INSTITUT
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UNIVERSITÉ de Picardie Jules Verne
CAMPUS universitaire de Saint-Quentin
PÔLE TECHNOLOGIQUE

2021
GEOPOLYMERCAMP

13th GP-Camp

LTI PÔLE TECHNOLOGIQUE SAINT-QUENTIN
UNIVERSITÉ de Picardie Jules Verne

MAG
Matériaux Avancés en Géopolymère

Saint-Quentin (France)

Aug. 30-31, Sep.1, 2021

2021 GEOPOLYMERCAMP

Tuesday, October 31, 3021

Geopolymer and archaeology

South America (Tiwanaku/Pumapunku) and the relations with Easter Island : artificial geopolymer stone?

3 Parts

1) Contribution of LTGS (*Low Temperature Geopolymeric Setting*) in the development of Tiwanaku/Pumapunku.
2) The hypothesis on the transfer of artificial geopolymer stone Technologies from Tiwanaku/Pumapunku to Easter Island statues.
3) Efficient use of geological knowledge.

   3 examples from our present research:

   - red sandstone, weathered raw material,
   - volcanic andesite, natural volcanic sand.
   - volcanic tuf in Easter island, sandy tuf.

Easter Island

2016 Ralph Davidovits

Chemamülles

Rano Raraku volcano

Thor Heyerdahl 1987

Maoi Ahu Tongariki

1980, I had met a Peruvian anthropologist, Francisco Aliaga from the National Institute of Culture in Huankayo, Peru. He had met ancient Peruvian artisans who made delicate objects in stone using an ancient technique that consisted of softening stone by using plant extracts.

According to him, in the stories told by the native Peruvians, the builders of the megalithic fortresses of Sacsayhuaman near Cuzco had used a traditional technique that made the rock malleable by incorporating plant extracts (I know now that these are organic acids).

Fabrication of Stone Objects, by Geopolymeric Synthesis, in the Pre-Incan Huanka Civilization, Peru *by Joseph Davidovits and Francisco Aliaga*

"All the News That's Fit to Print"

The New York Times

THE WEATHER
Metropolitan area: Sunny, dry today; clear tonight. Mostly sunny tomorrow. Temperature range: today 63-77; yesterday 53-77. Details are on page 33.

THE NEW YORK TIMES, SUNDAY, MAY 24, 1981 39

Testing of Relics Results in Surprises

By WALTER SULLIVAN

Is a skull from Petralona Cave, Greece, the oldest evidence of man in Europe? Was the allegedly 2,500-year-old head of a woman in a Geneva museum faked by gamma ray treatment? Were the giant heads of Easter Island and other notable monuments cast from plastic rock instead of being hewn?

Answers to these and a variety of other archaeological questions were described last week at an international symposium on archaeometry, held at Brookhaven National Laboratory in Upton, Long Island. Archaeometry is the use of scientific techniques to determine the ages of archaeological specimens as well as their places and circumstances of origin.

Several surprising discoveries were reported. P. T. Craddock of the British Museum Research Laboratory in London, told of one that occurred when the museum restorers brought him a plaque produced in the Roman Empire about the time of Christ. They had been unable to remove its purple-black coating.

The laboratory found that the surface layer was copper oxide with some gold and silver. It had apparently been produced in the same manner as the highly prized Shakudo alloys supposedly invented by the Japanese 15 centuries later.

Use of Rhubarb and Bitter Plum

That the Romans used the same method is suggested by records of the ancient alchemists of Alexandria, who obtained a purple patina by treating the metal with rhubarb, rich in oxalic acid, and salts. The Japanese used similar acids derived from the bitter plum.

It is possible, Dr. Craddock said, that objects thus treated were the "Corinth bronzes" that, Pliny wrote at that time, brought enormous prices. Until now no specimens of these so-called bronzes were known.

The authenticity of the terra cotta head of a woman, acquired two years ago by the Museum of Art and History in Geneva as a rare example of Etruscan art, had been challenged. Four nude satyrs on the diadem ringing her head were unlike anything else from that period. They seemed an improbable decoration for a woman's headband.

An effort to determine the age of the piece by a technique known as thermoluminescence supported its authenticity, but skeptics argued that this could have been faked by firing gamma rays at the head. In thermoluminescent age determinations a pottery specimen is heated until it glows with energy stored since it was fired from its exposure to natural radiation. The more stored energy, the longer its exposure.

Second Test Confirms Age

It was said that a counterfeiter could greatly increase the apparent age by artificial radiation. Now, the Brookhaven meeting was told, another test has confirmed the great age. Extremely sensitive measurements of earth magnetism captured by the head when it was removed from the kiln and cooled showed an intensity characteristic of the period 2,500 years ago.

The recorded intensity was from 65 to 77 microtesla whereas today the magnetic field of the earth in central Italy has weakened to 45 microtesla.

Probably the most sensational proposal at the meeting was that many of the most impressive ancient monuments of the world were not carved but cast from stone converted into a plastic form by plant extracts, such as oxalic acid, found abundantly in rhubarb leaves.

Examples cited included stones forming the pyramids of Egypt, the ancient beetle-browed statues of Easter Island and the great stone structures of the high Andes, such as the famous Gate of the Sun built by the ancient Huanka civilization at Tiahuanaco.

The Work of Witch Doctors

The proposal was made by Joseph Davidovits of the Geopolymer Institute in Saint-Quentin, France, who has been working with Francisco Aliaga, a Peruvian ethnographer. He pointed to a groove in the stonework of the Gate of the Sun that could have been produced by a fold in the rubberized cloth onto which the plastic rock had been poured.

It has recently been discovered, he said, that some witch doctors, in the Huanka tradition, still make small stone objects in this manner. He cited evidence of oxalic acid derivatives in such monuments as those on Easter Island.

Others have attributed these oxalates to fungi or microorganisms. For a number of years Mr. Davidovits has argued that ancient ceramics were produced by a cementing process without any need for firing.

His proposals were greeted with considerable skepticism.

"Intriguing, but definitely controversial," said Edward V. Sayre of Brookhaven, one of the conference organizers. Others argued that the use of heat to

At the meeting three scientists from the University of Cologne in West Germany reported an age determination of 200,000 years from the skull itself. The skull had been encrusted with calcite, which was removed in the cleaning.

The age tests, by electron spin resonance, were made on the calcite and bone splinters that had come loose with it. The technique measures the extent to which radiation exposure, over thousands of years, has freed electrons from atoms within the material.

Two researchers from the University of Georgia told of their analysis of marble forming the bust of a Roman woman now in the Fogg Museum of Harvard University and thought to date from about 50 A.D. They used the relative abundances of two isotopes, carbon 12 versus carbon 13 and oxygen 16 versus oxygen 18, as clues to the marble's origin.

The bust proved to be formed of five

tectors have made it possible to determine the positions of ancient coins when struck. A sharp hammer blow on the dies that imprint the coin, front and back, also imparts to the coin the magnetic field of the earth at that time. The vertical component of the field, surviving to this day, can be analyzed to show whether the coin was struck face up or face down.

G. S. Hoye of the University of Alberta reported that in all of the two dozen coins studied so far they were struck face down, as though it were taboo to hit the emperor in the face.

Some specialists have suspected that the accounts of Herodotus, the great historian of antiquity, were embellished. As an example they have cited his claims that gold was mined extensively on the Greek islands of Siphonos and Thasos. On the latter, he wrote, a "whole mountain has been turned upside down in the search for gold."

Technology unravels old riddles

Scientists date age, origin of artifacts by new techniques

By Walter Sullivan
New York Times

NEW YORK — Is a skull from Petralona Cave, Greece, the oldest evidence of man in Europe? Was the allegedly 2,500-year-old head of a woman in a Geneva museum faked by gamma ray treatment? Were the giant heads of Easter Island and other notable monuments cast from plastic rock instead of being hewn?

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"Intriguing, but definitely controversial," said Edward V. Sayre of Brookhaven, one of the conference organizers. Others argued that the use of heat to produce pottery from earliest times was well documented.

The proposal by Greek scientists that a skull found 20 years ago in Petralona Cave in northern Greece might be close to a million years old had been based on age determinations of material found near the skull. It would mean that human beings inhabited Europe far earlier than previously supposed, but the proposition was controversial.

