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## Great African Rift Interdisciplinary Research Group 2022 Scientific meeting

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*Interdisciplinary scientific meeting on the East African Rift*

# GDR RIFT

# COLLOQUIUM

Lyon

November 22 / 23 / 24 2022

<https://gdrrift2022.sciencesconf.org>



<https://rift-cnrs.fr/>



# Great African Rift Interdisciplinary Research Group 2022 Scientific meeting

22-24 Nov. 2022 Lyon (France)



## Welcome to the GDR Rift Scientific Colloquium 2022

The GDR Rift is pleased to present this first scientific colloquium which took place from 22 to 24 November 2022, at the Villemanzuy residence, in Lyon. This conference was open to all researchers, students, and staff involved in the GDR, wishing to address issues related to the Great African Rift in an interdisciplinary approach.

This meeting was dedicated to the presentation of the latest scientific results in or on the Great African Rift during plenary sessions, but also allowed for exchange and discussion during targeted workshops in smaller groups. Presentations were given in English, and plenary sessions were broadcast on video.

## Context

The Great African Rift Interdisciplinary Research Group brings together several communities and disciplines to work collaboratively to better understand the complex system that represents East Africa. Researchers in geosciences, environmental sciences, and humanities have been interacting for many years in common areas of the Rift or on related issues in order to understand the factors impacting the issues of this region, whether economic, political, environmental, geological...

The GDR Rift started on 1 January 2021 and brings together 44 research units around 3 CNRS supervisors: INSU, INEE and INSHS. It is managed by a steering committee which is advised by a scientific committee.

In order to receive the GDR Rift newsletter or to subscribe to the GDR, please contact [gdr-rift@services.cnrs.fr](mailto:gdr-rift@services.cnrs.fr)

## Objectives

This conference was an opportunity to review current research in the Rift or on the Rift, but also to share and discuss around targeted workshops. These workshops were the place to initiate new projects, to launch new collaborations, to enrich our sometimes too disciplinary visions, and to exchange.

The colloquium was also a moment dedicated to a joint reflection on target areas, federating observatories allowing the acquisition, sharing, and distribution of interdisciplinary data over the long term. Specific workshops were proposed to identify and build these target areas with our Rift partners.

## Scientific Committee

Doris Barboni, INSU  
Guillaume Blanc, INSHS  
Jean-Renaud Boisserie, INEE  
Didier Bompangue  
Gudrun Bornette, INEE  
Marie Bridonneau, INSHS  
Jessie Cauliez, INEE  
Marie-Laure Derat, INSHS  
Jean-Baptiste Eczet, INSHS  
Yves Geraud, INSU  
Benoît Hazard, INSHS  
Lama Khalidi, INEE

Florence Le Hebel, INSHS  
Mustapha Meghraoui, INSU  
Olga Otero, INEE  
David Pleurdeau, INEE  
Sandrine Prat, INEE  
Mathieu Schuster, INSU  
Pierre Sepulchre, INSU  
Virginie Tallio, INSHS  
Christel Tiberi, INSU

# Sessions / Workshops

## Understanding the rift and anticipating its future: Contributions of modelling

*Moderators: P. Sepulchre, M. Schuster*

Successive IPCC reports highlight the vulnerability of East Africa to the consequences of anthropogenic climate change. In this context, modelling appears as an essential transverse tool for understanding and projecting the future evolution of the Rift socio-ecosystems. This workshop welcomes all contributions whose common point is the use and/or development of models, whether sociological, biological or (geo-)physical, to understand the future evolution of the Rift system. Discussions will focus on the limits and locks of the models, but also on their relevance and predictive capacity. Can we consider enough interactions and factors? What is the impact of the tools and their adaptability to the problems? Finally, what is the role of the researcher if his models can assist political decisions?

## What is heritage?

*Moderators: J.R. Boisserie, O. Otero, J. Cauliez, M. Bridonneau.*

Management, conservation, enhancement: so many terms and practices included in the notion of heritage. What role can scientific research play in heritage policies? Which policies for the multiple faces of heritage?

## Rift as a factory of diversity

*Moderators: J.R. Boisserie, J.B. Eczet*

What is the effect of the rift on diversity? How can the unity of a natural and social space be defined by the heterogeneity in which it participates and not by a homogeneous whole?

## Energy versus Resources

*Moderators: B. Hazard, Y. Geraud*

Resources have always been essential to our survival, and have had a strong influence on our mobility, innovations, politics, behaviour, and environmental management for millions of years. This workshop will explore energies and resources in time and in their diversity (tourism, water, minerals, ores, etc.). Attention will also be paid to the qualification of these notions, which are defined differently according to the disciplines: is an energy or a resource potential and existing before use, or only produced and defined by use?

## Wet Places

*Moderators: B. Hazard, O. Otero, D. Barboni*

Oases, waterholes, rivers, riparian forests, etc., located in the arid landscapes of East Africa, the Rift wetlands are shaped by tectonics, climate, and life. Places of life and exchange, they are at the heart of past, present, and future socio-ecological and bio-geological interactions. This workshop aims to identify the aspects/themes of research on wetlands located in arid environments and the challenges of approaches at the crossroads of disciplines and their potential complementarities.

## Systems Dynamics

*Moderators: P. Sepulchre, C. Tiberi, O. Otero*

The rift gathers very diversified systems, whose dynamics are particularly difficult to understand. This complexity is due to the many different types of data and disciplines, the sometimes extremely contrasting scales of time and space, or concepts that are sometimes very distant from one another. This workshop aims to approach the dynamics of systems by addressing, among other things, the question of mobility and connectivity in the rift, but also by questioning how spatial or temporal scales can intertwine and interact. How have and will climatic changes or geodynamic phenomena alter environments? How does the rift structure cultures, populations and their mobility? What is a barrier and how does it affect systems? The expected examples may be from different fields (e.g. linguistics, climatology), or can already integrate several (e.g. geology, biology).

## Health-Environment Relations

*Moderators: G. Bornette, D. Bompangué*

Declination of one health approaches in the Rift: what are the issues, what methods, what hopes?

In recent years, it has become clear that public health issues can no longer be analyzed rigorously without placing them in their ecological context. In particular, the relationships between human societies, fauna and flora, and the ecosystems that the organisms occupy, are key elements determining the health risks to which these living beings are exposed. The One Health concept was born to address this issue: how the health of living organisms (animals and plants) and the functioning of ecosystems interact with humans and contribute to the health risks they face. This workshop aims to address this issue in the geographical context of the African rift, focusing on infectious diseases affecting the populations of these territories. The objective is to take stock of current research and to initiate a brainstorming session on scientific approaches and means to improve the prevention of health risks in the context of increasing anthropogenic pressure on ecosystems and climate change.

## Definition and management of the risks (merged with Systems dynamics)

*Moderators: M. Meghraoui, C. Tiberi*

The Rift is characterized by active geodynamic processes (seismicity, volcanism, degassing), but also results in significant contrasts in the relief and in the climatic seasonality, implying the existence of additional natural hazards (floods, landslides, ...). Due to its favorable environmental conditions, this structure has also allowed the development of a high density of human occupation (especially since the Middle Quaternary), implying an increase in risks. A realistic assessment of the risks related to the Rift and an inventory of resilience actions is one of the objectives of this workshop. We will also address the issues of vulnerability, risk, and resilience in the Rift. These aspects will be discussed in the context of environmental change, whether at large spatial and temporal scales (continental and geological) or at regional scales and abrupt changes (soil erosion, lava flows, pollution,...). We expect contributions from all disciplines, whether they address the definition of hazards, their impact on the environment, or the role of scientists in their management. What are the risks present in the rift, their distribution, their impact, and for whom (public policies, inhabitants)? What role can science and local knowledge play in their management? What are the temporalities of the processes, of the crises, and how to approach them?

