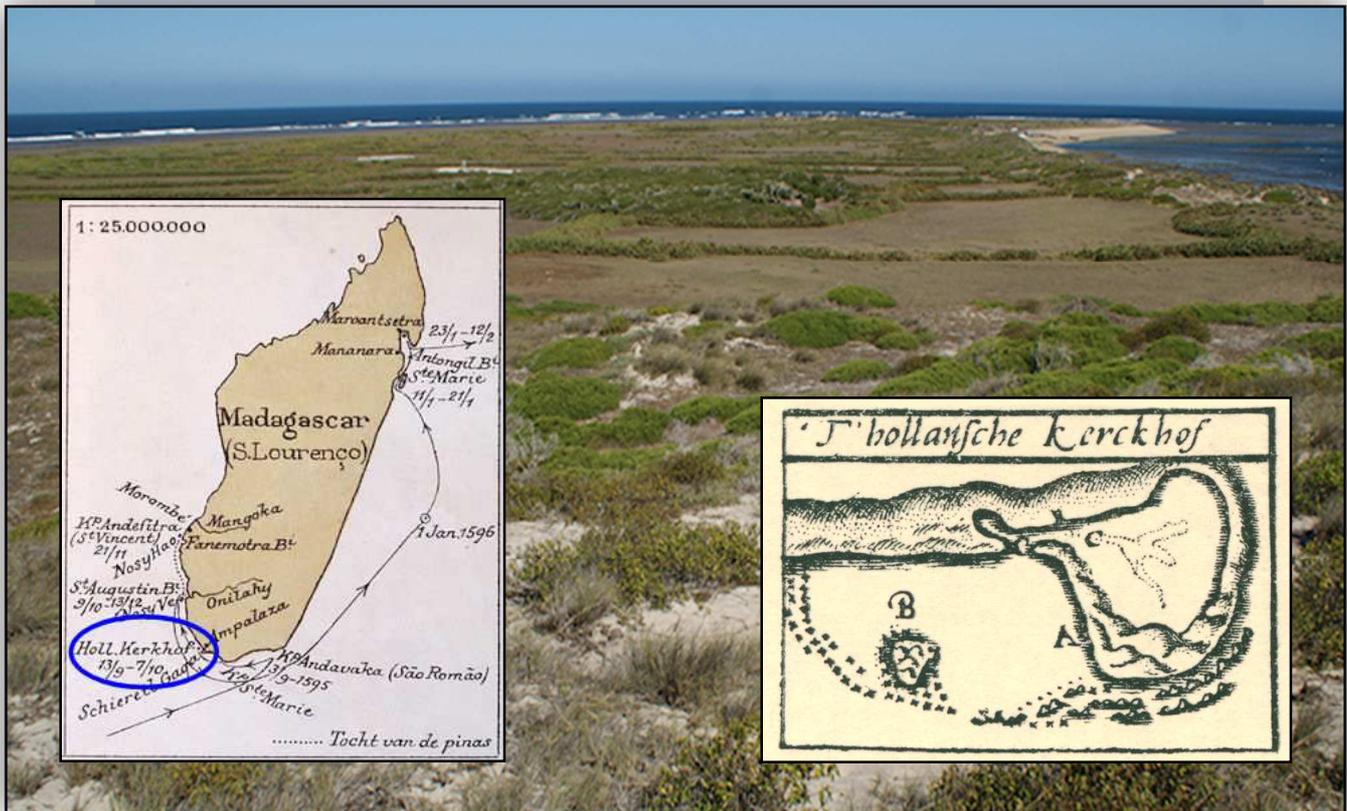


Physical Research of late 16th Century Human Skeleton Remains, found on Nosy Manitsa, Madagascar



Report of the scientific research of a human skeleton remains sample found on Nosy Manitsa (Madagascar), to verify if these belong to the Dutch sailors of the First Ship Voyage to East-India in 1595.