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May 18 — 22, 1981

Brookhaven National Laboratory
Upton, Long Island, New York 11973

Easter Island

2016 Ralph Davidovits

Chemamülles

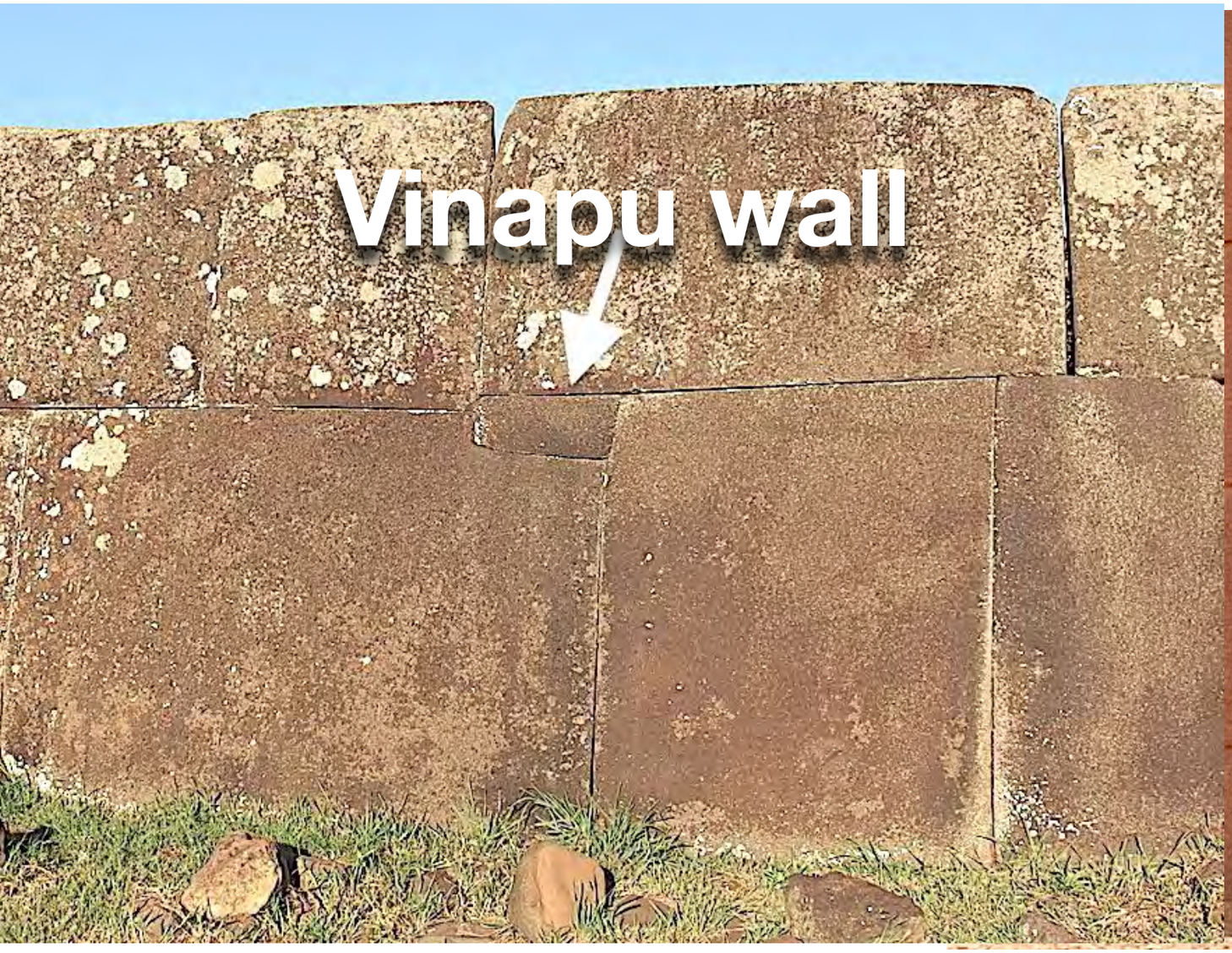
Rano Raraku volcano

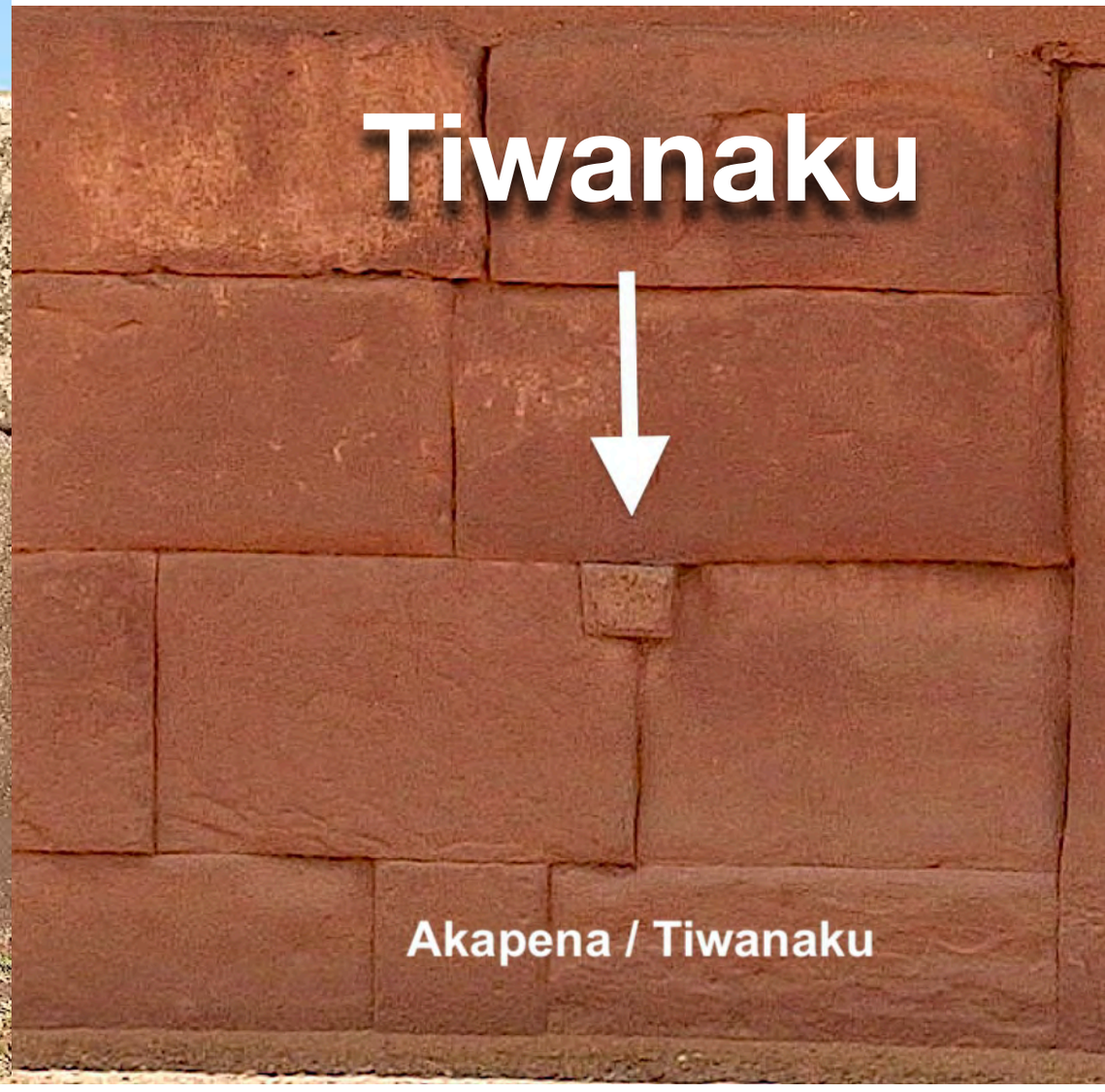
Thor Heyerdahl 1987

Maoi Ahu Tongariki

Easter Island: *Vinapu* wall

AD 900 ?



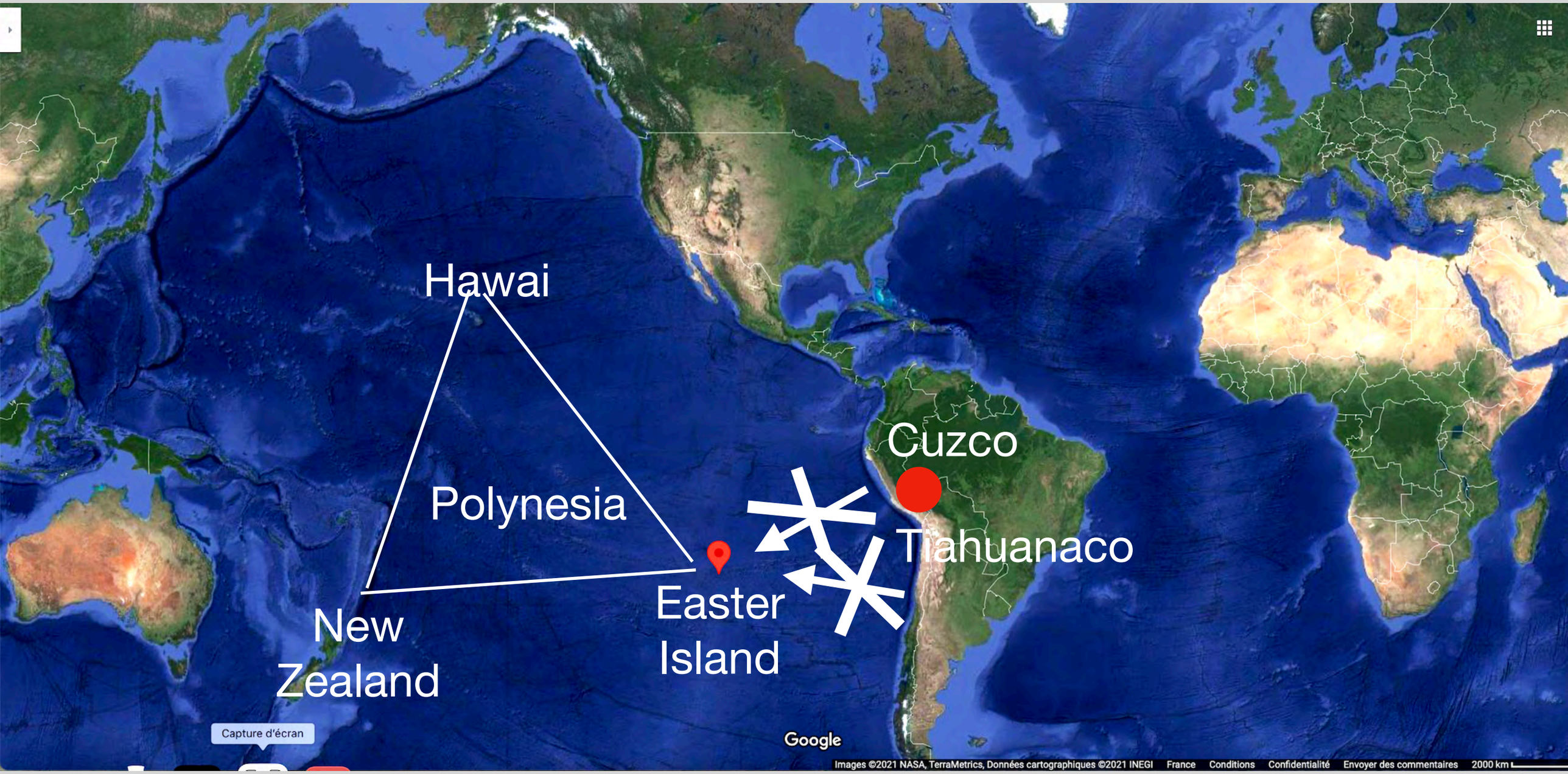


Easter Island AD 850-950

Tiwanaku AD 600-650

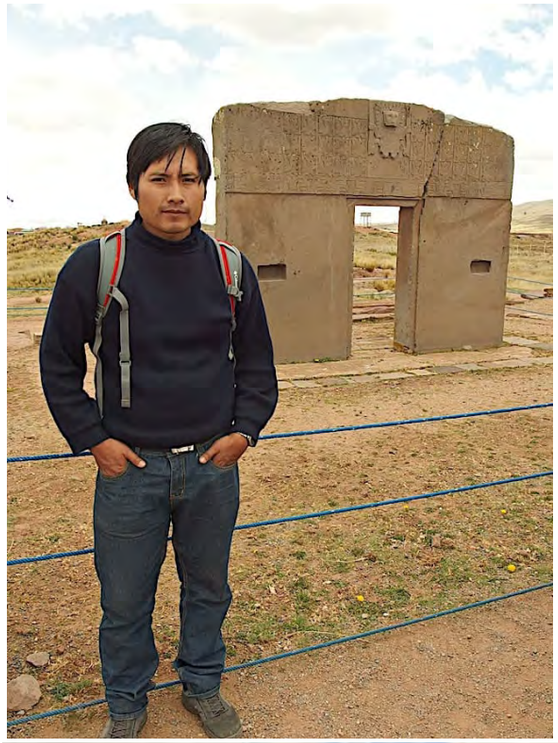
Does same architecture means same geopolymer technology ?

What is the problem ?



November 2017: Altiplano, Bolivia

altitude: 3850 - 4000 m



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géologist UCSP,
Aréquipa, Pérou

Ralph Davidovits,
Geopolymer Institute
St-Quentin, France

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Ancient geopolymer in south-American monument. SEM and petrographic evidence

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[b] Escuela Profesional de Geología, U.N.S.A., and CITEM, U.C.S.P., Arequipa, Peru
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online 8 october 2018

Grain boundaries
Microstructure

ABSTRACT

The make-up of the sandstone megalithic blocks, weighing between 130 and 180 tonnes each, from Pumapunku -Tiwanaku, Bolivia, was compared with three geological sandstone sites from the area. The SEM/EDS, XRD and thin section results suggest that the sandstone megalithic blocks consist of sandstone grains from the Kallamarka geological site, cemented with an amorphous ferro-sialate geopolymer matrix formed by human intervention, by the addition of extra alkaline salt (natron) from the Laguna Cachi in the Altiplano, Bolivia.

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Ancient organo-mineral geopolymer in South-American Monuments: Organic matter in andesite stone. SEM and petrographic evidence

Joseph Davidovits[a,*], Luis Huaman[b], Ralph Davidovits[c]

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ARTICLE INFO

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Carbon
Precursors: organic
Structural applications

online 04 January 2019

ABSTRACT

A recent study has shown the presence of artificial construction materials in pre-Columbian monuments at Pumapunku-Tiwanaku, Bolivia. In addition to ancient geopolymer sandstone-concrete megalithic slabs, the Pumapunku site contains puzzling "H" structures made of andesitic volcanic stone. The SEM study of this gray andesite shows the presence of organic matter: carbon, nitrogen, and minerals: Na, Mg, Al, Si, P, S, Cl, K, Ca. Organic matter is very unusual, if not impossible in a solid volcanic stone and suggests ceramic-like man-made stone. Our research demonstrates that these architectural components manufactured 1400 years ago (ca. CE 600) were fashioned with a type of organo-mineral precursor.

….. global approach and to integrate the different knowledge acquired in the fields

of ***anthropology*** and ***archaeology***

on the one hand,

and ***chemistry*** on the other.

It seems to me that finding satisfactory answers in only one single discipline does not allow us to understand and explain the adventure of Homo sapiens forced to live under extreme environmental conditions like those in the Altiplano.

What are the ***geopolymer science*** topics that will help us understand the history of Andean civilizations and the development of the Tiwanaku/Pumapunku civilisation ?

