The Royal Academy for Overseas Sciences

Royal Museums of Art and History

The Belgian Science Policy Office

EASTER ISLAND: COLLAPSE OR TRANSFORMATION? A STATE OF THE ART

Guest Editors: N. Cauwe & M. De Dapper

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International Conference

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Welcome Address

by

Jacques CHARLIER*

This is a real pleasure in my capacity as president of the Royal Academy for Overseas Sciences to welcome you today. Let me introduce the three colleagues who will chair the various sessions of our meeting:

Dirk Huyge got his PhD from the *Katholieke Universiteit Leuven* of Belgium in 1995. He is the curator of the Prehistoric and Early Dynastic Egypt department at the Royal Museums of Art and History in Brussels. He has conducted archaeological fieldwork at the pharaonic site of Elkab in Upper Egypt and is also in charge of prehistoric rock-art surveys at el-Hosh and Qurta, also in Upper Egypt. From 2001 until 2006, he co-directed an excavation project on Easter Island, Chile (along with Nicolas Cauwe).

Nicolas Cauwe, holder of a PhD (archaeology specialization) from the University of Liege, is the curator of the Prehistory and Oceania collection at the Royal Museums of Art and History in Brussels. He is also a lecturer at the *Université catholique de Louvain.* Member of the Commission 14 (European Neolithic) of the International Union for Prehistoric and Protohistoric Sciences, he was recently elected member of the Royal Academy for Overseas Sciences. Throughout his career, he carried out many archaeological excavations in Belgium, Portugal, Syria, Siberia, Uzbekistan and Turkey. For twelve years, in collaboration with the *Universiteit Gent* and the Royal Belgian Institute of Natural Sciences, he has been conducting, together with Dirk Huyge, Morgan De Dapper and Johnny De Meulemeester (†), archaeological excavations on Easter Island. He is the author of more than a hundred and eighty scientific publications relating both to European and Asian prehistory and to Easter Island.

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Morgan De Dapper, member and past president of the Royal Academy for Overseas Sciences, is a professor of physical geography at the *Universiteit Gent*.

His main research interests include regional geomorphology and geo-archaeology of tropical and mediterranean regions. He did research in different countries in Africa, the Near East, Central and Southeast Asia and Latin America.

He is the vice-chairman of the Belgian Society for Geographical Studies, past president of the Belgian Association of Geomorphologists and honorary member of the National Committee for Geography and the National Committee for the Study of the Quaternary of the Belgian Royal Academy of Sciences.

He is a member of the Advisory Board of *BELGEO, the Belgian Geography Journal*, the interdisciplinary journal on tropical geography and ecology *Geo-Eco-Trop* and *Afrika Focus*, the open access journal of the GAP (*Gents Afrika Platform*).

He is currently the Secretary General of the IAG, the International Association of Geomorphologists, and honorary president of the IAG-Working Group on Geo-archaeology which he created in 1995.

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Introduction

by

Nicolas CAUWE* & Morgan DE DAPPER**

Easter Island... the model in the highest sense of the word of an ecological crisis and, as a consequence, of a cultural collapse. A godsend for popular press and tourist agencies fond of catastrophic scripts. More earnestly, this model has its roots in the 19th century testimonies, but also through modern scientific analyses. Maybe William Thomson, a paymaster of the US Navy, was the first to evoke abandonment of the quarries, interruption of *moai* transportation, large presence of 'obsidian spearheads', and finally intertribal warfare. If the first hypotheses (*e.g.* abandonment of the quarries) were documented by some observations, the conflicts were illustrated only by tales recorded with the natives.

Since then, very few critics have emerged. Most scholars seem to be in agreement with the desertion of the Rano Raraku and the Puna Pau quarries; nobody sees the lying statues along the paths other than as abandoned during transport; it seems clear that all obsidian tools were used as weapons! However, during the 1980s of last century, new documents were filed with the study of the deforestation processes of the island. Henceforth, this fact is a masterpiece of the Rapa Nui history, and denying this evidence would be incomprehensible. Nevertheless, the estimated consequences of the drastic transformation of the landscape, especially starvations, intertribal warfare, heritage destructions, demographic crisis... are not supported by any sound evidence, only by hypothetical deductive approaches.

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Some decades later, maybe the time has come for a critical study of the aftermath of deforestation, insomuch as additional multidisciplinary research, especially field investigations, has provided a lot of new data about monumental architecture, agricultural practices, biology of population, transportation of images, management of fresh water and so on, which allow to question the large and catastrophic collapse of Rapanui society. Between the extreme scenarios of stagnation and cultural crash, there are a lot of intermediate options.

'Collapse or transformation': the question can now be asked thanks to the maturity of recent research. About ten scholars from Germany, Great Britain, the Netherlands and Belgium were invited to present a state of the art of their research for this international conference organized in Brussels by the Royal Academy for Overseas Sciences, in collaboration with the Royal Museums of Art and History and the Belgian Federal Public Planning Service for Scientific Policy (Belspo). The lectures dealt with topics as different as land-use management, paleoclimatology, stress indicators on skeletons, fall of the *moai*, technological analysis of obsidian tools, rock art, single images along the old paths, ... A closing round table came to the final conclusion that, despite profound ecological changes, the Rapa Nui people adapted to the challenges of isolation in a marginal environment with remarkable resilience.

We would like to take advantage of this opportunity to thank those who allowed us to organize this international conference and to publish its proceedings: Jacques Charlier, President of the Royal Academy for Overseas Sciences in 2012, Danielle Swinne and Philippe Goyens, successive Permanent Secretaries of the Academy, the Direction of the Royal Museums of Art and History, and Philippe Mettens, President of the Federal Scientific Policy of Belgium. Thanks also to Patricia Bulanza and to Philippe Mol of the permanent staff of the Academy for their reliable and effective help both for the organization of the conference and the preparation of this volume. We are also grateful to our colleague Dirk Huyge, who skilfully moderated the round table.

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The Road of the Moai, an Interrupted Travelator?

by

Nicolas CAUWE* & Morgan DE DAPPER**
(with the collaboration of Cornelis STAL***)

The rain had evidently collected on the head [of the images] *and run down the back; it must therefore have stood for a considerable time in a vertical position. It was again a noticeable fact that, though some single figures are lying unbroken, others, like the large one on the north road, proved to be shattered that no amount of normal disintegration or shifting of soil could account for their condition – they had obviously fallen.*
Katherine ROUTLEDGE (1919: 195)

KEYWORDS. — Ancient Roads; Geomorphological and Archaeological Approach of Isolated Statues; Transportation of Images; Ceremonial Paths.

SUMMARY. — Recently a Belgian archaeological mission had the opportunity to re-examine some forty-six statues scattered along what is generally called the *camino de los moai*, ancient roads which are thought to have been used to transport the stone giants from the quarries. Many authors interpret this statues' scattering as a proof that only complete and finished *moai* were moved and that their transport was suddenly interrupted: the road of the *moai* as an interrupted travelator. Two circumstances make this idea unlikely. The first one is the good state of preservation of these statues: almost half of them are intact, despite their supposed fall. Others are broken, but the fragments remain contiguous to one another, meaning the breaks result from subsidence which occurred when the statues were lying down, not from the impact of their fall. The second element which argues against the fall of the statues is the presence of chocking stones, showing the horizontal position of these *moai* was premeditated, an intention which is confirmed by their excellent state of conservation. Furthermore, these *moai* scattered along the old roads are marked with deep

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and narrow runnels issuing from the differential erosion by rainwater following the sedimentary layering of the original tuff they were carved from. The orientation of these long runnels indicates these statues were placed vertically for several decades. Perhaps we should turn our perspective round and consider these roads not as leaving Rano Raraku, but as providing access to it. And then we find that all these statues, when still vertical, were turned to face people who were heading towards the famous volcano! In other words, these statues are like signs to anyone who wanted to approach the ancient quarries. This hypothesis accounts for all the facts: the unvarying orientation of the *moai*, the original vertical position betrayed by the runnels carved out by runoff of rainwater, the interest in installing them on all the roads which converge to the volcano, even those which were never used to transport a statue. Otherwise, we are sure, thanks to recent excavations, that during the 18th century and the first half of the next one the Islanders toppled carefully the *moai* from the *ahu*. Apparently, the single *moai* of the road have had the same fate.

1. Introduction

In 1919, Katherine Routledge published the first interpretation of the *moai* scattered in the landscape, laying far away from any architecture. Her hypothesis was twofold: she found that some of them probably had adorned the paths that could carry large statues to their final destination, while others seemed to her to have been abandoned during transport (ROUTLEDGE 1919: 194-196). This dichotomy held that she had conducted excavations at the vicinity of some statues. She found nothing around them, except for one partially buried in a pit (ROUTLEDGE 1919: 196). But, she had perceived the interest of the runnels carved by runoff of rainwater on the back of the statues (ROUTLEDGE 1919: 195). Then, she claimed that part of the images were upright for a long time; other statues were lying without any reason justifying their location, except abandonment during their transfer.

Afterwards, few studies have been devoted to this phenomenon of isolated statues. In the 1990s and 2000s, following the definitive recognition of a profound change of landscape on Easter Island, a catastrophic scenario has been suggested, talking about intertribal warfare, with struggles for survival, destruction of cult platforms and desertion of the quarries. In such a framework of collapse, single statues, lying on their belly or on their back, were interpreted as *moai* which transport was disrupted by consecutive hostilities due to the 'ecological crash' (BAHN & FLENLEY 1992, 2011; FLENLEY & BAHN 2002; DIAMOND 2005). More recently, a new research by Carl LIPO, Terry HUNT & Sergio RAPU HAOA (2012), based on the same principle of abandonment of the statues during transport, came to the conclusion that the *moai* could 'walk', which seems to solve the question of transport technique but not the history of these statues.

Anyway, it seems that it is time to produce a comprehensive analysis of these remains, for which neither inventory nor detailed study have been published yet. However, there are many questions. Are all these statues in the same archaeological and geomorphological conditions? Are they all carved from Rano Raraku tuff? What is the reality of the roads on which they are supposed to rest? Why did the Islanders move so many statues at the same time? Why did they abandon the majority of the *moai* only at the vicinity of the quarries and not all along the roads? Therefore, in 2010 and 2011, as part of the Belgian Expedition on Easter Island, a database was built to list all single statues still visible on Rapa Nui (see annex; research organized with the support and financing of the Federal Public Planning Service Science Policy (BELSPO), MO38/18 project). We found sixty-seven *moai*, but some statues could have been partially destroyed or removed over time and some others are now locked in private properties difficult to access. Anyhow, we can assume that the sample considered here is representative of the phenomenon: for example, Routledge recorded fifty-six isolated *moai* (ROUTLEDGE 1919: 194-199), Carl Lipo and his colleagues sixty-one (LIPO *et al.* 2012).

2. Historical Testimonies

Concerning these isolated images, the main historical data we have is the testimony of Wale, a lieutenant of Cook during his second travel around the globe (1772-1775):

> This side of the Island is full of those Colossean [*sic*] Statues which I have mentioned so often, some placed in Groups on platforms of Masonry others single and without any being fixed only in the Earth, and that not deep; these latter are in general much larger than the others. I measured one which was fallen down & found it very near 27 feet long & upwards of 8 feet over the breast, or shoulders and yet this appeared considerably short of this size of one which dined near: its shade at a little past 2 oClock being sufficient to shelter all our party, consisting of near 30 persons from the Rays of the sun (BEAGLEHOLE 1969: 825).

This quotation of Wale's report takes place during his account of a party on the southeast sector of the island. We cannot know what he exactly saw, but on this sector of Rapa Nui there are only images associated with cult platforms, *moai* erected on the south slopes of Rano Raraku (but these are buried inside deep pits and nobody at that time had never seen the quarries), and probably isolated *moai*. Wale's description of single *moai* corresponds to the images we can observe today of statues lying along the supposed

ancient paths. Indeed, they have more impressive dimensions than those associated with cult platforms. According to Wale, in the 18th century, a part of these *moai* were upright, as some images placed on *ahu*.

Anyway, no other explorer in the 18th or 19th centuries noted the presence of isolated statues or considered important to record this phenomenon. Only William Thomson gave a short mention of single *moai*:

> Scattered over the plains extending towards Vaihu are a large number of images, all lying face dounward. The indications are that they were being removed to their respective platforms when the work suddenly arrested. These heavy weights were evidently moved by main strength, but why they were dragged over ground face downward instead of upon their back, thus protecting their features, is a mystery yet unsolved. One statue in a group of three is that of a female; the face and breast is covered with lichen, which at a sort distance gives it the appearance of being whitewashed (THOMSON 1889: 496).

This testimony maybe is the starting point of the hypotheisis that all of the single *moai* scattered between Rano Raraku and Vaihu were abandoned during transport. But the most interesting detail of Thomson's account is that all of the isolated images were still lying down at te end of the 19th century. If we give some credibility to his report or to Wale's, only a part of single *moai* were still lying down at the end of the 18th century, but all of them fell down at the middle of the next one.

Katherine Routledge was the first to put forward such hypothesis, established by the observation of the importance of the runnels eroded by rainwater runoff on the statues since they were in vertical position (ROUTLEDGE 1919: 195). Thus, all of the historical testimonies do agree. In the 18th century, some *moai* were still upright in the southern plain of Easter Island, but some decades later, all of them were lying down. Routledge recorded also that the larger part of the images concerned were unbroken. Then, only some of them would have fallen by accident, natural process or violence... (ROUTLEDGE 1919: 195).

3. Archaeological Data

CATEGORIES OF SINGLE STATUES

The sixty-seven *moai* recorded during our surveys, can be categorized in six groups [1]*:

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* The number in brackets [ ] refers to the note, p. 34.

— The most important group (forty-six *moai*) concerns the statues lying along what is usually called the *camino de los moai* (road of images). Except four of them, all are carved in Rano Raraku tuff.
— Six *moai* are partially buried in front of two *ahu* (five at Ahu Hanga Poukura [M47 to M51] and one at Ahu Ura Uranga te Mahina [M52]). Their story seems different from that of the statues along the ancient roads.
— Two *moai* are very small (only 1 m high) with a strange round head and without facial details (M54 and M63). They form a special type unrelated to the images of the *ahu* and Rano Raraku.
— On the northern slope of Rano Kau, an outcrop of basalt is carved in the shape of a *moai*, but in unusual proportions and without comparison on the island (M53).
— One image (M55) is inside a small cave that opens on the eastern flank of Vai a Heva (Poike); this original archaeological context has no relationship with the problem of *moai* transport.
— Finally, eleven *moai* were probably moved at recent times (M56 to M67). Those of the Hotuiti Bay (M56 to M58) lie fragmented over a wide range of pebbles and probably their bad state is consecutive to natural phenomena, such as tidal waves. M59 is lying in front of Ahu Tongariki, a monument destroyed by a modern tsunami (1960) and recently restored. M60 is now re-erected near Ahu Tongariki after its use for an experimental moving of a *moai* by Pavel Pavel (PAVEL 1988, 1995). M61 lies in front of Ahu Runga Va'e, a platform recently consolidated by a retaining wall; the statue was moved during this work (Rapu, pers. comm.). M62 was re-erected in 2000 by some young Islanders (*Rapa Nui Journal*, **14** (4-2000): 120). The face of M64 lying near Ahu Riata (Hanga Piko) is 'repaired' with cement. M65 is re-erected on Hotu Matua Plaza at Hanga Roa (entrance of the *caleta*), while M66 and M67 are upright inside the garden of the Museum Sebastian Englert.

Only the first category — the *moai* scattered along the 'roads' — can support analysis. The recently moved statues can no longer be considered, while other categories form special cases. The forty-six *moai* concerned by our analysis (M01 to M46) are now lying, sometimes on their back (sixteen *moai*), sometimes on their face (thirty *moai*). This situation has long led to claim that the statues came from Rano Raraku (the volcano quarry) and were installed upright on wooden sledges. The unexpected break of their transportation or their 'abandonment' caused their fall on the ground, in one or other direction.

State of Conservation of the Forty-six Moai Scattered along the Paths

Lipo, Hunt and Rapu mentioned 37 % of broken *moai* along the old paths (Lipo *et al.* 2012). It is strange that they focused on this third of fragmented statues and not on the two thirds of intact ones. Nevertheless, they concluded from the presence of broken *moai* that all of the images scattered along the paths did fall while they were being moved. Actually, only two statues were probably broken before or during they were lying down back or being moved (M04 & M05); there are two small *moai* in red scoria abandoned along the 'North-Western road' of Routledge (1919: fig. 74), or at the end of the 'road B' of Lipo & Hunt (2005).

For the rest, twenty-eight statues are undamaged, while others (sixteen *moai*) are broken, but their fragments remained into connection. Lipo and Hunt did not make any difference between the two categories of broken *moai*, those maintained in connection and those with scattered fragments. However, the reasons of both situations cannot be the same. The only explanations for the non-dispersion of the fragments are a deliberate reconstruction of the statues after they were lying, or breaks occurred later on through a phenomenon of overhang or bending when the images were already lying, the tuff being not homogeneous and compact enough to withstand such pressures (figs. 1 & 2). The two circumstances may have existed. The biggest *moai* (M01) has its face partially fragmented, but the nose and other fragments were replaced in their original position, certainly before the Mana Expedition of Katherine Routledge (Routledge 1919: 195). We can observe the same process of face reconstruction on the M22 image. Moreover, inside the

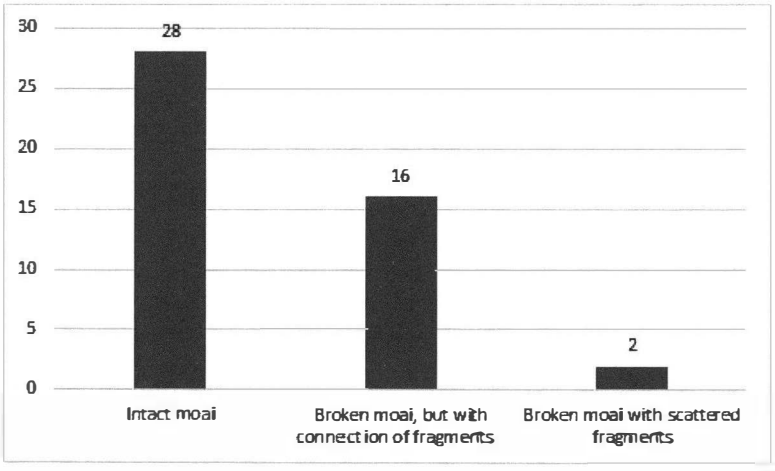


Fig. 1. — Intact or broken images along the ancient roads (total: forty-six items).

a b

Fig. 2. — More than half of the images lying along the roads are intact (a: M33), the rest is broken, but without dispersion of their fragments (b: M34). It is very difficult to explain these facts by violence or accident. It is more logical to accept these *moai* were toppled with care.

Fig. 3. — An example (M35) of a 'repaired' statue (small stones inside the break). The development of lichens inside the break and on the small stones prove the antiquity of this 'healing' of the *moai*.

breaks of nine *moai*, small blocks were deposited. This operation is far from new: slow-growing lichens form a continuous veneer on both sides of the fragments of the images and also on small stones put inside the breaks. Maybe the insertion of small stones can be considered as a symbolic repair or a 'healing' (fig. 3). But there are also *moai* undoubtedly broken by overhang (M22, M26, M31, M34, M37, M38 and M39), without rebuilding or repair (fig. 2). In this case, Routledge spoke about 'cleavage' and 'partial fall' (ROUTLEDGE 1919: fig. 76).

Pavements, Chocking Stones and Pits

Overall, very few statues supported an accidental lying position. If the *moai* along the roads were abandoned during their transportation, they had to be moved in horizontal position, sometimes on their belly, sometimes on their back. If this was not the case and if they were transported in vertical position, they were toppled with care, not through an unintentional process. Another hypothesis is that the images along the roads were not in a transport mode and were not abandoned. Considering this, it is significant that thirty of them (65 %) are maintained in horizontal position with the help of chocking stones, or are lying on stone pavements, which gives evidence for their intentional position (fig. 4).

a b

Fig. 4. — Images of the *camino de los moai* lying on stone pavements (left: M30; right: M12).

Furthermore, four other *moai* are partially buried inside small pits (fig. 6) and four of them cover a grave (fig. 5). Whatever the story of these statues was, these circumstances indicate that their current position is the result of voluntary acts, totally independent of a failed transport: stone pavements, burials or pits are not normal conditions for transportation of colossal statues. This last remark attests only that the last phase of the isolated images is unrelated with abandonment or deliberate destructions, not that these *moai* were not in move before.

Bevelled Eyes and Rock Art

The orientation of the glance of all *moai* along the roads is also interesting. Now they are lying on their back or their face. But if we re-erected all these statues, they would turn their back to the Rano Raraku, the quarry from which the raw material they are made with was extracted. This particularity was recorded by Routledge (1919). This favourite orientation cannot be due

Fig. 5. — *Moai* M31 covering a burial. We do not know if the grave is contemporaneous with the statue, but the latter is lying on a stone pavement on which were also buried one or two bodies. One can be sure the pavement is older than the burial and the lying position of the image.

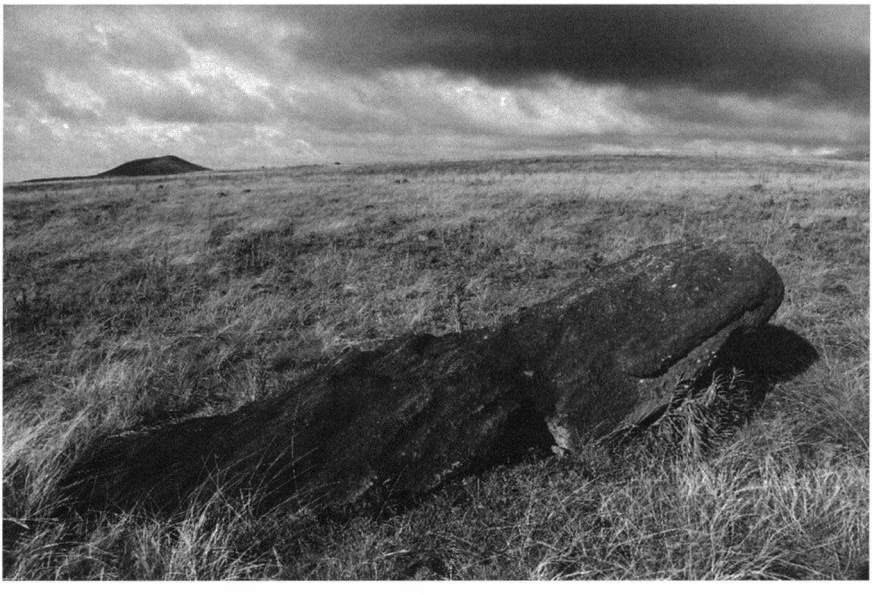
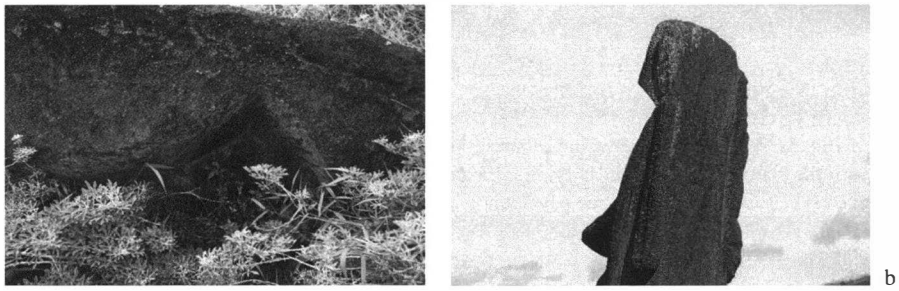


Fig. 6. — *Moai* M07 partially buried in a pit.

to pure chance. Some will argue that it is probably further evidence of the moving of upright statues, their face turned to their destination and their back turned to their starting point (LIPO *et al.* 2012). However, the other archaeological data lead us to reject this hypothesis (see below). But, it is very exciting to note that thirty-eight *moai* (83 %) have their eyes carved only by bevels — as the images of Rano Raraku —, not by sockets — as the statues of the *ahu*. The traditional hypothesis is that the bevels were carved after transport in order to inlay the eyes. However, except for a few recent images as those of Ahu Nau Nau, the *moai* of the *ahu* have eye sockets without any trace of primitive bevels! Moreover, a large part of the *moai* from Rano Raraku or those lying along the ancient roads have so deep bevels that it is no longer possible to carve eye sockets inside (fig. 7).



a b

Fig. 7. — *Moai* with bevelled eyes (a. M21, along an old road; b. A big statue on the southern slope of Rano Raraku). Often the bevels are too deep to carve eye sockets inside.

It seems that there are two categories of statues: the *moai* along the ancient roads and those erected on *ahu*, without possibility for a large part of the first type to support a transformation to the second one. The sizes of the two classes are also discordant, the *moai* from the roads are on average bigger and wider than those of the platforms (see below). Once more, it is not so easy to accept that statues along the paths were intended for some *ahu*. They are of another type, they are also lying on stone pavements or inside pits and have non-convertible bevelled eyes to receive inlaids.

Finally we have observed the presence of engravings on five *moai* along the roads. The *rei miro* is the main theme (three cases: M21, M25 and M46; fig. 8) and one of them has also on its left cheek the face of Makemake (M25; fig. 9). On two other *moai*, we can only see some engraved lines (M16 and M34). All of the figurative patterns were drawn after the lying-down of the statues concerned. In fact, one *rei miro* is engraved on the base of a *moai* (M46), all others are in place despite the lying position of the images.

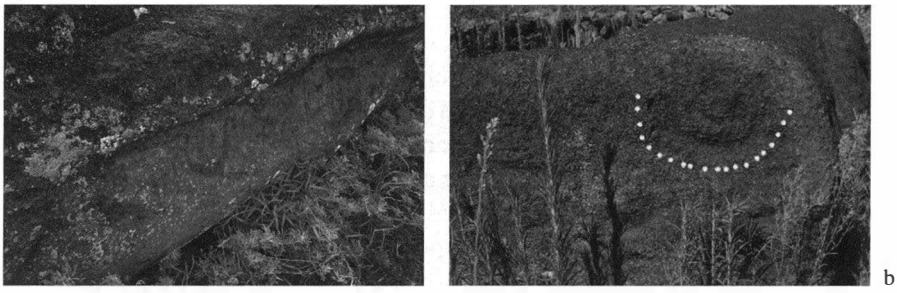
a  b

Fig. 8. — Engraved statues (a. M21 with a line of *rei miro* along its right arm; b. M46 with a *rei miro* on its base).

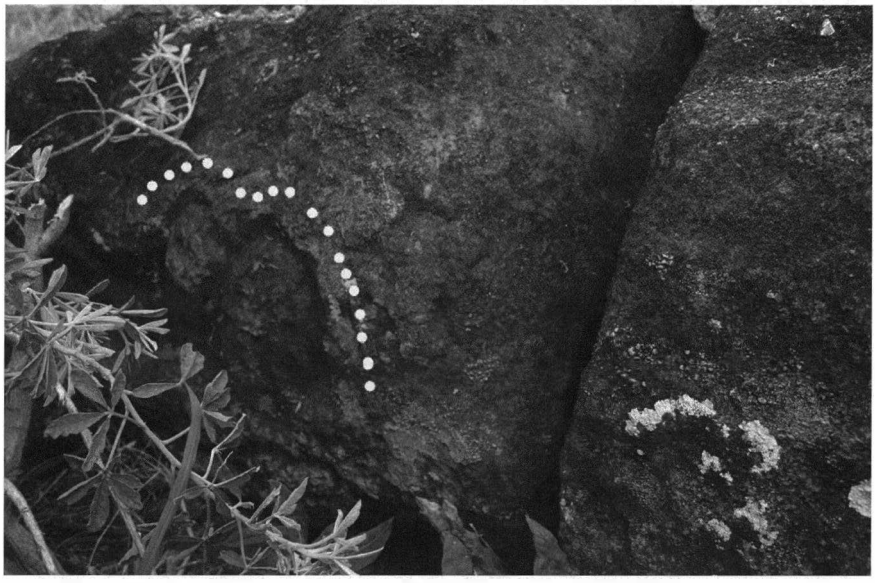


Fig. 9. — Head of M25, with the two eyes of Makemake carved on its left cheek.

In other words, some *moai* along the roads have supported a symbolic re-use after their installation in lying position.

3. A New Geomorphological Approach

This brief archaeological analysis of the statues along the *camino de los moai* shows that they had a more complicated story than a simple abandonment during their transport. However, a geomorphological approach allows to go further in the reconstruction of the role of these images.

GEOMORPHOLOGICAL PROCESSES ON THE STATUES

The vast majority of the statues studied are carved from the Rano Raraku palagonite tuff (GONZALES-FERRAN *et al.* 2004; fig. 10). This tuff, resulting from the interaction between water and basalt melt, can be considered as sedimentary rock, with a certain strike and dip, consisting of alternating more or less horizontally bedded coarser and finer pyroclastics. It stands to reason that such a sedimentary structure is prone to differential erosion by water runoff, the layers with finer clastics being more erodible than those with coarser ones. As a result, when exposed for a considerable time to rainfall, which was certainly the case on Easter Island, the originally smooth surface of the *moai* will be transformed into a rough one, marked by a distinct network of runnels, the pattern of which will depend on two variables: (1) the way the statue was cut from the tuff and (2) its position when attacked by rainfall.

The pattern of the sedimentary layer on the statues will depend on the spatial position of their structural axes (x,y,z, *cf.* annex) with regard to the ones (strike, dip) of the tuff. To assess this effect a simulation was done using

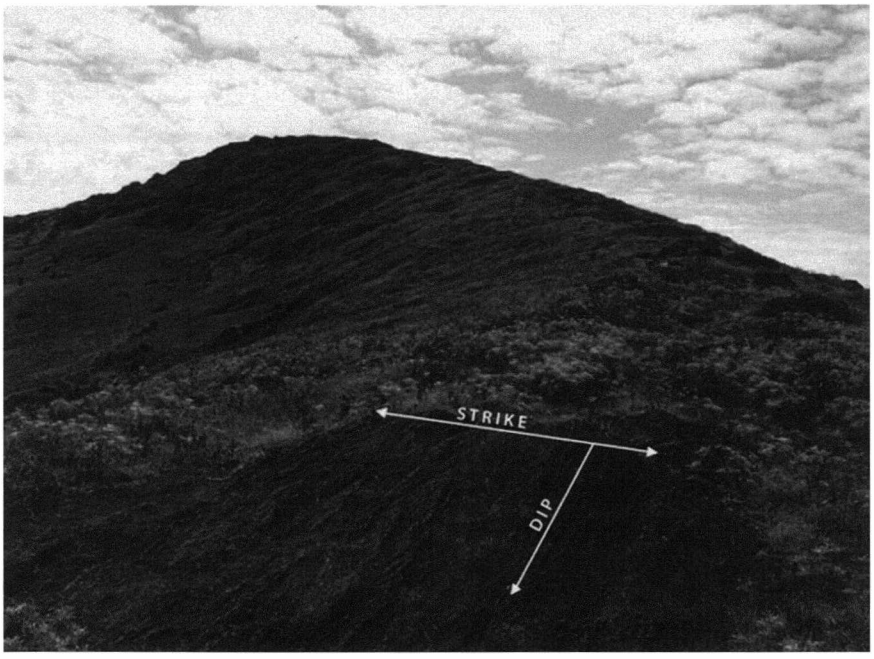


Fig. 10. — Exposure of palagonite tuff on the inner slope of Rano Raraku.

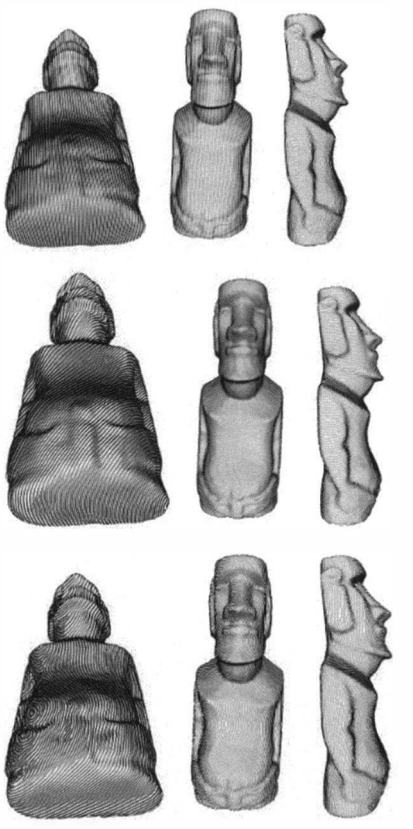
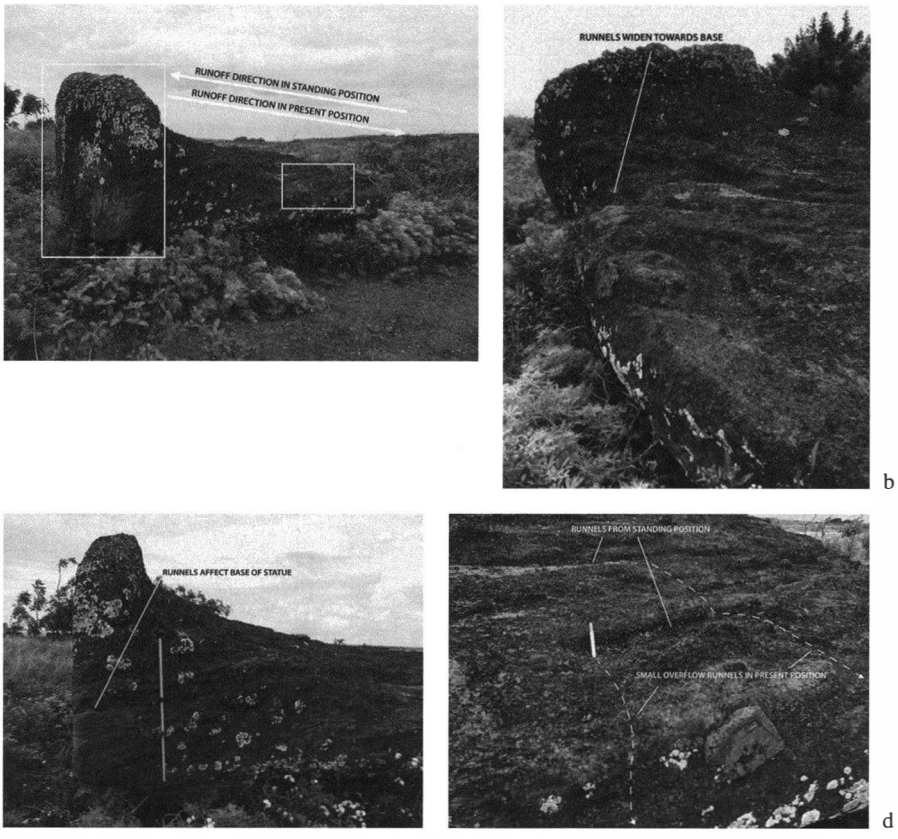


Fig. 11. — Statues with bedding planes of the tuff running more or less along the y-axis.

a digital 3D-model (*cf.* annex). It stands to reason that the morphology of the runnel network will also depend on the position of the statue — standing or lying, as it is at present day — when subjected to differential erosion by rainfall runoff. The effect of the latter will be strikingly different when, as a result of cutting, the bedding planes of the tuff run more or less along the y-axis, which is in most cases as such (fig. 11).

A few examples may illustrate the effect of the position: standing upright or lying down. In case of M20 (fig. 12a) the runoff direction is opposite whether in standing or present position. However, the major runnels widen consistently towards the base (fig. 12b) and even affect it (fig. 12c); moreover, a distinct network of small overflow runnels, superimposed on the major ones, are active at present (fig. 12d). Following conclusions can be drawn



a b c d

Fig. 12. — Geomorphologic study of the *moai* M20 (a. Runoff directions are opposite whether in standing or lying position; b. Runnels widen towards the base as a result of an upright position; c. Runnels affect the base of the statue which was not standing in a pit – the walking stick measures 1 m; d. Detail of area indicated on fig. 12a. Small overflow runnels, actively developing in the present lying position, are superimposed on a major runnel network developed in the former standing position – the pen measures 15 cm).

from this observation: (1) the statue was standing upright for a considerable time; (2) while standing the base was free; (3) the present lying position was much shorter than the upright one.

Similar to the first example, M22 has two opposite runoff directions depending on its position (fig. 13a); however, the runnels widen towards the base and the chin is affected by deep runnels (figs. 13b,c,d) which can only be explained if the water is running down from the top of the head of a standing statue.

