NOTES ON FOSSIL VERTEBRATES AND STONE TOOLS FROM SULAWESI, INDONESIA, AND THE STRATIGRAPHY OF THE NORTHERN WALANAE DEPRESSION

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ABSTRACT: These notes intend to clarify some details concerning the palaeontological and archaeological investigations in the northern Walanae depression in Sulawesi. The question of the age of the fossils and artifacts is elucidated, and it is argued that the fossils are older than the tools. Furthermore, information on the general geological framework is given, substantiating the view that the vertebrate remains erode from the upper part of the Walanae Formation. Also, four interesting fossil vertebrate finds are presented.

KEYWORDS: Southeast Asia, Sulawesi, Walanae depression, Walanae Formation, Walanae terraces, fossil vertebrate localities, *Archidiskodon-Celebochoerus* fauna, Palaeolithic Cabenge industry.

1. INTRODUCTION

ThePlio-Pleistocene of the island of Sulawesi, formerly Celebes, has won a certain fame with its vertebrate fossils of the *Archidiskodon-Celebochoerus* fauna and its stone implements of the Cabenge industry.[1] In this paper we delve into the history of the research, and into the general Neogene stratigraphy of the area with the most promising fossil localities: the Walanae depression in the southwestern peninsula. This paper might be regarded as a sequel in a recent series on Sulawesi. The first one summarized our hypothesis that contrary to general belief the fossils and artifacts in the Walanae area are not equal or near-equal in age, and that the Cabenge industry could be associated with early *Homo sapiens* (Bartstra et al., 1991). A second paper dealt with newly acquired fossil remains, especially mentioning a stegodont molar from the northwestern part of Central Sulawesi (Bartstra & Hooijer, 1992). A third paper focuses on the artifacts of the Cabenge industry, and is also presented in this volume (Keates & Bartstra).

Figure 1 explains the geographic situation, with the area of interest. This prime region of the various finds lies directly south of a marked topographic depression (the so-called Singkang embayment (Beltz, 1944) or Tempe depression (van Bemmelen, 1949)) which separates the southwestern peninsula of Sulawesi from the central part of the island and which extends from the mouth of the River Sadang to the mouth of the River Cenrana (the shaded area in fig. 1). Until recently this depression was covered by the sea; the three present lakes are a vestige of this situation. The largest is Lake Tempe, and the River Walanae debouches herein. The drainage area of the Walanae, which stretches far to the south and is bordered by mountain ranges, is here referred to as the Walanae depression.

2. THE NOTION OF NON-CONTEMPORANEITY

One should approach the hazy shores of Sulawesi from the west, via the Makassar Strait. Sailing this sea, one can imagine being part of the first groups of *Homo sapiens* that travelled from Sundaland[2] eastwards and which saw Sulawesi appear as the new frontier. There is yet another reason to favour this western approach: one will be sailing renowned waters. In 1860 the great naturalist Wallace (the one who almost beat Darwin) expressed his idea of a zoogeographical boundary straight through the archipelago of Southeast Asia. To the west of Wallace's Line[3] there was an Asiatic animal world with highly developed mammals; to the east of it an Australian one with primitive types like the duck-billed platypus and marsupials. According to Wallace this boundary coincided with *inter alia* the deep Makassar Strait, which would mean that the fauna of Sulawesi should be totally different from that of Java or Borneo (Kalimantan).

However, when around the turn of the century the exploration of the interior of Sulawesi slowly got under way, it became clear that animals were living there of clearly Asiatic origin, like monkeys, buffaloes, and pigs. It was therefore assumed that land-bridges had existed, which had from time to time connected Sulawesi with mainland Asia, and across which animals had been able to migrate. The Sarasins (1901, 1905), for example, concluded that such early invasions had occurred, on the basis of the existence of archaic forms in the present-day fauna. The Sarasins were already undermining Wallace's Line by proposing that the fauna of Sulawesi is a mixed fauna, with a predominantly Asiatic character. In their opinion there never was a land-bridge to Borneo, but most probably there was one linking Sulawesi to Asia via the Philippines. This idea remained hypothetical, however, as during their expeditions (from 1893-1896 and from 1902-1903) the Sarasins did not find any fossils that could have provided them with supporting evidence. It was not until much later that such fossils came to light.

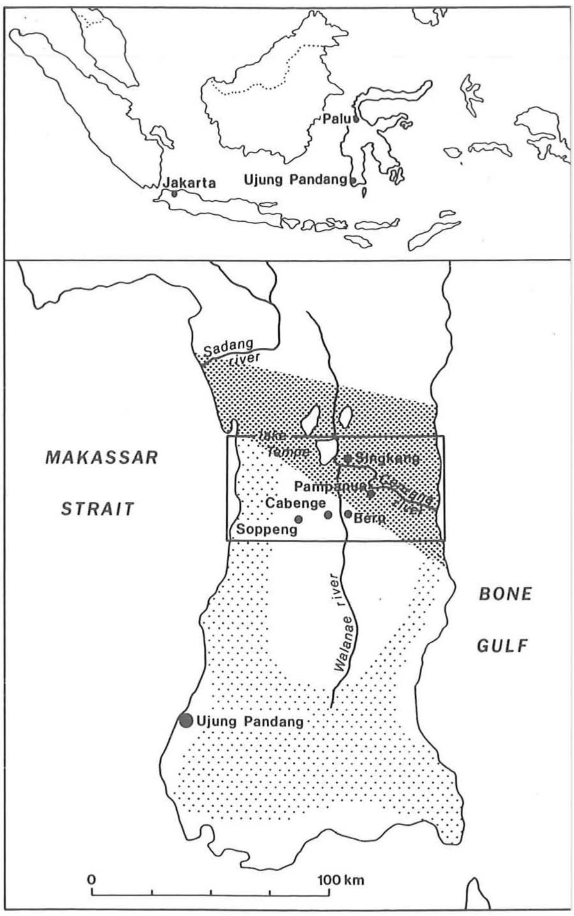

Fig. 1. Island Southeast Asia, and the southwestern peninsula of Sulawesi with geographic features and names referred to in the text. The shaded area (schematic) is the so-called Tempe depression. The dotted area (idem) indicates the Neogene island. The area within the rectangle is the main region of artifact sites and fossil localities.

In the summer of 1970 a dream came true for van Heekeren, a Dutch prehistorian and former employee with the Indonesian Archaeological Service. As organizer and co-leader of a scientific team, he was able to return to the area of his most cherished discoveries. In the hilly country east of the small town of Cabenge in South Sulawesi, in the area of the great Walanae river (figs 1 and 2), he had found in the years 1947-1950 fossil fragments of vertebrates together with heavily patinated flakes and cores of a presumably Palaeolithic stone industry (van Heekeren, 1949a; 1949b; 1949c).

Already in 1946 van Heekeren had started looking for fossils and implements on remnants of raised beaches along the Makassar Strait and Bone Gulf. He found them a year later in the interior of South Sulawesi (Bartstra, 1993). The fossil vertebrate fragments were brought to the Netherlands, where they were identified and described in a long succession of papers by one of us (D.A.H.), in those far-off days the newly appointed curator of the Dubois collection of fossil vertebrates at the Museum of Natural History at Leiden.[4] The first paper on the fossil fauna of Sulawesi appeared in 1948 and gave details of a giant suoid, *Celebochoerus heekereni*, with which species designation the finder of the new material was uniquely honoured. In the course of further publications, in which also elephantoid bones were described, the new fauna of southern Sulawesi became well-known under the name: *Archidiskodon-Celebochoerus* fauna (for summaries see: Hooijer, 1949b; 1960; 1975).

Meanwhile the political instability in Sulawesi and the worsening relations between the young republic of Indonesia and the Netherlands had made it impossible for van Heekeren to continue his research. Twenty long years elapsed, but at last in 1970 Uncle Bob (as van Heekeren was known to his friends) returned into the field for a prolonged period.[5]

The 1970 Joint Indonesian-Dutch Sulawesi Prehistoric Expedition was financed by WOTRO, the Netherlands Foundation for the Advancement of Tropical Research. In a final proposal to (presumably) WOTRO, written in January 1970, van Heekeren's ideas become quite clear.[6] He developed a working hypothesis for the field: the fossils and artifacts to the east of Cabenge are equally old and date from the Pleistocene. According to him, there is a good chance that *Homo erectus* (*Pithecanthropus erectus*) is to be found in the area. This latter possibility was van Heekeren's true dream, cherished from the days of the first finds, as is apparent from the small molars and molar fragments that he continually picked up, in the hope of finding *Pithecanthropus* at last, but which invariably turned out to come from suoids (Bartstra & Hooijer, 1992).

The members of the 1970 expedition were housed in the village of Beru, directly east of Cabenge (fig. 2), and for more than six weeks (in June, July and August) the surroundings were thoroughly explored, all on foot. We know, for three of us were members of the team: two (G.J.B. and B.K.) at that time still mere students of prehistory, but the third (D.A.H.) by then a well-known curator of fossil vertebrates at the Leiden museum.[7] The fourth author (M.A.A.) was a schoolboy then, often accompanying us on our trips. The geomorphology and stratigraphy of the Beru region became very familiar, and many artifacts and fossils were collected, from the surface as well as from excavations. In re-reading our fieldnotes from that period, we vividly remember the discussions on the high verandah of our home in the hot and lazy afternoons, van Heekeren clad in sarong and every now and then extinguishing his half-finished cigarettes. The discussions centred on the contemporaneity of artifacts and fossils, and, of course, on *Pithecanthropus erectus*.

In 1974 van Heekeren died unexpectedly. He was working on a monograph concerning the Sulawesi expedition, but only a few notes and the introductory pages of this manuscript seem to have survived. These became available to us some five years ago when van Heekeren's sons emptied a large cabin trunk in the attic of his former house. It is interesting to know what van Heekeren thought about his working hypothesis after the 1970 expedition, nurtured by six weeks of field research and discussions with fellow scientists.[8]

An indication might be found in van Heekeren's ideas on the chronology of the Indonesian prehistory, published posthumously in 1975. The stone implements from the surroundings of Beru, meanwhile officially termed the Palaeolithic Cabenge industry, are dated to the very beginning of the Upper Pleistocene (estimated age between 200 and 100 ka), while the same age is given to the fossil vertebrate remains of South Sulawesi, the *Archidiskodon-Celebochoerus* fauna. Van Heekeren was thus still convinced of a contemporaneity of artifacts and fossils. *Pithecanthropus* is still in the picture, albeit a late one, for in the chronology van Heekeren associates the tools from Sulawesi with *Homo soloensis*[9]; a thought-experiment, of course, for no hominid remains were unearthed during the expedition of 1970.

