TECHNOLOGY, SUBSISTENCE STRATEGIES AND CULTURAL DIVERSITY IN SOUTH SULAWESI, INDONESIA, DURING THE TOALEAN MID-HOLOCENE PERIOD: RECENT ADVANCES IN RESEARCH

Yinika Lotus Perston[1*], Basran Burhan[1], Kim Newman[1], Budianto Hakim[2], Adhi Agus Oktaviana[3,4] and Adam Brumm[1]

1. Australian Research Centre for Human Evolution, Griffith University, Brisbane, Australia
2. Balai Arkeologi Sulawesi Selatan, Makassar, Indonesia
3. Pusat Penelitian Arkeologi Nasional, Jakarta, Indonesia
4. Griffith Centre for Social and Cultural Research, Griffith University, Gold Coast, Australia

*Communicating author, yinika.perston@griffithuni.edu.au

Keywords: South Sulawesi, Holocene, adaptive strategies, Toalean, Wallacea

ABSTRACT

The central Indonesian island of Sulawesi has played an important role in modern and pre-modern human migration through the Southeast Asian island chain. Over the last two decades, archaeological excavations in South Sulawesi have provided new insights into the ancient human past of this region, in particular the extensive Mid-Holocene or "Toalean" sites, as well as several significant Pleistocene-age discoveries. This paper assesses the latest research and what implications these works have for prior models of human prehistory in the region. We show that recent studies have revealed that Toalean-era toolmakers were able to adapt to different environments and raw material sources, but would also transport desired raw materials for production of certain artifact types. Early quarry sites have also been identified for the first time. In addition, new excavations have revealed complex tool forms in forested highland environments, previously thought to hold only sparse and elementary assemblages, allowing us to reassess 20th century models of Toalean cultural subgroups and distribution. The rich parietal art initially attributed to the Toalean has now been dated to the Late Pleistocene, roughly contemporaneous with the production of "portable art"—the existence of which was also recently revealed—in this region, while lithic artifacts dated to between at least 194–118 thousand years ago at Talepu appear to predate modern Homo sapiens *occupation. Two newly reported highland sites have also yielded rich and deeply stratified archaeological deposits. These may offer the best opportunity to test hypotheses such as the transitional "Ceramic Toalean" contact phase, as site disturbance and subsidence have formerly compromised the stratigraphic integrity of most excavations. This review shows that, while much work is still needed—particularly in obtaining a reliable body of well-stratified and reliable dates—recent research presents an image of early innovation in the region in the form of Late Pleistocene "art" production and Mid-Holocene technological developments that are both earlier and more extensive than previously known.*

INTRODUCTION

The large Wallacean island of Sulawesi presents a rich archaeological record that has drawn the attention of researchers for over a century. A thorough review of these works can provide a deeper understanding of the unique archaeological assemblages, and outline both the progress

made to date but also highlight the significant gaps in our understanding of the region. This review largely relates to the Mid-Holocene technocomplex known as the "Toalean"—a pre-agricultural group apparently unique to southwestern Sulawesi and occasionally attributed with a hypothesized transfer of ideas and developments with Australia (e.g., McCarthy 1953; Bellwood 2013: 113–121; Fillios and Taçon 2016).

The large archipelago of "Nusantara"—consisting of modern-day Indonesia and its neighbors—is made up of approximately 25,000 islands, and as such has always posed challenges to human migration. Yet modeling data (see Kealy *et al*. 2015, 2018), coupled with Australian archaeological evidence, indicates that anatomically modern humans must have passed through this region, perhaps by ca. 65 thousand years (ka) ago (Clarkson *et al*. 2017), but certainly by 50 ka (O'Connell *et al*. 2018, Williams *et al*. 2021). Furthermore, an earlier hominin species had made significant water crossings to Flores island by at least 1 million years (Ma) ago (Brumm *et al*. 2010). Sulawesi is a large and central island in the archipelago, and noteworthy archaeological discoveries on the island include the dating of some of the world's oldest rock art (Aubert *et al*. 2014; Aubert *et al*. 2019; Brumm *et al*. 2021c), and the recovery of stone artifacts dating to ca. 200 ka (van den Bergh *et al*. 2016), confirming longstanding claims (van Heekeren 1949a) for early occupation by an as yet unknown population of archaic hominins.

The southwestern arm of Sulawesi, a province known as South Sulawesi, has long been the focus of this archaeological research. While the first century of publications has already been thoroughly reviewed by others (e.g., van Heekeren 1957, 1972; Soejono 1969; Chapman 1981; Glover 1986; Macknight 1993, 2018; Bartstra 1998; Bulbeck 2000; Bulbeck *et al*. 2000; Simanjuntak 2015), such summaries are yet to address the implications of recent advances, particularly findings revealed by locally initiated research projects. The last two decades have seen a growing body of published excavations, often presented in national journals and books and largely in Indonesian. The discoveries presented in these works have the potential to reshape how we interpret the early occupation phase of the region, in particular the Toalean period, for which there are the most abundant deposits.

The present review compiles the most recent research out of South Sulawesi, and considers the implications for current interpretations of the South Sulawesi archaeological record. Particular focus is given to publications that may have been overlooked internationally, due to language-barriers or the narrow distribution of the journals and books. This review also allows a reassessment of current models of the region.

Given that Sulawesi falls within the Inter-Tropical Convergence Zone of inter-hemispherical air-mixing, calibrated radiocarbon ages presented in this document have been calculated using an unrestricted (between 0–100%) mixed IntCal20 (Reimer *et al*. 2020) and SHCal20 calibration curve (Hogg *et al*. 2020), as recommended by Marsh *et al*. (2018). These were produced using OxCal (Version 4.4) with a 95.4% confidence interval, using uncalibrated radiocarbon (^{14}C) dates taken from the original publications. Depths are conventionally given in Indonesian publication as depth below datum (BD) and stringline, which typically sit 10 cm above the highest points of the original ground level of the test pit. The soil composition within Toalean deposits is usually quite homogenous, and where stratigraphic boundaries cannot be identified and deposits must be removed in arbitrary spits many excavators employ 10-cm spits. This is also the standard spit depth when removing deposits from within a single, deep, stratigraphic layer. In this report the height of the datum and depth of spits has been accounted for, meaning that depths given represent the depth below the surface of the excavation. Excavations in the region are usually carried out in "test pits" (TP) or "units" of 1 square meter.

BACKGROUND: ARCHAEOLOGY IN THE 20TH CENTURY

Recent developments are based on an extensive, but often *ad hoc*, pre-existing body of work. Early archaeological research in South Sulawesi at the start of the 20th century initially identified stratified occupation deposits in the Bone

Regency containing undated bone tools and what were described at the time as stone "arrowheads" (Sarasin and Sarasin 1905), as well as heavily weathered but undated stone artifacts in the Walanae Depression (van Heekeren 1949a). Over the following decades, several research projects attempted to expand on these preliminary projects, most notably excavations led by Dutch (e.g., van Heekeren 1949a, 1949b; Hooijer 1950; Bartstra *et al*. 1992), Australian (e.g., McCarthy 1940; Glover 1976; Bulbeck 1992) and Indonesian researchers (e.g. Soejono 1961; Mulvaney and Soejono 1970a, 1970b; Darmawan *et al*. 1991). As a result, by the turn of the 21st century it had been established that in addition to one dated Pleistocene site (Glover 1981), most early assemblages from the South Sulawesi region appeared to contain what are known as "Toalean" deposits.

Research has shown that Toalean assemblages are dominated by small flakes and cores, most commonly made of chert, but they could be distinguished from other periods by the inclusion of distinctive serrated stone "Maros points" (as the so-called arrowheads were dubbed by Mulvaney and Soejono 1970b), bone points, and backed microliths (Figure 1) (e.g., Perston *et al*. 2021b). Dating the Toalean has proven difficult as the tropical South Sulawesi sites are often shallow, heavily disturbed, and/or the resources or materials for dating are lacking; in addition, until recent years most excavations of Toalean sites occurred prior to the advent of radiocarbon dating. However, the current understanding is that the Toalean period ranged from around 8–1.5 ka ago (Mulvaney and Soejono 1970a; Bulbeck *et al*. 2000), largely based on the assemblage from Ulu Leang I (Glover 1976) and a regional dating project led by Mulvaney and Soejono (1970a, 1970b) during a single field season in 1969.

Early attempts have been made to place the stone artifact technology into a chronological sequence (van Heekeren 1957; Bulbeck 2004), although such approaches are declining in popularity globally. Bulbeck's (2004, 2008b) concept of a late "Ceramic Toalean" phase is still referred to, in which he argues that deposits containing ceramics intermixed with classic Toalean artifacts may represent a late Toalean period of exchange with Austronesian groups around 3500–2000 BP before a full technological replacement/assimilation occurred, rather than stratigraphic mixing. Ceramics and ground-edge lithic technology (i.e., axes and adzes), as well as modified shells and beads, are otherwise associated with the subsequent arrival of "Neolithic" Austronesian-speaking or "Nusantao" agriculturalists (see Solheim (1996) for a discussion on terminology) from southern China around 3.5 ka ago (Bellwood 1997; Simanjuntak 2015). Ground-edge axes are understood to have been exclusively produced during the post-Toalean or "Neolithic" period. However, recent work on Obi, a small island off the northeast arm of Sulawesi, has recovered igneous flakes with ground faces at the site of Kobi 6, which appears to indicate that ground stone axe production occurred on the island during the early Holocene, pre-dating Austronesian influences and providing the earliest known evidence for ground stone technology in Wallacea (Shipton *et al*. 2020).

Toalean technology is sometimes described as part of South Sulawesi's "Mesolithic" period, including in 21st century works (e.g., Bulbeck *et al*. 2000; Nur 2000; Oktaviana *et al*. 2016; Forestier *et al*. 2017). Similarly, the Late Pleistocene assemblages have occasionally been referred to as "Upper Paleolithic" (e.g., Glover 1981; Alink *et al*. 2017). However, Allen (1991) has argued that the application of European terminology and subsequent implications of linear development is inappropriate, and others have argued that to apply such linear sequences—ones that originate from models developed for the archaeology of Europe and neighboring regions—is not always suitable in other parts of the world (e.g., Moore 2013; Wilkins 2020). In this paper we therefore avoid such terms in favor of the less loaded labels of "Mid- to Late Holocene/Toalean" and "Late Pleistocene", respectively. Finally, the Late Holocene Austronesian period of South Sulawesi is frequently referred to as the "Neolithic" (e.g., O'Connor 2015; Bulbeck 2018: 104)—while recognizing the biases inherent in the use of this term, however, it is difficult to find an alternative label for this period.

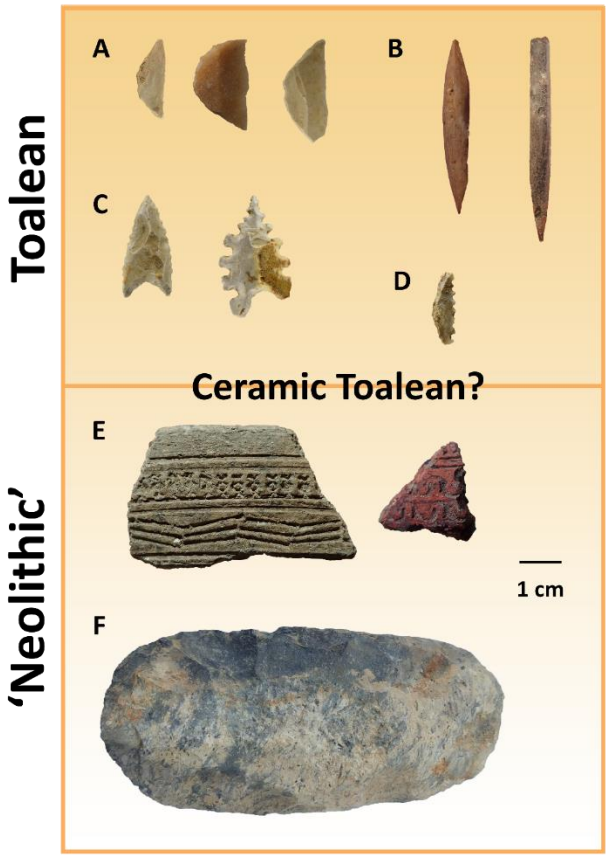

Figure 1. Defining artifact forms from the Holocene Toalean and "Neolithic" period of South Sulawesi. These artifacts are accompanied by large assemblages of less distinctive stone flakes and cores during both periods. A: backed microliths. B: osseous points. C: Toalean points including Maros points. D: serrated backed microliths, or "sawlettes". E: ceramics. F: ground-edge stone axes (photos: Hasliana). The axe in F was recovered from the surface at Leang Jarie in 2018 by authors BH and KN and is now stored at the Balar Sulsel storehouse facilities, Makassar.