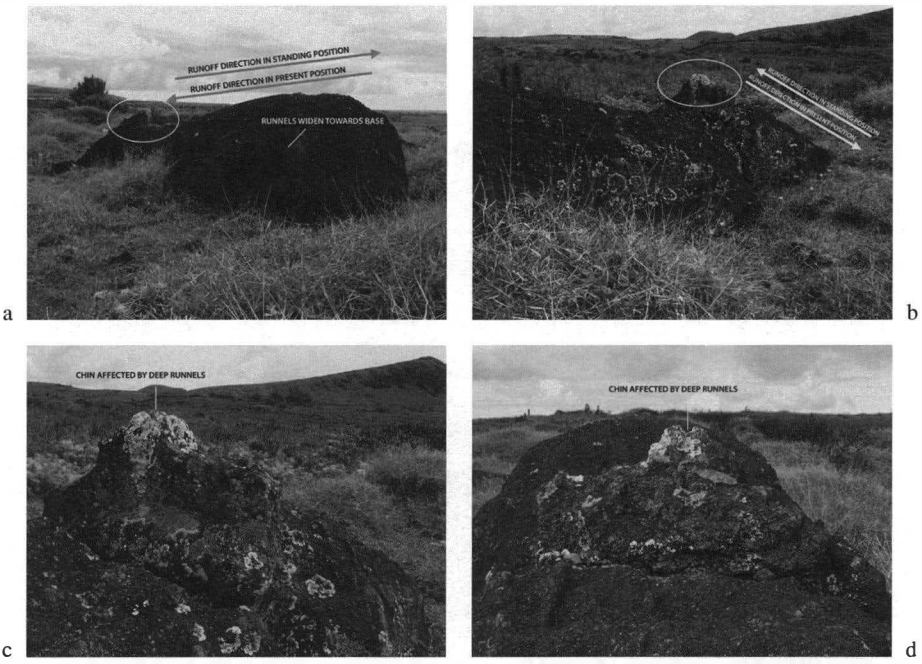


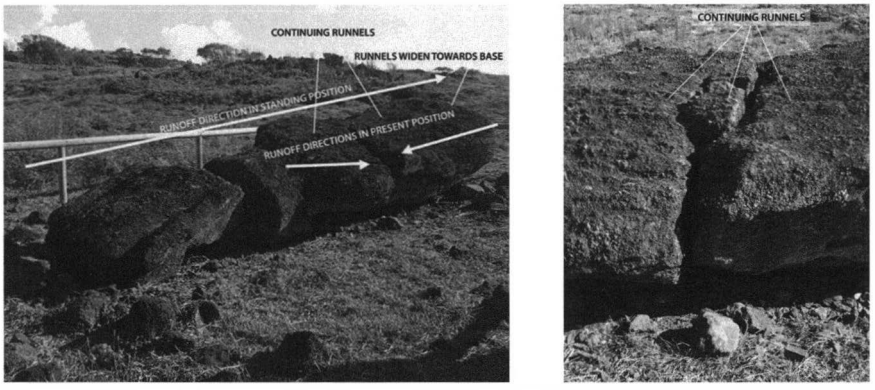
Fig. 13. — Geomorphologic study of the *moai* M22 (a. Runoff directions are opposite whether in standing or lying position, runnels widen to the base as a result of long upright position; b. The head has two opposite runoff directions whether in upright or present position; c.-d. Details of the head (seen respectively from the base and from the top of the head) indicated on figs. 13a, b. The chin is affected by deep runnels, a phenomenon which can only be explained if the statue is standing upright for a long time).

At present M31 lies broken in several large pieces (fig. 14a); as a result it has two runoff directions, one of which is opposite to the single one in standing position. On the back of the head the runnels widen in opposite direction of the present runoff and they continue, as if the statue were intact, on the lower back (figs. 14b,c). The fracture plane at the base of the head is only slightly affected by runoff (fig. 14c). Here again one can conclude the statue was standing upright for a considerable time. The relatively fresh fracture plane points to a relatively young event; most likely the head broke off at the moment the statue was laid down but it is also possible this happened later on (*cf. infra*).

M39 lies also broken in large pieces (fig. 15a); it is affected by long runnels which continue over the large and even smaller fragments (fig. 15b) and widen towards the base. Here again a long standing position is the most plausible explanation.

a b c

Fig. 14. — Geomorphologic study of the *moai* M31 (a. The *moai* lies broken in large fragments which have opposite runoff directions different from the unique runoff direction in upright position; b. Head fragment as seen from the top of the head. Runnels widen in opposite direction of the present-day runoff and continue along the fragments. Both phenomena are evidence for a long-standing position; c. Head fragment as seen from aside. The fracture plane is only slightly affected by runoff indicating a relatively recent fragmentation which happened when the statue was laid down. However, the segmentation could also happen some time after lay-down due to overhang or bending).



a b

Fig. 15. — Geomorphologic study of the *moai* M39 (a. The image is fragmented and has opposite runoff directions whether in standing or lying position. Runnels continuing over the fragments and widening towards the base are evidence for a long upright position; b. Detail of runnels continuing over connected large and smaller fragments).

Archaeological Consequences

Similar phenomena as the ones described in the few examples above are observed on all of the forty-six studied statues along the *camino de los moai* and lead to the conclusion that they stood upright for a considerably long time.

Six of them (M10, M11, M23, M33, M42 & M46) show runnels ending some centimetres above their base ensuing a narrow unaffected rim; this phenomenon is undoubtedly due to the fact they were erected in small pits. This conclusion is corroborated by the morphology of those *moai,* having a base which is narrower than the rest of the body. On the other hand, statues on which the runnels continue up to the end have very large bases allowing them to stand and remain upright without the support of a pit or another structure (see fig. 12).

On all isolated statues detailed observation of the runnel network allows to distinguish a secondary generation, actively developing in the present lying position, superimposed on a primary 'dead' generation resulting from the standing position (see fig. 12d). In case of broken statues the older generation of runnels continues over the fragments (see figs. 14, 15), corroborating the supposed original upright position. However, in some cases even the younger generation of runnels continues over the scars of the fragmentation. This observation has some archaeological consequences. The fragmentation of a lot of *moai* on Easter Island is commonly considered as a result of violence. During tribal wars, Islanders would have toppled images and destroyed several *ahu*. However, a large part of the statues' fragments are still in connection. Some time ago, we proposed an explanation of this strange situation: perhaps the segmentation occurred some time after the statues were laid down, not during the lay-down itself (Cauwe 2011; *cf.* fig. 14). In this case, the *moai* was surely intact after it was put in horizontal position, the cracking occurring later, because of overhang or bending. This hypothesis is demonstrated by the continuity on some isolated images of the secondary runnel network over the fragments, which is impossible if the *moai* were broken at the moment of their fall.

Other *moai* have the top of their head intact, without any major alteration by rainfall erosion. Once more, this phenomenon was only possible if the head had a protecting cover, such as a *pukao* for example. The case was observed at Ahu Matá Ketu, where a *moai* is lying on the ceremonial terrace of an *ahu*. At the back of the monument lies an isolated *pukao* which is most probably the headdress of the *moai*, whose top of head is not affected by weathering (fig. 16). It may be demonstrated that a careful and detailed geomorphological analysis of the *moai* adds considerable evidence to unveil their story.

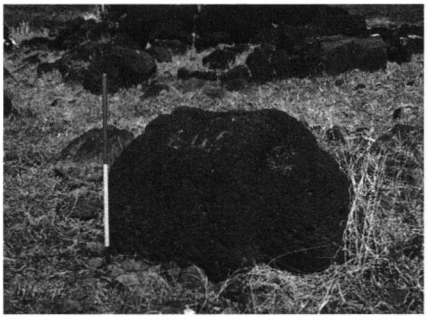
a   b

Fig. 16. — Ahu Matá Ketu (inland platform). A *moai* is now lying in front of a monument (a). Back of the *ahu* lies an isolated *pukao* (b). Maybe *moai* and *pukao* go together, the head of the statue having no damage due to weathering.

4. Some Strange *Ahu* near the Antique Roads

We have seen that there are two different classes of *moai*, characterized by bevelled eyes or glances indicated by sockets for inlays. Furthermore, the head of the majority of the statues scattered along the ancient roads (with bevels), as well as the complete ones left in or around Rano Raraku, is the third of the total body height; on the *ahu* (*moai* with eye sockets), it is about a quarter of the body. Finally, the width of the body of the *moai* from the *ahu* is regular; the road images have often a large base, adapted for an upright position without the support of any architecture.

But there are some exceptions: on the terrace of three cult platforms, *moai* are of road or Rano Raraku type, with big head, bevelled eyes, and large base. The most impressive site is inland, not so far from Lapérouse Bay (without number on Englert's map added by Mulloy [ENGLERT 1974]; probably no. 59 in Martinsson's inventory [MARTINSSON-WALLIN 1994]). The second one is also inland, not so far from Hanga Poukura (Ahu Matá Ketu; no. 230 on Englert's map; no. 140 in Martinsson's inventory). The last one is Ahu Oroi, close to the south coast (no. 199 on Englert's map; no. 116 in Martinsson's inventory). Confronted with these situations, the first hypothesis is that some *ahu* received statues of the road type, similar to the last productions of Rano Raraku. In this sense, these three inland platforms would be recent (last productions from the quarries), although the architecture of these monuments is also out of the ordinary.

Ahu Matá Ketu does not appear as an actual platform: we can only observe the back wall of a hypothetic podium, but no traces of a front wall, wings or

terrace (ramp). Moreover, the current position of the boulders of the back wall is precariously balanced on the foundations and a quick observation allows to understand that these blocks could never have been installed in a better stability (fig. 17). It is beyond doubt that never a so fragile and elementary building would have supported a big image of several tons. It can be argued that the podium was destroyed and that the statue is now lying in front of these ruins. However, we cannot understand the disappearance of the front wall after the statue's lay-down (the base of the lying *moai* would protect a part of them); moreover, it is impossible to imagine a destruction of the entire front wall before the toppling of the *moai*, which would collapse at the same time, but there are no elements of the front wall beneath the image (fig. 18). An incomplete *ahu*, an abnormal type of statue..., maybe Ahu Matá Ketu is a sham! Furthermore, the lying *moai* covers a grave. This is not exceptional, elsewhere around the island, there are also tombs below some toppled *moai* of several real *ahu*: for example, Ahu te Niu (fig. 19; CAUWE 2011: 71-72), Ahu Vinapu I (Tahira, fig. 20; MULLOY 1961: 95-115), Ahu Hanga Poukura (fig. 21), or Ahu te Peu (SMITH 1961: 189-194). Did the Islanders of Matá Ketu need such a situation for some of their dead? In the absence of any *ahu*, they would have built a small monument evoking a platform transformed into a cemetery. Then they would have taken advantage of an isolated statue along a road ('Southern image road' of ROUTLEDGE [1919]; 'road E' of HUNT & LIPO [2005]).

A similar situation occurred for an *ahu* at the vicinity of Lapérouse Bay. Above the cairn which covers the ramp of the monument, the Islanders dug two burial pits covered by a pair of *moai* of the road type. Once again, the two images seem too big for the platform, and there are no traces of pedestal for them. Moreover, their position is abnormal on the top of the cairn, not inside or beneath it (fig. 22). If these images came from the *ahu*, the Rapanui moved them a first time, then they built the cairn, finally they moved again the *moai* to put them above the cairn. This hypothesis is very complicated; a simpler one (Ockham's razor!) is to accept that the Rapanui recovered two *moai* along an ancient road (the monument is near the 'Northern image road' of Routledge, the 'road A' of Hunt & Lipo) and used them as a roof for two burial vaults dug through the ramp of the old platform.

The last case, Ahu Oroi, is along the 'Southern Image Road' of Routledge ('road E' of Hunt & Lipo). In fact, this monument is a natural outcrop of basalt with some partial walls above them. It is an opportunistic monument, allowing some doubts about its operating way, with a real podium for big erected images (fig. 23). Once more, the *moai* with bevelled eyes cover some burial vaults.

Fig. 17. — Back wall of Ahu Matá Ketu.

Fig. 18. — Ahu Matá Ketu from the south.

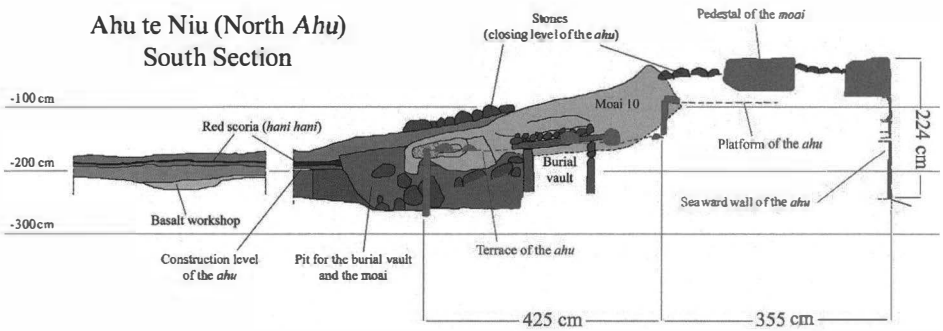


Fig. 19. — North section of Ahu te Niu (excavations by the Royal Museums of Art and History, Brussels, Belgium). A *moai* lying in front of its *ahu*, above a burial vault.

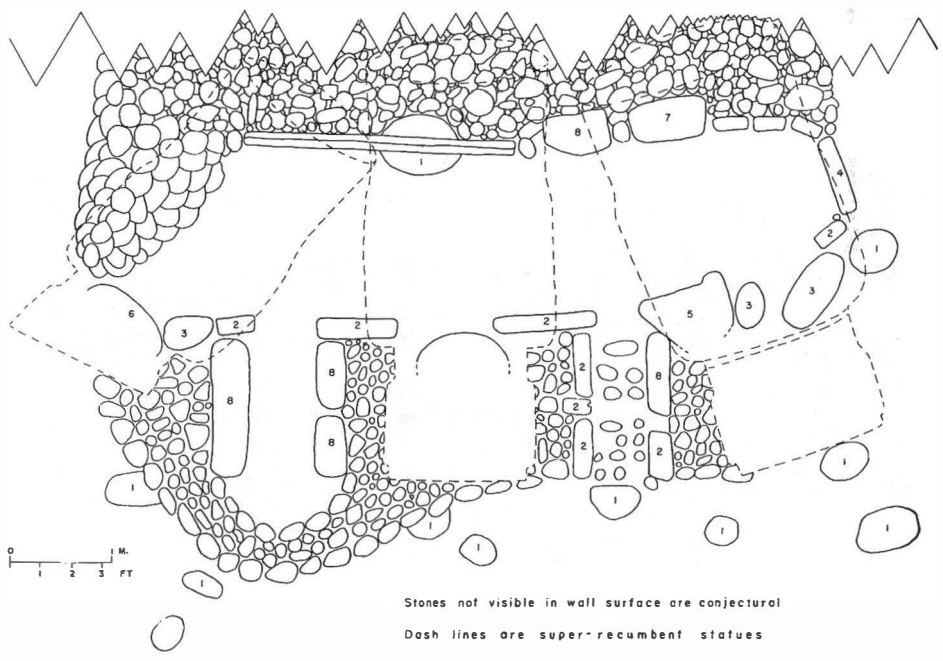


Fig. 20. — Ahu Tahira (Ahu Vinapu I). Sketch plan of a burial vault with two entrances, built on the ramp of the *ahu* and covered by three *moai* (after MULLOY 1961: fig. 18).

Fig. 21. — Burial vault built through the ramp of Ahu Hanga Poukura. A *moai* covers the tomb, its forehead incorporated into the wall of the burial vault.

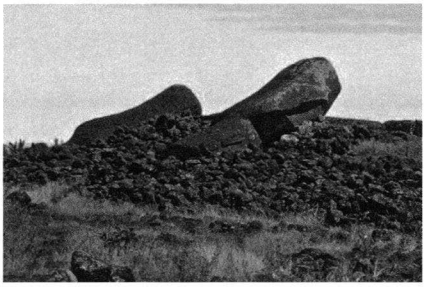
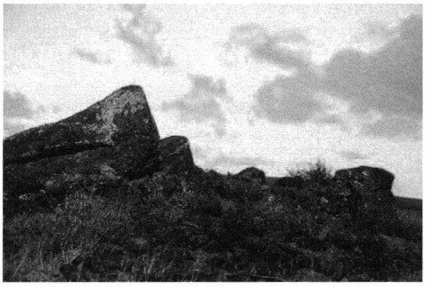
a   b

Fig. 22. — Inland *ahu* near Lapérouse Bay. Two big *moai* are lying on the top of the closing cairn (a), covering two graves. Despite the big size of the statues (b), no trace of pedestal was found on this monuments. Actually, the association between platform and images is perhaps recent, only with the intention of closing the two tombs dug through the ramp of the *ahu*.

Altogether, *moai* with big head and bevelled eyes without sockets only occur isolated along the old roads, around Rano Raraku quarries or associated with abnormal *ahu*. In the latter case, they systematically cover graves and we can prove that they never were erected on the platforms. Therefore, the shape of the *moai* seems to indicate specific roles.

Fig. 23. — Ahu Oroi (near the southern coast). This *ahu* is a natural outcrop of basalt, with small walls. All *moai* of this monument have bevelled eyes.

5. Discussion

The new geo-archaeological approach of the *moai* scattered along the roads leads to several observations, which must be considered before any interpretation:

— All these statues were upright for a long time (several decades minimum). This fact is evidenced by the formation of a first network of runnels produced by rainwater runoff. Therefore, these *moai* never fell down by accident during their transportation.

— The analysis of the base of these *moai* indicates that they were carved for an upright position: a majority have a large base, sufficient to keep them in vertical position on the ground without help of any architecture; on the others, with a smaller base, the runnels stop systematically some centimetres above it, indicating they were partially buried in a pit.

— Subsequently, these *moai* were laid down with care. In fact, 93 % of them are intact or broken but without scattering of their fragments. From that moment, a secondary network of runnels, adapted to the new horizontal position, started to form and is still active.

— The lay-down of the statues was premeditated: 62 % of them are lying with the help of chocking stones or on pavements, even on older structures.

Some indications exist about the chronology of these events. The *moai* along the roads belong to the same type of the ones erected around or inside Rano Raraku. Therefore, we are sure that the statues set up on the slopes of Rano Raraku are recent. In fact, they close access to the volcano and the quarries and one of them has on its stomach an engraving of a ship from the 18th century. The engraving could be more recent than the *moai* itself, but when the drawing was discovered by the Norwegian expedition (1955), it was on a fresh statue, without any alteration by weathering. Henceforth, the statue and the drawing belong to the same period. Anyway, at the end of the 18th century, Wale saw *moai* erected in the south-eastern sector of the island, but at the middle of the next century, no statue was still upright on the island. Therefore, *moai* were erected along the roads before the end of the use of quarries (middle of the 17th century?). Some decades later (before the end of the 18th century and Wale's visit), Islanders started to topple them, an operation finished no later than the middle of the 19th century.

Taking all these facts and their chronological framework into account, it is difficult to accept a simple story of abandonment along some roads during transportation. An abandonment is not possible because the form of these *moai* is adapted to an upright position or to a partial burial inside pits. Accident or violence also must be rejected by the good state of conservation of the statues and by the premeditation of their lay-down. This last argument is corroborated by the development of the first network of runnels: undoubtedly the images were upright a long time before their lay-down.

Concerning the shape adapted for an upright position, Lipo, Hunt and Rapu recently proposed that it was to organize the moving of the *moai* (a large base would be adapted for 'walking statues'); when the images were in place in front of an *ahu*, Islanders re-carved their base and sculpted the eye sockets (Lipo *et al.* 2013). This hypothesis neglects two facts. First, the size of roads' *moai* is different from those of the platforms, not only at the base level, but also concerning the proportions of the head and the height (more than 5 m for the single *moai*; between 3 et 5 m for the majority of the images associated with an *ahu*). If the statues along the roads were intended for an *ahu*, then it was necessary not only to re-carve the base and the eyes as proposed by these scholars, but also the whole body. Moreover, why did the Islanders move so many big statues unadjusted for cult platforms? If the hypothesis of Lipo, Hunt and Rapu is right, it means that at recent times the

Rapanui people have changed their conception of an ideal *ahu* with a new type of *moai*. Therefore, the Islanders would have carved tens of statues, started to transport these big images, but without any building platforms for them: nowhere on the Island, new *ahu* waiting for this kind of *moai* are to be found!

Leaving the hypothesis of *moai* abandoned during their transportation, allows a more meaningful interpretation. Shape and first network of rainwater runnels lead to accept a voluntary erection of *moai* along the roads for a long time. Moreover, reminding that ROUTLEDGE (1919: 195-196) excavated in 1914 a single statue partially buried in a pit, it is possible to see along the old paths three other isolated *moai* in such a situation (M07, M13 and M32). Otherwise, some years ago, we excavated similar statues on the western slope of Maunga Terevaka (fig. 24; CAUWE 2011 : 37-38). Thus, it seems that single *moai* had a particular function along the roads. If we take the chronological indications into account, the erection of single statues is probably contemporaneous with the carving of the last *moai* on the slopes of Rano Raraku. Consequently, at the end of the 17th century and/or at the beginning of the next one, the Rapanui people closed the Rano Raraku quarries with a lot of big statues erected in deep pits (VAN TILBURG 2010, 2011; LOVE 2010: 83; CAUWE 2011). They also closed the workshops by carving unfinishable figures (CAUWE 2012). At the same time, they erected single statues along the roads, especially at the vicinity of Rano Raraku (ROUTLEDGE 1919: 195; see also the map in annex 1): twenty-nine isolated *moai* (63 %) are lying less than 5 km from the Rano Raraku. Maybe the isolated *moai* were part of the closing procedure of the volcano: their glance turned to someone who would like to go to the famous volcano. In this scenario of forbidding to go to the volcano quarries one can understand why some of them are not found along large roads used for the transportation of *moai*, but along small paths coming from inland and never used for transportation.

Moreover, the lay-down of single images is more recent, as indicated by the development of runnels, and according to the 18th century testimonies. Therefore, two periods have to be considered: one for the erection of single statues along the road (end of the 17th century and/or beginning of the next one); a second one for their lay-down (from the middle of the 18th century). However, we are sure, thanks to the first explorers' tales, that during the 18th century and the first half of the next one, the Islanders closed the cult platforms, re-used them as a necropolis, and toppled the *moai* from the *ahu* (fig. 25; CAUWE 2011). Apparently, the single road *moai* have had the same fate, although some of them also had to protect burials as shown by several lying *moai* from *ahu*. The only statues still upright are the big ones buried inside deep pits on the inner and outer slopes of Rano Raraku.

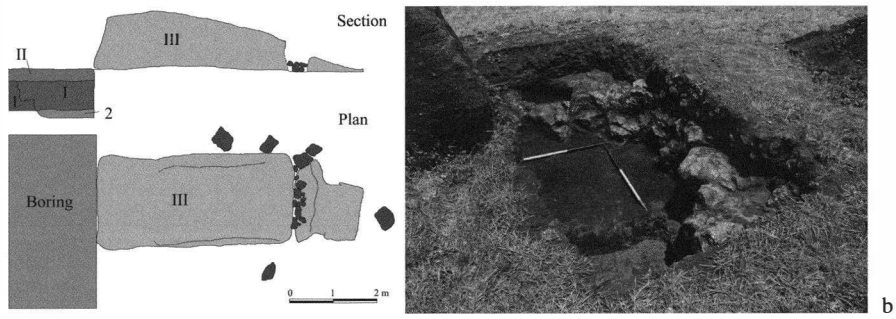


Fig. 24. — *Moai* M42. A small boring was made in front of the base of this image (excavation by the Royal Museums of Art and History, Brussels, Belgium). A pit for the erection of the statue was found (1. Bedrock; 2. Natural layer of saproliths; I. Pit; II. Anthropic level of small stones (chocking stones); III. Lying *moai*).

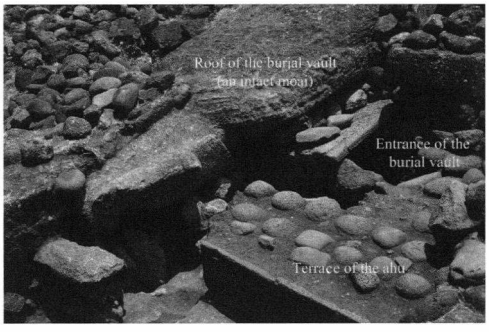


Fig. 25. — Ahu te Niu (western coast), excavation by the Royal Museums of Art and History, Brussels, Belgium. Through the terrace (ramp) of the *ahu*, a big burial vault was built and a *moai* was used as a roof for this grave.

NOTE

[1] All the isolated *moai* are named in this paper by their number in the database presented in annex 1.

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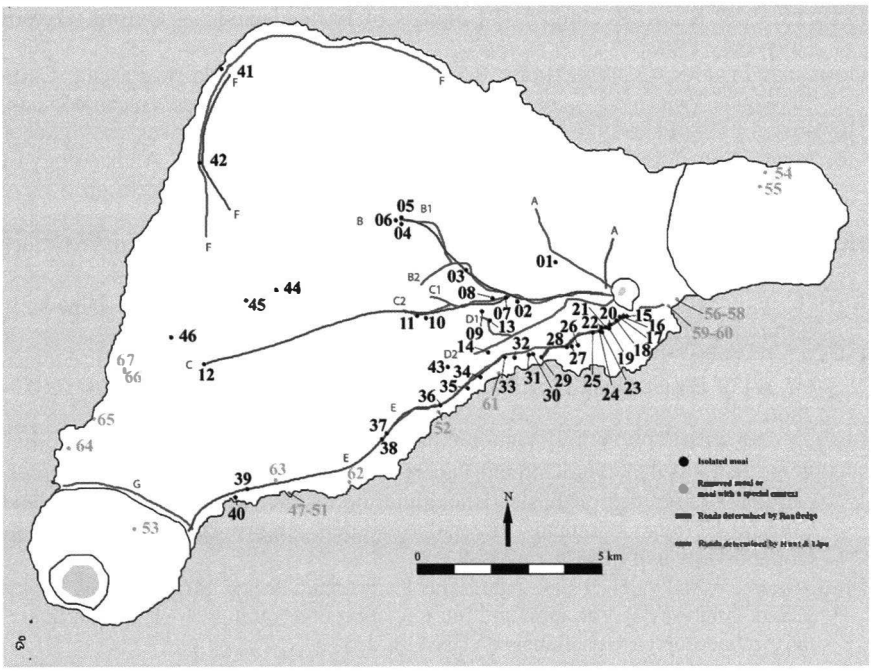
ANNEX 1

Summary inventory of the single *moai* of Easter Island



Isolated *moai* are presented as follows:

Picture	**N. of the *moai* (MXX)** Context Location (Map datum: WGS 84; coordinates: UTM, grid 12J)

Geomorphological observations
- ☐ Runoff runnels
- ☐ Secondary network of runnels
- ☐ Ancient upright position
- ☐ Ancien erection pit

Archaeological observations
- ☐ Raraku tuff ☐ Red scoria
- ☐ Complete
- ☐ Intact ☐ Broken
- ☐ Broken but in connection
- ☐ On back ☐ On belly
- ☐ Structure beneath the *moai*
- ☐ Bevelled eyes ☐ Eye sockets

Remarks:

M01
Road A
X 0667913; Y 6999868

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: small stones in breaks; reconstruction of the face.

M02
Road B
X 0666746; Y 6998868

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:

M03
Road B
X 0665438; Y 6999698

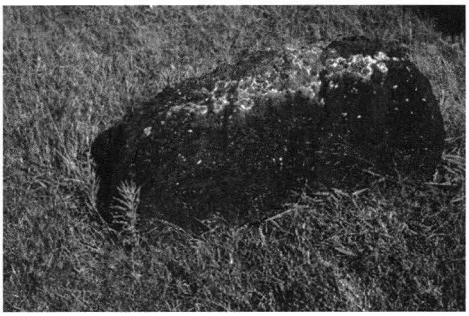
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: ablation of the ears.

M04
Road B
X 0663834; Y 7001103

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☐ Raraku tuff ☑ Red scoria
☐ Complete
☐ Intact ☑ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: headless body.



M05
Road B
X 0663834; Y 7001103

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☐ Raraku tuff ☑ Red scoria
☐ Complete
☐ Intact ☑ Broken
☐ Broken but in connection
☑ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: headless body.

M06
Road B
X 0663834; Y 7001103

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☐ Raraku tuff ☑ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks: no ears.

M07
Road C
X 0666516; Y 6998867

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: partially buried in a pit.

M08
Road C
X 0666578; Y 6998921

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: ablation of the ears.

M09
Road C
X 0665925; Y 6998699

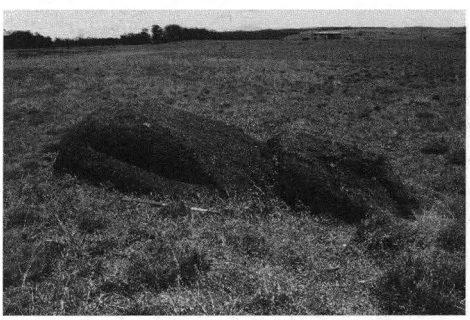
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☑ Eye sockets
Remarks:

M10
Road C
X 0664350; Y 6998416

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☑ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:



M11
Road C
X 0664203; Y 6998436

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☑ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☑ On back ☐ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: ablation of the ears.

M12
Road C
X 0658408; Y 6997422

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: ablation of the ears; engravings (*rei miro* & modern script).

M13
Road D
X 0666060; Y 6998308

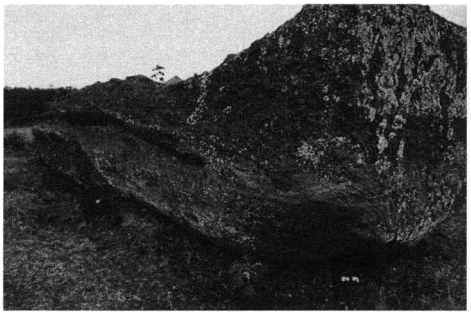
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: partially buried in a pit.

M14
Road D
X 0665876; Y 6997454

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

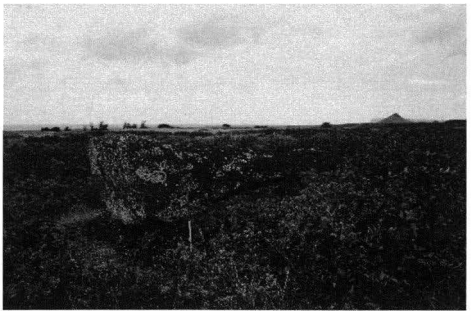
Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☑ On back ☐ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:



M15
Road E
X 0669442; Y 6998237

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:



M16
Road E
X 0669394; Y 6998179

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: engravings (lines).

M17
Road E
X 0669385; Y 6998173

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:

M18
Road E
X 0669337; Y 6998136

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:

M19
Road E
X 0669142; Y 6998018

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:

M20
Road E
X 0669139; Y 6998022

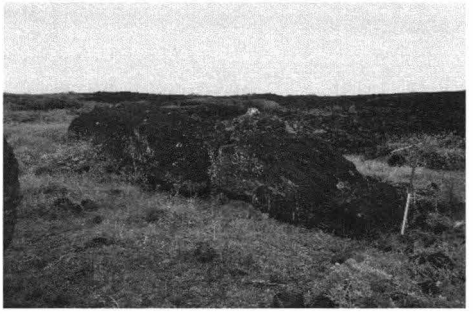
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:

M21
Road E
X 0669152; Y 6998019

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: engravings (*rei miro*).



M22
Road E
X 0669040; Y 6997980

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: reconstruction of the face.

M23
Road E
X 0669046; Y 6997976

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☑ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: no ears.

M24
Road E
X 0669038; Y 6997974

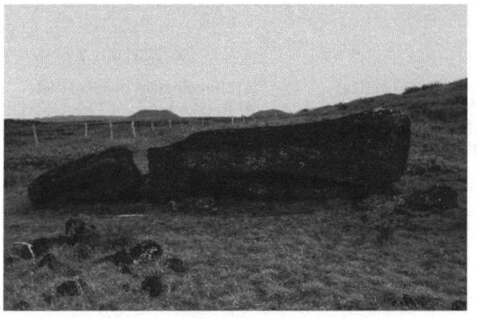
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: small stones in breaks.

M25
Road E
X 0668836; Y 6997863

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: small stones in breaks; engravings (*rei miro* & Makemake).



M26
Road E
X 0668344; Y 6997593

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:

M27
Road E
X 0668164; Y 6997564

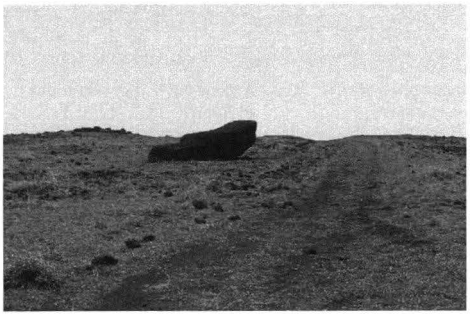
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: small stones in breaks.

M28
Road E
X 0668052; Y 6997484

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:



M29
Road E (*Moai Nonga Nonga*)
X 0667414; Y 6997264

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:

M30
Road E
X 0667190; Y 6997496

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:

M31
Road E
X 0667176; Y 6997495

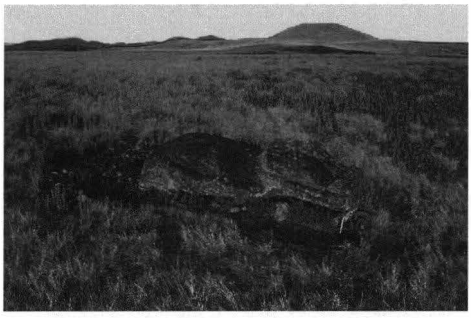
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: burial below the *moai*.

M32
Road E
X 0666629; Y 6997325

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks: partially buried in a pit; no ears.



M33
Road E
X 0666373; Y 6997320

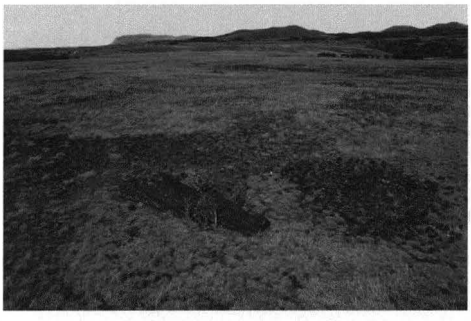
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☑ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: probably a burial below the *moai*.

M34
Road E
X 0665741; Y 6996870

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: small stones in breaks; engravings (lines).



M35
Road E
X 0665352; Y 6996582

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: small stones in breaks; ablation of the ears.

M36
Road E
X 0664762; Y 6996032

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: ablation of the ears.

M37
Road E
X 0663460; Y 6995638

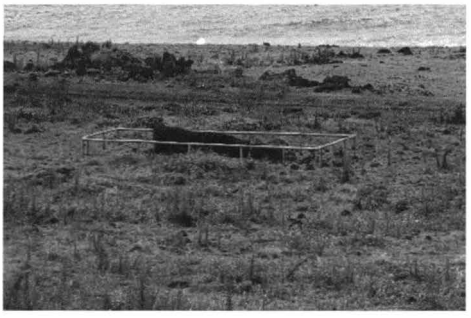
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: small stones in breaks.

M38
Road E
X 0663161; Y 6995535

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:



M39
Road E
X 0659502; Y 6994117

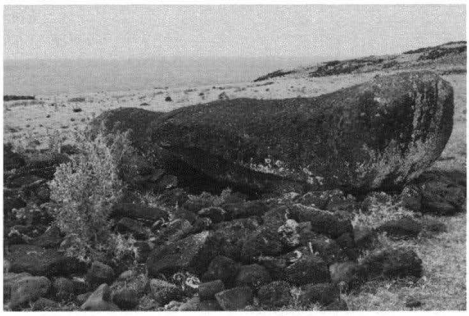
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: small stones in breaks.

M40
Road E (*Moai a Umo*)
X 0659008; Y 6993997

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit
Remarks: probably removed statue at recent times.

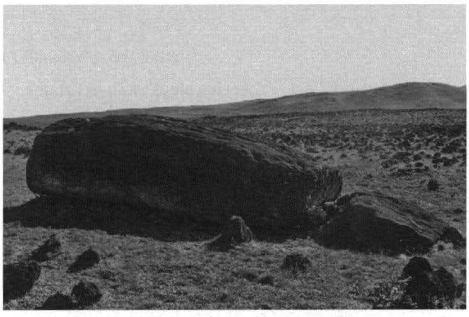
Archaeological observations
☐ Raraku tuff ☑ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks:



M41
Road F (in front of *Ahu Vai Mata*)
X 0659293; Y 7005224

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: above a burial vault.



M42
Road F (near *Ahu te Niu*)
X 0658664; Y 7002777

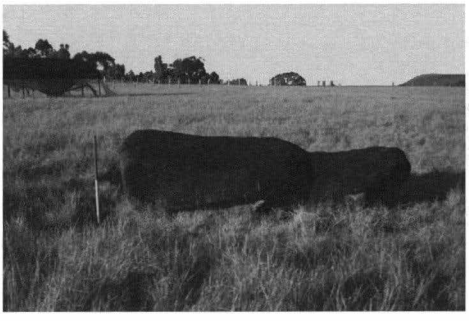
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☑ Ancien erection pit
Remarks: erection pit also observed by excavations.

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: small stones in breaks.