From the cabin trunk there also emerged an incomplete type-written report, possibly prepared in the fall of 1970 for WOTRO or the Indonesian Archaeological Service.[10] From this it becomes clear why van Heekeren's belief in the contemporaneity of fossils and artifacts could not be shattered. Although he mentions fossil localities around Beru where no artifacts could be traced (for instance Sompe and Celeko, fig. 2), he recollects the second excavation of the 1970 expedition where flake tools and vertebrate remains were found together 'in the very heart of the gravel'. Van Heekeren is referring here to the excavation at Marale (officially termed Beru or Baru II), immediately south of the main village of Beru, in which an abraded *Stegodon* molar had been found on top of a river-laid, gravelly, reddish sand. The superincumbent bed was a coarse, fluviatile gravel, with some worked flakes at the very top. In this report van Heekeren does consider the possibility that the molar from Marale comes from older deposits, but in his heart he continues to believe in contemporaneity, to be demonstrated in forthcoming 'large-scale excavations'.

The research of 1970 had made it clear that the implementiferous stream gravels near Beru (including this superincumbent Marale gravel), apparently all remnants of a terrace system of the Walanae river, might actually be fairly recent from a geomorphological viewpoint, that is to say Upper Pleistocene at most. Thus in his 1970 fall report and in later publications van Heekeren was forced to take into account the possibility of this relatively recent age. A rather advanced technology exhibited by some of the flakes of the Cabenge industry could only confirm this dating, but van Heekeren's belief in contemporaneity would also imply that the vertebrate fossils of Beru were then of Upper Pleistocene age. Support for this viewpoint could be found in the peculiar status of the *Archidiskodon-Celebochoerus* fauna which had already become clear before 1970: impoverished, endemic, and insular, with full-sized species and dwarf descendants together. Nobody knows how long it takes for full-sized species to dwarf; therefore, an Upper Pleistocene age for some of the fossil remains did not seem improbable to van Heekeren.

The notes and introductory pages, including a table of contents, of the Sulawesi manuscript van Heekeren was working on, and which emerged from the trunk, indicate that the final volume might have been quite substantial. Reading the pages, it can nowhere be surmised that the author had had second thoughts as to the supposed contemporaneity of fossils and artifacts. On the contrary, van Heekeren writes about fossil vertebrates "recovered in association with Palaeolithic tools", and stone implements "always accompanied by remains of the *Archidiskodon-Celebochoerus* fauna". Thus it appears that van Heekeren had not essentially changed his views about the fossils and artifacts of South Sulawesi after the field campaign of 1970; at most he had become more cautious with regard to the age interpretation. As a final check one can consult van Heekeren's book about the Stone Age of Indonesia, published in 1972. This work is in fact a revised and extended version of an earlier publication on the same subject that appeared in 1957. The new text was undoubtedly concluded before the 1970 campaign in Sulawesi, but it should still have been possible to correct the galleys, if new results would have provided reason for doing so. But in the 1972 text it is still stated that the "Palaeolithic artifacts and the fossil vertebrates, or at least the larger part of the latter, are presumably of the same age".

In 1977 one of us (G.J.B.) voiced a different opinion in a paper on the stratigraphy of South Sulawesi: fossils and artifacts are not contemporaneous. The vertebrate remains of the *Archidiskodon-Celebochoerus* fauna occur in situ (autochthonous) in the top-sediment of the

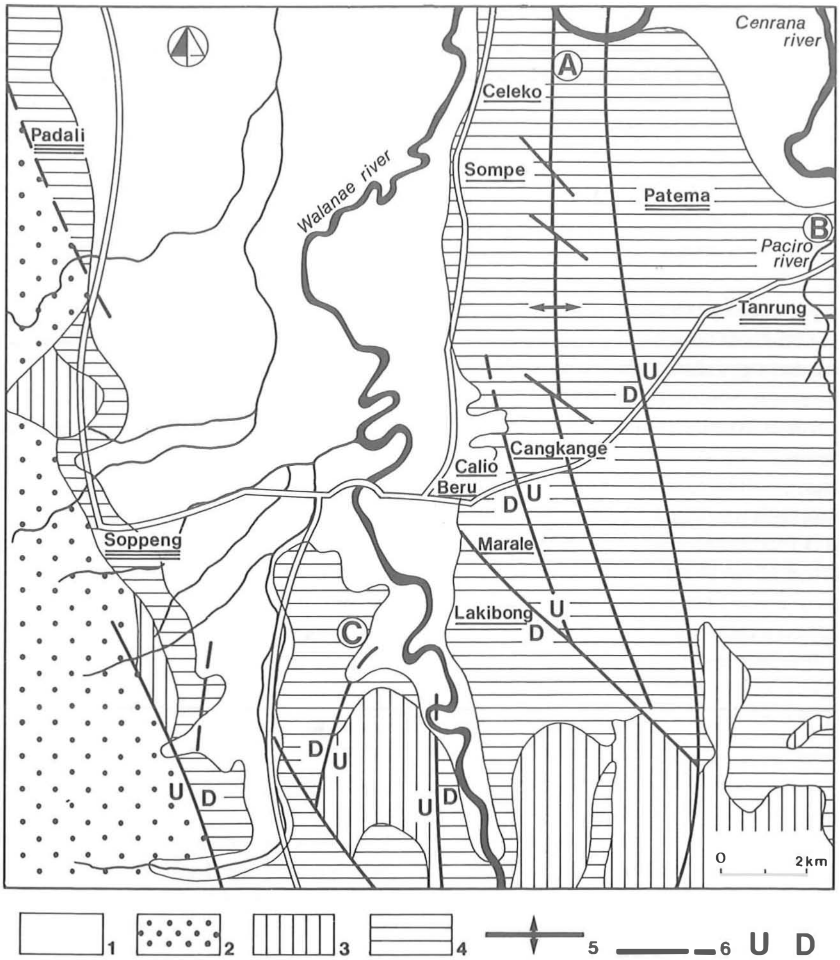

Fig. 2. Sketch map of the main area of interest in the northern Walanae depression, giving geomorphological and stratigraphical information, as well as names referred to in the text (partly after Sjahroel (1970), Sukamto (1975) and Sartono (1979). 1. Alluvial; 2. Volcanic rock; 3. Limestone; 4. Walanae Formation; 5. Anticline; 6. Fault line; U. Up; D. Down. The volcanic rock, the limestone and the greater part of the sediments of the Walanae Formation are all Tertiary in age (see text). The alluvial deposits are mainly Holocene.

The amplitude of the anticlines to the right of the Walanae diminishes toward the east. Whereas the first anticline (A) is a distinct geomorphological feature, the second one (B) is difficult to recognise in the landscape. The crest of (B) is situated just outside the right edge of the above figure.

The various fossil localities are underlined: those clustered on the first anticline with a single line, those probably located on the western slope of the second anticline with a double line. Triple lines indicate the localities west of the Walanae. The town of Soppeng is not specifically mentioned in the text as a fossil locality. But there seem to exist some minor bone-bearing outcrops in the northern part of this town, probably belonging to the same sediment sequence which is exposed at Padali.

Not drawn on this map are the scattered remnants of riverterrace gravel, all Pleistocene in age, and overlying the Beru member of the Walanae Formation on the west-facing slope of the first anticline. This gravel is implementiferous (Palaeolithic Cabenge industry; Keates & Bartstra, this volume), and is mainly found between the localities of Beru and Lakibong. It is matched by a gravelsheet on the left side of the Walanae, for example near Jampu (C).

The small town of Cabenge, which gave its name to the Palaeolithic Cabenge industry, but is not of particular importance as far as fossil finds are concerned, is also not located on this map (see fig. 1; and Keates & Bartstra, this volume).

bedrock of the region, around Beru consisting of partly consolidated sandstones and conglomerates. The Walanae river has cut into this bedrock, and therefore abraded (allochthonous) fragments of vertebrates are to be found in the Walanae terrace fills. Erosion of the bedrock also occurs where these sandstones and conglomerates outcrop, so that the fossil fragments become scattered over the fields. What Bartstra sees as being most important, as it has been the source of all the confusion, is an unravelling of the various gravels that can be traced around Beru. These are either true river-terrace gravels, or the residue of conglomeratic bedrock sediment, or a local mixture of the two. Fossils of vertebrates occur in all three gravels. The Palaeolithic artifacts of the Cabenge industry can only be associated with the terrace gravel; it is even possible that they lie only on the surface in the fields around Beru, concentrated in true, prehistoric sites. Bartstra thus emphasizes a distinct difference in age between fossils and artifacts: the vertebrates are Lower Pleistocene or Upper Pliocene, but the implements are definitely Upper Pleistocene, and for a large part maybe even younger. *Pithecanthropus* or *Homo erectus* is not mentioned in the 1977 text, but it is clear that no finds of this particular hominid can be expected around Beru: the faunal remains are too old and the artifacts are too recent.

These ideas put forward in 1977 did not simply come out of the blue. As mentioned above, all four of us took part in the 1970 field trips, and thus we had the opportunity to make our own observations and to take notes. However, our initial approach to the questions of geomorphology and stratigraphy was biased by the postulate of contemporaneity, and it took quite some time before opposite views became established. In 1971 one of us (G.J.B.) published a popular report about the 1970 expedition, in which the contemporaneity of the fossils and artifacts was not yet contested. When another one of us (D.A.H.) published, in 1972, the fossil material that the expedition had yielded, the question of contemporaneity was not discussed. In an article published by Hooijer in 1973 it was still suggested that the extinction of the *Archidiskodon-Celebochoerus* fauna might have been caused by early man, in view of the presence of stone implements.