The Maros points and backed microliths that are used to define the Toalean period have only been identified in the southwestern region of the South Sulawesi province, presumably representing the extent of a culturally distinct group of people (Bulbeck *et al*. 2000). Maros points have been described as a likely late Toalean innovation post-dating the appearance of backed microliths (e.g., van Heekeren 1957: Figure 17; Glover 1976; Glover and Presland 1985: 192; Bulbeck 2004: 141), or even a "Neolithic" development (Bellwood 2013: 116), though the present review will show that this is unlikely. Osseous points are found throughout Sulawesi (e.g., Aplin *et al*. 2016; Ono *et al*., 2021); however, within southern South Sulawesi they seem to disappear at the same time as backed microliths and Maros points and are therefore seen as Toalean tools in this region.

Geologically, the Toalean range within South Sulawesi extends across a limestone karst environment with pockets of volcanic intrusions, although the region is now volcanically extinct. The northern extent of the known Toalean distribution is marked by the Cenrana Valley, Lake Tempe, and an associated fault-bounded sedimentary depression, which Bulbeck *et al*. (2000) argue may have been partially submerged during the Mid-Holocene, thus physically isolating the Toalean population. In the center of the peninsula, the topography rises towards an elevated and poorly archaeologically explored highland region, broken in two through the northeast by a depressed region along the Walanae River basin (Figure 2). Along the southwest margin of the peninsula, in the Maros and Pangkep (Pangkajene dan Kepulauan) regencies, lies a low coastal plain that extends up to roughly 8–14 km inland where it abuts abrupt karstic limestone cliffs. The limestone caves that fringe this southwestern coastal plain are a short distance from the capital city of Makassar. As a result of their proximity to a major urban center, these rich archaeological deposits have been the main focus of most research conducted over the last century.

It has been argued that two distinct cultural "entities" can be identified within the Toalean range. A "southwestern" entity occurring in coastal and near-coastal lowland regions and up to the uppermost reaches of the Walanae watershed produced osseous points, backed microliths, and stone points including hollow-based denticulated "Maros points" (Bulbeck *et al*. 2000; Bulbeck 2004: 131, 146–153; Bulbeck 2008a: 187). This entity, Bulbeck has argued, represents a complex hunter-gatherer society that intensively exploited the endemic Sulawesi warty pig (*Sus celebensis*), produced rock art, and supported high population densities. The second entity, the "northeastern" group, produced a lithic toolkit that lacked the backed microliths and denticulated or notched stone points. Here, Bulbeck (e.g., 2004, 2008a) has postulated, the populations may have depended more heavily on forest-based fauna, existed in smaller, more dispersed

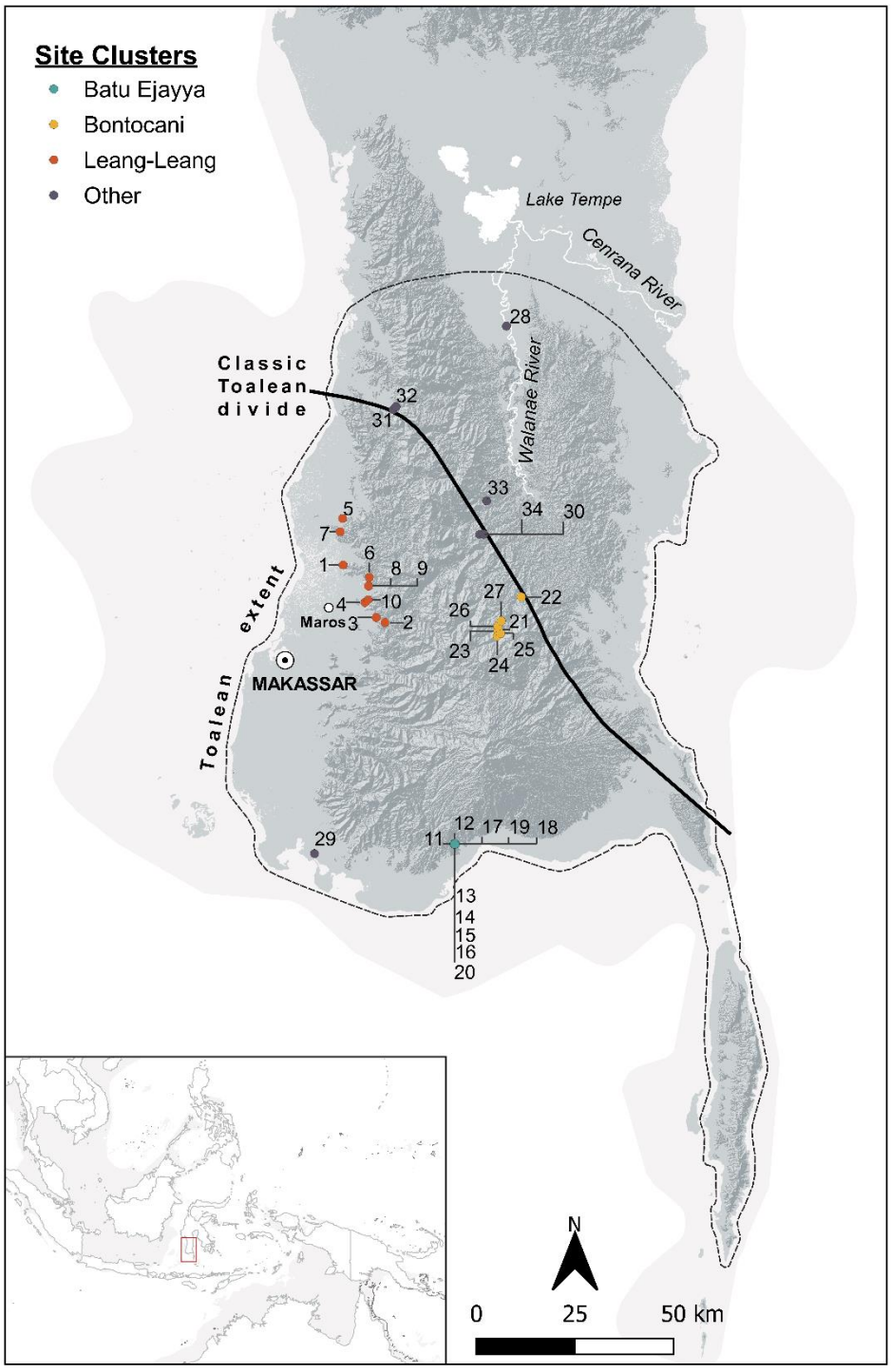

Figure 2. Map of South Sulawesi, Indonesia, showing sites mentioned in the text.

1: Gua Pasaung. 2: Leang Karassak. 3: Leang Jarie. 4: Leang Timpuseng. 5: Leang Bulu' Sipong 4. 6: Leang Tedongnge. 7: Leang Sakapo. 8: Leang Rakkoe. 9: Bomboro. 10: Leang Bulu Bettue. 11: Batu Ejayya. 12: Panganreang Tudea I. 13: Panganreang Tudea II. 14: Panganreang Tudea III. 15: Panganreang Tudea IV. 16: Bulu' Saraung. 17: Tinggia. 18: Paenre. 19: Pangnganikang. 20: Pattanungang. 21: Leang Balang Metti. 22: Leang Batti. 23: Gua Anja. 24: Cappalombo. 25: Sanggalore. 26: Lonrae. 27: Tobua. 28: Talepu. 29: Gua Karama. 30: Mallawa. 31: Tille. 32: Wessae. 33: Leang Panninge. 34: Liang Uttange 1. The black line represents Bulbeck et al*.'s (2000) proposed division between the northeast and the southwestern "entities". Basemap made with Natural Earth 2009-2020 under CC-O, DEM created from STRM files available from the USGS Earth Explorer.*

groups, and did not appear to produce cave art—although more recent work has shown that investigated rock art in the province appears to long pre-date the Toalean period (e.g., Aubert *et al*. 2014). Furthermore, given the southwest coastal plain was the main focus for archaeological research during the last century, it is also possible that the relative richness of these assemblages is a sampling error. Within the 21st century archaeologists have worked to expand this sample, meaning that we can now reassess earlier models of South Sulawesi with more evidence.

At the southern extent, reports of six Maros points (undated surface finds) on Selayar Island (Hakim 2000; Perston *et al*. 2021b) may represent the southernmost distribution of the Toalean. These finds have led some authors to go so far as to suggest that Toaleans were "able to travel vast distances by sea" (Fillios and Taçon 2016: 789), or at the very least to have utilized some form of watercraft (Bulbeck *et al*. 2000: 94; Hakim, 2000). This, and superficial technological similarities with Australia, Japan, and Java have been interpreted as signs of regional contact and long-distance cultural diffusion (e.g., McCarthy 1953; van Heekeren 1972; Fillios and Taçon 2016; Suryatman *et al*. 2017: 105). However, these models are largely speculative and the technological evidence for contact has been questioned (e.g. Perston *et al*. 2021b).

In summary, by around the beginning of the 21st century, the image of the Toalean was that of a group of people who may have been cut off from the rest of the island, and who used bow-and-arrow technology to hunt large fauna (especially *S. celebensis*). The population could be subdivided into those who lived in the highland rainforests and those who existed as thriving coastal groups and possessed a richer lithic toolkit and may have utilized watercraft. When Toalean people came in contact with Austronesian migrants it was thought they adopted new technologies rather than being culturally or physically replaced, at least initially. It was not known where the Toalean techno-culture originated, and dating has been difficult. By reviewing the most recent literature we can revisit these models and determine what aspects have been updated or clarified.

LIMESTONE CAVES FRINGING THE SOUTHWESTERN COASTAL PLAINS OF MAROS AND PANGKEP

Gua Pasaung, Leang-Leang cluster, Rammang-Rammang valley, Maros Regency

An early but oft-overlooked study of the site of Gua Pasaung describes a fairly typical lowland Toalean cave site and presents an insight into coastal adaptations. Situated in the Rammang-Rammang Valley approximately 10 km from the current coastline, the published results of a 1 m^2 test pit (TP6) revealed faunal remains, abundant shells and flakes, and typical Toalean artifacts including two Maros points and 12 bone tools (Hakim *et al*. 2009). A single charcoal sample returned a ^{14}C age of 7153–6667 cal BP, falling within the Toalean period as it is currently understood. The uppermost deposits are reportedly less dense with artifacts than at other similar sites, and are intermixed with ceramics (Intan 2002; Hakim *et al*. 2009). The excavation stopped at a layer of brecciated deposits in spit 18 (around 180 cm below the surface). A subsequent excavation of TP1 and TP3 led by Michael (Mike) Morwood and Budianto Hakim extended over 6 meters deep; however, the results of that excavation remain unpublished.

The published data from Gua Pasaung can provide insights into aspects of the Toalean period. Hakim *et al*. (2009) suggest that a high frequency of marine "*japing*" bivalves (*Placuna epiphium*) at the site, as well as undated rock paintings of boats and fish in the nearby caves of Leang Karassak and Gua Karama, may indicate that the coast was much closer during the Toalean period and that subsistence relied heavily on coastal resources. However, the age of these possible maritime images has not yet been established so it is not clear if they relate to the Toalean. While the abundant parietal art common throughout the Maros and Pangkep cave sites was initially interpreted as belonging to the Toalean period (e.g., Nur 2010), recent dating projects have only identified Late Pleistocene ocher cave paintings, including figurative representations of animals and anthropomorphic figures (e.g., Aubert *et al*. 2014; Brumm et al. 2021c), and distinctive narrow-fingered stencils made by

painting over or overlapping stencils (Oktaviana *et al*. 2016). Black, stick-like motifs in the region have also recently been successfully radiocarbon dated to the "Neolithic" period (Huntley *et al*. 2021), but no parietal Toalean art has yet been identified. Rock art images of watercraft and aquatic species such as those described by Hakim *et al*. (2009) and others (e.g., Darmawan *et al*. 1991) currently remain undated.