Authors: Marco Roling and David Bouman

Maritime Research & Consultancy (MR&C)
report 15D - 025

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With very special thanks to:

Prof. Chantal Radimilahy – University Museum of Antananarivo, Madagascar
Prof. Jean Aimé Rakotoarisoa – National Linguistic Institute for Oriental Civilizations, Madagascar
Prof. dr. Vladimir Stissi – Faculty of Archaeology, University of Amsterdam
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Dr. ir. Dominique J.M. Ngan-Tillard – Geo Engineering, Delft University of Technology
Dr. ir. Jouke Verlinden – Industrial Design Engineering, Delft University of Technology
Prof. dr. ir. Hans van der Plicht – Centre for Isotope Research, University of Groningen
Prof. dr. Menno L.P. Hoogland – Faculty of Archaeology, Leiden University
Dr. Jason E. Laffoon - Faculty of Archaeology, Leiden University
Drs. Martijn Manders – Maritime Program, Dutch Cultural Heritage Agency

Colophon

Maritime Research & Consultancy (MR&C) report 15D - 025
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Appendix to this report

A DVD with the following folders with digital content:

- MADG-HK-3Dprintfiles (2 files)
- MADG-HK-Formalities (5 files)
- MADG-HK-MoreImages (50 image files)
- MADG-HK-Photo (17 image files)
- MADG-HK-Presentation_PPT (2 files)
- MADG-HK-Reports (4 files)
- MADG-HK-Video (2x3 video files)

1. Introduction and summary

The archaeological project “Dutch Cemetery of 1595 on Madagascar” is an initiative of Maritime Research & Consultancy (MR&C) and is a collaboration between Universities and heritage agencies in Madagascar and the Netherlands. The international multi-disciplinary scientific project aims to locate and research the Dutch cemetery of 1595 on Nosy Manitsa, Madagascar. The project is setup in separate stages and this report is the result of the second stage.

The first stage from May 2013 until January 2014 was about the organization and realization of a ten day reconnaissance expedition to Nosy Manitsa. The objective was to gather information about the logistics, the local fishermen and the landscape of this remote and uninhabited small island on the South-West coast of Madagascar. According to Dutch archives, on this small island, ten miles from the Madagascar mainland, an undiscovered Dutch cemetery of 1595 would be located. Unforeseen, local fisherman on the island pointed out and showed human skeleton remains to the expedition team in August 2013. A human jaw bone (mandible) and some small bone fragments were collected for research purposes and deposited at the University of Madagascar, official leading partner of this project.

In the second stage of the project, from February 2014 until January 2015, scientific research was performed on the human skeleton remains in order to establish provenance, age and gender of the remains. This report summarizes the results of this research. Formal agreements were signed to legalize the transportation of the remains to the Netherlands in March 2014 and the subsequent research. The research was independently done at five different Universities in the Netherlands.

Historical background information about *‘The First Ship Voyage of the Dutch’* can be read in more detail in the earlier reports mentioned in this report.

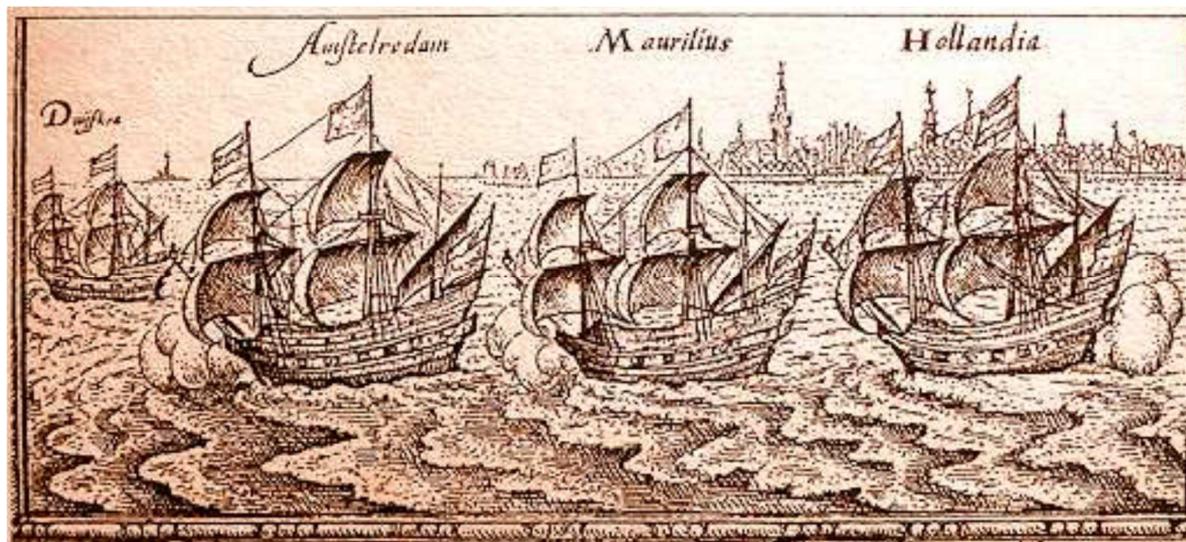


Image 1. The four ships of the First Ship Voyage, fragment of a copy of the original title print for Houtman's *‘Journael vande reyse der Hollandtsche schepen ghedaen in Oost Indien’* in 1598 (source: Collection Rijksmuseum Amsterdam)