## Workshop Target zones (Turkana)

*Moderators: J.R. Boisserie, C. Tiberi, S. Prat, O. Otero*

The aim of these two workshops is to bring together our different disciplines around two target areas that can be defined as interdisciplinary observatories. These areas have extremely rich potential biodiversity, geodynamic processes, sedimentary and fossil records, and are also the site of major societal issues (economic, political, cultural, energy, etc.). We hope to initiate a reflection with all the partners to build common interdisciplinary and participative observatories.

## Workshop Student Workshop

*Moderators: D. Pleurdeau, F. Le Hebel*

The workshop is made by and for students to propose actions that are dedicated to them and beneficial. The idea here is to interact directly with the research actors of tomorrow in order to better promote interdisciplinarity and internationality.

## Abstracts

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# Renewable Energy Projects and Indigenous Peoples in Rift Valley, Kenya

Lankeu Reson<sup>\*1</sup>, Aloys Osano<sup>\*†1</sup>, and Bakari Chaka<sup>\*‡1</sup>

<sup>1</sup>Maasai Mara University – Kenya

## Abstract

**Renewable Energy Projects and Indigenous Peoples in Rift Valley, Kenya**  
By;

**Aloys Osano<sup>1</sup>, Reson Lankeu<sup>2</sup> & Bakari Chaka<sup>3</sup>**

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### Abstract

This project sought to explore the plight of Indigenous Peoples against Renewable Energy Projects in Rift Valley. Renewable energies have been pointed as the key source of surplus energy to drive the economy while also maintaining a low-carbon environment. Most of the REPs in Kenya begun operations after liberation of the energy sector in 2008. The field attracted many local and foreign investors; some with questionable human rights characters. Even then, energy institutions were unable to regulate these players or reprimand them when they violated human rights policies. Unsurprisingly, the REPs went ahead to violate all forms of human rights accorded to indigenous peoples during project developments. This is despite the REPs having clear and detailed documents on human rights, energy and land policies to guide them. Unlawful eviction, unfair compensation, doctored environmental and social impact assessment (ESIA) reports and unfollowed benefit-sharing policies have all been witnessed. The alleged-illiteracy of IPs to contemporary education system, lack of state knowledge and low economic capacity have been pointed as the key challenges of IPs in their quest for justice. The report has identified these weaknesses and proposed a strategic advocacy action plan. The plan highlights the key players involved using already established policy documents while benchmarking on successful IPs who walked through the same paths. Should the plan be realized, then the plight of IPs can be significantly resolved.

**Keywords:** Renewable energy projects, Rift Valley, Indigenous Peoples

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# One Health and the African Great Rift

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## Abstract

### One Health and the African Great Rift

The One Health concept initiated at the beginning of the century as the "One World One Health" initiative has many roots historically, has been given plenty of definitions and populates a constellation of related concepts (ecohealth, planetary health, global health, environmental health, etc.). It has gained momentum with the increasing frequency of disease emergence and pandemics and the failure of traditional public health approach and biosecurity to prevent them. This led WHO, WOAHA, FAO and UNEP to jointly propose a "new definition (of One Health) for a sustainable and healthy future" (OHHLEP et al., 2022). However, there is still a long road ahead to fully integrate the multiple disciplines and concepts, to organize governance making their implementation possible in the field, and to subsequently mobilize sufficient manpower and appropriate funding (Destoumieux-Garzón et al., 2018; Giraudoux et al., 2022). Here we discuss the challenges posed by the increasing emergence of human, animal and ecosystem health issues and how a nexus approach of those issues is necessary (see e.g. IPBES (2020) and ongoing nexus assessment 2022-2024, IPBES (2019)). This applies to a large number of human health issues in the African Great Rift, those known (e.g. Ebola disease, Monkeypox, Malaria, Cholera, Echinococcoses, etc.) as well as those still unknown and incubating, whose origin and expansion combine with the deterioration of local socioecosystems.

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Casas, N., Becerra, N.C., Charron, D.F., Chaudhary, A., Zanella, J.R.C., Cunningham, A.A., Dar, O., Debnath, N., Dungu, B., Farag, E., Gao, G.F., Hayman, D.T.S., Khaita, M., Koopmans, M.P.G., Machalaba, C., Mackenzie, J.S., Markotter, W., Mettenleiter, T.C., Morand, S., Smolenskiy, V., Zhou, L., 2022. One Health: A new definition for a sustainable and healthy future. *PLOS Pathog.* 18, e1010537. <https://doi.org/10.1371/journal.ppat.1010537>

**Keywords:** One health, ecohealth, socioecosystem, emerging diseases, biodiversity, nexus

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# Insights into household fuel use in Southern Rift Valley, Kenya

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<sup>1</sup>Maasai Mara University – Kenya

## Abstract

**Insights into household fuel use in Southern Rift Valley, Kenya**

By;

**Aloys Osano<sup>1</sup>, Reson Lankeu<sup>2</sup>, Bakari Chaka<sup>3</sup>**

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Clean household fuel use is a cornerstone of the development of sustainable cities, in order to minimise household combustion emissions in communities and the negative air quality and human health impacts associated with this. In developing countries, factors determining fuel use are multi-faceted and complex. A survey was thus conducted to better understand the current household fuel usage profile in South Rift Valley (Bomet and Narok counties) versus other part of Kenya (Voi and Mombasa counties). The fuel use parameters investigated covered bio-data and economic status, dwelling type, fuel choice and usage, combustion devices and ventilation in kitchens. The fuel type usage was distributed between firewood (25 %), charcoal (24 %), kerosene (24 %) and liquefied petroleum gas (LPG) (23 %). Three-stone stoves were still predominant in rural communities, whilst cleaner devices burning kerosene and LPG were used more widely in urban Mombasa. With the exception of Voi, there were more chimneys in urban dwellings than in the rural homes, even though brick houses were the most popular dwelling type overall (52 %). It was noted with a lot of concern that the popular fuels in use in South Rift Valley had a lot of emissions with numerous health effects. The results of this study will provide a useful basis for decision making regarding potential future clean energy intervention strategies in Kenya in order to promote sustainable development.

**Keywords:** Household fuels, South Rift Valley, health, gaseous emissions

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# COMMUNITY ENGAGEMENT IN ENERGY PROJECTS IN KENYA; THE EXPERIENCE OF KENGEN OLKARIA GEOTHERMAL STAKEHOLDER COORDINATION COMMITTEES (SCC)

Lankeu Reson\*<sup>1</sup>

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## Abstract

**COMMUNITY ENGAGEMENT IN ENERGY PROJECTS IN KENYA; THE EXPERIENCE OF KENGEN OLKARIA GEOTHERMAL STAKEHOLDER COORDINATION COMMITTEES (SCC)**

By;

**Reson Lankeu**

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## Abstract

**The success of any project by and large depend on the quality of engagement of stakeholders who are directly or indirectly affected by the project.** Olkaria, a village in Naivasha within the greater rift valley, Kenya, is endowed with steam (geothermal resource). The resource has since been exploited to generate electricity for national consumption.