Hakim *et al*. (2009) compared Gua Pasaung to the open site of Mallawa, to explore concepts of contact and cultural diffusion at the end of the Toalean. Located on an inland plateau, the Mallawa site sits around 60 km east of Gua Pasaung. Here one carbon sample, dating to 2350-2139 cal BP, was obtained from three test pits (Hakim *et al*. 2009), placing it around or shortly after the end of the Toalean period. This is supported by key findings, including ceramics and ground axes—typically post-Toalean or "Neolithic" artifacts. Three "arrowheads" were also recovered, although it is unclear if these are Maros points, as well as five undescribed microliths.

Hakim *et al*. (2009) have tentatively concluded that the two sites represent different spatial and temporal activities: Mallawa represents an inland Late Holocene "Neolithic" group, and based on a chemical analysis by Intan (1995, 2002) the inhabitants imported their ceramics from an external source (Hakim *et al*. 2009). Hakim *et al*. (2009: 46) report that "similarities in type and manufacturing techniques" reflect a cultural overlap with the Toalean—but as these similarities are not described this suggestion is difficult to assess—or a sign of conflated deposits. In contrast, Gua Pasaung reflects a greater connection to coastal resources (Hakim *et al*. 2009).

Leang Jarie, Leang-Leang cluster, Maros Regency

The limestone cave complex of Leang Jarie is another cave site on the edge of the Maros-Pangkep coastal plains, and was initially described as having "no deposit for excavation" (Glover 1978: 70). However, later work has revealed Neolithic and Toalean deposits as well as dated Late Pleistocene rock art from on the cave walls (Aubert *et al*. 2014). Artifacts from Leang Jarie were used to form the first reduction sequence model for Toalean lithics (Suryatman *et al*. 2019).

The site name translates as "cave of the fingers", named by van Heekeren's team (van Heekeren 1957: 96) for the prolific hand stencils on the walls. Many of these stencils are deteriorating, however, a problem common to many of the region's art sites (Huntley *et al*. 2021). Two of the Leang Jarie hand stencils have been dated to at least 39.9 ka ago (Aubert *et al*. 2014)—roughly contemporaneous with figurative motifs in nearby caves including Leang Timpuseng (Aubert *et al*. 2014), Leang Bulu' Sipong 4 (Aubert *et al*. 2019), and Leang Tedongnge (Brumm *et al*. 2021c).

In 2018, excavations at Leang Jarie revealed a shallow, fully articulated human skeleton. This apparent burial is associated with ceramics, mollusks, stone artifacts, and the bones of small animals, and a fragment of charcoal dating to 2847–2747 cal BP, suggesting the remains are "Neolithic" (Suryatman *et al*. 2019: 7; Fakhri and Hakim 2019). The individual has been identified as a 166 cm tall, 35–40-year-old male, with features suggesting East-Southeast Asian descent according to Fakhri and Hakim (2019; Hakim, 2017a). The skeleton is badly fragmented and remains *in situ* at Leang Jarie. A second radiocarbon date of 542–506 cal BP from the same layer is associated with Canidae (dog) and Suidae bones with bite and cut marks (Fakhri *et al*. 2021).

Two additional layers were identified below the apparent "Neolithic" level. The first of these contains ceramics, small animal bones, glossed artifacts, mollusks dominated by freshwater *Tylomelania* spp., and stone artifacts including "classic" Maros points (after Perston *et al*. 2021b) and geometric backed microliths (Hakim 2017a; Suryatman *et al*. 2019). Suryatman *et al*. (2019) interpret this layer as comprising mixed Neolithic and Toalean deposits, although Fakhri and Hakim (2019) suggest it may represent cultural overlap. An out-of-sequence ^{14}C date from a single freshwater shell sample of 8026–7963 cal BP further suggests this deposit may be disturbed, while a carbon sample of 5904–5746 cal BP may be more reliable (Fakhri *et al*. 2021). Two small backed, serrated microliths were also

recovered from the upper two deposits, described in Perston *et al*. (2021b) and labeled "sawlettes".

The lowest layer of the excavation appears to contain purely Toalean type-artifacts, and charcoal samples returned ^{14}C dates of 7917–7705 cal BP and 7911–7691 cal BP, suggesting better stratigraphic integrity (Hakim *et al*. 2018; Suryatman *et al*. 2019; Fakhri *et al*. 2021). The 10 to 60 cm thick layer yielded larger animal remains, mollusks (again dominated by *Tylomelania* spp.), and lithic artifacts including 15 classic Maros points. Additional dates would help clarify the reliability of this age and the rate of accumulation for the layer, but if the ^{14}C dates can be taken to represent the whole stratigraphic layer then these artifacts represent the oldest known Maros points yet identified, and upturn all prior Toalean artifact chronologies (Suryatman *et al*. 2019). An analysis of the faunal remains from the Leang Jarie excavations by Fakhri *et al*. (2021) offers a species list for the deposits, from small mammals and amphibians up to Suidae and Anoa. Bone points and tools were recovered from all three layers, though the occurrence in the "Neolithic" layer may be a result of mixing with older deposits. These osseous artifacts have evidence for utilization including striations, gloss and tip damage (Salmia 2020: 76–80; Fakhri *et al*. 2021).

Leang Rakkoe and chert quarry, Leang-Leang cluster, Bomboro Valley, Maros Regency

Chert is the dominant material in Toalean lithic assemblages (e.g., Perston *et al*. 2021b), although few local chert sources had been identified by early research. Van Heekeren reported chert nodules in the Pattunuang Asue riverbed in front of Leang Karassak (Glover 1978: 68–69). This has now been confirmed to be a seam of chert nodules eroding from the limestone bedrock (Perston *et al*. 2021a), but there is no direct evidence for resource exploitation. In 2017, two of the authors (AB and BH) identified the first chert quarry in the Maros regency, in the Bomboro Valley (Perston *et al*. 2021a). Here, an eroding seam of flaked chert nodules is surrounded by an extensive scatter of lithic artifacts that stretches for around 255 m down the narrow valley. A small test pit confirmed that the artifacts continue below the surface. While no datable material or defining artifact types were encountered, it is possible the raw material source was utilized during the Toalean (Perston *et al*. 2021a).

A short distance from this quarry is the limestone rockshelter of Leang Rakkoe, where a series of engraved vertical lines (possible rock art) have been identified on the overhanging cliff face (Perston *et al*. 2020). Excavations revealed Toalean artifacts including Maros points, bone points, and a painted bivalve (Brumm *et al*. 2020; Perston *et al*. 2020). However, deposits were highly unstable, and no stratigraphy could be identified (Perston *et al*. 2020). This site is the first known instance in South Sulawesi of such engraved marks, although linear engraved grooves also appear on horizontal rockfaces at several nearby sites (Brumm *et al*. 2020; Perston *et al*. 2020). A comparison with limestone grooves in the Lower Pecos Canyonlands, U.S. suggests the marks at Leang Rakkoe are more likely symbolic than functional (Connolly 2012; Perston *et al*. 2020). Further research of the assemblage and engraved markings at Leang Rakkoe is ongoing.

Pleistocene sites in the Leang-Leang cluster, Maros and Pangkep Regencies

The discovery of three Late Pleistocene cave assemblages, presumably produced by *H. sapiens*, has shown that human occupation began well before the Toalean period. These discoveries are reasonably accessible to international researchers, so are only covered briefly here. All three sites are located within the "Leang-Leang cluster". The first to be discovered was Leang Burung 2, by Ian Glover and his team (Glover 1981). The site was reassessed by Mike Morwood and his team—later led by AB, BH, Muhammad Ramli and colleagues—in the 21st century, who found the site held deep but heavily disturbed and difficult to define deposits which have been dated using various methods to around 35–51 ka ago, though dating the site has proved complex (Brumm *et al*. 2018). This was followed by the discovery of shallow but ancient deposits at Leang Sakapao 1 (Bulbeck *et al*. 2004) excavated by Iwan Sumantri (1996), containing lithic

artifacts associated with ^{14}C ages of up to ca. 30–20,000 BP, though dating was again complicated.

Most recently, Leang Bulu Bettue has been found to contain deep, well stratified deposits from the Late Pleistocene dating up to 51.8±0.6 ka ago, and Holocene deposits that appear to have been largely stripped away through erosion. The Leang Bulu Bettue site holds rich faunal remains and lithic assemblages, as well as the earliest examples of portable art and personal ornamentation on the island (Brumm *et al*. 2017, 2020; Langley *et al*. 2020), finds that are roughly contemporaneous with the growing body of well-dated parietal art within the Leang-Leang cluster (Aubert *et al*. 2014, 2019; Brumm *et al*. 2021c). Cranial fragments of an elderly individual (*H. sapiens*) have also been recovered from Leang Bulu Bettue, dating to between 25–16 ka (Brumm *et al*. 2021a).

Open chert sources, Tille and Wessae sites, Ralla, Barru Regency

In addition to Bomboro, two open chert sources, Tille and Wessae, have been identified in the highland area of Ralla. The Tille site appears to be a chert quarry source next to the small Tille village, with chert artifacts and boulders extensively scattered across an exposed hill-face (YLP pers. obs.; Ratno Sardi pers. comm., 11 March 2021). Today, chert is collected from this site for archaeological replication experiments. Tille is approximately 1 km (geodesic) from the open chert quarry of Wessae, both within the same geological feature. Artifacts at both sites are undated surface finds. Wessae quarry may have been exploited during the Toalean, as Utomo (2003) describes what he suggests is a workshop site where two types of arrowheads were produced: classic Maros and/or Mallinrung points with serrated edges (after Hakim 1990 and Perston *et al*. 2020), and points without serrations—dubbed Lompoa and/or Pangkep points by Perston *et al*. (2021b). Utomo compares these raw material sources to other open sites that reportedly hold serrated stone points, which include Bukit Bikulung, Salekowa Tua, Moncong Moncong and Pamangkulang Batua in Gowa Regency as well as Batang Matasapo on Selayar Island (Bulbeck *et al*. 2000: Table 5; Hakim 2000). Maps and descriptions of the Gowa sites are provided by Bulbeck (1992), and a technological analysis of the Pamangkulang Batua lithics is provided by Pasqua and Bulbeck (1998).

SOUTHERN COASTAL TOALEAN SITES IN A VOLCANIC LANDSCAPE

Batu Ejayya cluster, Bantaeng Regency

The Batu Ejayya cluster on the southern coastal area provides an example of Tolaean adaptability in a volcanic landscape. The complex contains the archaeological cave and rockshelter sites of Batu Ejayya I and II, Panganreang Tudea I – IV, Bulu' Saraung (a separate feature to the mountain of the same name), Tinggia, Paenre, Pangnganikang, and Pattenungang (Suryatman and Hakim 2017: 26–27). The cluster of sites is situated approximately 7 km inland, at 289 m above sea level (asl), and are considered "coastal sites" (Suryatman and Hakim 2017: 23–24). The area is unusual, as unlike other the Toalean deposits in South Sulawesi that are largely associated with chert-bearing limestone formations, the Batu Ejayya site cluster is located in a region dominated by volcanic stone from the Lompobatang volcanic formation (Suryatman and Hakim 2017: 24).

'Panganreang Tudea' means "place to eat shellfish" in the Makasar language, reflecting the prevalence of mollusk remains at the site. The Panganreang Tudea I assemblage historically formed the basis of van Stein Callenfels and van Heekeren's model of three stages of Toalean technological development (van Heekeren 1957: 92–93). However, when an attempt was made to re-excavate the site for dating, it was found that the deposit had already been completely removed by van Stein Callenfels and his team in 1937 (Soejono 1961, 1969). Attempts to excavate Batu Ejayya I and II, Batu Tuda (now Pangnganikang; see Suryatman and Hakim 2017: 29), and several other sites (Mulvaney and Soejono 1970b; but see Mulvaney and Soejono 1971 for corrections on the dates) also yielded disappointing results, with shallow and apparently disturbed deposits containing shell, ceramics, coins, and lithics including retouched points with fine serrations, and backed microliths—or in most cases "nothing of

significance" (Mulvaney and Soejono 1970b: 168).