After the first reconnaissance expedition undertaken in August 2013¹ and project planning for the next stages², it was decided together with the Malagasy University in the beginning of 2014 to utilize research facilities in the Netherlands to assess the provenance and age of these human remains. The

¹ See: MRC Rapportage HK 2013.pdf

² See: MRC PVA HK 2014 20140317 fin.pdf (in Dutch)

hypothesis was that the human remains belong to Dutch sailors who died during three weeks between September 14th and October 7th 1595 and were buried on the island Nosy Manitsa.

X-ray scanning and 3D replication was done at the Delft University of Technology.

Physical anthropological research was done at the University of Amsterdam.

Radio Carbon dating was done at the University of Groningen.

Stable Isotope Research was done at Leiden University in collaboration with the VU Amsterdam.

The following statement best reflects the combined results of the research:

'The human skeleton remains found on the Northern beach at Nosy Manitsa, Madagascar, belong to a male individual, aged between 20 to 30 years old, with some dental problems, who died between 1520 and 1645, and originated from North Western Europe.

This statement fits the hypothesis and supports the recommendation to organize a next project stage in which a survey is to be organized to actually locate and survey the Dutch cemetery. Before a survey is planned, it is advisable to release a mutual press release about the project in both Madagascar and the Netherlands. Also is it is advised by the Malagasy University to organize a courtesy mission by Dutch representatives to the Madagascar Authorities to increase awareness and commitment of the Malagasy government ministries.

We want to take the opportunity here to greatly thank all the researchers and contributors, their enthusiasm and cooperation, in the research of the human skeleton remains sample of Nosy Manitsa. The research has been very successful and the results exceed our expectations.

2. Formal agreements

The process of transportation, delivery and research of the Nosy Manitsa human remains required four documents to be written, signed and are worth mentioning in this report.

First, a formal letter was send on March 7th 2014, by Prof. dr. ir. Hans van der Plicht of the Centre for Isotope Research, University Groningen (RUG) to Prof. Chantal Radimilahy of the University Museum of Antananarivo, Madagascar, accepting the invitation to do a Radio Carbon dating of the human remains³.

Second, a formal letter was send on March 10th 2014, by Prof. dr. Vladimir Stissi of the Faculty of Archaeology, University of Amsterdam to Prof. Chantal Radimilahy of the University Museum of Antananarivo, Madagascar, accepting the invitation to handle the human remains for transport to RUG and to support other stages of the research project⁴.

Third, a Memorandum of Understanding (MoU) was written in order to legalize and formalize the transportation and research of the human remains found on Nosy Manitsa⁵. The MoU was signed by Prof. Panja Ramanoelina, President of the University of Antananarivo, and Prof. Frank Van Vree, Dean of the Humanities faculty of the University of Amsterdam, on April 30th 2014. It declares overall collaboration on the project to discover, research and possibly excavate the Dutch Cemetery of 1595 on Nosy Manitsa. The MoU is set for three years and is open to other parties to join in.

³ See: Formal Letter RUG.pdf

⁴ See: Formal Letter AAC UvA.pdf

⁵ See: Formal MoU Agreement UA UVA 20140312.pdf, MoU Un AMS Un TNR signed.pdf

Fourth and finally, a formal document was written and delivered with the human remains by Prof. Jean Aimé Rakotoarisoa to David Bouman and Marco Roling on May 10th 2014. This document declares the authenticity of the human remains, and the official reason the human remains are to be transported to the Netherlands for research purposes at Dutch Universities. Copies of the letters are available on the DVD with this report.