M43
Out of known road
X 0664936; Y 6997522

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

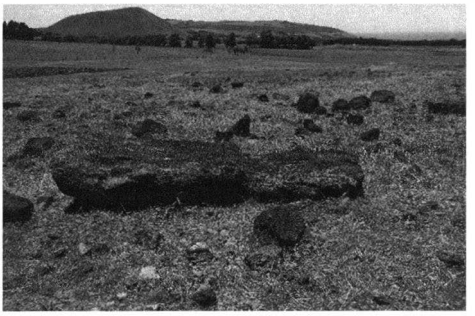
Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks: above a grave.



M44
Out of known road (*Moai Mata Kio'e*)
X 0660442; Y 6999349

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: ablation of the ears.



M45
Out of known road
X 0659527; Y 6999070

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: ablation of the ears.

M46
Out of known road
X 0657657; Y 6998173

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☑ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: ablation of ears; engravings (*rei miro*).

M47
In front of *Ahu Hanga Poukura*
X 0660512; Y 6994021

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: buried in a pit.

M48
In front of *Ahu Hanga Poukura*
X 0660510; Y 6994028

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: buried in a pit.

M49
In front of *Ahu Hanga Poukura*
X 0660465; Y 6994054

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: buried in a pit.

M50
In front of *Ahu Hanga Poukura*
X 0660459; Y 6994062

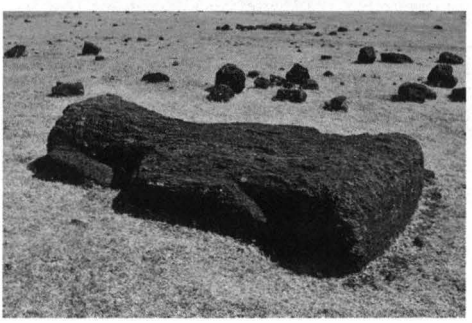
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: buried in a pit.

M51
Buried in front of *Ahu Hanga Poukura*
X 0660454; Y 6994075

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☐ Complete
☐ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks: buried in a pit; headless body.



M52
In front of *Ahu Ura Uranga te Mahina*
X 0664550; Y 6995877

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: buried in a pit.

M53
Rano Kau
X 0656392; Y 6993220

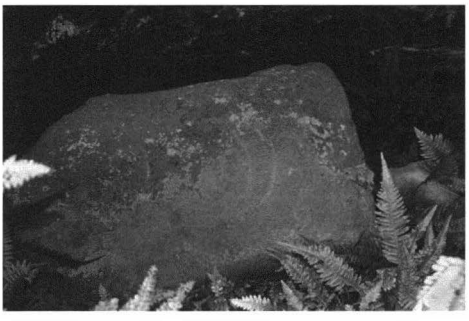
Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☐ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☑ On back ☐ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: carved bedrock (basalt).

M54
On top of Parehe hill (*Poike*)
X 0673461; Y 7001869

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☐ Complete
☐ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks:



M55
Inside a cave at *Vai a Heva (Poike)*
X 0673308; Y 7001431

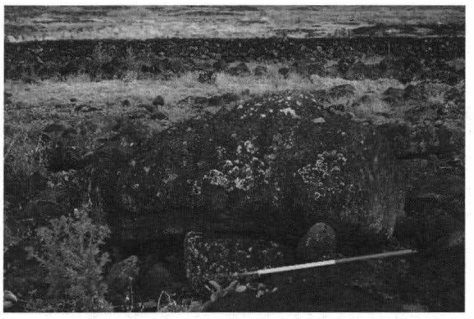
Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☑ Eye sockets
Remarks: engravings (*rei miro*); ablation of the ears.

M56
Removed (*Hanga Hotuiti*)
X 0671159; Y 6998709

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☑ Broken
☐ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☑ Eye sockets
Remarks: ablation of the ears.



M57
Removed (*Hanga Hotuiti*)
X 0671159; Y 6998709

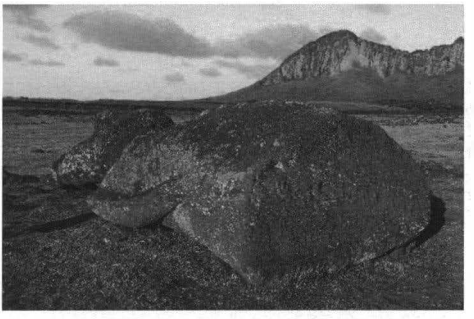
Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☑ Broken
☐ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☑ Eye sockets
Remarks: ablation of the ears.

M58
Removed (*Hanga Hotuiti*)
X 0671159; Y 6998709

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☐ Complete
☐ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks:



M59
Removed (in front of *Ahu Tongariki*)
X 0670687; Y 6998504

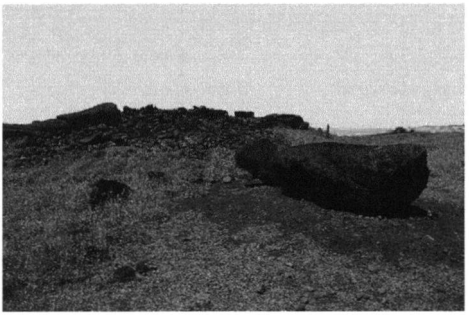
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☑ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks:

M60
Removed (on west side of *Ahu Tongariki*)
X 0670670; Y 6998358

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks: ablation of the ears; engravings (lines).



M61
Removed (in front of *Ahu Runga Va'e*)
X 0666625; Y 6996930

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☑ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks:

M62
Removed (near *Hanga Te'e*)
X 0662119; Y 6994273

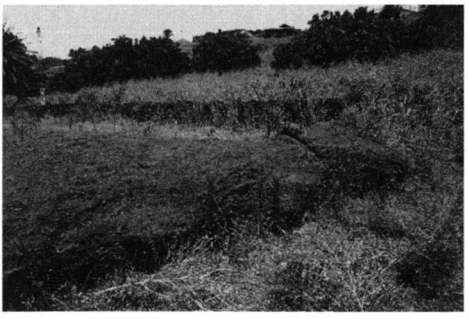
Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks:

M63
Removed (near *Hanga Poukura*)
X 0660320; Y 6994149

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

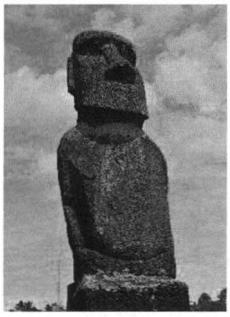
Archaeological observations
☑ Raraku tuff ☐ Red scoria
☐ Complete
☐ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☐ Eye sockets
Remarks:



M64
Removed (*Hanga Piko*)
X 0654697; Y 6995410

Geomorphological observations
☑ Runoff runnels
☑ Secondary network of runnels
☑ Ancient upright position
☑ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☐ Intact ☐ Broken
☑ Broken but in connection
☑ On back ☐ On belly
☐ Structure beneath the *moai*
☑ Bevelled eyes ☐ Eye sockets
Remarks: ablation of the ears.



M65
Removed (*Hotu Matua Plaza, Hanga Roa*)
X 0655546; Y 6996320

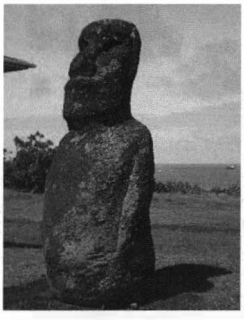
Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks:

M66
Removed (garden of the museum)
X 0656135; Y 6997328

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☐ Raraku tuff ☑ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks:



M67
Removed (garden of the museum)
X 0656136; Y 6997362

Geomorphological observations
☐ Runoff runnels
☐ Secondary network of runnels
☐ Ancient upright position
☐ Ancien erection pit

Archaeological observations
☑ Raraku tuff ☐ Red scoria
☑ Complete
☑ Intact ☐ Broken
☐ Broken but in connection
☐ On back ☐ On belly
☐ Structure beneath the *moai*
☐ Bevelled eyes ☑ Eye sockets
Remarks:

ANNEX 2

3D-modelling

The virtual reconstruction is based on a large series of photographs of a small replica of a typical statue along the *camino de los moai* (fig. 1). These images are taken circularly around the object and processed using 'Structure from Motion (SfM)' and 'MultiView Stereo (MVS)' software. SfM-MVS is a computer vision technique and enables the construction of 3D models based on a large series of images. SfM-MVS is a technique to reconstruct the camera acquisition parameters and to calculate a sparse point set of the scene (SfM). Moreover, it is a technique to acquire the 3D geometry of an object, or a series of objects (MVS), using a series of 2D images. The acquired geometry is triangulated and a texture map is projected on the resulting mesh, allowing an accurate and photorealistic representation of the modelled object which can be rotated around three axes (fig. 2). By giving the modelled statue different positions in relation to strike and dip of a digital model of a horizontally layered sedimentary rock one can simulate the resulting pattern of differential erosion (figs. 3-7).

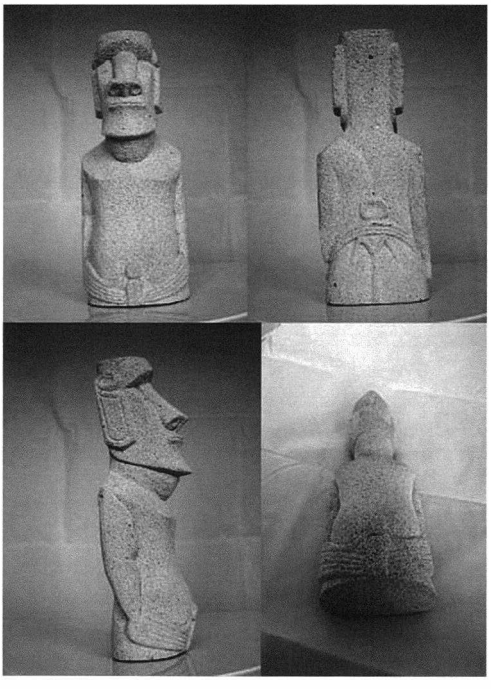


Fig. 1. — Small replica of a typical statue along the *camino de los moai*.

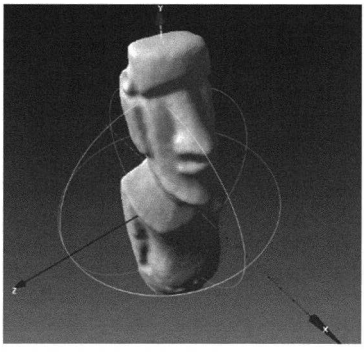


Fig. 2. — Accurate and photorealistic representation of the modelled replica; it can be rotated around three axes.

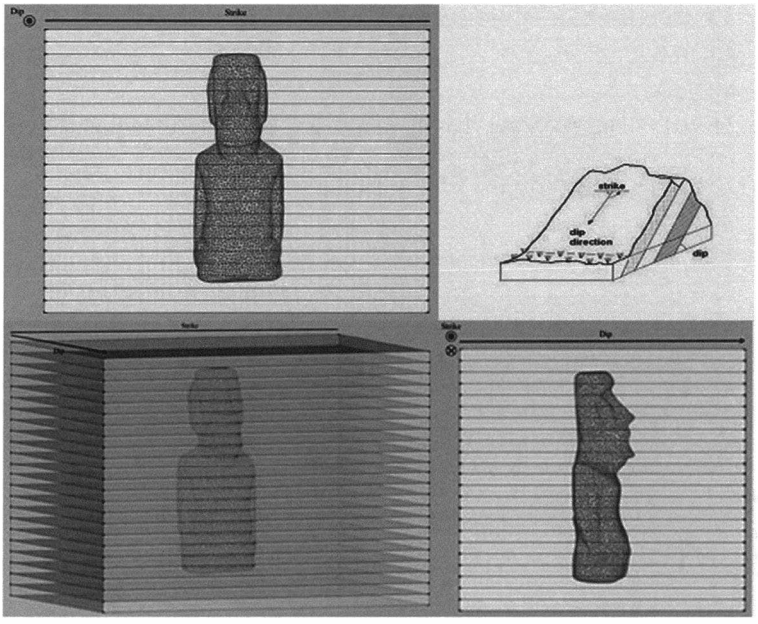


Fig. 3. — Simulation with z-axis parallel to strike and y-axis at 90° angle to dip.

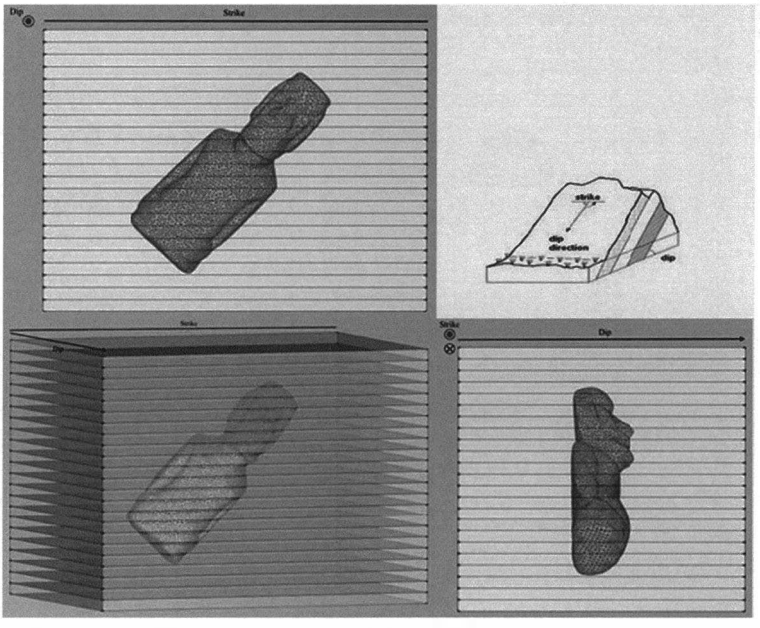


Fig. 4. — Simulation with z-axis at 45° angle to strike.

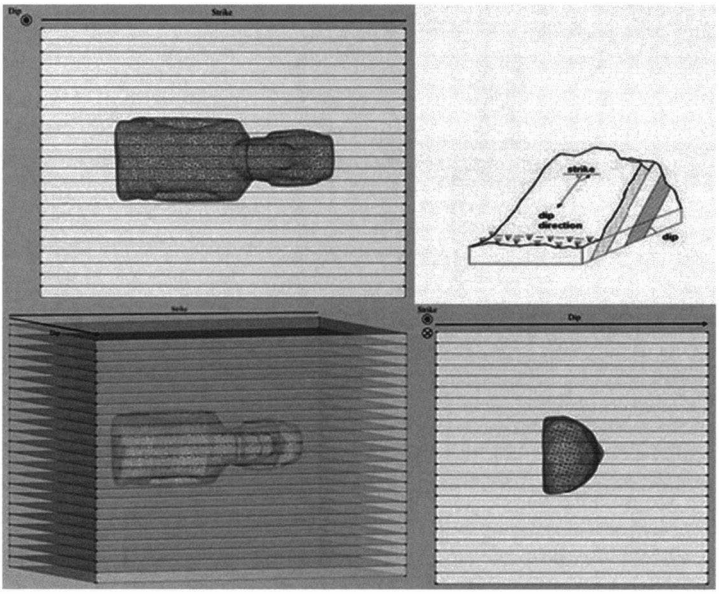


Fig. 5. — Simulation with z-axis parallel to strike and y-axis at 45° angle to dip.

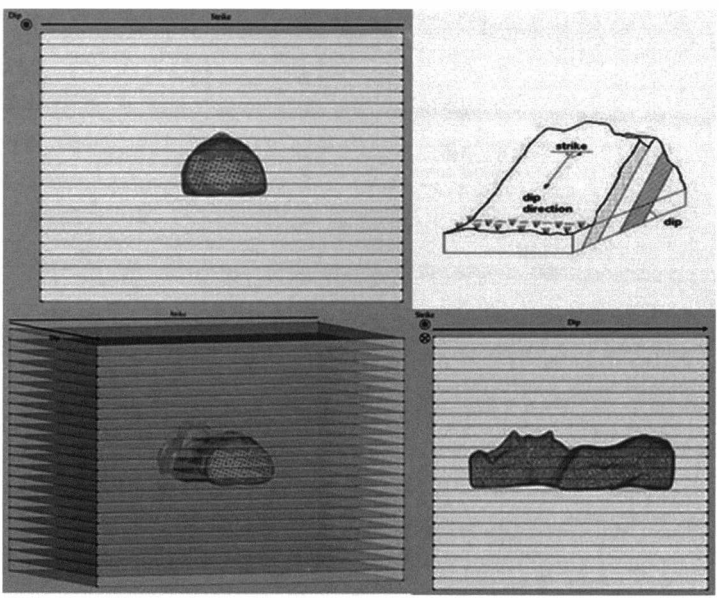


Fig. 6. — Simulation with y-axis parallel to strike, x-axis parallel to dip and z-axis at 90° angle to dip.

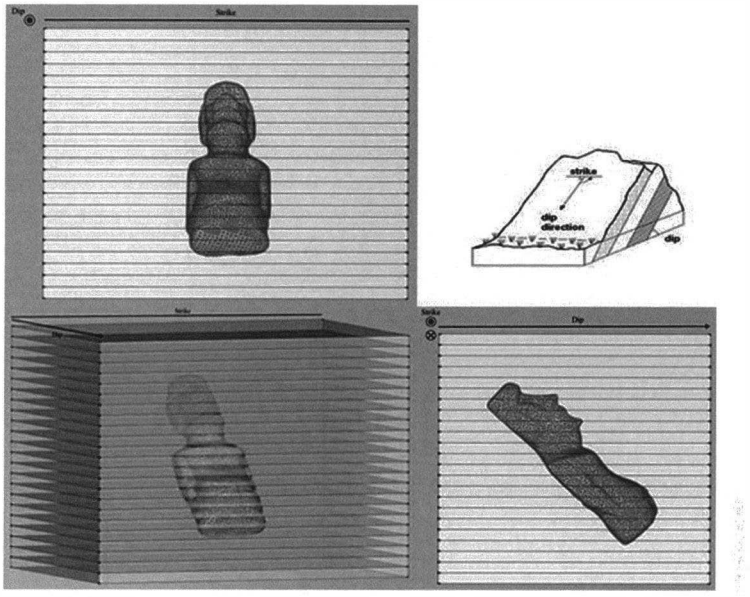


Fig. 7. — Simulation with z-axis parallel to strike and y-axis parallel to dip.

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Royal Museums of Art and History
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The *Mata'a* and the "Collapse Hypothesis"

by

Damien FLAS*

KEYWORDS. — *Mata'a*; Obsidian; Lithic Technology; Typology; Function.
SUMMARY. — The *mata'a* is a lithic artefact emblematic of the Rapa Nui aboriginal material culture and it plays an important role in the "collapse hypothesis". According to this hypothesis, this tool could be one of the elements showing the development of war-like conflicts following the exhaustion of the natural resources due to overexploitation of the environment by the Rapa Nui people. However, this tool type has rarely been the topic of detailed studies on large samples. The technology of its production, its typological diversity and its function(s) remain thus poorly understood. The study of a significant sample of *mata'a* allows here to shed a new light on these issues and to discuss the role of the *mata'a* in the "collapse hypothesis".

1. Introduction

A *mata'a* is a stone tool characterized by the presence of a tang. These tools are almost always made of obsidian, there are only very rare examples of *mata'a* made of basalt (METRAUX 1940). All tools with a tang found on Easter Island are thus classified in this category despite the diversity of their shapes and sizes. So, there is a typological issue: how can we study and understand this huge variability? Besides this issue, another question is related to the technology of these tools: how were they made? What were the methods used to produce them? And, of course, there is an important functional issue: how were they used? Were they weapons?

As seen below, this last question is directly related to the general issue of this volume since the *mata'a*, seen as projectile tips, have been considered in the frame of the "collapse hypothesis" as one of the archaeological traces

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of the so-called wars that would have destroyed Rapa Nui society (BAHN & FLENLEY 1992, DIAMOND 2007).

Since Thomson at the end of the 19th century (THOMSON 2007), different scholars have tried to create typological classifications of the *mata'a*, amongst them, most notably, BALFOUR (1917), ROUTLEDGE (1919) and METRAUX (1940). But the first rigorous and detailed analysis of the *mata'a* was made later, by MULLOY (1961). From the end of the 20th century until now, there have been more works tackling these different issues of the typology, technology and function of the *mata'a* (BOLLT *et al.* 2006; CHARLEUX 1986, 2011; CHURCH & ELLIS 1996; LIPO *et al.* 2010).

To provide more data related to these issues and to discuss different hypotheses previously put forward, a study of a hundred specimens of *mata'a* has been performed. The sample consists of thirty-seven *mata'a* gathered during the 1934-35 French-Belgian expedition and held in the Royal Museums of Art and History (Brussels), thirty-three *mata'a* held at the Ethnographic Museum Sebastian Englert (Rapa Nui), and twenty-six specimens coming from private collections belonging to Rapa Nui inhabitants. In all cases, the sample is made up of random surface collections without precise provenance. Moreover, four *mata'a* coming from stratified deposits at Ahu O Rongo (Belgian excavations, 2001-2002; HUYGHE & CAUWE 2002) have also been included in this sample. This results in a database of one hundred *mata'a* with observation of metrical, morphological and technical features.

2. Typology, Technology and the Issue of *Mata'a* Variability

The *mata'a* have a huge morphological diversity and can have very different shapes and sizes. Actually, their only common feature which justifies their classification in a same tool-type category is the presence of a tang (in itself of quite variable shape; LIPO *et al.* 2010). In front of such a variable tool type, some scholars have proposed to subdivide the *mata'a* into several types to sort out this morphological diversity. As early as 1891, Thomson made a first attempt to categorize *mata'a*'s typology and described nine different types, assigned Rapa Nui names, based on information he obtained from Easter Island inhabitants (THOMSON 2007). However, he did not believe that these different types corresponded to different functions but, on the contrary, that they were just the result of "individual skills and preferences".

Later on, there were other typological classifications, notably by ROUTLEDGE (1919). But the typological work that had the greatest influence was

the one published by METREAUX (1940) who proposed a classification into six types of *mata'a* (fig. 1*).

However, the first work trying to reliably distinguish between typologies, MULLOY's (1961), clearly showed that these were based on fuzzy features and that the wide morphological diversity of the *mata'a* challenged such a classification into such a limited number of typological categories. Mulloy used Metreaux's typology and performed a blind test applied to three hundred and fifty-five *mata'a* from Vinapu. The results indicated the subjectivity and inconsistency of this typological classification. Mulloy thus concluded that the *mata'a* "represents a continuous range of variation without objective natural order" (MULLOY 1961, p. 151). Interestingly, he also emphasized that most of the *mata'a* were not retouched and thus "in most cases the outline of the blade is determined by the fortuitous shape of the unmodified flake" (MULLOY 1961).

Therefore, since Mulloy's study, it has been believed that the *mata'a* show too random a morphological diversity to be separated into meaningful typological categories. This led some scholars to suggest an alternative hypothesis (BOLLT *et al.* 2006; fig. 2). They produced replicas of *mata'a* and tried to understand how to explain the different types described by Métreaux. They proposed that the different *mata'a* types actually corresponded to different stages throughout the life of the tool. This started with an unretouched *mata'a* and in a second stage (and sometimes in a third stage) the edges were retouched, creating these different shapes of *mata'a*. The *mata'a* then would often be discarded after a more or less developed rejuvenation process.

However, this explanation is based on a theoretical approach using replicas, and it is actually quite inconsistent with the archaeological artefacts. If we look at the *mata'a* we have, most of them, as already highlighted by Mulloy, were not retouched, or had only minor retouch that did not really modify the shape of the blank (except for the tang). For example, figures 3, 4, 6.1, 7.1 show *mata'a* having very different shapes and cutting edges, but this morphological diversity cannot be explained by a reduction of the *mata'a* as none of them display retouch except for the tang. More precisely, it appears that if "type 2" can indeed correspond to a reduction by retouch of the other five types, on the contrary, "type 5" and "type 6" cannot be the result of a transformation of other types as they were actually not retouched. Among the hundred *mata'a* studied here, only twenty-two had significant

* *Cf.* figures at the end of the text (pp. 71-75).

retouch that really modified the edge shape (figs. 6.2, 9.2). Moreover, these *mata'a* with significant edge modification through retouch, rarely correspond to any of the types defined by Métreaux or others (for example, fig. 7.2). So, there are some strongly retouched *mata'a* but they are quite rare, and this can explain only a small part of the observed variability in *mata'a* shape.

The *mata'a* studied here show a wide range in size, a phenomenon already emphasized in former works (CHARLEUX 2011, LIPO *et al.* 2010): a length between 3.4 cm (fig. 9.1) and 15.5 cm (fig. 3). The mean length of the complete *mata'a* (n = 84) is 8.64 cm. The median and the mode are also between 8 and 9 cm.

Interestingly, the location of the tang is actually very variable. The choice of the place where the tang is created is an important feature that determines the tools' final shape, and explains a part of their wide variability. This choice has also some important potential implications for tool function. In fact, contrary to what is common for European Palaeolithic tanged points (PESESSE & FLAS 2012), the tangs of the *mata'a* are not always carried out in the proximal part of the flake (figs. 3, 4, 7.1, 9.1). Proximal position is actually quite rare and the tangs are often off-axis compared to the debitage axis of the flake (for example, perpendicular to the debitage axis; figs. 6.2, 7.1) or even in the distal part of the flake. In fact, among ninety-two *mata'a* for which the position of the tang is determined, only twenty-two have a tang in the proximal part of the blank and in the axis of the debitage. This variability in the position of the tang has already been noticed by MULLOY (1961) and CHARLEUX (1986, 2011).

The tang position is obviously very important to understand the morphological diversity of the *mata'a*. If you have a blank with a convergent distal part (more or less "pointed"), this point will be in the axis of the tang if the latter is created on the proximal part of the blank (fig. 3). However, it can be transformed into a *mata'a* with a transverse distal cutting edge and an asymmetrical section with a natural back (acting as the striking platform of the blank) opposed to a convergent cutting edge, if the tang was made on the lateral edge of the blank at a 90° angle from the debitage axis (fig. 7.1). These different choices are not functionally equivalent: transverse or convergent distal edge, concave or convex cutting edges, plano-convex or asymetrical section, etc.

As has been pointed out already, in a few rare cases, retouch can strongly modify the edges of the *mata'a* (for example, fig. 7.2 where two notches have been made on the left side). Anyway, the results do not seem to correspond to a potential use as an efficient projectile head. It must be noted that there is no case of a retouched axial point in the studied sample.

Almost all the studied *mata'a* are made on obsidian flakes, they can sometimes be elongated (fig. 7.2) but there is no *mata'a* made on a blank-shaped blade (no flake whose length is at least twice its width). Some of these flakes are cortical, showing part of the external part of the obsidian block from which the flake was knapped. There are also two examples of *mata'a* directly shaped on a core, thus being especially thick, heavy, and without any cutting edge (tab. 1).

Table 1
Type of *mata'a* blanks in the studied sample

Blanks	
Flakes	80
Cortical flakes	8
Hinged flakes	10
Core	1
Undetermined	1
TOTAL	100

What were the knapping methods and techniques used to produce these obsidian flakes subsequently chosen to be shaped into *mata'a*? Only the works of CHARLEUX (1986, 2011) provided some precise observations on this issue. He studied *mata'a* from the *Musée de l'Homme* and French private collections and observed that a part of the flakes used as *mata'a* had been produced by a method similar to the Kombewa debitage (OWEN 1938), with flakes being knapped from the ventral face of a thicker flake. This identification of the Kombewa method by Charleux was later cited in other French works (GARANGER 1988; TIXIER & TURQ 1999), giving the impression that the Kombewa method was the most commonly used to produce the *mata'a* blanks.

The sample studied in this paper shows that the Kombewa method is indeed used as it can be recognized on at least eight *mata'a* and has been likely used for sixteen others (for example, figs. 5, 9.2, tab. 2). However, the Kombewa method is clearly not the only one used to produce the *mata'a.* Flakes knapped from centripetal cores, sometimes quite similar to the Levallois method, have also been used (at least forty-seven cases). Some *mata'a* are also made on flakes coming from a unidirectional (at least five cases, fig. 7) and bidirectional debitage (at least two cases, fig. 8) (for the terminology of lithic technology, see INIZAN *et al.* 1999).

Table 2
Knapping method used to produce *mata'a* blanks

Centripetal	44
Likely centripetal	12
Kombewa	8
Likely Kombewa	16
Unidirectional	5
Likely unidirectional	4
Bidirectional	2
Undetermined	8
TOTAL	100

The percussion technique most likely involves only a hard stone hammer, with clear percussion points, often located at several millimetres from the edge of the striking platform, producing flakes displaying a thick proximal part (for example, fig. 7.1).

Interestingly, this variety of methods (centripetal, Kombewa, unidirectional, bidirectional) produced flakes with different morphologies and different characteristics. For example, if Kombewa flakes often have a biconvex section and a continuous convex cutting edge (fig. 5), this will not be the case with other flakes produced by other knapping methods. Centripetal debitage yields flakes with a more quadrangular outline and, if the knapping surface is convex enough, the flake will often have one or several concave edges (fig. 4). So, the choice of the knapping method and the selection of a particular flake greatly predetermine the final shape of the *mata'a* that is thus not random but the result of a sequence of deliberate choices among several technical possibilities. Moreover, these different options are not *a priori* functionally equivalent: it is not possible to perform the same task in the same way and with the same efficiency using a tool with a convex cutting edge or using a tool with a concave cutting edge.

To sum up, the morphological diversity of the *mata'a* can be understood as the result of the mix between two variables.

First, the shape of the blank that is actually related to the choice of a knapping method. Different knapping methods can be recognized in the production of the *mata'a*, and these different methods yielded flakes which display different geometrical and morphological features (different cutting edges, different sections).

The second variable that will have a strong influence on the shape (and thus the function) of the *mata'a*, is the position of the tang.

If we mix these two variables, we can obtain a vast number of tools with very different features that can hardly be used to perform the same task. For example, figure 1 is a *mata'a* made on a flake from a centripetal core with the tang in the proximal part, creating a tool with more or less pointed convergent edges. On figure 4, a *mata'a* was created on a debordant blank knapped from a centripetal core with quite a curved debitage surface that produced a large flake with three concave cutting edges, with the tang then created in the axis of the flake, keeping the three cutting edges. On figure 7.1, a unidirectional debitage was used giving a shorter flake with a more or less convex cutting edge, and the tang was placed on the side of the flake, perpendicular to the debitage axis, creating a *mata'a* with a very thick and non-cutting left edge, an asymmetrical section and a convex cutting edge on the right side. *Mata'a*'s morphological variability is thus not just accidental, it is the result of several deliberate choices leading to a particular goal.

3. *Mata'a* and the Collapse Hypothesis

3.1. Functional Issue

3.1.1. *Travellers' Testimonies*

What do we know about the *mata'a* from the first accounts by European sailors who reached Rapa Nui in the 18th century when the local population and its way of life was still preserved? Not much, actually. From the Roggeveen expedition in 1722, we have no testimonies about use of weapons by the Rapa Nui population. During a fight with Dutch sailors (Easter Island... 2007, pp. 26-27), they resorted to simply throwing stones. Interestingly, one of the members of the Dutch crew mentioned that they used a black cutting stone to cut bananas (Lipo *et al.* 2010, p. 2553). Later on, we had some more information from two Spanish officers but they never noticed any weapons except for once, when they wrote about injuries probably made by "cutting instruments" (Easter Island... 2007, p. 63).

In 1774, Forster, a member of James Cook's expedition, mentioned "spears" twice but without any more detail (Easter Island... 2007, pp. 159, 161). However, he also wrote: "As harmless and friendly as these people seem to be, they are not without offensive weapons, such as short wooden clubs, and spears; which latter are crooked sticks about six feet long, armed

at one end with pieces of flint" (Easter Island... 2007, p. 173). It is the only reliable testimony about stone tools hafted on long shafts and interpreted as spears before the severe demographic drop of the Rapa Nui population in the 19th century.

Later on, La Pérouse (in 1788) and other travellers like von Kotzebue and Beechey (first part of the 19th century) did not write about weapons, only mentioning that Rapa Nui people were throwing stones and using clubs in case of fights (VOGLER 1990).

Actually, it was only in the late 19th century, after the almost complete destruction of the local population, especially between 1859 and 1861 (VOGLER 1990), that we had more detailed descriptions of spears with obsidian tips. These late descriptions form the basis of the hypothesis that the *mata'a* are spearheads. For example, Pierre Loti, who came to Easter Island in 1872, described this type of weapons, and he even brought back with him two specimens of these spears that were produced by Rapa Nui inhabitants at his request (LOTI 2011). The description made by Geiseler a few years later made a strong impression: he claimed to have seen a skull that had been pierced through by a spear with a *mata'a* (AYRES 1995, p. 72). This interpretation of the *mata'a* as spearheads was then repeated in numerous later works (METREAUX 1940, HEYERDHAL & FERDON 1961, BAHN & FLENLEY 1992) but, as we can see, it is neither based on ancient and reliable testimonies nor on archaeological data. Drawing upon one testimony at the time of Cook's expedition, the only established fact is that some of the *mata'a* were hafted on long shafts.

3.1.2. *The Use-wear and Technical Data*

Moreover, the *mata'a*'s function as a projectile tip has more recently been challenged by the development of some micro-wear analyses (CHURCH & RIGNEY 1994, CHURCH & ELLIS 1996). Four *mata'a* have been analysed, and the observed micro-wear corresponds to a function as knife or saw to cut plant material. Of course, four specimens is a very small sample but it already confirms that the *mata'a* are certainly not only spearheads, a result that is consistent with the variability of their shapes.

In fact, a successful weapon (and if you are involved in a real war, as implied by the "collapse hypothesis", you must have successful weapons) has to be designed to be effective, particularly in the case of the projectile points that have to be shaped according to important ballistic requirements (SHEA 2006, NEWMAN & MOORE 2013). The features of most of the studied *mata'a* do not seem to fit with such ballistic requirements. Few of them are symmetrical,

and even fewer are pointed. Some of them are also very heavy, which is surprising for a supposed projectile tip.

For example, figure 3 is one of the rare *mata'a* in the sample that could look like a projectile because it appears quite symmetrical and pointed but it is nonetheless a very unlikely projectile tip as it is very thick (27 mm), very heavy (217 g.) and has only one cutting edge (the other one being a cortical edge). As is well-known for Palaeolithic tools, all pointed lithic artefacts are not spearheads (PLISSON & BEYRIES 1998).

If *mata'a* were really projectile points, we should have observed some impact damages such as those described so many times for prehistoric stone points (ROTS & PLISSON 2014). As far as the author knows, there have been no experiments carried out using *mata'a* replicas as projectiles, and the study of the archaeological *mata'a* has never identified such traces. So, there are currently no data supporting the interpretation of these tools as weapons.

Obviously *mata'a* were designed to be hafted but we don't have much information about the type of shaft. At least seven hafted *mata'a* have been mentioned in the literature: four with short shafts and four with long shafts (CHARLEUX 2011, SIMPSON 2010). But all these hafted *mata'a* were gathered in the late 19th century and early 20th century and we are not sure they really correspond to what was done before Europeans came to the island. In fact, the *mata'a* on long shafts involve exogenous raw materials (metal and wood which did not exist on Easter Island; CHARLEUX 1986, 2011) and they are thus a late production that does not correspond to the pre-contact context. Moreover, even if some *mata'a* were really hafted on long shafts, as is attested by the above-mentioned testimony by Forster, this does not necessarily imply they were used as projectiles.

Finally, some scholars proposing that *mata'a* are mainly projectile points despite all these issues, wrote that "It has been claimed that the spear heads were, in fact, horticultural implement. This seems unlikely because of their delicate construction and elaborate hafting design" (FLENLEY *et al.* 2007, p. 102). It seems to me a very subjective and poor argument which cannot be seriously considered. Is a Neolithic *adze* less "delicate" or "elaborate" than a *mata'a*?

3.2. CHRONOLOGY

Another question related to the *mata'a* in the context of the collapse hypothesis, is the chronological issue. It has been claimed that there was a particular development of *mata'a* production from the 16th to the 19th century, a development that could be related to the increase of internal wars following the decrease of food resources (BAHN & FLENLEY 1992, FLENLEY

et al. 2007). It is actually very difficult to understand on which chronological data this assertion is based. We have thousands of *mata'a* but most of them lack chronological context as they are surface finds. Few of them come from stratified deposits, and these deposits have rarely been precisely dated (MULLOY 1961, STEVENSON *et al.* 2000). It is actually impossible to know if the quantity of *mata'a* produced changed during Rapa Nui history.

4. Conclusion

According to the "collapse hypothesis", the *mata'a* are one of the archaeological traces of the wars that destroyed Rapa Nui society from the 17th century onward, following the overexploitation of the environment. However, as already suggested by other scholars (HUNT & LIPO 2007), a closer look at the data available for this type of obsidian tools is not consistent with such a scenario.

Use as a weapon is unlikely for most of the *mata'a*:

— Precise and reliable testimonies about the *mata'a* used as spearheads are more than scarce.
— No use-wear analysis confirms their use as weapons. Typical impact damages resulting from use as projectile points have never been observed on *mata'a*. On the contrary, the rare use-wear studies that have been performed point to a use as horticultural implements.
— Clearly, very few of them could have been designed to be effective projectile heads, most of them being neither symmetrical nor pointed, and often heavy.

