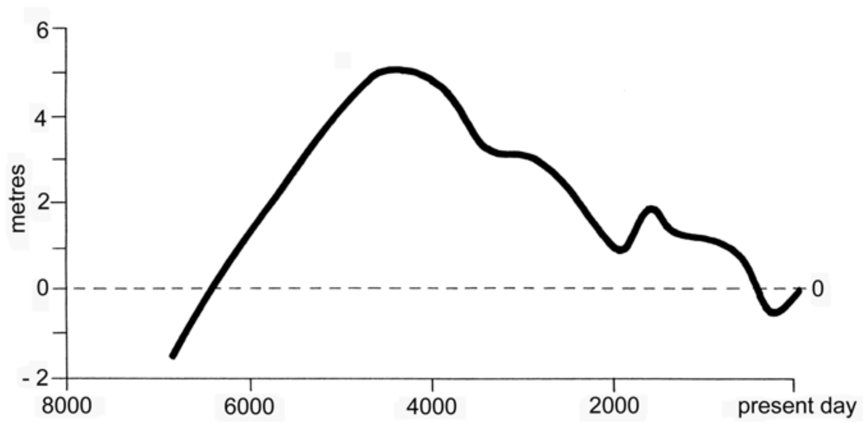

Figure 3. Changes in sea level over the last 7000 years determined from a study in the southwest peninsula of Sulawesi (after De Klerk 1983).

In July 1999, coring was carried out by the authors at the lake margins on the southern side and on the northwestern side of Rawa Lampulung. On the southern side (RL-A1) the borehole stratigraphy showed 0.2 m of dark grey clay-silts with fine sands over partially oxidised silt-clays. The degree of oxidation reduces below 1.2 m depth, and occasional c. 0.025 m limestone inclusions were recorded to the base of this horizon at 2.3 m depth. At this point the sequence graded to very compact, partially oxidised blue-grey clays which became too dry and compact to penetrate below 2.4 m depth. This sequence produced no indication of the organic-rich clays and peats recorded by Gremmen (1990) from the central lake area. This suggests that the sample site, on the southern edge of the swamp area fringing the lake, represents the edge of the lake basin, and indicates that the organic-rich deposits exhibit a discrete areal extent focused towards the mid-point of the present lake. Similar sedimentary sequences on the northwestern side of the lake (RL-A2) confirm this observation, with 1.6 m of partially oxidised sandy clays and silts being excavated onto similar dry, compact, weathered material that proved too compact to penetrate past this depth. Again, no indication of marginal or backswamp peats were encountered at this location, which lies at about the 20 m contour line on the base of the molasse ridge.

4.2. *The relationship of Rawa Lampulung and Lake Tempe in the mid-Holocene*

As noted above, saline influences disappear from Rawa Lampulung at c. 2610 ± 50 BP (843-766 BC). However, the Groningen borehole survey on the eastern side of Lake Tempe, carried out at the same time as the Rawa Lampulung survey, produced a date of 4410 ± 100 BP (3367-2783 BC) for the basal sediments at a depth below the lake surface of 8.6 m (3.4 m real height assuming a lake surface height of 12 m)[4]. The basal sediments exhibit saline influences, suggesting that saline waters (which led to the Rawa Lampulung sequence of mangrove development) also extended into Lake Tempe. Extrapolation of the heights between Rawa Lampulung and Lake Tempe indicates that some discrepancies exist in the chronostratigraphy of Gremmen’s (1990) cores. At Lake Tempe, the sediments would appear to have an age of 4410 ± 100 BP at 8.6 m depth because of the close proximity of mangrove species in pollen zone DT-1. The vegetation change at c. 7.2 m depth in the Lake Tempe core (4.8 m real height) would securely bracket the onset of mangrove development on the east side of the molasse ridge at Rawa Lampulung at 7100 ± 70 BP. An explanation for the discrepancies may be sought in the tectonics of this region. Southwest Sulawesi is tectonically active, but as yet there is no detailed study of the nature of tectonic movements in the region of Sengkang. Higher resolution stratigraphical survey will potentially provide insights into both the effects of any tectonic activity and the apparent discrepancies between Gremmen’s (1990) cores.