3. Research stages and results

3.1. Initial documentation

After the jaw bone was received in May 2014, it was immediately labeled, repacked and photographed by Marco Roling. Sand that came with the jaw bone was separately packed, as well as bone and tooth fragments. As all came together from the same archaeological context, it was decided to identify and label the jaw bone, sand and fragments all together as: **MADG-HK-2013-0001**

The human remains are packed in a medium size plastic container box, with:

- The original formal document by the University of Antananarivo, stating that the jaw bone can be transported to the Netherlands for research at the University of Amsterdam, Delft University of Technology and other institutions. The document is signed by Dr. Chantal Radimilahy May 2nd 2014, D. Bouman and M. Roling on May 10th 2014⁶.
- A jaw bone, protection from damage by cutout foam
- A small container box, with:
 - o a zipbag containing sand
 - o a zipbag containing bone and tooth fragments
 - o a memory stick with digital files and documentation



Image 2. The Nosy Manitsa human remains repacked

Jaw bone, bone fragments and tooth fragments have been photographed. Some examples are shown below:



Image 3. The mandible (left) and bone and tooth fragments (right) [photo: M. Roling]

More photographs are available on the DVD with this report (see folder: MADG-HK-Photo).

⁶ See: LetterUniversityMadagascar_BoneReceived_20140510.pdf in DVD folder MADG-HK-Reports

3.2. X-ray scanning and modeling

The jaw bone was given to Dr. ir. Dominique J.M. Ngan-Tillard of the Faculty of Civil Engineering and Geo Engineering of the Delft University of Technology. She was able to scan the jaw bone in a Phoenix nanotom® computed tomography (nano CT) system. Using a high resolution x-ray she was able to capture a full model of the jaw bone. This means that the model can later on be digitally sliced and projected in unlimited ways and directions without losing any detail.

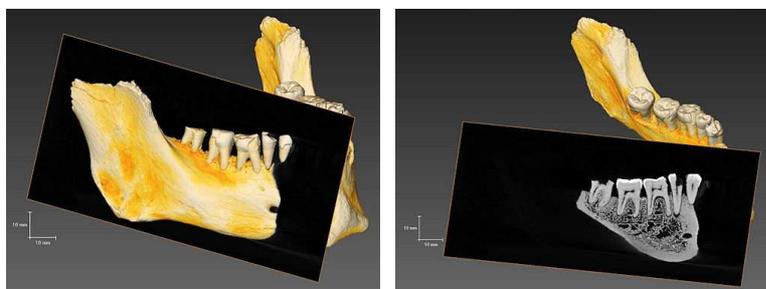


Image 4. The Phoenix nanotom (left) and the mandible placed in the CT scanner (right)

The original x-ray digital model is a grey-scale model (see upper left image below) that can be saved in high resolution TIFF images (in this case 776 images). The model can be rendered to make a visualization of the surface, distinguishing between hard and softer tissues (see upper right image below). In this way the bone, teeth and enamel are colored slightly differently to make a realistic 3D view of the jaw bone.



The model can be digitally sliced in numerous ways in order to visualize the inner bone structure and tooth base. This slicing can be combined with the outer surface for optimal visual representation of the scanned bone (see example images below).



The 3D model is presented in short in a PDF document and in video (different formats), that can be found on the DVD with this report⁷.

⁷ See: MADG-HK-2013-0001_cross sections v2.pdf, MADG-HK-2013-0001.avi

3.3. Geological analysis

The sand was photographed under a microscope and analyzed briefly, also at the faculty of Geo Engineering of the Delft University of Technology. The sand of Nosy Manitsa is a combination of quartz, coral and some bone fragments. The amount of sand available for research was limited, but still it can be said that the majority is a variety of quartz minerals, with some carbonated sea life forms.

A short presentation is available in PDF on the DVD with this report⁸.



Image 5. Detailed photograph of sand sample Nosy Manitsa

3.4. 3D replication

The first stage of replication was creating a 3D model, suitable for printing. Dr. ir. Dominique J.M. Ngan-Tillard used the software tool Avizo for creating a solid model⁹. As the original X-ray model represents also the interior open bone structure, this had to be digitally solidified in order to be used with a 3D printer. The solid model was recorded in the 3D print format STL¹⁰.

The STL file was transferred to Dr. ir. Jouke Verlinden of the faculty of Industrial Design Engineering, Delft University of Technology. This faculty works on robotics, 3D printing and other disciplines. Dr. ir. Jouke Verlinden enhanced the 3D model digitally with a supporting print structure and shifted the printing orientation to upside down for better printing result.

Then he was able to print the jaw bone on a 1:1 scale with a FORM 1+ SLA High Resolution Formlabs printer. Stereolithography (SLA) is an additive manufacturing process which employs a vat of liquid ultraviolet curable photopolymer "resin" and an ultraviolet laser to build parts' layers one at a time. For each layer, the laser beam traces a cross-section of the part pattern on the surface of the liquid resin.