Moreover, no archaeological data supports the statement that they developed particularly from the 17th century onward, and it is thus not possible to connect/ascribe them to the hypothetic wars imagined as part of the collapse scenario.

The *mata'a* is not a tool, it is a typological category merely characterized by the presence of a tang. This category actually gathers a lot of different tools, with different shapes, different active edges and different morphologies that cannot all be used in the same manner. Their diversity is puzzling and challenges any typological subdivision; nonetheless it does not seem to be random. On the contrary, their variability seems to be related to a mixed combination of two deliberate choices: the shape of the flakes (which itself relates to the choice of the knapping method: Kombewa, centripetal, unidirectional, or bidirectional) and the choice in the position of the tang.

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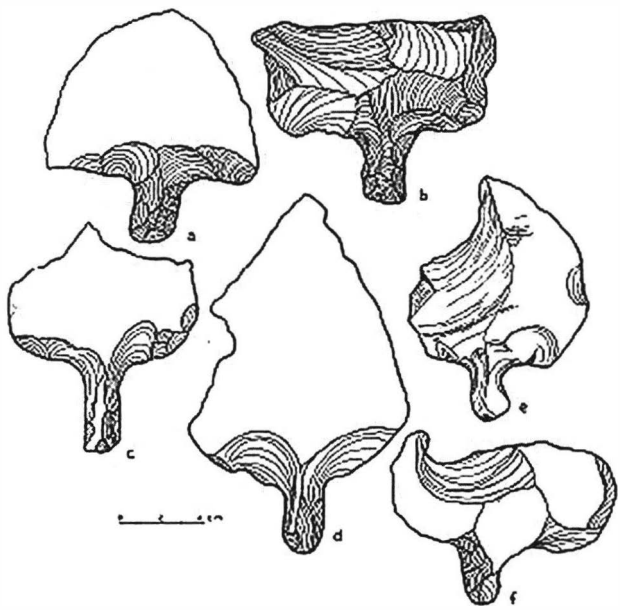

Fig. 1. — Typology of the *mata'a* as proposed by METREAUX (1940).

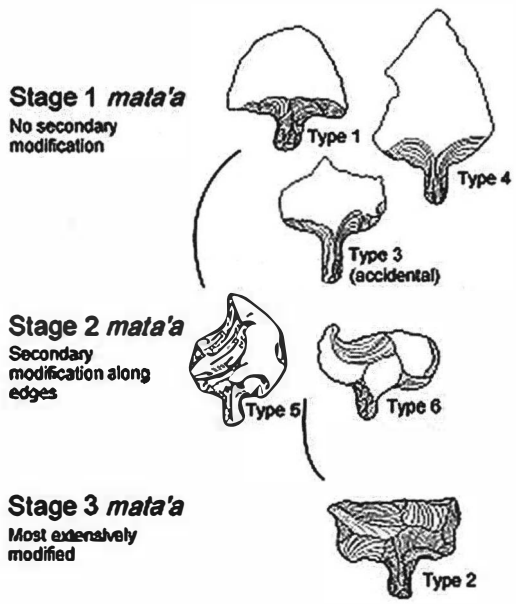

Fig. 2. — Hypothesis of "life history" of the *mata'a* explaining their typological variability according to BOLLT *et al.* (2006).

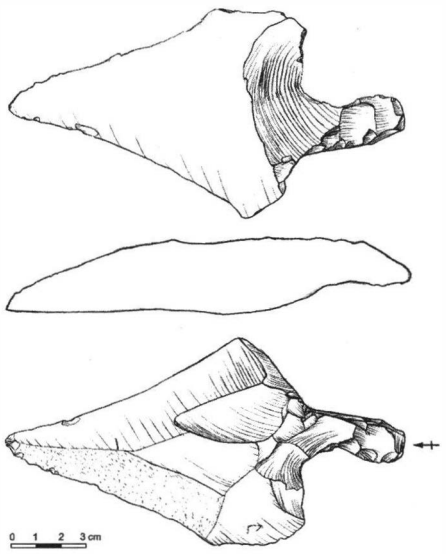

Fig. 3. — *Mata'a* collected during Lavachery's expedition (1934-35), Royal Museums of Art and History (Brussels, no. ET.35.5.185). Centripetal debitage, proximal tang (drawing by D. Flas).

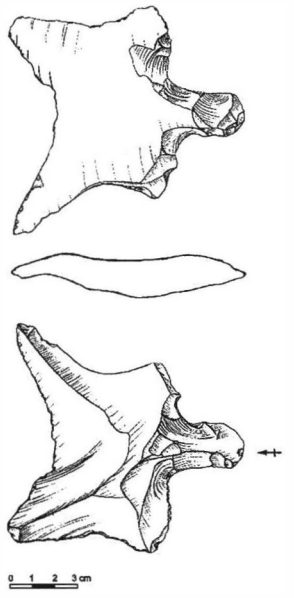

Fig. 4. — *Mata'a* collected during Lavachery's expedition (1934-35), Royal Museums of Art and History (Brussels, no. ET.35.5.180). Centripetal debitage, proximal tang (drawing by D. Flas).

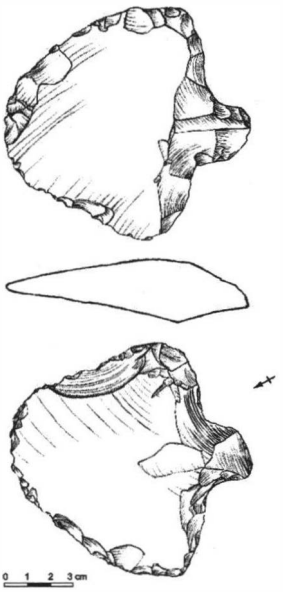

Fig. 5. — *Mata'a* collected during Lavachery's expedition, Royal Museums of Art and History (Brussels, no. ET.35.5.187). Kombewa debitage, tang on the proximal left edge (drawing by D. Flas).

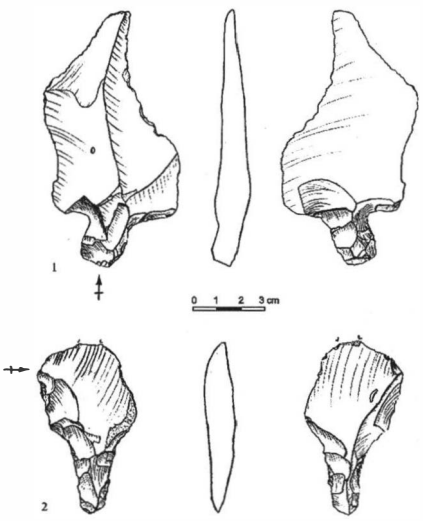

Fig. 6. — *Mata'a* collected during Lavachery's expedition, Royal Museums of Art and History (Brussels). 1: no. ET.35.5.191, centripetal debitage, proximal asymmetrical tang; 2: no. ET.35.5.214, unidirectional debitage?, tang on the right edge (drawing by D. Flas).

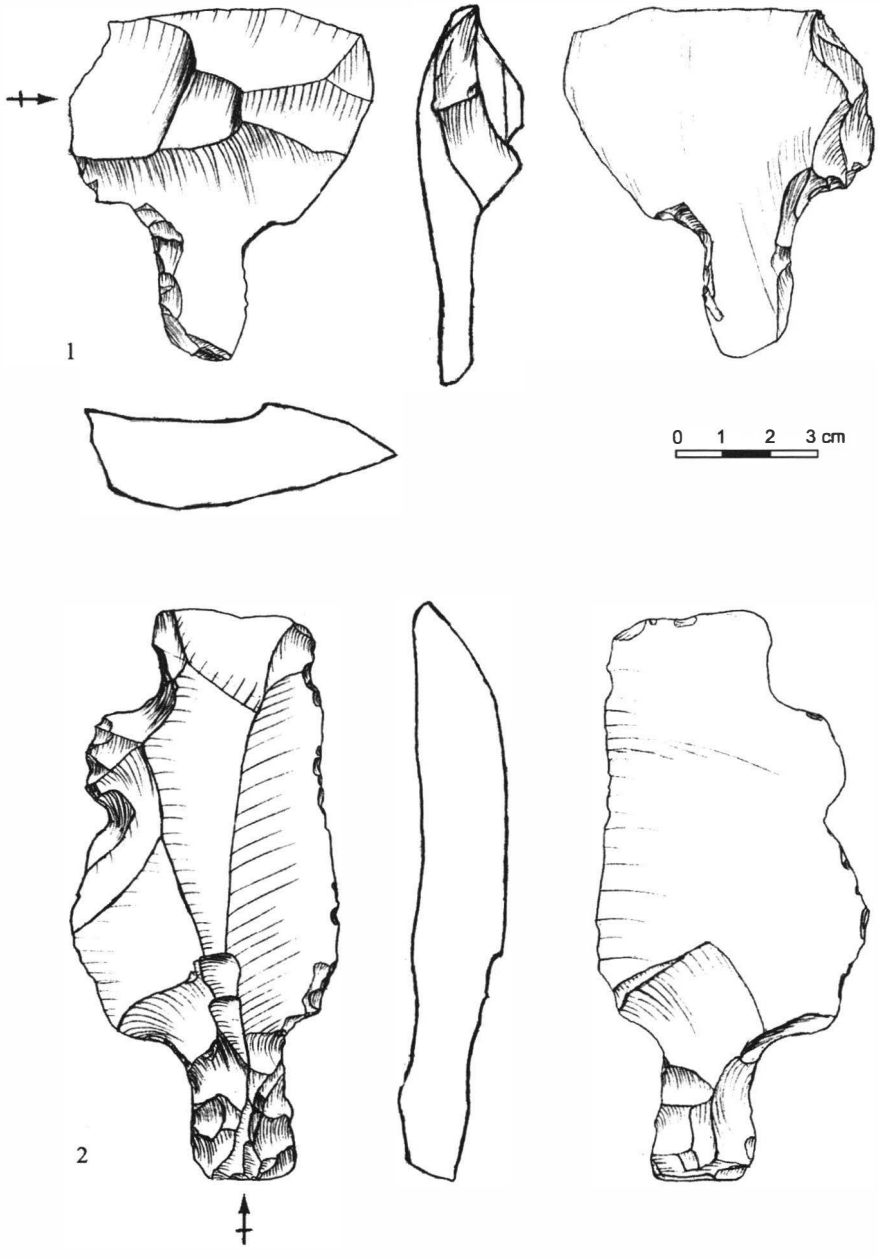

Fig. 7. — *Mata'a*, private collections, Rapa Nui. 1: Unidirectional debitage, tang on the right edge; 2: Unidirectional debitage, proximal tang, denticulate on the left edge (drawing by D. Flas).

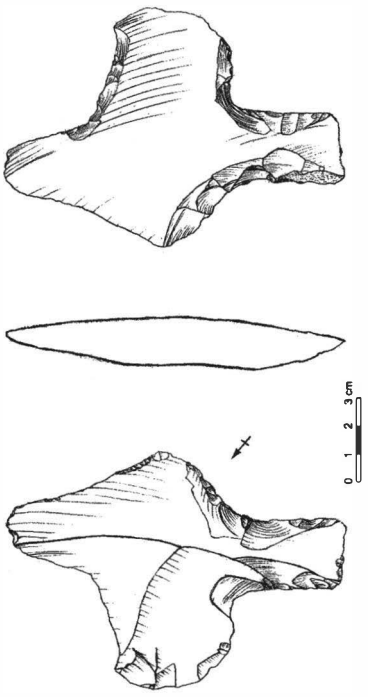

Fig. 8. — *Mata'a* collected during Lavachery's expedition, Royal Museums of Art and History (Brussels, no. ET.35.5.181). Bidirectional debitage, tang on the left side (drawing by D. Flas).

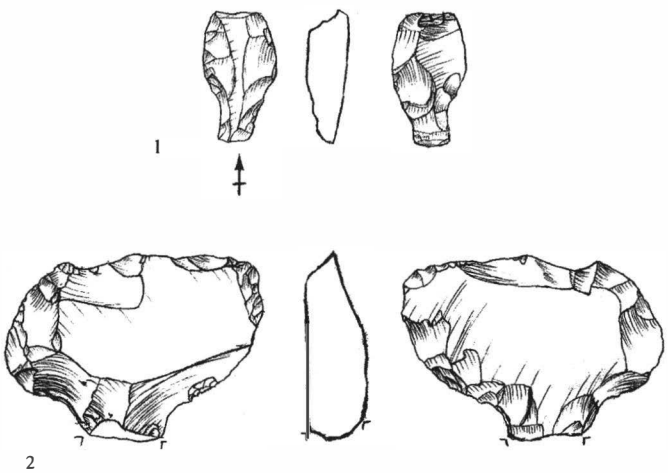

Fig. 9. — *Mata'a* from Ahu o Rongo (excavations 2001-2002, HUYGE & CAUWE 2002). 1: Unknown debitage method, proximal tang; 2: Kombewa debitage?, tang on left edge (drawing by D. Flas).

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History of Easter Island on the Rocks

by

Serge LEMAITRE*

KEYWORDS. — Rock Art; Birdman Figure; Chronology; Iconography.

SUMMARY. — Many early visitors and researchers noted and commented upon petroglyphs. Except for the PhD thesis of Georgia Lee, little attention was paid to the island's rock art to understand Rapa Nui civilization, even if more than four thousand petroglyphs and four thousand cupules were recorded. The engravings are located in every sector of the island and present a large iconography. This rock art is likely to give us information not only on the mental and spiritual functioning of those who made them, by analysing the graphic content, but also on their social functioning. The study of chronology, location, technique of carving and variation of the iconography could help us to understand the evolution of these "artistic" creations and see if it could be the evidence of a collapse or a transformation of Easter Island's civilization.

1. Problematic Issues

Apparently, following the decline of the forest, there was in Rapa Nui a transformation of the power of the ancestors and the guardian gods, to give more latitude to some divinities. In other words, in front of difficulties consecutive to a transformation of the environment, Rapanui people tried to create a new global identity to their society, by giving a new visibility to the god Make-make to the detriment of the ancestor personified by moai.

For over ten years, the entire history of this island has been reconstructed thanks to archaeological work, completely renewing the vision of Easter Island's culture established so far. However, rock art remains a totally underutilized area in these studies, whereas this type of artistic expression abounds on the island. No comprehensive approach has never been attempted,

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nor was the establishment of a timeline or recognition of regional traditions. We know that the Rapa Nui society experienced great cultural changes from the mid-seventeenth century, which resulted in changes in all areas: socio-political organization, religion, economics, ...

If a general explanation of this phenomenon is starting to be seen (for example thanks to this conference), only an approach involving all the available documentation will achieve greater refinement. Rock art is now a research field that cannot be neglected and which could be a fundamental contribution in the absence of written record.

In this paper, we will not make a large overview of rock art in Easter Island but we will only focus on some elements which could help to solve the problematic issues of the collapse. We will try to give some elements to answer the following questions: Is there any iconographic change in the motifs of rock art? How did techniques evolve? What is the geographical dispersal of the representation of the god Makemake and his substitute on Earth, the Tangata Manu? and of course, one of the question most frequently asked about rock art is "how old is this?" and that's also the main question today to understand the changes.

2. Rock Art of Easter Island

For more than a century, archaeological studies have been in progress on Easter Island but most of the works have focused on the monolithic statues (*moai*) and ceremonial shrines (*ahu*). Already at the end of the 19th century, THOMSON (1891, p. 480) described some birdman petroglyphs and in 1919 ROUTLEDGE (1919) surveyed the rocks at Mata Ngarau, near Orongo village. In 1934, Lavachery paid much attention to these archaeological remains and eventually published a book on this topic (LAVACHERY 1939). But little attention — until the PhD of Georgia LEE (1992) — was paid to the island's rock art, either generally or specifically. This could be due to the lesser visibility of rock carvings: the statues and ahu stand out clearly in the landscape, but petroglyphs are often hidden in high grass and many of them are eroded and indistinct. However, thousands of petroglyphs can be found on this island. In fact, on Easter Island, more than four thousand petroglyphs and about the same number of cupules were described by Georgia Lee. Many represent animals, notably birds, turtles and fish (tuna, swordfish, sharks, ...), crab, and octopus designs, sea mammals (whales and dolphins) or anthropomorphic figures. But the most representative in Easter Island is the Birdman and the figure of Makemake (see below).

On Easter Island, we can observe petroglyphs in many locations of the island where there are suitable surfaces. Favourite surfaces are smooth areas

Fig. 1. — Wave designs on red scoria in the vicinity of Maunga Pu'i (photo by S. Lemaitre).

Fig. 2. — Ahu Nau Nau at Anakena. Several paenga are decorated with petroglyphs (photo by S. Lemaitre).

of lava flow (called "papa" in Rapa Nui), or smooth basalt boulders. We even found petroglyphs on red scoria in the vicinity of Maunga Pu'i inside the island (fig. 1), but most of the carved surfaces occur along coastal areas and are often associated with major ceremonial centres.

Some important ahu have, as part of their structure, carved basalt or red scoria stones (*paenga*), with petroglyphs on them like those at the Ahu Nau Nau or Ahu One te Mahiki (fig. 2) and even some moai are the support for carvings. Paintings have survived in caves or in some of the stone houses at Orongo where they are protected against the weathering process.

3. Dating and Chronology

As in many other parts of the world, the dating of rock engravings is very difficult and only a few techniques can help us to understand the chronology. We really have little dating for the rock art sites of Easter Island. Some clues are coming from archaeological excavations like those made at the Ahu o Rongo site. The Belgian team discovered a paenga with an incised whale. They dated the strata thanks to charcoal and proved that the engraving could be associated to the 14th century (CAUWE *et al.* 2002) (fig. 3).

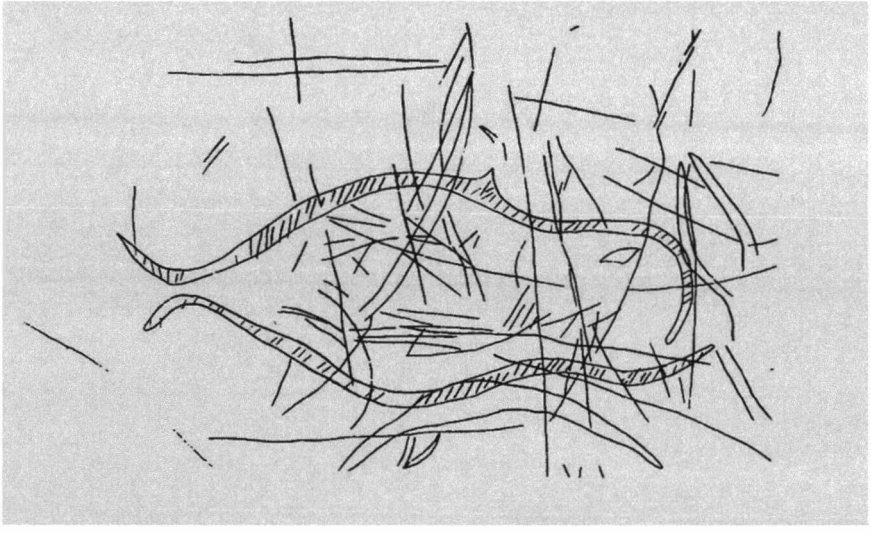

Fig. 3. — Whale engraved on a paenga at the Ahu o Rongo (record by D. Huyge).

Apart from the statues, there are also some representations of moai carved in flat rocks or small blocks like the one known on Motu Nui, Papa te Kena or the one we discovered in 2010 near Hanga Te'e (fig. 4). Legless, they may have indications of arms and facial features may be present. Nearly all of

them have eyes. They are often found in groups of two or more. Pecked and abraded, some are partly in bas-relief. But anthropomorphic figures are rare. We can assume that they were performed at the same period of the ahu construction and the moai creation.

Fig. 4. — Several small moai carved on a block on the "path of the moai", near Hanga Te'e (photo by N. Cauwe, enhanced by the author).

We also have some motifs that are clearly "modern", such as the design of a ship on the torso of a moai at Rano Raraku which could be dated from the 18th or 19th century (fig. 5). Routledge also recorded an historic ship under a bird painting at Ana Kai Tangata (ROUTLEDGE 1919, p. 259).

In the same way, if we agree on the late creation of rongorongo, we also have a few rock engravings which can be dated from the same late period, thanks to comparison. There are few depictions of human images on the island, and most of these are in bas-relief. There are no real stick figures but some double-outlined figures like those we can see in the Marquesas Islands or a quite naturalistic representation. Some have a pointed shape on the head similar to those on rongorongo boards. It could be a hat, called *ha'umaroki*, or a hat made with feathers. It could be the same with the portraiture of faces with headdress like those painted on the Orongo houses. This motif could be older but at least it endured at the time of the houses' construction at Orongo (fig. 6). Other motifs similar to the rongorongo have been recently discovered on the Terevaka slopes (HAOA-CARDINALI *et al.* 2007) (fig. 7).

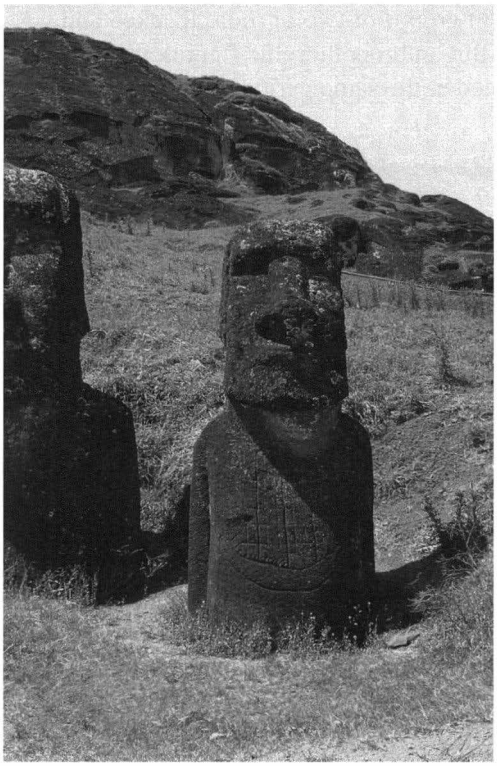

Fig. 5. — Moai with a Western ship on the torso at Rano Raraku (photo by N. Cauwe).

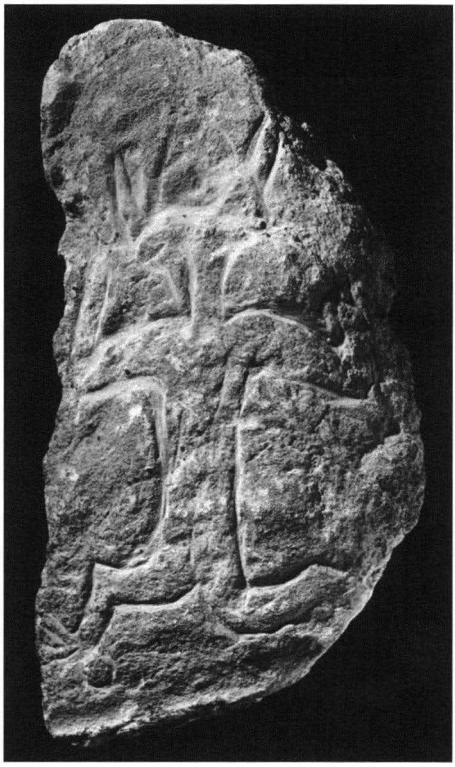

Fig. 6. — Anthropomorphic figures with a "hat" engraved. Block from Motu Nui, collected by H. Lavachery and stored at the Royal Museums of Art and History in Brussels (et. 35.5.310).

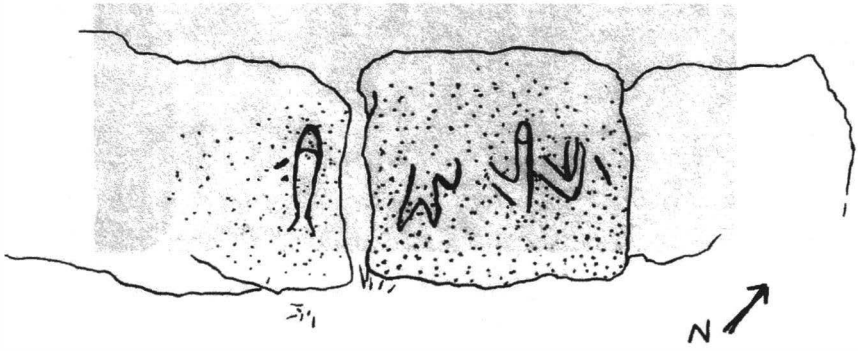

Fig. 7. — Motifs similar to rongorongo engraved on a rock in the slopes of Terevaka (HAOA-CARDINALI 2007, p. 149).

Around the island and on different kinds of sites, we can observe rock engravings on peculiar support. In fact, some of the topknots (*pukao*) of the fallen statues (fig. 8) or still present in the quarry of Puna Pao are sometimes deeply carved. Some of the statues have also engravings on their bodies. This is the case for some standing moai at Rano Raraku (fig. 9) and some lying statues of ahu or on the "path of the moai" (fig. 10). Thanks to the analysis of the position and the orientation of the motifs, we could assume that these engravings were made quite recently and at least after the moai were put down and the quarries not in use anymore. Cupules are the most frequent ones but motifs in the shape of canoes or a curved line were also frequently carved (LEE 1992, p. 122; VAN TILBURG & LEE 1987). We can observe many examples on the back of moai standing in the inner crater of Rano Raraku, on the arms of moai lying on the ground, on pukao and even on some ahu 's paenga (for example at Ahu Akahanga, Ahu Vinapu, Ahu One Makihi) (fig. 11). We can also add some representations of Makemake we can find on the body or shoulder of some moai (fig. 12). Of course, the most well-known moai with petroglyphs is Hoa Haka Nana i'a (exhibited at the British Museum in London) but its history is quite different because it was re-used in a house of the Orongo village.

Fig. 8. — Pukao deeply carved, Hanga Te'e (photo and enhancement by the author).

Fig. 9. — "Canoe" designs on the back of a moai in the inner side of Rano Raraku, excavation by Van Tilburg (photo by S. Lemaitre).

Fig. 10. — "Canoe" designs on the body of a moai lying on the "path of the moai" (photo by S. Lemaitre).

Fig. 11. — Red scoria paenga engraved with "canoe" designs, Ahu One Makihi (photo by N. Cauwe).

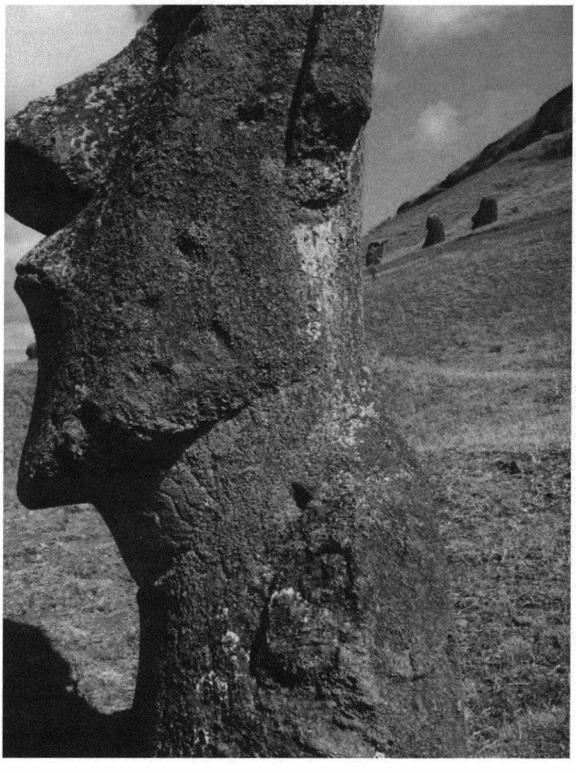

Fig. 12. — Moai on the slopes of Rano Raraku with the face of Makemake on its shoulder (photo by S. Lemaitre).

The later fertility cult ceremonies at Orongo resulted in numerous *komari* or vulva designs (ROUTLEDGE 1919, p. 263), sometimes incised over the existing Birdmen. It is the most frequent design but it is also the most frequent superimposing figure. It stands clearly that it is the most recent one.

At last, we can observe the weathering of some petroglyphs but it's getting quite difficult because to please the tourists many engravings have been "renewed" with chalk or the previous carvings have been abraded (LEE & PADGETT 1996). Nevertheless, we can observe, for example, that the figures of Papa Vaka — with boat, hooks, octopus, ... — are more eroded than the engravings of Papa Ta which contains Makemake and birdmen figures (figs. 13, 14).

Fig. 13. — A large petroglyph of a fish at Papa Vaka (photo by S. Lemaitre).

Fig. 14. — Makemake faces and birdman figure at Papa Ta (photo by S. Lemaitre).

4. Location

Georgia Lee has been working on the evolution of petroglyphs at Mata Ngarau (Orongo) and overall on the birdman figure. This crouched human figure in profile with its huge eye and bird beak is the second most used motif on Rapa Nui. It has been recorded five hundred times around the island but 86 % are located near Orongo, a clear evidence of its association with the birdman ceremony. In the same way, 66 % of komari (or vulvae) are present in the site of Orongo and often superimposed on later birdman figures (LEE 1992, p. 64). Makemake, the god related to fertility and birdman cult, also appears in abundance at the top of the Rano Kao site but is more often represented outside of this sacred place and is visible in caves, in relation with water and humidity, and also on statues.

These three new symbols are often combined and appear together on large panels, overall near the village of Orongo but also in some other places such as the large lava surfaces in front of Ahu Tongariki or in a place near Vai Mata and on the island of Motu Nui where the competitors are supposed to find an egg during the Birdman competition. All these new motifs are well

connected with the religious centre of Orongo. This new importance given to more centralist divinities, which appeared around the 17th century, is thus perceived from some elements of rock art. In particular, the "explosion" of the number of representations of birdmen and the eyes or the faces of Make-make. Also, vulvae or komari, as symbols of fertility, are engraved in large numbers, especially at the Orongo site. This centralization of the most important motifs at the top of the Rano Kao seems clear (VAN TILBURG & LEE 1987, p. 136) (fig. 15).

Fig. 15. — Many birdmen figures in champlevé technique at Mata Ngarau (photo by N. Cauwe).

5. Techniques

Thanks to the analysis of the rocks of Mata Ngarau, where an important activity took place for a short time, it is possible to trace the evolution of petroglyph motifs from simple, incised forms to elaborate, bas-relief designs. Rock art is mainly made by pecking the surface, sometimes completed by an abrasion of the lines to have smooth surfaces. Some rare figures (often komari) are also incised. A later evolution, unique in Polynesia, is the technique of bas-relief or champlevé. This technique consists in pecking around a form, which allows the motif to protrude above the rock (LEE 1992). Such

a technique is used overall at the Mata Ngarau site and in front of the Ahu Tongariki, two locations — as already seen — known for the high number of representations of the famous triad (birdman, Makemake and vulvae). The figure of Makemake is also one of the few to have been painted on the walls of small caves. The mask of this divinity is often made by pecking and enhanced by (white, red or yellow) paint (fig. 16).

Fig. 16. — Petroglyphs of Makemake enhanced by paint, Ana o Hera (photo by N. Cauwe).

6. Conclusion

I think that there is no clear view of a collapse. There is no clear evidence of violence in rock art, at least no representation of it. Moreover, if there are some superimpositions, they are few and no destruction of the previous ones can be assumed.

As far as the designs on the moai and pukao are concerned, the ancient Easter Islanders made carvings on nearly everything, including some statues and topknots. Whether this was a way to re-use the sacred or to extract *mana* (power) from the sacred shrines and statues, we don't know. It could be also

the reflection of the emergence of a new way of thinking and then the appropriation of the oldest shrines. The ancient way to contact deities by a cult directed toward the ancestors in the form of huge statues was replaced by the election of a human being chosen through a competition. The god Makemake played then the major role associated with the Birdman figure and the komari. The Rapa Nui representations of birdmen are exactly the same as some in Hawaii, a proof that this important figure is already part of the society and shared with other Polynesian people (LEE & STASACK 1999, pp. 161-170). Birdman cult is a characteristic of Polynesian culture and was more or less developed, sooner or later on each island. This cult played a more important role over the years and finally replaced the ancestors/moai cult. And while the statues were spread throughout the island, the new religion and its representations were concentrated in three main areas: Rano Raraku, Rano Kao and Motu Nui.

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Degradation of Resources and Successful Land-Use Management on Prehistoric Rapa Nui: Two Sides of the Same Coin

by

ANDREAS MIETH* & HANS-RUDOLF BORK**

KEYWORDS. — Easter Island; Collapse; Environment; Resources; Degradation.
SUMMARY. — Prehistoric Easter Island society not only caused severe environmental degradation on the island, but suffered as well from its consequences. A dramatic loss of forests, biodiversity, and fertile topsoils posed considerable peril for the continuity of the social structure. Nevertheless, by means of innovative, adaptive land-use management, the inhabitants of pre-contact Rapa Nui successfully thwarted cultural and social collapse. New research results strengthen the thesis that, despite increased environmental hardships, Easter Island society achieved and sustained high cultural levels. Even after the complete loss of forest cover, the island's population was capable of extraordinary accomplishments that are exemplified in stone mulching, the erection of monumental structures, and an industry in pigment production.

Introduction

The impression that the island might once have suffered an ecological and cultural catastrophe strikes even an impartial visitor. The landscape alone embodies a picture of collapse. There, where one would expect a subtropical forest, one finds — apart from recent plantations of non-native tree species — a dry, treeless, island-wide grass steppe (fig. 1). Millions of stones cover an apparently infertile land. On parts of the island, topsoils are completely

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eroded and deep gullies crease desert-like zones (fig. 2). These impressions of a massively altered landscape mix with those of demolished cultural relicts. Eroded ceremonial platforms, sediment-buried habitation remains, and fallen, broken stone statues support the vision of the collapse of a culture once highly developed (fig. 3). Not only the uninitiated visitor, but also notable scientists see in these pictures the indices of an ecological and cultural collapse that had already played itself out before the arrival of the first Europeans at Easter Island.

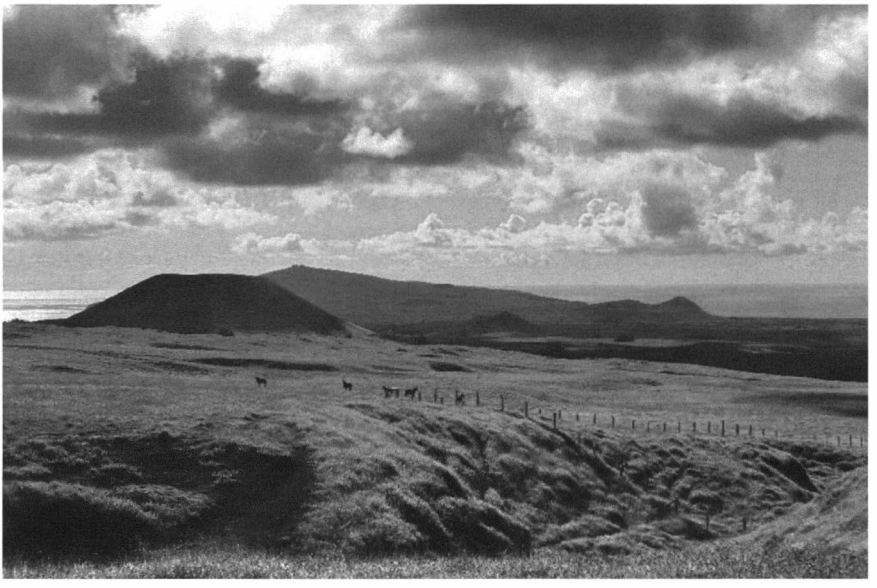

Fig. 1. — Treeless landscape in the south-east of Easter Island (Rapa Nui).

Easter Island's landscape and its cultural phases have undergone intense scientific research since the second half of the twentieth century. In the framework of archaeological investigations, HEYERDAHL & FERDON (1961) and MULLOY (1979) found in carbonized wood remains the first evidence for earlier-existing forest vegetation and were the first to hypothesize a causal connection between ecological transformations and ensuing human crises, cultural decay, and wars. In their pioneering palynological work, FLENLEY & KING (1984) evidenced a shift from a woodland landscape to open grassland and found clues to related erosion and fire events, suggesting a rapid transformation that began shortly after the island's first human arrivals. This knowledge was supported in encompassing research by ORLIAC (2000) and ORLIAC & ORLIAC (2005), who were able to document a landscape vegetation

cover transition in light of changes in fireplace charcoal compositions. Rapid, prehistoric vegetation transition along with its effects on soils has also been demonstrated by MANN *et al.* (2003). Broad research by MIETH & BORK (2003, 2004, 2005, 2006, 2012) has forwarded new conclusions for an understanding of the interactions between landscape transformation, soils, and land use on Easter Island.