Recently the area has been revisited, and the work compiled in the book *Butta Toa* ("Old Land" in the Makasar language) by Mahmud and Hakim (2017). At the Batu Ejayya site, two 130 cm deep (140 cm below the baseline) test pits revealed a pre-ceramic assemblage, and contained non-diagnostic flaked artifacts dominated by volcanic material, as well as 53 retouched stone points that lack the denticulations or basal indentation of classic Maros points (i.e., "Pangkep points", after Perston *et al*. 2021b) (Hakim and Suryatman 2013; Suryatman and Hakim 2017). Hakim and Suryatman (2013) identify two stages of occupation at the site, with a shift from exploiting locally available volcanic stone materials to more distantly sourced cherts, possibly coinciding with the arrival of ceramics and perhaps supporting the concept of a Ceramic Toalean phase.

Excavations at other sites in the cluster include Pattanungan, Panganreang Tudea, and Pangnganikang (Supplementary file **Error! Reference source not found.**) (Mahmud and Hakim 2017). These sites similarly contained a mix of volcanic and chert artifacts, animal bones, shells, and ceramics in shallow deposits. The Panganreang Tudea deposits are likely those which were disturbed by van Stein Callenfels's 1937 excavation (Suryatman and Hakim 2017: 30). The occurrence of ceramics intermixed with Toalean artifacts at sites in the Batu Ejayya cluster is interpreted as representing cultural contact and cultural exchange with the subsequent Austronesian-speaking societies, perhaps some 3.5 ka ago (Suryatman and Hakim 2017: 31, 44). Again, this may support the Ceramic Toalean hypothesis (e.g., Bulbeck, 2008b), although once more a lack of direct dating means stratigraphic mixing of Toalean and Neolithic deposits cannot be ruled out.

A review of the faunal remains at Pangnganikang (Fakhri 2017a) provides one of the few specialist species lists of a Toalean site. Here Fakhri has identified large species including Sulawesi warty pig, babirusa (*Babyrousa celebensis*), lowland anoa (*Bubalus depressicornis)*, small mammals such as Sulawesi dwarf cuscus (*Strigocuscus celebensis*), and marine shellfish, but freshwater *Tylomelania* spp. are absent (Fakhri 2017a). One of the shells has been modified into a tablet-shaped object with two holes drilled through it (Fakhri 2017a; Mahmud 2017: 69), perhaps representing rare evidence for Toalean ornamentation. The assemblage again lacks direct dates; however, it is tenuously placed at around 4 ka old, based on Bulbeck's (2000) radiocarbon dates for the nearby Batu Ejayya I as well as a lack of fossilization occurring on the faunal remains (Fakhri 2017a: 62). Two hand stencils of unknown age at Batu Ejayya I and one at Panganreang Tudea II (Hakim and Suryatman 2013: 49–50; Hakim 2017b) extend the known range of such art in South Sulawesi.

This multi-site study has allowed researchers to investigate technological adaptations to material availability in the Toalean period. Through an analysis of 226 stone artifacts from the Pangnganikang excavations as well as surface collections from four other sites in the cluster, Suryatman and Hakim (Suryatman 2017; Suryatman and Hakim 2017) found that during the Toalean occupation phase the locally available volcanic materials (andesite and tuff) were used to produce large artifacts with little modification. Chert, on the other hand, was used to produce artifacts that were smaller on average, and bipolar reduction and retouch were also more likely to occur on chert. While modified artifacts were often damaged or incomplete, five Maros points and 11 backed microliths were identified (Suryatman and Hakim 2017: 36). Only one backed microlith is made on volcanic material, and it was broken in production, while several "scrapers" are made on volcanic material (Suryatman and Hakim 2017: 36–37). Glossed stone artifacts were also recovered, indicating plant processing likely occurred (Suryatman and Hakim 2017: 40). The studies conclude that volcanic material was reduced on-site for general use, whereas chert artifacts were reduced off-site from a bedrock source and brought to the sites for use and/or further modification into relatively complex tools (Suryatman 2017; Suryatman and Hakim 2017).

HIGHLAND SITES: LIMESTONE CAVES

Leang Balang Metti, Bontocani Karst cluster, Bontocani District, Bone Regency

Work at Balang Metti has revealed a large collection of Toalean backed microliths in a highland site, and may provide further evidence for late Toalean/Austronesian cultural overlap. This site is a limestone cave, ca. 511 m asl (Hakim 2017a: 22), one of several in the Bontocani cluster (Balar Sul-Sel 2016; Sardi 2016). While a highland site, Balang Metti falls within Bulbeck's "southwestern entity" (e.g., Bulbeck 2008a). Excavations in 2015 and 2016 have uncovered 218 backed microliths (Suryatman *et al*. 2017), but no Maros points were recovered, demonstrating that the two artifact types do not always occur in the same context.

An analysis of 25,933 lithics from these excavations by Suryatman *et al*. (2017) provides metric data, average flake size, and the occurrence of cores and debris are interpreted as showing that the site was used as a microlith production site. Lithic production appears to have occurred both inside and outside the cave. Many flakes and retouched artifacts are longer than the negative scars preserved on the cores, leading Suryatman *et al*. (2017) to conclude that the blanks (Suryatman *et al*. refer to these as "support", after the French terminology) for these artifacts were struck outside of the cave, perhaps closer to a raw material source (Suryatman *et al*. 2017: 102–104). Several flakes also have "potlid" damage on the ventral face (Suryatman *et al*. 2017: Figure 2), indicating uncontrolled burning occurred after they were struck (pers. obs., YLP). While the dominant material was chert, limestone and igneous stones were also occasionally utilized (Suryatman *et al*. 2017: 103–104).

Leang Balang Metti also contains ceramic fragments, faunal remains, and human remains. A specialist report identifies a similar species list to that of Pangnganikang although without the marine species, and 30–86% of bone fragments were burnt (Fakhri 2018: 25, 27). A human skeleton was found 50–70 cm below the current cave floor surface, and designated as an individual from the Neolithic period based on apparent East-Southeast Asian morphological features (Fakhri 2017b; Hakim 2017a). The remains do, however, appear to be associated with backed microliths (Fakhri 2017b: 94).

Ceramic fragments were recovered from Balang Metti, including decorated pieces. These occurred in the upper 20 cm of one test pit and the lower 20–80 cm of the other two test pits (Suryatman *et al*. 2017: 97). Given the occurrence of backed microliths alongside the skeletal remains and ceramics, this cave has been tentatively interpreted as representing a contact site between the Toaleans and the first Austronesian-speaking migrants, inferred to occur ca. 3-3.5 ka ago (Suryatman *et al*. 2017; Fakhri 2018). However, as this site lacks absolute dates, the inconsistent ceramic distribution may indicate that the deposits are disturbed.

Leang Batti, Bontocani Karst cluster, Bontocani District, Bone Regency

The site of Leang Batti (sometimes Gua Batti) has been used to study the origins of Toalean technology (Suryatman *et al*. 2020). Leang Batti is a large highland cave site close to a tributary to the Walanae River. The cave contains at least 36 rock art images, including ochre hand stencils and naturalistic animal motifs typical of identified Late Pleistocene panels (e.g Aubert *et al*. 2014; Brumm *et al*. 2021c). Black angular charcoal drawings at the site resemble similar motifs in Maros-Pangkep lowland sites around and including Leang Bulu Bettue that have been radiocarbon-dated to the "Neolithic" period by Huntley *et al*. (2021). Ten test pits were excavated in 2010–2018, and here stone artifacts, small amounts of ocher pieces, and animal bones (including bone tools) were recovered (e.g., Sardi 2016: 74), as well as ceramic fragments in the uppermost 20 cm (Hakim 2011: 200; Suryatman *et al*. 2020). Faunal remains include anoa and Suidae, echoing the genera depicted in the art (Saiful and Hakim 2016; Suryatman *et al*. 2020: 200), and this site expands the known distribution of such art.

A technological study by Suryatman *et al*. (2020) focusses on 1376 artifacts recovered from a 2018 excavation. The work provides a comparison of two Holocene lithic assemblages at the site: an undated but technologically Toalean

layer—which includes three backed microliths and two Maros point "candidates" (i.e., incomplete points)—and a second underlying layer dated to around the transition of the Early to Mid-Holocene (after Walker *et al*. 2012). However, the two ^{14}C samples used to date these deposits appear to be out of sequence, with a sample returning a date of 8991–8655 cal BP recovered 27 cm above a sample dating to 7254–7020 cal BP. A third date of 1700–1543 cal BP was discounted as an intrusive sample.

Nonetheless, the results suggest a small relative increase in the preference for chert over volcanic materials in the later assemblage, and the late adoption of small amounts of jasper (Suryatman *et al*. 2020). This shift is accompanied by a decrease in the mean size of the artifacts and a reported increase in "complexity". A chopper-like chert cobble core was recovered from the lower deposits, resembling artifacts observed at the Pleistocene site of Leang Bulu Bettue (Brumm *et al*. 2017), but large flake-blanks are rare and limited to the Mid-Holocene assemblage at Leang Batti. Commonalities were also observed across both layers, including a high prevalence of flakes over cores, the general range of raw materials, reduction through freehand direct percussion (except on the microliths), a lack of bipolar artifacts, and use-wear on both retouched and unmodified artifacts (collectively referred to as "scrapers" in Suryatman *et al*. 2020).

These results from the Leang Batti site are interpreted as illustrating a gradual influence of the Toalean techno-complex from the Early Holocene into the Mid-Holocene. Suryatman *et al*. (2020) note that the appearance of distinct Toalean tool types is limited, suggesting a resistance to techno-cultural change. With abundant Toalean artifacts at other sites in the Bontocani cluster, the group responsible for producing the stone artifacts of Leang Batti may represent a cultural island "trapped in the middle of the Toalean culture" (Suryatman *et al*. 2020: 212). This site can therefore provide an insight into the regional development of Toalean lithic technologies. However, as the dates largely fall within the currently accepted Toalean period of ca. 8-1.5 ka ago (Bulbeck *et al*. 2000: 71), a large gap still remains in the archaeological record between this and the youngest occupation dates of ca. 22,000 cal BP from Leang Bulu Bettue (Brumm *et al*. 2017: SI).

Leang Batti has also been studied as an insight into Toalean lifeways and human-animal interactions (Hakim 2011; Saiful and Hakim 2016). In addition, a number of rockshelters have been identified in the Bontocani cluster near the village of Pattuku (approximately 8–10 km from Leang Batti) including the cave and rockshelter sites of Gua Anja, Cappalombo, Sanggalore, Lonrae, and Tobua (Sardi 2016). From early excavations at Cappalombo, Fakhri (2018: 30–33) has described bone points and bipoints made from the roots of pig teeth, an observation also confirmed by Perston *et al*. (2021b) among lowland Toalean assemblages, showing that both bone and teeth were used for these tools during the Toalean. Six human burials have also been uncovered from the Cappalombo site, including that of an infant, and are the focus of ongoing study. These appear to be associated with Toalean artifacts including engraved hematite flakes and plaqettes (Suryatman *et al.* 2021). Undoubtedly these sites will contribute to the growing picture of the highland Toalean occupation in the near future.

Leang Panninge, Mallawa District, Maros Regency

The site of Leang Panninge presents a promising example of well-preserved Toalean deposit in a highland setting. The cave site has been the subject of seven excavations over 2014–2019, by local and international government bodies and universities (Balar Sul-Sel Research Team 2014, 2016; BPCB Research Team 2015; Balar Sul-Sel *et al*. 2016; Hasanuddin 2017; Duli *et al*. 2018; Saiful and Anggraeni 2019). These excavations revealed deep, well-stratified deposits within the cave, including well-preserved human remains (Hasanuddin 2017: 82; Carlhoff *et al*. 2021). The cave does not appear to contain any surviving rock art and is devoid of the brecciated formations that are ubiquitous on the walls of most other cave sites in South Sulawesi. Such breccia consists of sediment cemented by calcareous deposits that leach from the surrounding limestone, and those that are adhering to cave walls have

previously been interpreted as possible signs of subsidence or erosion (Glover 1979), thus their absence from Leang Panninge may indicate unusually good stratigraphic integrity.