KenGen, is leading Kenya's shift to renewable energy, and has previously rolled out big-ticket wind and geothermal projects that involved relocating communities. Its construction of wind farm in Ngong and extraction of geothermal energy in Naivasha have attracted resistance from the local communities.

KenGen has prioritized a "structured dialogue" with communities to prevent conflict as its rolls out projects to expand access to electricity The Company established Stakeholders coordination committees at the community and project level as a tool to ensure smooth operations and timely completion of geothermal projects.

Community expectations however, continue to change over time, which calls for the company to adjust the way it relates with them to ensure successful implementation of projects There

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\*Speaker

is a growing need for communities to have a greater voice in the priorities and decisions that affect them in the process of project cycle The recent projects implemented by KenGen include the 280 MW project and the 560 Olkaria 1 project.

The company established Stakeholder coordination committees comprising; Ken Gen representatives, community representatives (chairmen) elected at the village level. Provincial administration, representatives of elected leaders, Professionals, women, youth and other special groups

Subcommittees were developed to spearhead Employment, Economic opportunities, Safety Health and Environment. The committees developed a criteria for sharing resources and the available opportunities in an equitable manner.

The presentation aims to share first hand experiences on implementation of geothermal projects; the community perspectives and challenges in the future.

**Keywords:** Stakeholders Co, ordination Committee, Community Engagement, Energy projects

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# Distribution géographique et diversification des petits mammifères en Afrique sub-saharienne : intégration des données fossiles et modernes

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## Abstract

Cette communication a pour but de présenter un projet de collaboration franco-tchèque initié en 2021 dans le cadre d’un Partenariat Hubert Curien (PHC) ” Barrande ”, qui porte sur l’étude de petits mammifères est-africains. L’Éthiopie en particulier possède une faune de rongeurs riche et très particulière. De plus, si on la considère dans un contexte panafricain et phylogénétique plus large, la région apparaît également comme le ”berceau” de nombreux taxons, qui ont ensuite émigré vers le reste du continent. L’Éthiopie a également joué le rôle de carrefour biogéographique, en intégrant des faunes du Moyen-Orient, d’Afrique du Nord et d’Afrique sub-saharienne. L’étude approfondie de cette biodiversité nécessite donc non seulement une identification et une classification des espèces, mais aussi une bonne connaissance de leur phylogénie et de leur histoire évolutive. Elle nécessite également une bonne connaissance de l’histoire des taxons fossiles à travers le temps afin de mieux appréhender l’impact des changements climatiques et tectoniques sur ces processus de diversification. Dans ce projet nous adoptons une approche intégrative combinant des données génétiques (inférence de phylogénies complètes et robustes, inférence de processus démographiques, phylogéographie et génétique des populations), des données morphométriques (obtenues sur des spécimens modernes et fossiles quaternaires) et des données de modélisation de niche écologique (conservatisme de niche *versus* divergence adaptative). Cette approche intégrative nous permettra de mieux comprendre les processus évolutifs qui ont conduit à la diversification des petits mammifères africains. Elle nous permettra également de répondre à des questions clés en biologie évolutive telles que le rôle des changements géo-climatiques sur les processus de diversification et d’extinction, la manière dont les changements morphologiques et génétiques varient dans le temps et les mécanismes de spéciation. Une étude

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préliminaire sur le site pléistocène-holocène de Goda Buticha, dans l'est de l'Éthiopie, a également montré l'importance d'une bonne connaissance des taxons modernes et de la constitution de référentiels robustes pour l'identification fiable des spécimens fossiles au niveau spécifique. Nos résultats permettront ainsi une meilleure estimation de la diversité et de la distribution actuelles et passées des espèces de petits mammifères africains, également cruciale pour l'établissement d'un statut de conservation précis des espèces.

**Keywords:** rongeurs, musaraignes, Ethiopie, génétique, morphométrie, modélisation de niche

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# NYKISHU: Interactions between the NYiragongo volcano, lake Kivu, its aquatic ecosystem and the HUMAN system: an integrated knowledge approach

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## Abstract

Nyiragongo is a strato-volcano, part of the Virunga volcanic chain, located in the western branch of the East African Rift, in the east of the Democratic Republic of Congo, where it borders Rwanda and its district of Rubavu. The volcano culminates at 3,470 m above the city of Goma, a city of 1,100,000 inhabitants, and Lake Kivu. Historically, Nyiragongo erupted in 1884, in 1977 and in 2002, killing each time several hundreds of people. The most recent eruption occurred in 2021, killing 100 people and displacing up to 400,000. Following the 6 hours long fissural eruption, a 25 km long magmatic intrusion propagated laterally at shallow depth under Lake Kivu posing the threat of a potential limnic eruption. Such an eruption would have potentially released large amount of gas (CO<sub>2</sub>, methane and toxic hydrogen sulfide), asphyxiating all living species around Lake Kivu on the Congolese and Rwandan side and causing thousands of deaths in both countries. Moreover, Lake Kivu is a major economic resource. The pumping of methane from Lake Kivu in Rwanda has existed on a small scale but has recently been drastically intensified and is expected to increase in the near future, without a clear understanding on the impact and safety. The combination of the monetary value of Lake Kivu, its potential explosive capacity and the wide range of opinions on how best to deal with it, calls for more scientific work on the lake. The aquatic ecosystem of Lake Kivu is similar to the African rift lakes in that strong seasonal changes occur. However, it is much more eutrophic than the African rift lakes. The phytoplankton and zooplankton assemblages can be used as markers of dynamic changes in the lake and disturbances such as volcanic eruptions and ongoing gas extraction. Last but not least, the last two volcanic crises have particularly highlighted the socio-economic vulnerability of the region in the short and long term. More than two million people now live around Lake Kivu, on which they are heavily dependent. Fishing and agriculture are the main means of subsistence for these communities. In this context, the multidisciplinary NYKISHU project aims to improve our knowledge on both the scientific and societal aspects of the NYiragongo

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\*Speaker

volcano and lake Kivu integrated system. It will develop on 3 complementary axes:

1) Study the volcanic physical system via modeling using fluid dynamics and continuum mechanics. In particular, the volcanic system will integrate the coupling between the volcano and the volcanic lake, the two entities being separated by only 20 km.

2) Study the aquatic ecosystem through its plankton assemblages (zooplankton, phytoplankton) and testing the markers of changes in aquatic assemblages due to volcanic activity.

3) Study the human system through an assessment of the social impact of volcanic crises on neighboring Rwandan communities of the lake and through the identification of vulnerability factors, such as access to consumer goods such as drinking water, loss of income, security and gender mainstreaming.

**Keywords:** Volcanic eruption, Georesources, Aquatic ecosystems, Social impact of volcanic crises



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# NEOTAPHONOMIC STUDY OF CARNIVORE BEHAVIOR AT TARANGIRE NATIONAL PARK AND ITS IMPLICATIONS FOR THE INTERPRETATION OF THE EARLY HUMANS AT OLDUVAI GORGE (TANZANIA)

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## Abstract

Out of the six million years of human evolution, more than half of that time was spent as hominins being prey of carnivores. At a certain moment in time, some hominins evolved into more advanced and modern-looking forms that are at the base of what paleoanthropologists refer to early Homo, our genus. Understanding how humans coped with predation and carnivore competition two million years ago is crucial to understand the first steps of the evolution of our genus.