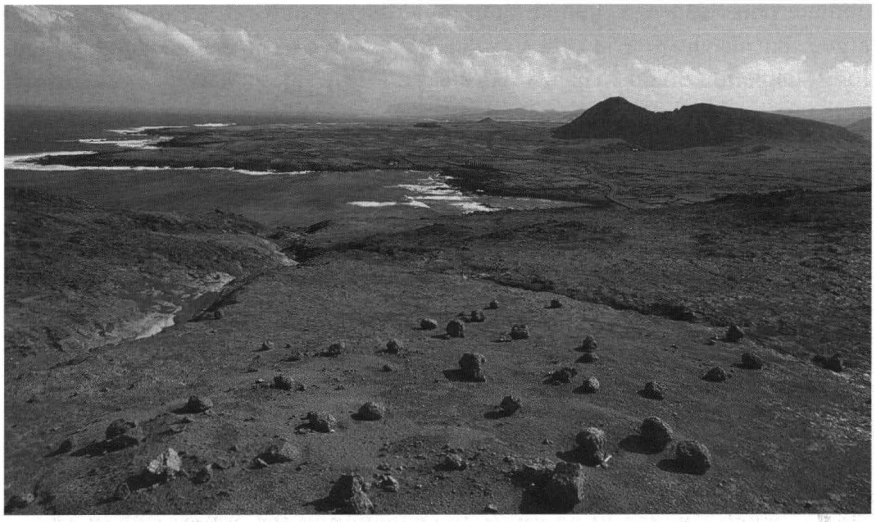

Fig. 2. — Erosion area in the south-west of Poike Peninsula.

Fig. 3. — Fallen moai at Hanga Te'e O Vaihu in the south of Rapa Nui.

In view of research results over the last fifty years, to the fact of dramatic landscape transformations is no longer disputable. Nevertheless, controversy continues as to the causes of the transformation (RULL *et al.* 2010). While the majority of scholars follow the thesis that the causes of vegetation degradation were mainly anthropogenic (MANN *et al.* 2008, MIETH & BORK 2010), some other authors present contrasting arguments. Thus, ORLIAC & ORLIAC (1998) argue that the loss of forest cover was due rather to extreme El Niño climate phases than to human manipulations whereas HUNT & LIPO (2009) argue that the Polynesian rat introduced by humans was the main cause of forest depletion. In this paper, we discuss our own finds, analyses, and answers to these theses.

A lively debate exists concerning the consequences of landscape transformation on the society and culture of Easter Island. BAHN & FLENLEY (1992) were the first to formulate a model of causal relationship between resource use, landscape change and a "collapse" of civilization. Two decades later in the third edition of their book, BAHN & FLENLEY (2011, p. 314 ff.) replace the expression "collapse" with the term "decline". Clearly, the accumulation of newer scientific data in the meantime had prompted the authors to a somewhat less dramatically drawn picture. Nevertheless, fascination with the term "collapse" has continued — the Diamond bestseller (2005) is a prime example — renewing sustenance for the image of social breakdown resulting from ecological collapse. The metaphor of the "Easter Island Syndrome" (STRIENING 2001), which apparently describes the situation of the entire earth, is strong in its effect on the public. Countless essays are devoted to the question of what knowledge can be concluded from the Easter Island "case study" of "collapse", "ecodisaster", or "ecocide" for its application to other societies. A societal collapse is often simply derived from the ecological changes and merely assumed by authors without circumstantial evidence (RAINBIRD 2002, NAGARAJAN 2006, FOOT 2007, DE LA CROIX & DOTTORI 2008, PAKANDAM 2009). Other authors inquire more critically about actual evidence for a collapse on Easter Island. CAUWE (2011, p. 96 f.) argues more for a culturally evolved development than for a collapse. HUNT (2006, 2007), HUNT & LIPO (2010), PEISER (2005), and MULROONEY *et al.* (2010) also argue against the collapse theory. These authors do not deny the dramatic transition in the availability of natural resources, but rather dispute that the degradation of natural resources led necessarily to a breakdown of society and culture. In this paper, we argue similarly, although, on the grounds of our findings, not in complete agreement with these authors in their analyses of the **reasons** for the environmental changes. We present our own research findings that speak for achievement-capable cultural phases, occurring in fact after the forest removal. Furthermore, we present the concept that there was not a breakdown

of society until the 19th century: a breakdown not due to ecocide, but due to the genocide practised by European slave traders and colonial rulers.

The question whether there was already a significant retreat in population numbers before the first European contact is also controversial (COLE & FLENLEY 2008, HUNT & LIPO 2009, FLENLEY & BAHN 2010). In this respect, it is useful to remark that neither reliable figures on the size of the early population, nor dates of its periods of fluctuations are available. Nonetheless, records of early land-use strategies can give clues to early population size. Here, we put forth reasons why, when faced with such relicts, we refute the hypothesis of a dramatic, downward population spiral during prehistoric times.

The Original Island Environment

When the first Polynesians stepped upon Rapa Nui, the island was predominantly covered with thick forest. The existence of this subtropical forest composed of over twenty species of trees and shrubs has been ascertained in pollen and charcoal analyses (FLENLEY *et al.* 1991, ORLIAC 2000). It is also certain that the forest was dominated by at least one, perhaps more, palm species that is/are today extinct and was/were closely related to the Chilean Wine Palm (*Jubaea chilensis*) which still exists in small populations on the continent (DRANSFIELD *et al.* 1984, DELHON & ORLIAC 2010). Testimony to the previous existence of the palms is given by traces left in the island's geoarchives: pollen in crater lake sediments, carbonized wood and nutshells (endocarps) in fireplaces and soil fire layers, as well as weakly deteriorated nutshells from preserving environments. A unique feature includes palm root casts in the Holocene soils: 3-7 mm thick hollow tubes that once were the root canals (fig. 4). Such root casts were recorded by BORK & MIETH (2003) over more than 80 % of the entire island area and in the latest research on Maunga Terevaka up to a height of 500 m above sea level. These pedogenic relicts verify the domination of the palms in the forest ecosystem as well as the islandwide spread of the previous palm forest (fig. 5). From density and distribution of the individual root patterns, MIETH & BORK (2004) calculated the number of palms at *ca.* sixteen million trees before the forest began to disappear.

The last representatives of the indigenous palms were most likely extinct before the first European contact in 1722. If there had been any remaining specimens at this point in time, their numbers must have been very small. Clear references to palms in the reports of mariners do not exist.

For the early Polynesian settlers of Easter Island, the palms represented a vast resource, extending in use far beyond that of firewood supply. Leaves

Fig. 4. — Root casts of the extinct palms of Easter Island.

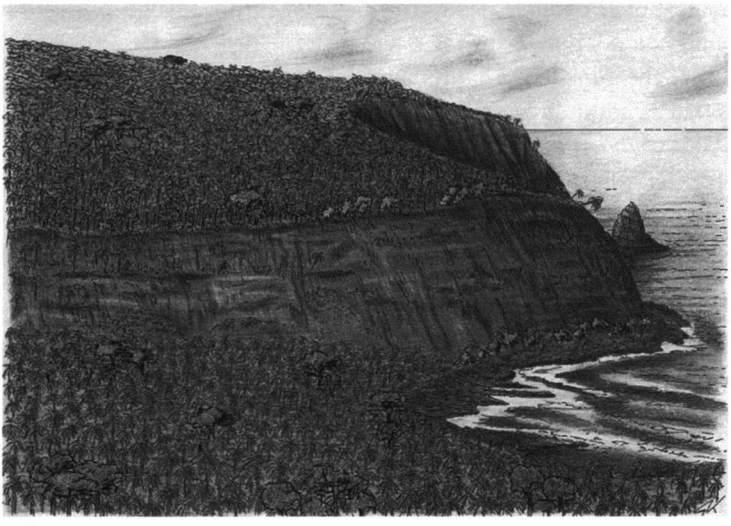

Fig. 5. — An elapsed environment: thick woodland on Rapa Nui.

and stems could have been employed as multipurpose materials. In addition, the palms themselves may have been a valuable food source in the form of large quantities of nutritional nuts and sugar-rich sap that could have been collected out of felled trunks. Of significance equal to the material resources of the trees was the entire protective ecosystem of the forest. For several hundred years, the early settlers planted their food cultivars under the roof

of the forest crown, thereby protecting crops from the hazards of desiccation, heavy rainfall, and storms. These forest gardens are evidenced clearly in geoarchives as cultivated soils and planting holes carefully arranged at appropriate distances from palm roots (MIETH & BORK 2003). Through the importation of organic material and wastes, the Rapanui were able to create anthrosols that decisively elevated soil fertility and harvests. The islandwide number of planting holes from this period of forest gardens run into the millions and provide evidence for large-scale land use before the clearing of the forest.

Forest Degradation and Related Labour Expenditure

Around 1250 AD, Easter Island began to experience a dramatic landscape transformation. Over centuries, man cleared the island of its palm forests. Associated with this clear-cutting were extensive fires that are documented by ash and charcoal strata throughout the island's geoarchives. Very often there is evidence of new land use in the form of garden sites or monumental constructions over the cleared and burned areas (MIETH *et al.* 2002, CAUWE *et al.* 2010, CAUWE 2011). Buried under colluvial deposits, MIETH & BORK (2003) found numerous carbonized palm tree stumps, demonstrating that the trees were felled before the setting of fires. Carbonized stumps and burn strata are important evidence of human action and speak against the hypothesis of palm forests destroyed mainly by rats as assumed by HUNT (2007). That distinct chronological and spatial phases of fire occurrences can be determined (fig. 6) is further evidence for human intervention and also speaks against the thesis of a climate-caused forest die-off (ORLIAC 2010).

Remarkably, apart from the carbonized palm stumps, only few fragments of carbonized palm wood have been found in prehistoric fireplaces (DELHON & ORLIAC 2010), thus suggesting that the palms were not felled for the purpose of firewood. Also, the possible main use of the logs as "technical wood" does not serve as a convincing cause for the woodland clearance. As long as the techniques are unexplained, the scale of log use in the transport of the moai or in the construction of the monumental constructions remains unclear. Alone the large number of once available trees in comparison to the number of constructions and statues discounts an overwhelming use of the trees for such purposes. Another possible reason for the felling of palms seldom discussed in the literature is that the Rapanui may have extracted the sweet sap of the palms, as has been practised in Chile for centuries with the Chilean Wine Palm (GRAU 2004, p. 128 f.). For the extraction of sap, it is necessary to cut off the top of a felled tree and renew the cut diameter by

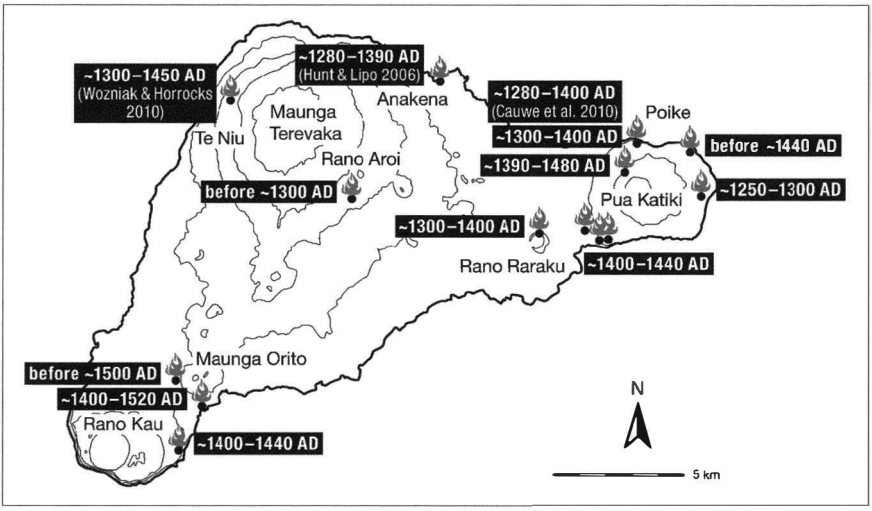

Fig. 6. — Chronological and spatial evidence of slash-and-burn activities on Rapa Nui.

repeated slicing, proceeding in this fashion until the log has been consumed (fig. 7). The liquid obtained would have been a calorie-rich nutritional drink and an alternative to the low-quality water of volcanic crater lakes and coastal brackish water sources. If the Rapanui had indeed recognized the value of the "palm honey" and made use of it, then one conclusion would

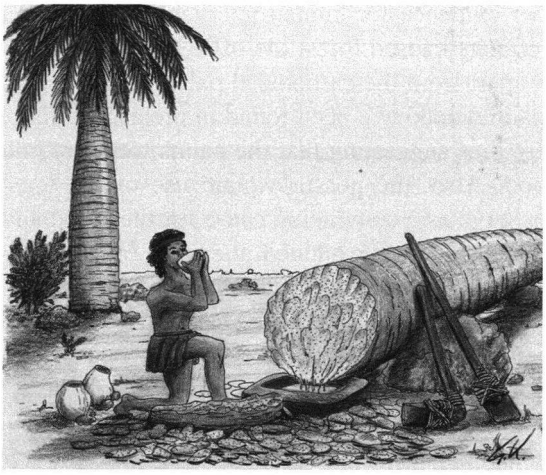

Fig. 7. — Was the intensive harvest of palm sap the driving force of deforestation?

be plausible that the palm forests were depleted for the sake of extracting palm sap (BORK & MIETH 2003).

In order to clear the forests, the Rapanui expended immense effort in labour. BORK & MIETH (2003) calculated that over a time span of perhaps eight hundred years, about four hundred people on average were daily employed in the clearing of the palms, and more during the main phase of clearing. On average, 10 % of the population or more would have been occupied in the felling and working of trees. Such labour intensity along with the demonstrable forest-clearing commencement date of 1250 AD indicate the high availability of workers needed and therefore imply a high population size. This forms an important argument against the thesis of HUNT & LIPO (2006) that the island was not settled until the late date of 1200 AD.

Ecological and Cultural Consequences of the Forest Clearing

The removal of the forest on Easter Island had serious effects on soils of some parts of the island. In large areas on the upper slopes of some volcanos, runoff during heavy rain events led to the erosion of topsoils, which were deposited downslope as massive colluvial layers, such as are exemplified on the Poike Peninsula (fig. 8; MIETH *et al.* 2002, MIETH & BORK 2003).

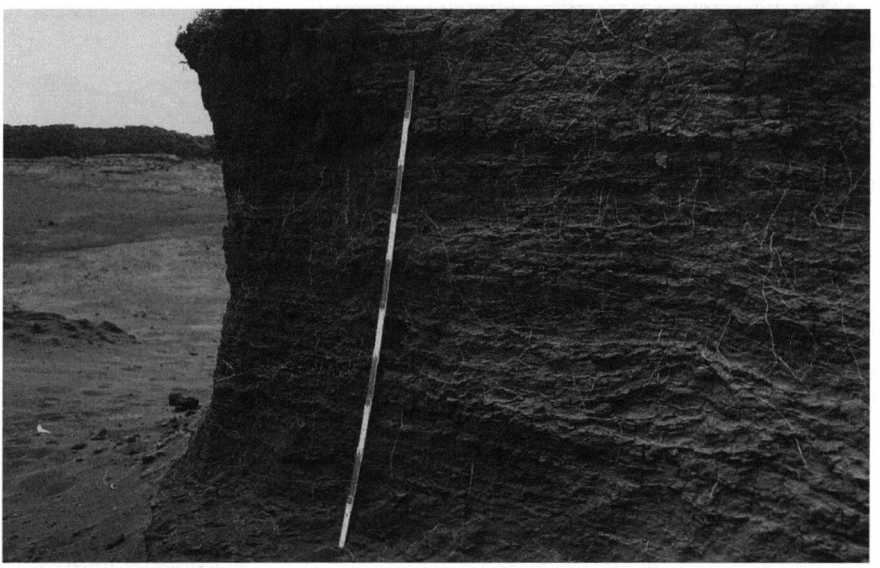

Fig. 8. — Finely-layered colluvium in the east of Poike Peninsula deposited by sheet erosion after the degradation of woodland.

Not only on Poike, but also at other sites such as Rano Kau, Maunga Terevaka, Maunga Orito and on Rano Raraku, colluvial layers document intensive phases of soil erosion dated to the time immediately after forest clearance (WOZNIAK 1998, STEVENSON *et al.* 2006, MIETH & BORK 2010). Such extensive soil erosion had incisive cultural consequences for the affected areas: garden soils were washed away and sediment depositions buried fertile soils, grave sites, and settlements, thus leading to the abandonment of these areas by their inhabitants and users. The Poike Peninsula is an extreme example demonstrating the consequences of forest clearing, where once fertile soil has been for the greater part either fully eroded or buried under thick layers of weathered volcanic rocks. For centuries thereafter, the peninsula remained uninhabited (MIETH & BORK 2003). Land uses were also

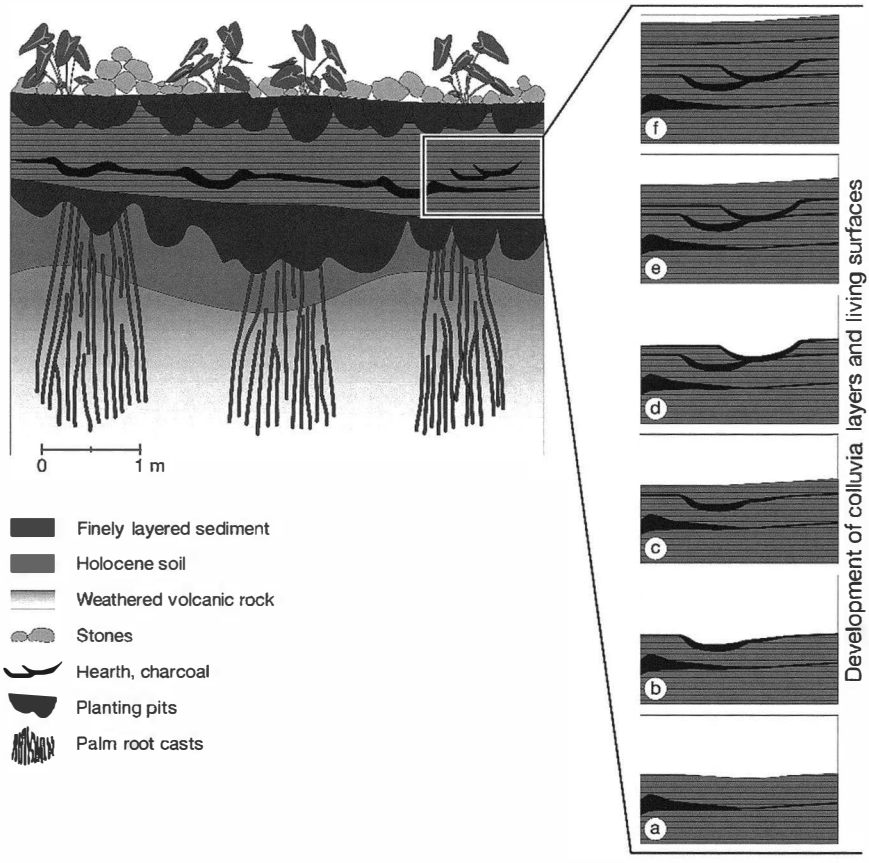

Fig. 9. — Sequence of land use at Maunga Orito (modified after STEVENSON *et al.* 2006).

altered in other places after the loss of forests. Corresponding records were found, for example, on the lower slope of Maunga Orito, where crop cultivation came to a standstill after intensive erosion and deposition occurrences. In contrast to the Poike Peninsula, land use in this area was not completely abandoned. Fireplaces lying in chronological sequence, vertically layered in colluvia, indicate human activity lasting until the early historical period (fig. 9; STEVENSON *et al.* 2006).

The Invention of Lithic Mulching and its Labour Demand

One could suppose that the destruction of the forests and the subsequent environmental effects led to a cultural collapse. Primarily, areas suitable for horticulture diminished because of soil erosion. Secondly, the resources based on the existence of the palm forest — fruits, palm honey, wood, and leaves — were missing after the deforestation. Stocks of other useful plant and animal species were either extinguished or drastically reduced. Finally, in spite of these scarcities that occurred at the latest in the 15th and 16th centuries, it was necessary to feed a population that numbered several thousands. This dilemma could have, in fact, led to a cultural breakdown if the inhabitants of the island had not developed fully new horticultural techniques. They invented and developed the technique of lithic mulching, which was the key to the preservation of their culture. There, where palms had previously protected the soil, inhabitants transferred stones of varying size to be placed over areas of cultivation in order to protect them from erosion, amounting to about 45 % of the island's surface (WOZNIAK 1999, STEVENSON *et al.* 2002, BORK *et al.* 2004, BAER *et al.* 2008) (fig. 10).

The lithic mulch cover protected the soil from wind and water erosion, improved the microclimate for the cultivars, stabilized added organic mulch substrate, protected the soil from the drying effects of the sun, and deterred weeds. Until today, the stones have continued to preserve fertile, cultivable soils, thus proving that this technique was able to compensate for the negative results of forest removal. The technique was, however, highly labour-intensive. On about five hundred test plots distributed over the island, BORK *et al.* (2004) calculated that a total of more than one billion stones rest on all lithic mulch areas, stones that were necessarily transported, distributed over the fields, and moved for each planting procedure. The authors calculated that for four hundred years, one hundred to one hundred and fifty people must have been daily occupied with the working and the distribution of stones, whereby the harvest and management of crops are not included. Such

labour would never have been accomplished under conditions of malnutrition or social breakdown. To the contrary, the post-forest clearing cultural phase was not only very innovative, but also demonstrated a high capacity for achievement. Sufficient food resources must have been available to enable such work intensity.

The establishment of the lithic mulch cover of Easter Island was significantly more labour-intensive than the erection of all moai and ahu together, a labour demand that would constitute sufficient justification for the cessation of the moai culture. The end of the moai culture was, however, not also the simultaneous end of the Easter Island culture.

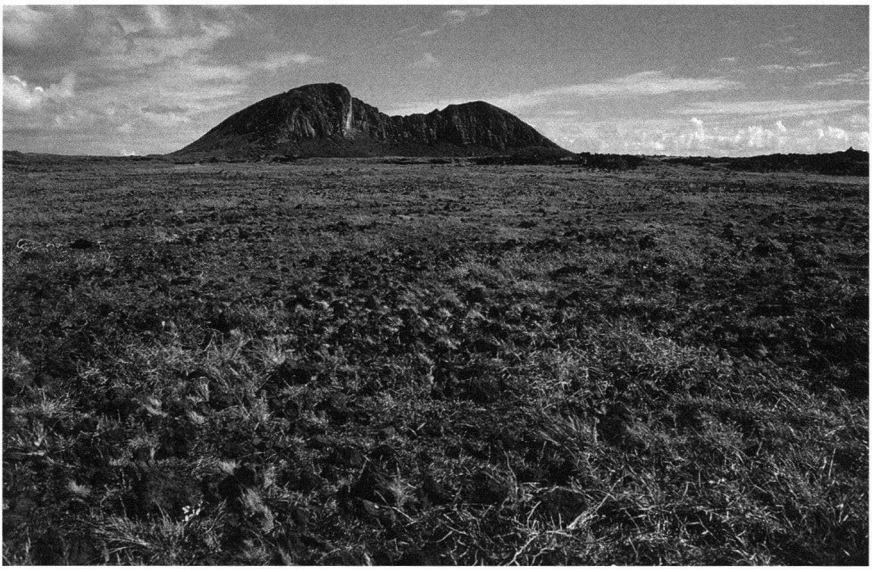

Fig. 10. — Lithic mulch garden south of Rano Raraku.

Monumental Architecture of the Post-clearing Period at Rano Aroi

Impressive new evidence for a highly developed culture — even after the loss of forests — has been delivered by the German Archaeological Institute from the southern slope of the Maunga Terevaka at Ava Ranga Uka A Toroke Hau. Since 2007, a large complex of stone constructions in the Quebrada Vaipu, a narrow valley below Rano Aroi at an elevation of 270 m a.s.l., has been annually researched by excavations. The multiphase complex is

comprised of several-meter-high and -wide support walls and immense stone-paved terraces that once traversed the entire valley (VOGT & MOSER 2010). When construction began in the 13th century, the palm forest had already disappeared. This is documented by palm root casts underneath the oldest foundation stones.

It is still unclear for what purpose the monumental construction in the Quebrada Vaipu was built. There is evidence that it served a special cult in which water was significant, spoken for not only by the special and technically demanding placement in one of the few temporarily water-carrying valleys of Rapa Nui, but by the construction of a stone-lined basin in the centre of the valley (VOGT & MOSER 2010). Further research will delve into the question whether ritualistic ceremonies in possible connection to previous forest-related environmental metamorphosis could have been practised there since there are striking references to the palms of Easter Island. An anthropogenic depot of undecayed palm nuts and other organic material was uncovered in a mud layer under the water basin (VOGT & MOSER 2010). Additionally, we recently found planting pits containing palm root casts integrated into stone pavements (fig. 11). This is a strong indication that palms were

Fig. 11. — This ahu with a fallen moai is part of the monumental architecture in the post-clearing period at Ava Ranga Uka A Toroke. The arrow indicates a planting pit with palm root casts integrated in the stone pavement in front of the ahu.

planted in the middle of what may have been a ceremonial site. Even if a functional interpretation of the monumental terrace structures at Ava Ranga A Toroke Hau has not yet been completed, the structure is exemplary of an active, highly developed culture continuing to flourish even after the loss of forest benefits and resources.

Post-clearing Period Industrial-scale Production of Pigments

Recently, in a neighbouring valley of the Quebrada Vaipu, we discovered further evidence for an intensive cultural phase that continued after the removal of the forest. There, embedded in the sediments of fluvial terraces, we found several hundred pits, measuring up to 2.4 m in diameter and 0.4 m in depth, filled with a reddish silt-like substrate (figs. 12 & 13; MIETH *et al.* 2012).

The characteristics of the reddish substrate and the large number of pigment-containing pits permit the conclusion that the place was a huge outdoor workshop for the large-scale manufacture of special pigments, dyes or paints. Wood charcoal and ash bands in the pigment fillings of the pits provide evidence that intensive burning processes played a role in the process of pigment production. Stratigraphy and radiocarbon dating results show that there were at least two post-clearing phases of pigment processing: one during the first half of the 13th century and the other approximately during the 15th century. The reddish pigment has been identified as biogenic iron oxide of high purity, extracted apparently by the burning of plants high in iron content. Our laboratory investigations yielded indications that the iron oxide was derived from the rhizomes of the totora reed (*Schoenoplectus californicus* ssp. *tatora*). This indigenous plant grows in the crater swamp of Rano Aroi (fig. 14) above the site of the pigment production. Its rhizomes (fig. 15) store concentrations of iron taken from the naturally high iron content of the groundwater.

Our experimental burning of the dried rhizomes resulted in a reddish ash high in iron that is very similar to the reddish pigment material in the pits. We conclude that Rapanui workers burned totora rhizomes to obtain this special reddish pigment. The intended use of the pigment is still unclear. The raw material quantities necessary for appreciable extraction of pigment must have been very high. The calculated total volume of all pits on the site is *ca.* 96 m^3. Alone production of 1 kg pure iron oxide would have required the input of 1.7 t of fresh totora rhizome. From this relation between input (rhizomes) and output (iron pigment) we can conclude that

Fig. 12. — Fluvial terrace in a neighbouring valley of Quebrada Vaipu. The arrows indicate pits with reddish pigment fillings.

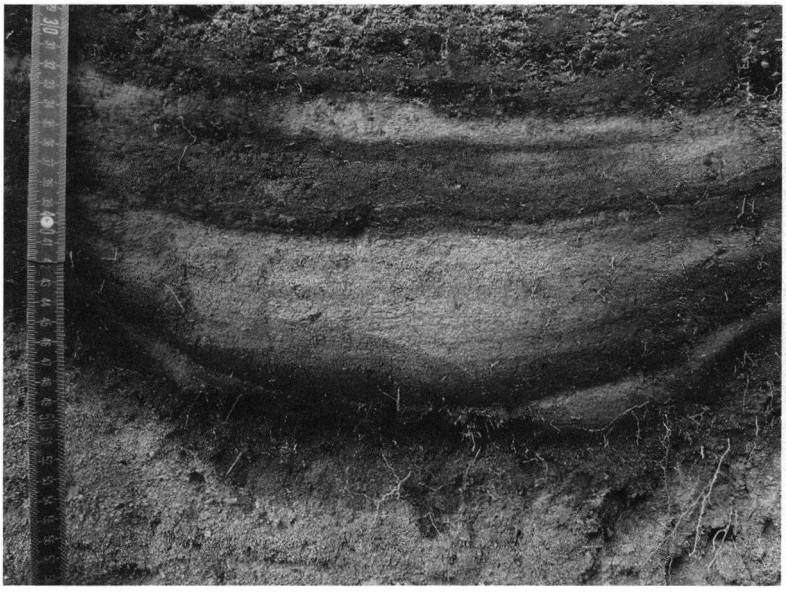

Fig. 13. — Pigment pit in detail. The filling consists of biogenic iron oxide, traversed by charcoal and phytolith bandings.

Fig. 14. — The swamp of Rano Aroi with vegetation dominated by totora reed (*Schoenoplectus californicus* ssp. *tatora*).

Fig. 15. — The rhizomes of the totora reed contain iron in high concentration. They are the assumed raw material for the former pigment production.

the harvesting of totora rhizomes in the Rano Aroi swamp must have been carried out to an exceedingly high scale. To that must be added the necessity of clearing wide areas of vegetation for the purpose of providing fuel for the burning process. As the forest in this area had been clearcut before the period of pigment production, firewood could hardly have served as a fuel source. Currently performed analyses of phytoliths found in the pit fillings deliver the first testimony that this fuel consisted primarily of grasses (LUBOS 2013).

The intensive exploitation of raw materials in the production of pigment may have led to the end of the megalithic culture in the neighbouring valley at Ava Ranga Uka A Toroke Hau. We know that in pre-contact times, the terrace constructions there were partially destroyed by a violent runoff event. This event and changes in the water regime in the Rano Aroi crater swamp were likely consequences of the degradation of vegetation cover in the catchment. This would be a further example for the seemingly conflicting, but nevertheless productive existence of a highly developed culture with an excessive exploitation of natural resources and the resultant environmental and cultural reactions.

Discussion and Conclusion: Was there a Collapse?

There are no indications for a prehistoric cultural collapse that can be arrived at by a critical evaluation of the existing research results. On the contrary, there is numerous evidence that Rapa Nui has had several cultures from the time of the first settlement until the early historical period that were both labour-demanding and labour-capable, even in conjunction with a dramatically impaired ecosystem. Labour expenditure such as that which was necessary for the creation of the ahu and the moai, for the construction of the monumental structures of Ava Ranga Uka A Toroke Hau, for the nearly islandwide establishment of lithic mulching, or for the newly discovered industry in pigment production, could only have been accomplished by a well-cared for and healthy society. In all of these cultural phases, a population of sufficient size must have been available in order to recruit the required labour force. Workers could only have borne the enormous workload if they had had continuous and sufficient nutrition. Even after the loss of forests, soil fertility over a wide portion of the island was sufficient for the production of food. Today, the stone-mulched soils demonstrate significantly higher fertility than do areas without lithic mulching (LADEFOGED *et al.* 2010). Substantial arguments for cultivation productivity sufficiently above the subsistence

minimum are supported by soil research from LOUWAGIE *et al.* (2006). The fact that the stone-mulch areas of cultivation comprise almost half of the island area underlines the further statement that a large demand for food from a large population must have existed. The Rapanui would not have spread the highly work-intensive stone-mulching method to 45 % of the island area if there had not been a large demand for horticultural produce.

On the basis of (human) physiological nutritional proxy data, there are no clues to undernourishment in the late prehistoric phase. Quite contrarily, available research on the question of nourishment, based on the micro-surface structure of tooth relicts, indicate a thoroughly sufficient and diverse supply of animal and plant foods (POLET 2011).

For us it remains certain and without question that the island population altered and transformed its own environment over centuries. The destruction of the island forests and the massive harvest of plants for pigment production are succinct examples. Unquestionably, these environmental disturbances caused survival hardships and induced resource scarcities. The local destruction of cultivated areas due to soil erosion and the forced abandonment of habitation and economically useful areas, such as happened on the Poike Peninsula, can surely be described as crises. However, ecosystem alterations and resulting resource scarcity led very likely only to temporary and local problems. Repeatedly and with remarkable resiliency, the Rapanui devised new cultural solutions to the environmental setbacks that they themselves were causing. The catastrophic crises that in fact threatened their culture and led the Rapanui society to the brink of collapse began in the 18th century as a result of European influence. Removal of nearly half of the population by slave traders, accompanied by the introduction of diseases, had reduced the society in a matter of years to a mere one hundred and ten individuals by the end of the 19th century, a society that had flourished for centuries despite all environmental obstacles. This is what finally broke the ingenious resiliency of the Rapanui and destroyed the larger part of their cultural heritage.

Productive land use, exploitation of resources, alteration of the ecosystem, and steady, adaptive response to the irreversible landscape transformation are multifarious aspects of the successful culture of Rapanui (fig. 16). Until the Europeans' arrival, the island community had been able to surmount quite admirably their own problematic ambivalences. There are no weight-bearing indices for a pre-European collapse in the sense of a societal and cultural breakdown. The terms "degradation", "diminution", or "decline" apply much better than the term "collapse" as descriptions of the ecological and economic situation after the loss of the forest on Rapa Nui.

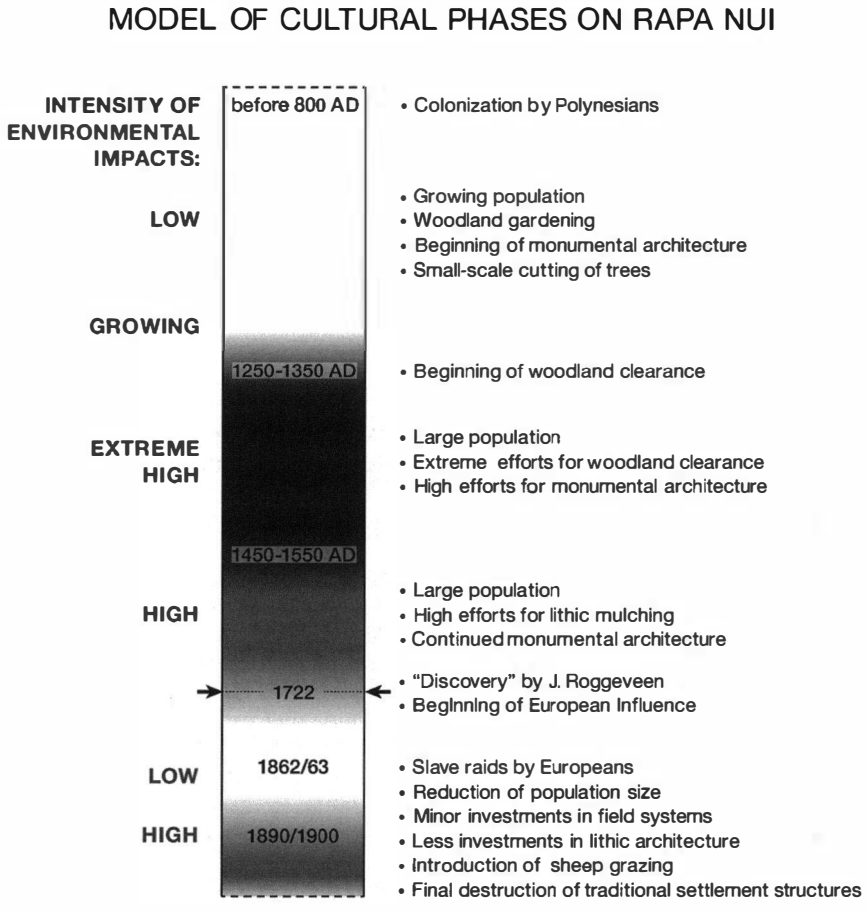

Fig. 16. — Model of cultural development on Rapa Nui.

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Starvation and Cannibalism on Easter Island? The Contribution of the Analysis of Rapanui Human Remains

by

CAROLINE POLET*

KEYWORDS. — Easter Island; Diet; Stress Indicators; Dental Microwear; Stable Isotopes.

SUMMARY. — This paper relates to the study of the ancient Easter Islanders' diet dating mainly from the 17th to the 19th century. The dietary reconstitution is based on stress indicators, dental microwear and stable carbon and nitrogen isotope analyses. The study does not demonstrate cannibalism and indicates that infantile malnutrition was far from being severe, which is in contrast to the catastrophist theories popularized by Jared Diamond. The dental microwear pattern demonstrates the dominance of tubers in the diet. The stable isotopes also show that, on average, more than one third of the dietary proteins came from the sea and that children were breastfed until they were three years old. Our results suggest gender and social status disparities in the access to food resources.

1. Introduction

The starting point of this paper is the worst-case scenario developed by several authors (HEYERDAHL 1958; YOUNG 1991; PONTING 1992, pp. 1-7) and popularized by the best-selling environmentalist author Jared Diamond in his 2005 book called "Collapse: How Societies Choose to Fail or Survive". The scenario is as follows: the Rapanui society destroyed itself by overexploiting its own resources. More precisely, the people of Easter Island destroyed their forest, degraded the island's topsoil, wiped out their plants and drove animals to extinction. As a result of this self-inflicted environmental devastation, its

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complex society collapsed, descending into civil war, starvation, cannibalism and finally self-destruction. This contribution aims to focus on two of these assumptions: starvation and cannibalism.