DNA has been successfully extracted from the petrous bone of "Bessé", the individual uncovered at the site, allowing researchers to construct the first Toalean genomic profile (Carlhoff *et al*. 2021). Associated with Maros points and carbon samples dating to approximately 7.3–7.2 ka cal bp, the individual is described as a female aged around 17–18 years old with Australo-Melanesian characteristics, buried in a flexed position and covered with several large river cobbles. Her genome reveals a previously undescribed ancestry profile, which branched off from the Indigenous Australian and Papuan lineages around 37 ka ago and includes both Denisovan and deep Asian ancestry. The implications of this are difficult to resolve given the scarcity of preserved ancient DNA in the broader region, but it may be that the Toalean genome represents admixture with a pre-existing group on Sulawesi—and potentially the introgression ("hybridization") with the Denisovan lineage occurring within Wallacea—followed a level of genomic dilution or replacement occurring over the intervening time-period to the present day.

Among the rich lithic assemblage of Leang Panninge are abundant backed microliths (Hasanuddin 2017; Perston *et al*. 2021b), and, as these fall beyond the proposed extent of the southwestern entity, it may indicate that the location of the division should be reconsidered. These microliths are unique among Toalean examples, as they include multiple cases of additional retouch across the dorsal and ventral faces of the blank, retouch which was struck after backing occurred (Perston *et al*. 2021b). The backed microliths at Leang Panninge appear in the younger Toalean layers, appearing after Maros points, supporting the evidence from Leang Jarie that these points are not a late addition to the technocomplex—possibly even a Neolithic phenomenon—as had previously been suggested (e.g., van Heekeren 1957; Glover and Presland 1985; Bellwood 2013).

From the upper deposits, a study of the Suidae remains by Saiful and Anggraeni (2019) provides physical hints at possible early forms of wild pig management. Their analysis shows that both *S. celebensis* and *B. celebensis* were present at the cave toward the end of the Toalean period, and incomplete skeletal elements suggest the animals appear to have been butchered at the site. From a dental analysis, Saiful and Anggraeni (2019) identified a high occurrence of Linear Enamel Hypoplasia (LEH) on Suidae teeth. LEH is a type of enamel deformation caused by stress during development, leading the study's authors to propose that, along with an increase in the proportion of juvenile and immature individuals, this could indicate that the wild pigs were being systematically managed at this site (Saiful 2019; Saiful and Anggraeni, 2019). Given this, the authors infer that Toaleans may even have emulated Austronesian pig (*Sus scrofa*) domestication practices (Saiful and Anggraeni 2019), supporting the earlier proposal of a commensal relationship between Toaleans and *S. celebensis* in the Maros karsts by Simons and Bulbeck (2004).

However, hypoplasias are not causally linked to domestication and the dental study does not rule out the possibility of alternative causes of LEH in this instance. Furthermore, a recent review of the painted "pig" figures found on the cave walls in the region has raised the possibility that a special and uniquely close relationship may have been established between hunter-gatherers and *S. celebensis* soon after initial human colonization of the island (Brumm *et al*. 2021b).

Liang Uttange 1, Mallawa District, Maros Regency

A 2018 survey in the Mallawa District of the Maros Regency describes 13 new cave sites and three open sites with Toalean and Austronesian artifact scatters on the surface. One of these, Liang Uttange 1, was excavated to reveal what Hasanuddin *et al*. (2020) suggest may be evidence for cultural interaction and exchange between Toalean and Austronesian-speaking people. This cave site also contains damaged hand stencils, the first recorded instance of cave art in the district.

From a report of two excavation test pits at Liang Uttange 1 (Hasanuddin *et al*. 2020), it

appears that the upper 30–40 cm contain classic Toalean artifacts—Maros points, backed microliths and "blades" (however, see Suryatman *et al*. (2019: 10–11) and Perston *et al*. (2021b) who present evidence that blades were not a deliberate part of the Toalean toolkit)—occur intermixed with "Neolithic" pottery shards. This mixing occurs in two stratigraphic layers, which sit above an additional 30–40 cm of deposits containing exclusively Toalean finds, including osseous points made of Suidae remains. As the excavation have not reached bedrock the full stratigraphy is unknown. The upper layer is undated; however, four AMS ^{14}C dates from the lower two layers range from 3360–3158 to 7257–7018 cal BP and lie chronologically. Also recovered was a triangular piece of shell with jagged edges and signs of grinding on both faces, which the authors suggest may reflect an attempt at producing a Maros point from shell. Hasanuddin *et al*. (2020) argue that such modification of shells is a typical "Neolithic" practice and that the artifact may therefore provide further evidence for cultural overlap—however, the painted shell from Leang Rakkoe (Perston *et al*. 2020) and the modified shell at Pangnganikang (Mahmud 2017) have both been tentatively attributed to the Toalean, and there is also ample evidence for shell modification in Island Southeast Asia dating back to the Late Pleistocene (e.g., O'Connor 2015).

Walanae Basin

Dates of nearly 200 ka old obtained in association with flaked artifacts at Talepu, in the Soppeng Regency, have confirmed the early occupation of the Walanae Basin/Depression by a pre-modern hominin species (van den Bergh *et al*. 2016). These provide the earliest occupation dates for the island, and the age implies the artifacts were produced by an unidentified archaic hominin species. Following these finds, Hakim has described the distribution of several open sites, probably Pleistocene or "Paleolithic" (Hakim 2018) along the banks of the Walanae River, West Bone region. From a comparison of nine prehistoric open sites in the Walanae Suryatman *et al*. (2016) have also developed a lithic reduction model for the Walanae basin. Their report presents the location and extent of these sites, probably pre-Toalean, identified by their artifact scatters. Suryatman *et al*. (2016) also report on the presence of 42 small "hand axes" and 217 "choppers" with low levels of flaking, although the illustrations provided (Figure 16) suggest these are not hand axes *sensus stricto* under Isaac's (1977) typology, and modifications appear to be minimal. Suryatman *et al*.'s study discusses their theories on reduction trajectories aimed at producing functional cores versus functional flakes, arguing that the differentiation is made very early on in the reduction sequence (Suryatman *et al*. 2016).

OTHER WORKS

In addition to the sites already discussed, a further eight stone artifact sites were identified during surface surveys along the southern coast of the peninsular by Hakim (2000), some of which are described as "Mesolithic" (i.e., Toalean) although none of which have been excavated or have absolute dates. Current Indonesian government legislation encourages researchers to publish the results of all state-funded research. Nonetheless, an unknown numbers of unpublished survey and excavation reports are also both produced and held by Balai Pelestarian Cagar Budaya (BPCB)—the government organization tasked with carrying out protection, development and utilization of cultural heritage—as well as the South Sulawesi Office of Archaeology (Balai Arkeologi Sulawesi Selatan, or Balar Sulsel), which carries out a small number of research-oriented excavations each year and falls under the National Research Center for Archaeology (Pusat Penelitian Arkeologi Nasional, or Puslit Arkenas). Balar also manages the archaeological journal *Walennae*. The archaeology department at Universitas Hasanuddin (Unhas) in Makassar regularly runs excavations as part of its teaching program. Unhas staff produce reports, and students are required to conduct research in their final year culminating in a *skripsi*, or thesis. These unpublished works may be accessed by contacting the relevant bodies, as local agencies take control of the narrative of the region's past. As local pride and interest in the region's prehistory grows, Balar Sulsel has produced a series of six children's books focusing on the region's

archaeology with topics including local rock art (Saiful 2018), stone artifacts (Suryatman and Hakim 2018), and site exploration (Hakim *et al*. 2020), as well as producing short video diaries of excavation projects and media releases. Maros-based businesses have also begun to produce archaeologically-themed puzzles, souvenirs, and artworks.

DISCUSSION

From the body of recent research, the old models of early human occupation of South Sulawesi can now be reassessed. While research into the Pleistocene period (especially early rock art) has received international attention (Aubert *et al*. 2014, 2019; van den Bergh *et al*. 2016; Brumm *et al*. 2017, 2021c), the growing body of Toalean research is at risk of being overlooked, yet it provides a new understanding of past human lifeways during this period.

The geographical distribution for the Toalean described in Bulbeck *et al*. (2000) still stands, as no Toalean sites have been identified outside of this range. Whether the Toalean cultural sphere extended as far south as the Selayar Island chain may require further fieldwork, as no photographs are available to confirm the reported instances of Maros points (Hakim 2000). However, Hakim's observations appear to suggest that contact was made with the island during the Toalean period, and by extent watercraft were utilized for crossings of up to ca. 30 km. Whether or not sailing trips extended beyond this, however, perhaps as far as Australia, requires stronger evidence as perceived technological similarities could simply represent convergence upon superficially similar toolkits (Perston *et al*. 2021b).

The origin of the Toalean remains unsolved. While work at Leang Batti hints at technological continuity with the Late Pleistocene (Suryatman *et al*. 2020), in the absence of Early Holocene assemblages this is difficult to test. The genetic ancestry of the early Toalean individual from Leang Panninge may also represent a coalescence between a local genetic group—perhaps the descendants of the Leang Bulu Bettue individual (Brumm *et al*. 2021a) and/or the Pleistocene cave artists—and an arrival population, but this is currently difficult to assess with such a limited human skeletal record. Furthermore, while this Toalean individual shares a common ancestor with Australian and Papuan lineages, this does not appear to represent a mid-Holocene connection between the regions (as implied by recent Toalean-diffusion/migration-to-Australia models; e.g., Bellwood 2013; Filios and Taçon 2016). The authors of the genetic study from Leang Panninge also raise the possibility that the admixture between the *H. sapiens* and Denisovan lineages occurred in Wallacea (Carhoff *et al*. 2021), though again the scarcity of ancient human remains from the region leave this open to debate.

The growing body of work being carried out in highland sites is providing instances of rich and deep assemblages at Leang Panninge and Leang Balang Metti. These assemblages include clear and classic Toalean Maros points and backed microliths, as does Liang Uttange 1 (Hasanuddin 2017; Suryatman et al. 2017; Hasanuddin *et al*. 2020). This expands on the previous understanding that the distribution of backed microliths along the Walanae watershed did not extend north of the Lamoncong highlands (Bulbeck 2004: 146–147). At Leang Panninge, we also see that wild Suidae species might have been managed as a food source (Saiful and Anggraeni 2019). It also appears that any prior scarcity of assemblages in highland sites may have been a sampling error.

Lithic data from Leang Panninge also shows us that the prior models for a chronology of Toalean artifact development through time are flawed (e.g., van Heekeren 1957; Glover 1976). At this site, we see that Maros points clearly occurred at the site before backed microliths, not after. Further, evidence from Leang Jarie on the edge of the coastal plains suggests that Maros points may date back nearly 8 ka (Suryatman *et al*. 2019). At Leang Jarie, and at the nearby site of Leang Bulu' Sipong 1, we also see a previously unidentified Toalean lithic artifact type, the sawlette (Perston *et al*. 2021b). Further research is required to determine the item's function, but it provides yet another cultural indicator for Toalean sites. Recent work has also seen the development of reduction sequence models for some of the South Sulawesi artifact types (Suryatman *et al*. 2016; Suryatman 2017; Perston *et al*.

2021b). Further, a technical analysis by Perston *et al*. (2021b) highlights how different the backing technology is to the delicate pressure flaking required for Maros point production.

Our understanding of raw material sources has also developed over the last two decades. In terms of osseous artifacts, new work has illustrated that the so-called "bone points" were not only formed from bones of large mammals but that the hard roots of teeth were also utilized (Fakhri 2018; Perston *et al*. 2021b). Earlier reports of creek sources have been confirmed as an exposed seam of nodules, and open quarry sites have been identified (Darmawan *et al*. 1993; Nur 2000; Utomo 2003; Perston *et al*. 2021a). Meanwhile, in a volcanic landscape on the southern coast we see Toalean flintknappers adapted to local volcanic material, while also deliberately importing cherts for more refined artifacts (Suryatman *et al*. 2017; Suryatman and Hakim 2017), demonstrating that the more complex artifacts were still considered necessary under raw material constraints.