But the seed of doubt was sown definitively during the six weeks of fieldwork in 1970. With hindsight, it is curious to read in our notes several puzzling entries about the occurrence of fossils and artifacts. Why were artifacts never found in the fossiliferous consolidated sandstones and conglomerates? Why were they found only in loose gravels? Experience acquired in the years directly after 1970, during fieldwork on Java, Flores, and Timor, in which much attention was devoted to the genesis and morphology of river terraces, was very valuable for the ultimate verification of the view that the Walanae terrace gravels should be distinguished from the eroding cemented conglomerates, thus indicating that vertebrate localities and artifact sites around Beru are separate in terms of time and place. Many of our field observations, with which the emerging notion of non-contemporaneity could be tested, were shared with Sjahroel, the geologist of the 1970 expedition. All three of us have on many occasions accompanied Sjahroel on his trips in the field, and we have learnt a lot from him. In the end, our ideas on the local stratigraphic section differed from Sjahroel's (for instance, he saw Plio-Pleistocene beach gravel in many of the coarse clastics that we designated as Upper Pleistocene Walanae high terrace veneer), but on the basic stratigraphy of the area around Beru we all agreed. Thus, at the end of the 1970s the working hypothesis for palaeontological and archaeological fieldwork in the region was precisely the opposite of what it had been at the beginning of the decade.

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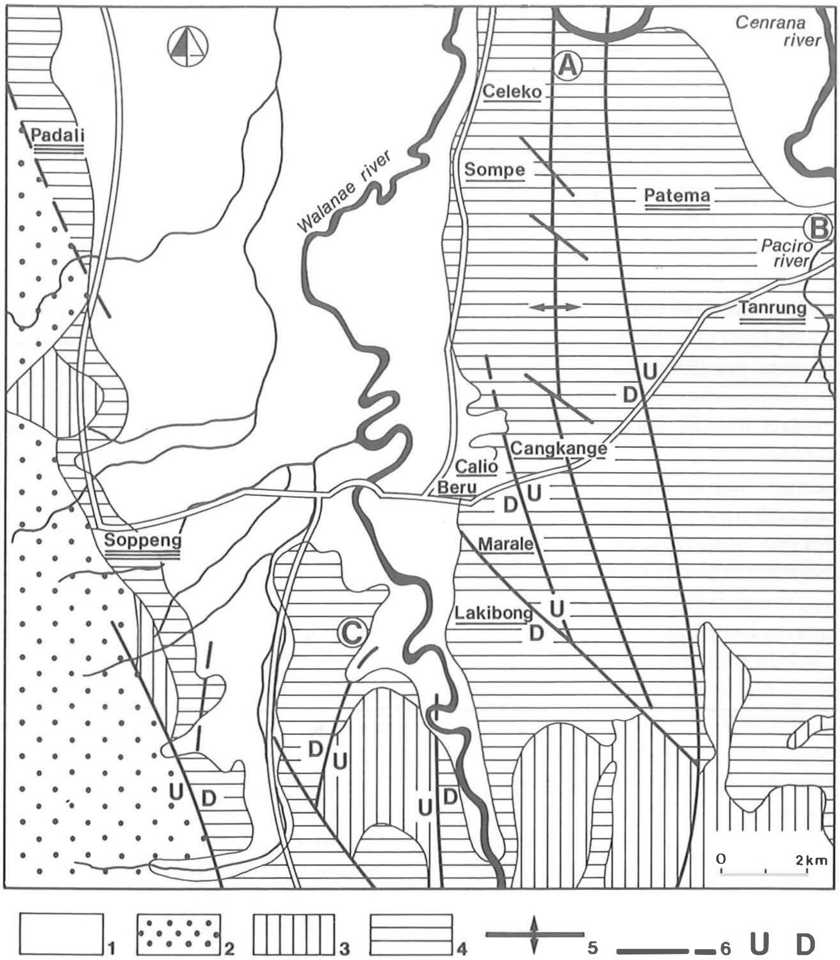

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In a paper published in 1977 one of us (G.J.B.) considerably diminished the importance of terrace sediments in the area around Beru. Such sediments do occur, but apart from accumulated clays in the low terrace they are only recognizable in rather thin, loose gravel veneers, laid down on the hill-slopes facing the river. Where a seemingly thicker fill occurs on the higher levels, slope wash must be reckoned with (local alluvium). The consolidated clastics that outcrop in this landscape have nothing to do with terrace sediments. These clastics form the bedrock of the region, pushed up in anticlinal ridges with a north-south orientation (fig. 2), consisting in the oldest parts (the cores of the anticlines) of fine-textured sediments such as clay shales, tuffaceous and calcareous sandstones, and marls, and in the younger parts (the outer layers of the anticlines) of coarser material such as gravelly sandstones and conglomerates. The whole sequence is graded and distinctly coarsening upward, and is therefore indicative of the shallowing of a former sedimentary basin.

A glance through the literature shows that the general geological situation of the area has been well known for some time. It was Wichmann (1890) who first mentioned a conspicuous anticlinal sandstone ridge with marine fossils, situated east of Lake Tempe and extending southwards. This observation is later confirmed by 't Hoen and Ziegler (1917), while they identify more anticlines. They attribute the layered anticlinal rock to what they define as the Walanae or Bone Formation. According to the two authors this is a typical basin fill, of Neogene age. Rutten (1927, 1932) estimates the thickness of this formation to be at least 3000 m. In his opinion folding took place around the transition from Pliocene to Pleistocene, after which 'severe denudation' occurred.

These subsiding basins, where large quantities of sediment could accumulate, are characteristic of the Neogene in many places in island Southeast Asia, when the greater part of the present archipelago was covered by the sea. In southern Sulawesi such a basin fill occurs not only in the Walanae depression (the study area of 't Hoen and Ziegler), but also to the east (Wichmann's anticline) and to the north of Lake Tempe, where for instance de Koning Knijff (1914) found extended deposits of sandstones and marly clays. One has to envisage the southern part of the southwest peninsula of Sulawesi at the beginning of the Neogene (Miocene) as a separate, U-shaped island (the dotted area in fig. 1), where western, southern and eastern mountain ranges enclosed an expanse of sea. This was the basin in which the sediments of the Walanae Formation developed: for a large part the erosional debris (the socalled extra-basinal deposits[12]) of the surrounding mountains and their foothills. In the south much tuffaceous material was also deposited; there is less of this in the north, but this latter region was more distant from the Neogene cores of volcanic activity.

The silting up of this basin began in the south, and as a result the regressive order of the sediments of the Walanae Formation is still best preserved in the north. When in the south deltaic, littoral, or even fluvial sediments were already laid down, in the north (around the present-day village of Beru) marine sedimentation was still taking place. The southern non-marine deposits have subsequently been eroded in the long eons of the Pliocene and Pleistocene, and it is only in the north (once again, around Beru), the last area of the former basin to become dry, that remnants of non-marine (deltaic and fluvial), or mixed marine/non-marine (estuarine and littoral) or shallow marine (nearshore, subtidal) deposit have been preserved, nowadays constituting the matrix of the *Archidiskodon-Celebochoerus* fauna.

The Sarasins (1901, 1905) invented the term Celebes molasse, encompassing various kinds of clay shales, sandstones, and conglomerates that they mapped during their expeditions, and that in their view were Neogene. In his overview of the geology of Indonesia, van Bemmelen (1949) does not explicitly use this term Celebes molasse with reference to the sedimentary rock of the Walanae Formation (although he does do this for similar gradational clastics in the eastern and south-eastern arm of Sulawesi; see also Marks, 1956). Celebes molasse and Walanae Formation are treated as one, however, on a later geologic map of Indonesia (Sheet Ujung Pandang; Sukamto, 1975). We are of the opinion that the outcropping consolidated clastics in the Beru area cannot simply be classified together with the poorly stratified, often loose masses of sediment that the Sarasins mapped as molasse in various parts of Sulawesi.

This problem of classification might be solved by setting apart, as Sartono (1979) has done, the coarser top part of the Walanae Formation and naming it as a separate unit. Sartono refers to this top part as the Beru Formation[13], reserving the old name Walanae Formation exclusively for the lower and finer clastic part of the total basin fill. In fact, Sartono makes this division into two formations on account of the stratigraphic position of a mass of limestone to the south of Beru (fig. 2), in his view intertonguing with the clastic sequence. This may be correct, but this limestone is a very local phenomenon, and cannot be decisive for a main division of the Walanae Formation. In the sections around Beru without limestone the placing of stratigraphic boundaries becomes very arbitrary. We are therefore more inclined to retain the original concept of the Walanae Formation, as envisaged by 't Hoen and Ziegler, and to continue applying it to the whole regressive sequence of clastic sediments which is the bedrock in the Walanae depression. As for Sartono's concept of a Beru Formation, we prefer to speak of a Beru member instead, situated at the very top of the Walanae Formation. For reasons explained above it must be emphasized that this Beru member only occurs in the northern part of the Walanae depression. The lower boundary of the Beru member does not necessarily coincide with the lower boundary of Sartono's Beru Formation; but an informed guess could be made concerning the total thickness of this member. Measured along the west flank of the first anticline, we give an estimate of between 300 and 500 metres.

It is not easy to give a lithostratigraphic definition of the Beru member. The upper boundary is clear: it is the unconformity (erosion surface) between the capped top sediment of the Walane Formation and the unconsolidated river-terrace gravels and clays. But the lower boundary presents problems. In the local sections of the Walanae Formation there is no definite level where coarse clastics become predominant and fines disappear. A coarsening upward is definitely present, as well as a thickening upward of the coarser strata, but the total picture is obscured in a bewildering variety of clays, sands, and gravels, consolidated and unconsolidated in layers, lenses, and tongues. The delineation of a shale unit, sandstone unit, and conglomerate unit in the local sections in the Beru area, with the aim of demonstrating this coarsening upward (Sjahroel, 1970; Sartono, 1979) may have theoretical value, but is of limited use in the field. One of the key characteristics of the Beru member is its fossil vertebrate content. Making use of faunal indices in placing boundaries in lithostratigraphic sequences is not to be recommended; but on the other hand it is clear that the Beru member constitutes a rather restricted local depositional environment within the former sedimentary basin with a deltaic, littoral, or estuarine facies, and that distinct lithological characteristics will reflect this situation. Much sedimentological research will be needed in the future to unravel the precise facies of the fossiliferous deposits at the various exposures. The clastics of the Beru member occur in all varieties, from fine-textured clayey and marly sandstones to rather coarse conglomerates with even cobble-sized components.

