The African Initiative for Planetary and Space Science

David Baratoux

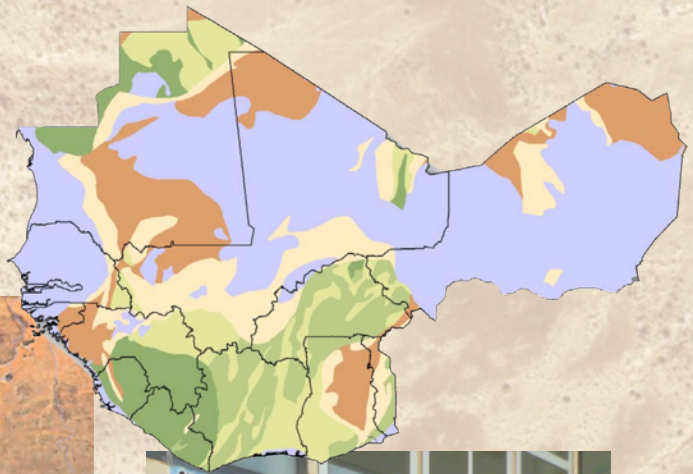
Geosciences Environment Toulouse, Observatory Midi-Pyrénées,
Research Institute for Sustainable Developement

A brief history of the initiative

- Fall 2013 – “A Martian in West Africa”

After 15 years of research experience in Solar System exploration in Toulouse, I moved to Dakar in 2013 to start new research projects about the geology of the West African Craton and its mineral resources with IRD.

West African Exploration Initiative
Geology and Mineral Resources
Institut Fondamental d’Afrique Noire Cheikh Anta Diop



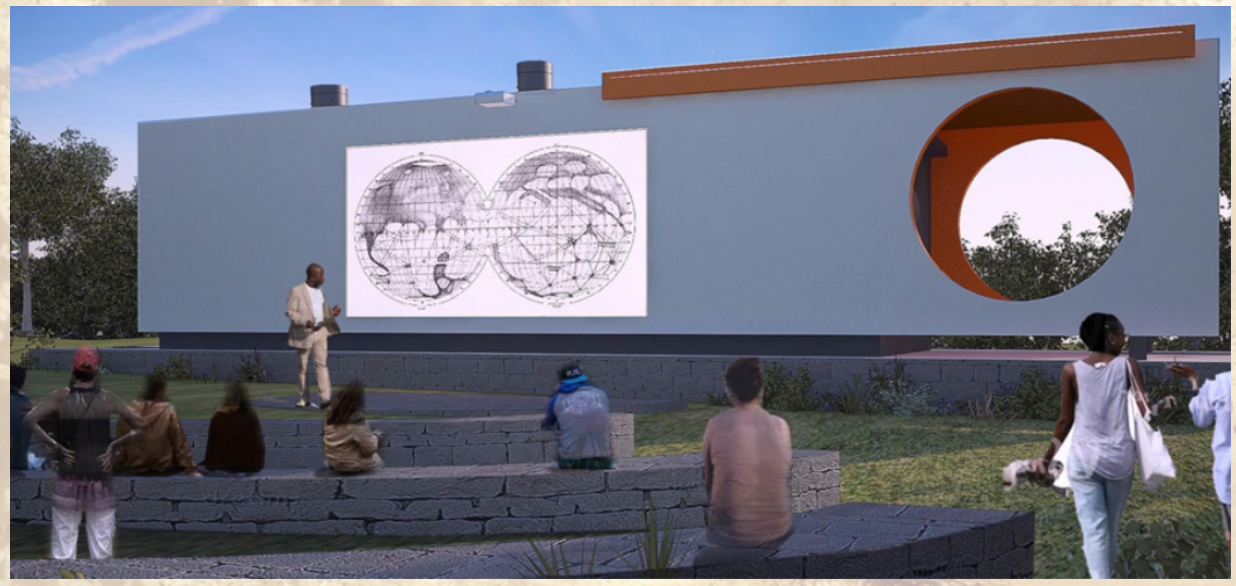
A brief history of the initiative (2014)

Association Sénégalaise pour la Promotion de l'Astronomie

October, 19th, 2014
Close encounter between Siding Spring and Mars

Observations in Senegal with ASPA

A brief history of the initiative (2016)



Université Cheikh Anta Diop

La Faculté des Sciences et Techniques (FST) et l'Ecole Supérieure Polytechnique (ESP) de l'Université Cheikh Anta Diop vous convient à une journée de conférences et d'échanges sur le thème

L'Astronomie au Sénégal

Présentation de projets pour l'émergence de l'astronomie à l'UCAD
Observatoire astronomique, prospective scientifique, formation universitaire

Le 26 Juillet 2016 de 10h à 16h à l'Amphi de l'ESP

10h – Mot de bienvenue
Prof. Joseph SARR
Doyen de la Faculté des Sciences et Techniques

Scientific strategy for the development of Astronomy in Senegal

David Baratoux, Sylvain Bouley, Katrien Kolenberg, Maram Kaire

- Monitoring of the atmosphere of giant planets
- Exoplanets : search and characterization
- Monitoring of impact flashes on the Moon and Jupiter
- Monitoring and characterization of asteroids, stellar occultations
- Monitoring of variable stars

Document elaborated at the invite of the Ministry of Research, Higher Education and Innovatio of Senegal

A brief history of the initiative (2017)

35TH INTERNATIONAL GEOLOGICAL CONGRESS

27 AUGUST - 4 SEPTEMBER 2016 | CAPE TOWN, SOUTH AFRICA

Theme Champions

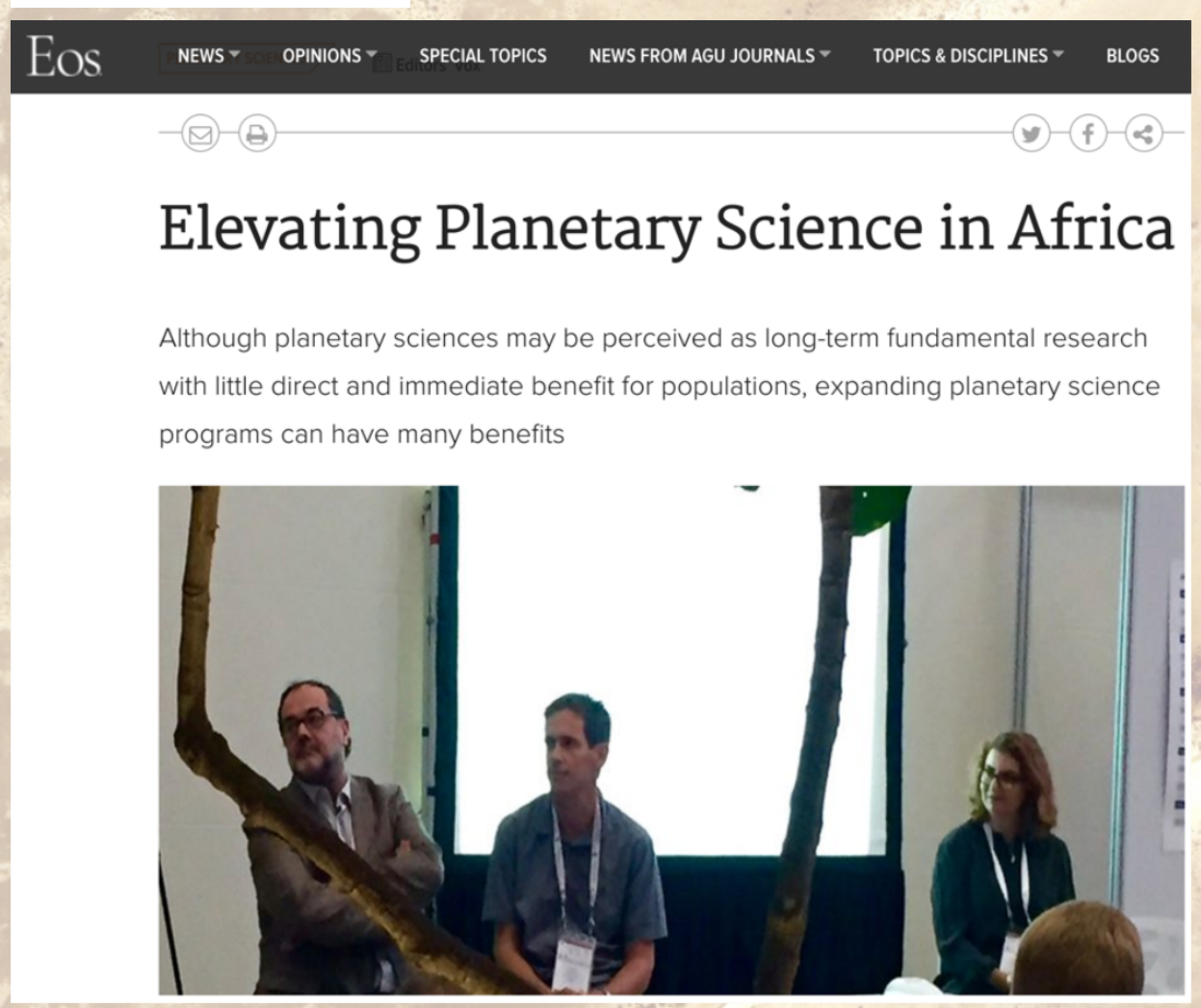
Jesús Martinez-Frias
Institute of Geoscience, IGEO (CSIC-UCM)
E-MAIL JESÚS

Christian Koeberl
Natural History Museum Vienna
E-MAIL CHRISTIAN

Hasnaa Chennaoui
Hassan II University, Casablanca
E-MAIL HASNAA

The appointment of theme champions may not be complete and names will continue to be added as invitees are confirmed.

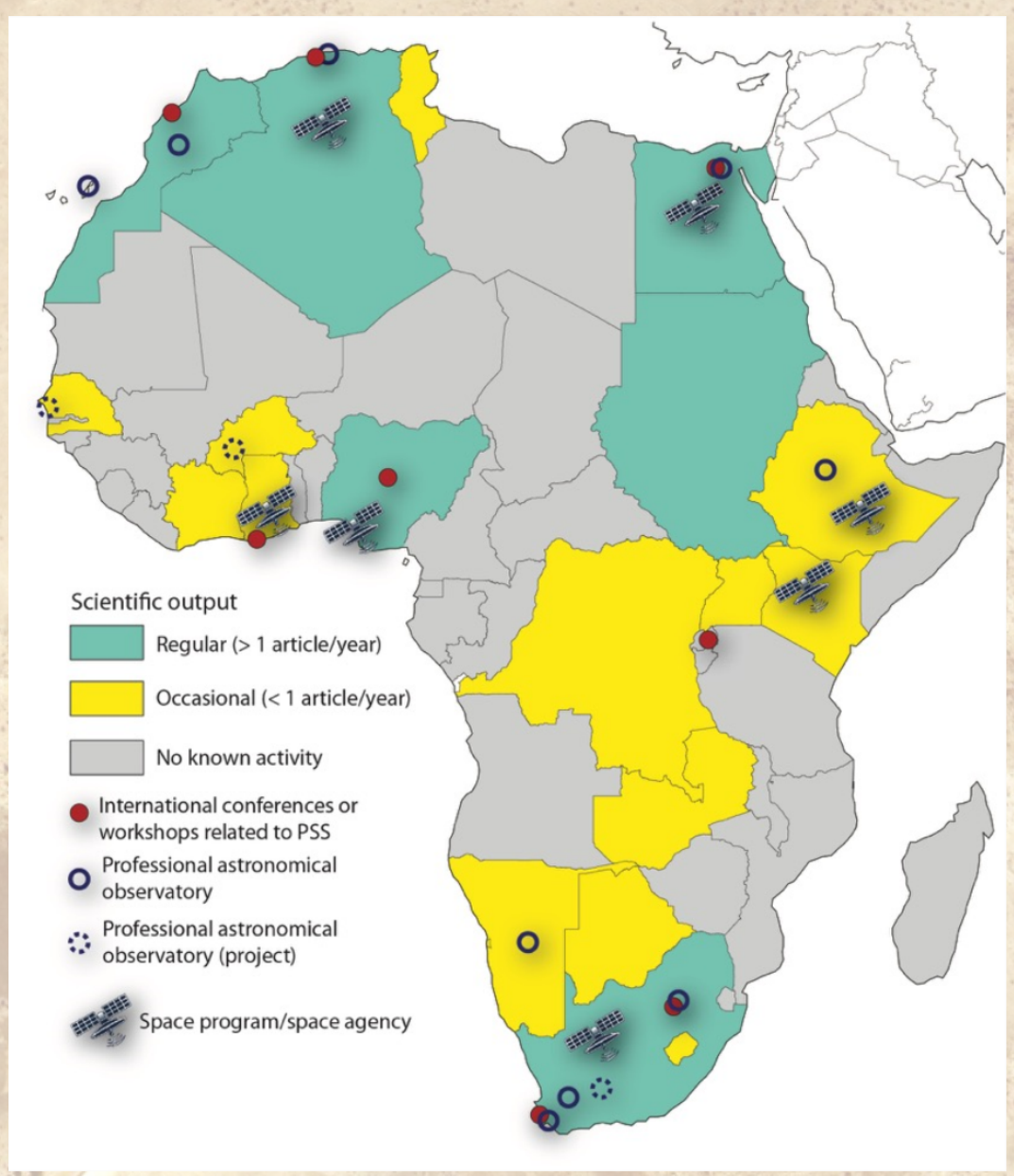
A brief history of the initiative (2018)