Chronologically, the date for the base of the Lake Tempe core is inconsistent with the date obtained from the base of the Rawa Lampulung core, but in light of the fact that

[4] The contemporary lake surface heights in relation to Ordnance Datum are not given in Gremmen (1990). Here we follow an estimated mean of 12 m based on the height given for Ujungpere on the south side of Lake Tempe on Bakosurtanal (n.d.) 1:50,000 map Batubatu 2011-64.

the Lake Tempe sequence is incomplete, the base of the Lake Tempe core does not reflect the onset of saline influences but the upper temporal limit of mangrove development. In addition, we do not have data on the precise stratigraphical relationships between the Lake Tempe and Rawa Lampulung boreholes. According to Gremmen (1990), the Lake Tempe diagram does indeed correlate, at least temporally, to the upper part of the Rawa Lampulung core. The existence of the salt tolerant taxa at the base of the Lake Tempe core is puzzling given Gremmen's (1990: 131) statements that the Lake Tempe diagram 'reflects a predominantly fresh water vegetation and not a mangrove [vegetation]' and that 'it can be concluded that the sea did not reach the Danau Tempe area at that time.'

Little is yet known of sea level changes in southwest Sulawesi, but on the basis of the mapped contour lines on the 1:50,000 Bakosurtanal (n.d.) map (Sengkang-2111-43) it would appear from the above data that there were saline influences at possible heights of 6.55 m at 7100 ± 70 BP and at 10.05 m at 2610 ± 50 BP at Rawa Lampulung (cf. and contra Gremmen 1990: 132). This height range would account for the existence of salt tolerant species and the close proximity of mangroves at the Groningen borehole location, where possible heights of 3.4 - 4.8 m for the saline zone DT-1 exist from 4410 ± 100 BP (see above).

Even allowing for the apparent inconsistencies in the borehole heights, Lake Tempe appears to have received saline influences, however limited. These influences could have occurred any time between c. 7000-2500 BP, because we do not have the precise onset or cessation of saline tolerant taxa attested at Lake Tempe in an absolute dated framework. What we do know for certain is that in the middle of this period, at 4410 ± 100 BP, there is evidence for salt tolerant species in Lake Tempe, and to quote Gremmen (1990: 129-130): 'suggesting that the mangrove vegetation was not far away.' In this context, the potential biasing factors include the seasonal expansion of Lake Tempe, which may have resulted in a higher base elevation for Gremmen's (1990) core, and which would reduce or remove the apparent inconsistencies between the borehole locations. However, the inconsistencies in the borehole heights, which need to be addressed at a higher level of analysis, do not affect the evidence for saline influences acting on the lake system. A higher resolution coring and dating program by the authors, currently in the planning stages, should produce detailed evidence of local and regional vegetation changes and provide insights into sea level indices and any Holocene tectonic activity, as well as generate accurate height data regarding these Holocene vegetation and sea level changes.

4.3. *The borehole sequence at Padaelo on Lake Tempe*

The second borehole site, on the western side of the molasse ridge, was chosen in an attempt to establish the areal history of Lake Tempe (as represented by the modern lake of that name) during the recent Holocene. The deposits flanking Lake Tempe comprise a system of swamps that are mapped around roughly 75% of the lake edge on the 1:50,000 map Sengkang-2111-43 (Bakosurtanal n.d.). The main exceptions are the higher ground on the western side at Padaelo where the core was taken and the east side of the lake between Sengkang and Tancung. Areas of swamp vegetation appear to predominate below the 15 m contour line. As with the areas to the east of the molasse ridge, the physiographic types recorded by RePPProT (1998) comprise alluvial plains (07-Danau Lindu: DKU) and permanently waterlogged peaty floodplains (13-Klaru: KLR). Higher ground is mapped as hillocky tuffaceous sedimentary plains (45-Sungai Aur: SAR) in the central eastern parts of the area adjacent to the lake. These latter areas form the foothills of the very steep ridges overlying basaltic volcanics (69-Bukit Masung: BMS) that demarcate the western boundary of the Walanae depression.

The borehole was excavated at an elevation of approximately 22 m on the western side of Lake Tempe at a point approximately 0.8 km east of Padaelo and less than a kilometre from the edge of the lake as shown on the Bakosurtanal (n.d.) map. The borehole revealed a mixed/dumped topsoil onto oxidised dark grey-brown clay-silts and fine sands. These became lighter with depth, reflecting the reduction of organic content. Below 0.3 m the sand content increased, with greater staining in evidence. At 0.39 m depth this deposit graded to light brown iron-stained clayey sands which appeared marl-like in texture. These clay-sands became increasingly sand dominated as the depth increased, being less oxidised below 0.85 m depth. Occasional clay lenses were visible to 1.2 m depth where clays dominated the sequence. At 1.6 m depth the deposit consisted of coarse sand dominated material with some clays, iron concentrations and weathered limestone. This sequence was completed at 2 m depth due to the compact nature of the weathered interface at this location.