As for the identification of the Celebes molasse, we propose that the Walanae Formation be included in a related group of rock-stratigraphic sequences in Sulawesi, all of which show uniform conditions of graded sedimentation. The Walanae Formation would then no longer be simply equivalent to the Celebes molasse or, for example, to de Koning Knijff's sandstones and shales north of Lake Tempe, but would have an identity of its own, representative of the bedrock sediment in the Walanae depression alone.

Already in his first reports on the finds in Sulawesi van Heekeren mentions that the fossils found on the surface often show bits of cemented sediment, indicating that they have been washed out. This matrix belongs to the Beru member of the Walanae Formation, and not, as van Heekeren thought, to a terrace fill. Years ago already one of us (D.A.H., 1949b) was able to conclude from an analysis of fossil-adhering sediment that there exist around Beru at least two vertebrate horizons. At the moment it is better to state that no distinct fossil horizons exist, but that almost every stratum of the Beru member is fossiliferous. Vertebrate fossils are to be found everywhere in exposures of the top part of the Walanae Formation; the fossil localities referred to in this text and figures are just major exposures of the top layers. Taphonomic research could be very illuminating here, and should also constitute a key element of future investigations.

The best preserved skeletal remains of the *Archidiskodon-Celebochoerus* fauna come from fine to medium-textured sandstone. Hooijer (1949b) has given an analysis of a sandstone matrix from Sompe, one of the most northerly fossil localities in the Walanae depression (fig. 2). It is lateritic, has detrital grains, the interstices are partly filled with amorphous limonitic silica and opaque components, there are a few pieces of quartz and veins of rhombohedral calcite, and the volcanic constituents are diopside and to a lesser degree alkaline feldspar. In all fossil localities on the river-facing slope of the first anticline east of the Walanae this sandstone is to be found, locally with intercalated thin gravel seams or lenses: in Celeko, Sompe, Calio, Cangkange, Marale and Lakibong (fig. 2).[14] Among ourselves, we often refer to this conspicuous, grey-yellowish, fine to medium-textured, vertebrate-bearing sandstone as the Sompe sandstone. There is also a more marly or argillaceous and very fine-textured variety, apparently intertonguing with this Sompe sandstone, which can be traced at many localities, but which is almost devoid of fossils. In those places where the Sompe sandstone becomes coarser or more gritty the profusion of complete fossils disappears, and one finds fragmented bone and isolated teeth or molars (and very often the rather distinct canines of *Celebochoerus*; see also the worn molar fragment in conglomeratic sandstone of fig. 3). These 'diminishing returns' are even more noticeable in the true conglomerates of the Beru member. These can still be called fossiliferous, but one finds only isolated, small, and often heavily abraded pieces of bone or molar.

The sub-tidal, estuarine, and deltaic environment of the Beru member is very clear at the two fossil localities of Patema and Padali, which have been discovered in the last few years (fig. 2).[15] The first is probably situated on the flank of a second anticline east of Beru; the other is situated on the left side of the Walanae. In these two localities fossils of land-based vertebrates are found, together with many remains of sea-dwelling species, like sharks and rays. Shells are also abundant. At Patema a vertebral body of *Celebochoerus* was picked up, still partly embedded in a matrix of calcareous sandstone with shell fragments. At Padali, a short distance away from a mandible of *Celebochoerus* still stuck in sandstone, a dental fragment of an eagle-ray has been discovered (Bartstra & Hooijer, 1992). Van Heekeren had also found remains of marine vertebrates, notably at the localities of Sompe and Celeko. Because he thought that the fossiliferous sediments were river terraces, complicated explanations were put forward to account for the occurrence of marine species in freshwater deposits (see also Hooijer, 1960).

It appears as if the presence of a sea-dwelling fauna in association with a land-based fauna is more pronounced at these most northerly localities than

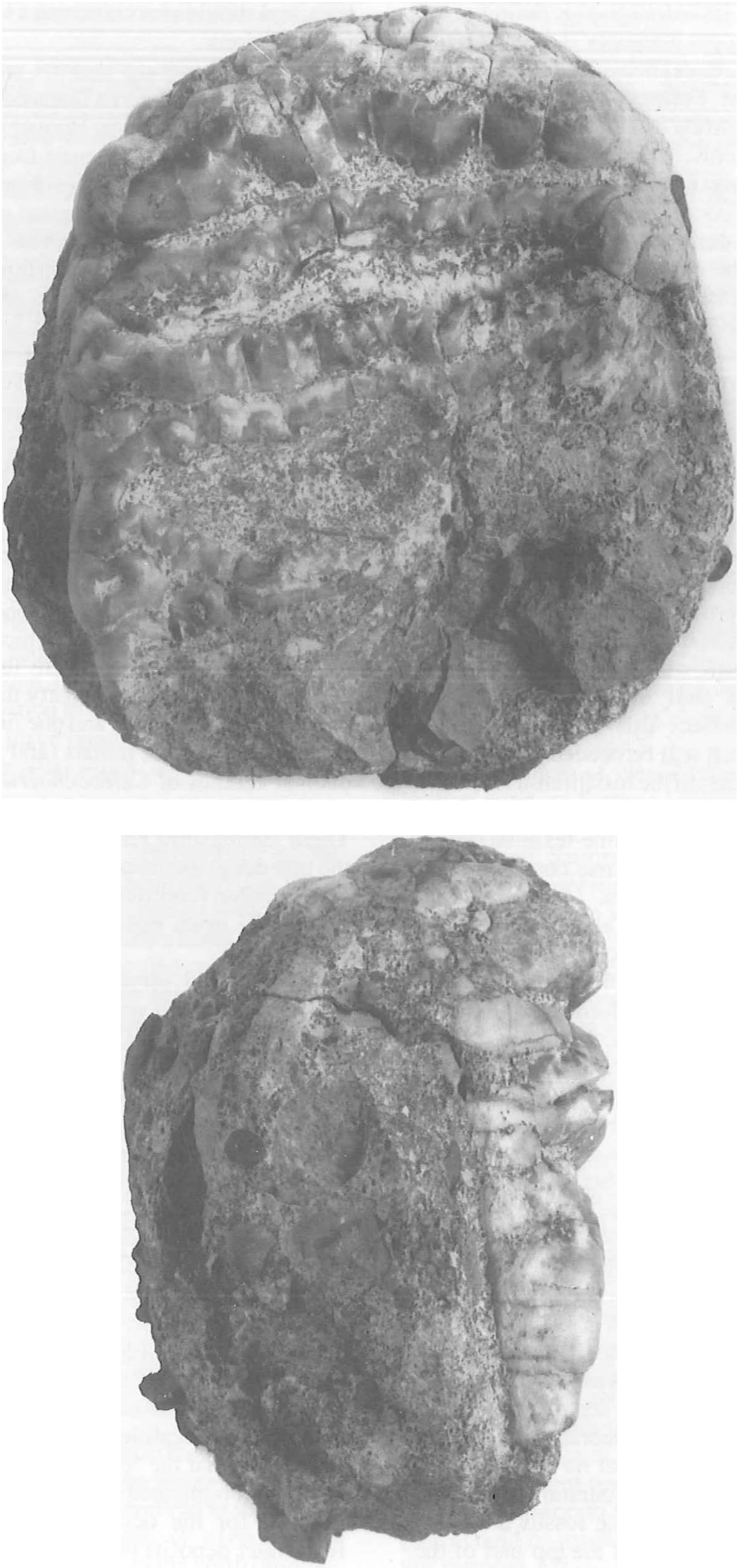

Fig. 3. Portion of a large upper molar of *Stegodon* cf. *trigonocephalus* eroded from conglomeratic sandstone some two hundred metres east of Marale. Upper figure: crown view; lower figure: left side view (Museum of Prehistory, Calio; number: C 3.27.86). Scale 1:1.

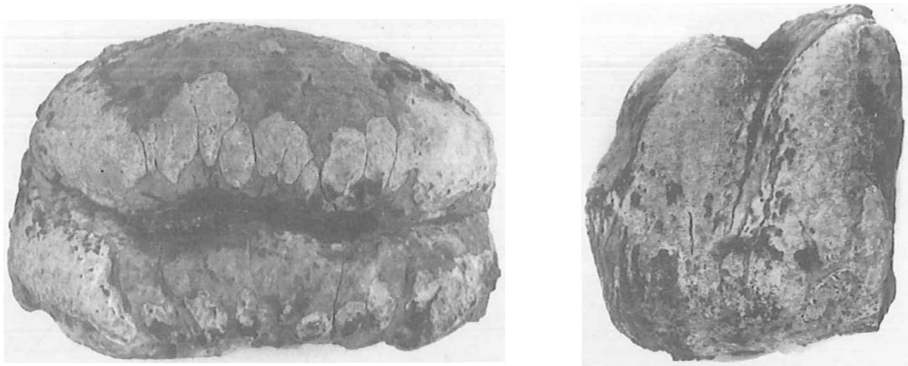

Fig. 4. Portion of a lower molar of *Stegodon* cf. *trigonocephalus* from Tanrung. At this locality the small river of Telle, a tributary stream of the Paciro, cuts through the vertebrate-bearing sediments (see fig. 2). Left: crown view; right: left side view (Museum of Prehistory, Calio; number: TRG 12.01.91). Scale 1:1.