Many of the studies reviewed here favor the possibility that mixed Toalean and more typically "Neolithic" artifacts indicate that Toaleans and Austronesian groups lived through a period of overlap and assimilation, supporting Bulbeck's (2004) "Ceramic Toalean" phase (e.g., Hasanuddin *et al*. 2020). However, this issue arguably remains unresolved as these mixed deposits are almost consistently undated and the stratigraphic integrity of the archaeological deposits in the region are frequently unreliable (Glover 1979; Brumm *et al*. 2018). For example, clear stratigraphic layers identified at Ulu Leang 1 (Glover 1977) were thrown into doubt by two ceramic pieces from separate layers but which could be refitted together, and the main body of deposits has badly slumped (Glover 1979). The Toalean site of Ulu Leang 1 (Glover 1976) is frequently cited as a type sequence for the Toalean, yet here potshards are associated with deposits dated to ca. 4500–6000 BP. Given the estimated arrival date for Austronesian-speaking people to the province of no earlier than ca. 3500 BP, it appears that this is clear evidence of the ability of ceramics to become vertically displaced into deeper and older deposits (according to Bulbeck 2008c: 32). It may be that direct dating of the ceramics could be the best way to resolve this. Ideally, future work will provide sufficient dating samples to assess the theories, and several sites present good potential for this including the deep and well-stratified sites of Balang Matti and Leang Panninge (Suryatman *et al*. 2017). The lack of brecciated deposits on the cave walls of Panninge further suggests this site may be undisturbed.

CONCLUSIONS

At the culmination of over 100 years of archaeological research, our understanding of the Toalean describes an isolated but culturally distinct group. Toaleans may have utilized watercraft, but at present evidence is lacking for elaborate or long-distance trade routes. The population produced distinctive stone tool types, including the minute sawlette, and these may have been utilized for hunting, though this has not yet been directly confirmed. Local fauna was exploited, including large quantities of mollusks, and gloss indicates high-silica plants were processed but there is no evidence for agriculture, suggesting this was a foraging society. The origins and even the conclusion of the techno-culture remain poorly understood at this point, but new assemblages are being assessed annually. The study of well dated stratigraphic deposits would no doubt help to address many of the unknowns that still surround the Toalean period of South Sulawesi, and newly described sites such as Leang Panninge may offer this possibility.

ACKNOWLEDGEMENTS

The Maros-Pangkep Research Project is funded by an Australian Research Council Future Fellowship award to AB (FT160100119) and Griffith University. The research was authorized by Kementerian Riset dan Teknologi (RISTEK, the State Ministry of Research and Technology, Jakarta), and is conducted in collaboration with counterpart institution the Pusat Penelitian Arkeologi Nasional. All necessary permits were obtained for the described study, which complied with all relevant regulations. Other key participating organizations in Indonesia include Balai Arkeologi Sulawesi Selatan, Balai Pelestarian

Cagar Budaya Sulawesi Selatan, the Archaeology and Cultural Heritage department at Universitas Hasanuddin in Makassar, South Sulawesi, and the Department of Archaeology, Faculty of Cultural Sciences at Universitas Halu Oleo in Kendari, southeast Sulawesi. We also thank the Maros and Pangkajene dan Kepulauan regional governments.

We would like to thank Andi "Ipul" Muhammad Saiful and Putu Bagus Mahardika for additional assistance with translations from the Indonesian, Bugis, and Makasar languages. We also thank the three reviewers, Campbell Macknight, Sue O'Connor and an anonymous reviewer, for their valuable feedback and advice.

REFERENCES

Alink, G., S.Adhityatama and T. Simanjuntak. 2017. The descriptive analysis of Palaeolithic stone tools from Sulawesi, collected by the Indonesian-Dutch Expedition in 1970. *Amerta* 35**:** 75–92.

Allen, H. 1991. A review of the Late Pleistocene/early recent stone tool assemblages of Java. *Bulletin of the Indo-Pacific Prehistory Association* 11**:** 36–47.

Aplin, K., S. O'Connor, D. Bulbeck, P.J. Piper, B. Marwick, E. St. Pierre and F. Aziz. 2016. The Walandawe tradition from Southeast Sulawesi and osseous artefact traditions in Island Southeast Asia. In M.C. Langley (ed.) *Osseous Projectile Weaponry: Towards an Understanding of Pleistocene Cultural Variability*, pp. 189–208. Dordrecht, Netherlands: Springer.

Aubert, M., A. Brumm, M. Ramli, T. Sutikna, E.W. Saptomo, B. Hakim, M.J. Morwood, G.D. van den Bergh, L. Kinsley and A. Dosseto. 2014. Pleistocene cave art from Sulawesi, Indonesia. *Nature* 514**:** 223–227.

Aubert, M., R. Lebe, A.A. Oktaviana, M. Tang, B. Burhan, Hamrullah, A. Jusdi, Abdullah, B. Hakim, J.-X. Zhao, I.M. Geria, P.H. Sulistyarto, R.M. Sardi and A. Brumm. 2019. Earliest hunting scene in prehistoric art. *Nature* 576**:** 442–445.

Balar Sul-Sel Research Team 2014. Laporan Penelitian Arkeologi di Mallawa, Kabupaten Maros, Sulawesi Selatan. Unpublished report. Makassar: Balai Arkeologi Sulawesi Selatan.

Balar Sul-Sel 2016. Laporan Akhir. Penelitian Ekskavasi Tahap II di Situs Balang Metti I, Kecematan Bontocani, Kabupaten Bone: Bukti Hunian Prasejarah di Gugusan Karts Bontocani. Unpublished report. Makassar: Balai Arkeologi Sulawesi Selatan.

Balar Sul-Sel, Unhas and USM Research Team. 2016. Laporan Ekskavasi Liang Panningnge. Unpublished report. (Tim Penelitian Kerja Sama Universitas Hasanuddin, Universitas Sains Malaysia, B. A. S.-S.). Makassar: Balai Arkeologi Sulawesi Selatan.

Balar Sul-Sel Research Team 2016. Laporan penelitian arkeologi ekskavasi Gua Panninge, Mallawa, Maros. Unpublished report. Makassar: Balai Arkeologi Sulawesi Selatan.

Bartstra, G.-J. 1998. Short history of the archaeological exploration of the Maros caves in South Sulawesi. *Modern Quaternary Research in Southeast Asia* 15**:** 193–210.

Bartstra, G.-J., D.A. Hooijer, B. Kallupa and M. Anwar Akib. 1992. Notes on fossil vertebrates and stone tools from Sulawesi, Indonesia, and the stratigraphy of the northem Walanae depression. *Palaeohistoria* 34**:** 1–18.

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

Bellwood, P. 2013. *First Migrants: Ancient Migration in Global Perspective.* Chichester: Wiley.

BPCB Research Team 2015. Laporan Ekskavasi Penyelamatan Situs Leang Panning di Desa Batu Putih Kecamatan Mallawa Kabupaten Maros Provinsi Sulawesi Selatan. Unpublished report. Makassar: Balai Pelestarian Cagar Budaya Sulawesi Selatan.

Brumm, A., G.M. Jensen, G.D. van den Bergh, M.J. Morwood, I. Kurniawan, F. Aziz and M. Storey. 2010. Hominins on Flores,

Indonesia, by one million years ago. *Nature* 464**:** 748–752.

Brumm, A., B. Hakim, M. Ramli, M. Aubert, G.D. van den Bergh, B. Li, B. Burham, A.M. Saiful, L. Siagian, R.M. Sardi, A. Jusdi, Abdullah, A.P. Mubarak, M.W. Moore, R.G. Roberts, J.-X. Zhao, D. McGahan, B.G. Jones, Y. Perston, K. Szabó, M.I. Mahmud, K. Westaway, Jatmiko, W.E. Saptomo, S. Van Der Kaars, R. Grün, R. Wood, J. Dodson, and M.J. Morwood. 2018. A reassessment of the early archaeological record at Leang Burung 2, a Late Pleistocene rockshelter site on the Indonesian island of Sulawesi. *PLOS ONE* 13(4): 1–43.

Brumm, A., M.C. Langley, B. Hakim, Y.L. Perston, Suryatman, A.A. Oktaviana, B. Burhan, and M.W. Moore. 2020. Scratching the surface: Engraved cortex as portable art in Pleistocene Sulawesi. *Journal of Archaeological Method and Theory* 27**:** 1–29.

Brumm, A., M.C. Langley, M.W. Moore, B. Hakim, M. Ramli, I. Sumantri, B. Burham, A.M. Saiful, L. Siagian, Suryatman, R.M. Sardi, A. Jusdi, Abdullah, A.P. Mubarak, Hasliana, Hasrianti, A.A. Oktaviana, S. Adhityatama, G.D. van den Bergh, M. Aubert, J.-X. Zhao, J. Huntley, B. Li, R.G. Roberts, E.W. Saptomo, Y. Perston, and R. Grün. 2017. Early human symbolic behavior in the Late Pleistocene of Wallacea. *PNAS* 114**:** 4105-4110.

Brumm, A., D. Bulbeck, B. Hakim, B. Burhan, A.A. Oktaviana, I. Sumantri, J.-X. Zhao, M. Aubert, R. Sardi, D. McGahan, A.M. Saiful, S. Adhityatama, and Y. Kaifu. 2021a. Skeletal remains of a Pleistocene modern human (*Homo sapiens*) from Sulawesi. *PLOS ONE*, 16(9), e0257273. doi:10.1371/journal.pone.0257273.

Brumm, A., A.A. Oktaviana, B. Burhan, B. Hakim, R. Lebe, M. Ririmasee, P.H. Sulistyarto, A.A. MacDonald and M. Aubert. 2021b. Do Pleistocene rock paintings depict Sulawesi warty pigs (*Sus celebensis*) with a domestication character? *Archaeology in Oceania* 0: 1–24. DOI: 10.1002/arco.5245.

Brumm, A., A.A. Oktaviana, B. Burhan, B. Hakim, R. Lebe, J.-X. Zhao, P.H. Sulistyarto, M. Ririmasse, S. Adhityatama, I. Sumantri and M. Aubert. 2021c. Oldest cave art found in Sulawesi. *Science Advances* 7**:** eabd4648.

Bulbeck, F.D. 1992. A Tale of Two Kingdoms: The Historical Archaeology of Gowa and Tallok, South Sulawesi, Indonesia. Ph.D. dissertation. Canberra: The Australian National University. https://openresearch-repository.anu.edu.au/handle/1885/116897.

Bulbeck, D. 2000. A historical perspective on the Australian contribution to the practice of archaeology in Southeast Asia. *Australian Archaeology* 50: 45–53.

Bulbeck, D. 2004. Divided in space, united in time: The Holocene prehistory of South Sulawesi. In S.G. Keates and J.M. Pasveer (eds) *Quaternary Research in Indonesia*, pp. 129–166. Quaternary Research in Southeast Asia 18. Leiden: A.A. Balkema.

Bulbeck, D. 2008a. An archaeological perspective on the diversification of the languages of the South Sulawesi Stock. In T. Simanjutak (ed), *Austronesian in Sulawesi*, pp. 185–212. Jakarta: Center for Prehistoric and Austronesian Studies.

Bulbeck, D. 2008b. A century of archaeology in Sulawesi. In T. Simanjutak (ed), *Austronesian in Sulawesi*, pp. 3–7. Jakarta: Center for Prehistoric and Austronesian Studies.

Bulbeck, D. 2008c. An integrated perspective on the Austronesian diaspora: The switch from cereal agriculture to maritime foraging in the colonisation of Island Southeast Asia. *Australian Archaeology* 67**:** 31–51.

Bulbeck, D. 2018. Holocene site occupancy in Sulawesi. In S. O'Connor, D. Bulbeck and J. Meyer (eds), *The Archaeology of Sulawesi: Current Research on the Pleistocene to the Historic Period*, pp. 93–116. Terra Australis 48. Canberra: ANU Press. DOI: http://doi.org/10.22459/TA48.11.2018.

Bulbeck, D., M. Pasqua and A. Di Lello. 2000. Culture history of the Toalean of South Sulawesi, Indonesia. *Asian Perspectives* 39**:** 71–108.

Bulbeck, D., I. Sumantri and P. Hiscock. 2004. Leang Sakapao 1, a second dated Pleistocene site from South Sulawesi, Indonesia. In S. G. Keates and J. M. Pasveer (eds) *Quaternary Research in Indonesia*, pp. 111–128. Quaternary Research in Southeast Asia 18. Leiden: A.A. Balkema.