Despite local informant reports that at times Lake Tempe extends up to the edge of Padaelo, the sedimentary sequences revealed during coring about 0.8 km east of the settlement showed little in the way of 'characteristic' lacustrine sedimentation processes. The marl-like and sand dominated sequences below 0.39 m depth would appear to reflect natural, in situ weathering processes at this location. On the basis of the lithostratigraphical evidence, it would appear that the seasonal flooding currently experienced at the borehole location represents a combination of extreme, though natural, events. It is possible that an exacerbated lake condition has been produced by the reported sediment infilling of Lake Tempe over the past 30 years or so. This latter phenomenon would result in an increased need for the lake to expand its areal extent during wet seasons in order to compensate for the reduction in lake depth.

5. SEDIMENTATION PROBLEMS IN LAKE TEMPE

Of particular interest in the context of the potential for palaeoenvironmental research is the recent reporting of sedimentation problems occurring at Lake Tempe. The Indonesian language newspaper *Pedoman Rakyat* of Saturday 24th July 1999 reported that:

> 'If the present rate of sedimentation continues [in Lake Tempe] it can be stated with certainty that the lake will exist for only 13 more years. After that, Lake Tempe will disappear beneath sediment and only the memory of it will remain. In the past 20 years the lake has shrunk from a surface area of 33,000 ha to just 12,000 ha. This areal decrease has been caused by the accumulation of sediment. At present, more than half of the former area of the lake is buried by mud, sand and gravel. The depth

> of the lake has decreased drastically from c. 5 m 20 years ago to c. 1 m today. Most of the sediment is transported by two rivers, the Bila and the Walennae, each of which discharge about 500 tons of sediment annually into the lake. An additional 400 tons of sediment enters the lake from other sources. In the 1950s the lake produced c. 50,000 tons of fish annually, making it the largest freshwater fish producing lake in Indonesia at that time.' (Authors' translation.)

Quite apart from the depletion of fish resources from Lake Tempe, numerous implications for the ecology and palaeoenvironmental record of this area of Southwest Sulawesi are inherent in this report. Clearly, sediment sources are increasing in this region. This phenomenon may have a number of influencing factors. Erosion and soil depletion will have contributed in part, as the reported 900 tons of sediment input into Lake Tempe attest. As the areal extent of the lake recedes, the fertile sediments of the emergent lake plain are gradually being encroached upon for agricultural exploitation. In addition to visible ecological changes, these developments will eventually result in the drying out and consolidation of the contained palaeoenvironmental record spanning the last 4000 years or so of the recent Holocene, which lies up to 6.2 m below the lake bed.

6. DISCUSSION AND CONCLUSION

The present authors found no sedimentological or palaeoenvironmental evidence for a single great lake as described in Manuel Pinto's letter. The 2 m core extracted down to weathered bedrock at Padaelo at a distance of less than a kilometre from the western edge of Lake Tempe showed no evidence of a permanent lake bed beyond the present lake boundary. Seasonal flooding, which appears to be increasing in severity as the lake silts up, was, however, evident in the occasional clay lenses visible to 1.2 m depth[5].

What Pinto evidently witnessed was the remarkable annual expansion of lakes Sidenreng, Tempe and Buaya into a single, vast sheet of water, which occurs from April to June each year. According to Whitten et al. (1987; see Fig. 2), the sheet of water stretches more than 30 km from the northern shore of Lake Sidenreng to the southern shore of Lake Tempe; during major floods the sheet of water stretches more than 40 km to Watassoppeng and 60 km if measured from the northern edge of the inundation. Against these dimensions, Pinto's description of a lake 'twenty leagues long and four or five leagues wide' (roughly 100 by 20-25 km) does not seem quite so preposterous. Viewed from its northern edge, with the southern shore of the vast sheet of water lying below the visual horizon, Lake Sidenreng in flood appears immense, as the present authors have witnessed.

Pinto does not mention a channel running from one side of the peninsula to the other. We would argue that this is an independent tradition with no direct relationship to Pinto's report of a great lake, and that the two traditions have been conflated in modern scholarship. The emphasis in the La Galigo as reported by Pelras is on a channel rather than a large standing lake, and on a permanently flooded Cenrana valley. The Groningen

[5] Diatom and foraminifera analyses would confirm this observation (Shennan & Andrews 2000).

borehole survey potentially indicates that as late as c. 800 BC the sea came right up to Rawa Lampulung and was influencing vegetation on the western edge of Lake Tempe. The existence of a channel running from one side of the peninsula to the other still needs to be assessed in geomorphological and sedimentological terms but seems quite plausible in the light of earlier discussion of a potential sea level maximum of 6.55 m above present day sea levels at around 4500 years ago. The Austronesian ancestors of the Bugis are believed to have moved into southwest Sulawesi between 2500 and 1500 BC (Bellwood 1997: 229) at a time when the sea still came up to Rawa Lampulung. It therefore seems possible that the La Galigo's depiction of a permanently flooded Cenrana valley reflects an ancient oral tradition reaching back to the time of receding water levels after about 800 BC.