Recent excavations at the FLK North site in Olduvai Gorge have yielded a very intense taphonomic signature that shows that carnivores, namely felids, were responsible for the accumulation of animal carcasses at this site. In other sites, hominins have been argued to have interacted opportunistically with felids, especially lions, to obtain scavenged food. Given the immense repercussions of these interpretations for the reconstruction of early human behavior, it is necessary to model these behaviors in as wide a range as possible of similar environments to those occupied by our earliest ancestors two million years ago.

The present study confirms that carnivores particularly lions efficiently deflesh small and medium-sized carcasses and they can even thoroughly deflesh carcasses heavier than 500 kg, such as buffaloes. Ecology plays a major role in the intensity with which lions deflesh their prey. The most intensive carcass consumption episodes in Tarangire were documented in alluvial environments near water. The research result shows that bone damage is proportional to the intensity of carcass consumption and upper limb bones are usually the most defleshed and heavily damaged elements.

**Keywords:** Neotaphonomic, Carnivores, Early humans

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# Estimation of Soil loss Rate Using RUSLE, Remote Sensing and GIS Technics: A Case Study of the Maasai Land Scape in Arusha, Tanzania

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## Abstract

Soil loss caused by runoff is a serious and ongoing ecological issue in the Maasai landscape in northern Tanzania. Soil erosion has been accelerated as a result of deforestation, poor farming practices, and overgrazing. Soil loss information is crucial to promote agricultural production and natural resource management. Main objective of this paper was to estimate and map the average annual soil loss by interpreting Revised Universal Soil Equation (RUSLE) with GIS and remote sensing techniques. RUSLE's soil loss variables were derived using a topographic map at a scale of 1:50,000, an Aster Digital Elevation Model (DEM) with a spatial resolution of 20 m, a digital soil map at a scale of 1:250,000, 15 years rainfall data from Tanzania Meteorological Agency (TMA) and land sat imagery (TM) with a spatial resolution of 30 m. To estimate and map the annual soil loss of the research site, the RUSLE parameters were examined and merged using a raster calculator in the geo-processing tools in the ArcGIS 10.1 environment. The results showed that the landscape annual soil loss ranges from none in the lower and intermediate portions to 265 t ha<sup>-1</sup> year<sup>-1</sup> in the portion with a steeper slope, with a mean annual soil loss of 47 t ha<sup>-1</sup> year. The majority of these soil erosion affected sites are geographically located just near the mountains where there is a high slope. These are regions dominated by caly and clay loam soil with higher soil erodibility character (0.25) values. Soil erodibility parameters and slope gradient and length were discovered to be the primary causes of soil erosion. Therefore, the steepest top portion of the research area should implement sustainable soil and water conservation methods.

**Keywords:** Soil loss, GIS, Remote sensing, Satellite image, RUSLE and Landscape

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# DefVolc: Interface and web service for fast computation of volcano displacement

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## Abstract

DefVolc is a suite of programs and a web service intended to help the rapid interpretation of InSAR data, acquired on volcanoes at an increased frequency thanks to the various dedicated satellites. Our objective is to help to rapidly inverse volcano displacements, whether these displacements result from fractures (sheet intrusions or faults) or massive magma reservoirs. These sources may have complex geometries, and they may deform simultaneously. Moreover, volcanoes are associated with prominent topographies. This makes the analysis of surface displacements complex. To appropriately analyse the InSAR displacements, we conduct inverse modelling, using 3D elastostatic boundary element models and a neighbourhood optimization algorithm . We simultaneously invert non-linear model parameters (source geometry and location) and linear model parameters (source stress changes), and further assess mean model parameters and confidence intervals. In order to speed up the setting up of inversions, we developed a users friendly graphical interface. In order to accelerate the inversions, they run on clusters. A web server is proposed to registered users in order to run the inversions on University Clermont Auvergne clusters. An application is shown for the May 2021 Nyiragongo eruption, for which models were conducted as the intrusive crisis was going on.

**Keywords:** Modélisation, déformation, Nyiragongo

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# Reconstructing the Changes in Sedimentation and Source Provenance in East African Hydropower Reservoirs: A Case Study of Nyumba ya Mungu in Tanzania

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## Abstract

This study aimed to reconstruct the sedimentation rates over time and identify the changing sources of sediment in a major hydropower reservoir in Tanzania, the Nyumba ya Mungu (NYM). Fallout <sup>210</sup>Pb measurements were used to estimate age of sediment deposits and broad changes in sedimentation rates were reconstructed. Sedimentation peaks were cross referenced to geochemical profiles of allogenic and autogenic elemental constituents of the sediment column to confirm a causal link. Finally, geochemical fingerprinting of the sediment cores and potential sources were compared using a Bayesian mixing model (MixSIAR) to attribute the dominant riverine and land use sources to the reservoir together with changes through recent decades. Reservoir sedimentation generally increased from 0.1 g cm<sup>-2</sup> yr<sup>-1</sup> in the lower sediment column to 1.7 g cm<sup>-2</sup> yr<sup>-1</sup> in the most recent deposits. These results correlated to changes in allogenic and autogenic tracers. The model output pointed to one of two major tributaries, the Kikuletwa River with 60.3%, as the dominant source of sediment to the entire reservoir, while the other tributary, Ruvu River, contributed approximately 39.7%. However, downcore unmixing results indicated that the latest increases in sedimentation seem to be mainly driven by an increased contribution from the Ruvu River. Cultivated land (CU)

was shown to be the main land use source of riverine sediment, accounting for 38.4% and

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44.6% in Kikuletwa and Ruvu rivers respectively. This study explicitly demonstrated that the integration of sediment tracing and dating tools can be used for quantifying the dominant source of sediment infilling in East African hydropower reservoirs. The results underscore the necessity for catchmentwide management plans that target the reduction of both hillslope erosion reduction and the sediment connectivity from hillslope source areas to rivers and reservoirs, which will help to maintain and enhance food, water and energy security in Eastern Africa.

**Keywords:** sediment, geochemical fingerprinting, sedimentation, tracers, mixing model, dating

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# Farmers' knowledge and awareness of avocado pests status in the avocado-growing regions of Tanzania

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## Abstract

Insect pest infestation has recently become a serious problem for avocado fruit production in different parts of Africa, including Tanzania. Research has been, however, scanty to assess farmers' knowledge and awareness of avocado insect pests, particularly the *Thaumatotibia leucotreta*, commonly known as False Codling Moth (FCM) presence, its status, and the associated effect it poses on the avocado production system. To contribute to this research gap, a survey of five hundred and eighty-eight (588) smallholder farmers was conducted in five main avocado-growing regions in the northern and southern zones of Tanzania. The survey results indicated the dominance of the Hass variety by 72.6% over all other varieties planted in the surveyed area, with 75.6% of farmers cultivating it for commercial purposes. The significant difference ( $P = 0001$ ) was observed in the number of avocado trees planted in relation to the period (years) that a farmer had stayed in cultivation. Up to 100% of farmers with farming experience of 4–7 years had 51 to 100 or above avocado trees planted on their farms. Possible effects reported to have been associated with FCM presence were the loss of fruit quality, rejection of produce from buyers, and the total fruit loss due to pre-mature fruit drops and post-harvest decay. Surprisingly, 77.6% ( $n = 456$ ) were unaware of the pest presence on their avocado fruits, with only 22.4% ( $n = 132$ ) confirmed to have seen the pest. Of the challenges, insect pests were the most frequently reported by a good number of farmers across regions, followed by a lack of a reliable market in the regions of Iringa, Kilimanjaro, and Njombe, while Mbeya and Songwe complained of disease challenges. These results highlight the necessity of educating farmers on the presence of FCM and the significance of educating them about the potential effects of pest damage to the livelihood of smallholder avocado growers in Tanzania if suitable management measures are not put in place.