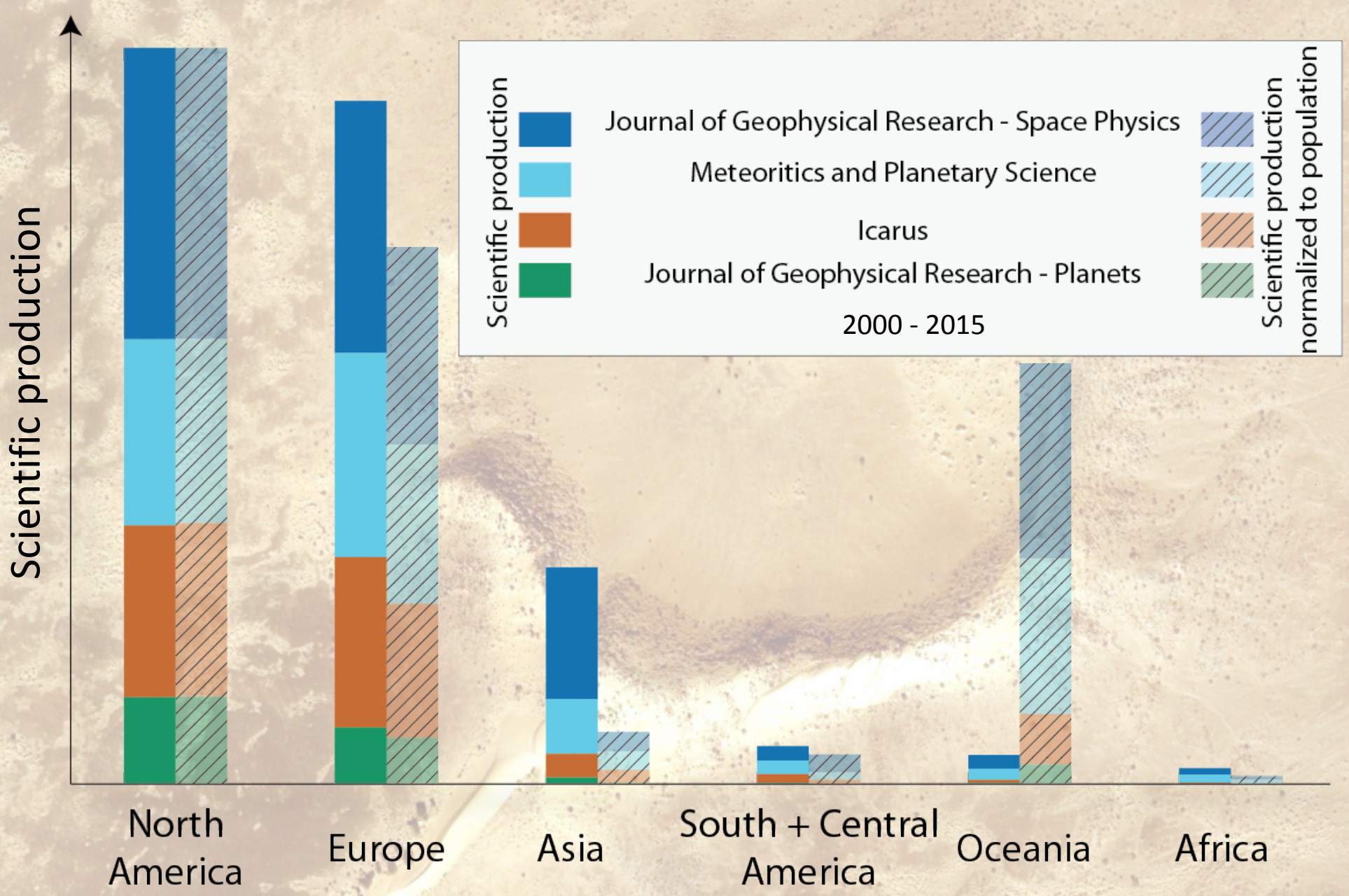
Panel discussion's outcome

- Investigate the State of Planetary and Space Sciences in Africa.
- Make the demonstration that a community of African scientists is willing to develop this research domain
- Identity the assets and the benefits of developing planetary and space sciences in Africa
- Launch of the Africa Initiative for Planetary and Space Sciences

Africa's contributions to Planetary and Space Sciences

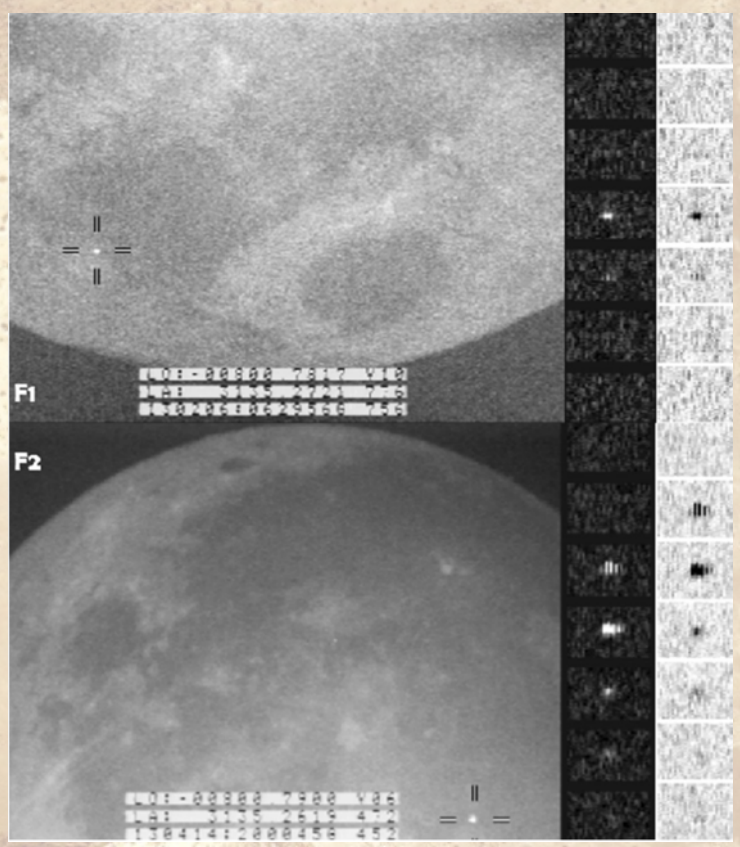


Africa's contributions to Planetary and Space Sciences

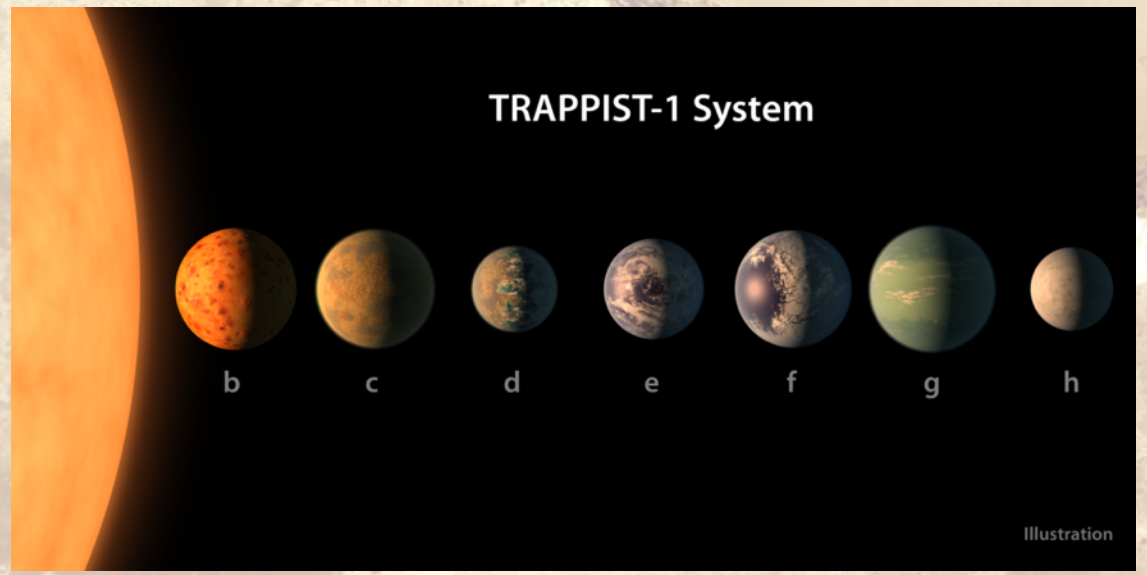


Example of PSS activities in Africa by regions

Morocco's Astronomical Observatory of Cadi Ayyad University, in the High Atlas Mountain.



Ait Moulay Larbi et al. 2015, Earth Moon and Planets



Gillon et al. 2017, Nature

Launch of the African Initiative for Planetary and Space Sciences

Why Focus on Planetary and Space Sciences in Africa ?

- PSS focuses on universal questions, such as the origin of life and the evolution and habitability of planets. Facts gained through science also help to fight against obscurantist tendencies.
- Lack of experts in science, technology, engineering, and mathematics subjects.
- Widespread misperception that funding fundamental science costs society a lot but has little or only long-term societal impact.
- The subjects inspire people to think of the world as a single planet, not as a collection of countries. This favors international and intra-African cultural exchanges, which may contribute to **peace** alongside economic and social development.

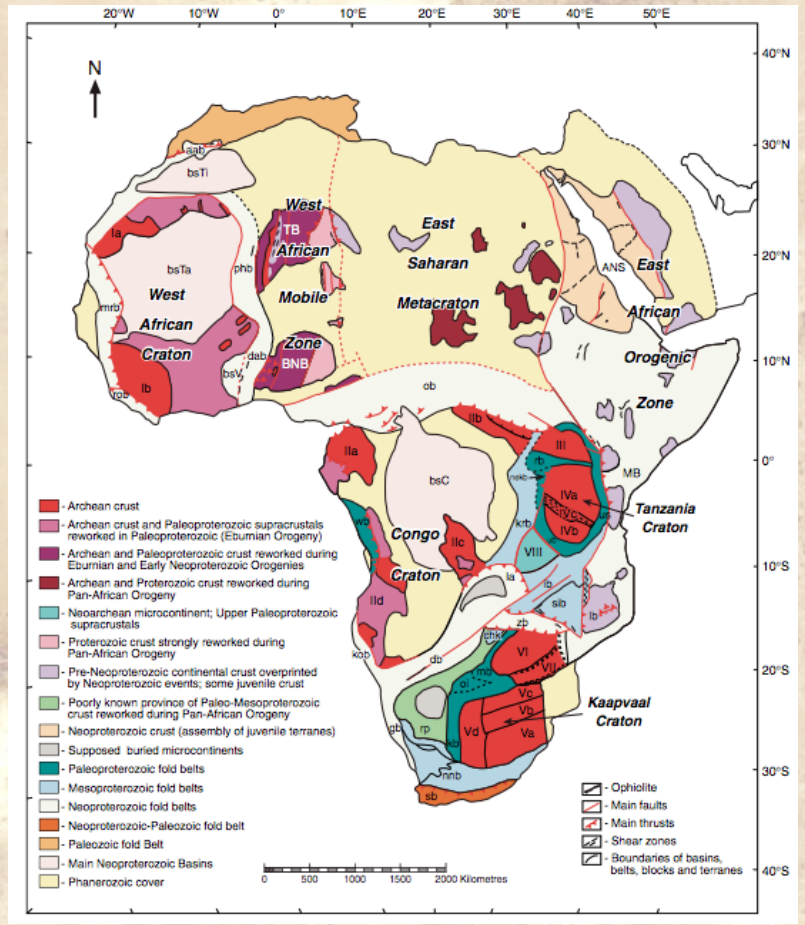
Published in EOS in 2017

Launch of the African Initiative for Planetary and Space Sciences

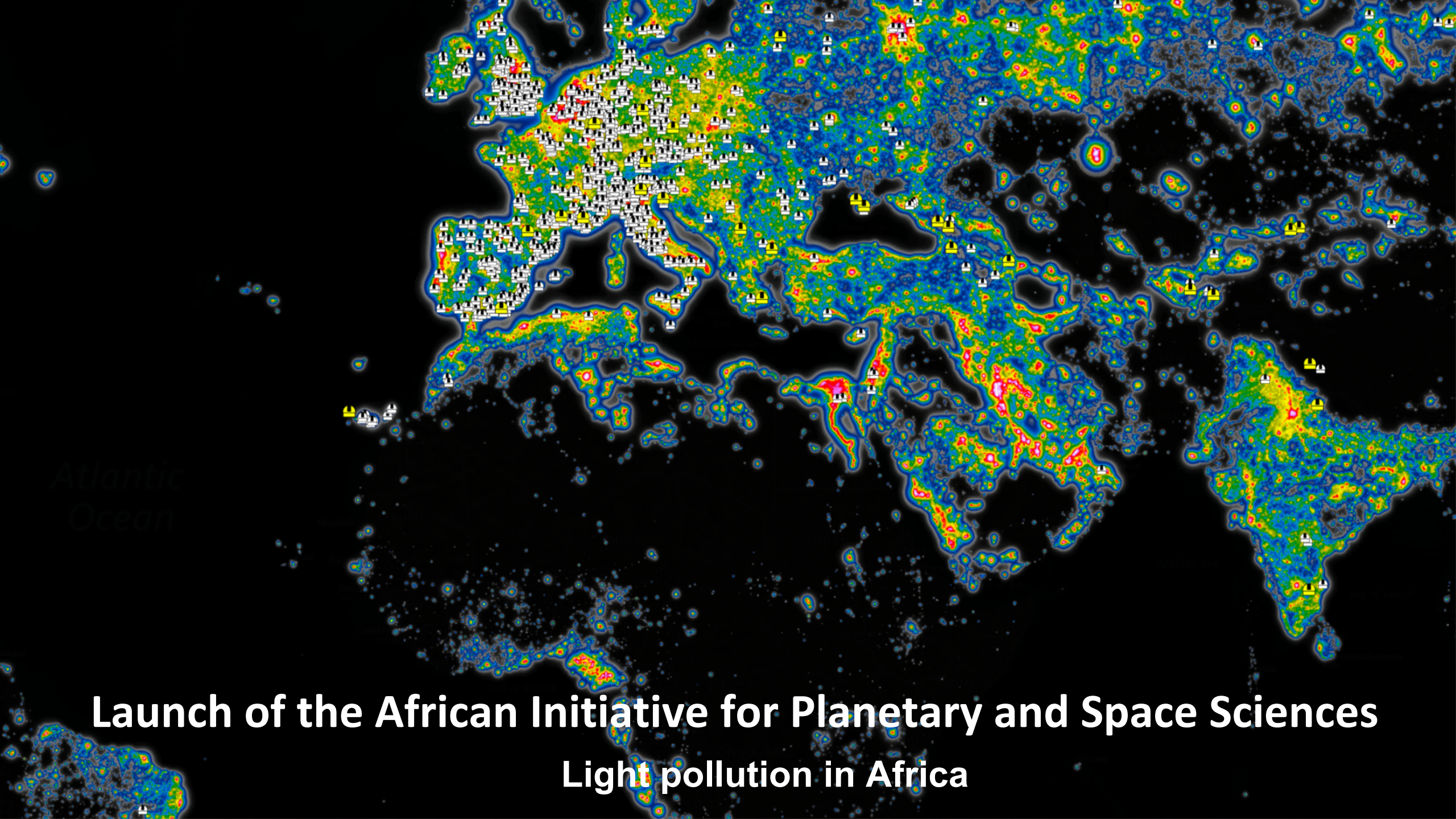
Tapping into Africa's wealth of Geological history

Geological records offer windows to understand the early history, global changes and interactions between interior/surface and atmosphere of planets

Archean spherule deposit, South Africa (photo: D. Baratoux)