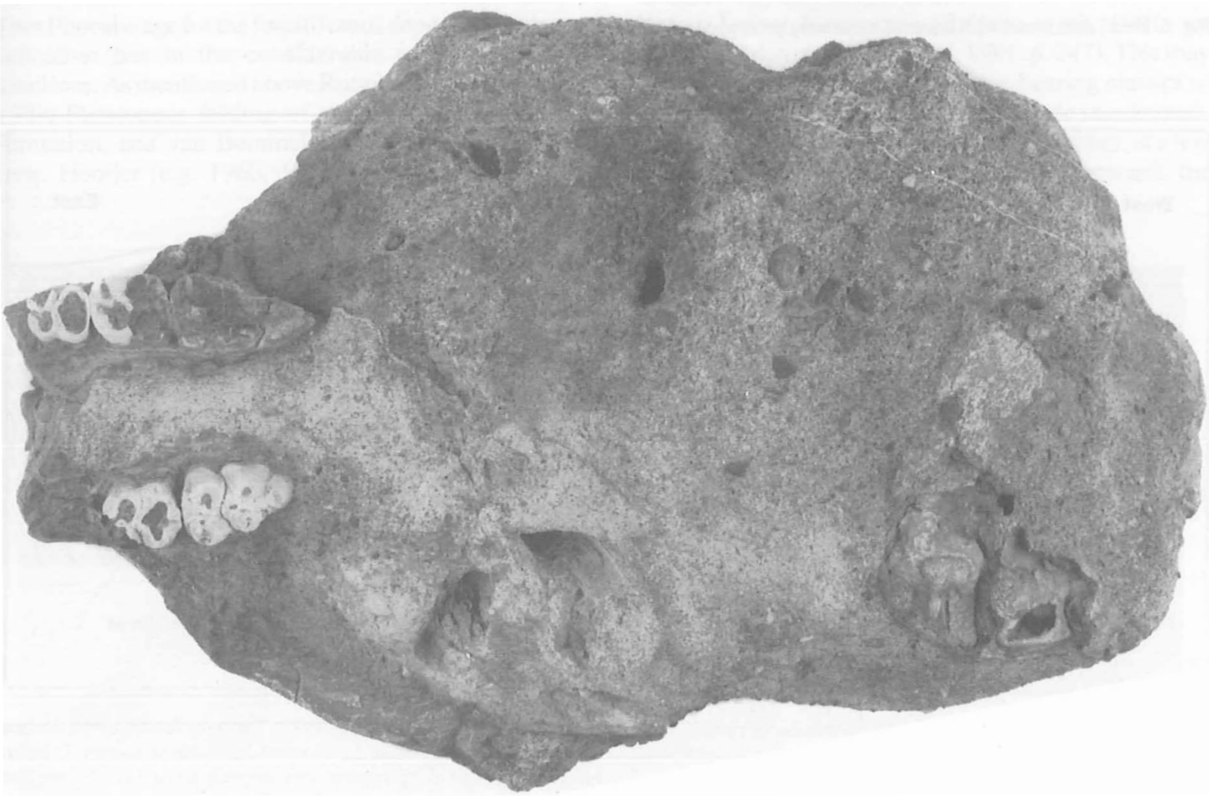

Fig. 5. Palatal view of a cranial portion of *Celebochoerus heekereni* embedded in sandstone, and found at Cangkange in 1978 (B.A.I.). Scale 1:2.

elsewhere. The feature might have to do with the Neogene regression of the sea having started in the south, and a migrating shoreline toward the north, which, however, in the end never quite reached the area. More details are needed concerning these matters, especially quantitative assessment, and we reiterate our plea for sedimentological and taphonomic investigation.

Worthy of mention is also the locality of Cangkange (find-spot of an almost complete skull of *Elephas celebensis* during the 1970 expedition, see Hooijer, 1972a; and a large portion of a cranium of *Celebochoerus*, fig. 5) where intercalated in the vertebrate-bearing Sompe sandstone a horizon of fossil wood occurs, which actually contains fragments of tree trunks (fig. 7).

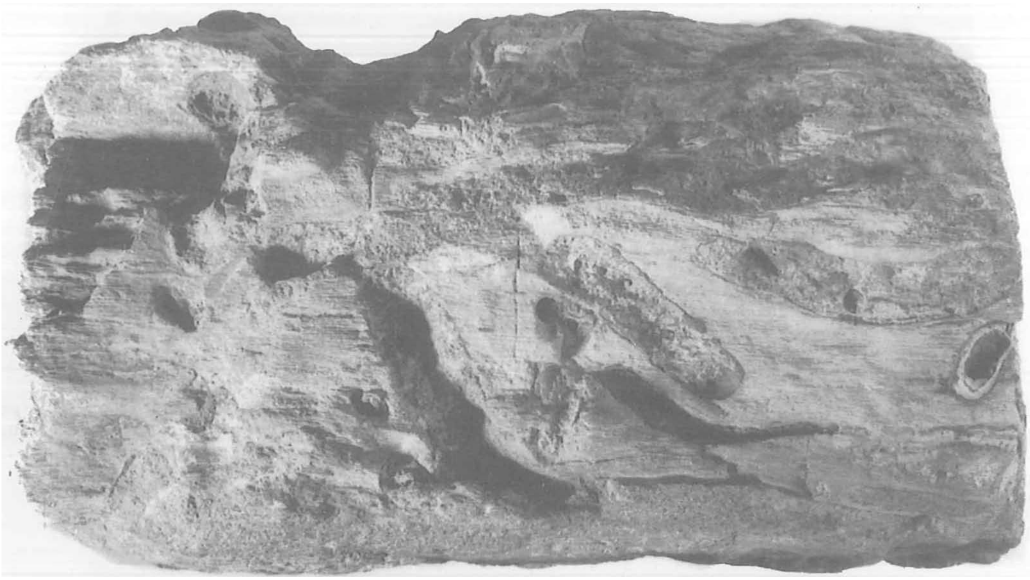

Fig. 6. Fossil drift wood with traces of burrowing pelecypods. Scale 3:4.

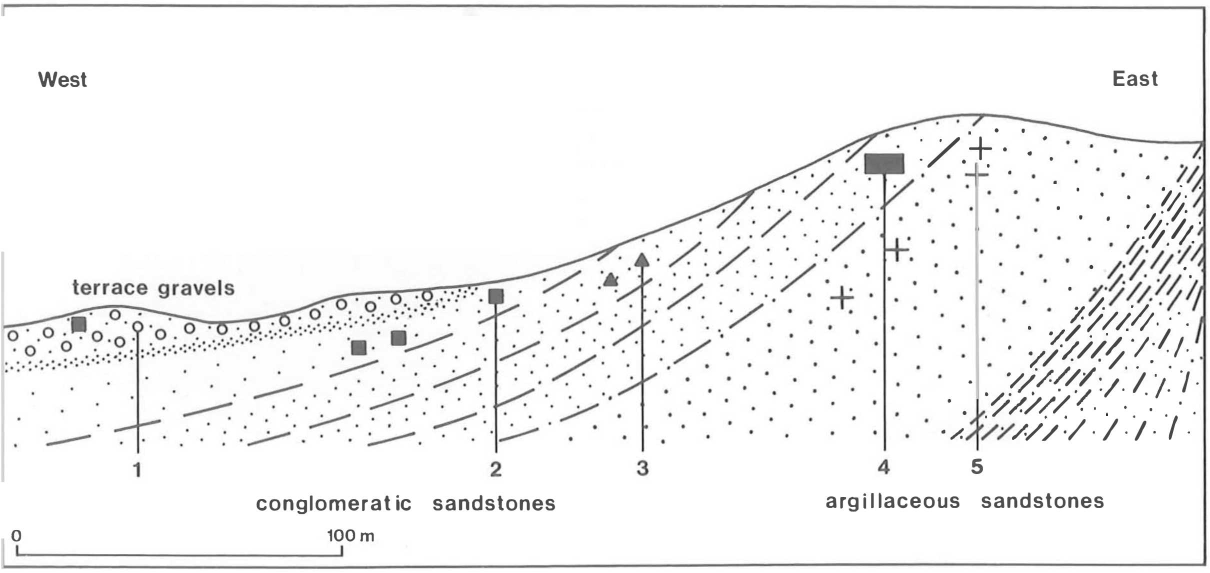

Fig. 7. Diagram of the upper part of the Beru member between Calio and Cangkange (partly after Sjahroel, 1970). The steep folding of the Walanae Formation is shown, as well as the considerable capping or truncation of the anticlines, outcome of a prolonged denudational history. Climbing the slope of this first anticline from west to east, the strata become progressively older and more fine-textured. Between terrace gravels and Beru member there is a distinct unconformity. The terrace gravels contain allochthonous fossil vertebrate remains and in situ Palaeolithic artifacts (1). In the Beru member are worn vertebrate fossils (2), mineralized wood remains (3), and the Cangkange cranial portions of *Elephas* and *Celebochoerus*, referred to in the text (4). Still higher up the slope marine invertebrates are to be found (5).

A few kilometres to the north, about halfway between Sompe and Beru (eastward into the field from kilometre post 23) a similar (or identical?) horizon is exposed, where tree-trunk fragments can be found with encrustration of shell and biogenic perforations (pelecypods; see fig. 6). These perforations are tunnels coated with calcareous shelly matter technically called 'the tube', which is white, thin and strong, and has no connection with the animal that makes it. If these tubes are found in fossil wood from marine or brackish water sediments they can safely be considered Teredinidae, family of Mollusca: Bivalvia, including the genus *Teredo*

Linnaeus or so-called ship-worms, very destructive pelecypods that first appear in the Jurassic and are well-known in the Cretaceous (Turner, 1966).

At the locality of Lakibong (find-spot of a very fine lower left first molar of *Elephas celebensis*; Bartstra & Hooijer, 1992)[16] the sediments with a marine fauna and a land-based fauna are clearly separated. Mollusc-bearing, argillaceous deposits occur distinctly higher on the west slope of the anticline than the vertebrate-bearing clastics. It is worth bearing in mind that the locality of Lakibong, stratigraphically seen, probably belongs to the oldest. Lakibong is situated farther south than any of the other localities, and thus must exhibit older strata. The various deposits at Lakibong are steeply folded.

Also at other exposures of the Beru member (e.g. in Cangkange) it can be seen that the layered sediments are folded almost vertically (fig. 8). Although Sulawesi is an island with a turbulent geological history, such steep folding indicates at least a Middle to Lower Pleistocene, if not Pliocene age for the fossiliferous deposits; another indication lies in the considerable capping of the anticlines. As mentioned above Rutten (1927) speaks of a Plio-Pleistocene folding of the Neogene Walanae Formation, and van Bemmelen (1949) supports this view. Hooijer (e.g. 1960, 1975) usually speaks of a Pleistocene age for the fossiliferous beds without any further specification, none of the fossil forms necessarily being Pliocene as to type. Palaeontological considerations, however, let Hooijer distinctly favour a Lower Pleistocene age; this in contrast to e.g. Sondaar (1981) who suggests the Middle to Upper Pleistocene.