**Keywords:** *Thaumatotibia Leucotreta*, Avocado, insect pests, False codling moth (FCM), Smallholder farmers

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# Integrated management of cholera problem along the African rift

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## Abstract

Intensification of extreme climatic events has been announced since the beginning of the 1970s (World Meteorological Organization (WMO), 2014, <https://library.wmo.int/>). This early 1970s also corresponds to the emergence of cholera in the Great Lakes region, signing the arrival of the seventh cholera pandemic along the Rift Valley (Gaffga 2007). Denial of the disease, ignorance of the transmission mechanisms, approximations in essentially medically-centered interventions characterized the first approaches of cholera management in this region (Bompangue 2009).

From an epidemic situation in 1977, the disease became endemic from 1990s (Bompangue, 2011). The complex crises ravaging much of this rift region (Aliyu 2015) have only made it more difficult to govern cholera epidemics whose was already heavily influenced by environmental (Bompangue, 2009, Batumbo, 2020) and anthropogenic factors (Bompangue 2008).

In terms of management, the end of the 2000s was marked by the adoption of integrated multisectoral strategies for the management of cholera epidemics with the objective of eliminating this disease as a public health problem (WHO, <https://www.gtfcc.org/about-gtfcc/roadmap-2030/>; Muyembe 2013).

However, the implementation of these integrated multisectoral approaches is thwarted by challenges related to governance and those related to the integration of One Health approaches in the management of epidemics.

**Keywords:** Cholera, Rift, Management, Environment, complex emergency, climat, gouvernance, elimination

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\*Speaker

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# Technological variation, innovation and change from a design theory and functional analysis perspective.

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## Abstract

Understanding ground stone tools variation observed in archaeological assemblages may untangle key dynamics marking technological developments and human behavioural traits. Technological and typological studies are crucial for identifying and characterizing when and where changes in production modes, design and artifact maintenance occurred. Although change is perceived over time in different regions, reconstructing the nature of technological innovations remains limited, obscuring the character of the underlying behavioural changes, neglecting triggering processes and distorting our understanding of major developmental steps. The analysis of the chaîne opératoire of materials processing, supported by a design theory approach and a functional analysis, can fill this gap to build comparative frames of reference and assess questions about raw material variability, tool design and performance. This paper explores how resources for tool making are acquired and managed; how the socio-dynamics of different groups and different cultural elements affect the macro-lithic tool industry: production, function, and technological choices, and analyses economies of manufacture, use, reuse, and discard of stone tools. This approach has been successful in assessing assemblage functional variability and facilitates identification and characterization of new classification features. It provides crucial evidence to infer on functional and economic aspects of artifacts, and processes of cultural trait transmission.

**Keywords:** Stone tools variation, technological innovation, chaîne opératoire and design theory.

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# Crushing ochre at the Hamar, Ethiopia: chaîne opératoire, design and gender

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## Abstract

In South Omo valley, in Ethiopia, the Hamar, both men and women, use ochre as a corporal cosmetic substance; a practice which is imbued with symbolism. Detailed reconstructions of ochre processing techniques are rare, and mostly associated with the grinding and scrapping a range of ferruginous rocks. This research distinguished and recorded the different extraction techniques, transformation processes, and uses of several types of ochre by the Hamar. A detailed examination of the chaîne opératoire reveals that ochre use is more complex than previously thought. The different colours of ochre, the tools used, and the transformation processes differ between the two sexes and offer insights in the Hamar social construct. A functional analysis, incorporating design theory and usewear analysis, offers a better understanding of ochre use in general, also informing archaeological findings.

**Keywords:** Ethnoarchaeology, ochre, chaîne opératoire, design theory, usewear

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\*Speaker

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# Impacts of geodynamical processes on the socio-ecosystem of North Tanzania

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## Abstract

In North Tanzania, magmatic processes interact with tectonic to give rise to recurrent seismicity and volcanic eruptions, leading to sparse and heterogeneous hazards. North Tanzania is also experiencing a growing economy and an extremely rapid population expansion. The presence of protected areas, natural parks and an active volcano (Oldoinio Lengai) drives a lot of tourism and increases the stakes in the region. The purpose of this work is first to estimate the seismic and volcanic hazards in the area. It implies understanding the interaction between deep and surficial processes. For this purpose, we combine geophysical imaging (seismology, gravimetry) with petrophysical analysis of rocks and lavas. It helps us to reach different scales in space and time and to obtain constraints for crust and mantle

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\*Speaker

structure. Second, we intend to map the structural vulnerabilities to conduct a diagnosis of the geological risk. We assess a priori and human vulnerability by questioning the populations' volcanic and seismic risk perception. The people in North Tanzania are differently exposed to natural hazards. The proximity to volcanic edifices or seismic crises experience can strongly influence a population's naive knowledge. We thus aim to understand the dynamics between the naïve knowledge that people can get from their experience and culture and the scientific knowledge obtained from education. Finally, we will use formal modelling approaches to model the ecosystem dynamics in light of our results. With these models, we identify the components and processes favouring a resilient system behaviour or a more dangerous one.

**Keywords:** geodynamics, natural hazard, modelling, North Tanzania, natural hazards, education

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# Risk assessment and recovery trajectories of a social-ecological system after a volcanic eruption

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## Abstract

A risk assessment for natural disasters is usually composed of hazard, vulnerability and exposure variables, which are hardly considered and modeled simultaneously. In volcanology, it becomes ambitious to predict its trajectories of pre- and post-eruption regimes. The interdependencies and feedback loops of the system's geological, ecological, social and economic components give rise to trade-offs and synergies that have to be disentangled for supporting decision-makers and helping local communities to face the risks. We developed here an innovative discrete-event and possibilistic model based on a dynamical network representation to assess volcanological multi-risk and long term post-eruption impacts of such a multifactorial system. We illustrated our method with the region around Mount Meru (Northern Tanzania), a strato-volcano with various eruption styles, located in a growing economic and touristic region (> 1 M.inhab.).

We used qualitative and rule-based Petri nets, still largely unused in environmental sciences, for an integrated assessment of the overall system dynamics and associated risks. As a central result, we showed that the region could recover from a blast eruption, irrespective of the timescale. Our study highlights the fact that agriculture and pastoralism remain key activities to reinforce the recovery of this region. Yet, as soon as subsidies from governmental and non-governmental organizations are lacking, the modeled region remains isolated from national and international systems and shifts to rural dynamics. Our case study can equip environmental risk assessment with innovative models, new dynamical indices (e.g. desirable and non-desirable trajectories), and rigorous reasoning for an ultimate integrated management of social-ecological systems at stake.