Begg et al., 2009



Launch of the African Initiative for Planetary and Space Sciences

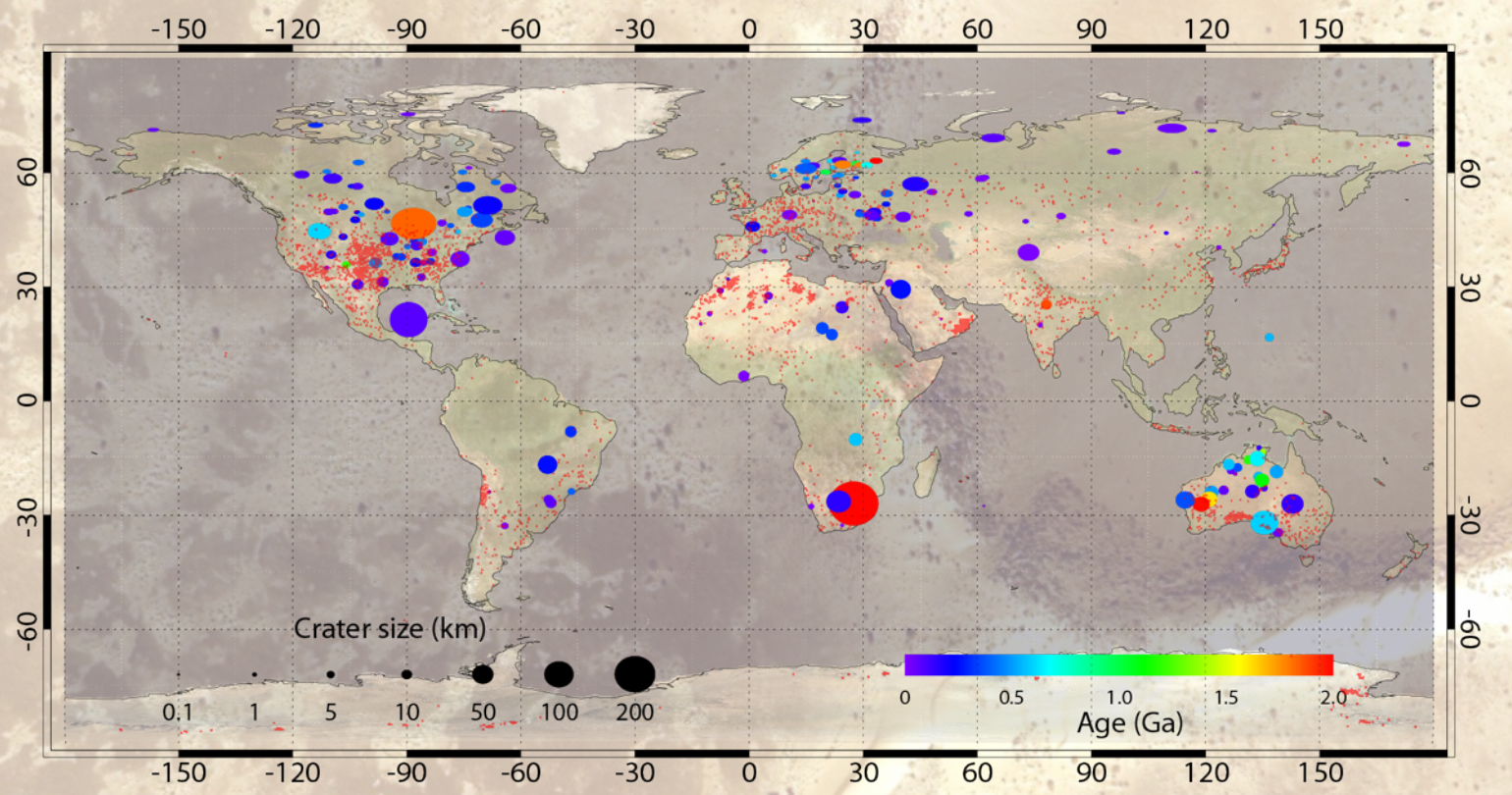
Light pollution in Africa

Launch of the African Initiative for Planetary and Space Sciences

Tapping into Africa's wealth of Geological history

Geological records offer windows to understand the early history, global changes and interactions between interior/surface and atmosphere of planets

Meteorite impact structures and meteorites



More than 50% of meteorites are collected in North West Africa, including rare ones

Shatter cones from the Agoudal impact structure (Morocco) (Chennaoui et al., 2016)

Chennaoui et al. 2016

Tissint Martian fall
Chennaoui et al., 2012

Launch of the African Initiative for Planetary and Space Sciences

Science for Society

- Protection of geological treasures (meteorite impact sites) and sight sky (dark sky reserves)
- Curation of African meteorites in African museums for educational purposes will foster sustainable scientific and economic (tourism) development on local and regional levels, as well as contribute to education of the wider public.

Forging Partnerships

- Develop international networks within African countries (across traditional language barriers) and between African countries and the rest of the world.
- Support the elaboration of common strategies at the national/regional/African scale Projects involving several countries, Communication & sharing of information

Launch of the African Initiative for Planetary and Space Sciences

> 330 individual endorsements, > 800 “followers” on http://africapss.org, Endorsement by 25 institutions

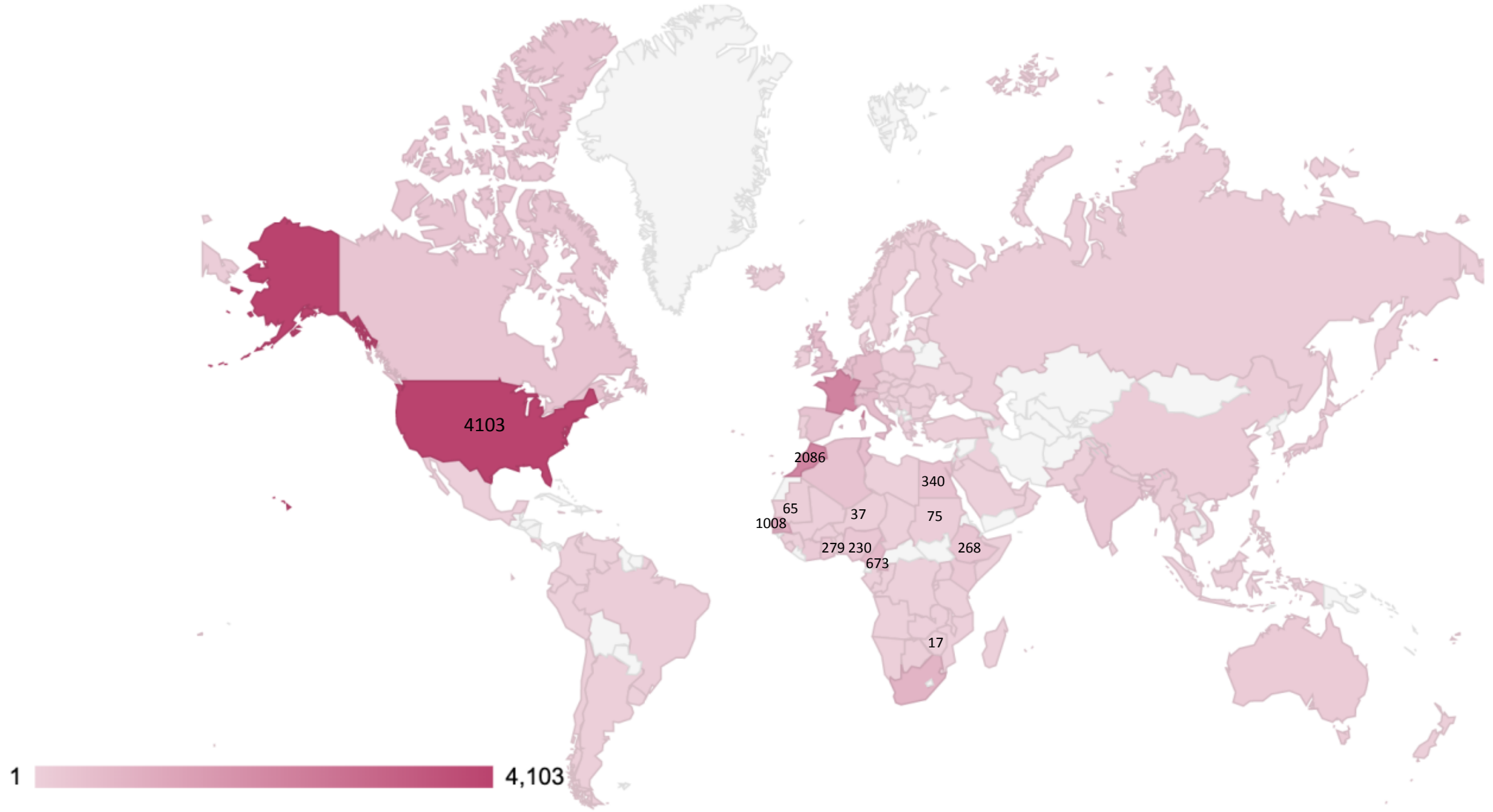
PSS scientists outside Africa

African PSS Scientists

African PSS students

Endorsing Institutions

Stats : Depuis le premier jour



African Initiative for Planetary and Space Sciences

A growing network of projects and African researchers

What happened next ?

A few projects and scientific results involving AFIPS members and related stories

Launch of the African Initiative for Planetary and Space Sciences

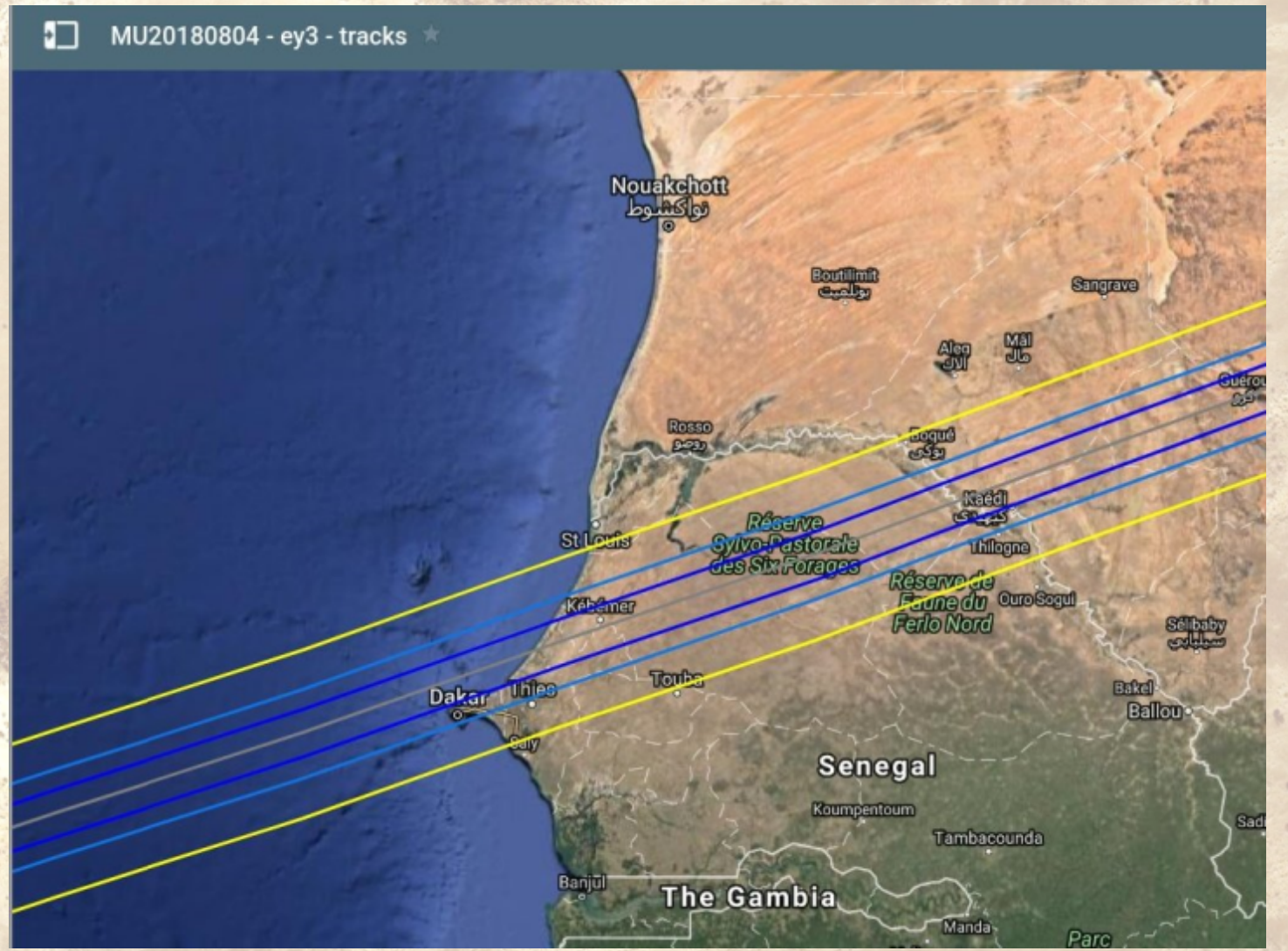
Scientific focus

- Observational astronomy
- Planetary sciences, Remote sensing techniques with implications for the Observation of the Earth
- Meteoritics & Impact science

AGU Fall meeting 2017

Discussion with A. Stern, M. Buie and A. Verbiscer (New Horizons)

Would it be feasible to observe the stellar occultation by Arrokoth, Senegal, in preparation for the January 1st 2018 New Horizons Flyby ?