Sartono (1979) gives an Upper Pliocene age for the vertebrates, on the basis of the foraminiferal content of vertebrate-bearing sandstone, deposited in a shallow marine and estuarine environment. The forams mentioned by Sartono are not sensitive to facies differences and are thus suitable for dating. In addition, an upper boundary of the Pliocene of 1.8 or 1.6 Ma has been assumed. However, it is not known where Sartono got his sandstone samples, whether from the immediate surroundings of Beru, or from farther south or north. As there has been a gradual silting-up of the former Neogene basin from the south, we wish to consider the possibility that part of the fossiliferous sandstones of the Beru member may be younger than 1.8 or 1.6 Ma, and is thus in fact Lower Pleistocene (Bartstra et al., 1991; we correct the date given by Allen, 1991: p. 247). This may be true especially for the vertebrate-bearing clastics of Celeko and Padali, and for conglomeratic standstones, presumably still belonging to the Beru member, at a few minor but even more northerly outcrops towards the

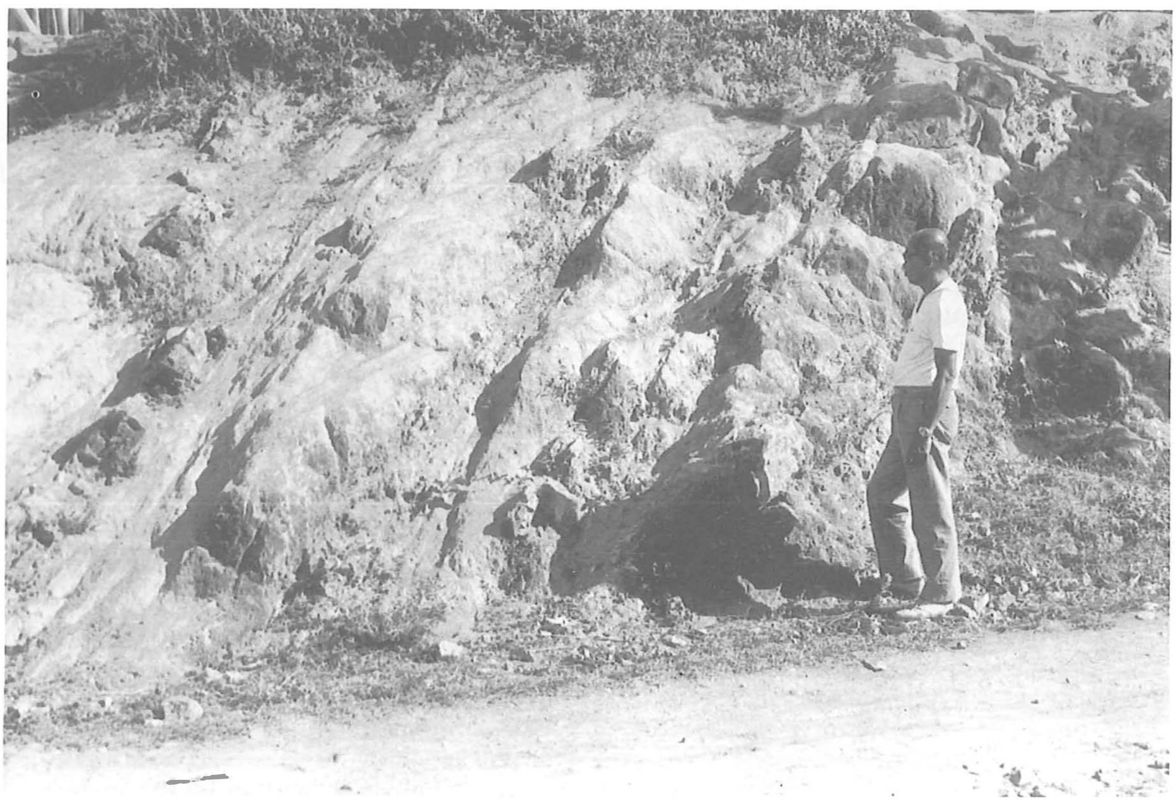

Fig. 8. Exposure of the Beru member near Cangkange, along the road from Cabenge to Pampanua. The folded sediments consist of alternating claystones and sandstones. From this area comes the *Celebochoerus* skull of fig. 5, described in the text.

town of Singkang in the Tempe depression.

The best age determination would result from radiometric dating. However, preliminary attempts at U-series analysis of some vertebrate fragments from the surroundings of Beru were not very successful, ostensibly due to the low U-content of the bone. This in itself could be an indication of considerable age, but further attempts (including ESR) are under way.

4. THE EVIDENCE ON THE FOSSIL SCENE

The composition of the fossil fauna from the Walanae region was ascertained soon after its discovery. In 1947 the first vertebrate remains were collected by van Heekeren and sent to Holland; in 1948 three papers were published by Hooijer, on *Celebochoerus heekereni* nov. gen. nov. spec., *Testudo margae* nov. spec., and *Anoa depressicornis* (Smith) subsp. and *Babyrousa babyrussa beruensis* nov. subsp., respectively. A year later the identification of *Archidiskodon celebensis* nov. spec. was announced. The general term *Archidiskodon-Celebochoerus* fauna came into use at the beginning of the 1950s. It appeared to be of a peculiar, endemic, typical insular composition, characterized by dwarfing and giantism alike.

Archidiskodon celebensis is a distinct element of this fauna. The genus name *Archidiskodon* was abandoned in 1974, since when it has been customary to speak of *Elephas celebensis*. This is a pygmy species; the shoulder height of adult individuals was approximately one and a half metres (e.g. Hooijer, 1949a; 1972a). At first sight it could be taken for a rather primitive species of *Elephas*, on the basis of the presence of functional premolars and the occurrence of tusks in the lower jaw, notably in male specimens. Initially Hooijer regarded *Elephas celebensis* as the only elephantid species with mandibular tusks, and he looked for its direct ancestor in a still unknown mastodontoid elephant. But it appears that this phenomenon of mandibular tusks also occurs elsewhere (*Primelephas gomphotheroides*, Upper Pliocene, Kenya), and, what is more important, that vestigial incisive chambers occur in mandibles of *Elephas planifrons*, a normal-sized species quite common in the Plio-Pleistocene of Southeast Asia (Maglio, 1973; Hooijer, 1972a; 1975). *Elephas celebensis* is now considered to be a direct descendant of *Elephas planifrons* (Groves, 1985), the reappearance of mandibular tusks being the result of dwarfing (paedomorphosis). The remains of *Elephas planifrons* have never been discovered in the fossil localities of the northern Walanae depression. This is significant, because it means that *Elephas celebensis* came to the area as an already dwarfed species. *Elephas planifrons* does not occur in the Philippines either, nor in Flores nor Timor.

In fact we are confronted here with a palaeontological enigma. This is because another proboscidean, of which the fossil remains have also been found in the Beru

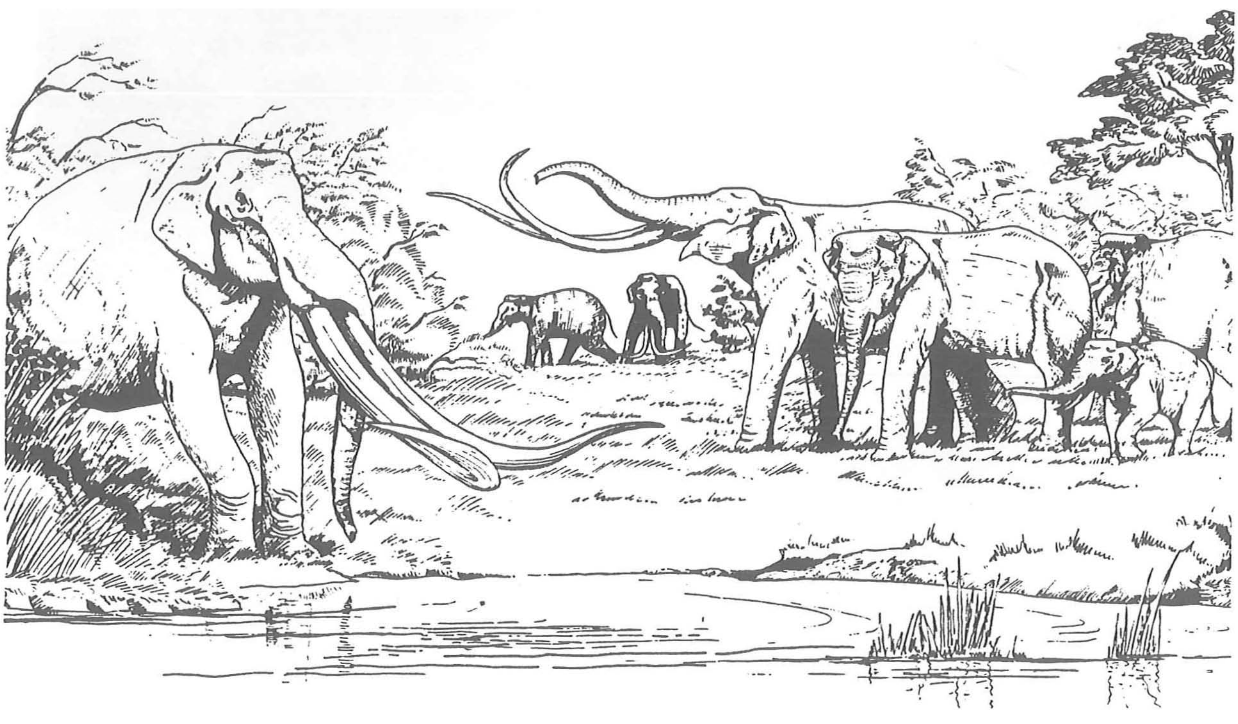

Fig. 9. Browsing *Stegodon trigonocephalus*, showing in the male specimens the interesting feature of too closely implanted tusks, hampering the trunk. This drawing was made for Hooijer by the British artist Margaret Lambert. Hooijer published this picture for the first time in 1973.

member, occurs as both a normal and a dwarf-sized species: *Stegodon* cf. *trigonocephalus* and *Stegodon sompoensis*, respectively. Among the fossil material that van Heekeren had sent to Leiden, Hooijer (1953) initially could not identify anything more specific than *Stegodon* spec., although he believed that a dwarf species might have roamed the Walanae region. In 1964 this was confirmed by Hooijer by mentioning in a publication the new pygmy species of *Stegodon sompoensis*.[17] In 1972 it became possible to identify the large *Stegodon* cf. *trigonocephalus* among the extensive material collected during the 1970 expedition. Especially the male specimens of this browser could be rather large[18]; it is known that their tusks were so close together that the trunk could not reach between them (fig. 9).