**Keywords:** volcanic hazard, integrated model, social, ecological system, dynamical system, discrete, event models, Petri nets

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# Geological determinants of cholera outbreaks along the African Rift

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## Abstract

The African Great Lakes have been an endemic area for cholera since the late 1970s. We focused on the Katana health zone, bordering Lake Kivu, as during outbreaks, this is, (together with the Kalemie health zone located along the west coast of the Tanganyika lake) the health zone in which the first cases of Cholera are usually observed, and the highest number of cases are also usually reached in this area. The persistence of this aquatic bacillus, usually associated with warm and salty waters, led us to formulate the hypothesis that the geothermal springs supplying Lake Kivu, mainly from the Nyiragongo volcano, should control the physico-chemical characteristics of the lake and promote the persistence of the bacillus. The lake would thus be a reservoir of the pathogen, which could contaminate local residents through the consumption of water and fish. Over the 2007-2012 period, we demonstrated a long-term unidirectional relationship between volcanic activity and cholera cases in the Katana health Zone. Contamination of the lake's water and fish was also correlated to the lake characteristics. The activity of the volcano can thus be used for predicting epidemic risks. A more comprehensive approach to the Kivu-Tanganyika chain of lakes is underway to determine how the volcano tectonic and hydrogeological functioning of the area governs the epidemic dynamics on both sides of the Rift. The question of the role of food webs in the survival of the bacillus during inter-epidemic periods is also a problem that we would like to address.

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**Keywords:** cholera, volcanic activity, one health, environmental risk, volcano observatory

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# Heritage: Research, Innovation and Development in Africa

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## Abstract

The paper presents the interface between research, innovation and development in Africa and the concept(s) of heritage. Due to a myriad of historical contents, heritage, in all its forms, has been the preserve of experts who conducted scientific research to manage and conserve it. However, the role of heritage in the wider society has been gradually changing in the last two decades such that the demands that are put on it are beyond just the scientific nature. Issues of community beneficiation and heritage's role in national as well as continental development have taken centre stage. The general populace also demands greater social and economic benefits from heritage. This paper, therefore, explores the implications that all these demands have on scientific research and how scientific research can inform and contribute to the aspirations attached to heritage. The paper draws on the case of Zimbabwe's recently introduced heritage-based education philosophy for institutions of higher learning where all research should be drawing from 'heritage', an added demand to the discipline. The heritage-based philosophy emphasises scientific research that informs and contributes to other developmental sectors such as health, sustainable food systems, technology etc. In this case, scientific research on heritage will not only inform heritage policies but feed into innovation and development. This approach resonates with the expectations of continental blueprints such as Africa's Agenda 2063. It would be important, therefore, to look into these issues

**Keywords:** African Heritage, Heritage and Development, Role of Heritage, Heritage Policies

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\*Speaker

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# LAND USE AND LAND COVER CHANGE AND ITS IMPLICATIONS ON GULLY EROSION IN SUSWA CATCHMENT, NAROK COUNTY, KENYA

Charity Konana\*<sup>1</sup>

<sup>1</sup>Prof. Benoit Hazard – School for Advanced Studies in the Social Sciences (ehess) – France

## Abstract

### LAND USE AND LAND COVER CHANGE AND ITS IMPLICATIONS ON GULLY EROSION IN SUSWA CATCHMENT, NAROK COUNTY, KENYA

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## Abstract

This study investigated land use and land cover change for the last 26 years in Suswa Catchment, Narok County using satellite imageries. Changes in land use and land cover (built up areas, agricultural land, grassland, bareland and shrubland) for 1985-2000, 2000-2011 and

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\*Speaker



1985-2011 were determined using Chi-square test. Results showed no significant changes in built up areas, agricultural land, bareland, grassland and shrubland during the period. Overall change of built up area, shrubland, bareland, agriculture increased in 26 years, while grassland decreased. Grasslands were therefore converted to built up areas, shrubland, bareland and agricultural areas during this period. An increase in built up area, bareland and agricultural land and a decrease in grassland are therefore drivers of gully erosion. A decrease in grassland results in an increase in soil erosion. Projections (2020) indicate a significant increase in built up area, agricultural land and bareland and a decrease of grassland.

**Keywords:** Land use and cover change, Soil Erosion, Remote Sensing, GIS, Narok County

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# Atmospheric Drivers of Rainfall Events in the Republic of Djibouti

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Djibouti. – Djibouti

## Abstract

The Republic of Djibouti is a small country (23 200 km<sup>2</sup>) in East Africa, characterized by an arid context coupled with a high variability of rainfall that generates flash floods causing severe damage to the population and infrastructure (Assowe et al., 2021). The mechanisms controlling climate dynamics in Djibouti and the Eastern Africa region remain poorly understood. In this study, we document the atmospheric mechanisms associated with extreme rainfall events in the Republic of Djibouti. To that end, we use at the daily timescale rain-gauge data (a network of 40 stations on the period 2013-2020), satellite-based rainfall estimates (CHIRPS, IMERG, MSWEP and RFE) and atmospheric reanalyses (ERA5), selected over their common period 2001-2020. A multivariate Hierarchical Ascendant Classification of rainy days in Djibouti ( $\geq 10\%$  of grid-points exceeding 1 mm.day<sup>-1</sup>, according to all four satellite products) reveal 4 clusters (intense rainfall, moderate rainfall, rainy in the southwest, rainy in the east) which differentiate from each other by the intensity and spatial extent of rainfall. These clusters show a non-homogeneous seasonal distribution, occurring mainly in the March-April-May (MAM) and July-August-September (JAS) seasons, and more rarely in October-November-December (OND). The atmospheric circulation anomaly patterns associated with the clusters are quite similar and highly season-dependent. In MAM most clusters display an anomalous trough over the Red Sea from 700 hPa to 200 hPa. In JAS, an anomalous low over the southern Red Sea drives a thicker than normal monsoon flow at 700 hPa (especially for the southwest cluster), while upper northerlies prevail at 200 hPa. In OND, most rainy events result from moisture advection from the Western Indian Ocean favored by positive phases of the Indian Ocean Dipole. Some highly unusual atmospheric circulation patterns, which are not depicted by the above classification (e.g., associated with tropical cyclones), also result in intense rainfall events in the Republic of Djibouti.

**Keywords:** Climate, Atmospheric rainfall patterns, Republic of Djibouti

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\*Speaker

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# Morpho-volumetric shifts in the Middle Stone Age (MSA) pointed tools from Gademotta and Kulkuletti site complexes (280-180 ka), Main Ethiopian Rift, Ethiopia

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## Abstract

Pointed tools are one of the most characteristic end-products of the MSA and highlight major transformations from the late Acheulean to the MSA, in particular in terms of production systems. They are prominent tool types in many eastern African MSA assemblages and are often used to illustrate inter-site variability and regional cultural diversity. However, our current understandings of these specific tool types are limited due to a lack of standard approaches to establish robust comparative analysis in geographically and chronologically distinct sites. This study aims at overcoming such methodological limitations and to investigate morpho-volumetric evolution of pointed tools in two securely dated early MSA sites in the Main Ethiopian Rift; at Gademotta and Kulkuletti site complexes dated between ~280 ka and 180 ka. Here, we introduced an innovative methodological approach that combined a technological analysis focused on blank types and modification patterns with classical morphometric and 3D geometric morphometric analyses. Our results display the feasibility of our methodological approach and shed light on the gradual shift in the production strategy of the pointed tools without a significant change in their final morphology.