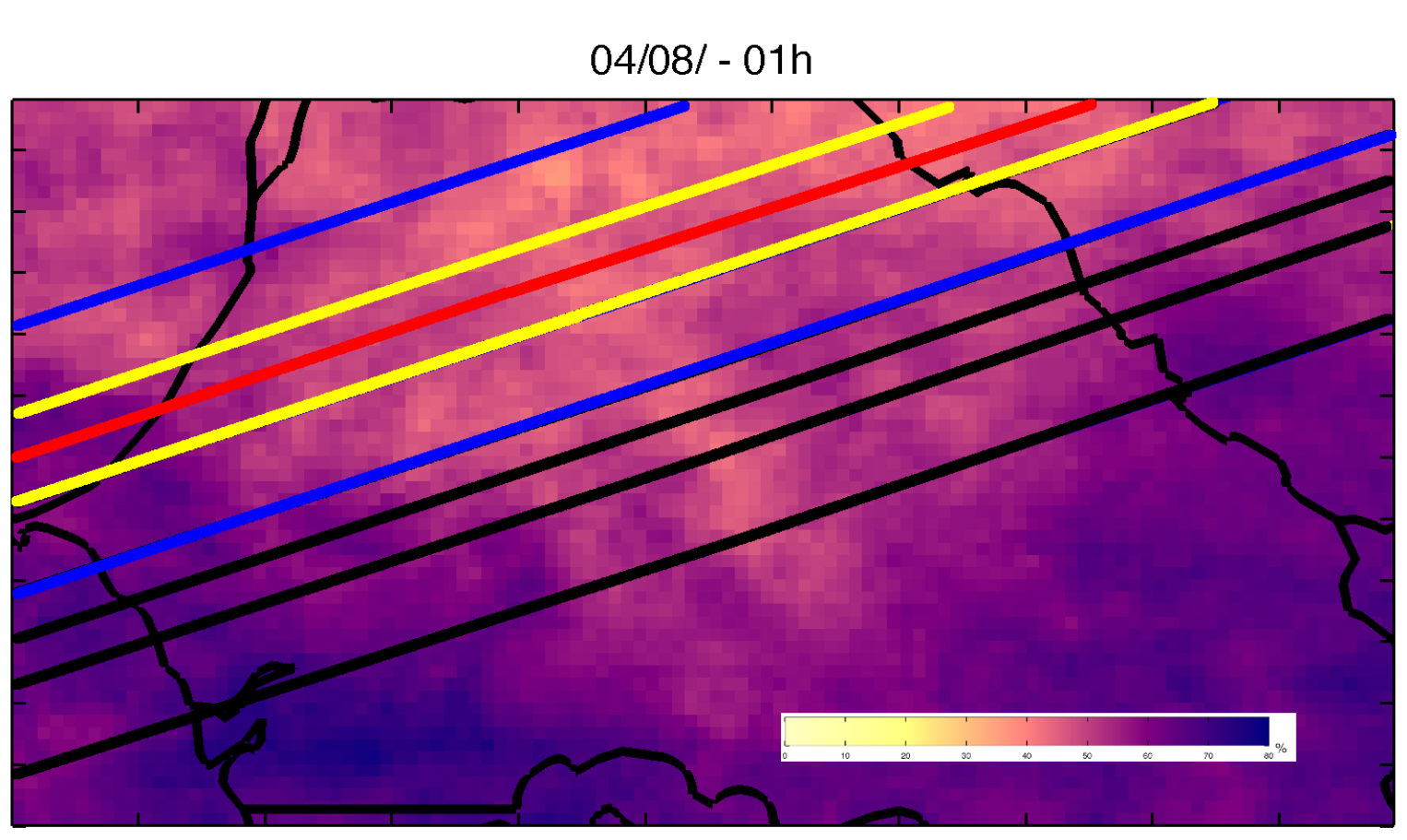
Motivations

The 2018 occultation may provide

- Priority 1: Validation that MU69's orbit and Gaia astrometry are working as expected--risk reduction
  - Second extreme-precision astrometric measurement: Looking for consistency with 2017 data
- Priority 2: 2017 results hinted that MU69 could be a binary or trinary. If it is binary, odds strongly favor seeing both components separately in 2018
  - Binary confirmation or likely rejection; could also clinch the trinary case, currently disfavored
  - Important to image targeting during flyby
  - Observation would then improve binary orbit solution → measure of mass
- Priority 3: 2nd profile of MU69 at a different aspect for building its 3D shape
  - Combine multiple occultations with New Horizons data to measure volume of body
  - Scientifically important but most likely superseded by flyby data unless MU69 is a slow rotator
- Bonus: A boost in public interest
- Best benefit of all could be surprising results that we can't predict

When ?
August, 4th, 2018 !

25-yr meteorological data (1991-2015) compiled by Lahat DIENG (LPAOSF)
Color scale bar is percent of cloud cover. Yellow =0%, Dark Purple = 80%



Black lines are the previous prediction (now outdated).

The likelihood of clear skies during event night is now higher along the updated, current prediction track, but only 50%...

April 2018 : Decision was made – we will do it !

Anne Verbiscer <av4n@virginia.edu> 3 avril 2018 à 05:06
À : David Baratoux <david.baratoux@gmail.com>, Maram KAIRE <maramkaire@gmail.com>
Cc : Marc Buie <buie@boulder.swri.edu>

Dear David,

I'm writing to let you and Maram Kaire know that Marc Buie has decided to send the team of 22 portable telescopes to Senegal to observe the stellar occultation by MU 69. The latest occultation prediction can be found at https://www.boulder.swri.edu/~buie/occ/MU20180804.html <https://www.boulder.swri.edu/%7Ebuie/occ/MU20180804.html>

There are of course many details to work out yet, but I wanted to be sure you knew of this decision. Thank you again for requesting and acquiring the historic weather information specific to August 4 for all of Senegal. I hope that there may be ways in which this expedition can be coordinated with the African Initiative for Planetary and Space Science in support of a successful occultation campaign in Senegal this coming August.

-Anne

Deployment in Senegal

- About 50 planetary scientists, including 21 Senegalese researchers and 6 French participants (CNES-funded)

- Plan: deployment of 21 teams composed of three observers at 21 sites

- Three days of training, before the “night”

U.S.A, Senegal and French collaboration

With active participation of 21 Senegalese scientists

Successful observation of the occultation

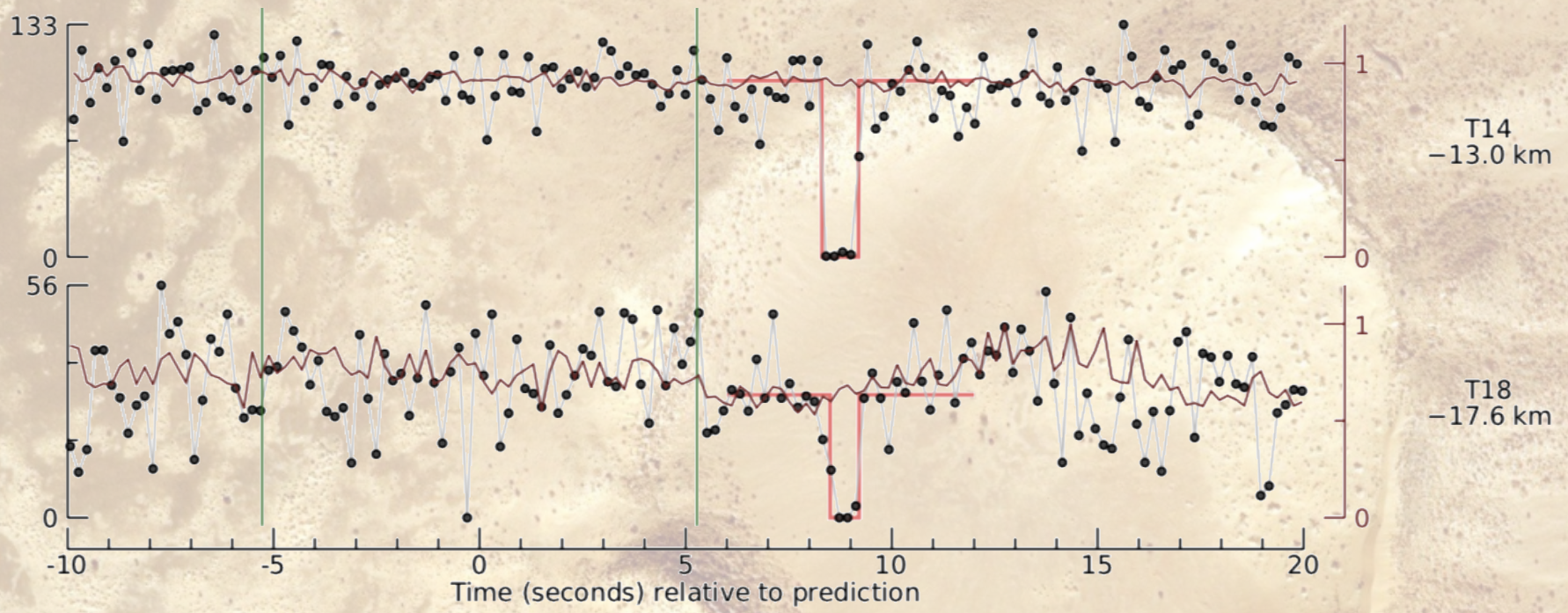


Table 7. Occultation timings 2017 Aug 04

Team ID	UT Disappearance	UT Reappearance	Length [km]	Offset [km]
T14	01:21:30.206	01:21:31.094	19.0	−13.0
T18	01:21:30.604	01:21:31.308	15.1	−17.6

NOTE—All times are on 2018 August 04. Offset is relative to the last pre-event prediction.

Publication in *Astrophysical Journal*, involving all co-authors

Buie et al. (2020) Size and shape constraints of (486958) Arrokoth from stellar occultations

Promoting Planetary sciences in Senegal

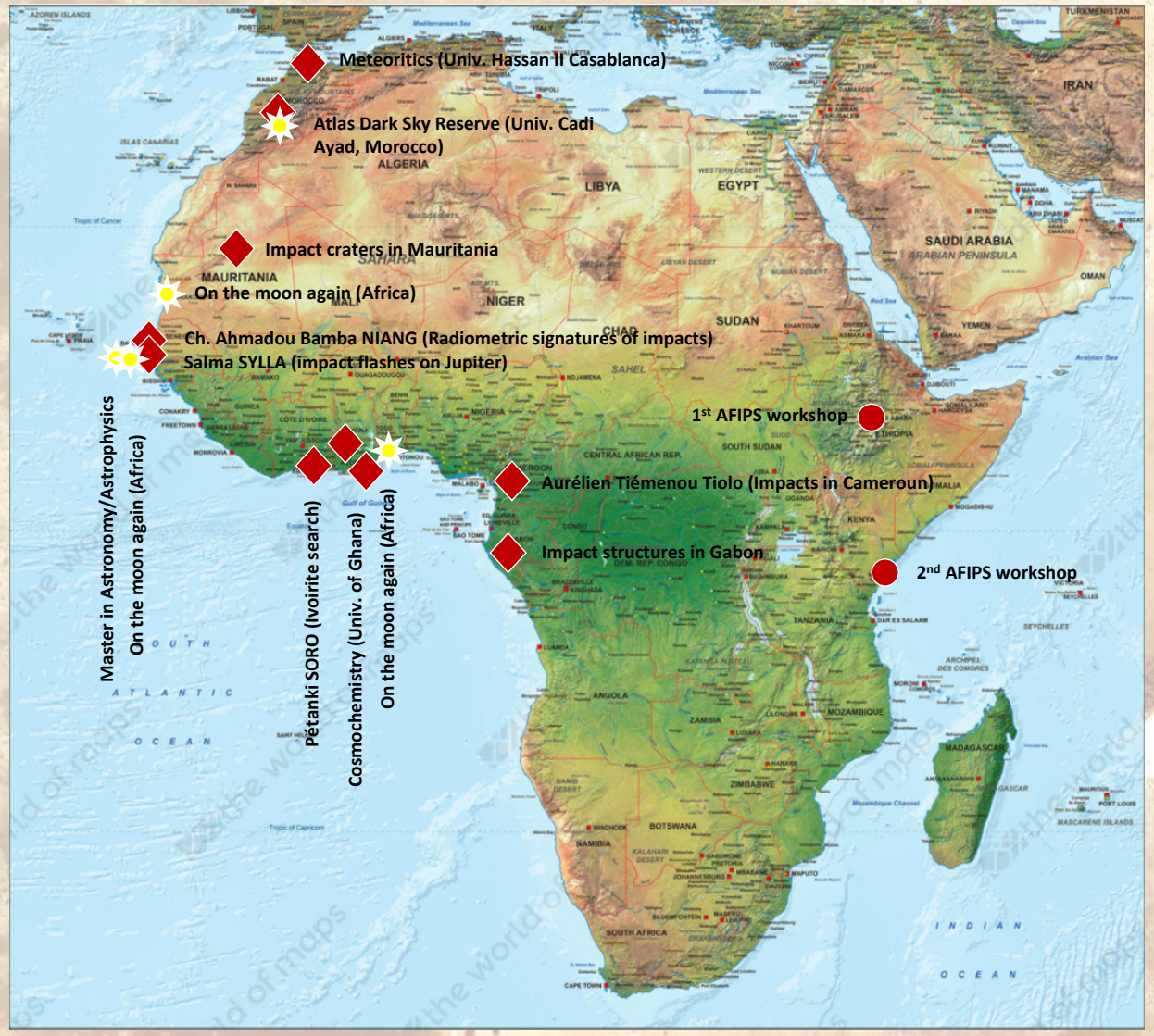
Exceptional involvement of the Senegalese government and institutions, large press coverage,
a series of public events and public conferences with French and NASA researchers…

+ two movies (Universcience)

African Initiative for Planetary and Space Sciences

A network of researchers, research and education projects, workshops

Highlights



AFIPS workshops

On-going research projects (master or PhD students)

Education or public outreach projects

AFIPS workshops in 2019

Eastern Africa Global Navigation Satellite Systems and Space Weather Capacity Building Workshop

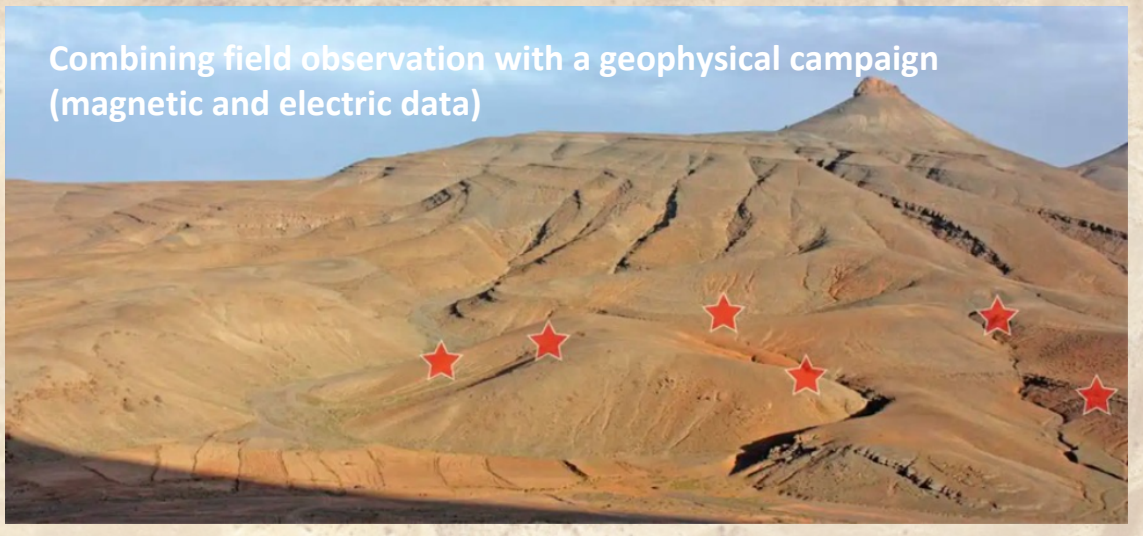
13th – 17th May, 2019 | Pwani University