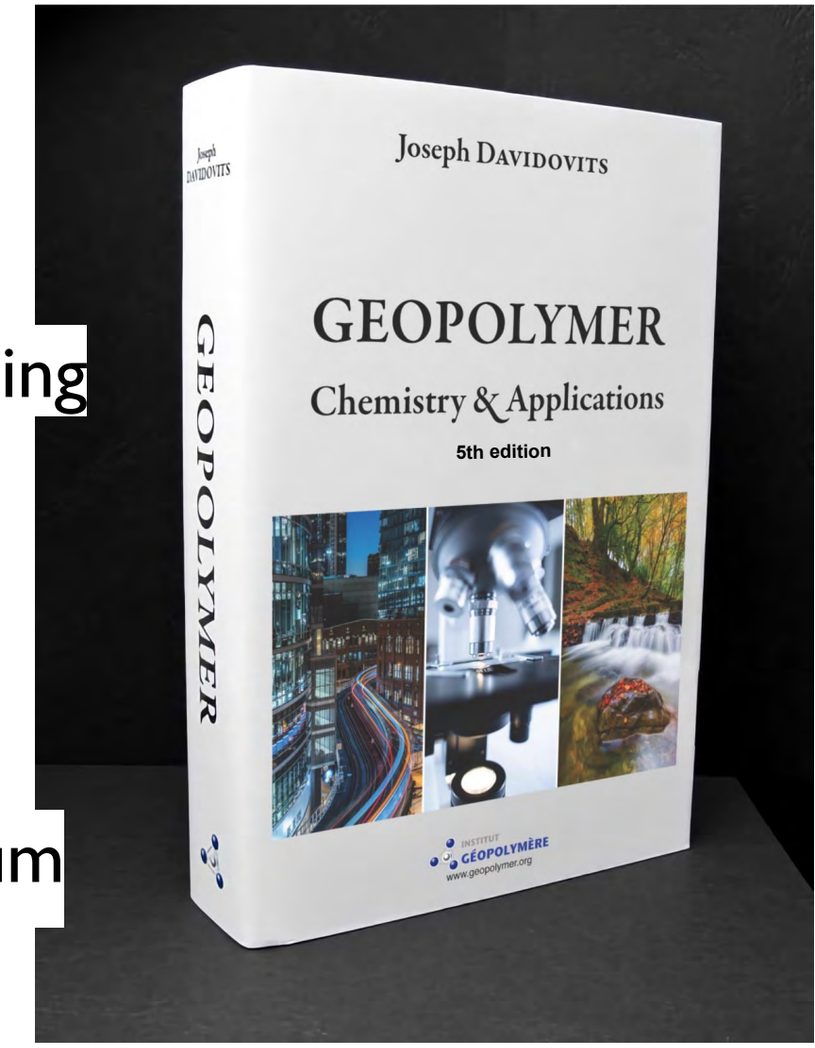
1) ***Contribution of LTGS*** (Low Temperature Geopolymeric Setting in Ceramics)

Chapter 25: Geopolymers in ceramic processing

2) ***Contribution of Phosphate-based / organic-acid-based*** geopolymer binders.

Chapter 14: Phosphate-based in acidic medium

Chapter 15: Organo-mineral geopolymer



There is no text, nothing engraved in Stela

Museo Nacional de Arqueología Tiwanaku, La Paz, (2017)

Thick-walled bowl (until AD 400).

Multicolored red *tazon* bowl (AD 500), thin-walled and very strong LTGS (geopolymer type) ceramic

Kero beaker (AD 500)

LTGS allows the production of a solid ceramic at a temperature between 400°C and 600°C, compatible with the quality and availability of the fuel and fireplaces used in the Altiplano. It is known that the combustibles were ***camelid dung*** (llama, alpaca, etc.), ***grasses*** and other ***shrubs*** from the savannah. Normally, under these conditions, only vulgar "terracotta" is manufactured, the firing temperature being less than 600°C.

A recent study conducted by M. L. Sidoroff, (2019), reproduced the experimental conditions when firing pottery with camelid (dromedary) dung in arid desert conditions in Jordan. Her team only obtained an average maximum temperature of ***596°C for 10 firings***. This is a relatively low temperature because the ceramics are made in an open fire (bonfire), like a garden fire.

The LTGS technology is of two types:

1) ***addition of alkaline reagent***, generally natron salt, (sodium carbonate), Kali (potassium carbonate) mixed with lime and water, to provide caustic soda NaOH, caustic KOH, geopolymerisation in alkaline milieu;

2) ***addition of acid reagent***, usually phosphoric acid and oxalic acid obtained by the reaction between an organic acid extracted from plants (acetic acid/vinegar, lactic acid, citric acid) and guano (calcium phosphate, calcium/ammonium oxalate), or bone powder (calcium phosphate hydrate), geopolymerisation in acidic milieu.

From LTGS ceramics, Pumapunku/Tiwanaku artisans were able to extrapolate and invent technologies for the manufacture of geopolymeric rock blocks and structures.

Red Geopolymer Sandstone
100-180 metric tonnes

Grey Geopolymer Andesite stone
impossible to carve

What is the connexion with Easter Island ?

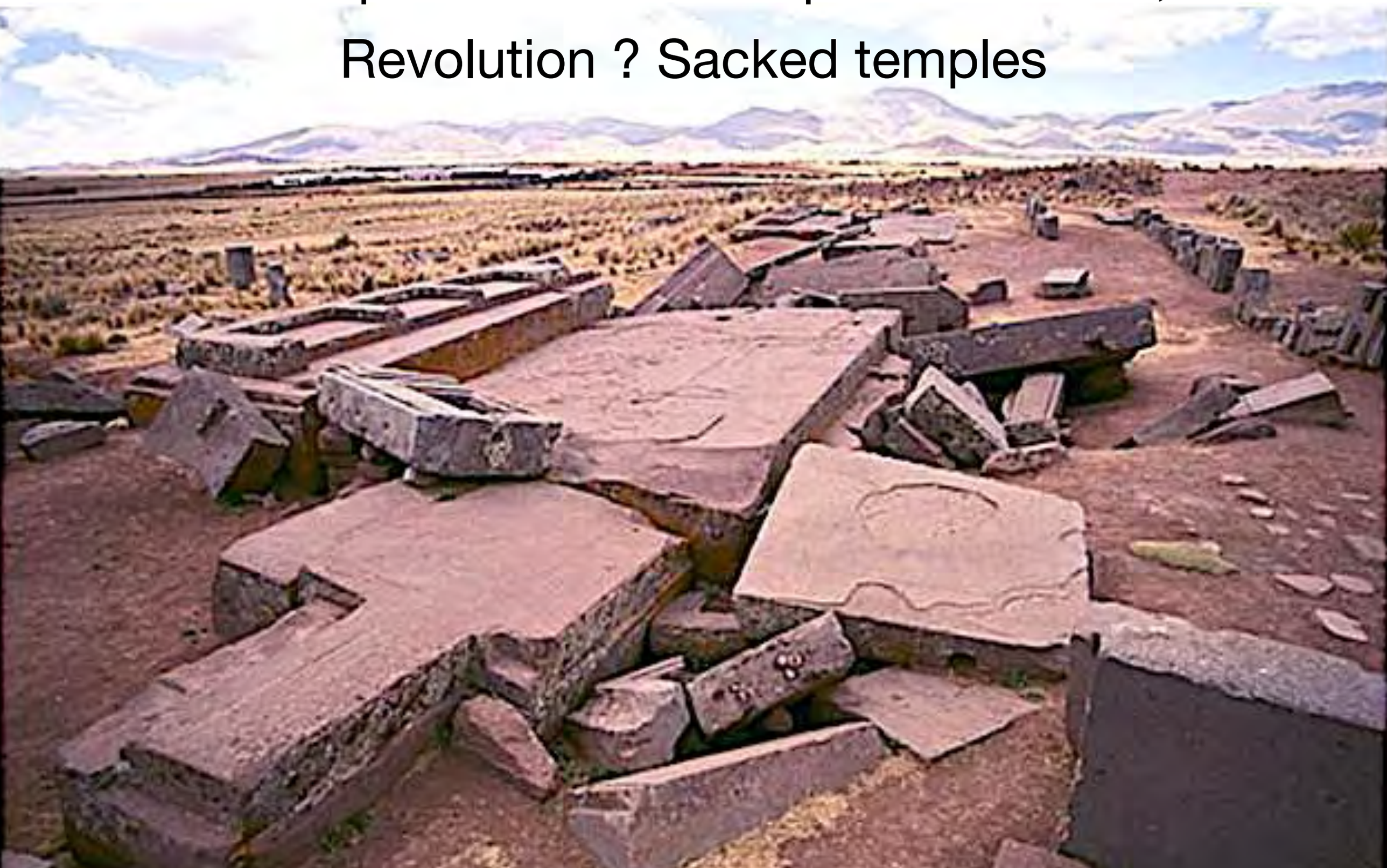
From whom came the knowledge ? When?

How did it happen?

AD 800-850.

Pumapunku / Tiwanaku political unrest,

Revolution ? Sacked temples

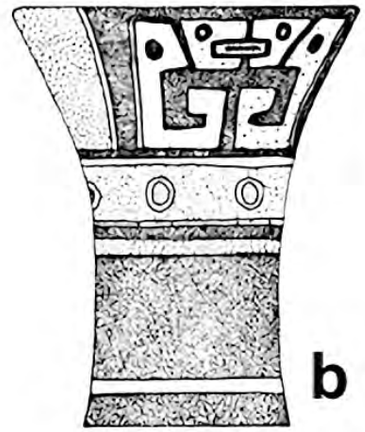


AD 800-850

Priests are forced to go into exile: where?

The Chilean archaeologist Mauricio Uribe, from the Universidad de Chile in Santiago, published an article in 2004 entitled: "*Tiwanaku ceramics and a jar from the Azapa Valley (Arica, Norte Grande, Chile)*".