**Keywords:** Middle Stone Age, Pointed Tools, Eastern Africa, Geometric Morphometrics, Lithic analysis

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\*Speaker

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# Probabilistic Seismic Hazard Analysis for Northern Tanzania Divergence Region and the Surrounding Areas

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## Abstract

This study presents the seismic hazard levels for the Northern Tanzania Divergence (NTD) and adjoining areas by using area seismic source zones. The 15 source zones were considered based on the major geological and tectonic features, faulting style, and seismicity trends. For each source, earthquake recurrence parameters were computed by using the earthquake catalogue with events compiled from 1956 to 2011. The peak ground accelerations (PGA) and spectral accelerations (SA) at 0.2 and 2.0 seconds, respectively, were computed for a 10% probability of exceedance in 50 years at sites defined by a 0.1° x 0.1° grid. The recurrence parameters of 15 zones and attenuation relations developed by Akkar et al. (2014) and Chiou and Youngs (2014) were integrated into a logic tree. Obtained results that are presented as hazard maps show strong spatial variations ranging from 60 to 330 cm/s/s for PGA, from 100 to 650 cm/s/s at 0.2 sec and from 6 to 27 cm/s/s at 2 sec for 475 years mean return period and 5% damping. Hazard levels depict the general tectonic setting of the study area with the western (Eyasi-Wembere) and central (Natron-Manyara-Balangida) rift segments having relatively high PGA values compared with the eastern Pangani rift. This work provides indications of seismic hazards to policymakers and planners during planning and guidelines for earthquake-resistant design engineers. Further, this study is currently extended to include the whole of the country, especially, the areas traversed by the East Africa rift System.

**Keywords:** Homogeneous Earthquakes Catalogue, GMPE, PSHA, NTD

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# Magnetic Signatures and Topographical Expression of the Polymetallic Mpanda mineral field, SW Tanzania

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## Abstract

Geological structures play an important role in the genesis of most of the structural controlled epigenetic metal deposits. For such deposits, studies of geological structures including lineaments are paramount, although mapping of such structures in the fields can be hard, time consuming and costly. The polymetallic Mpanda Mineral Field (MMF) hosts a number of veins within the Ubendian Belt. In this study, aeromagnetic and topographical data were used to ascertain the magnetic signatures and topographical expressions of MMF mineralisation. The reduced to pole total magnetic intensity image of the MMF illustrate the distribution of magnetic fabrics reflecting the general properties of surface geology. A zone of long wavelength magnetic anomalies surrounded by short wavelength anomalies characterises the central part of the MMF. Low to medium amplitude anomalies are related to the Proterozoic Uruwira sandstone found on the north-eastern part of the study area. Another zone of low magnetic anomalies trending N-S and NW-SE is related to Neogene sediments and metapellitic rocks of the Katuma Block. Surface manifestation of structures was mapped from the Shuttle Radar Topography Mission - Digital Elevation Model (STRM-DEM). Aided with tonal variations on the STRM-DEM, lineaments were manually extracted from the MMF by using two different techniques. In the first place, shaded relief image that was created from the Digital Elevation Model was used in manually extracting lineaments at different orientations of topographic illuminations. In the second-place, flow direction was used in delineating different crustal blocks, which correspond to different lineaments. The latter approach revealed a large number of lineaments through demarcated tectonic blocks from patterns created by flow directions. Some of these lineaments were also picked from interpretation of the SRTM-DEM and aeromagnetic data. Most of the identified lineaments trend in a NW - SE direction, which is a preferred orientation of the Paleoproterozoic Ubendian Belt. These basement fabrics may have played a great role in localisation of metalliferous hydrothermal fluids responsible for the mineralisation in the MMF.

**Keywords:** Mpanda, Polymetallic, Mineral fields

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# Southwestern propagation of the East African Rift System: insight from geomorphology of the Makgadikgadi Basin (Botswana).

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## Abstract

The Makgadikgadi Okavango Zambezi Basin (MOZB) is a wide low area composed of two main depressions among the Kalahari Desert and the Southern-African plateau. To the north-west, the Okavango Graben (that hosts the Okavango Delta, a biodiversity hot-spot classified as World Heritage by UNESCO) is considered as the termination of the southwestern branch of the East African Rift System (EARS). To the south-east, the Makgadikgadi Basin (MB) forms wide flat areas, covered by evaporitic deposits and hosting paleolake features. The MB is affected by normal faulting, locally showing a horst and graben structure (Eckardt et al., 2016). The role of these faults in the regional geodynamics remains unclear, and their temporality is still poorly constrained. Their orientation and their proximity with the Okavango Graben's faults suggest potential tectonic relations between these two structures. However some authors suggested two different axes of the EARS propagation in the region (e.g. Daly et al., 2020). The very flat regional topography and the widespread sediment cover offer almost no fault-plan outcrop, limiting the use of classic tectonics markers to study these faults. Based on fieldwork and topographic interpretations, we conducted a geomorphologic study of the fault scarps, linear dunes and paleo-shorelines within the MB. It allows us to precise the previous fault maps in and around the MB, showing a propagation of the deformation oriented toward the south-south-west, from the Kariba Lake Valley and fading out into the MB. A second fault family with a west-south-west direction forms a relay zone between the deformation of Kariba Lake Valley and the Okavango Graben. On the other hand, the morphological analysis of some major paleo-shorelines in the MB shows the presence of nearshore sand bars on the west and north sides of the depression. They rise at a constant elevation of approximately 941m above sea level, proving that they have undergone no or very little deformation since their deposit. Thus, the major lake development phase that corresponds to their formation post-dated the main tectonic activity of the faults affecting the MB. Based on these results and existing dates in the literature, we propose that i) the Makgadikgadi faults developed in a pre-existing depression and are not at the origin

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of the MB formation, ii) the EARS related deformation affecting the MB is currently much slower than in the Okavango graben that has potentially "captured" it, and iii) the MB has been filled at least once by a lake with a water level at around 945m since the fault scarps formation.

Daly, M.C., Green, P., Watts, A.B., Davies, O., Chibesakunda, F., Walker, R., 2020. Tectonics and Landscape of the Central African Plateau and their Implications for a Propagating Southwestern Rift in Africa. *Geochemistry, Geophysics, Geosystems* 21, e2019GC008746. <https://doi.org/10.1029/2019GC008746>

Eckardt, F.D., Cotterill, F.P.D., Flügel, T.J., Kahle, B., McFarlane, M., Rowe, C., 2016. Mapping the surface geomorphology of the Makgadikgadi Rift Zone (MRZ). *Quaternary International, The African Quaternary: environments, ecology and humans Inaugural AFQUA conference* 404, 115–120. <https://doi.org/10.1016/j.quaint.2015.09.002>

**Keywords:** Tectonics, Geomorphology, Rift propagation, Makgadikgadi, Okavango, Paleolake

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# Hominids within Plio-Pleistocene ecosystems: an integrative approach of paleontology, zooarcheology, data analysis and modelling

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## Abstract

Plio-Pleistocene ecosystems in the eastern African rift valley witnessed a major change in trophic position of hominids, from opportunistic omnivorous to dominant predators. The PHECOPAAD project will explore timing and processes involved in this major transition in human evolution, by developing an integrative and interdisciplinary approach to characterize ecosystems in Turkana Basin (Shungura and Koobi Fora formations). Paleocological and zooarcheological analyses will be combined for the first time to innovative developments in

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data analysis (geometric morphometrics, analysis and modelling of networks, Artificial Intelligence). Prey-predator relationships documented by various proxies (bone taphonomy, biogeochemistry) will allow modelling trophic position of hominids and interactions with other animals (predation, competition) within dynamic trophic networks.