Carlhoff, S., A. Duli, K. Nägele, M. Nur, L. Skov, I. Sumantri, A.A. Oktaviana, B. Hakim, B. Burhan, F.A. Syahdar, D.P. McGahan, D. Bulbeck, Y.L. Perston, K. Newman, A.M. Saiful, M. Ririmasse, S. Chia, Hasanuddin, D.A.T. Pulubuhu, Suryatman, Supriadi, C. Jeong, B.M. Peter, K. Prüfer, A. Powell, J. Krause, C. Posth and A. Brumm. 2021. Genome of a middle Holocene hunter-gatherer from Wallacea. *Nature* 596(7873): 543–547. doi:10.1038/s41586-021-03823-6.

Chapman, V. 1981. An Analysis of the Artefact Collections Excavated by the Australian-Indonesian Archaeological Expedition to Sulawesi, 1969. Unpublished M.A. dissertation. Canberra: The Australian National University.

Chapman, V. 1986. Inter-site variability in Southwest Sulawesi: Results of the 1969 Australian-Indonesian Archaeological Expedition. *Archaeology in Oceania* 21**:** 76–84.

Clarkson, C., Z. Jacobs, B. Marwick, R. Fullagar, L. Wallis, M. Smith, R.G. Roberts, E. Hayes, K. Lowe, X. Carah, S.A. Florin, J. Mcneil, D. Cox, L.J. Arnold, Q. Hua, J. Huntley, H.E.A. Brand, T. Manne, A. Fairbairn, J. Shulmeister, L. Lyle, M. Salinas, M. Page, K. Connell, K. Norman, T. Murphy and C. Pardoe. 2017. Human occupation of northern Australia by 65,000 years ago. *Nature* 547**:** 306–310.

Connolly, C. 2012. Groove marks in the Lower Pecos Canyonlands. *Ethnoarchaeology* 4**:** 185–198.

Darmawan, M.R., A.R. Husain and S. Darmawan. 1991. *Gua-Gua Prasejarah dibatas Kabupaten Maros-Pangkep Sulawesi Selatan*. Ujung Pandang [Makassar]: Suaka Peninggalan Sejarah dan Purbakala Sulawesi Selatan dan Tenggara.

Darmawan, M.R., M. Ramli and Albertinus. 1993. *Artefak Epipaleolitik Situs Ralla.* Ujung Pandang [Makassar]: Suaka Peninggalan Sejarah dan Purbakala Sulawesi Selatan.

Duli, A., A.M. Akhmar and M. Nur. 2018. Awal Peradaban di Sulawesi, Kajian Arkeologi pada Situs Gua Panningnge di Kecamatan Mallawa, Kabupaten Maros [internal report]. Makassar: Universitas Hasanuddin, Fakultas Ilmu Budaya.

Fakhri 2017a. Fauna dan strategi subsistensi penghuni situs Pangnganikang 4000 tahun yang lalu. In M.I. Mahmud and B. Hakim (eds), *Butta Toa: Jejak Arkeologi Budaya Toala, Logam, & Tradisi Berlanjut di Bantaeng*, pp. 49–74. Yogyakarta: Penerbit Ombak.

Fakhri 2017b. Identifikasi rangka manusia situs Gua Balang Metti, Kabupaten Bone, Sulawesi Selatan. *Walennae* 15**:** 89–100.

Fakhri 2018. Arkeofauna kawasan karst Bontocani Kabupaten Bone, Sulawesi Selatan | The archaeofauna of Bontocani karst area, Bone, South Sulawesi. *Walennae* 16**:** 21–38.

Fakhri and B. Hakim. 2019. Identifikasi awal dan rekonstruksi aspek biologis temuan rangkamanusia LJ-1 Situs Leang Jarie, Maros, Sulawesi Selatan. *Walennae* 17**:** 113–124.

Fakhri, B. Hakim, Yulastri, Salmia, and Suryatman. 2021. Pemanfaatan fauna vertebrata dan kondisi lingkungan masa okupasi 8.000 – 550 BP di situs Leang Jarie, Maros, Sulawesi Selatan. *Amerta* 39(1): 17–34. DOI:10.24832/amt.v39i1.17-34.

Fillios, M. and P.S.C. Taçon. 2016. Who let the dogs in? A review of the recent genetic evidence for the introduction of the dingo to Australia and implications for the movement of people. *Journal of Archaeological Science: Reports* 7**:** 782–792.

Forestier, H., M. Grenet, A. Borel and V. Celiberti. 2017. Les productions lithiques de

l'Archipel indonésien. *Journal of Lithic Studies* 4(2): 231–303.

Glover, I.C. 1976. Ulu Leang cave, Maros: a preliminary sequence of post-Pleistocene cultural development in South Sulawesi. *Archipel* 11**:** 113–154.

Glover, I.C. 1977. The Late Stone Age in Eastern Indonesia. *World Archaeology* 9**:** 42–61.

Glover, I.C. 1978. Survey and excavation in the Maros district, South Sulawesi, Indonesia. *Bulletin of the Indo-Pacific Prehistory Association* 1**:** 60–102.

Glover, I.C. 1979. The effects of sink action on archaeological deposits in caves: An Indonesian example. *World Archaeology* 10**:** 302–317.

Glover, I.C. 1981. Leang Burung 2: An Upper Palaeolithic rock shelter in South Sulawesi, Indonesia. *Modern Quaternary Research in Southeast Asia* 6**:** 1–38.

Glover, I.C. 1986. Publications on Indonesian archaeology arising out of research undertaken at the Institute of Archaeology. *Indonesia Circle. School of Oriental & African Studies. Newsletter* 14**:** 68–69.

Glover, I.C. and G. Presland. 1985. Microliths in Indonesian flaked stone industries. In V. Misra and P. Bellwood (eds), *Recent Advances in Indo-Pacific Prehistory*, pp. 185–195. Leiden: E.J. Brill.

Hakim B. 1990. Alat-alat batu pada sisi timur alirang Sungai Walanae di Libureng Kabupaten Bone. Unpublished B.A. (Hons) dissertation. Makassar: Universitas Hasanuddin.

Hakim, B. 2000. Mata panah bergerigi dari situs Pamangkulang Batua dan Batang Matasapo, Sulawesi Selatan. *Walennae* 4**:** 37–42.

Hakim, B. 2011. Polar pikir dan tingkah laku manusia prasejarah (Toala?) di situs Gua Batti, Bontocani: Berdasarkan variabilitas temuan arkeologis. *Walennae* 12**:** 47–60.

Hakim, B. 2017a. Interpretasi awal temuan gigi manusia di situs Bala Metti, Bone dan situs Leang Jarie, Maros, Sulawesi Selatan. *Walennae* 15**:** 19–30.

Hakim, B. 2017b. Lukisan cap tangan prasejarah di kawasan Batu Ejaya. In: I.M. Mahmud and B. Hakim (eds), *Butta Toa: Jejak Arkeologi Budaya Toala, Logam, & Tradisi Berlanjut di Bantaeng*, pp. 75–86. Yogyakarta: Penerbit Ombak.

Hakim, B. 2018. Sebaran situs paleolotik di tepi aliran Sungai Walennae, Wilayah Bone Barat, Sulawesi Selatan. *Walennae* 16**:** 85–104.

Hakim, B., M. Nur and Rustam. 2009. The sites of Gua Pasaung (Rammang-Rammang) and Mallawa: Indicators of cultural contact between the Toalean and Neolithic complexes in South Sulawesi. *Bulletin of the Indo-Pacific Prehistory Association* 29**:** 45–52.

Hakim, B. and Suryatman. 2013. Stone tools technology and occupation phases at Batu Ejayya, South Sulawesi. *Review of Indonesian and Malaysian Affairs* 47(2)**:** 47–62.

Hakim, B., M.I. Mahmud, Fakhri, Muhaeminah, Hernianti, A.M. Saiful and Suryatman. 2018. Penelitian Situs Gua Prasejarah di Wilayah Maros dan Pangkep Sulawesi Selatan (Tahap I). Unpublished report. Makassar: Balai Arkeologi Sulawesi Selatan.

Hakim, B., Suryatman and Fakhri. 2020. *Bertemu Arkeolog di Situs Batang Matasapo*. Makassar: Masagena Press.

Hasanuddin 2017. Gua Panningnge di Mallawa, Maros: Kajian tentang gua hunian berdasarkan artefak batu dan sisa fauna. *Naditira Widya* 11**:** 81–96.

Hasanuddin, Bernadeta, A.M. Saiful, L. Yondri, I. Sumantri, M. Nur, Supriadi, Rustan, Isbahuddin, K. Al Ansyary and K. Sirajuddin. 2020. Interaction between the Toalean and Austronesian cultures in the Mallawa area, Maros district, South Sulawesi. *Journal of Indo-Pacific Archaeology* 44**:** 329–349.

Hogg, A.G., T.J. Heaton, Q. Hua, J.G. Palmer, C.S.M. Turney, J. Southon, A. Bayliss, P.G. Blackwell, G. Boswijk, C. Bronk Ramsey, C. Pearson, F. Petchey, P. Reimer, R. Reimer and L. Wacker. 2020. SHCal20 Southern Hemisphere calibration, 0–55,000 years cal BP. *Radiocarbon* 62**:** 759–778.

Hooijer, D. A. 1950. *Man and other Mammals from Toalian Sites in South-Western Celebes*. Amsterdam: North-Holland Publishing Company.

Huntley, J., M. Aubert, A.A. Oktaviana, R. Lebe, B. Hakim, B. Burhan, L.M. Aksa, I.M. Geria, M. Ramli, L. Siagian, H.E.A. Brand and A. Brumm. 2021. The effects of climate change on the Pleistocene rock art of Sulawesi. *Scientific Reports* 11 **(**9833).

Intan, F.S. 1995. Keadaan geologi dan peninggalan arkeologi Situs Mallawa, Kab. Maros, Sulawesi Selatan. Unpublished report. Ujung Pandang [Makassar]: Balai Arkeologi Ujung Pandang.

Intan, F.S. 2002. Analisis teknologi laboratoris gerabah situs Gua Rammang-Rammang, Maros, Sulawesi Selatan. *Walennae* 5**:** 34–42.

Isaac, G.L. 1977. *Olorgesailie: Archaeological Studies of a Middle Pleistocen Lake Basin in Kenya*. Chicago: University of Chicago Press.

Kealy, S., J. Louys and S. O'Connor. 2015. Islands under the sea: A review of early modern human dispersal routes and migration hypotheses through Wallacea. *The Journal of Island and Coastal Archaeology* 00: 1–21.

Kealy, S., J. Louys and S. O'Connor. 2018. Least-cost pathway models indicate northern human dispersal from Sunda to Sahul. *Journal of Human Evolution* 125: 59–70.

Langley, M.C., B. Hakim, A. Agus Oktaviana, B. Burhan, I. Sumantri, P. Hadi Sulistyarto, R. Lebe, D. McGahan and A. Brumm. 2020. Portable art from Pleistocene Sulawesi. *Nature Human Behaviour* 4**:** 597–602.

Macknight, C.C. 1993. *The early History of South Sulawesi: Some recent Advances*. Centre of Southeast Asia Studies Working Paper 81. Clayton, Vic.: Monash University.

Macknight, C. 2018. The joint Australian–Indonesian archaeological expedition to South Sulawesi in 1969 in context. In S. O'Connor, D. Bulbeck and J. Meyer (eds), *The Archaeology of Sulawesi: Current Research on the Pleistocene to the Historic Period*, pp. 9–17. Terra Australis 48. Canberra: ANU Press.

DOI: http://doi.org/10.22459/TA48.11.2018.

Mahmud, M.I. 2017. Perhiasan prasejarah kawasan Batu Ejaya, Bantaeng. In M.I. Mahmud and B. Hakim (eds), *Butta Toa: Jejak Arkeologi Budaya Toala, Logam, & Tradisi Berlanjut di Bantaeng*, pp. 105–124. Yogyakarta: Penerbit Ombak.

Mahmud, I.M. and B. Hakim (eds). 2017. *Butta Toa: Jejak Arkeologi Budaya Toala, Logam, & Tradisi Berlanjut di Bantaeng*. Yogyakarta: Penerbit Ombak.

Marsh, E.J., M.C. Bruno, S.C. Fritz, P. Baker, J.M. Capriles and C.A. Hastorf. 2018. IntCal, SHCal, or a mixed curve? Choosing a 14C calibration curve for archaeological and paleoenvironmental records from tropical South America. *Radiocarbon* 60**:** 925–940.