A portion of a large molar of *Stegodon* cf. *trigonocephalus* has been found some 200 metres east of Marale (figs 2 and 3). It is the hinder end, heavily worn, with four ridges and the posterior talon. The foremost preserved ridge from behind is almost completely destroyed; the other three ridges are rather well preserved and, although worn, clearly were less high than wide in the unworn state. This is a feature of *Stegodon*. The last ridge is narrower than the second last ridge, 72 mm at base transversely against 88 mm in the penultimate ridge; it is only some 18 mm thick against some 26 mm in the second ridge. It is an upper molar, because the gingival line, the lower boundary of the crown enamel, falls off rootward at the penultimate ridge, and thus is convex toward the crown. There is no posterior pressure scar; this should certainly show on a molar in this advanced stage of wear caused by the molar following it behind. This is an indication that the present molar is the last molar, M^3. The three ridges preserved show transverse rows of subequal conelets and no dilatation in the middle, another *Stegodon* characteristic. The third ridge from behind is damaged buccally but certainly was some mm wider than the ridge behind it. The width of the fourth ridge from behind cannot be measured. This is all that can be observed in the present specimen of the posterior taper that characterizes last molars. Last upper molars of *Stegodon trigonocephalus* are widest near the middle, the fifth ridge from the front, as in two specimens from Flores (Hooijer, 1972b). The greatest width of the present molar, in the middle portion of the crown that is not preserved, may have been some 20 to 25 mm wider than is the second ridge from behind, or 108 to 113 mm. This is not outside the variation range in M^3 of the Java *Stegodon trigonocephalus*, however; we have a specimen in the Dubois collection that is 113 mm wide (Hooijer, 1955), and in Yogyakarta in 1972 we observed a specimen that is 119 mm wide. Last upper molars of *Stegodon trigonocephalus* have up to twelve ridges plus the posterior talon. In the present specimen the talon is a low series of conelets, some eleven in all, 61 mm wide but not very thick anteroposteriorly (2-4 mm only); it rounds off the crown evenly behind. The molar portion is slightly curved anteroposteriorly, with one side flat and the other side convex. In upper molars the flat side is the lingual side; the present molar portion is from the right side. Two full ridges, the 2nd and the 3rd from behind, occupy an anteroposterior length of 55 mm, which means that the laminar frequency (number of ridges in 10 cm of anteroposterior length) is $100/55 \times 2 = 3.6$. These data indicate that this molar portion from 200 metres east of Marale agrees with the M^3 of the Java *Stegodon trigonocephalus*, which varies in crown width at base from 76 to 119 mm, and in laminar frequency from 3.25 to 5 (Hooijer, 1955); in the more anteriorly placed M^2 and M^1 the crown width becomes less and the laminar frequency higher.

A smaller molar portion of *Stegodon* cf. *trigonocephalus* has been obtained from Tanrung (figs 2 and 4). Both the last ridge and the talonid are unworn. The height of the ridge is 41 mm by a basal width of 67 mm, the *Stegodon* feature, the talonid 40 mm high by a width of 62 mm; such a large talonid may also be interpreted as the last ridge, in which case there would be an extremely small talonid or none at all. The rows of subequal conelets on the ridge and talonid or ridges confirm the identification as *Stegodon*. The forward inclination of the ridges shows that it is a lower molar, more probably from the right than from the left side; this cannot be ascertained from such a small crown portion. The laminar frequency, based upon the observation that the anteriormost preserved ridge is 19 mm anteroposteriorly, is $100/19 = 5.2$. These data indicate that the Sulawesi specimen is like the M_2 of *Stegodon trigonocephalus* from Java, which is 68-85 mm in basal width, 41-50 mm in crown height, and 3.8-6.5 in laminar frequency (Hooijer, 1955).

The above given two molar portions have to be recorded as *Stegodon* cf. *trigonocephalus*, because we cannot be quite certain that they do actually represent the species *Stegodon trigonocephalus*. Perhaps they merely agree with the Java *Stegodon* in molar morphology, but not in all trigonocephalous characters.

This brings us to the arrival of the Plio-Pleistocene proboscideans in southern Sulawesi. As explained, the vertebrate-bearing Beru member only occurs in the northern part of the Walanae depression; towards the south the suitable sediments have been eroded. This means that in the Beru area one is confronted with an already substantial, albeit impoverished and endemic fauna, without previous recorded history. How did this fauna come to the Neogene U-shaped island?

As yet there is no valid reason for placing the three proboscideans in the Beru area in a biostratigraphic sequence. The remains of *Elephas celebensis*, *Stegodon sompoensis*, and *Stegodon* cf. *trigonocephalus* all occur in the Beru member, and their worn allochthonous bones in the terrace sediments. It is supposed that

Stegodon sompoensis evolved from *Stegodon* cf. *trigonocephalus*, but we have no stratigraphic proof of this in the Beru area. All three proboscideans came together as fully developed species to southern Sulawesi, and lived there together. As one of us has explained concerning *Stegodon*, contemporaneity poses no problem: the larger one may have had five times the body size of the dwarfed species, a difference probably big enough to permit (peaceful) coexistence (Hooijer, 1970).

The idea of a biostratigraphic sequence in southern Sulawesi as far as *Stegodon* is concerned could possibly arise if one were to glance through the literature too fleetingly: after all, Hooijer (1972a) begins his exposé about *Stegodon* cf. *trigonocephalus* with the description of a few worn remains from terrace sediments (including the previously mentioned hinder end of an upper molar from the Marale excavation in 1970), while *Stegodon sompoensis* is initially mentioned from places where river terrace remnants do not exist (Sompe, Celeko). So one could gain the impression that the large stegodont appeared later on the scene than the small one, but this is not the case. The two above-described molar portions of the large *Stegodon* cf. *trigonocephalus*, for example, come from areas where there are no terraces, and they have clearly been derived from outcropping Beru member sediment.[19]

The situation observed thus far in southern Sulawesi is different from that in Timor or Flores, where also a normal-sized and a dwarf-sized *Stegodon* occur; but as far as Timor is concerned with only the pygmy one in the top strata (Astadiredja, 1972), and on Flores seemingly the reverse: only the normal-sized one in the top strata.[20]

For us, the idea of proboscideans that arrived swimming in southern Sulawesi (and if distances play a role, probably coming from the north) is now more appealing than the idea of legendary Stegoland (Hooijer, 1975; Sondaar, 1981; Braches & Shutler, 1984; Heany, 1985). The paucity of the Beru fauna is difficult to account for if landbridges existed. In the beginning of the 1970s the paucity could be explained by the small-scale nature of the research carried out. This is no longer possible; it appears as if the larger vertebrate genera and species of the fossiliferous Beru member are now all known.

Just as interesting as the arrival of the *Archidiskodon-Celebochoerus* fauna is its ultimate fate. As stated, in the region concerned the Neogene has been a period of prolonged subsidence and deposition. In the course of time the basin encompassed by the U-shaped island dried up, folding and faulting movements set in, and denudation severely capped the Walanae Formation. During this period, apparently the entire Pleistocene, conditions seemed not favourable for the preservation of bones of terrestrial or near-shore vertebrates. But the faunal composition must have changed. For instance, proboscidean remains are not found anymore in the Holocene deposits east of Wallace's Line.

We have abandoned the idea, once toyed with, that the extinction of the *Archidiskodon-Celebochoerus* fauna was brought about by man. The implementiferous terrace fills in the Walanae depression do not contain autochthonous vertebrate fossils. In another paper we have mentioned Fooden (1969) and Musser (1987) and the notion that the *Archidiskodon-Celebochoerus* fauna could have disappeared as a result of competition with other faunas, when southern Sulawesi became attached to the central part (Bartstra & Hooijer, 1992). This must periodically have been the case during the Pleistocene, when the Tempe depression fell dry, due to eustatic sea level changes.

For the time being we have to view the occurrence of the *Archidiskodon-Celebochoerus* fauna in the northern Walanae region as a fleeting episode in the eons of geological time, a single still frame, as it were, in the faunal evolution of island Southeast Asia. It is not yet known how the *Archidiskodon-Celebochoerus* fauna came into being, or into what it evolved (Hooijer & Bartstra, in press).

Some light could be shed on this matter, however, by investigation into the parent sediment of a fossil skull of *Sus celebensis*, described by Hooijer in 1969. This fossil was found by a Dutch missionary in the 1930s, in the bed of the River Paciro, not very far east of Beru (fig. 2).[21] After changing hands a few times this skull finally ended up in the Zoölogical Museum in Amsterdam.

In his work on the subfossil fauna of the Toalian caves in southwestern Sulawesi, Hooijer (1950) had also devoted attention to *Sus celebensis*, an animal that nowadays still lives all over the island. From the comparison of subfossil and recent remains of this species, he had come to the conclusion that in contrast to a trend with other vertebrates, *Sus celebensis* had actually increased in size in the course of the Quaternary. The skull in the Amsterdam museum is marginally smaller than the subfossil remains from the caves and much smaller than recent specimens of *Sus celebensis*. Consequently Hooijer (1969) decided that it must be of Pleistocene age. The Amsterdam skull is also fossilized (mineralized) and thus not sub-fossil, as suggested by Hardjasasmita in 1987.