a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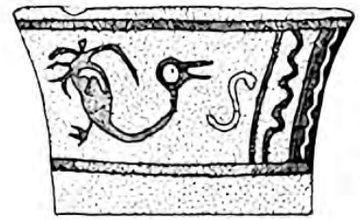
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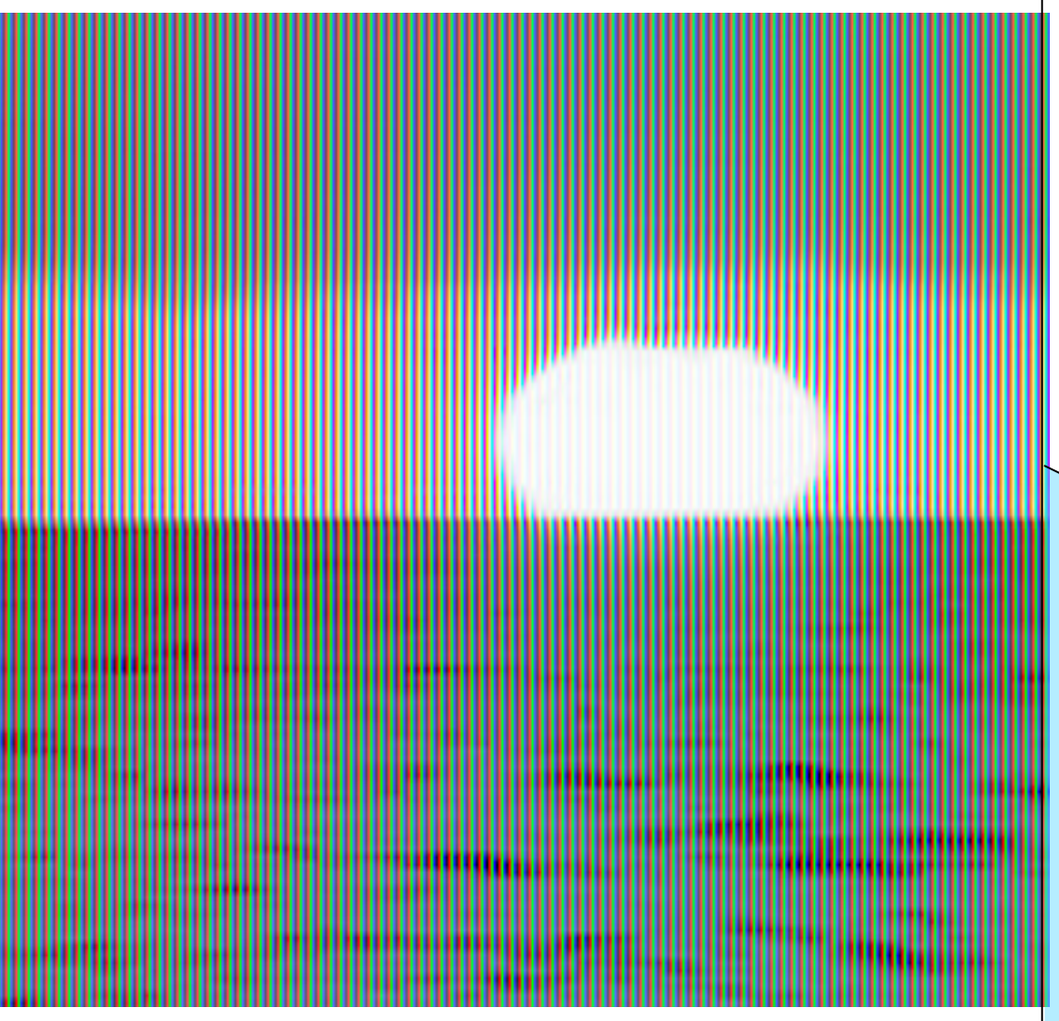
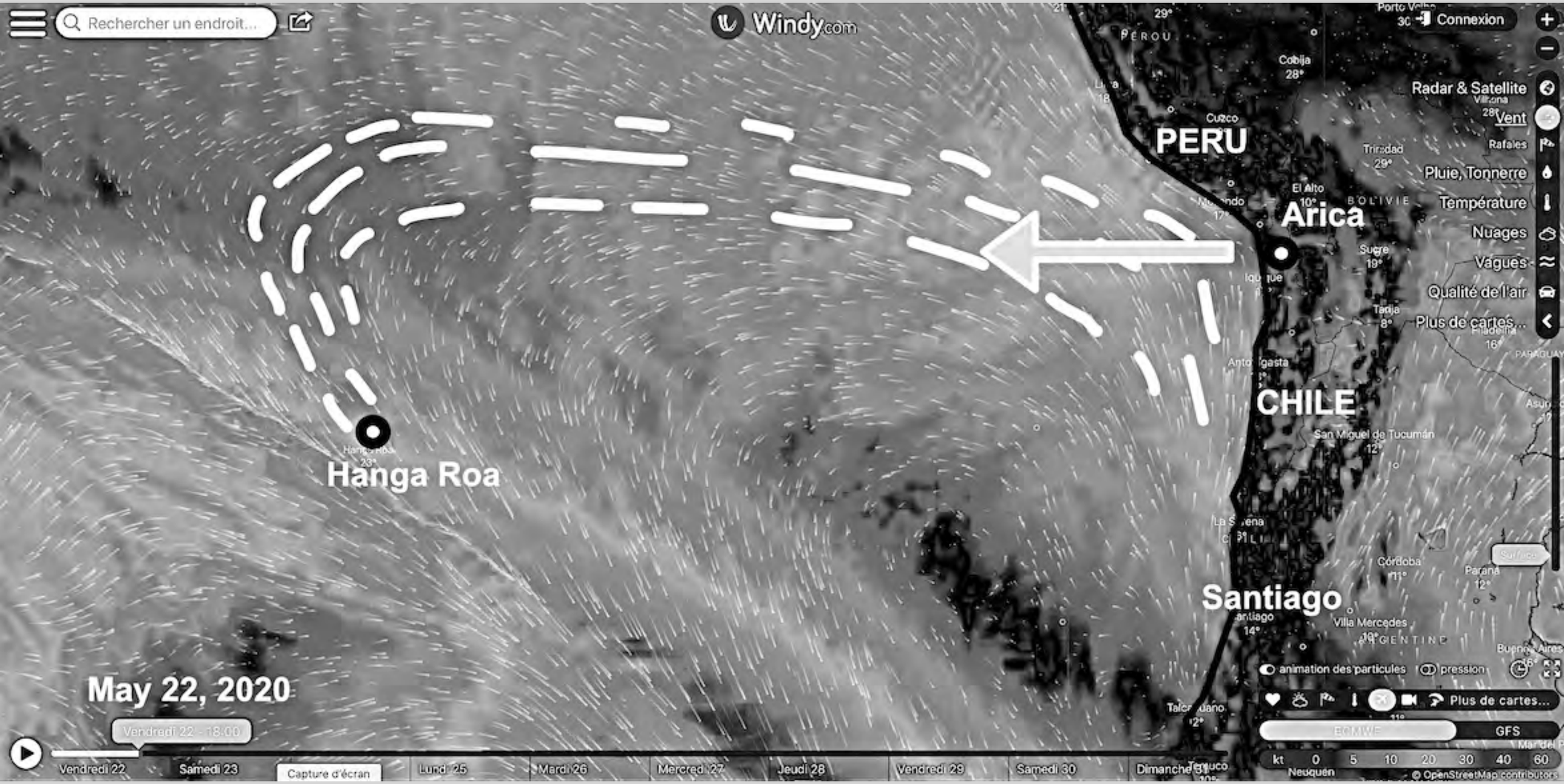
Why did they go to sea?
An order from the sun god?

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Cuzco
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29°
El Alto
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Arica
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Température
Nuages
Vagues
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Plus de cartes...
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San Miguel de Tucumán
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Hanga Roa
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Hanga Roa
Santiago
Villa Mercedes
Córdoba
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Mercred 27
Jeudi 28
Vendredi 29
Samedi 30
Dimanche 31

N

Easter Island

Anakena

Maunga Terevaka

AD 1550

Rano Raraku

Poike

millions of palm trees

Hanga Roa

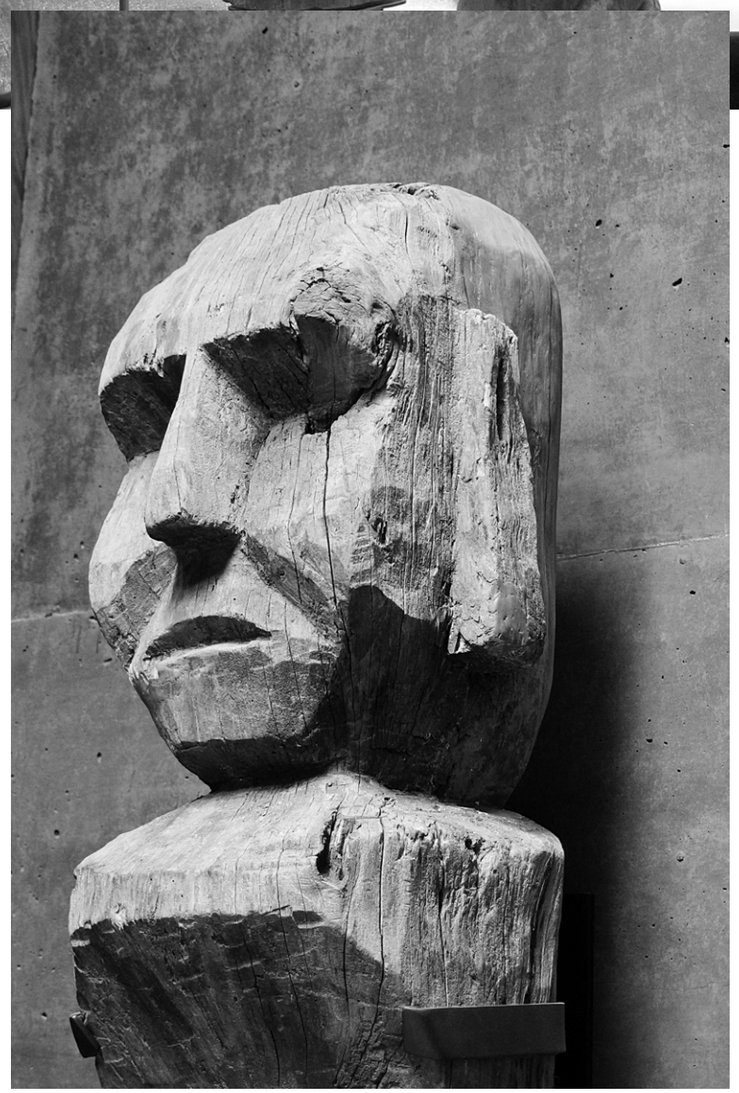
AD 800-900

Vinapu

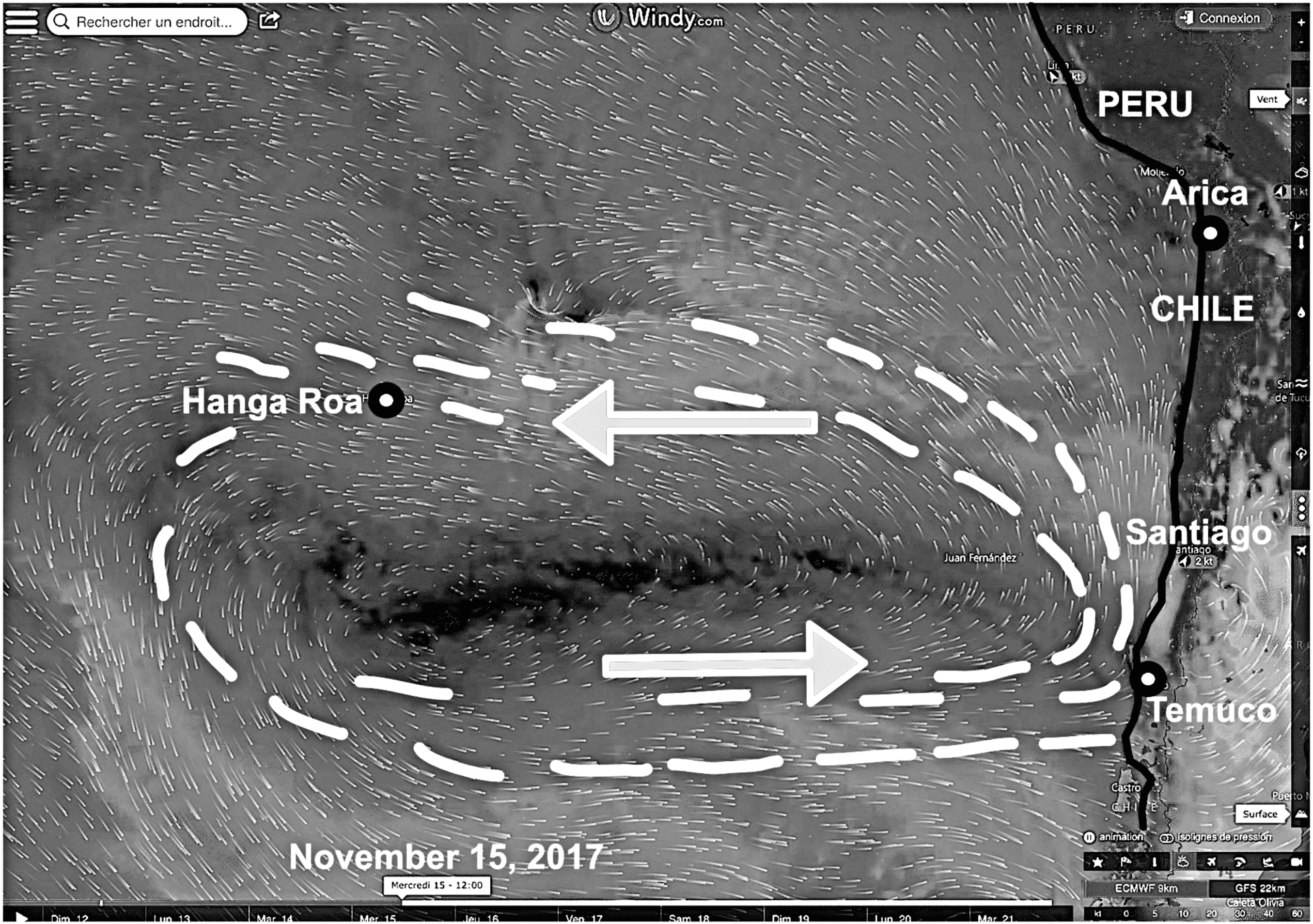
Rano Kau

How and by whom were the statues built?