⁸ See: MADG-HK-2013-0001_sand v2.pdf

⁹ See: MADG-HK-2013-0001_jaw surface.am

¹⁰ See: MADG-HK-2013-0001_jawsurf500000facets.stl

Exposure to the ultraviolet laser light cures and solidifies the pattern traced on the resin and joins it to the layer below.

A short presentation video about the 3D printing is available in PDF on the DVD with this report¹¹.

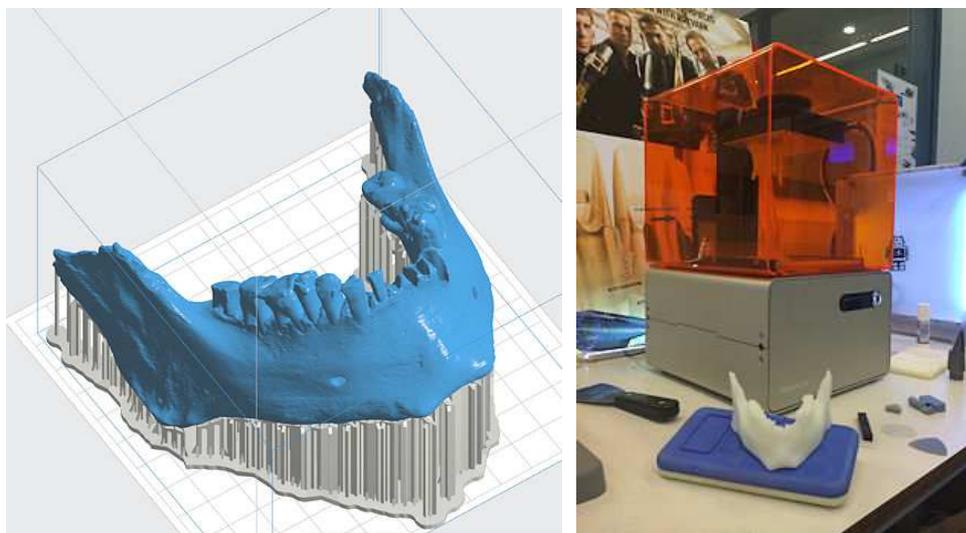


Image 6. 3D model with support structure (left) and the Formlabs printer with 3D replica (right)

The produced replica remains in the Netherlands as a physical model and the original jaw bone will be returned to Madagascar in time.



Image 7. Replica and original mandible frontal and side [Photo: M. Roling]

3.5. Physical anthropological assessment

In June 2014 Dr. Liesbeth Smits of the Faculty of Archaeology of the University of Amsterdam has made an physical anthropological study of the jaw bone (mandible). The research focused on the biological features such as gender, age and pathology¹².

The mandible is very well preserved and suitable for study. Only a few teeth are missing, most of the enamel, but this is not problematic for the research purposes.

The mandible is assessed for its gender by scoring on four distinct characteristics of the bone shape. Three out of four indicate masculine for this mandible.

¹¹ See: MADG-HK-2013-0002.avi

¹² See: MADG-HK-2013-0001 PhysicalAnthrop 20140721.pdf

Age estimation is based on permanent dentition. The wisdom teeth are present here, and attrition of the teeth are an indication of the age of the person at death. In this case a conservative indication points to an age between 17 and 35 years old. One could however consider that the age probably ranges between 20 and 30 years.

Overall dental condition is rather healthy without any indications of caries or ante mortem tooth loss, nor any diseases or hardships during the growth period. There are however indications of slight periodontitis (infected gum) and receding of the bone showing the molar roots.

Overall conclusion is that the mandible is very likely to have belonged to an adult male person who died at the age probably between twenty to thirty years old. The person likely had some slight gum disease at some point in time.

3.6. Radio carbon dating

In July 2014 Prof. dr. ir. Hans van der Plicht of the Centre for Isotope Research at the University Groningen has performed a radiocarbon dating of a sample of the jaw bone. A small section of the upper part of the back side of the mandible was taken and a tooth for extracting carbon. The process of extraction of the pure carbon is mostly a chemical one and the resulting carbon is then heated in a particle accelerator. The carbon isotopes can be counted and the result indicates for the time that has passed since the person has deceased.

The outcome of the Madagascar sample GrA-60046 is 310 +/- 35 BP (in Radiocarbon years) which corresponds to the calibrated date of 1520-1645 AD¹³.