The Groningen borehole survey, which has provided the fundamental basis for the discussion in this text, combined with our own low-resolution survey, has provided significant insights into sea level influences, vegetation developments and landscape history between c. 7100 and c. 2600 BP. The resulting picture highlights the considerable potential for palaeoenvironmental reconstructions in southwest Sulawesi. In particular, further work needs to be carried out to establish the precise relationships between the lithostratigraphical sequences occurring on either side of the molasse ridge that divides Lake Tempe from the Cenrana valley. This work would allow reconstruction of both tectonic and sea level developments, and, if extended westwards towards Parepare, could yield considerable insights into the trans-peninsula waterway suggested by the La Galigo.

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REFERENCES

Anon. 1979. *Draft Final Report on Master Plan Study for the Central South Sulawesi Water Resources Development Project*. Tokyo: Japan-Indonesia Cultural Association.

Anon. 1982. *Potensi Danau, Masalah dan Pengembangannya*. Ujung Pandang: Pusat Studi Sumber Daya Alam dan Lingkungan Hidup, Universitas Hasanuddin.

Bakosurtanal [Badan Koordinasi Survei dan Pemetaan Nasional. (Indonesian) National Coordination Agency for Surveys and Mapping] n.d. 1:50,000 maps Sengkang 2111-43 and Batubatu 2011-64. Bogor.

Bellwood, P. 1997. *Prehistory of the Indo-Malaysian Archipelago*. Honolulu: University of Hawai'i Press. Revised edition.

Brooke, J. 1848. *Narrative of Events in Borneo and Celebes, down to the Occupation of Labuan: From the Journals of James Brooke, Esq. Rajah of Sarawak and Governor of Labuan* [edited] *by Captain Rodney Mundy*. London: John Murray.

Bulbeck, D. & I. Caldwell 2000. *Land of Iron; the Historical Archaeology of Luwu and the Cenrana Valley*. Hull: Centre for South East Asian Studies, University of Hull.

Caldwell, I. 1995. Power, state and society among the pre-Islamic Bugis. *Bijdragen tot de Taal-, Land- en Volkenkunde* 151: 394-421.

Crawfurd, J. 1820. *History of the Indian Archipelago*. Volume 3. Edinburgh: Frank Cass & Co. Ltd.

De Klerk, L.G. 1983. *Zeespiegels, Riffen en Kustvlakten in Zuidwest Sulawesi, Indonesië; een Morfogenetische-Bodemkundige Studie*. PhD thesis. Utrecht: Rijksuniversiteit Utrecht.

Forrest, T. 1792. *A Voyage from Calcutta to the Mergui Archipelago*. London: Robson, Owen and Balfour.

Gremmen, W.H.E. 1990. Palynological investigations in the Danau Tempe depression, southwest Sulawesi (Celebes). *Modern Quaternary Research in Southeast Asia* 11: 123-134. Rotterdam: A.A. Balkema Publishers.

Pelras, C. 1981. Célébes-Sud avant l'Islam selon les premiers témoignages étrangers. *Archipel* 21: 153-184.

Pelras, C. 1996. *The Bugis*. Oxford: Blackwell.

Raffles, T.S. 1817. *History of Java*. Volume 2. London: Black, Parbury & Allen.

RePPProt [Regional Physical Planning Programme for Transmigration] 1998. *Land Resources of Indonesia; A National Overview*. Jakarta: [U.K.] Land Resources Development Centre, Foreign and Commonwealth Office.

Schurhammer, G.S.J. 1980. *Francis Xavier: His Life, His Times*. Volume III. *Indonesia and India 1545-1549*. Rome: The Jesuit Historical Institute.

Shennan, I. & J.E. Andrews 2000. *Holocene Land Ocean Interaction and Environmental Change around the North Sea*. London: The Geological Society.

Stuiver, M. & P.J. Reimer 1993. Extended ^{14}C data base and revised CALIB 3.0 ^{14}C age calibration program. *Radiocarbon* 35: 215-230.

Whitten, A.J., M. Mustafa & G.S. Henderson 1987. *The Ecology of Sulawesi*. Yogyakarta: Gajah Mada University Press.

Wichmann, A. 1890. Bericht über eine Reise nach dem Indonesischen Archipel. *Tijdschrift Koninklijk Nederlandsch Aardrijkskundig Genootschap* 7: 921-994.