Retrieving information on Easter Islanders' dietary habits is not an easy task given the absence of written archives and the disappearance of the majority of the ancestral culture holders during the slave raids and epidemics of the 19th century (LAVACHERY 1935, MAUDE 1981, FISHER 2005). The main source of direct information on the diet of ancient Easter Islanders is, in fact, food waste (midden heap) and human remains. This study focuses on dietary reconstruction through the analysis of human teeth and bones.

2. Material

Archaeological surveys undertaken from the end of the 19th century on Easter Island allowed the discovery of the remains of several hundreds of individuals where often, unfortunately, only the skulls were taken. The majority were buried in monuments (*ahu*). In the ancient period (13th-15th centuries), the dead were generally incinerated and their ashes gathered in stone-lined cists located at the rear of the *ahu* (AYRES & SALEEBY 2000, HUYGE & CAUWE 2002, POLET 2003). After the deforestation, the progressive abandonment of the giant statues (*moai*) cult and their overthrow, Easter Islanders continued to bury their dead in the *ahu* but, this time, mostly in niches dug in the platform or under lying *moai* (SEELENFREUND 2000, CAUWE 2011). In addition, there were burials in caves that seem to have taken place after the discovery of the island by the Europeans (SHAW 2000). Some of them may have contained individuals who died during the great epidemics of the 19th century.

The chronological attribution of the skeletons, however, is problematic as most of the monuments were used over long periods. Moreover, dating was mainly carried out on obsidian artefacts (SEELENFREUND 2000, SHAW 2000) but rarely directly on human remains. Diachronic studies cannot thus currently be considered.

The samples studied come from twenty sites (mainly *ahu* and caves), principally dating from the 17th to the 19th century (fig. 1, tab. 1). They are composed of:

— Skulls and long bones brought back to Europe in 1935 by A. Métraux and H. Lavachery (LAVACHERY 1935). These come from the north of the island and belong to the collections of the Royal Belgian Institute of Natural Sciences (RBINS).

Table 1

Composition of the sample studied for stress indicators, dental microwear and stable isotopes (G = Gill, LM = Lavachery and Métraux, SH = Stevenson and Haoa, CH = Cauwe and Huyge)

	Site	Excavated by	Antiquity	N microwear	N stress indicators	N stable isotopes
Ahu	Nau Nau	G	end 17th-19th c.	28	41	17
	Tautira	G	?	1		
	Tongariki	G	?	4		
	Kihi Kihi Rau Mea	G	beginning 17th c.	1	14	12
	O'Nero	G	end 17th-19th c.	2	12	8
	Akahanga	G	?	5	8	6
	One Makihi	G	?	2	3	2
	Mahatua	G	?	6		13
	Hanga O Onu = La Pérouse Bay	LM	19th c. ?	3		6
	Papa Tekena	LM	19th c. ?	1		2
	Tepeu	LM	19th c. ?			2
	O Rongo	CH	end 13th c. – beginning 14th c.	2		3
	Motu Toremo Hiva	CH	end 19th c. – beginning 20th c.	1		
cave	Akahanga	G	18th-19th c.	1	4	4
	Koe Hoko	G	18th-19th c.	2	8	6
	Mahiha	G	18th-19th c.	3	6	6
	Oroi	G	18th-19th c.	6	17	10
other	Puna Marengo	LM	19th c. ?	2		1
	La Pérouse	SH	1700-1850	1		
TOTAL				**71**	**125**	**98**

— Skeletons exhumed at the end of the 1970s by G. Gill (GILL & OWSLEY 1993). These belong to the collections of the Father Sebastián Englert Anthropological Museum of Easter Island which holds the majority of the anthropological material recently excavated.

— Fragmentary human remains collected in 1996 by C. M. Stevenson and S. Haoa from cult and settlement sites at La Pérouse Bay (STEVENSON & HAOA 1998). These are housed at the Museum Sebastián Englert.

— Skeletons recently discovered by N. Cauwe and D. Huyge (HUYGE & CAUWE 2002, CAUWE *et al.* 2006, CAUWE 2011). These are housed at the Sebastián Englert Museum (except for the individual from *Ahu Motu Toremo Hiva*, which was reburied according to the demand from the local authorities).

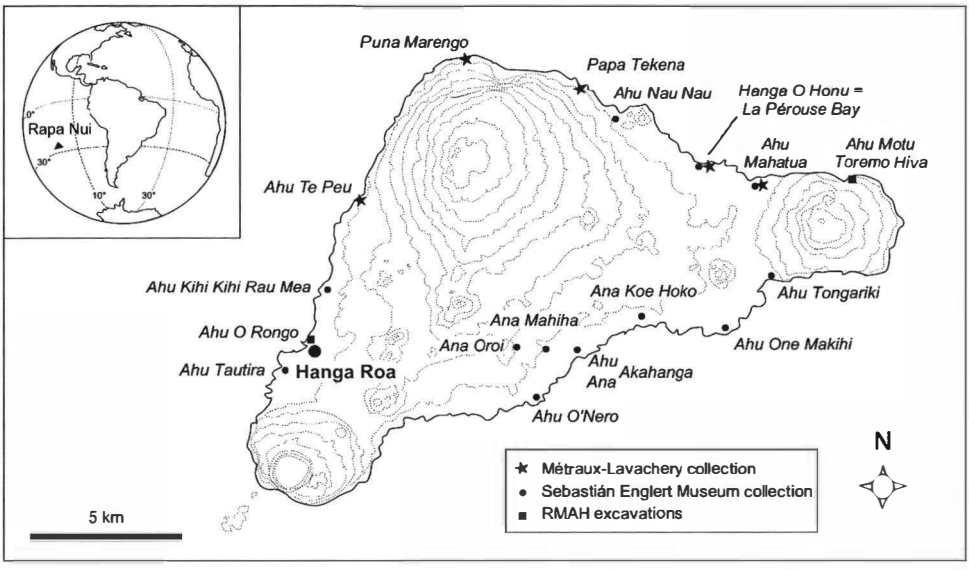

Fig. 1. — Location of Easter Island and the different sites studied (RMAH = Royal Museums of Art and History).

3. Methods

In order to bring information on the dietary habits of ancient Easter Islanders, we have recorded stress indicators and applied dental microwear and stable isotope analyses.

3.1. Stress Indicators

To get a glimpse of the general health status of ancient Easter Islanders, we have studied two skeletal markers which reveal bad living conditions during growth (stress indicators): dental enamel hypoplasia and *cribra orbitalia*.

Dental enamel hypoplasia consists of localized defects in the tooth crown (fig. 2). This is generally expressed in the form of horizontal depressions due to a temporary disturbance in amelogenesis (Goodman & Rose 1990). In most cases, hypoplasias originate from a problem of malnutrition and/or health (high fever or infection). The formation of a defect requires at least several weeks of stress. As enamel does not remodel once it is formed, hypoplasias are permanent markers left on the tooth. The presence of hypoplasia on the deciduous and permanent incisors and canines has been recorded (Polet 2006).

Cribra orbitalia is a porotic lesion in the bony orbital roof (fig. 3). It has long been strictly associated with iron-deficiency anaemia (Stuart-MacAdam

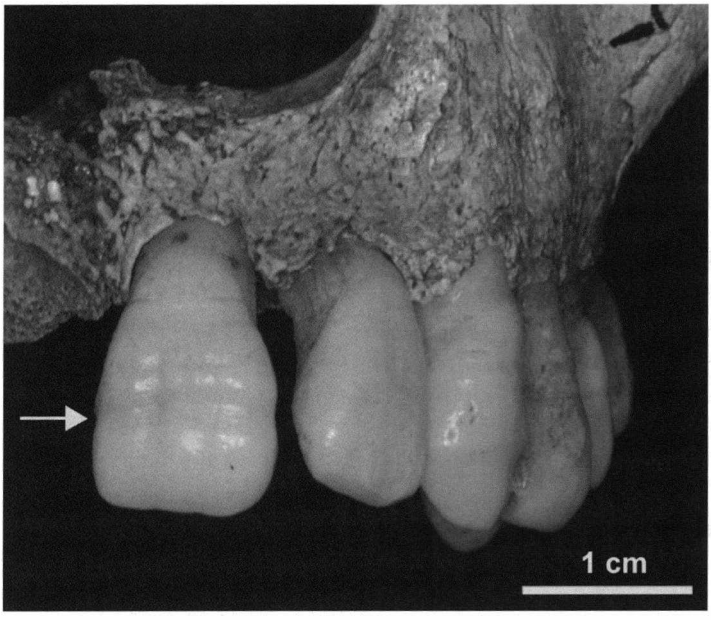

Fig. 2. — Enamel hypoplasia in a child of approximately twelve years old from Ahu O Nero.

Fig. 3. — *Cribra orbitalia* in a young woman from Oroi cave.

1992) but recent studies have shown that it can also be related to a vitamin-B_{12}-deficient diet, scurvy or chronic infections (WALKER *et al.* 2009, OXENHAM & CAVILL 2010). The presence of *cribra orbitalia* on individuals presenting at least one complete orbital roof has been recorded (POLET 2006).

3.2. DENTAL MICROWEAR

Dental microwear are microscopic scratches and pits that form on a tooth surface as the result of its use (TEAFORD 1994). The density, dimensions, as well as the orientation of these microstructures are a function of the type of food as well as its preparation (MOLLESON *et al.* 1993, LALUEZA *et al.* 1996). On the vestibular surface of the teeth, the vertical and long striations are caused by meat chewed quickly while the short horizontal and oblique striations would result from crushing harder (more abrasive) vegetal food. Vegetarians show more striations than carnivores.

Dental microwear was examined on the buccal (vestibular) surface of the first and second permanent molars with scanning electron microscopy at 178 X magnification (Philips SEM 515 of the RBINS) (POLET *et al.* 2008). The total number of striations, their length and their orientation in relation to the cement-enamel junction were recorded in a circular area of 300 µm diameter (fig. 4) using the software Microware 4.02 of UNGAR (1995) [This program can be downloaded at the following internet address: http://comp.uark.edu/~pungar/software.htm.]. The lengths were divided into ten classes with increments of 30 µm (L1 to L10) and the orientations into four classes: horizontal (0-20° and 160-180°), horizontal/oblique (20-40° and 140-160°), oblique (40-60° and 120-140°) and vertical (60-120°).

3.3. CARBON AND NITROGEN STABLE ISOTOPE ANALYSES

Carbon and nitrogen stable isotope analyses have proved to be efficient methods for reconstructing palaeodiets (TYKOT 2004, BOCHERENS & DRUCKER 2005). They are based on the fact that the differences in chemical composition between different categories of food are reflected in the bones or teeth of the consumer (in other words: "you are what you eat"). They give a direct measure of long-term diets on the individual level and consequently enable associations to be highlighted between diet and other attributes such as social status, age or sex (POLET 2008).

C and N isotopes are chiefly measured in bone (and dentine) collagen, the main component of their organic fraction. Results are expressed as isotopic ratios (= ratio of abundance of heavy to light isotopes) relative to an

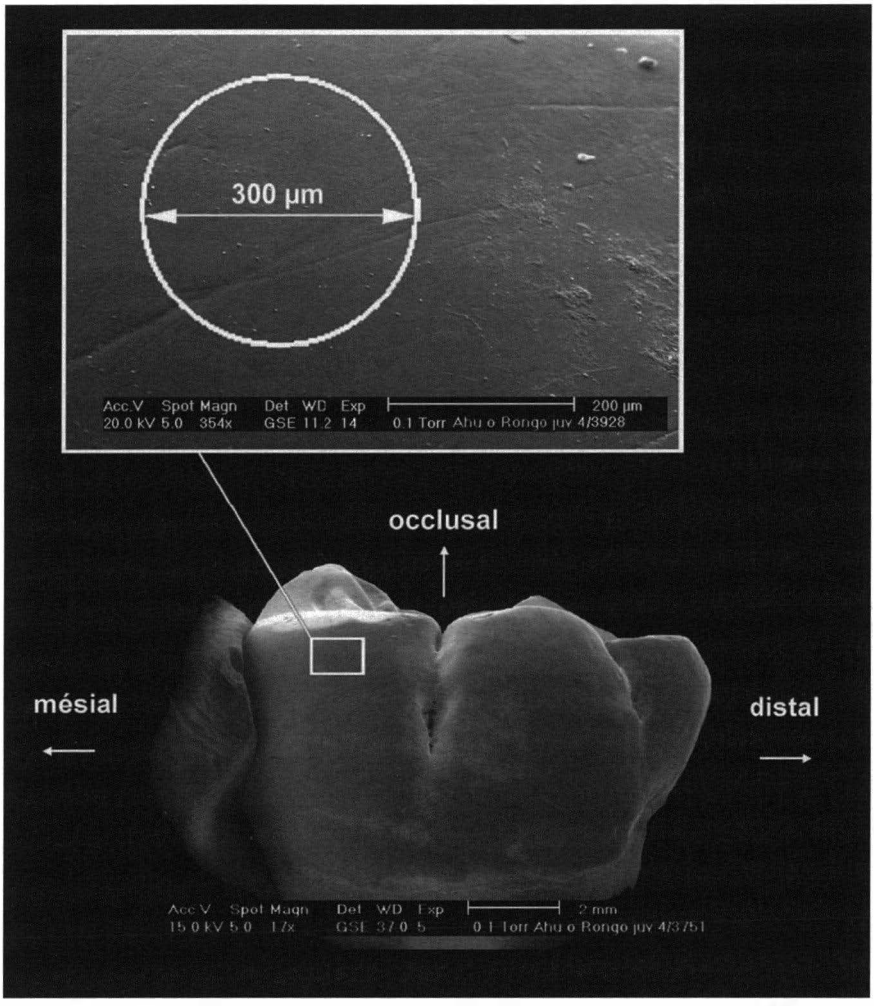

Fig. 4. — Positive replica of a molar from *ahu O Rongo* seen from its buccal side. The selected zone (rectangle) is located on the mesio-buccal cusp near the occlusal surface. Microwear was recorded in a circular area of 300 µm diameter.

international standard. They are reported as delta (δ) notation in units per mil (‰). δ is calculated in the following way for carbon and nitrogen stable isotopes:

$$\delta^{13}C\ (‰) = [(^{13}C/^{12}C)\ \text{sample} / (^{13}C/^{12}C)\ \text{standard} - 1] \times 1000$$

$$\delta^{15}N\ (‰) = [(^{15}N/^{14}N)\ \text{sample} / (^{15}N/^{14}N)\ \text{standard} - 1] \times 1000$$

δ is positive if the sample is enriched in heavy isotopes compared to the standard; a negative δ indicates the opposite.

For carbon isotopes, the internationally defined standard is V-PDB (for Vienna Pee Dee Belemnite). Nitrogen isotopes are reported relative to AIR (for atmospheric air).

We sampled 200-300 mg of compact bone with a drill. Collagen was extracted by acidic demineralization followed by a treatment to remove the contaminants (BOCHERENS *et al.* 1991). Carbon and nitrogen isotopic compositions were measured with the Finnigan MAT 252 mass spectrometer of the University of Tübingen, Germany.

4. Results and Discussion

4.1. STRESS INDICATORS

No enamel hypoplasia was observed in the seven deciduous dentitions of Easter Island. On the island of Guam, however, 12.7 % (17/134) of the individuals display this stress indicator in their primary teeth (STODDER 1997). This pathology concerns 18.0 % of the permanent teeth of Rapanui (tab. 2). *Cribra orbitalia* is present in 12.5 % of our Easter Island sample (tab. 2).

The percentage of permanent teeth with enamel hypoplasia and the percentage of *cribra orbitalia* are in the range of variation of other historic and prehistoric Pacific samples (POLET 2006) (fig. 5). These are, however, much lower than European medieval populations from the 6th to the 15th century AD (POLET 2006). The stress level of Easter Islanders was thus not higher than

Table 2
Frequencies of enamel hypoplasia (on permanent teeth) and *cribra orbitalia* in Easter Islanders

	Freq. *enamel hypoplasia*			**Freq. *Cribra orbitalia***	
	Absolute	**Relative (%)**		**Absolute**	**Relative (%)**
> 20 years	6/31	19.4	> 20 years	3/51	5.9
13-20 years	1/8	12.5	< 20 years	6/21	28.6
Male	1/19	5.3	Male	1/28	3.6
Female	4/11	36.4	Female	5/25	20.0
TOTAL	7/39	18.0	**TOTAL**	9/72	12.5

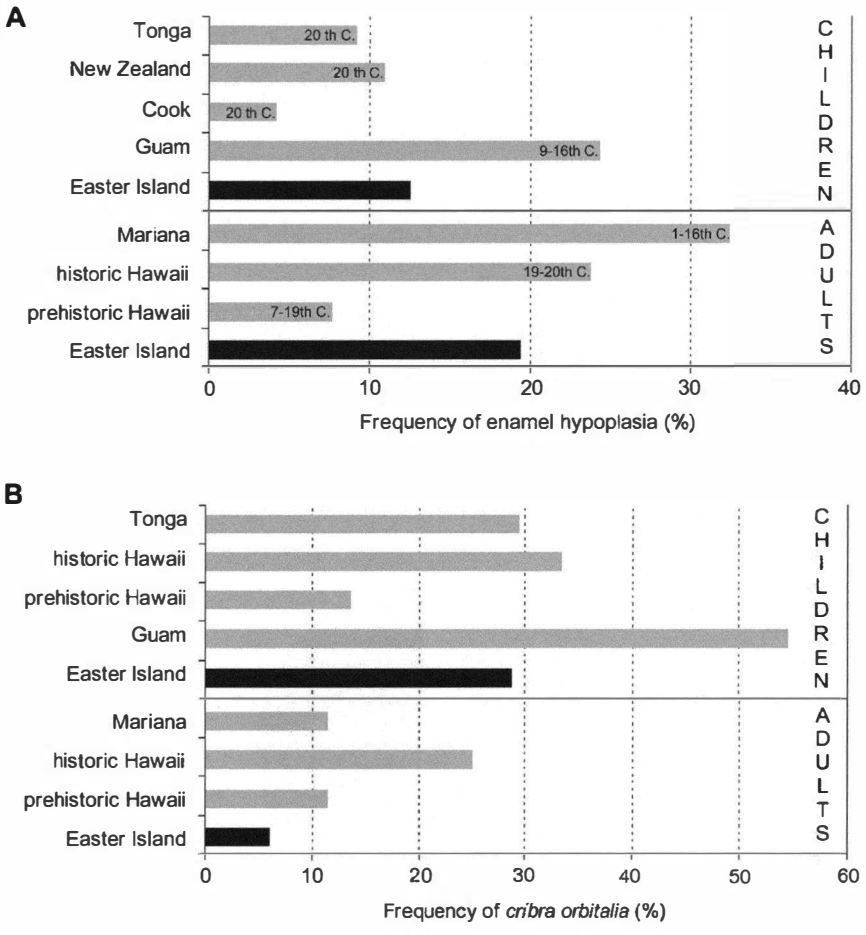

Fig. 5. — A. Frequencies of enamel hypoplasia on permanent teeth in the Easter Island sample compared to those collected in seven archaeological and extant Polynesian samples (POLET 2006); B. Frequencies of *cribra orbitalia* in the Easter Island sample compared to those collected in five archaeological Polynesian samples (POLET 2006).

that of other ancient populations of the Pacific but it was lower than that of European mediaeval populations.

Within the Rapanui sample, women show significantly higher hypoplasia frequencies than men (tab. 2). This leads to the assumption of a preferential investment in boys (GUATELLI-STEINBERG & LUKACS 1999) as the tooth crown records stress events that occurred during its formation, *i.e.* childhood.

The percentage of *cribra orbitalia* is higher in children than in adults (tab. 2), as in many other populations (POLET & ORBAN 2001, p. 120; PIETRUSEWSKY *et al.* 1997). This result could be explained by the healing and disappearance of the lesions with age.

4.2. DENTAL MICROWEAR

In the sampled circular area, the total number of microscratches of Easter Islanders varies between 21 and 119 with an average of 53.9 features (or 77 scratches/mm²). Their average length is 50.9 µm. The majority of the scratches belong to the class L1 and L2 (1 to 60 µm). The first two classes alone gather 75 % of all the features. The horizontal orientation is predominating (33 %) (fig. 6). The horizontal, horizontal-oblique and oblique striations total 82 %.

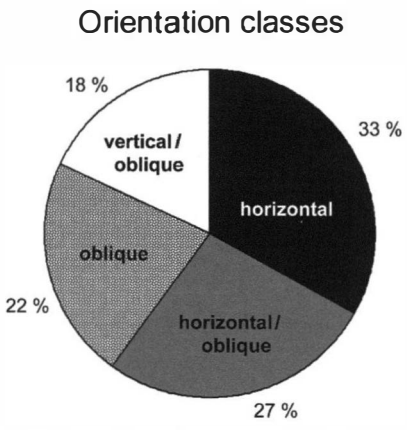

Fig. 6. — Distribution (pie-chart) of the Easter Islanders' micro-striations in four orientation classes (horizontal, horizontal/ oblique, oblique and vertical/oblique).

In summary, Easter Islanders are characterized by very few features, by short and mainly horizontal or oblique scratches. If one refers to studies carried out on individuals of known diet (LALUEZA *et al.* 1996), the first results indicate a diet with a prevalence of carnivorous food, the second and the third ones a prevalence of herbivorous food. So, there is a contradiction. This may be removed if the abrasiveness of the plant component of the diet is low. This result can be related to the dominance of the sweet potato (*Ipomoea batatas*) in their daily meals as stated by historical (POLLOCK 1993, FLENLEY 1993),

ethnographical (ROUTLEDGE 1919, METRAUX 1971) and archaeobotanical (FLENLEY 1993, CUMMINGS 1998) data. The high percentages of caries recorded by OWSLEY *et al.* (1983, 1985) confirm this hypothesis because sweet potato and other tubers eaten by Easter Islanders (taro, yam and arrow-root) are rich in starches and highly cariogenic (LINGSTROM *et al.* 2000).

There is unfortunately no dental microwear study of other Polynesian populations. So, we have decided to compare our group with samples studied by GARCIA-MARTIN (2000). These are individuals from Belgium belonging to the collections of the RBINS: Neolithics from the Meuse Basin (end of the 5th millennium – first half of the 3rd millennium before our Era), mediaeval individuals from the Dunes abbey of Coxyde (12th-15th c.) and from Ciply and Torgny (6th-7th c.). Compared to these samples, Easter Islanders display a small total number of striations. Furthermore, multivariate statistical analyses based on the length and the orientation of the scratches have revealed that the microwear pattern of Easter Islanders shows the most similarity with that of the Cistercians of Coxyde (POLET *et al.* 2008) where marine fish consumption is attested. This ichtyophagy is confirmed by marine faunal remains (STEADMAN *et al.* 1994, AYRES *et al.* 2000) and fishing implements (LAVACHERY 1935, AYRES 1985) discovered in Easter Island's archaeological sites.

Within our adult sample, we did not observe any sex or age-related differences in microwear pattern (POLET *et al.* 2008).

With regard to social status, our study shows that *Ahu Nau Nau*, the royal *ahu*, can be distinguished from the other sites according to its dental microwear (POLET *et al.* 2008). It is characterized by a lower number of striations and fewer short features (0-30 μm). A greater meat and/or fish consumption could be the cause of this distinction.

4.3. CARBON AND NITROGEN STABLE ISOTOPE ANALYSES

We present here the results for ninety-eight Rapanui individuals. Their isotopic ratios are plotted in figure 7 and compared to data of animals with known feeding strategies. Easter Island humans are located between the values of the terrestrial and the marine reference ecosystems. To estimate the proportion of marine food in their diet, we have applied the linear mixing model of MAYS (1997) based on carbon isotopes. In this model, an entirely terrestrial diet leads to a value of –21.5 ‰ and a wholly marine-based one to –12 ‰. The contribution in marine products for Easter Islanders varied between 11.1 and 63.2 %, with an average of 33.7 % [The actual proportion of marine food in their diet must have been rather lower since collagen is preferentially produced from dietary proteins (AMBROSE & NORR 1993)]. It would be nevertheless

informative to analyse animal remains coming from archaeological sites of Easter Island in order to establish a local faunal reference frame.

We have compared our isotopic data with those coming from other Pacific islands: Fiji studied by VALENTIN *et al.* (2006) and Marianas studied by AMBROSE *et al.* (1997). On the basis of the $\delta^{15}N$, Easter Islanders are located approximately one trophic level higher than the inhabitants of Fiji and Marianas (fig. 7). As they do not present higher $\delta^{13}C$, we can propose that they consumed more terrestrial animal proteins, such as chickens, rats and eggs, than the other Pacific islanders.

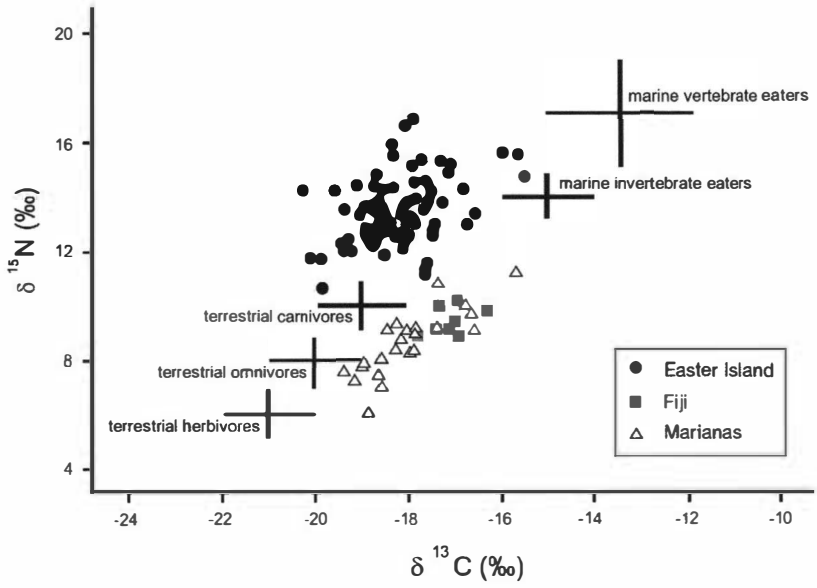

Fig. 7. — Bivariate plot of $\delta^{15}N$ and $\delta^{13}C$ values from animals of known feeding strategies (data from SCHOENINGER & DENIRO 1984), ancient inhabitants from Easter, Fiji and Mariana islands.

We have also investigated if there were any trends within our Easter Island sample.

We have compared the individuals buried in *ahu* with those buried in caves. They do not display significant differences in their isotopic signals (tab. 3). On the basis of stable isotope analysis, we can state that there were no noteworthy differences in diet between these two samples.

If we examine the isotope distribution according to sex (adult individuals), we can observe that males display higher carbon and nitrogen isotopic values than females (fig. 8 and tab. 3). This difference is significant for $\delta^{15}N$ and

Table 3

Statistical parameters of the comparison of isotopic signatures ($\delta^{13}C$ and $\delta^{15}N$ in ‰) between individuals buried in *ahu* and those buried in caves, between males and females (NS = not significant, *** = very highly significant)

	Ahu			**Caves**			**Student's t-test**	
	N	**Average**	**Standard deviation**	**N**	**Average**	**Standard deviation**	**p**	**Significance level**
$\delta^{13}C$	73	-18.3	0.81	25	-18.1	1.01	0.33	NS
$\delta^{15}N$	73	13.4	1.22	25	13.4	0.99	0.91	NS
	Males			**Females**			**Student's t-test**	
	N	**Average**	**Standard deviation**	**N**	**Average**	**Standard deviation**	**p**	**Significance level**
$\delta^{13}C$	31	-18.1	0.85	25	-18.5	0.67	0.08	NS
$\delta^{15}N$	31	13.6	0.85	25	12.9	0.42	0.00015	***

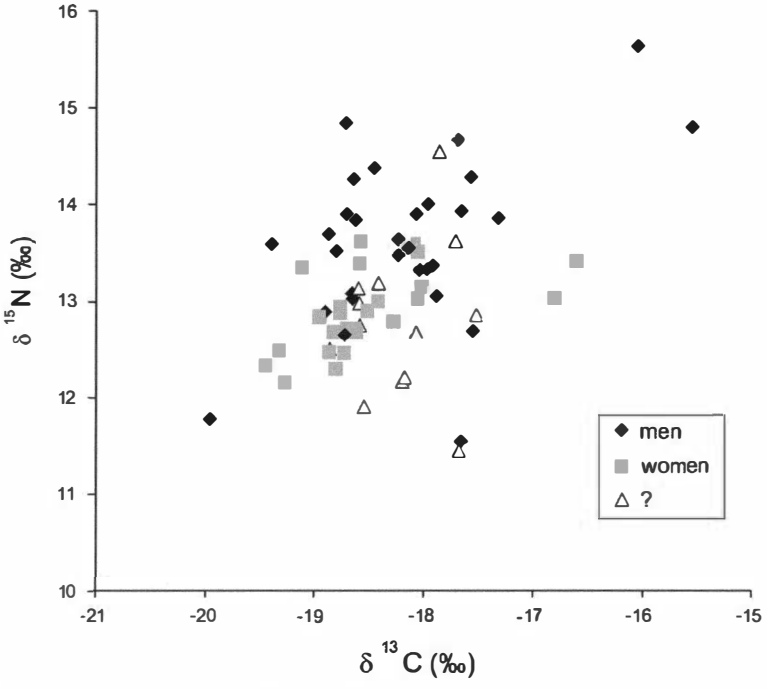

Fig. 8. — Bivariate plot of $\delta^{15}N$ and $\delta^{13}C$ values from males, females and individuals of unknown sex from Easter Island.

indicates that they had a higher intake in terrestrial animal proteins than women.

We have also studied the isotope distribution according to age at death (fig. 9). We have divided our sample into four age categories: 0-3 years, 4-11 years, 12-18 years and adults. Individuals who display the highest nitrogen isotopes belong to the first category. This can be explained by the fact that they were breastfed. In consuming mother's milk, a human product, babies are one trophic level higher than their mother. Two young children are exceptions: a two-year old individual who was probably already weaned and a baby who probably died at birth without consuming any mother's milk. The diet of the children of four years or more is more or less similar to that of adults.

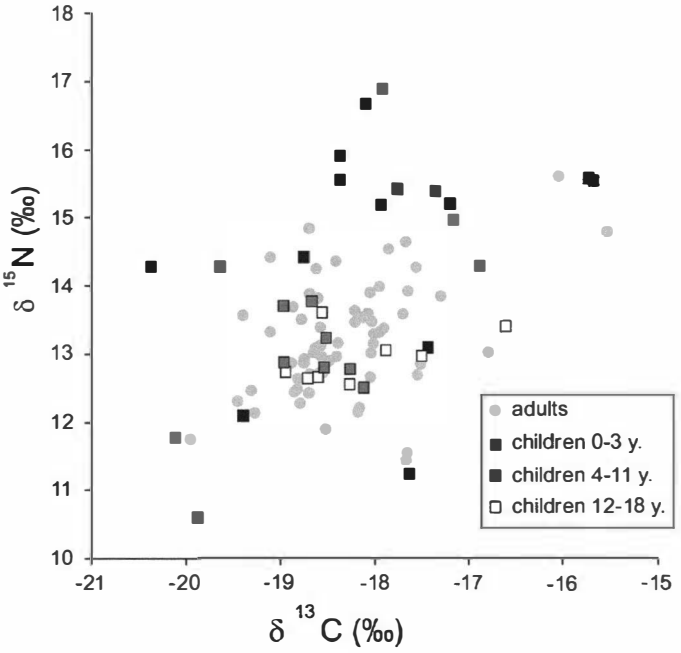

Fig. 9. — Bivariate plot of $\delta^{15}N$ and $\delta^{13}C$ values from Easter Islanders belonging to different age categories.

The distribution of isotopic signatures according to the site of origin has also given interesting results. There are clusterings of individuals according to their provenance (fig. 10). The individuals from *Ahu Nau Nau*, which is said to be the royal *ahu*, display the highest value of nitrogen and carbon isotopes. Those from *Ahu Kihi Kihi Rau Mea* are among the lowest values even if they were supposed to be members of the same clan as the royal *ahu*.

Members of a clan thus did not seem to have eaten the same food. However, the tribes territory boundaries were recorded as late as the 20th century (ROUTLEDGE 1919) and one can therefore doubt their reliability.

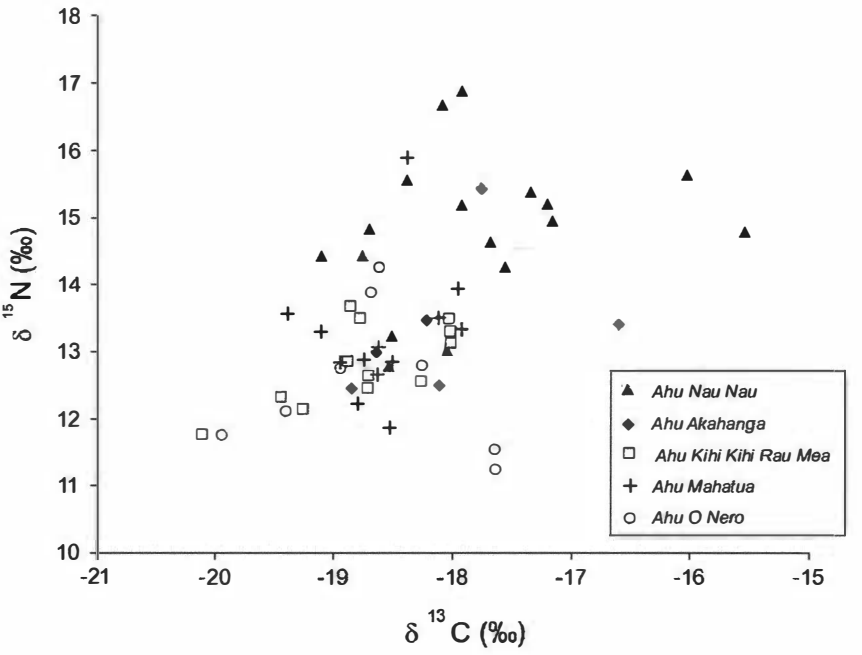

Fig. 10. — Bivariate plot of $\delta^{15}N$ and $\delta^{13}C$ values from Easter Islanders coming from different *ahu*.

5. Conclusion

The aim of this study was to document the diet of ancient Easter Islanders mainly dating from the 17th to the 19th century. Dental microwear confirms that tubers were their staple food. Stable isotopes indicate that on average more than one third of their proteins came from the sea. They also show that Rapanui people had a higher intake in terrestrial animal protein than other Pacific islanders. No evidence of cannibalism was found (if we except the fact that a nursing infant eats a human product!). Stress indicators show that child malnutrition was far from severe. These results are in opposition to the catastrophist theories (chaos, wars and famines following the deforestation) popularized by DIAMOND (2005, pp. 79-119).

Within our sample, we observed sex differences in stable isotopes revealing that women ate significantly less terrestrial animal products. Stress indicators also suggest gender disparities in the access to basic resources, resulting from a preferential investment in sons. We have shown that children were breast-fed until three years old. With regard to social status, our study shows that the "royal *ahu*" can be distinguished from other *ahu* on the basis of its stable isotopes. A greater marine product consumption could be at the origin of this distinction.

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The End of the Moai – Did they Fall or Were they Pushed?

by

Paul BAHN*

KEYWORDS. — Moai; Toppling; Earthquakes; *Mata'a*; Conflict.

SUMMARY. — The paper examines the wide range of explanations that have been put forward to account for the toppling of the statues of Easter Island. Some were purely speculative, others based on oral traditions. Archaeological excavation has begun to shed light on the phenomenon, and although there may have been multiple factors at work, the bulk of the evidence points clearly to the toppling being deliberate acts of violence and warfare at a time of great conflict which is attested not only in numerous oral traditions but also in artifacts and skeletal data.

Introduction

It has always been known that many of the Rapa Nui statues or *moai* were erected on platforms around the island, and that they all eventually came down. Doubt remains about the explanation for this phenomenon of toppling the statues. From the 1774 visit of Captain Cook onwards, a wide variety of causes has been suggested, some purely speculative, and others based on oral traditions. In recent decades, archaeological excavation has also begun to shed light on — or at least provide new data concerning — this phenomenon, and an active debate persists. Were the statues brought down by natural factors, or were they all deliberately toppled by humans, and — if the latter — did this involve vandalism and warfare, or was it purely a peaceful activity forming part of the long-standing tradition of constantly rebuilding and modifying the platforms? There may, of course, have been multiple factors at work, but nevertheless the bulk of the evidence currently available points clearly to one particular explanation.