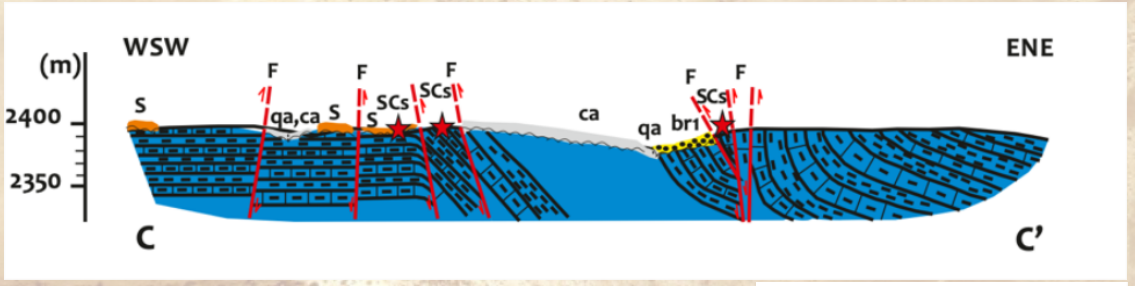
The 2ND Eastern Africa Global Navigation Satellite Systems and Space Weather Capacity Building Workshop, June 1st – 5th, 2020 at Pwani University

Sponsored by:

Impact craters in Africa – Results

The enigma of Agoudal, Atlas, Morocco





THE CONVERSATION

L'expertise universitaire, l'exigence journalistique

Culture Économie Éducation Environnement International Politique + Société Santé Science Mondes francophones

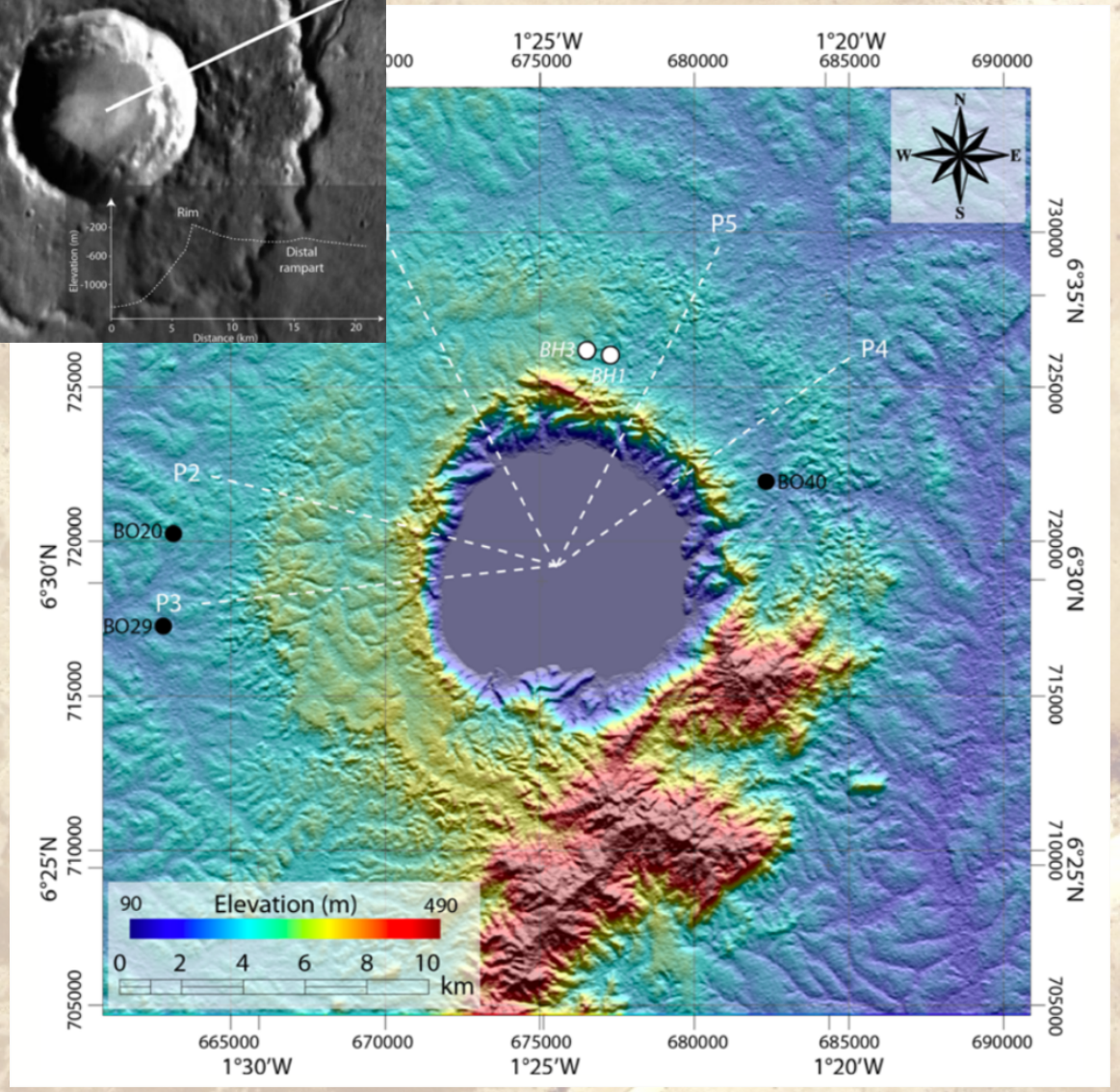
What a Moroccan crater reveals about a rare double whammy from the skies

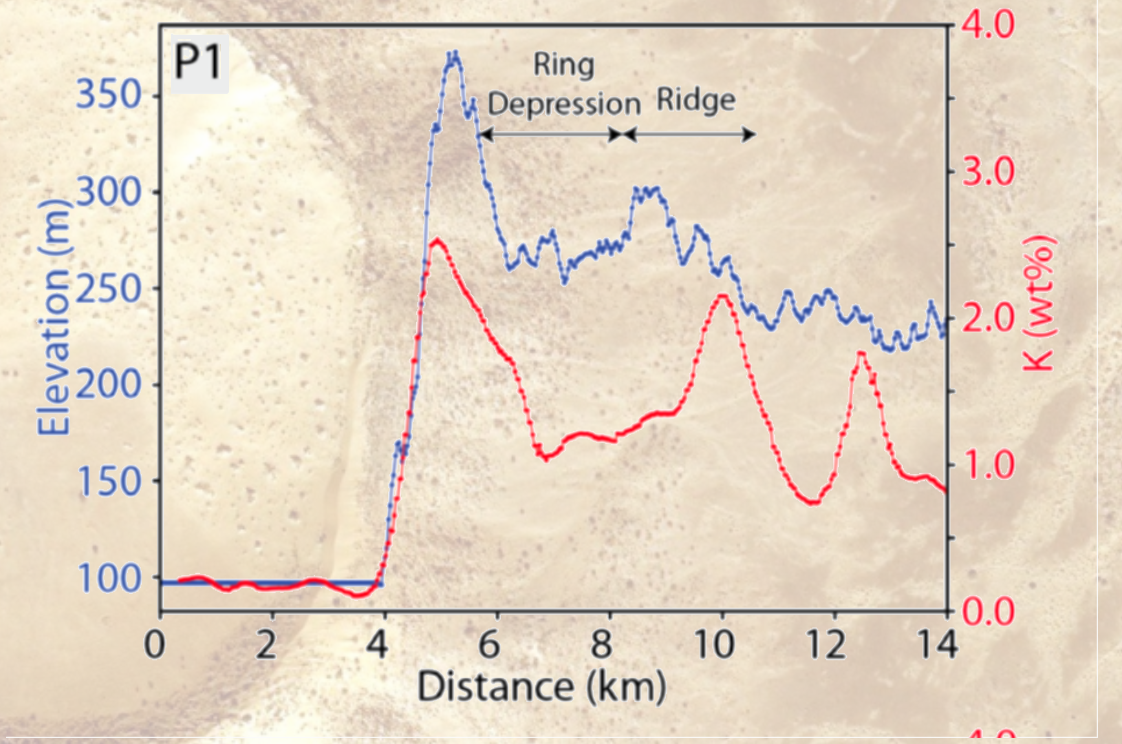
El Kerni et al. (2019) Geological and geophysical studies of the Agoudal impact structure (Central High Atlas, Morocco): New evidence for crater size and age. Meteoritics & Planetary Science 54, Nr 10, 2483–2509 (2019) doi: 10.1111/maps.13347

Houda El Kerni, now post-doctoral fellow at the University of New Mexico.

Impact craters in Africa – Results

The fluidized ejecta of Bosumtwi impact structure, Ghana





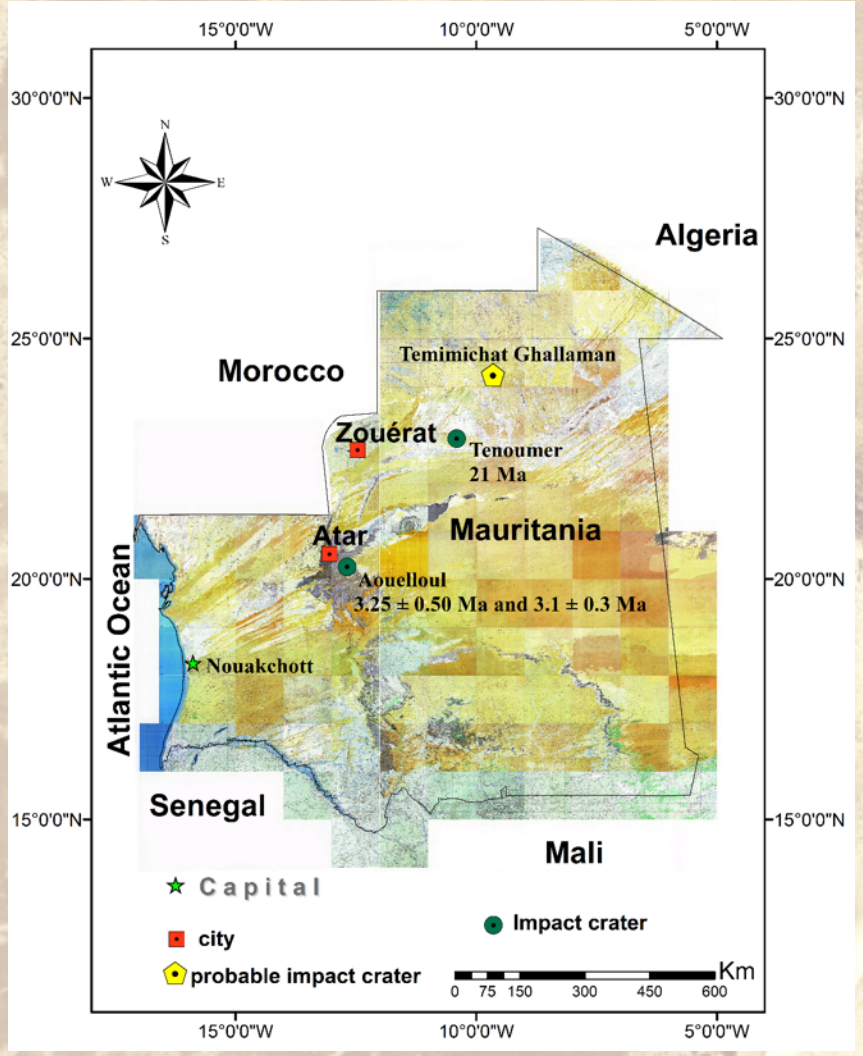
Baratoux, D., Niang, C.A.B. et al. Bosumtwi impact structure, Ghana: Evidence for fluidized emplacement of the ejecta. Meteoritics & Planetary Science 1–16 (2019) doi: 10.1111/maps.13253

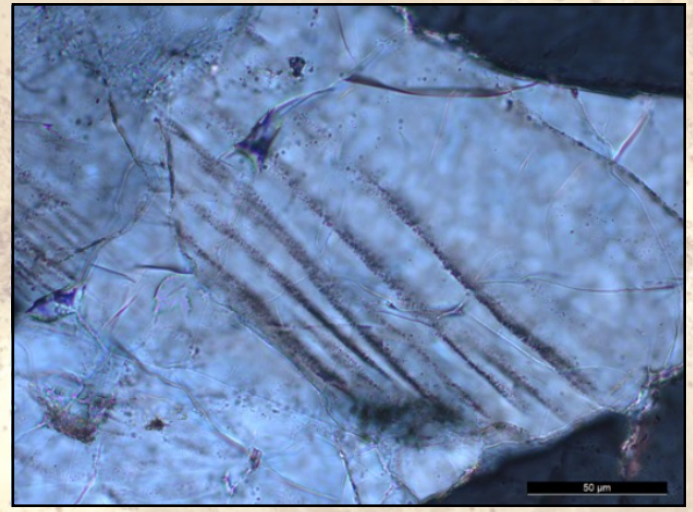
Impact craters in Africa – new projects

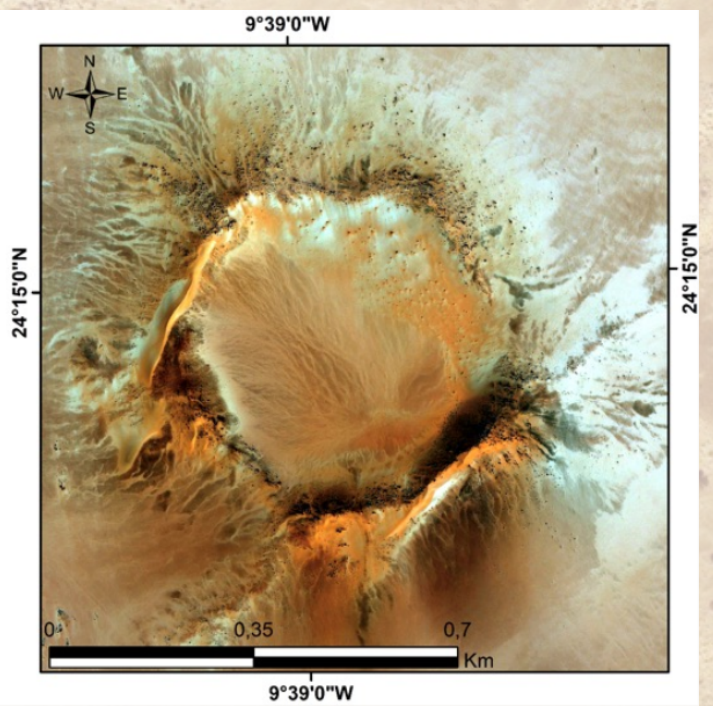
Impact structures in Mauritania (PhD student Elycheikh Naviee)

Collaboration: H. Chennaoui (Univ. Hassan II), L. Ferrière (MNHN, Vienna), M. Sabar (Univ. Nouakchott)

Field campaigns, sampling, lithostructural mapping and search of shock evidence.