Rano Raraku volcano



Contact with the Mapuches / Chile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animation
isolignes de pression
November 15, 2017
Mercredi 15 - 12:00
ECMWF 9km
GFS 22km
Caleta Olivia
Dim. 12
Lun. 13
Mar. 14
Mer. 15
Jeu. 16
Ven. 17
Sam. 18
Dim. 19
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Anakena

Hanga Roa

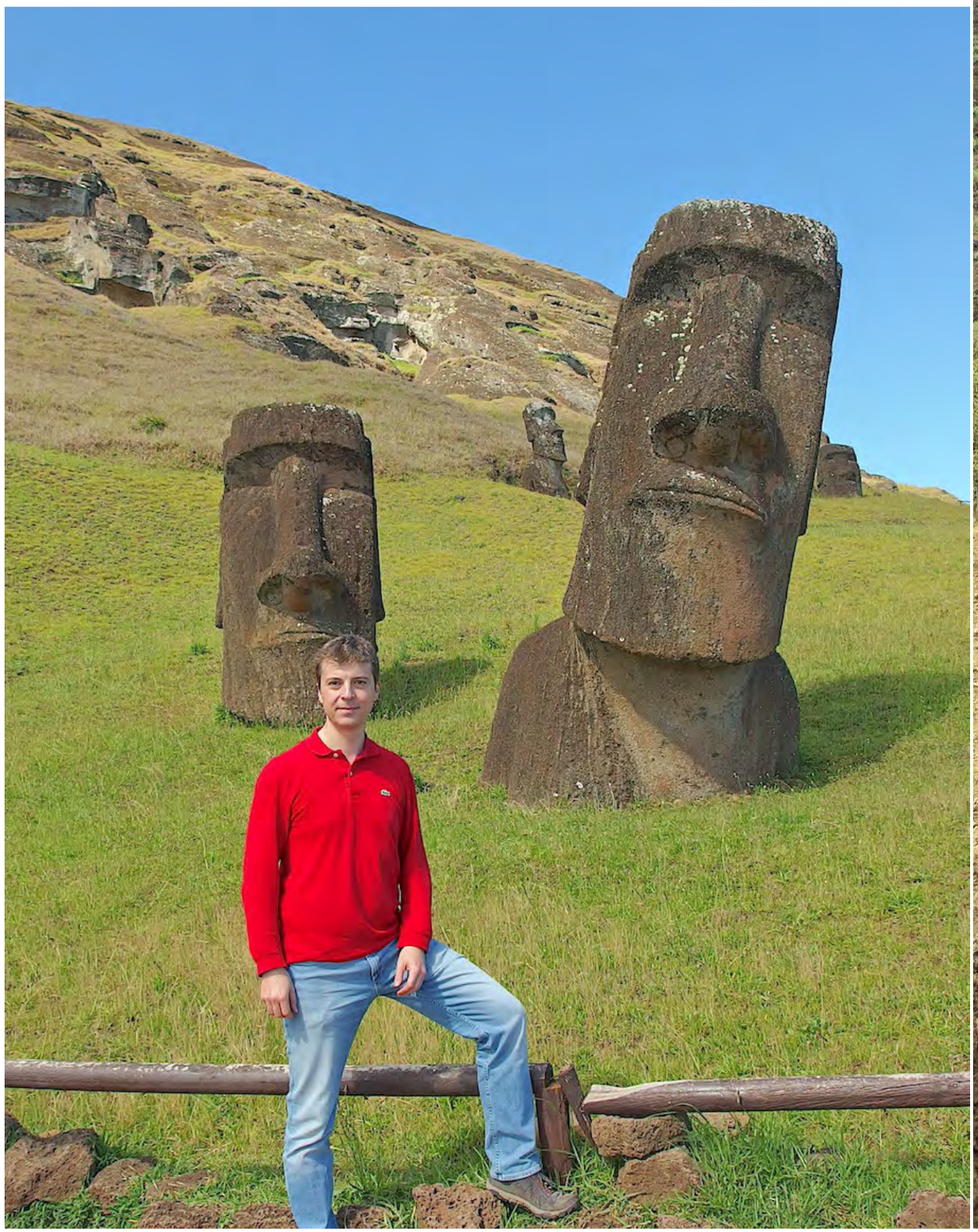
Poike

Rano Kau

Easter Island

Chemamülles

Rano Raraku volcano



Thor Heyerdahl 1987

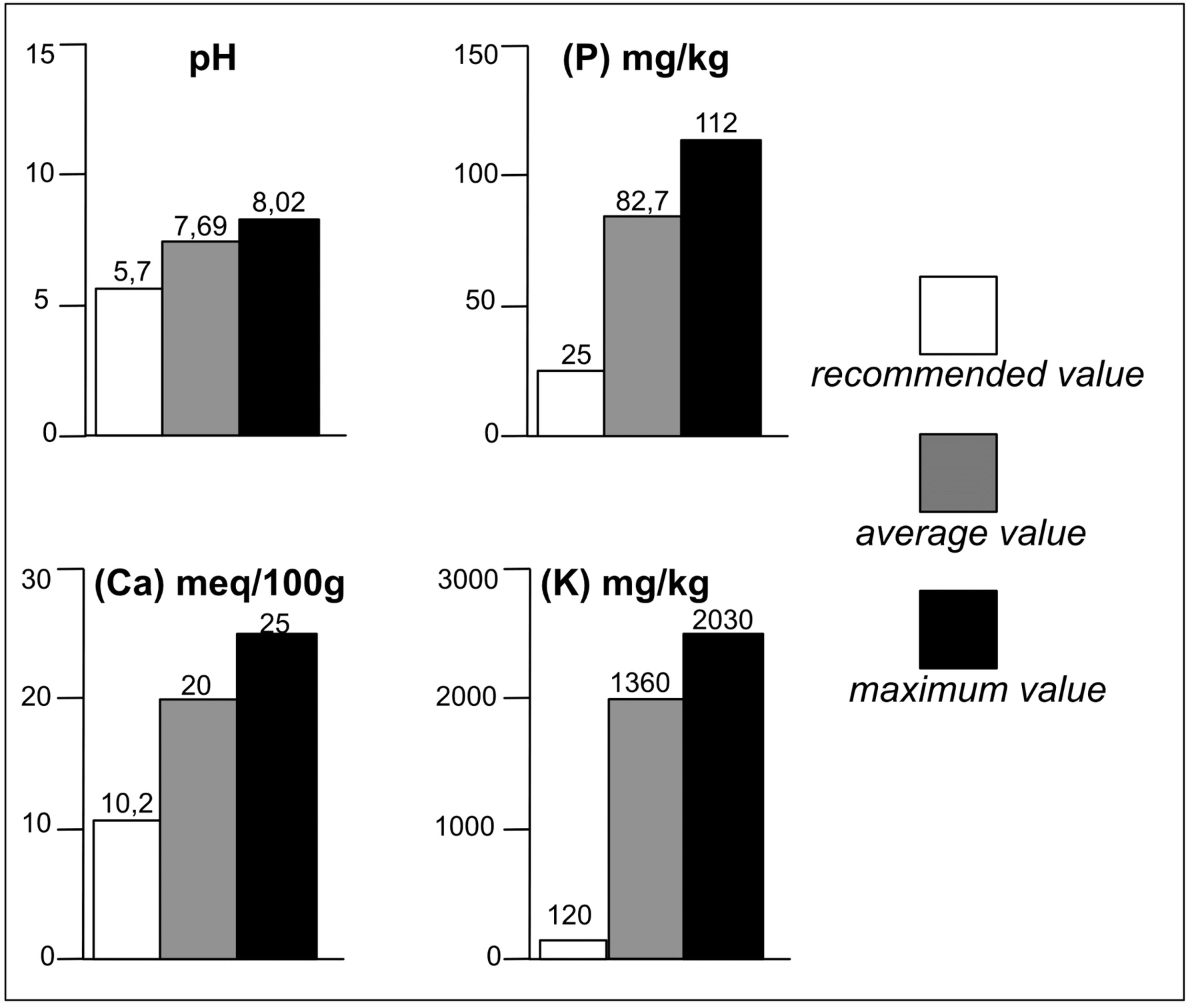
Do we have scientific analysis?

Interior of the Rano Raraku volcano with some planted statues.

New excavations in Easter Island's statue quarry: Soil fertility, site formation and chronology, Sherwood, et al., 2019, *Journal of* Archaeological *Science*, 111 (2019) 104994.

Interior of the Rano Raraku volcano, its pond, the locations of the statues, place (arrow) where Sherwood, *et al.* carried out their study.

Abnormally high amounts of chemical elements.



Pages 11-12:"(...) *The phytolith assemblages throughout the profile are dominated by palms (up to higher than 70%) (...) The large to very large amounts of palm phytoliths throughout the entire profile could seem in disagreement with the coincident low pollen values for this plant (…).*"

- Phytholites are natural mineral elements made of silica that are generally found in the fibres of certain plants, in this case, the ***palm tree***.
- Since there is no significant trace of pollen, this means that in the soil of the volcano, no palms were growing nearby, but that palm extracts, such as ***palm sap*** and/or palm ash, have been brought in from outside in large quantities, carrying their SiO2 phytoliths.

We now possess all information to describe how the mixing of the “geopolymer concrete" took place inside the volcano.

Water was available on site together with ***disintegrated volcanic tuff*** , only the chemical elements needed to be added,

i.e., ***organic acids*** from the maceration of ***palm sap***, ***guano*** as a reaction hardener (calcium phosphate and calcium oxalate), ***palm wood ash*** (C-14 dating + potassium carbonate and the SiO2 phytoliths), plus other minerals to be determined.

This geopolymeric ***stone paste*** was then transported in baskets to the statue construction site on the outskirts of the volcano.

This recent scientific paper provides us with evidence that the Easter Islanders may well have used geopolymer chemistry to build their statues.

Easter Island

N

Anakena

Maunga Terevaka

AD 1100-1200

Poike

Hanga Roa

Vinapu

Rano Kau

Ahu Tongariki

Gisèle Hyvert, UNESCO Report in 1973.

Do we have scientific analysis?