McCarthy, F.D. 1940. Comparison of the prehistory of Australia, with that of Indochina, the Malay Peninsula, and the Netherlands East Indies. In F.N. Chasen and M.W.F. Tweedie (eds), *Proceedings of the Third Congress of Prehistorians of the Far East* pp. 30–50. Singapore: Government Printing Office.

McCarthy, F.D. 1953. The Oceanic and Indonesian affiliations of Australian Aboriginal culture. *The Journal of the Polynesian Society* 62**:** 243–261.

Moore, M.W. 2013. Simple stone flaking in Australasia: Patterns and implications. *Quaternary International* 285**:** 140–149.

Mulvaney, D.J. and R.P. Soejono. 1970a. Archaeology in Sulawesi, Indonesia. *Antiquity* 45: 26–33.

Mulvaney, D.J. and R.P. Soejono. 1970b. The Australian-Indonesian Archaeological Expedition to Sulawesi. *Asian Perspectives* 13**:** 163–177.

Mulvaney, D.J. and R.P. Soejono. 1971. Notes and News. *Antiquity* 45**:** 130–145.

Nur, M. 2000. Tipe budaya Mesolitik di Sulawesi Selatan. *Walennae* 3**:** 29–36.

Nur, M. 2010. Dari handstencil ke hand print, bukti kontak budaya Toala dengan leluhur orang Bugis. *Walennae* 12**:** 39–45.

O'Connell, J. F., J. Allen, M.A.J. Williams, A.N. Williams, C.S.M. Turney, N.A. Spooner, J. Kamminga, G. Brown and A. Cooper. 2018. When did *Homo sapiens* first reach Southeast Asia and Sahul? *Proceedings of the National Academy of Sciences* 115**:** 8482–8490.

O'Connor, S. 2015. Rethinking the Neolithic in Island Southeast Asia, with particular reference to the archaeology of Timor-Leste and Sulawesi. *Archipel: Études interdisciplinaires sur le monde insulindien* 90: 15–47.

Oktaviana, A.A., D. Bulbeck, S. O'Connor, B. Hakim, U.P. Wibowo and E. St Pierre. 2016. Hand stencils with and without narrowed fingers at two new rock art sites in Sulawesi, Indonesia. *Rock Art Research* 33**:** 32–48.

Ono, R., R. Fuentes, N. Amano, H.O. Sofian, Sriwigati, N. Aziz and A. Pawlik. 2021. Development of bone and lithic technologies by anatomically modern humans during the late Pleistocene to Holocene in Sulawesi and Wallacea. *Quaternary International* 596: 124–143.

Pasqua, M. and D. Bulbeck. 1998. A technological interpretation of the Toalean, South Sulawesi, Indonesia. In G.-J. Barstra (ed.), *Bird's Head Approaches: Irian Jaya Studies – A Programme for Interdisciplinary Research,* pp. 211–232. Rotterdam/Brookfield: A.A. Balkema.

Perston, Y.L., I. Sumantri, B. Hakim, A.A. Oktaviana and A. Brumm. 2020. Excavation report for Leang Rakkoe: A new Toalean site with engraved art in the Bomboro Valley, Maros Regency, South Sulawesi | Laporan ekskavasi terhadap situs Rakkoe: situs Toala yang baru dengan seni pahat di Lembah Bomboro, Kabupaten Maros, Sulawesi Selatan. *Walennae* 18**:** 51–64.

Perston, Y.L., A. Brumm, S. Suseno, B. Hakim, and Suryatman. 2021a. Excavation report for the Bomboro site: A chert quarry site in the Bomboro Valley, Maros Regency, South Sulawesi | Laporan ekskavasi terhadap situs Bomboro: Situs tambang rijang di Lembah Bomboro, Kabupaten Maros, Sulawesi Selatan. *Walennae* 1(1): 1-10.

Perston, Y.L., M. Moore, Suryatman, M.C. Langley, B. Hakim, A.A. Oktaviana and A. Brumm. 2021b. A standardised classification scheme for the Mid-Holocene Toalean artefacts of South Sulawesi, Indonesia. *PLOS ONE*

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0251138

Reimer, P.J., W.E.N. Austin, E. Bard, A. Bayliss, P.G. Blackwell, C. Bronk Ramsey, M. Butzin, H. Cheng, R.L. Edwards, M. Friedrich, P.M. Grootes, T.P. Guilderson, I. Hajdas, T.J. Heaton, A.G. Hogg, K.A. Hughen, B. Kromer, S.W. Manning, R. Muscheler, J.G. Palmer, C. Pearson, J. Van Der Plicht, R.W. Reimer, D.A. Richards, E.M. Scott, J.R. Southon, C.S.M. Turney, L. Wacker, F. Adolphi, U. Büntgen, M. Capano, S.M. Fahrni, A. Fogtmann-Schulz, R. Friedrich, P. Köhler, S. Kudsk, F. Miyake, J. Olsen, F. Reinig, M. Sakamoto, A. Sookdeo and S. Talamo. 2020. The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP). *Radiocarbon* 62**:** 725–757.

Saiful, A.M. 2018. *Melihat Gambar Purba di Kampung Bontocani*. Makassar: Masagena Press.

Saiful, A.M. 2019. Suidae dalam Strategi Subsistensi penghuni Liang Panningnge, Maros, Sulawesi Selatan. Unpublished MA dissertation. Yogyakarta: Universitas Gadjah Mada.

Saiful, A.M. and Anggraeni. 2019. Eksploitasi Suidae pada kala Holosen di Liang Pannininge, Maros, Sulawesi Selatan. *Purbawidya* 8**:** 81–100.

Saiful, A.M. and B. Hakim. 2016. Interaksi manusia terhadap binatang di Gua Batti | Human interaction to fauna in Batti Cave. *Walennae* 14**:** 1–10.

Salmia 2020. Jejak pakai alat tulang di Situs Leang Jarie, Kecamatan Simbang, Kabupaten Maros (Kajian eksperimental alat tulang): Bone tool usewear at Leang Jarie site, Simbang District, Maros Regency

(Experimental study of bone tools). B.A. (Hons) dissertation. Makassar: Universitas Hasanuddin.

Sarasin, P. and F. Sarasin. 1905. *Versuch einer Anthropologie der Insel Celebes. Erster Teil: Die Toala-Höhlen von Lamontjong*. Weiesbaden: C.W. Kreidel's Verlag.

Sardi, R.M. 2016. Eksistensi budaya pra-Neolitik di situs prasejarah Bontocani Sulawesi Selatan | The existence of pre-Neolitic culture in Bontocani prehistoric sites South Sulawesi. *Walennae* 14**:** 63–74.

Shipton, C., S. O'Connor, S. Kealy, Mahirta, I.N. Syarqiyah, N. Alamsyah and M. Ririmasse. 2020. Early ground axe technology in Wallacea: The first excavations on Obi Island. *PLOS ONE* 15**,** e0236719.

Simanjuntak, T. 2015. Progres penelitian Austronesia di Nusantara. *Amerta* 33**:** 25–44.

Simons, A. and D. Bulbeck. 2004. Late Quaternary faunal successions in South Sulawesi, Indonesia. In S.G. Keates and J.M. Pasveer (eds), *Modern Quaternary Research in Indonesia 18*, pp. 167–189. Leiden: A.A. Balkema Publishers.

Soejono, R.P. 1961. B. Preliminary notes on new finds of Lower-Palæolithic implements from Indonesia. *Asian Perspectives* 5**:** 217–232.

Soejono, R.P. 1969. The history of prehistoric research in Indonesia to 1950. *Asian Perspectives* 12**:** 69–91.

Solheim, W.G. II. 1996. The Nusantao and north-south dispersals. *Bulletin of the Indo-Pacific Prehistory Association* 15**:** 101–109.

Sumantri, I. 1996. Pola Pemukiman Gua-Gua Prasejarah di Biraeng Pangkep, Sulawesi Selatan. Unpublished M.A. dissertation. Jakarta: Universitas Indonesia.

Suryatman 2017. Artefak litik di kawasan prasejarah Batu Ejayya: Teknologi peralatan Toalian di pesisir Selatan Sulawesi. *Walennae* 15**:** 1–18.

Suryatman and B. Hakim. 2017. Teknologi alat batu Toalian di Kawasan Batu Ejaya. In M.I. Mahmud and B. Hakim (eds), *Butta Toa: Jejak Arkeologi Budaya Toala, Logam, & Tradisi Berlanjut di Bantaeng*, pp. 19–48. Yogyakarta: Penerbit Ombak.

Suryatman and B. Hakim. 2018. *Berlibur sambil Belajar Peralatan Batu Manusia Purba di Kampung Bontocani Kabupaten Bone*. Makassar: Masagena Press.

Suryatman, B. Hakim and R.M. Sardi. 2016. Industri alat batu Cabbenge di Lembah Walennae: Bukti kebudayaan awal di Sulawesi. In AKW, H.A. Bernadeta (ed.), *Lembah Walannae: Lingkungan Purba dan Jejak Arkeologi Peradaban Soppeng.* Makassar, Sulawesi: Balai Arkeologi Sulawesi Selatan.

Suryatman, B. Hakim and A. Harris. 2017. Industri alat mikrolit di situs Balang Metti: Teknologi Toala akhir dan kontak budaya di dataran tinggi Sulawesi Selatan. *Amerta* 35**:** 75–148.

Suryatman, B. Hakim, M.I. Mahmud, Fakhri, B. Burhan, A.A. Oktaviana, A.M. Saiful and F.A. Syahdar. 2019. Artefak batu Preneolitik situs Leang Jarie: Bukti teknologi Maros point tertua di kawasan budaya Toalean, Sulawesi Selatan. *Amerta* 37**:** 1–17.

Suryatman, Fakhri, R.M. Sardi and B. Hakim. 2020. Development of stone flake artifact technology in the early half of Holocene at Leang Batti, South Sulawesi. *Berkala Arkeologi* 40**:** 195–218.

Suryatman, Fakhri, B. Hakim, Y.L. Perston, R. Sardi, K. Newman, Hasanuddin, M. Nur and K. Muda. 2021. Incised stone artefact in the context of Middle Holocene burials at Cappalombo 1, South Sulawesi, Indonesia | Artefak batu bergores dalam konteks pengubur an Holosen Tengah di Situs Cappalombo 1, Sulawesi Selatan, Indonesia. *SPAFA Journal* 5.

Utomo, D.W. 2003. Alat batu bergerigi dari situs Wessae, Barru, Sulawesi Selatan. *Walennae* 6**:** 67–79.

Van den Bergh, G. D., B. Li, A. Brumm, R. Grün, D. Yurnaldi and M.W. Moore. 2016. Earliest hominin occupation of Sulawesi, Indonesia. *Nature* 529**:** 208–211.

Van Heekeren, H.R. 1949a. Early man and fossil vertebrates on the island of Celebes. *Nature* 163**:** 492.

Van Heekeren, H.R. 1949b. Rapport over de ontgraving van Bola Batoe, nabij Badjo (Bone, Zuid-Celebes). *Oudheidkundig Verslag 1941–47*: 89–107. Bandung: A.C. Nix & Co.

Van Heekeren, H.R. 1957. *The Stone Age of Indonesia*. The Hague: Martinus Hijhoff.

Van Heekeren, H.R. 1972. *The Stone Age of Indonesia*. Second, revised edition. The Hague: Martinus Nijhoff.

Walker, M.J., M. Berkelhammer, S. Björck, L.C. Cwynar, D.A. Fisher, A.J. Long, J.J. Lowe, R.M. Newnham, S.O. Rasmussen and H. Weiss. 2012. Formal subdivision of the Holocene Series/Epoch: a Discussion Paper by a Working Group of INTIMATE (Integration of ice-core, marine and terrestrial records) and the Subcommission on Quaternary Stratigraphy (International Commission on Stratigraphy). *Journal of Quaternary Science* 27**:** 649–659.

Wilkins, J. 2020. Is it time to retire NASTIES in southern Africa? Moving beyond the culture-historical framework for Middle Stone Age lithic assemblage variability. *Lithic Technology* 45(1)**:** 1–13.

Williams, M.A., N.A. Spooner, K. McDonnell and J.F. O'Connell. 2021. Identifying disturbance in archaeological sites in tropical northern Australia: Implications for previously proposed 65,000-year continental occupation date. *Geoarchaeology* 36**:** 92–108.