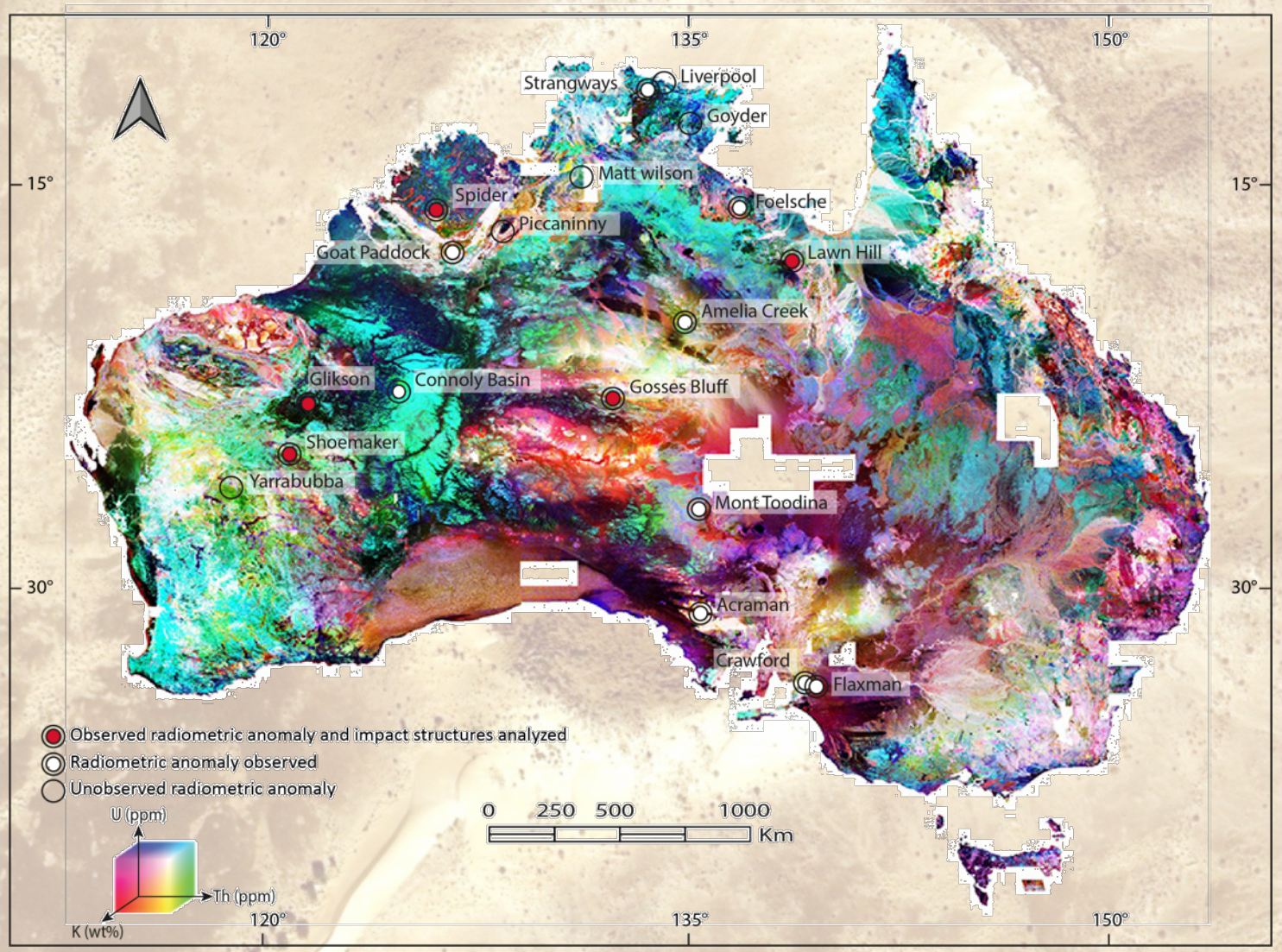




Impact craters in Africa – new projects

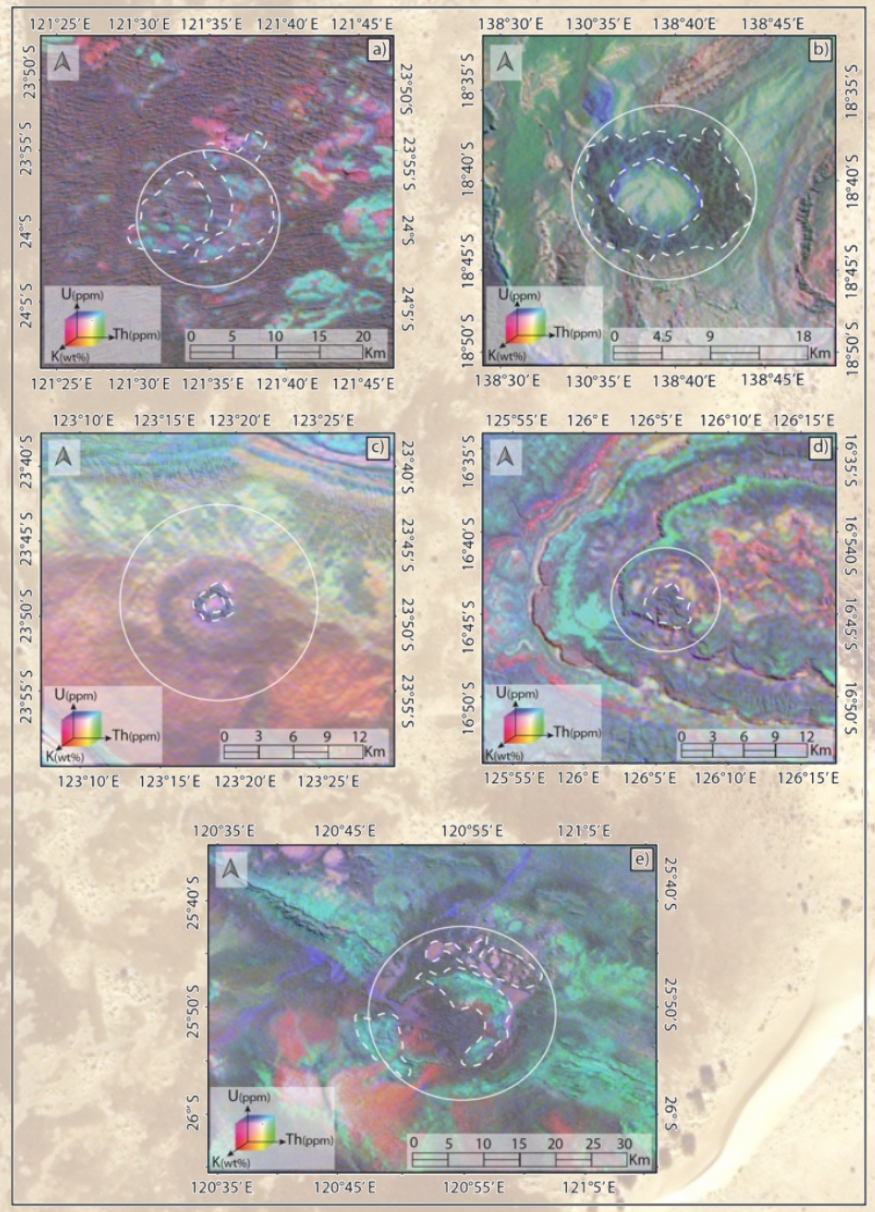
Radiometric signature of impact structures

Collaboration: D.P. Diallo (UCAD, Dakar), W.U. Reimold (UnB), Mark W. Jessell (UWA)



Impact craters in Africa – new projects

Radiometric signatures of impact structures

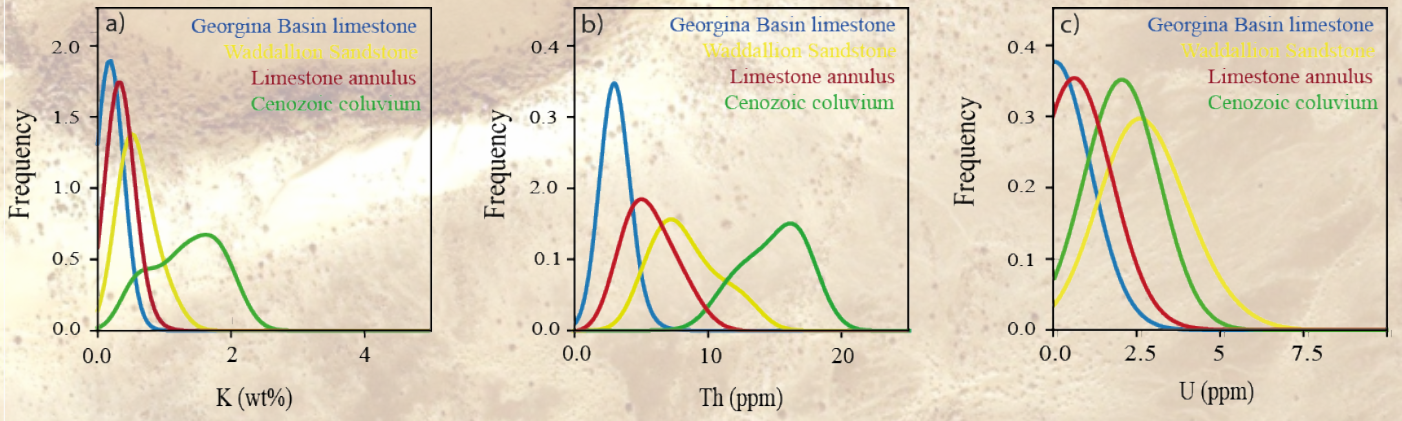


Many impact structures are associated with circular pattern of K, Th or U concentrations

Objective: to understand the (multiple) causes of these circular patterns (impact metamorphism, impact hydrothermalism, structural deformation and/or post-impact weathering)

Potential redistributions of K, Th, U by impact or post-impact processes are important for

- Early Earth history (K, Th and U = source of heat)
- Search for new impact structure from radiometric data in tropical areas (covered)