Distribution limitée
RM/PP/CONSULTANT

Ile de Pâques

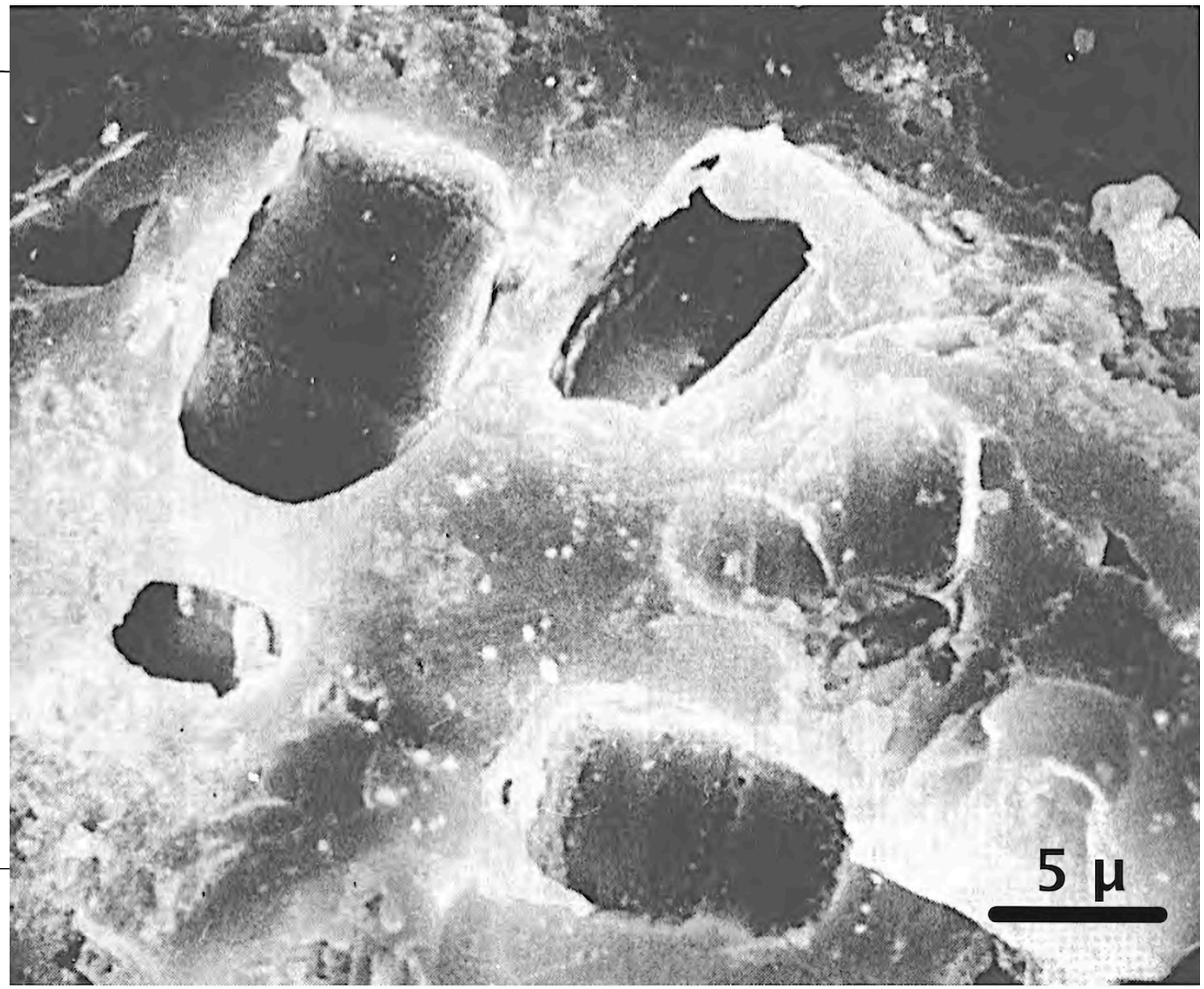
Les statues de Rapa Nui
Conservation et restauration

février-mars 1972

par G. Hyvert (Mlle)

N° de série : 2868/RMO.RD/CLP
Paris, mars 1973

Unesco

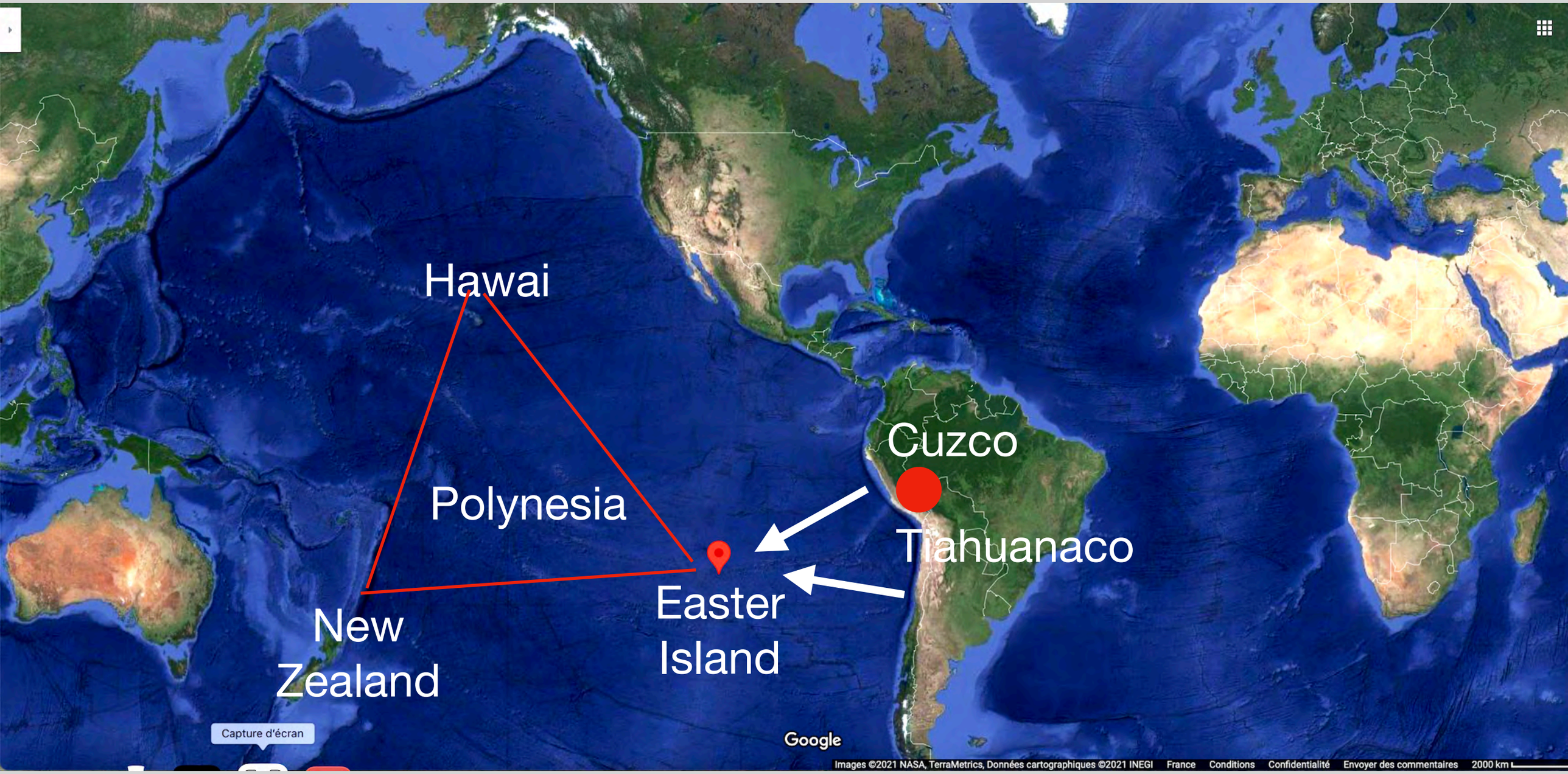


barrel-shaped fossilized micro-organisms (bact

Conclusion

Efficient use of geological knowledge.

I have presented the results of the preliminary research undertaken on the scientific data available, and often misinterpreted. They show the inter-relationship between South-America and Easter Island


Hawai
Polynesia
Cuzco
Tiahuanaco
Easter
Island
New
Zealand
Capture d'écran
Google
Images ©2021 NASA, TerraMetrics, Données cartographiques ©2021 INEGI
France
Conditions
Confidentialité
Envoyer des commentaires
2000 km

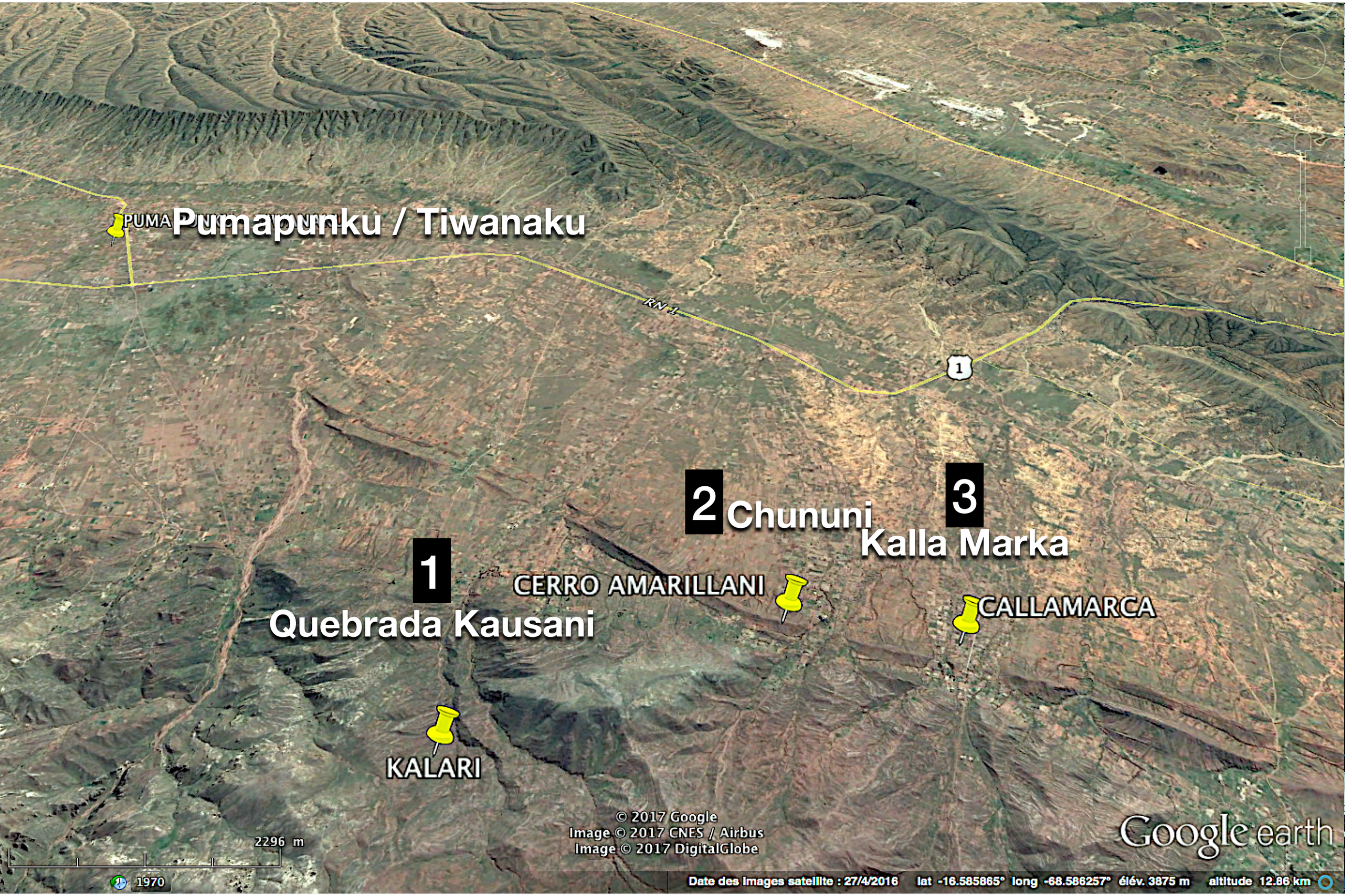
PART 2:

Efficient use of geological knowledge.

3 examples from our present research:

- red sandstone, weathered raw material,
- volcanic andesite, natural volcanic sand.
- volcanic tuff in Easter island, sandy tuf.

(Na,K,Ca)-(ferro-sialate)-geopolymer cement


Pumapunku / Tiwanaku
RN 1
1
2 Chununi
3 Kalla Marka
1 Quebrada Kausani
CERRO AMARILLANI
CALLAMARCA
KALARI
© 2017 Google
Image © 2017 CNES / Airbus
Image © 2017 DigitalGlobe
2296 m
1970
Google earth
Date des images satellite : 27/4/2016 lat -16.585865° long -68.586257° élév. 3875 m altitude 12.86 km

Quebrada de Kausani

ebrada de Kausani.