The locality and circumstances of this find are very interesting. The fossil has the appearance of a river cobble, but shows on closer inspection the palate and some incomplete molars (fig. 10). Every part of the fossil is abraded by fluvial transport, and it stands to reason that it came from farther upstream. The River Paciro has its source in the hills comprising the second anticline east of Beru (fig. 2). The rivulet of Tanrung, which cuts through the Beru member of the Walanae Formation at the locality of Tanrung (find-spot of one of the partial *Stegodon* molars described above), is in fact a tributary stream in the upper drainage area of the Paciro. However, as neither Tanrung (which apparently exhibits a normal *Archidiskodon-Celebochoerus* fauna)

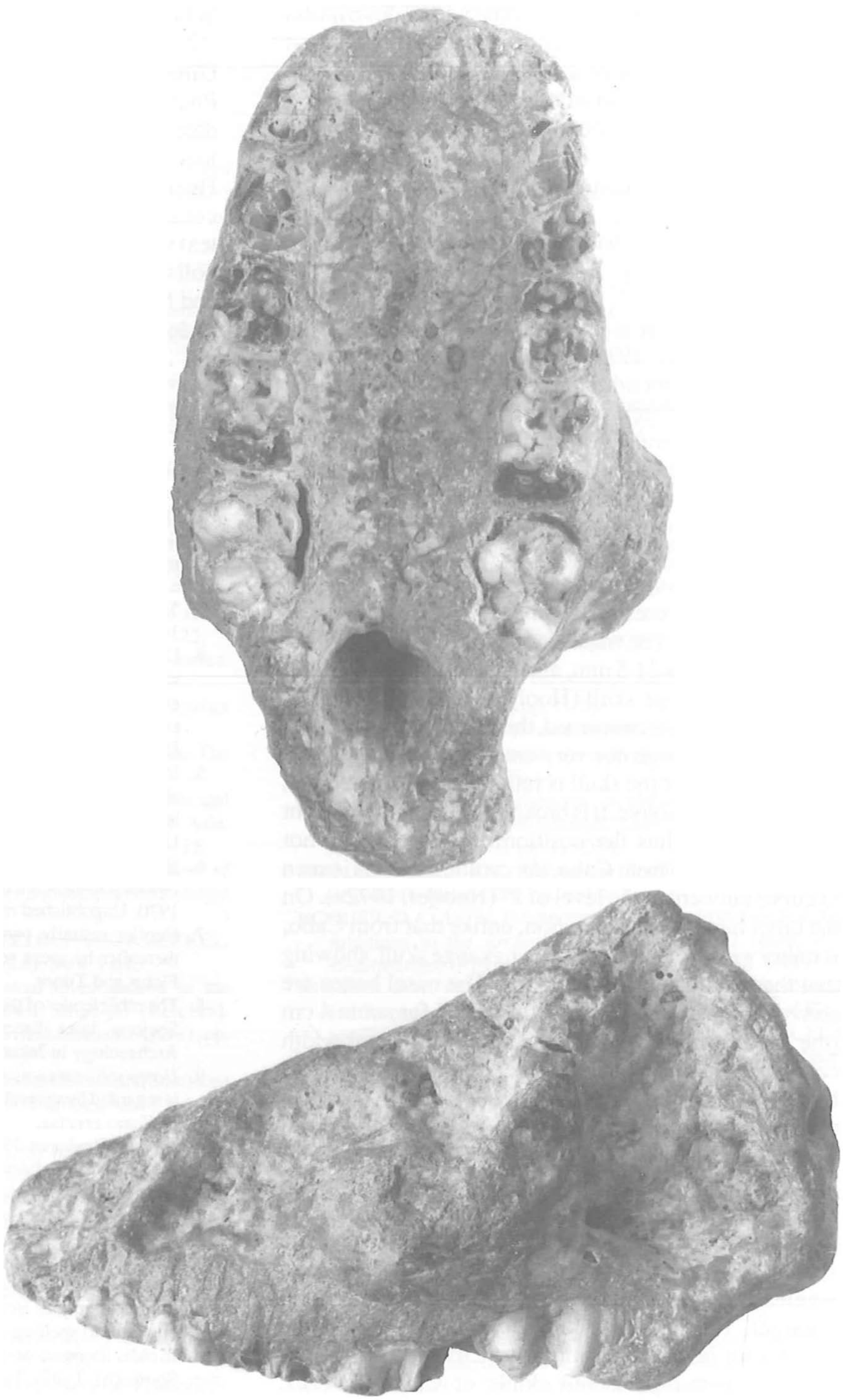

Fig. 10. Cranial portion of *Sus celebensis*, found in the bed of the River Paciro. Upper figure: palatal view; lower figure: left side view. As described in the text, this fossil could provide a clue in unravelling the ultimate fate of the *Archidiskodon-Celebochoerus* fauna. Another picture of this skull portion has appeared in Hooijer 1969 (Instituut voor Taxonomische Zoölogie (Zoölogisch Museum), Amsterdam; number: ZMA 10910). Scale 1:1.

nor any other locality on the flanks of the two anticlines near Beru has so far yielded remains of *Sus celebensis*, the possibility exists that the River Paciro or one of its tributaries cuts through a Pleistocene fossiliferous sediment that stratigraphically overlies the Beru member, and that, as explained, must be rather rare. Caves are not present in the area concerned. Because more information on this *Sus celebensis* find would seem to be of great importance, research in the Paciro area is now under way (Hooijer & Bartstra, in press).

We wish to conclude these notes with a description of a cranial portion of *Celebochoerus heekereni*, the most prolific fossil vertebrate from the northern Walanae depression, the remains of which are found in nearly every Beru member sediment, thus constituting an indelible tribute to the prime hunter of this suid: Uncle Bob van Heekeren. This particular *Celebochoerus* fossil comes from Cangkange, and it stresses the importance of this locality that has already yielded more large skeletal elements (figs 2 and 5).

The palate, or what is left of it, agrees with that from Marale, 19th July 1970 (Hooijer, 1972a). Of the M^3 only that on the right side is preserved; both M^2 are present although incompletely so, and of the M^1 there is only the left, damaged laterally. The width of M^2 is 17.8 mm; the anteroposterior and transverse diameters of the crown of M^3 are 26.0 and 20.3 mm, respectively. The width of the M^2 and the length of the M^3 are perfectly intermediate between those of a male and a female palate from Marale, but the width of the M^3 is slightly in excess of that in the larger, presumably male, palate from Marale, 25th July, 1970. The maximum width found for M^3 in *Celebochoerus* is 21.5 mm, and thus exceeds that found for this Cangkange skull (Hooijer, 1972a). Therefore, as far as tooth size is concerned, this Cangkange specimen is neither very large nor very small; just average.

The surface of the skull is rather damaged except in the nasal region above. It is broken off anteriorly in front of the M^1 and thus the position of the canine is not shown. In a skull from Calio, the canine alveolus is seen to curve outward at the level of P^3 (Hooijer, 1972a). On the other hand, the nasal region, unlike that from Calio, is rather well preserved in this Cangkange skull, showing that there is no lateral angulation. The nasal bones are convex transversely but only preserved for some 4 cm (the naso-frontal suture is indistinct). The nasal width cannot be established, and neither can the frontal or the bizygomatic width. The latter is not far from some 20 cm in so far as the state of preservation permits judgment. This is considerably larger, by one-third to one-half, than that in recent Indonesian suid skulls like those of *Sus verrucosus* Müller & Schlegel or *Sus vittatus* Müller & Schlegel (Hardjasasmita, 1987). *Celebochoerus* is verrucose in the cross section of its lower canines, whereas *Sus vittatus* is *scrofa*-like in that respect (Hooijer, 1954). *Sus macrognathus* Dubois, a known fossil from Java is larger than these living forms. Only new and better preserved skulls of *Celebochoerus*, hopefully to be discovered in the future, will allow full craniometrical comparisons with other extinct or living suid species.

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6. NOTES

1. Formerly spelled: Tjabenge (van Heekeren, 1949a); a small town near the main sites (see Keates & Bartstra, this volume).
2. Due to Pleistocene eustatic sea level changes, the islands of Java, Sumatra, and Borneo often became attached to the Asiatic mainland. This expanse of land is called Sundaland (for map see e.g. Bellwood, 1985: p. 1).
3. The notion of a zoogeographic boundary is given in Wallace, 1860; the designation Wallace's Line is found in Huxley, 1868.
4. Dubois discovered *Pithecanthropus erectus* in Pleistocene sediments in Central Java at the end of the last century. During his excavations a mass of fossil vertebrate material became available, part of which was shipped to Holland and is now known as the Dubois collection.
5. In fact van Heekeren visited the Cabenge area for a couple of days already in 1968, when he saw his chance to slip away from a team investigating prehistoric cave sites in the Maros region, near Ujung Pandang.
6. H.R. van Heekeren & D.A. Hooijer, 1970. Petition for a joint Indonesian-Dutch expedition to Sulawesi, Flores and Timor in 1970. Unpublished report.
7. Hooijer actually participated in the team for only ten days: thereafter he spent several weeks exploring fossil localities in Flores and Timor.
8. The other leader of the 1970 expedition in the Beru area was R.P. Soejono, later director of the National Research Centre of Archaeology in Jakarta.
9. *Homo soloensis* was discovered in Central Java in the 1930s, and is regarded by several anthropologists as an advanced subspecies of *Homo erectus*.
10. H.R. van Heekeren, 1970(?). The joint Indonesian-Dutch Sulawesi prehistoric expedition 1970. Unpublished report.
11. See report under note 10.
12. Extra-basinal (claystones or sandstones: brought into a basin from the outside) as opposed to intra-basinal (sediments that grew (bio)chemically in the waters of a basin); see e.g. G.M. Friedman & al., 1992.
13. Sartono mentions Berru Formation; Berru is the Buginese (local population) spelling of Beru.
14. In older literature or in Buginese spelling to be found as: Tjeleko, Sompo(h), Tjalio, Tjangkange and Lakiboong.
15. Patema also written as: Pattema.
16. In the caption of fig. 2 in this paper (Lutra), M^1 should be changed to M_1. Also, in fig. 4: M_3 should be M^3.
17. After the fossil locality of Sompo(h), now: Sompe.
18. According to Hooijer (1955) and Medway (1972), *Stegodon trigonocephalus* was a browser in shrubby or woodland vegetation.
19. The same holds true for a molar portion of a large stegodont from Padali, mentioned in Bartstra & Hooijer, 1992, picked up from eroding Beru member sediment.
20. Mentioned in: J. de Vos & R. van Zelst, Infusis (Intern informatieblad van het Nationaal Natuurhistorisch Museum te Leiden) 49, p. 5

21. Hooijer mentions: Salo Patjiro. The Buginese 'salo' means 'river', and Patjiro is nowadays written as: Paciro.

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