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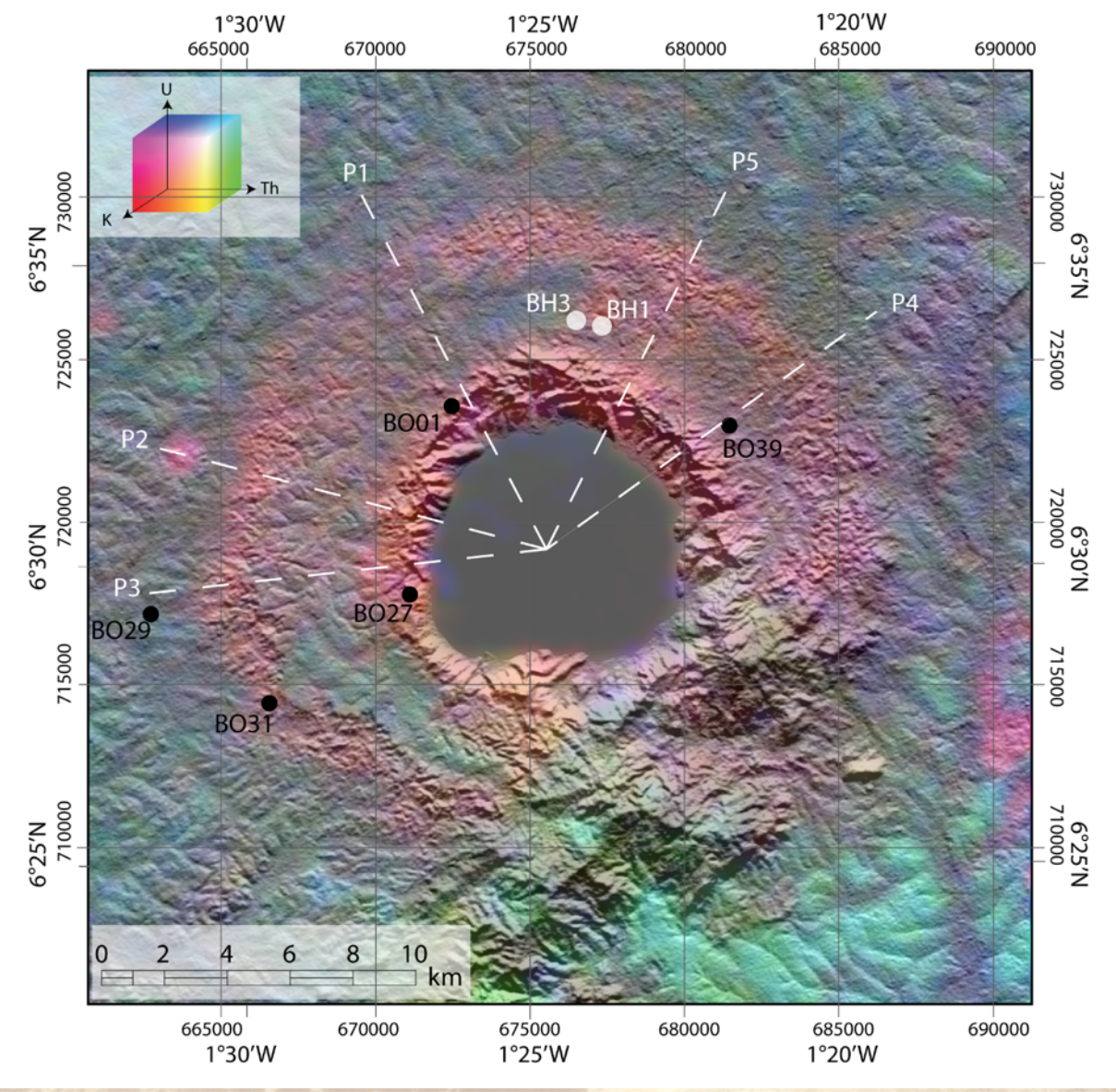
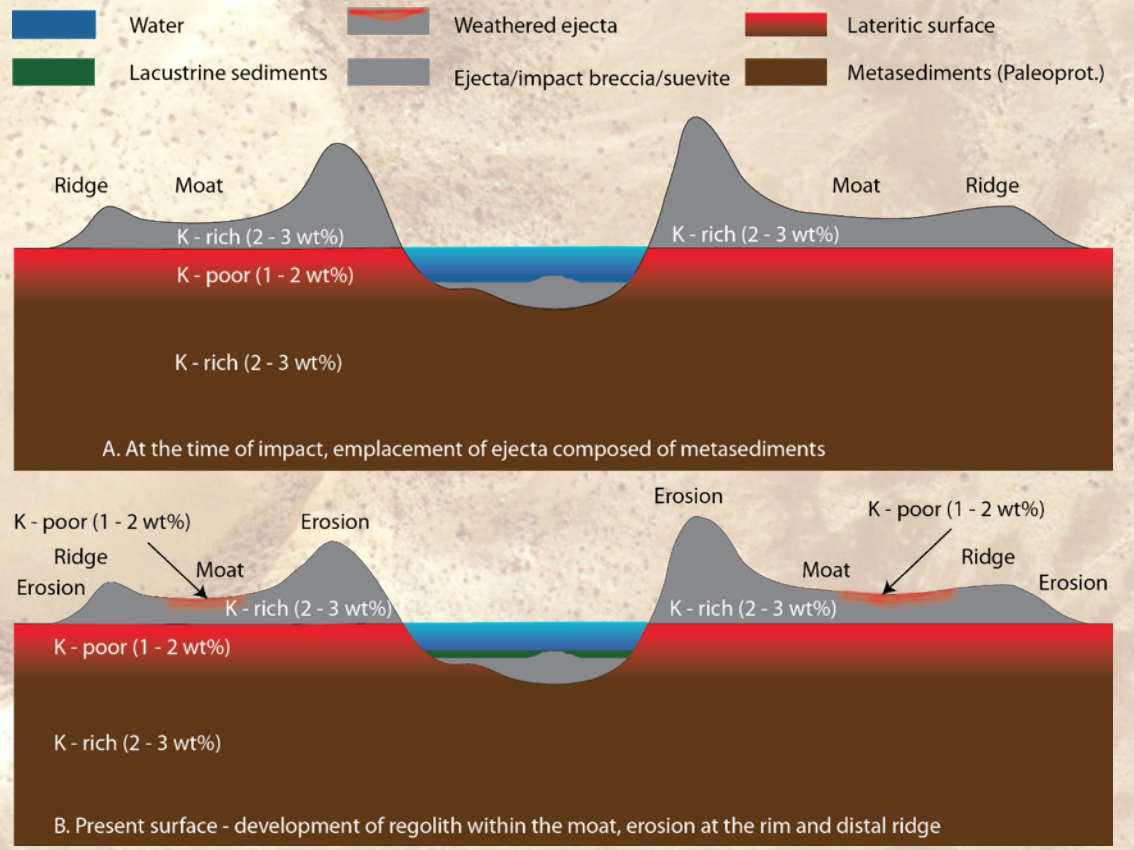
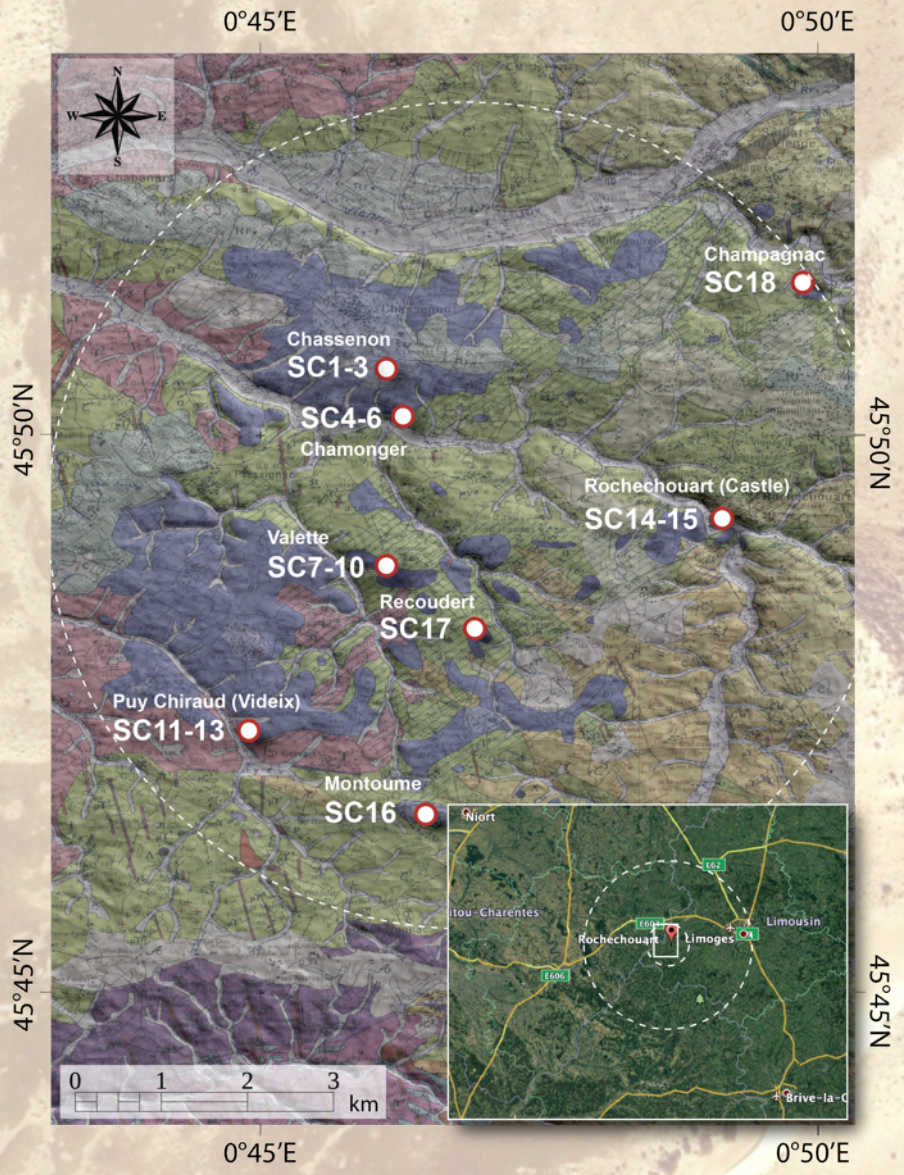


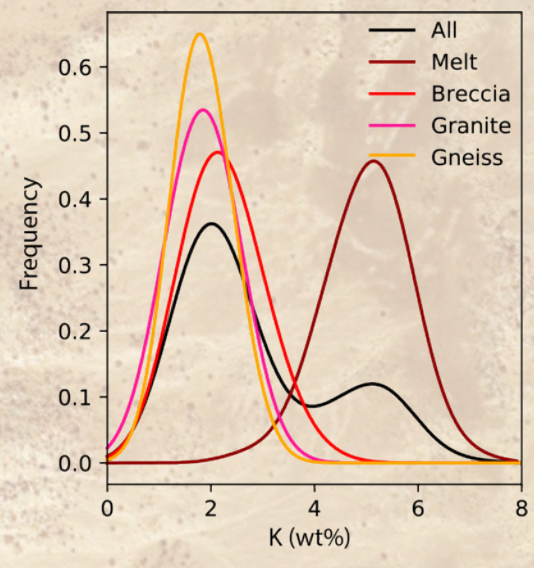


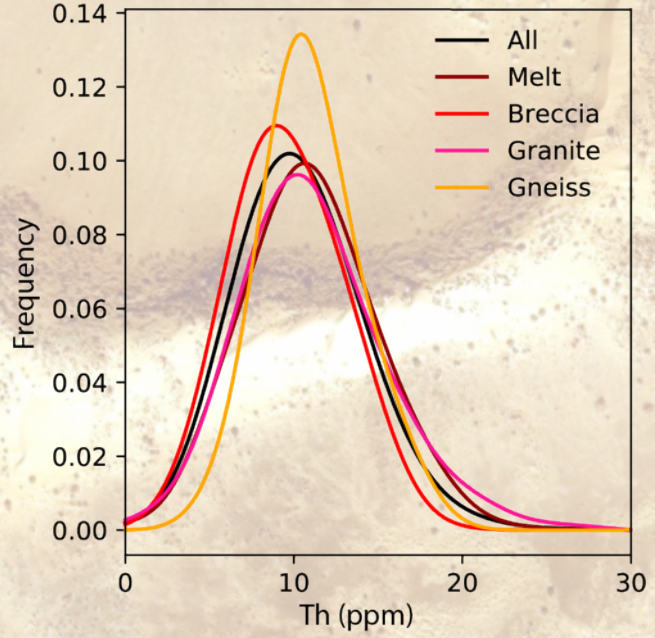
Impact craters in Africa – new projects

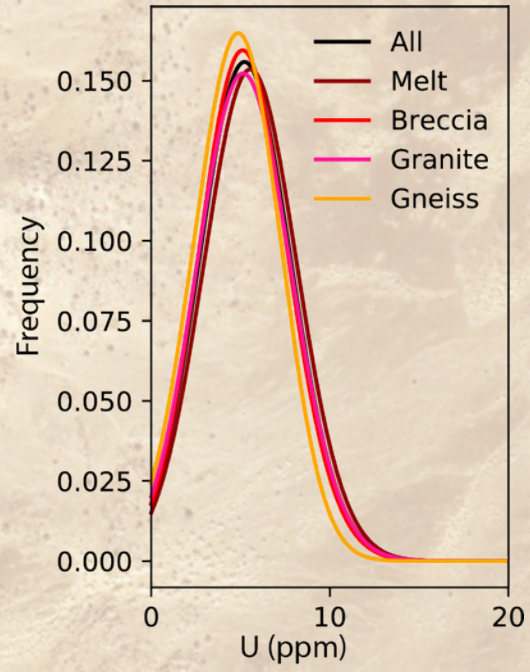
Radiometric signatures of impact structures - Rochechouart



Ch. Ahmadou Bamba NIANG (UCAD) with Ph. Lambert at the Rochechouart impact structure (drilling site)





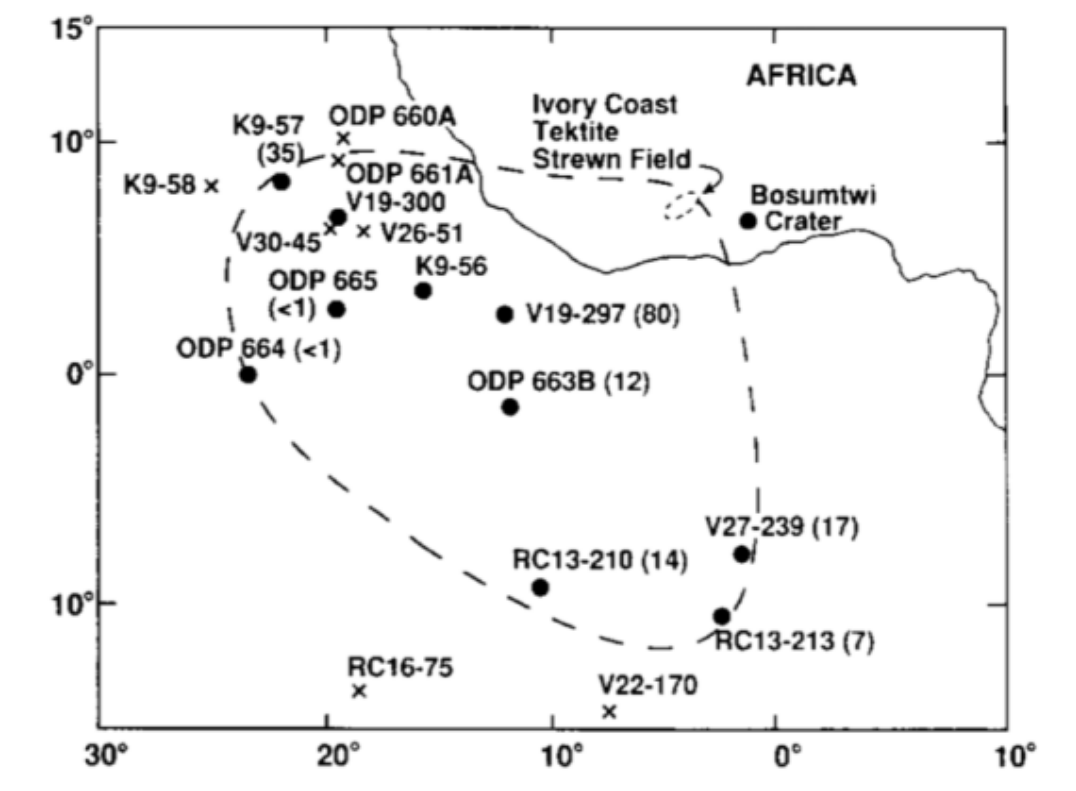


Impact craters in Africa – new projects

Ivoirites – Tectites from the Bosumtwi impact structure

Master student: Soro Pétanki

Collaboration: Pierre Rochette (CEREGE), Alain KOUAMELAN

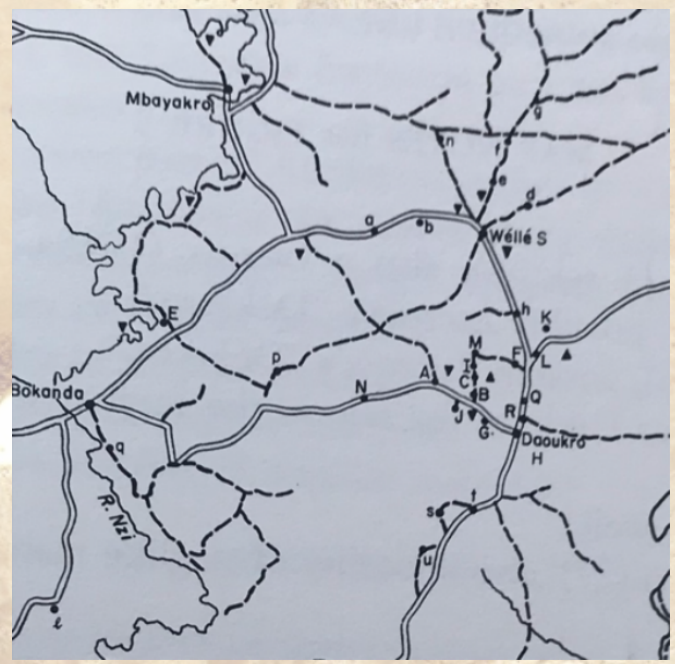


Glass et al. 1991

Dans la langue baoulé, les tectites sont désignées sous le nom d'*agna*. Tandis qu'en Extrême-Orient les indigènes leur attachent une idée astrale (*pierres, boules de lune, excréments d'étoile, crottes du diable*, etc.), les Baoulés leur attribuent une signification plus terre à terre ; orpailleurs, ils les considèrent du point de vue de leur intérêt immédiat. La présence de ces produits, aussi rares que l'or qu'ils cherchent, est pour eux l'indice de la richesse en métal jaune. Ils prétendent qu'à leur vue une angoisse saisit le mineur, comme s'il s'en échappait quelque effluve délétère. Certains en seraient morts, assurent-il !