1970

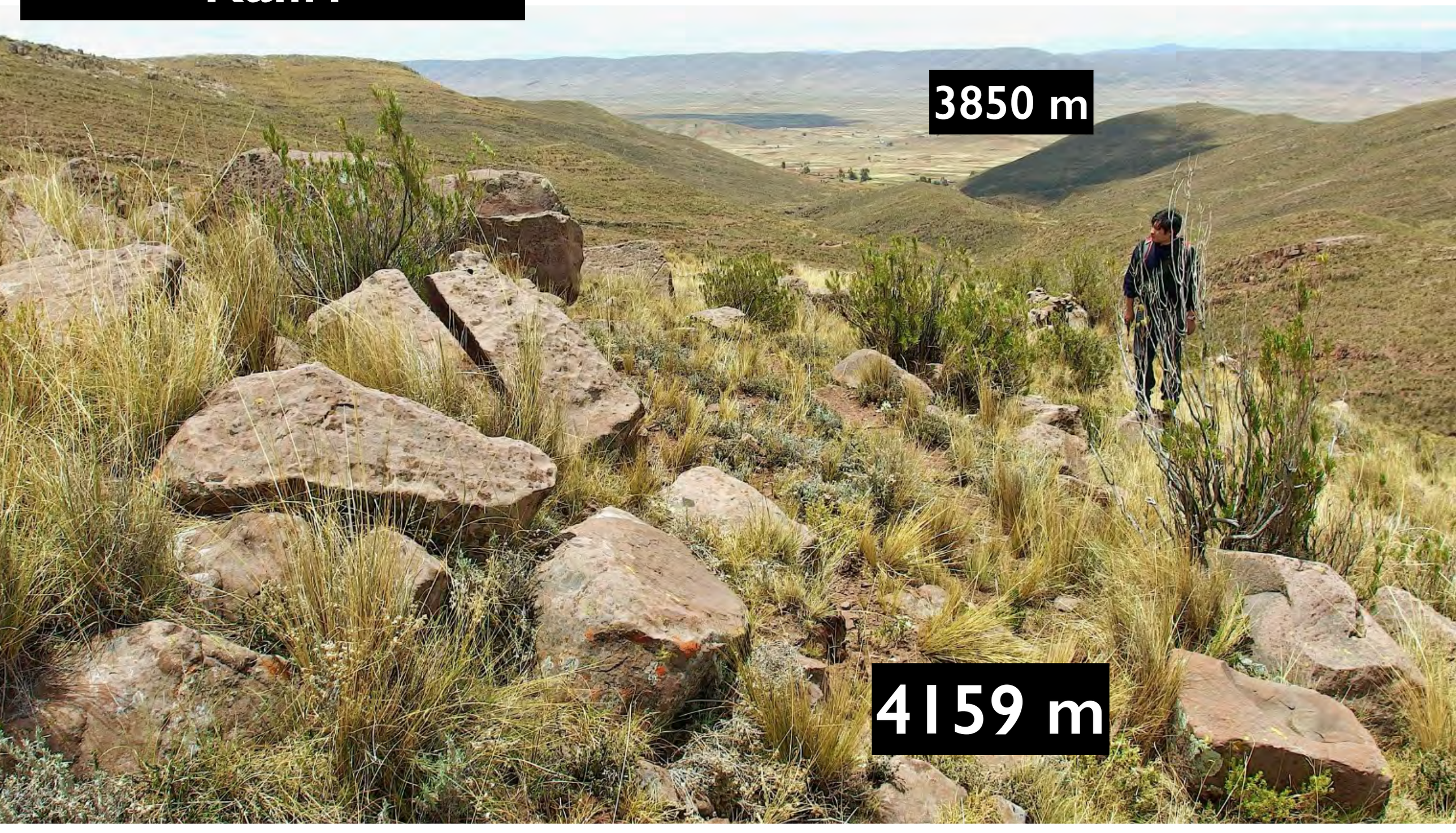
2017


End
Start
3850 m
Quebrada Kausani
1
4159 m
Image © 2017 CNES / Airbus
105 m
1970
Google earth
Date des images satellite : 27/4/2016 lat -16.641810° long -68.618499° élév. 4154 m altitude 4.66 km

Quebrada de Kausani

Quebrada de Kausani

Quebrada Kausani Kaliri



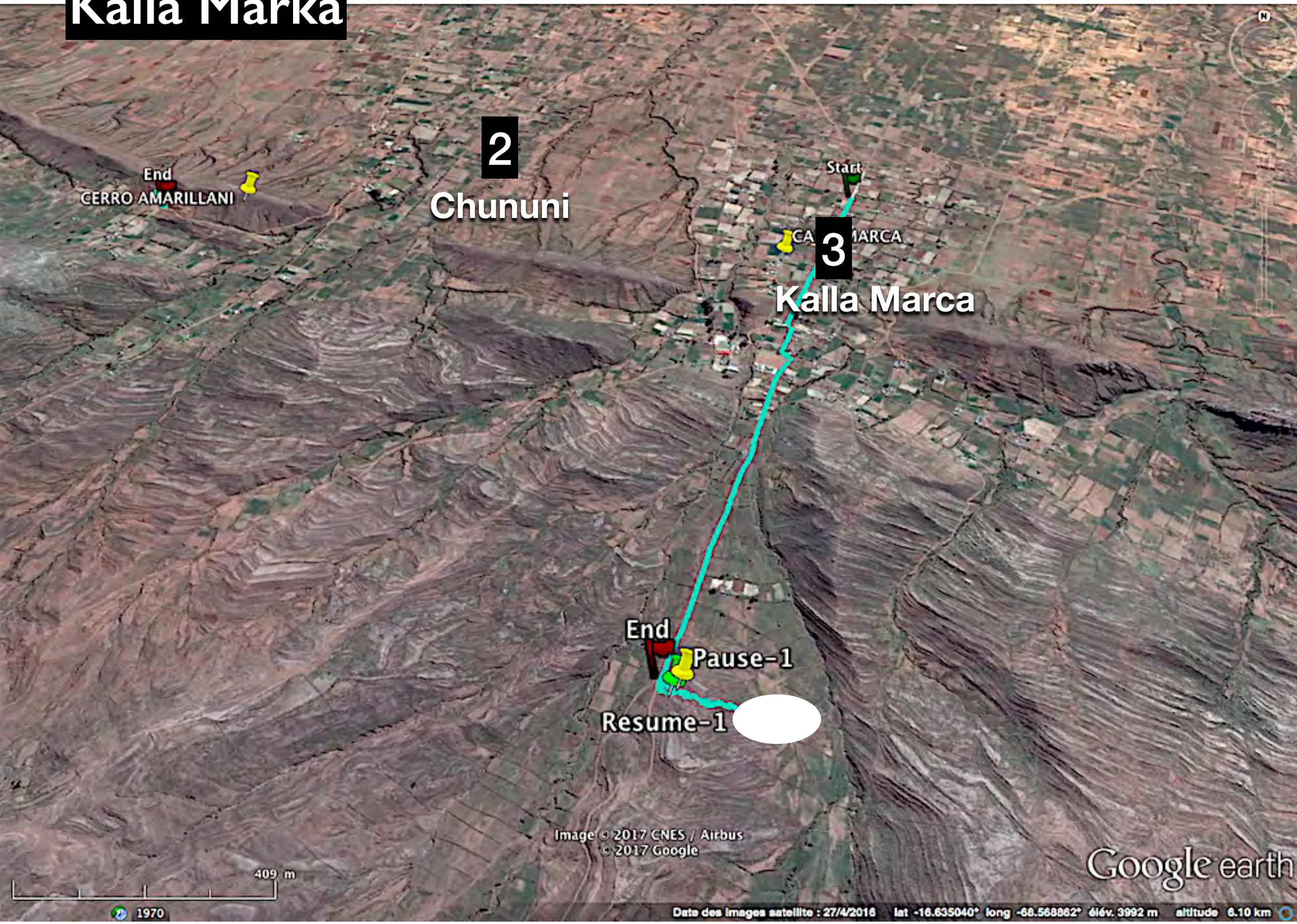
Cerro Amarillani

Cerro Amarillani

Callamarca (*Kallamarka*)

Kalla Marka

Kalla Marka


End
CERRO AMARILLANI
2
Chununi
Start
3
Kalla Marca
End
Pause-1
Resume-1
Image © 2017 CNES / Airbus
© 2017 Google
409 m
1970
Google earth
Date des images satellite : 27/4/2016
lat -16.635040° long -68.568862° élév. 3992 m
altitude 6.10 km

Kalla Marka

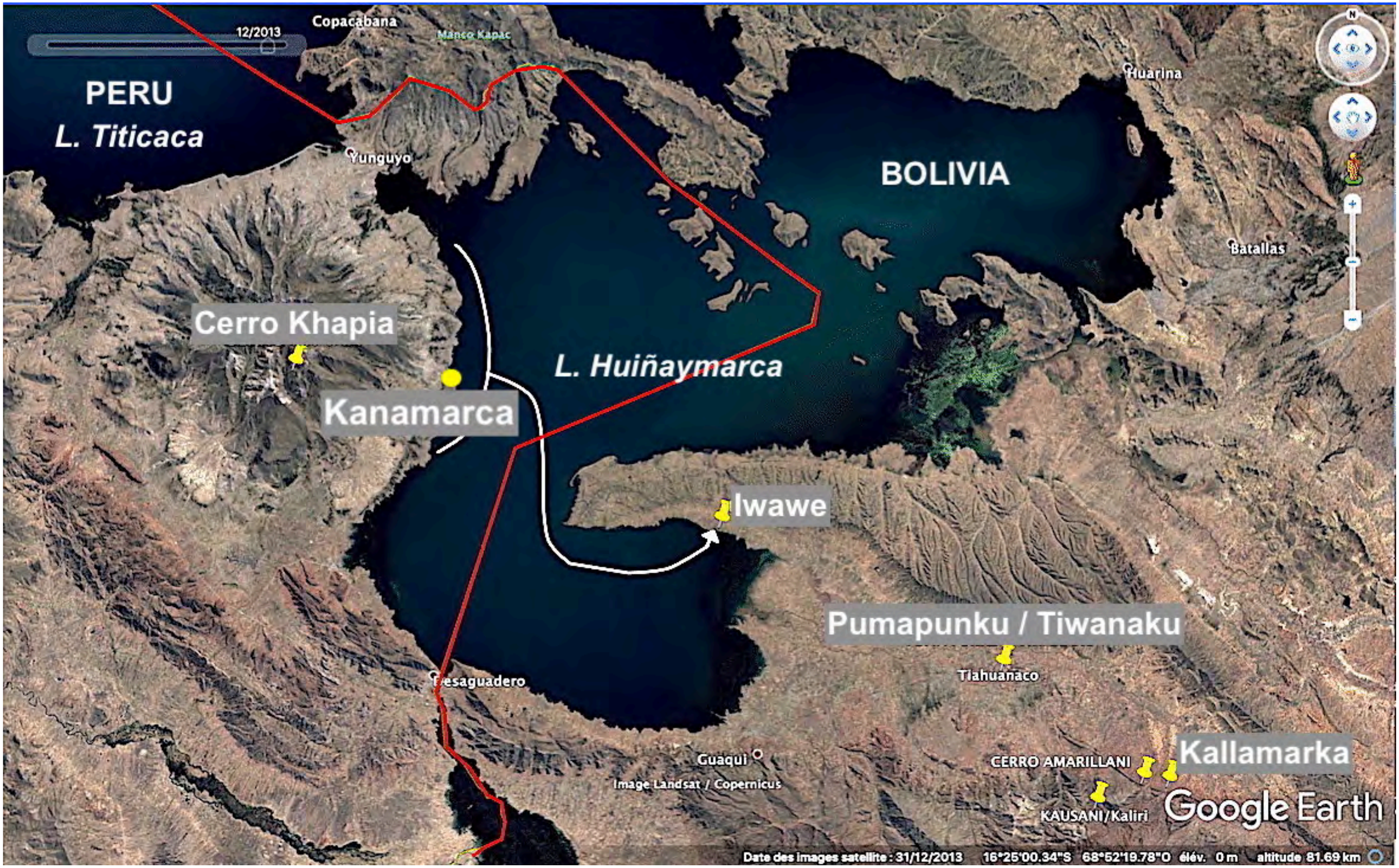
Kalla Marka

weathered
kaolinitized
sandstone

(organic acids-phosphate)-based geopolymer cement

Cerro Khapia: andesite blocks


Cerro
Kanamarca
a)



then, crossed the lake on rafts, landing at Iwawe and transported by land to Tiwanaku.