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Possible Natural Factors

The main theory concerning natural factors is that of earthquakes. This was first put forward by J. Forster on Cook's expedition of 1774, who said of fallen statues at Vinapu that they could have perhaps been toppled by an earthquake (FORSTER 1996, p. 111): "It should therefore seem that since that time [of Roggeveen's voyage] some disaster had befallen this spot... and thrown down many of the huge stone pillars, for we found several on the ground. Perhaps this happened in 1746 when Lima and Callao suffered so much by an earthquake". Later, AGASSIZ (1900, p. 33) suggested that some kind of volcanic catastrophe could have been the cause, with volcanic eruptions and great earthquakes destroying the monuments. Subsequent work by geologists has proved that no volcanic eruptions have occurred on the island since long before human arrival. The earthquake idea has persisted, however — for example, geologist Oscar González-Ferrán pointed out that Easter Island is in a very active earthquake zone; and since 80 % of the *moai* have fallen to the west, he speculated that they were toppled by an earth tremor (GONZALEZ-FERRAN *et al.* 2004). The idea has been promulgated most recently by EDWARDS *et al.* (1996) who claim that "natural events of this nature would have produced a profound effect on Polynesian inhabitants in the past" — this is certainly true, which is why the complete absence of any mention of earthquake damage in the island's oral traditions tends to disprove the theory from the start! In addition, it should be noted that none of the frequent earth tremors which have hit the island in recent decades has had the slightest effect on the many re-erected statues — for example, in 1987 a 6.3 magnitude quake hit the island, but no statues came down! The same applies to thirteen quakes in the region in June 2005, of 5.7 or less, and another three hundred miles to the west in May 2006, of 5.6 (BAHN & FLENLEY 2011, p. 246).

Edwards was told by elders in the 1960s that their parents and grandparents had felt tremors. "When asked if these earthquakes had knocked down the statues, they mentioned that they did not know exactly how they had fallen, except for those on Ahu Tongariki, which had been thrown down by an evil priest... Others owed their fate to a battle between the gods that took place one night in the remote past, or to witchcraft" (EDWARDS *et al.* 1996, pp. 3-4).

There is indeed a slight possibility that the Tongariki statues might have fallen due to a tremor, for the simple reason that none of the first European visitors mentioned this huge imposing platform, even though the Spanish, for example, sailed past that part of the coast — which suggests that its statues

were probably already down by 1770 (BAHN & FLENLEY 2011, pp. 243-244). In any case, EDWARDS *et al.* (1996) chose to interpret the Tongariki story in that way. METRAUX (1971, p. 87) recorded one version of the tale: "A priest came down from Virivovo. He entered a house near Vai-maho. The men and women living in the house had eaten all the fish, the lobsters and the congers without leaving anything for him... with his foot he pushed the supporting post of the house. The inhabitants of the house heard a loud noise, made by the falling statues of Ahu Tongariki. At dawn the men of this house said, 'When we were asleep the priest pressed the post with his foot and caused the statues to fall. It is because we did not give him fish, conger and lobster'. ROUTLEDGE (1919, p. 173) had a different version from another informant, in which the priest tapped his foot against the stone foundations of the house, thus causing the statues on Tongariki to fall. On the other hand, GEISELER (1995, p. 35) in 1886 reported that "they attribute the collapse of the idols to a nocturnal battle among the gods when the stronger gods chopped off the heads of the weaker ones" — a tale which provides no evidence either for or against earthquakes!

Man-made Factors

Since, with the possible exception of Tongariki, there is absolutely no evidence for quakes having brought down the statues, then humans must be the cause. Leaving aside the bizarre and silly suggestion made recently by HUNT & LIPO (2011, p. 153) that "in some cases toppling of statues may have been purposeful, but many more likely came down as a result of inattention and lack of maintenance", the basic question arises of whether the toppling was done peacefully or aggressively.

It has long been known that the island's history is filled with platforms being "constructed, utilized, abandoned, refurbished, and *moai* fragments were recycled into the fill of the reconditioned *ahu*" (STEVENSON 2012, p. 76). The final lowering of the *moai* was a process that took at least a century.

We have a rough idea of when the islanders began to topple the statues; neither Roggeveen in 1722 nor González in 1770 mentioned having seen fallen statues; the Dutch saw only a small part of the island, but the Spanish saw considerably more, so it is a fair bet that all *moai*, or very nearly all, were still upright in 1770 (except possibly Tongariki — see above). Only four years later, however, when Captain Cook arrived, the situation was very different: he was the first to report that many statues had been overturned

next to their platforms, and that the monuments were no longer maintained. Skeletal material was now strewn about the figures. One platform (probably at Vinapu) had three fallen and four upright figures, one of the latter having lost its headdress. According to Cook, his men "met with three platforms of stone-work, or rather the ruins of them. On each had stood four of those large statues, but they were all fallen down from two of them, and also one from the third; all except one were broken by the fall, or in some measure defaced" (cited by HEYERDAHL 1961, p. 55). Forster Senior, who participated in this exploring party, indicated wilful destruction, as he used the expression that several of the statues "had been overturned" (HEYERDAHL 1961). In 1786, Lapérouse reported that "some were fallen down, the natives taking no care to repair them" (HEYERDAHL 1961, p. 64).

Four statues were still standing in Hanga Roa (Cook's) Bay, and seven at Vinapu, when the Russian Lisjanskij visited in 1804 (he saw at least twenty-one upright statues altogether, on at least eight different monuments), but his compatriot Kotzebue found them toppled in 1816 except for two survivors at Vinapu; all monuments on the Bay had been totally destroyed by 1825. The last eye-witness account we have of standing statues on the island is that of the French admiral Abel Dupetit-Thouars in 1838 who, on the west coast, saw "... a platform on which were set four red statues, equidistant from one another, their summits covered with white stones". By 1868 the visiting English surgeon Linton Palmer reported that not a single *moai* remained upright, and the missionaries of the 1860s scarcely mentioned the statues at all. So between 1722, when the Dutch thought the statue cult was still underway, and 1774, when Cook thought it a thing **of** the past, something drastic had happened.

The Peaceful Version

CAUWE (2011, p. 72), in his excavation of Ahu te Niu, encountered a fallen statue which seems to form the roof of a tomb in the platform, and on the basis of this example, and a dozen others which he claims to have found elsewhere (pers. comm.), he has argued that all the statues were carefully lowered to the ground to be re-used in different ways. However, one might point out that, throughout the island's history, fragments of statues were constantly used in wall construction and platform-fill, so in fact it would have been a great help to the islanders to have them shatter into pieces when they fell — surely they were not all destined to be tomb roofs! As Cauwe (2001, p. 69) himself admits, "un peu partout, des chambres funéraires sont

aménagées dans les monuments sans qu'il ne soit nécessairement fait appel à des *moai* pour en assurer la fermeture". So one could argue that the examples he has encountered in Ahu te Niu and elsewhere are highly exceptional.

The archaeologist with the most experience in excavating the island's platforms was undoubtedly William Mulloy, so it is well worth looking at what he wrote about his findings at Vinapu (MULLOY 1961, p. 97): "The removal of these stones left the fragments of the three northernmost statues and the ramp side of the central section wall in a precarious and dangerous condition, just as they were at the time the statues were thrown down. Much of the ramp side of the central section of the *ahu* wall had come down with the statues... [he had to stabilise the statues by building continuous walls under them around their peripheries]... some [burials] were thrust into crevices under the statues which were closed with stones. During later phases of this activity, depressions were scooped out among previously placed stones for later burials, thus disarranging earlier interments. This disturbance was so great that no valid stratigraphic information could be recovered". Regarding the statues (MULLOY 1961, p. 109), "all were tipped landward, lay face down, and could not be moved with the means at hand. The three northernmost were badly broken and eroded, and the three southernmost were partly covered by the Late Period structure built around them".

Mulloy related in great detail the complex history of building and rebuilding of Vinapu, with periods of abandonment and erosion. Concerning the use of the monument after the toppling of the *moai*, he wrote (MULLOY 1961, pp. 112-114, 159): "The first activity at the *ahu* after the fall of the statues appears to have been the construction, in the protected area under the three southernmost statues, of [an] enclosed structure. The rubble was cleared away from under the statues and openings at either end... Evidence of use as a tomb is inconclusive. The charcoal in the floor suggests habitation. Perhaps it served at different times as both. It might have been occupied by refugees after the sack of Vinapu. The sturdiness of the structure, the unnecessary thickness of the west wall, the parapet, and the tiny entrances deliberately narrowed on the inside, as if to inhibit rapid passage of an intruder, all vaguely suggest some kind of defensive purpose... Unless the previously described enclosure is a tomb, no evidence of tombs or vaults was recovered... The function of the ahu appears to have differed in each period, apparently serving as an altar in the Early Period, a base for statues in the Middle Period, and a burial place in the Late Period. They were reconstructed and modified to suit requirements".

Mulloy was in absolutely no doubt that the demolition of Vinapu involved violence (MULLOY 1961, p. 111): "A usual feature of these hostilities was

the pulling down of statues on enemy *ahu*. There is ample evidence of violence at Vinapu during this period, both at the *ahu* and in the villages... Local stories say that statues were pulled down by means of ropes about their necks, or by undermining their bases by digging away the walls below them. Both methods could have been used at Ahu No. 1. The condition of the rampside wall and core, where the two northernmost statues stood, indicates that they might have been undermined. Enough of the base of the great statue next to the south remains level to suggest that another method may have been used here. The base of the second from the south still remains level and solidly placed without evidence of undermining. All the statues were tipped landward... The statues were badly broken either by the fall or by subsequent vandalism... The third statue from the south had the top of its head broken into two pieces. The other remained unbroken. The southernmost statue came to rest alongside, with its base supported on a pile of collapsed core at an angle almost equal to that of its neighbors, thus providing a space under it also. It was broken transversely across the neck... This destruction probably could have been completed in less than an hour by a determined group of enemies... it effectively destroyed the *ahu* in such a manner that its reconstruction would have been a major undertaking... The most insurmountable obstacle would seem to have been the statues themselves. Only one could have been re-used. All the others would have had to be replaced... The traditions and historical information suggest that the hostilities covered a considerable period of time, and that never again did conditions of peace and organization sufficient to make reconstruction possible prevail, until contacts with Europeans had produced enough cultural changes to destroy the motivation".

CAUWE (2011), on the other hand, believes that the positioning, torso-breakage patterns, and lack of damage to the face argue for a gentle lowering of all statues, thus symbolically changing the *ahu* and their surroundings from socio-religious precincts to burial mounds and necropolises. But, as STEVENSON (2012, p. 77) has pointed out: "How does one reconcile the broken statues on the ramps of the *ahu* with that of proposed gentle handling? Cauwe introduces the concept of 'flexion' or that of material stress and eventual fatigue as the head of the prone *moai* is elevated above the ground for a prolonged period before it simply drops off. A fuller argument with a consulting engineer will likely be required to convince a skeptical readership". I doubt that anyone seeing the broken statues at Vinapu and other platforms could agree that gentle handling followed by stress and fatigue can possibly account for their condition, as Mulloy showed so convincingly.

CAUWE (2011, pp. 60-65) also emphasizes the fact that the *pukao* or headdresses are often intact, but these are huge solid pieces of rock, which may have fallen onto soft earth. A fall of only a few metres would be most unlikely to have shattered most of them. And if, as Cauwe believes, it was important to preserve the statues' faces, why were they not lowered onto their backs, instead of thrown down into a prone position? He also claims (p. 65) that some people have thought the statues came down like dominoes or "des soldats de plomb", but I am not aware of anyone having made that suggestion; nor do I understand how the fact that two statues were brought down at the same time can be seen as evidence against the use of violence (CAUWE 2011, pp. 66-67).

The Evidence for Violence

Those who propose a peaceful (or a natural) toppling of the statues tend to minimize or brush aside the evidence found in oral traditions for violence and warfare: for example, EDWARDS *et al.* (1996, p. 2) claim that "only one tale mentions that the statues were toppled during inter-tribal warfare", and as for traditions that mention how a statue was deliberately thrown down (pp. 3-4), "the earliest reports of destruction during warfare can be attributed to Father H. Roussel, the first priest to live on the island. He apparently believed that everything had been destroyed during wars although the other missionaries with him on the island do not mention this possibility... tales describing strife are quite common and well remembered by the older generation. The many accounts they told about warfare described events with utmost precision... they related... how the statue Ahu te Pito Kura was thrown down during one of these battles".

This latter story was also documented by ROUTLEDGE (1919, p. 173) who even gave the names of those who overthrew the statue in c. 1835-1836 and the group to which they belonged: "The vandals were the group of the Tupahotu-o-uta, who had a grudge against the Tupahotu-oone, another ramage of the same group, over the death of a woman that had been captured and eaten by the Tupahotu-oone. To revenge her death the son captured thirty of the Tupahotu-o-uta in a cave and they were consumed. The statue was toppled in one of the struggles that followed this slaughter". On the basis of this story and because most of the statues lay fallen on their faces as if they had been deliberately thrown from the altars, Routledge deduced that "the conclusion that the images owed their fall to internecine warfare is confirmed by knowledge, which still survives, connected with the destruction of the last one".

She also referred to an attempt to behead a statue on the outer slope of Raraku during a feud between the Miru and the Gnaure of Akahanga. The toppling of statues that were in transport was attributed by some of Routledge's informants to the wrath of a female sorcerer who apparently acted as a priestess for those who transported the statues from the quarry to their ahu. During a festivity she was denied food and, in a fit of anger, she ordered the workers to abandon their work. That night the statues fell...

A similar tale was recorded by ENGLERT (1970, p. 105): "Three men went fishing and caught a lobster that was exceptionally large. They made an earth oven and cooked the lobster. An old woman who cooked the food for the statue carvers was not there when the earth oven was opened, and no food was put aside for her. When she returned she demanded her portion of the lobster and when they told her nothing was left, she cried in rage and shouted to the statues 'Fall down!' and that caused them to fall". In this legend it is not clear if the statues that were being transported fell down or if it refers to all the statues that were standing upon altars.

Yet, as ROUTLEDGE (1919, p. 173) emphasized, such folklore is "mixed up with more tangible statements to the effect that the figures were overthrown in tribal warfare by means of a rope, or by taking away the small stones from underneath the bed-plates, and thus causing them to fall forward. That the latter method had been used had been concluded independently by studying the remains themselves... The conclusion that the images owed their fall to deliberate vandalism during internecine warfare is confirmed by knowledge, which still survives, connected with the destruction of the last one". She also stated (p. 147): "We discussed the curious manner in which some of the statues had fallen. In four cases which we had seen that day, while the body lay on its front, the head had broken off in mid air, turned a complete somersault, and rested on its back with crown towards the neck"; and (p. 300) "We know that a large number, probably the majority, of the statues came to their end through being deliberately thrown down by invading enemies".

METRAUX too (1971, pp. 86-87) stated clearly that "The overthrowing of the last statues must have occurred between 1838 and 1864. This is fully confirmed by native tradition, which attributes the destruction of the monuments to the wars which broke out before the arrival of white men. De Lapelin (1872) ... received information from eyewitnesses: 'The statues were overthrown not long ago. Daniel, an employee of Mr. Brander in Tahiti, saw these two iconoclasts at work. During their intertribal wars, the victorious party threw down the statues of the defeated'". Métraux continued: "That the statues were voluntarily overthrown is evidenced by many signs. The position of the images and the damage they suffered prove that they were pulled down by

means of a rope or overthrown by removal of the slab on which they rested". He too then provided the legend about the priest.

As for ENGLERT (1970, p. 142), he stated that "Traditions relate that it was during this period of conflict that the ahu were destroyed and their statues toppled. This seems to have been a typical depredation of these intergroup conflicts. Perhaps the destruction of the statues of an enemy group was believed to obliterate the supernatural power of its ancestors and weaken its ability to resist. On the other hand, the cause may have been only an unfocused desire to destroy the valued property of an enemy. Whatever the reasons, during these conflicts excavations were made under statue pedestals and the statues made to fall, usually across the ahu ramps. Sometimes stones were deliberately positioned where statues were expected to fall, in order to break the statue across the neck and make re-erection impossible. Beautifully fitted basalt blocks of the ahu platforms were torn violently apart and left lying about. The thatched houses of the priests to landward of the ahu plazas were burned, and their carved foundation stones were sometimes carried away. Marks of these fires can be seen to this day on the precisely cut and fitted stones. This kind of depredation was the major cause of the present ruinous state of the monuments... Not all of this destruction appears to have been carried out at the same time".

Finally, HEYERDAHL (1961, p. 39) noted that stories of intertribal warfare were recorded by various researchers, "and sections of the same traditions were repeatedly volunteered to us. According to our informants, during this period of destruction no one could feel safe day or night for fear of blood revenge. Houses and personal property were burnt and destroyed, and even the large statues were overthrown... 'Those who had great statues on their land were proud of having them, and when they went to war, one family pulled down the statues on another's land just to annoy the owner.' This long sequence of destructive events took place within a general period referred to by our informants as the *huri-moai*, or the 'overthrowing-statue' time. The same term for this period of decadence had been recorded in early missionary times by Bishop JAUSSEN (1893, p. 245), who learnt from Easter Islanders in Tahiti that 'at a certain time, there broke out the war of overthrowing statues, *huri-moai*, and it gave the barbarians pleasure to throw down each other's statues.' [....] Routledge suspected that the war involving the overthrow of the statues began as late as in the 18th century, after the Dutch visit of discovery in 1722, but prior to the arrival of the subsequent European visitors half a century later. The oldest man living during Routledge's visit said he was an infant when the last statue on the island was thrown from Ahu Te-pito-te-kura (Paro) on the north coast, as an act of revenge in a cannibal feud".

Tales of Warfare

In short, every major researcher on Easter Island from the late 19th century onwards emphasized that there had been a period of warfare. As mentioned above, Roussel described a great deal of warfare, and CAUWE (2011, p. 137) admits this shows the island's society was not very peaceful. That is a considerable understatement. THOMSON (1891, p. 512), for example, said that "Long and bloody wars followed. Image-builders and platform-makers were drawn into the conflict from all parts of the island and, in a spirit of revenge, platforms were destroyed and images thrown down whenever opportunity offered. This is believed to have been the origin of the trouble which has laid waste the extraordinary works of this island"; and (p. 476) "Their wars were surprisingly numerous, barbarous, and unrelenting. The traditions are filled with accounts of sanguinary conflicts originating from trivial causes and continued through generations, until one party or the other were entirely exterminated. The slaughter on the field of battle was never very great, but in the event of a general defeat, the vanquished party was pursued by the victors to the hiding places, their habitations destroyed, females captured, children and infirm persons brutally murdered...". In short (THOMSON 1991, p. 533), "The clans were continually at war with each other".

According to ROUTLEDGE (1919, p. 223), "Legend tells of continual wars... In recent times general fighting seems to have been constant, and took place even between members of one clan..."; she went on to give accounts of warfare (p. 224). METRAUX too (1971, pp. 74, 87, 149) stated clearly that "References to intertribal wars are frequent in Easter Island folklore. They reflect real conflicts between tribes... whose quarrels and feuds ended only after the advent of the missionaries"; and "As reflected in legends and the accounts of missionaries, there was constant rivalry between the tribes, particularly between those of the eastern and western parts of the island. Wars were frequent and arose from the merest trifles, the principal causes being personal revenge, jealousy, greediness, and want".

And ENGLERT too (1970, p. 140) concurred: "During these times there appear to have been many battles between kin-groups, which were local and mostly of short duration. There was undoubtedly at least one actual war that lasted a considerable time and had devastating effects. This was fought between groups of the northwest coast and others of the southeast... We can deduce with some accuracy that this war must have occurred between 1771 and 1773, because none of the members of the González expedition... mentions any evidence of conflicts or its effects, at least during the few hours they were ashore. However, Captain Cook, who arrived four years later,

conveys in his whole account the strong impression that the island had just suffered a serious conflict".

Tangible Evidence of Conflict

CAUWE (2011), like HUNT & LIPO (2011) and others, attempted to minimize or even negate the existence of violence on the island in a number of different ways. For example, he stated (CAUWE 2011, p. 62) that no visitor ever witnessed a battle, which is true, but hardly relevant. He also noted that "Les Rapanui... ne construisirent aucune fortification", which is likewise true but irrelevant since the islanders had their countless hidden caves in which to take refuge — they had no need to build fortresses. As EYRAUD (2008, p. 29) wrote in his account of his 1864 stay on the island, "the whole island is full of deep caves, some natural, some artificial, that communicate with the outside only through a very narrow entrance, where one stone is enough to conceal or close the entrance. The entire island population could, at a given moment, disappear, hiding themselves in the underground". Above all, CAUWE (2011, p. 88) claims that the use of *mata'a* as weapons has been exaggerated: "on a très nettement exagéré le nombre des armes..." and (p. 104) "La très faible présence d'armes de guerre".

However, every major researcher on the island has emphasized the important role of the *mata'a* as weapons, and they were witnessed as such by some early visitors. For example, Cook (ANON 2004, p. 161) mentioned "a number of people... some of whom had spears in their hands". And (p. 173) "As harmless and friendly as these people seem to be, they are not without offensive weapons, such as short wooden clubs, and spears; which latter are crooked sticks about six feet long, armed at one end with pieces of flint. They have also a weapon, made of wood, like the *Patoo patoo* of New Zealand".

EYRAUD (2008, p. 8), in his account of his arrival on the island in 1864, reported that "The men were armed with a kind of spear made of a long stick and a sharp stone fixed at one extremity", and also mentioned "men armed with spears" elsewhere.

THOMSON (1891, pp. 474-476) devoted no less than three pages to weapons and war: "The native weapons in offensive and defensive operations were limited to obsidian-pointed spears, short clubs, and the throwing-stones... Two kinds of spears were used, one about 6 feet long for throwing and the other a shorter one... the various forms of obsidian points were secured by a lashing made from the indigenous hemp"; he also described (pp. 532-533) the tradition concerning the invention of the obsidian spearpoint, and presented

(p. 536) a large collection of obsidian spearpoints "showing the nine classes into which they are divided by the natives... These spear-heads were fastened to poles about 8 feet long, by lashings of hemp, and formed the chief weapon used by the natives in their frequent strifes..."

GEISELER too (1995, pp. 72-73) stated clearly that "The chief weapon was all along the spear... they bound onto an approximately 1 inch wide stick of [mulberry] an arrow-shaped, polished point of obsidian... The spear was a formidable weapon because of its sharp point". According to ROUTLEDGE (1919, p. 223), "the chief weapon was made from obsidian... hoards [of *mataa*] were occasionally found...."; while METRAUX (1971, pp. 166-168) presented a full account of obsidian spearpoints, including two in the British Museum with their original hafting (and one should not forget that Pierre Loti acquired a specimen fixed at the end of a long shaft — see ORLIAC & ORLIAC 2008, pp. 112-113), and also described (METRAUX 1971, p. 376) the "legend of the origin of the spears"! Finally, ENGLERT (1970, p. 139) explained that "The weapons used by the islanders in their own conflicts were primitive but deadly. Both traditions and archaeological evidence suggest that some of them at least may have been newly developed at the time of the internal conflicts to meet the problems that arose. One such weapon was the *mataa*, a large crudely percussion-flaked spearhead with a projecting tang... they used to be scattered over the surface of the island in endless numbers. Tremendous quantities of them must have been made. Though obsidian tools of many kinds are found buried in the earlier archaeological deposits, the *mataa* do not appear there. They seem to have come into use shortly before the arrival of the first Europeans... These large blades are described as producing ghastly wounds with their ragged, razor-sharp edges".

CAUWE (2011, p. 137), like HUNT & LIPO (2011) before him, argues that micro-wear studies on *mata'a* by Church, Ellis and others indicate that they were multi-purpose tools. FLENLEY *et al.* (2007, p. 102) have already refuted this point as follows: "We certainly agree that *mata'a* come in many shapes and sizes, and there are so many that they were probably used for all kinds of things — like the all-encompassing term 'handaxe' for what was almost certainly a multi-purpose tool in the Palaeolithic. Think of how many things a basic pocket knife or dagger would have been used for in prehistory or medieval times. So it is obvious that *mata'a* were probably multi-purpose implements. These were the Swiss Army Knives of ancient Rapa Nui".

Regarding use-wear analyses, it should be recalled that CHURCH & ELLIS themselves (1996, p. 84) stressed that obsidian is a particularly difficult material from which to derive accurate use-wear data. But even accepting the validity of the few published analyses — and we are perfectly content to do

so — it is noteworthy that in each case (CHURCH & RIGNEY 1994, CHURCH & ELLIS 1996, CHURCH 1998) only a very few *mata'a* were analysed, sometimes just fragments of them, and the vast majority of analyses were done on flakes.

It is true that these authors conclude that *mata'a* were not spearpoints but were used for cutting green plants; but this seems a somewhat sweeping statement after the analysis of a mere handful from a category of tools which, as HUNT & LIPO (2011) stressed, have a very wide variety of forms, and which were made in their hundreds, if not thousands.

There is another problem with their view of these artifacts. If they were all simple kitchen utensils, used for cutting and processing plants, why did they appear in such large numbers relatively suddenly and so late in the island's occupation? And why do they occur in large caches? Obsidian flakes were perfectly adequate for plant-processing tasks, as shown by use-wear analyses, so those who dismiss all *mata'a* as nothing more than utensils are ignoring other awkward facts; we are stunned that Hunt and Lipo are prepared to simply ignore the 1774 testimony of FORSTER (2000; FLENLEY & BAHN 2003, p. 153), one of the best scholars ever to visit Rapa Nui. We repeat his detailed observation that: "Some ... had lances or spears made of thin ill-shaped sticks, and pointed with a sharp triangular piece of black glassy lava". That seems pretty clear — or are they asserting that the islanders had suddenly decided to take a few kitchen utensils and attach them to the end of poles, in order to show them to the visitors? It is clear that one of the primary uses of *mata'a* was as spearheads, inconvenient as this may be to Hunt and Lipo. One can add that Cook himself also mentioned natives carrying spears (ANON 2004, pp. 159, 161, 173).

As Flas (this volume) has rightly pointed out, the *mata'a* have a highly varied collection of types, many of which look unsuitable for use as spearpoints. There may be many reasons for this — for example, as mentioned above, many of them probably had other uses. The apparently very late invention of this new tool type presumably meant that very few people were skilled enough to produce good ones, and many poorly-made specimens were thus manufactured by unskilled hands. As the vast majority of *mata'a* have been surface finds, it is unsurprising that their edges are usually somewhat damaged, and have lost sharpness — while cleaning has obviously removed any chance of finding residues reflecting their possible uses. Moreover, although THOMSON (1891) mentioned that long spears were for throwing, most *mata'a* make unlikely projectile points, and it is far more likely that shorter spears for thrusting and slashing were more commonly employed. Be that as it may, we have the clear testimony of Cook and the Forsters that they saw islanders armed with long obsidian-tipped spears.

CAUWE (2011, p. 65) also claims that "aucun témoin ne rencontra d'hommes blessés ou portant d'autres séquelles inhérentes à de la violence", which is simply not true, and has again already been refuted by FLENLEY *et al.* (2007, p. 102): "As for the supposed lack of evidence of wounds, we repeat that wounds were observed and mentioned in some early visits; and some have been seen on skeletal material. Hunt and Lipo claim that the latter are few; but without quibbling about numbers, it is worth mentioning that obsidian is ideal for cutting and slashing, and so it is extremely likely that many wounds or deaths caused by such weapons would have left no trace on bones. We will never know, so trying to deny the presence of such weapons by that route is not particularly helpful or relevant. On the other hand, we have testimony from early visitors: 'Wounds made by *mataa* were as serious as those made by pieces of glass; the scars were so conspicuous that they amazed the Spaniards under González' (METRAUX 1971, p. 165)". Indeed, F. A. de Aguera y Infanzón, on the Spanish expedition of 1770, wrote (ANON 2004, p. 63) that "in some we observed sundry wounds on the body, which we thought to have been inflicted by cutting instruments of iron or steel, we found that they proceeded from stones, which are their only [weapons of] defence and offence, and as most of these are sharp edged, they produce the injury referred to". GEISELER (1995, pp. 72-73) stated that the islanders' spears "caused deep, mostly fatal, and, in other cases, hard to heal wounds. One skull showed that it was pierced through by a single thrust of the spear". Zumbohm (METRAUX 1971) wrote that wounds produced by *mata'a* were always fatal if they were deep.

AYRES *et al.* (2000, p. 175), in a paper about use-wear, said that the *mata'a* is "referred to traditionally by Easter Islanders as a weapon ... that is, a point for a spear (*kaukau*) or thrusting lance (*vero*), and hafted examples are known in ethnological collections".

Conclusion

It is very hard to understand how so much evidence, both oral and archaeological, can be ignored by those wishing to deny the existence of conflict on the island. It is certainly possible that a few *moai* — on platforms or along the roads — may have been carefully lowered to the ground for some kind of re-use, since we know that platforms had constantly been modified over time in their form and their function. But it is overwhelmingly evident that the majority of them were finally toppled within a framework of endemic conflict and violence. The assertion that Rapa Nui was a peaceful island is simply not supported by the evidence, as we have seen above.

HUNT & LIPO (2011, p. 94) cite a 1994 paper by Owsley *et al.* to support their claim that "the skeletal remains of prehistoric Rapanui show few signs of lethal trauma". They thus appear unaware that in a 2003 television documentary Owsley stated that, after examining more than six hundred Easter Island skeletons, he realized he was looking at the evidence of people at war with themselves: "When I compare the frequency of injuries that I've observed in the Easter Island population with other collections that I've worked with, it certainly shows the high end, it's the extreme. It was a period of social disintegration. You've got endemic warfare, it's chronic — they're slugging it out, there's no doubt about it". So much for the "Peaceable Island"!

In conclusion, and with regard to the theme of this meeting, the term "collapse" has become somewhat overused where Rapa Nui is concerned — it is clear that the island's culture did not "collapse", in the sense of total disintegration, since the ever-resourceful islanders adapted to the new circumstances caused by the total deforestation and massive soil erosion, and were making a sustainable living at the time when Europeans arrived in the 18th century. It should, however, be noted that — according to the Forsters in 1774, generally reckoned to be the most reliable observers to visit the island in that period — they were in a wretched state, with impoverished resources, and earlier cultivated areas on the higher ground now abandoned: "We had been greatly disappointed in the expectation which we had formed of this island, as a place of refreshment. The only article of any importance was their sweet potatoes; but after we had regularly shared out all we had purchased, the common people had only a few scanty meals of them. As to the bananas, yams, and sugar-cane which we had bought, they were in such inconsiderable quantities, that they scarce deserve to be mentioned... Indeed, when I consider the wretched situation of the inhabitants, I am surprised that they parted with a quantity of provisions to us, of which the cultivation must have cost them great pains and labour... [the island was] extremely dreary and parched and these plantations were so thinly scattered upon it that they did not flatter our hopes of meeting with considerable refreshments... We saw but few plantations towards the north end... and we could easily perceive that there was not a tree upon the whole island which exceeded the height of ten feet... The general appearance of the natives seemed to argue a great sterility of the country. They were inferior in stature... not a single person amongst them who might be reckoned tall... their body was likewise lean and their face thinner than that of any people we had hitherto seen in the South Sea... We found the face of the country more barren and ruinous the farther we advanced... the poverty and wretched condition of its owners... They seemed...

to be so destitute as to have no provisions to spare. A few matted baskets full of sweet potatoes, some sugar-canes, bunches of bananas... the deplorable condition of the natives... The remains of plantations found on the summits of the hills... It is not in our power to determine by what various accidents a nation so flourishing could be reduced in number and degraded to its present indigence... The space which the plantations occupy is inconsiderable, compared with that which lies waste" (FORSTER 2000).

It is important to note that the eradication of the trees not only brought about a lack of timber, it also destroyed the islanders' only source of material for rope-making, and this is a much-neglected factor. Not only will lack of both wood and rope have helped to put an end to the moving of large stones, it will also have had a radical effect on the kinds of fishing which could have been accomplished. And one should not forget that the islanders also wiped out all the terrestrial birds, thus reducing their protein sources to chickens, rats and whatever fish they could catch near the shore. Their remains may not display a high degree of malnutrition or stress (Polet, this volume), but nevertheless the environmental destruction undeniably had a major effect on their subsistence level, as revealed by Forster's text.

In the most recent third edition of our book (BAHN & FLENLEY 2011) we decided to avoid the term "collapse" and instead substituted "decline" as being a more accurate and less dramatic description of what happened on the island. There were drastic changes in the social system, the religious system and the agricultural system, and each of these might be argued to be a "collapse" if we had better information on the timing and duration of these transformations. But since our data are so poor, it seems more sensible and cautious to adopt the term "decline" with regard to each of these changes. As Forster's testimony shows, the islanders were not doing very well — conditions were clearly far inferior to what had gone before — and one can justifiably wonder how long their new, more impoverished way of life could have lasted: for example, if the island had been hit by drought or some other natural disaster. We shall never know, since the arrival of Europeans eventually did cause a true collapse of a different kind. But it is clear that deforestation and soil erosion had major effects on the life and culture of the islanders, and that conflict arose where before there had been none, as far as we know. It is illogical to propose that these two phenomena were unconnected, as some have claimed — let alone to deny the very existence of violence on the island. In fact, in view of the violence endemic in early Polynesian societies, it is miraculous and admirable that the Easter Islanders seem to have lived in peace with each other for many centuries before conflict broke out — conflict for which we have not only massive oral testimony

but also artifactual and skeletal evidence. And it is equally admirable that the islanders were able to stem their decline by adopting the technique of lithic mulching, and changing their entire social and religious systems. Whether or not their culture "collapsed" or simply "declined", they managed to adapt successfully to their new circumstances — and that is perhaps the most important lesson they offer the world.

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Revisiting the Collapse of Rapa Nui (Easter Island) through a Voyage of 18th-Century Journals

by

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KEYWORDS. — Easter Island; 18th-Century Journals; Warfare; Food; Population.

SUMMARY. — In this article, all the published accounts of the four expeditions that visited Easter Island in the 18th century are discussed. What conclusions do they allow to be drawn about the ecological history of Easter Island and the alleged collapse as described by authors like Clive Ponting and Jared Diamond?

The accounts of the four expeditions have been analysed on the observations and notes relevant to the collapse theory, and in particular with reference to signs of warfare or strife, and the health of the inhabitants, to data on population numbers and to food and the cultivation of food crops.

The Easter Islanders underwent a possibly unwished-for transition from their spectacular statue culture to an equally fascinating bird culture, each of which in the beginning was sustainable, but were certainly different in quality. Both the nature and the culture gradually became impoverished. But the society displayed resilience and adaptability. They did not collapse. And the 18th-century accounts support that story.

Introduction

In recent decades, several different researchers have come to believe that on Easter Island in the pre-European period a collapse occurred as the result of the overexploitation of natural resources. This collapse is said to have commenced in the period prior to 1722, because in that year an expedition under the leadership of the Dutchman Jacob Roggeveen was the first European expedition to reach the island. In the same century expeditions from Spain (1770), England (1774) and France (1786) also came to the island. The

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European visitors, with Roggeveen as their vanguard, are said to have witnessed a society in severe decline and wrote about this in their accounts of their expeditions. Later research was to confirm these accounts and added additional detail.

The first to put forward the concept of a collapse was the American archaeologist William Mulloy. This he did in his article "Contemplate the Navel of the World", which in 1975 was published in the — little-known — periodical *Américas*. In the years that followed the theory appeared in all manner of formulations in literature related to the environment, but none of these reached a broader audience. This did not happen until 1991, when the British historian Clive Ponting opened his bestseller *A Green History of the World* with a chapter in which he described the dramatic situation on Easter Island as Roggeveen would have found it. Shortly thereafter the collapse theory gained a certain scientific status through the work of the British archaeologist Paul Bahn and the New Zealand geographer and botanist John Flenley, two renowned Easter Island researchers. In their 1992 book *Easter Island, Earth Island* they compare the computer models from the first report to the Club of Rome (1972) with their own reconstruction of the history of Easter Island. The analogy was striking: seriously declining natural resources, increasing pollution, and finally a dramatic fall in population numbers. What the Club of Rome foresaw for the world as a whole had apparently occurred already on Easter Island. In 1994 the film *Rapa Nui* was made, visualizing the collapse story as told in Bahn and Flenley's book. Finally, it was the American geographer Jared Diamond who in 2005 with his book *Collapse. How Societies choose to fail or survive* ensured that the story reached an audience of millions. To some extent as a result of this, the account of the collapse of the culture of Easter Island gained an iconic status in the environmental sciences. It became *the* lesson from ecological history, a grim warning. If we are not more careful with our natural resources the earth can also expect a similar collapse.

In this article, all the accounts of the four expeditions that visited Easter Island in the 18th century are discussed [1]*. From it, what image emerges of the island and its inhabitants? How should these historical sources be weighed and interpreted? How do they relate to the research results of later periods? What conclusions do they allow to be drawn about the ecological history of Easter Island? First, we propose a brief discussion of the collapse theory and of the elements important to this theory such as these have been described.

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* Numbers in brackets [ ] refer to the notes, pp. 167-170.

The Collapse Theory

When does one speak of the collapse of a society or culture? What distinguishes a collapse from a "fundamental change"? Some authors take a middle part in this, but from the descriptions that have been made there are indeed two important points of distinction [2]. First, the period of time in which it occurs. A true collapse happens quickly; if such a process takes place over centuries it is a change rather than a collapse. It is particularly the tempo at which population numbers diminish that is high, and this rate of decrease is always very large, the population being decimated rather than halved. With a collapse we must think of time spans such as decades or a maximum of a century, depending on the extent of complexity and the size of the society. A second characteristic is the scale of the phenomenon. This is not about a few elements of a society but a number of aspects. There must therefore be a certain complexity present in a society that is to a great extent wiped out by the collapse. In a collapse the important social structures crumble, resulting in chaos, hunger, poverty and strife, together with rapidly reducing population numbers as the result of death or flight. In the light of the radical nature of the decline in numbers there can be no question of recovery in a reasonably short space of time. It is for this reason that some authors speak of "vanished civilizations" [3].