Image 8. Particle Accelerator for Radio Carbon dating at the Groningen University

Additionally to the Carbon-14 dating, also the stable isotopes of Carbon-13 and Nitrogen-15 were counted. This is to check if the Carbon-14 is to be corrected for diet influences, causing a reservoir effect to the actual measurements. The slightly raised ¹⁵N and slightly depleted ¹³C poses the question whether there is a reservoir effect in this case. Without information of the consumed diet and the ratio of terrestrial with marine or freshwater food that is hard to interpret. Therefore the date for this sample is possibly somewhat younger. Still the assumed year of death of 1595 fits perfectly within the resulting time frame.

¹³ See: MADG-HK-2013-0001 PhysicalAnthrop 20140721.pdf

3.7. Stable isotope analysis

In September 2014 Prof. dr. Menno L.P. Hoogland and Dr. Jason E. Laffoon of the Faculty of Archaeology, Leiden University took a tooth sample from the mandible for isotope research. The stable isotopes of Strontium (Sr), Carbon (C) and Oxygen (O) were measured with a mass spectrometer at the facilities of the Faculty of Earth and Life Sciences, VU University Amsterdam.

Especially the Strontium value is an indicator for the geographical provenance of the individual. Strontium values vary regionally around the world. The element incorporates in the human body by diet especially during growth of the body. Comparison between known values and the measured value of the researched individual can support evidence of the region where a person grew up.

In the case of the human remains from Nosy Manitsa, it is not possible to determine if the individual is of local Malagasy origin owing to a lack of comparative (baseline) isotope data for the find location and surrounding region. The obtained results can, however, be compared to the large corpus of modern and archaeological isotope data from Europe. This comparison indicates that the combined isotope results are in fact consistent with natal origins in northwestern Europe, and probably the Holland region¹⁴.

This results fits with the assumed origin of the individual, being a sailor from the region of Holland at the time (presently the Netherlands western coastline province).

4. Evaluation and recommendations

Maritime Research & Consultancy has undertaken the utmost effort to fully explore and exploit the research possibilities and to maximize the research results, given the limited human remains sample available. Researchers and contributors from various Universities and institutions collaborated professionally and scientifically at this research stage, and with great enthusiasm and support.

The research results as presented in this report support the hypothesis that the human remains at Nosy Manitsa belong to the Dutch sailors who died there in 1595.

The next logical, desirably and strongly advised stage in the project, also described earlier in the overall project plan, is to organize and perform a local survey on Nosy Manitsa. This survey will focus on locating the cemetery, and the possible remains of the 1595 sick camp on the island, using remote sensing techniques and visual survey. A survey plan has been written already to assess the feasibility, logistics and required resources.

There is a strong commitment, especially from the Malagasy University, to continue the project. Organizing a courtesy mission by Dutch representatives to Madagascar is advisable and desirable. This will provide the opportunity to explain the project, and its results so far, to the Malagasy Ministries and other officials, creating awareness and increasing further commitment and support from the government.

Having reached results as mentioned in this report, it is also advisable to publish these results, the project plans and objectives in order to increase public exposure and support. This will help organization and financing of the next stages of the project. Before publishing results, it is important to create a mutual press statement about the project, which should be released at the same time in Madagascar and the Netherlands.

¹⁴ See: UL report isotope analysis MADG-HK-2013-0001.pdf

5. Financial overview

Organization Maritime Research & Consultancy (MR&C)

Activity	description	Amount
Organization	Total projectmanagement	€ 22.400,-
Reporting	Collecting results, elaboration and writing final report	€ 3.200,-
Expenses	Travel costs, other costs (MR&C)	€ 750,-
Transport	Airline return ticket Paris – Antananarivo for Prof Jean-Aimé Rakotoarisoa	€ 800,-
Research	Carbon dating (University Groningen)	€ 425,-
Total costs		€ 27.575,-

Contributions in kind

Partner	Description
University of Amsterdam	Research hours, reporting physical anthropology
Delft University of Technology	X-ray scanning, 3D modelling, Geological analysis, 3D printing, documentation
Leiden University	Isotopic research at facilities of VU Amsterdam, and reporting
Centre for Global Heritage and Development	Organization and networking hours
University of Antananarivo	Organization and administration hours

Financial contributions

Partner	Description	Amount
Maritime Program, Dutch Cultural Heritage Agency	General contribution	€ 2.000,-
Centre for Global Heritage and Development	Financial contribution for C14 Analysis	€ 425,-
Total contribution		€2.425-

Total financial costs and benefits

Description	Amount
Total Costs	€ 27.575-
Total Contribution	€ 2.425-
Ultimo not financed	€25.150,-