many quadrangular volcanic blocks, the famous "***piedras cansadas***", the tired stones, which are still lying on both sides of the lake Titicaca:

a) Kanamarca / Peru

b) Iwawe / Bolivia

Piedras cansadas, the work of the Incas, 800 years later, AD 1400

GEOPOLYMER INSTITUTE

Geopolymer and A

A Journal on Geopolymer Science

J. Davidovits and F. Davidovits / Geopolymer and Archaeology (2020) 36-43

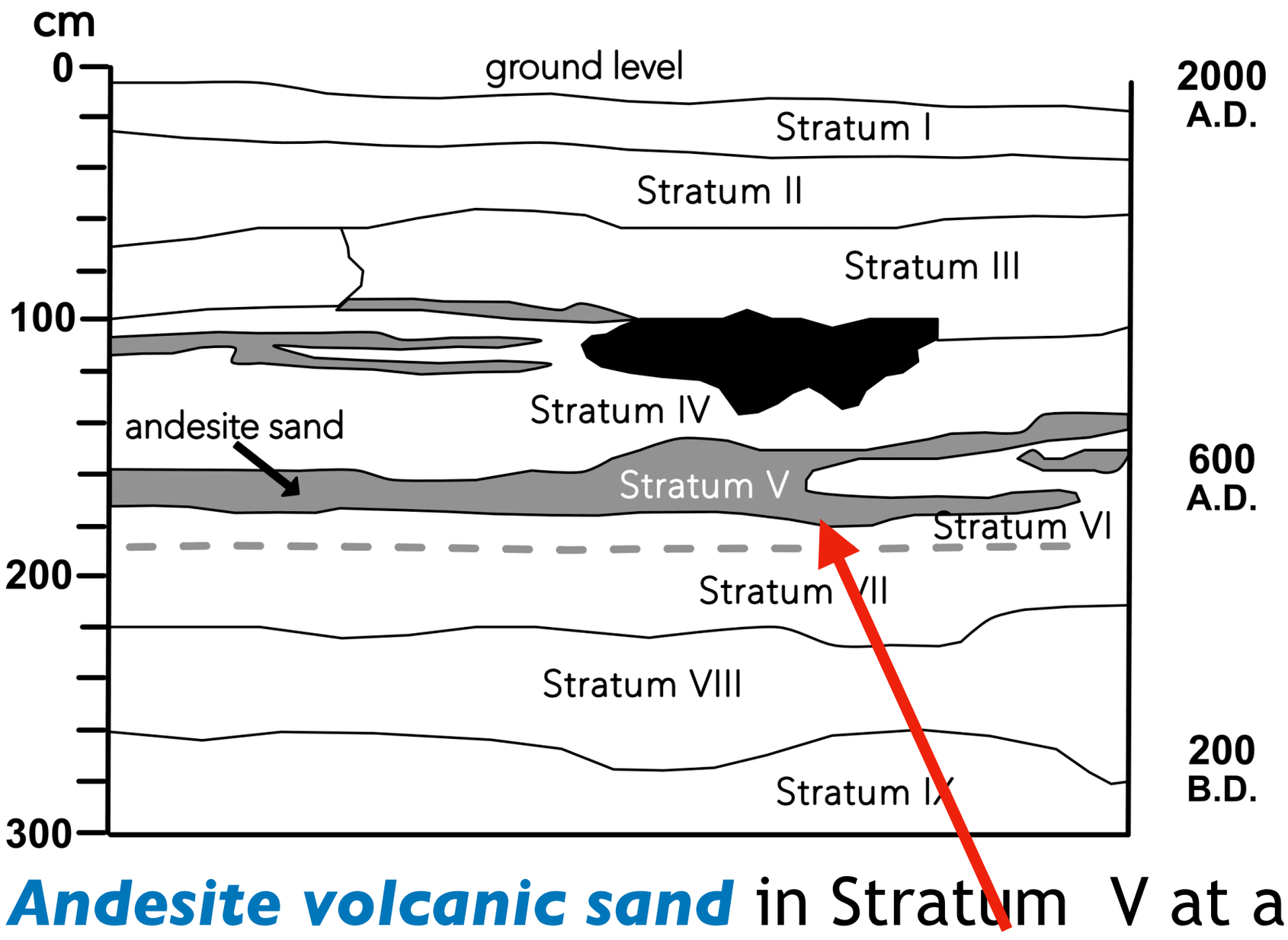
Ancient geopolymers in South-American Monum use of natural andesite volcanic sand (r

Joseph Davidovits and Frédéric

ABSTRACT

……..

To make geopolymer andesite stone, around AD 600 to AD 700, the builders had transported an andesite stony material having the ***consistence of natural volcanic sand*** from the Cerro Khapia volcano site, and added an organo-mineral geopolymer binder manufactured with local biomass ingredients.

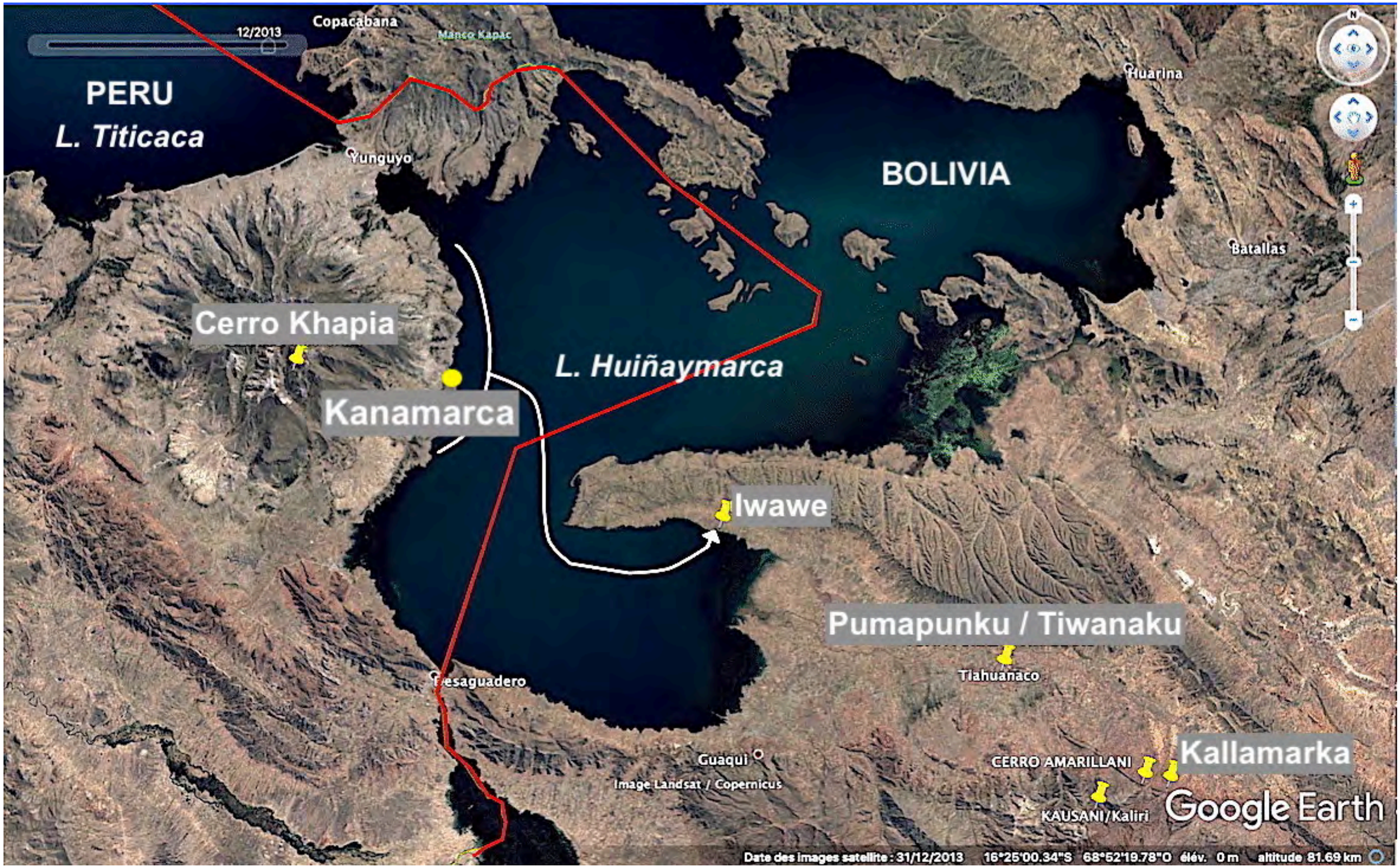


Excavations at Iwawe / Bolivia Isbell & Burkholder, (2002)

Andesite volcanic sand in Stratum V at a depth of 1m60 dated to AD 600, time of the construction in Tiwanaku/ Pumapunku.

For the making of their andesite geopolymer monuments, they did not need to crush andesite rock.

exploited a natural volcanic andesite sand from the volcano Cerro Khapia, transported and stored it at the shore village of Iwawe,



Chemamülles

Rano Raraku volcano

Thor Heyerdahl 1987

Maoi Ahu Tongariki

Nicolas Cauwe: “In these places, underground, at the construction level, I found enormous quantities of tuff dust-sand”.

Conclusion

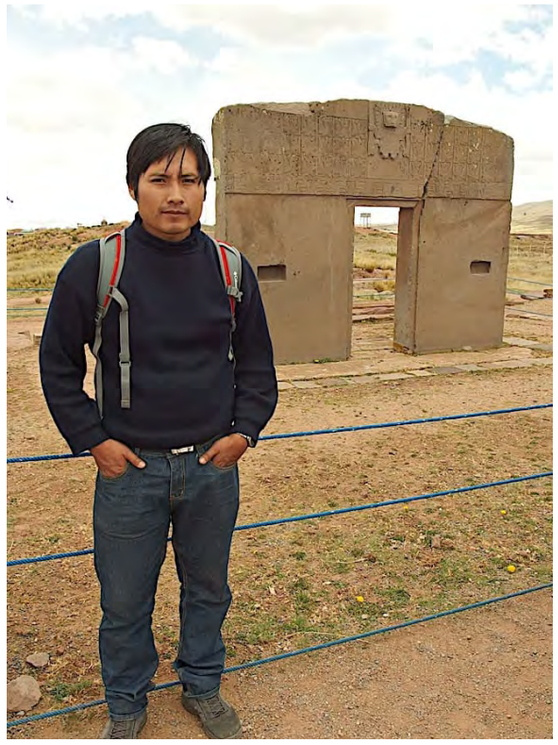
Efficient use of geological knowledge.

These 3 examples from our present research:

- red sandstone, weathered raw material,
- volcanic andesite, natural volcanic sand.
- volcanic tuff in Easter island, sandy tuf.

demonstrate our claims: we do not crush the natural stones but look at the availability of loose, easy to work with, geological materials.

Discussion



- Luis Huaman, PhD student on geology

- Ralph Davidovits, scientist on geopolymer science

2021
GEOPOLYMERCAMP

They came from America to build Easter Island

July 2021

JOSEPH DAVIDOVITS

Ils viennent d'Amérique pour

L'ÎLE DE PÂQU

First published in French. Spanish and English translations are available. Search for qualified publishers.

DERVY

2021

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State of the Geopolymer R&D 2021

Joseph Davidovits

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