The type of collapse that is said to have afflicted Easter Island distinguishes itself further by its cause: human (over-)exploitation of the natural environment. This is not about inescapable natural disasters, invading aggressors or unintentionally introduced diseases. In the 1960s, concern about the consequences of exploitation by mankind increased greatly, worldwide. In his article Mulloy quoted Paul Ehrlich's 1968 book *The Population Bomb*, in which the latter foresaw hundreds of millions of deaths as the result of food shortages before the turn of the century. Bahn and Flenley referred to the first report to the Club of Rome. Clive Ponting — and after him Jared Diamond — suggest a general pattern in the green history of the world. If the cultures are unable to maintain a balance with the natural environment, not only will that environment be lost, they themselves will also perish. Easter Island was in their eyes, no exception.

The theory posits a causal chain, in which there is a succession of cause and effect. At the foundation of the chain of occurrences on Easter Island was deforestation. Wood was the natural resource that gradually disappeared, from the time of the arrival of the Polynesian colonists and by their actions, so that in the 18th century the first European visitors encountered a bare, deforested island. Seaworthy canoes could no longer be built, and deep-sea

fish disappeared from the menu. Transporting the statues by the use of rollers was no longer possible. As a result of the disappearance of the trees the soil became drier and crops that required water were more difficult to grow. The ground was susceptible to erosion and fertile soil was washed away. There was a decline in food production, followed by scarcity and after a while hunger. The island's resources were insufficient for the size of its population. The hunger led to (food) wars. This not only had a high cost in human lives but also eroded the social structures. "The society" according to Diamond "spiralled down into chaos and cannibalism". If we are to believe the reconstruction of Bahn and Flenley, this decline began well into the second half of the 17th century and continued until well into the 18th century [4]. Roggeveen arrived, as it were, in the middle of the collapse. This is also how Ponting described the situation. This was for me reason enough to study the written accounts of the experiences of the island's first visitors, in which I expected I would find descriptions that would support the collapse theory.

The Accounts

For this article I draw in particular on the accounts of the visitors to Easter Island in the 18th century [5]. We can subdivide these into three categories.

First, there are the journals. A journal is an official logbook written by the leader of an expedition or by the captain of an individual ship, which has to include daily records of the weather conditions, the vicissitudes and the progress of the journey. On the basis of these data the owners of the ship or the directors could subsequently determine whether the expedition's leader or the captain had complied with his instructions and, if not, what the reason was for his non-compliance. All these matters were of importance when making the decision as to whether to pay the agreed salary. For example, Roggeveen had been instructed to look for the sandy Davis Island, which was said to lay off the coast of the unknown Southland (*Terra Australis Incognita*). When Easter Island did not match up to this description and thus could not be the island that he was instructed to look for, this was ascertained and in a well-substantiated manner recorded in the journal at a special meeting of all three captains and their first pilots.

The second type relates to the reports of crew members, illustrators or scientists also taking part in the journey. These reports can follow specific themes, but can also give more general descriptions.

Finally, there are accounts that have been written by people who themselves did not participate in the journey and who have therefore acquired their information indirectly. These could be publications relating to a special journey, written by writers of potboilers hoping to earn money from the

story, but could also be reviews that relate to a number of journeys and that are intended as historical works. The latter are usually published many years after the journeys described in them. There are, however, exceptions. In the third volume of a collection of travel accounts by François Valentijn (1726) there is a short passage about Roggeveen's journey. This is the first published report, but does not mention his visit to Easter Island.

It is clear that accounts of journeys can vary as to the extent of their reliability, and this is certainly the case for Easter Island [6]. The journals are the most authoritative, but do not cover everything. The captains did not see everything on the island, and could make mistakes in matters of detail or interpretation. Scientists had more knowledge in numerous fields, and they also wrote more systematically and generally more succinctly. The crew members, who wrote sometimes, felt free to record certain piquant or ostensibly unimportant facts.

The accounts of journeys are sometimes one-sided or bear evidence of personal embroidery. This also applies to the prints and paintings that have been passed down from the 18th-century expeditions. For example, in French accounts we read undisguised criticism regarding the accuracy of the work of the Englishman Hodges [7]. The sources can be complementary to one another, and apart from being assessed comparatively must also be judged on their own merits. In addition, the background of the writer must also be taken into account. Captain Cook, for example, who in his travels had acquired a large amount of knowledge about the Pacific, was quite ill when he anchored off the island. He and his crew had been roaming the seas for weeks and were in urgent need of fresh water and food. The expeditions that followed that of Roggeveen had some prior knowledge about the journey and the island from accounts that had been published previously and stories that had circulated [8]. These matters are also a factor in their descriptions and evaluation of the perceptions of Easter Island.

The second-hand stories about the Roggeveen expedition appear to have been the least reliable. The writer obtained his information from a returning crew member, and supplemented that insouciantly with his own speculations. We read of giants on Easter Island, beings who were about twelve feet tall, and under whose legs the Dutchmen could walk without having to stoop [9]. In order to make the publication more attractive a local illustrator was asked to create a couple of pictures. In the *TweejaarigeReyze* there are etchings by Matthijs Balen who, just as the printer Johannes van Braam, lived and worked in Dordrecht. The best known — 'Reyze naar het Zuydland' — portrays a large group of islanders armed with spears; they are being shot at by two sailors in a sloop, each with a gun. Off the shore lie three European ships at anchor, and on the island we can see, in addition to a few trees, a block

of stone with a head carved into it, apparently a *moai*, with islanders walking around it or kneeling before it. The print has been copied many times, often without the sloop, with, among other things, the caption "the earliest known depiction of Easter Island" [10]. However, Roggeveen and Bouman wrote in their journals that they saw neither weapons nor trees. Shots were never fired from a sloop. Sadly, these journals did not turn up until many years later, so that the conceptualization of Easter Island in the decades that followed 1722 was mainly determined by less reliable sources [11].

The accounts of the four expeditions have been analysed on the observations and notes relevant to the collapse theory, and in particular with reference to the following subjects:

— The presence of weapons, signs of warfare or strife, wounded people, the physical condition and the health of the inhabitants;
— Data on population numbers;
— Food, the cultivation of food crops and the circumstances in which to cultivate them.

Signs of Warfare and Strife, Injuries and Physical Condition

Polynesians are very keen to show their weapons to foreigners as a signal of "being in power" in their territory, so the lack thereof on Easter Island is remarkable. The absence of weapons is firmly attested in the first accounts of the 18th century, with that in the journal of Bouman being the clearest. The Dutch were apparently afraid of possible hostilities from the Easter Islanders, since both Roggeveen and Bouman reported that they should go exploring only if accompanied by a sufficient number of armed crew members. Their fear seems not to have been justified, the Dutch saw nothing resembling weapons:

> [...] they came on board unarmed, and the members of our crew that had been to the shore with the sloops also stated that they had seen not a single man with a weapon [12].

When after a couple of days the weather is favourable, they go ashore on Friday, April the 9th with "134 hands, and all of them armed with musket, cartridge bag and cutlass" [13]. As the whole group has come ashore and treks inland, in the rear-guard a tragic shooting incident takes place in which nine or ten islanders are killed by some crew members who had panicked. They claim later that the islanders had touched their flintlocks and clothing, and that a few had threatened to throw stones at them. Roggeveen and Bouman attach absolutely no value to their statement and heartily condemn their actions.

The German Carl Behrens has left us a testimony of two accounts of his travels, together with a report relating to Southland, drawn up for the VOC, which contain several passages about Easter Island. The first account dates from 1728 and is written in verse. In this we read nothing relating to weapons. In the report for the VOC, Behrens really does his best to make the existence of a Southland plausible. To that end he seeks to ally his claims with those that "Capitein Ferdinandus Dequier" had published about this Southland. According to Dequier, there live heathens who fight one another with spears and clubs. Behrens has also seen much heathenry and idolatry, *inter alia* on Easter Island, but mentions nothing of weapons there [14]. In his third report, which in a short space of time was published in French, German and Dutch, and which in 1923 was once more rewritten and published, Behrens is clearer:

> It looks like the islanders possessed no weapons [15].

The Spanish expedition that reach the island in 1770 also sees no weapons:

> They possess no arms [16].
> [...] natives, all of them unarmed, and some nude, wearing plumes on their heads [17].

The Spanish also test the acquaintance of Easter Islanders with weapons by giving them a bow and arrows, but they showed absolutely no knowledge of what to do with them; in fact, they hung the bow around their necks like an ornament. Knives also appear to be unknown [18]. In some of the islanders the visitors do see "wounds on the body, which we thought to have been inflicted by cutting instruments of iron or steel, we found that they proceeded from stones, which are their only defence and offence, and as most of these are sharp edged they produce the injury referred to" [19].

Just as all the visitors, the English are received peacefully. Cook recounts:

> We landed at the sandy beach where about 100 of the Natives, who gave us no disturbance at landing, on the contrary hardly one had so much as a stick in their hands [20].

The accounts of the expedition in 1774 under the leadership of James Cook report explicitly for the first time the presence of weapons. Georg Forster described fairly precisely what he saw:

> We saw but few arms among them; some however had lances or spears, made of thin ill-shapen sticks, and pointed with a sharp triangular piece of a black glassy lava (*pumexvitreus* Linn.) commonly called Iceland agate. One of them had a fighting club, made of a thick piece of wood about three feet long, carved at one extremity; and a few others had short wooden clubs, exactly resembling some of the New Zeeland patoo-patoos, which are made of bone [21].

The "fighting" club about which Forster here writes is later identified as *anua*, a leader's staff with a worked head. A few examples of these have survived.

Anders Sparrman mentions the following about the material:

> [...] an island that hardly produces anything more than a few bushes of a mimosa-like appearance, and a *Hibiscus populneus*, from which switch-like spears and a few small clubs are made [22].

Father Johann Forster only provides a kind of summary:

> Their Arms are Lances with sharp black flints & clubs & *pattapattow* [23].

Cook's journal has a similar description, possibly wholly or partially extracted from Forster as Cook himself arrived ill, spending only a short period on land:

> As inoffensive and friendly as these people seem to be they are not without offensive weapons, such as short wooden clubs and Spears, the latter are crooked Sticks about six feet long arm'd at one end with pieces of flint — they have also a weapon made of wood like the Patoopatoo of New Zealand [24].

The pieces of flint were almost certainly arrowheads made of obsidian. Since this material is found spread all over the island, this is taken to be evidence of the large-scale use of spears. In any case, in the 18th century there was no question of this, and it is possible that these finds were all identified incorrectly as arrowheads [25].

Lieutenant Richard Pickersgill, who was sent by Cook to explore the island, reports the following:

> Not one of them had so much as a stick or a Weapon of any sort in their hands [26].

The other, often brief, accounts by Elliot, Clerke and Wales contain no information about weapons.

In 1786 the last major European expedition arrived. The expedition's leader is Lapérouse. A number of accounts of this visit have also survived. In his journal Lapérouse observes the following about weapons:

> These natives were unarmed; 3 or 4 at the most, in such a crowd, had a kind of club made of wood and hardly dangerous [27].

The French make the acquaintance with the islanders' practice of throwing stones. When a few inhabitants are successful in stealing an anchor, the pursuing soldiers are pelted with stones. It is only after the French have fired a few shots that the anchor is brought back. Nevertheless, in most accounts the Easter Islanders are described as friendly and peace-loving. Georg Forster believes that he knows the reason for this:

> The disposition of these people is far from warlike; their numbers are too inconsiderable, and their poverty too general, to create civil disturbances amongst them [28].

The visitors are unanimously positive to very positive about the appearance and health of the Easter Islanders. They describe the inhabitants as being of attractive build, quite tall, powerful people with sufficient flesh on their bones, and excellent swimmers. Even Cook, who — as the result of his roaming the area — had a great deal of material for comparison and observed that the Easter Islanders are smaller than the inhabitants on some other islands, comes to a favourable general judgment:

> [...] in general they are a very Slender race but very Nimble and Active, well featured with agreeable countenances [29].

The population, or at least the hundreds that were observed by the visitors, give the impression of being healthy. What is at least as remarkable for the visitors is the absence of all manner of food or nutrient deficiency-related diseases. On this point the Spanish are the most outspoken. They see:

> No halt, maimed, bent, crooked, luxated, deformed, or bow-legged among them, their appearance being thoroughly pleasing [30].

All in all, this information from the 18th-century accounts offers no support for the descriptions from the collapse literature. There is no question of warfare and strife, or of a starving and desperate population, let alone of cannibalism because of a lack of food. Some lived in caves, but not because it was unsafe above the ground. On the contrary, Roggeveen sees during his visit that a new house is being built [31].

It goes without saying that the deforestation of the island has caused a shortage of wood, making it difficult to build large numbers of houses or to make good spears or hefty clubs. So if there were a question of bellicosity or tribal warfare, then they must have had to "manage" to carry this out with the use of stones. The accounts show little of this bellicosity and certainly not with such a large number of victims that, as a result, population numbers declined.

It cannot be ruled out that in the pre-European period armed combat had occurred on the island. But in that case the island apparently had recovered from the fighting and its consequences and were successful in achieving a reasonably stable situation. Theoretically, people could have died through lack of food prior to the arrival of the European visitors because the island could not feed the greatly increased population. However, there is as yet no archaeological evidence of such a scenario [32].

Population Growth and Size

If resources are reduced and population numbers continue to increase, there comes a time when the capacity of the whole is exceeded and one ends up in a swift downward spiral. That is the essence of the collapse theory. What can be said about the growth in population and size of Easter Island? Unfortunately, there are no hard figures. We must work with hypotheses. We know that the size of the groups of Polynesian colonists typically varied between fifty and one hundred. We also know that on average the growth figures of pre-modern societies were low; never greater than 0.5 % over a longer period, and mostly lower. These are then average figures in which all irregularities have been included. We do not know exactly when they had reached Easter Island. We have hard evidence of habitation from *ca.* 1100 AD. If we calculate using this data the following picture is created (fig. 1) [33].

The scenarios are based on a group of fifty colonists and a hundred colonists. The barely climbing lines (blue and red) are created by 0.1 % growth and the exponential-climbing lines (light blue and green) by 0.5 % growth.

How do these calculations relate to the estimates that we have from the earliest historical sources? In the table below, all the numbers from the

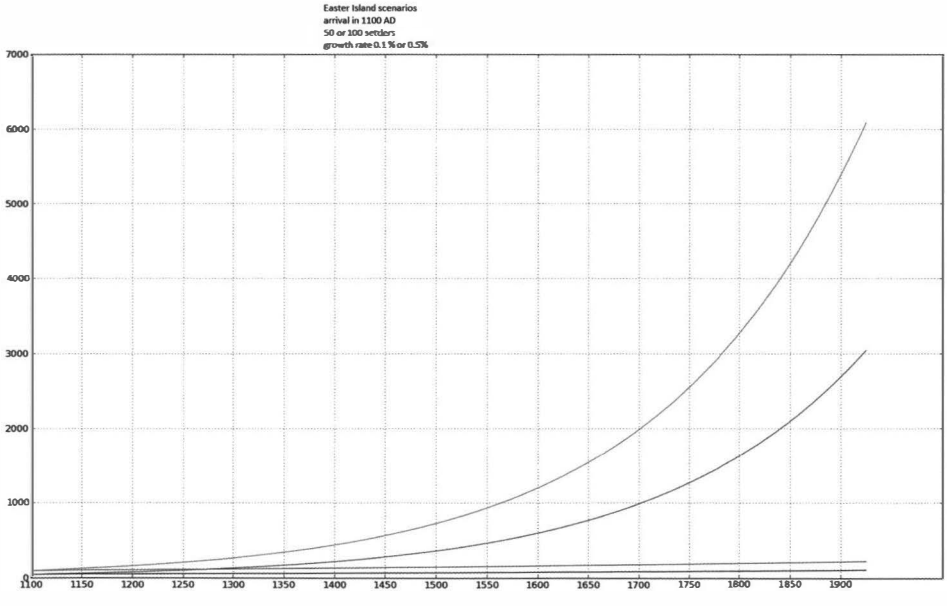

Fig. 1. — Four scenarios of population growth of Easter Island.

accounts have been put together. It is clear that this is not about accurate censuses, but they do fall within the bounds of the calculations. A group of a hundred colonists and an average growth of 0.5 leads to approximately three thousand inhabitants at the end of the 18th century, a group of fifty leads to approximately one thousand five hundred. Even if one assumes a much earlier colonization, as BAHN & FLENLEY (2011) appear to do, one can still reach the figures from the accounts if the growth rate is on average not much greater than 0.1 %. This is not an unrealistic figure over such a long period.

In general, sex ratios in population should be equal, but on Easter Island there might have been a sex ratio disparity. All 18th-century accounts point to a disparity, the European visitors saw far less women on the island. Later research has given some support to this disparity: the skeletal remains show a difference of 14 % [34]. As women fertility is key to reproduction figures, this disparity could be one more reason to assume low growth rates (tab. 1).

Table 1
Estimates of Easter Island's population in 18th-century accounts

Author	Number of inhabitants	Observations
Roggeveen 1722	Mention no numbers	See few women
Bouman		
Behrens 1722	"swimming around in their thousands" [35]	No numbers on land
González 1770	Never exceed 3,000 [36]	
Francisco Aguera	More than 800 people on the coast [37]	Estimated from the sloop
	One day more than 400 in the frigate [38]	Included few women
Hervé	900-1,000 [39]	
Cook 1774	600-700 in total [40]	Two thirds men
Georg Forster	Not beyond 700 [41]	
Johann Forster	3 or 400 people on our side, consequently not above 8 or 900 in the whole Isle [42]	
Clerke	Not exceeding 500 Souls [43]	"Of whom 350 are Men"
Wales	Several hundreds [44]	"Gathered on the shore"
	We saw at least 500 men [45]	"Not more than 6 or 8 women"
Sparrman	600-700 [46]	"scarcely thirty of the other sex"
Lapérouse 1786	Four or five hundred on the shore [47]	
	1,200 gathered around the bay	"Of whom 300 are women"
	2,000 in total [48]	"Without exaggeration"
M. de Langle	2,000 [49]	"Two times more men than women" [50]
James Baker 1793	1,500 to 2,000 [51]	"The natives seem numerous"

Calculations remain calculations, and they do not entirely exclude the high population numbers (10,000 to 20,000). But there are no plausible arguments for these enormous numbers.

Carrying Capacity, Water and Food

Water and food are essential in order to keep a population alive and healthy. On Easter Island there are no "living" sources of fresh water, brooks and rivers. There are three crater lakes, of which in any event the largest two have never been dry since the island was inhabited. The population also use cisterns, natural hollows in which rainwater was stored [52]. For household use they stored water in empty gourds and hollowed-out stone basins [53].

The French write that they are offered water in gourds [54].

The Easter Islanders have never experienced serious water shortage; the quantity was sufficient. The European visitors are, however, less enthusiastic. They find it brackish [55]. The English, in particular, complain about its bad taste, but that was partly because they were in a fairly poor state when they arrived [56]. The findings of these critical visitors do not relate exclusively to the cisterns close to the coast. Pickersgill, who treks with a group into the hinterlands, wrote:

> Towards the eastern end of the Island, they met with a well whose water was perfectly fresh, being considerably above the level of the Sea, but it was very dirty owing to filthyness, or cleanliness (call it which you will) of the Natives, who never go to drink without washing themselves all over [57].

Probably this relates to the crater lake Rano Raraku.

It is striking that the islanders also appear to gain moisture from certain foodstuffs. When the visitors make clear by using signs that they would like something to drink, the inhabitants arrive with sugar cane. It "contained a very sweet juice, which the inhabitants presented to us frequently, and particularly whenever we asked for something to drink" wrote Georg Foster [58]. Some researchers have made it plausible that the core of the trunk of the Easter Island coconut palm contained potable sap and that this can have been one of the reasons for cutting down the trees [59].

As regards food, we must be careful both about what is reported on foodstuffs and about the information relating to the collection and production of food. The European visitors write extensively about the food available. What kind of things do we find?

In Roggeveen's journal we read of "tree-fruit, crops from the earth and chickens as general categories" [60]. Further on he mentions bananas, sugar

cane, *ubaswortelen* (yam?), *bataat* (sweet potatoes) and he sees the opportunity of bartering sixty chickens and thirty bunches of bananas for linen [61]. In itself a transaction that does not really fit in with the collapse story.

Bouman refers to what he knows of Dutch Suriname and calls the bananas in Surinamese *backovens.* The sugar cane is thick, long and heavier than in Suriname. On his trek over the island, he also saw a few small coconut palms and in the small gardens, in addition to *jannes* also some other unknown tuberous plants [62].

The Spanish saw no domestic animals apart from chickens. They also saw a few rats and in the gardens "yuca, yams, sweet potatoes and several plantations of plantains and sugar cane". They also mentioned several "fruit bearing trees" with "very small figs" [63]. Hervé saw on the coast "sea urchins and small crabs, eggs of a sea-gulls and their fledglings" [64]. There will have been some coastal seafood, although without seaworthy canoes no tuna could have been caught, something that certainly had been done previously. Hervé also recorded that his men, just as the Dutch, were offered "fruits and hens". He also noticed that the islanders "do altogether without liquor of any kind" [65]. No alcohol, which certainly surprised the sailors.

Solid foodstuffs are reported in the English accounts, but they also add new ones. They saw that rats were caught for consumption [66]. In two places we read that the men are given fish to eat, but that is a scarce item and the men are themselves not capable to catch a fish on the coast [67].

The French expedition saw and was provided with not only Easter Island food, they also imported it. Apart from having seeds and plants, they had livestock on board, a few pigs and goats in the hope that these get the chance to multiply. We do not know whether that actually happened. The French themselves are unsure whether in the light of the poor quality of water the pigs will manage to survive. They are more optimistic about the goats "who drink but a little and like salt" [68]. Visitors who, fifteen years later, came onto the island reported nothing about this.

European visitors all wrote about the opportunities for growing food. At the end of his account of Easter Island, Roggeveen came to the conclusion "that the island is very fruitful, and could be made a paradise on Earth if the inhabitants were to do something about it. Now they only cultivate what they need" [69]. He will certainly have thought about the industrious Dutch farmers in Zeeland, the province which he came from. Remarkably enough, the French come to precisely the same conclusion more than sixty years later:

> Hardly a tenth of their land is under cultivation, and I am sure that 3 days of labour are enough to provide a year's subsistence for each of them.

We also read positive reports as to the way in which the Easter Islanders grow their crops. For example, Bouman wrote that the little square gardens looked cared for and well set out [70]. All visitors wrote that the bananas were grown in well-arranged plantations. Cook wrote: "Their Plantations are prettily laid out", by which he probably also meant the small gardens where the tuberous crops were grown [71]. Georg Forster had also noticed this: "they were in excellent order, considering the stony quality of the ground" [72]. He saw that the islanders used grass to cover the soil in order to prevent it from drying out, coming to the following cautious compliment:

> It should seem from these circumstances that the natives are not altogether ignorant of rural economy, and till the ground at a great expence of time and labour [73].

From later studies it is apparent that the islanders continued these agricultural practices all over the island until late in the 19th century [74]. The island's productivity was always high enough. Calculations indicate that even an (unlikely) population size of ten thousand inhabitants could have been well fed [75]. The island's capacity was greater than its people consumed for their own use. In the first half of the 19th century Easter Island became a place where whalers and other passing vessels could obtain considerable amounts of potatoes in exchange for whale blubber or clothing.

The **conclusion** of the rereading of the 18th-century travel accounts must be that they do not provide any support for the collapse theory as Ponting, Diamond and many others would have us believe.

Discussion

How can one understand that the collapse theory is defended on the basis of the European visitors' journals?

My impression is that it is predominantly English-language collapse authors who based themselves on the accounts of the journey of James Cook. They read these accounts from a present-day perspective and through spectacles tinted by modern environment, handed to them by the pessimistic literature of authors such as Paul Ehrlich and the Report to the Club of Rome. Too little has been taken into account that Cook and his fellow travellers compared the situation on Easter Island with what they knew from other islands in the Pacific. They were searching for a stopping-off point for the British Empire, where the nation's ships could berth in order to gain fresh supplies. But luck was against them. They did not find the fresh fruit that

would immediately relieve their scurvy, the water was considered undrinkable (or in any event by the English), and the inhabitants were scantily clad, giving as a whole a penurious impression. The houses looked dilapidated: "Its construction was such as evinced the poverty and wretched condition of its owners" [76]. It appeared that several statues had either fallen down or been pulled down deliberately. They found the population numbers to be small. But Easter Island is no Hawaii or Tahiti. It was no (sub)tropical paradise with palm trees, but a bare and lean island where the inhabitants had to make do with the very basics. But even after the deforestation this appeared sufficient for a simple but sustainable society. The islanders were able to produce enough food, and despite its very limited variety it nevertheless appeared to be sufficiently well balanced in terms of minerals and nutrients. Easter Islanders underwent a possibly unwished-for transition from their spectacular statue culture to an equally fascinating bird culture, each of which in the beginning was sustainable, but were certainly different in quality. Both the nature and the culture gradually became impoverished. But the society displayed resilience and adaptability. They did not collapse. And the 18th-century accounts support that story.

NOTES

[1] An overview of the accounts is to be found before the bibliography.

[2] Clive Ponting does not go so far as to give a description, but Joseph Tainter and Jared Diamond do. Tainter defines collapse as a "rapid, significant loss of an established level of sociopolitical complexity" (J. A. Tainter, *The Collapse of Complex Societies*. Cambridge, Cambridge University Press, 1988), p. 4. Diamond speaks of "a drastic decrease in human population size and/or political/economic/social complexity, over a considerable area, for an extended time" (DIAMOND 2005, p. 3). In Diamond's view, the "decrease" proceeds quickly and the effects are long-lasting.

[3] J. P. Barbier, *Vanished Civilizations. From the Ancients to Easter Island* (Paris, éd. Assouline, 2001).

[4] Bahn & Flenley 1992, p. 215 (reprinted in the 3rd edition, 2011, p. 321).

[5] Not all accounts that have been written during the 18th century are "officially" published. Some — we know of their existence — are lost, others we didn't know of, show up. While working on his biography of Jacob Roggeveen, Roelof van Gelder came across in the library of Regensburg a copy of an account of Carl Friedrich Behrens, which was printed in 1728 and ever since non-existent in the Easter Island literature (GELDER 2012). Recently Zuzanna Jakubowska reported an even more spectacular finding of a completely unknown manuscript found in the Jagiellonian Library in Cracow, and most likely composed by the Forsters, naturalists who travelled with James Cook (JAKUBOWSKA 2014).

[6] Translations could also be unreliable (see JAKUBOWSKA 2012).

[7] "M. Hodges, peintre, qui avait accompagné le capitaine Cook dans son second voyage, a fort mal rendu leur physionomie" (LAPÉROUSE 1987, pp. 59-60). And "Mr Hodges's drawings of the statues is a very poor rendering of what we have seen" (DUNMORE 1994, vol. 1, p. 61).

[8] This description also exactly corresponds with the Dutch account of Roggewein's voyage, printed at Dort in 1728" (THOMAS & BERGHOF 2000, p. 301). Georg Forster appears to have (read) a copy of the *Tweejaarige Reyze*.
[9] "Zoo dat wygemakkelyk (wie zal zich niet verwonderen) zonder het hooft te buygen, tusschen de beenen van deze Goliats kinderen zouden hebben konnen doorgaan" (Tweejaarige Reyze, 1728).
[10] BAHN & FLENLEY 1992, p. 139.
[11] Jacob Roggeveen's journal was confiscated in Batavia by the VOC (Dutch East India Company). A transcript turned up in 1836 in the archive of the WIC (Dutch West India Company) in Middelburg and is now in the National Archives of the Netherlands in The Hague. It was published in print in 1838. The journal of Cornelis Bouman was also lost. Part of it was found in 1910 in the estate of a Rotterdam harbour baron D. Hudig. That part (original?) is now to be found in the Rotterdam city archive. It was published in 1911 by the Royal Zeeland Society of Arts and Sciences.
[12] "[...] zyquamen aan boort sonder de minste wapenen, gelijk ons volk ook getuygde, die met de vaartuygen aan strant waren geweest, dat sy daar geen eenigh man met eenige wapenen hadden gesien" (BOUMAN 1911, pp. 86-87).
[13] ROGGEVEEN 1911, p. 118.
[14] BEHRENS 1728, p. 10.
[15] "Wie es schien, besaßen die Leute keine Waffen" (BEHRENS 1923, p. 69). In the French edition of 1739: "Les habitans de cette île ne portent point d'armes, du moins n'en avons-nous vu aucune" (BEHRENS 1739, p. 134).
[16] CORNEY 1903, p. 99. "No se conoce género de armas entre ellos" (FOERSTER 2012, p. 130).
[17] CORNEY 1903, p. 91. "Todos desarmados" (FOERSTER 2012, p. 118).
[18] Also noted by the Dutch: "Zy hadden geen kennis van yzer, staal, nogh wapenen..." (BOUMAN 1911, p. 91).
[19] CORNEY 1903, p. 99. Most likely this relates to obsidian. Bouman already noted the use of obsidian to separate a banana from the stalk.
[20] BEAGLEHOLE 1961, p. 339.
[21] THOMAS & BERGHOF 2000, vol. I, p. 303.
[22] SPARRMAN 1953, p. 117.
[23] HOARE 1982, p. 475.
[24] BEAGLEHOLE 1961, p. 355.
[25] HUNT & LIPO 2011, pp 93-107; FLAS 2012.
[26] BEAGLEHOLE 1961, p. 342.
[27] DUNMORE 1994, p. 60.
[28] THOMAS & BERGHOF 2000, vol. I, p. 323.
[29] BEAGLEHOLE 1961, p. 351.
[30] CORNEY 1903, p. 96.
[31] "gelijckwy sagen het geraamte van een nieuwe timmering" (ROGGEVEEN 1911, p. 123).
[32] See POLLOCK 1993, POLET 2012.
[33] Here I have used a simple growth function: $P = p.e^{rt}$, r being the growth rate, P the population, p the number of colonists and t the time.
[34] STEFAN 2000, p. 69.
[35] "Zu tausenden schwammen die Einwohner im Wasser herum" (BEHRENS 1925, p. 64). In a similar rhetoric way: "een ontelbaare menigte van wilden op de oever" ("an immense throng of savages on the shore"), *Tweejaarige Reyze* 1728, p. 43.
[36] "Los naturales cuyo número se cree no excedan de 3000" (FOERSTER 2012, p. 111).
[37] CORNEY 1903, p. 93; Foerster has: "más de 800 hombres" (FOERSTER 2012, p. 119).
[38] CORNEY 1903, p. 100. The introduction to González's journal includes a letter from Dalrymple to Dr. Hawkesworth, written shortly after González's return. This letter states: "Its natives number about 3,000 of both sexes" (CORNEY 1903, p. XLV). Dalrymple

received information from the Spanish expedition. It could be the same source (González) as mentioned by Foerster (note 14).

[39] CORNEY 1903, p. 127. Foerster attributes the same number to José de Moraleda (FOERSTER 2012, p. 138).

[40] BEAGLEHOLE 1961, p. 354.

[41] THOMAS & BERGHOF 2000, vol. I, p. 320.

[42] HOARE 1982, vol. 3, p. 468.

[43] BEAGLEHOLE 1961, Appendix IV, p. 760.

[44] BEAGLEHOLE 1961, Appendix V, p. 820.

[45] BEAGLEHOLE 1961, Appendix V, p. 821.

[46] SPARRMAN 1953, p. 116.

[47] DUNMORE 1994-1995, vol. I, p. 58.

[48] "la génération actuelle, dont je crois pouvoir, sans exagération, porter la population à deux mille personnes" (LAPÉROUSE 2008, p. 68).

[49] "Estimarse en dos mil personas" (FOERSTER 2012, p. 249).

[50] LAPÉROUSE 2008, p. 80.

[51] RICHARDS 2008, p. 20.

[52] The "wells" in some accounts are most likely cisterns or underground ponds, filled with rainwater.

[53] "callebassen, daar zy water in hadden, 't welk ik proefde en bevond seer brak te zijn" (BOUMAN 1911, p. 91).

[54] DUNMORE 1994, p. 65. This probably relates to the same fruit that the Dutch called *callebas*, and the Spanish *calabaza*.

[55] "a well very close to the sea... full of impurities. When our people had cleared it, they found the water in it brackish, but the natives drank of it with much seeming satisfaction" (THOMAS & BERGHOF 2000, p. 308). "There was little brackish water in holes by the shore" (DUNMORE 1994, p. 65).

[56] "this was so strongly impregnated with Iron ore that it made sick who drank of it" writes Cook in his journal.

[57] BEAGLEHOLE 1961, p. 350.

[58] THOMAS & BERGHOF 2000, p. 308.

[59] MIETH & BORK 2012, p. 75.

[60] ROGGEVEEN 1911, p. 120.

[61] "gestreept lijnweaet" (ROGGEVEEN 1911, p. 120).

[62] "kleyne kokos nootenboomen sagen wyweynigh". "[...] jannes en ander soort van aard vrughten, die ik niet en kon" (BOUMAN 1911, pp. 90-91). This relates to sweet potato, yam and taro.

[63] CORNEY 1908, p. 101. This could be the Malay apple (*Syzygium malaccense*).

[64] CORNEY 1908, p. 122.

[65] CORNEY 1908, p. 127.

[66] "The produce is Potatoes, Yams, Taro or the Eddy root, Plantains and Sugar Cane, all excellent in its kind, the Potatoes are the best of the sort I ever tasted". "[...] ratts which I believe they eat" (CORNEY 1908, p. 349).

[67] BEAGLEHOLE 1961, p. 350.

[68] DUNMORE 1994, p. 65.

[69] "de wylewy het selve niet alleen niet zandig, maar integendeel uytnemend vrugtbaar bevonden hebben [...] Sulx dit land tot een aardsch Paradijs te maaken is, indien het selve behoorlijck weird gecultiveerd en bearbeyd, 't geen nu alleen gedaan werd, nae de mate dat de Inwoonders benodigd sijn tot onderhoud des levens" (ROGGEVEEN 1911, pp. 125-126).

[70] "de inwoonders hadden kroonen kostgronden, vierkantigh met voren in goede ordre-afgedeelt" (BOUMAN 1911, p. 90).

[71] BEAGLEHOLE 1961, p. 357.

[72] THOMAS & BERGHOF 2000, p. 307.
[73] THOMAS & BERGHOF 2000, p. 311.
[74] MULROONEY 2013.
[75] BOERSEMA 2015.
[76] THOMAS & BERGHOF 2000, p. 307.

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T.d.H. Kort en nauwkeurig verhaal van de reize, door drie Schepen in 't Jaar 1721. gedaan, op ordre van de Ed. Heeren Bewindhebberen van de West-Indische Compagnie in Holland, om eenige tot nog toe onbekende Landen, omtrent de ZUID-ZEE gelegen, op te zoeken. Waar in alles wat haar op de Reize, van haar uitgaan tot haar terugkomste toe, is wedervaren, wordt aangetoont; alsmede veelewonderlyke manieren, gewoontens, en zeden der ontdekte volken, etc. Tweede Druk, verbetert. Te Amsterdam, By Johannes van Septeren, Boekverkooper op de Leydsestraat, tusschen de Heere- en Keysersgragt, 1727.

T.d.H. Het Waare en Nauwkeurige Journael der Reize, gedaan door drie Schepen, op ordre van de Ed. HeerenBewindhebberen van de West-Indische Compagnie, om eenige tot nog toe onbekende Landen, omtrent de ZUID-ZEE geleegen, op te soeken. Waar in alles wat haar op de Reize is wedervaren, wert verhaalt en aangetoont; als ook de wonderlyke manieren, gewoontens, en zeden der ontdekte volkeren, en hoe dese Reizigers op eenewonderlykewyze te Batavia zyn aangekomen etc. Den Derden Druk, van veele Drukfeilen verbetert, op nieuws nagesien door een ooggetuyge van deseReize, en met nodige Aantekeningen vermeerdert. Te Amsterdam, by Johannes van Septeren, Boekverkooper op de Leydsestraat, tusschen de Heere en Keysersgragt, 1727.

TweejaarigeReyze Rondom de Wereld, Ter nader Ontdekkinge der Onbekende Zuydlanden. Met drie schepen, in het Jaar 1721 ondernomen, door last van de Nederlandsche WestindischeMaatschappy, Waar in het wedervaaren en de Rampen op de Reyze verhaald, en de bezeylde en nieuw ontdekte Landen en Eylanden, met der zelver Bewoonders, beschreven worden. Nevens de Reyze van het Oostindisch SCHIP BARNEVELD, Uyt Holland tot aan de Kaap der Goede Hoope, in 't jaar 1719. BEHELZENDE Een verhaal van de langduurige tegenspoeden en zonderlinge voorvallen op het Eyland Madagascar, by de Woeste Souklaven, Met een Naauwkeurige Beschrijving van de vreemde Gewoontens,

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