Et voilà pourquoi ils recueillent avec soin, pour les conserver dans leurs cases, ces petites pierres noires si précieuses à leurs yeux, et c'est grâce à cette circonstance que nous avons pu les étudier.

Lacroix, 1935



Saul, 1968

Outstanding questions

Real extension of the strewnfield

Formation mechanism, source material (deep or superficial)

Impact craters in Africa – new projects

Ivoirites – Tectites from the Bosumtwi impact structure

Master student: Soro Pétanki

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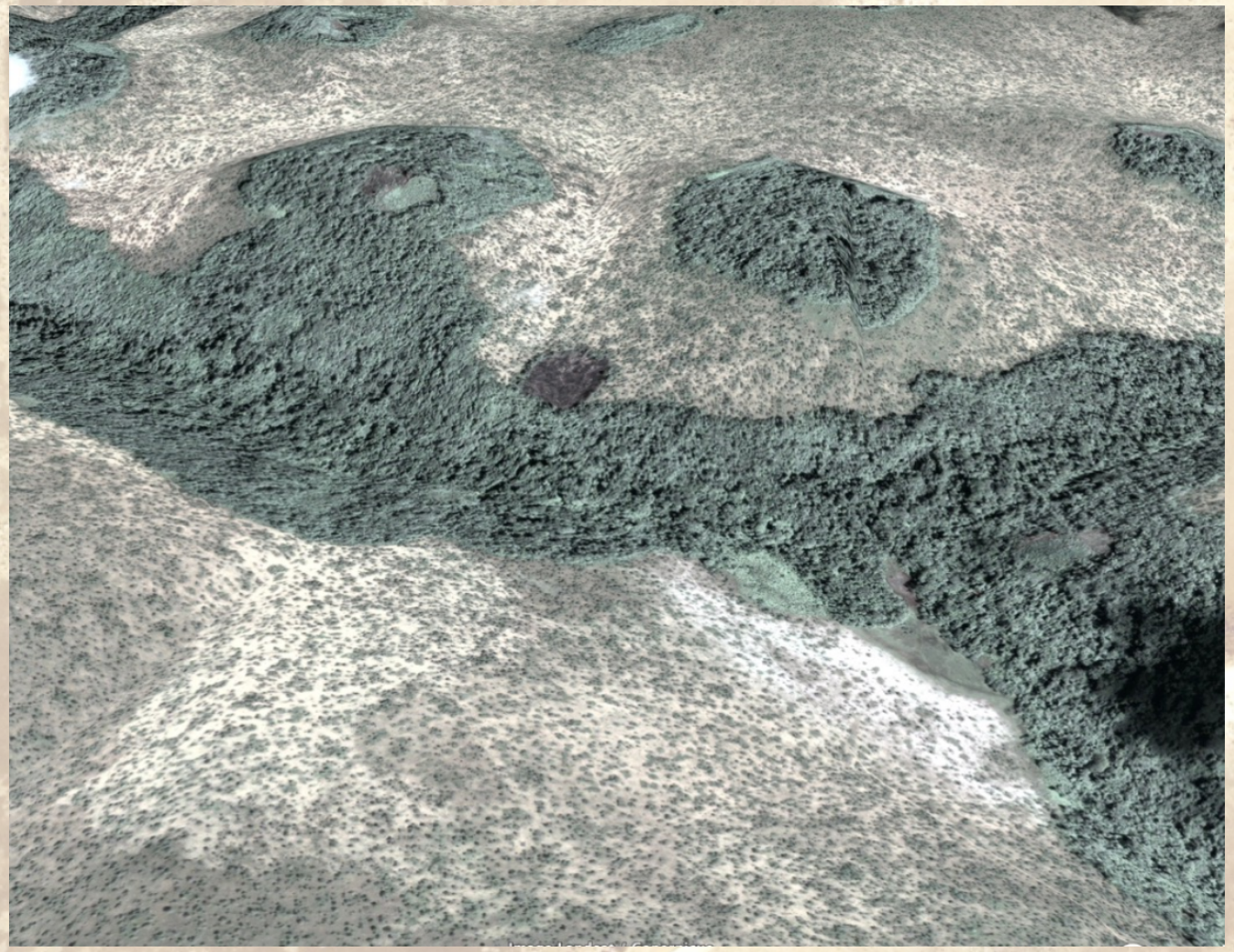
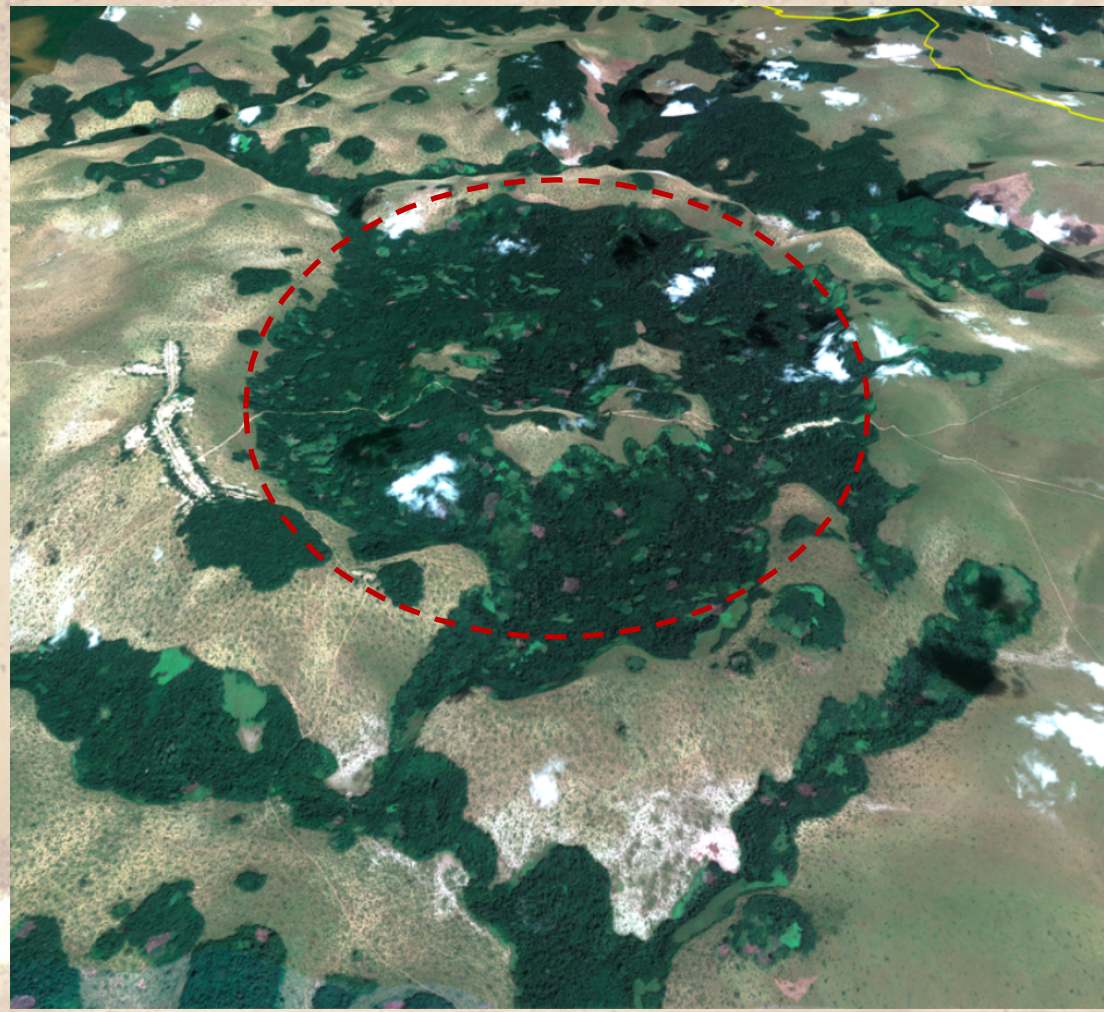
Impact craters in Africa – new projects

Gabon – Plateau Batéké

Collaboration: Ludovic Ferrière





5 km diameter potential impact structure
Field campaign planned in February 2020
New Pleiades images (cloud-free) just acquired !

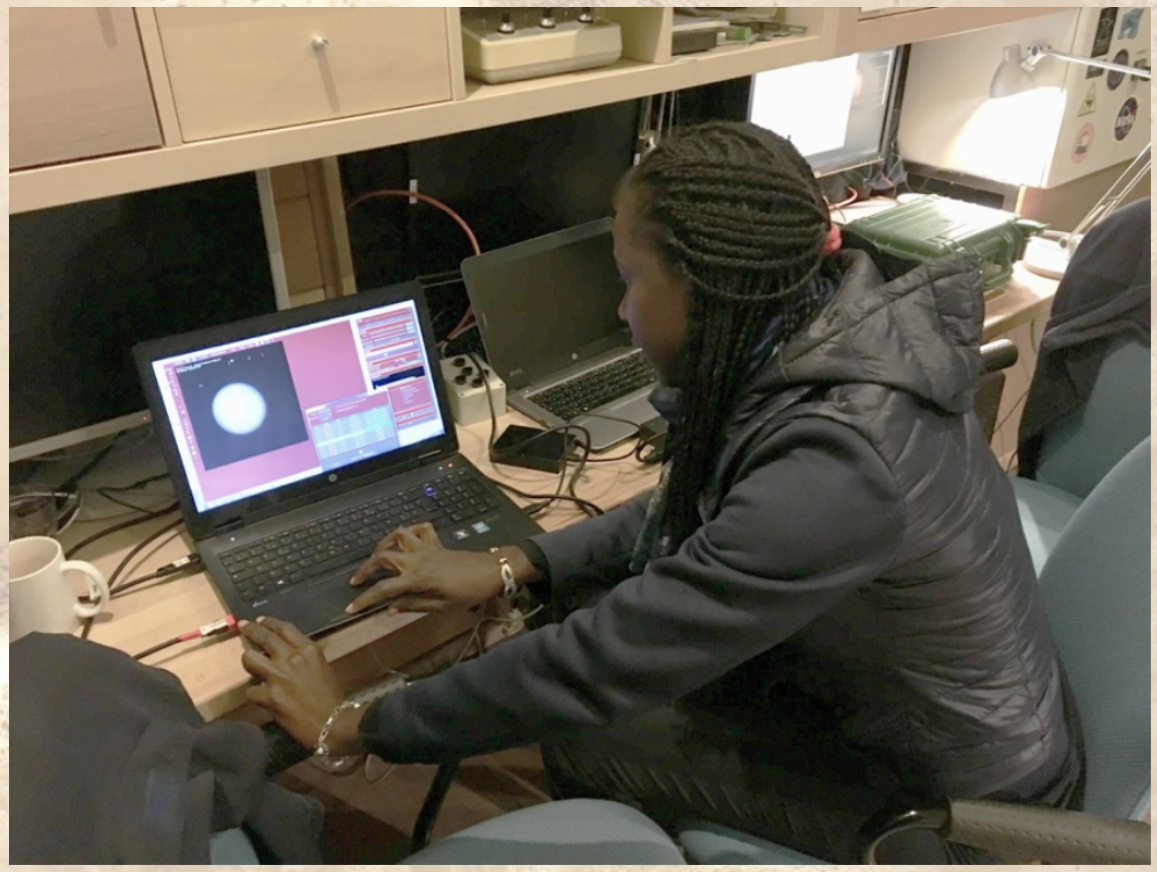
Astronomy in Africa – new projects

Monitoring impact flashes on Jupiter

Ph.D. student Salma SYLLA (UCAD, Dakar)

Collaboration: Observatory of Paris (F. Colas), Observatoire of Oukaimeden (Z. Benkhaldoun)

S. Sylla at the Oukaimeden Observatory (Morocco)



S. Sylla at the 1-m telescope of the Observatory of the Pic du Midi

Public outreach "On the Moon again in Africa"

Scientists worldwide invite you to get your telescopes on the street on July 12th and 13th 2019 to share the Moon with passers by.

2019 - 1335 events in 77 Countries - 46 events in Africa

Nouakchott, Mauritania

Christian Gbaba, 23 years old, student in geology at Lomé (Togo) won the contest « Pourquoi viser la lune ? »

Lomé, Togo

Dakar, Senegal

Promotion of Planetary science by Africans

Pourquoi chercher des cratères d'impacts?
RFI – Atour de la question
With Cheikh Ahmadoun Bamba NIANG (UCAD)

Meeting the challenges of research across Africa. Nature (2019)
Seven researchers from African nations discuss the career implications of developing their research at home or abroad.

Astronomy PhD student Salma Sylla Mbaye hopes to support and advance astronomy research in Senegal. Credit: Omar Ouchaou

Conference at the Univ. of Nouakchott – Meteorites
H. Chennaoui
EAG outreach program

comment

Peering into space with the Morocco Oukaïmeden Observatory

Moroccan scientific production in astronomy and astrophysics has shown sustained growth since the late 1980s. This growth is largely due to the dynamism of an increasingly entrepreneurial community and to the creation of an astronomical observatory in the Moroccan Atlas Mountains.

Zouhair Benkhaldoun

comment

Development in astronomy and space science in Africa

The development of astronomy and space science in Africa has grown significantly over the past few years. These advancements make the United Nations Sustainable Development Goals more achievable, and open up the possibility of new beneficial collaborations.

Mirjana Pović, Michael Backes, Paul Baki, David Baratoux, Solomon Belay Tessema, Zouhair Benkhaldoun, Michael Bode, Nana A. Browne Klutse, Phil Charles, Kevin Govender, Ernst van Groningen, Edward Jurua, Alemiye Mamo, Sivuyile Manxoyi, Vanessa McBride, Jamal Mimouni, Takalani Nemaungani, Pheneas Nkundabakura, Bonaventure Okere, Somaya Saad, Prospery C. Simpemba, Tefera Walwa and Abdissa Yilma

Nature astronomy (2019)

Promotion of Earth and space science by Africans

Association of Young Geologists and Environmentalists of Senegal. Promoting Earth and Space sciences in schools (1000 students)

Senegalese Earth and Space scientists at the AGU Fall meeting (2019)

Conclusions

Planetary and space sciences in Africa, assets and challenges

- Assets

A large number of opportunities for research (sky, geology)
A highly motivated community of colleagues

- Challenges

A large number of PhD students need training
Public funding of research activity
Planetary science not considered as a research priority for developing countries – fighting misconceptions
More pressing (short-term) issues to be solved

The future of AFIPS ? To be discussed today …

- We hope to continue to contribute to changing the State of Planetary and Space Sciences in Africa, by favoring the emergence of new collaborations, new projects (e.g. RISE project led by Mamadou and Eric)

- Join AFIPS - Build new collaborations, host African students, explore the African skies and African grounds