**Keywords:** Africa, Turkana, Artificial Intelligence, taphonomy, biotic interactions, paleoecology, paleobiodiversity, trophic networks

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# Effects of tectonic activities on the groundwater quality and distribution within the East African Rift System: a case study of Northern Tanzania

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<sup>1</sup>Geological Survey of Tanzania – Tanzania

## Abstract

In Northern Tanzania there is high demand in clean and safe water due to increasing population and farming activities. This water scarcity has impacted not only the people in this region but also the wildlife in National Parks and conserved areas. Groundwater is the major source of water for households, livestock and irrigation within the East African Rift System (EARS) in Tanzania. The availability, quantity, and quality of groundwater is determined by geological conditions and characteristics of the aquifer. Groundwater recharge and flow vary with geological settings. For instance, within the EARS in Tanzania groundwater flows laterally from the rift escarpment to the rift floor and the axial movement of groundwater is usually away from the rift floor culmination. The volcanic rocks underlying the rift valley are generally less permeable and aquifers are normally found in the confined fractured volcanic rocks. Aquifers that are found in the weathered crystalline basement rocks are considered to have less water storage as compared to thick porous sedimentary aquifers. This groundwater is susceptible to chemical and other mineral contamination which poses a threat to the health of human beings, livestock and agriculture within the EARS, especially in Northern Tanzania. In this part of the country, people have suffered serious health effects such as dental, skeletal, and crippling fluorosis. The purpose of this work therefore, aims to: 1) establish the potential of groundwater in Northern Tanzania by applying geophysical techniques (electrical resistivity, seismic refractive, magnetic and gravity) to understand the distribution, thickness, and depth of groundwater bearing structures or formations; 2) perform various geochemical and hydrogeochemical analysis of rocks, soils and water samples to understand major contaminants in groundwater system (groundwater modelling) in Northern Tanzania; and 3) create awareness about the danger of such contaminants and suggest an affordable and environmental friendly water purification technologies.

**Keywords:** water storage, aquiferes, farming activities, groundwater modelling, Northern Tanzania

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# Naturally occurring potentially toxic elements in groundwater from the volcanic landscape around Mount Meru, Arusha, Tanzania and their potential health hazard

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## Abstract

The population of the semi-arid areas of the countries in the East African Rift Valley (EARV) is faced with severe problems associated with the availability and quality of drinking water. In these areas, the drinking water supply largely relies on groundwater characterised by elevated fluoride concentration ( $> 1.5$  mg/L), resulting from interactions with the surrounding alkaline volcanic rocks. This geochemical anomaly is often associated with the presence of other naturally occurring potentially toxic elements (PTEs), such as As, Mo, U, and V, which are known to cause adverse effects on human health. This study reports on the occurrence of such PTEs in the groundwater on the populated flanks of Mt. Meru, an active volcano situated in the EARV. Our results show that the majority of analysed PTEs (Al, As, Ba, Cd, Cr, Cu, Fe, Mn, Ni, Se, Sr, Pb, and Zn) are within the acceptable limits for drinking purposes in samples collected from wells, springs and tap systems, suggesting that there is no immediate health risk associated with these PTEs. However, some of the samples were found to exceed the WHO tolerance limit for U ( $> 30$   $\mu$ g/L) and Mo ( $> 70$   $\mu$ g/L). The sample analysis also revealed that in some of the collected samples, the concentrations of total dissolved solids, Na<sup>+</sup> and K<sup>+</sup> exceed the permissible limits. The concerning levels of major parameters and PTEs were found to be associated with areas covered with debris avalanche deposits on the northeast flank, and volcanic ash and alluvial deposits on the southwest flanks of the volcano. The study highlights the need to extend the range of elements monitored in the regional groundwater and make a more routine measurement of PTEs to ensure drinking water safety and effective water management measures.

**Keywords:** Potentially toxic elements, Groundwater quality, Health risk assessment, Meru volcano, Tanzania, East African Rift Valley

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# Megalithism across regions and religions: From the Central Highlands to the Rift Valley areas of Ethiopia

Alebachew Birru\*<sup>1</sup>

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## Abstract

Megalithic sites in many parts of the world are found connected with different geographic features, such as water bodies. When it comes to Africa particularly in eastern Africa there are a series of megalithic sites located along the rift valley. In this regard, in the Central Highlands of Ethiopia, a medieval megalithic culture called the “Shay Culture” came to light in the 1990s. Subsequently, some significant archaeological missions were taken up by an Ethio-French team including a Ph.D. project of the present speaker (2016-2020). These research works shed light on the chronological framework, material composition, typo-morphological features, and spatial extent of the culture with due consideration of the landscape contrasts and the local memory that exist in the region. This permits intra- and inter-regional comparisons of the material and structural features of the Shay culture with Christian sites northward and megalithic and Islamic archaeological sites in the rift valley areas to the southeast. Accordingly, the monumental connection southward and the northward material networks were noted. Symbolic and architectural inheritances by the contemporary and later Christian, and Islamic cultures further east to the rift valley areas were identified. These shared values across regions and religions in and surrounding the rift valley imply a lot about the rift as a source of diversity. However, there is a need to further this effort and reconstruct the interaction and integration among these three groups through a broad range and multi-thematic archaeological investigations. In the meantime, developing these medieval architectural heritages and saving them from further destruction should appear to be the other concern.

**Keywords:** Ethiopia, Central Highlands, Rift Valley, Megaliths, Landscapes, Shay Culture

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# Le programme ” geothermal village ” : un accès à l’énergie en dehors des grands réseaux de distribution, exemples en Afrique de l’Est.

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## Abstract

L’objectif principal de ce projet est de développer des systèmes d’énergie électrique et thermique, à partir de ressources géothermales pour des régions isolées et non-connectées aux réseaux de distribution d’énergie en Afrique de l’Est. Ce projet est mis en œuvre dans le cadre du programme LEAP-RE pour le développement des énergies renouvelables à travers une coopération Europe-Afrique, financé par l’Union Européenne. La géothermie étant une source d’énergie flexible et permanente, il s’agit pour notre groupe de R&D (12 organisations partenaires africaines et européennes) de fournir des études de cas sur l’adaptation de ces systèmes énergétiques aux besoins de communautés ciblées. Ainsi, des forages relativement peu coûteux peuvent capter des fluides assez chauds (150°C), suffisants pour la production d’électricité et de nombreux processus domestiques, agricoles et industriels. Le fait que cette ressource énergétique ne soit pas utilisée est dû en grande partie à un manque de projets de référence et de démonstration. Le principe est compris, mais il faut encore une phase de R&D afin d’acquérir un savoir-faire pour assurer une mise en œuvre au niveau et par des organisations locales. Cette mise en œuvre doit en effet être dirigée par ces organisations afin de bien répondre aux caractéristiques locales, la nature de la ressource géothermique et la demande énergétique en Afrique étant sensiblement différentes de celles mieux connues en Europe (Varet et al, 2014 ; Onyango & Varet, 2018). La démonstration sera faite en choisissant des sites présentant des caractéristiques thermiques et socio-économiques différentes et en développant pour chacun un plan énergétique adapté. Il s’agit de maintenir le niveau de technologie approprié à l’exploitation, la maintenance et même la reproduction au niveau local. Enfin, ces systèmes peuvent fournir de l’eau douce et remplacer le pétrole et le bois de chauffage, ce qui, en plus des avantages pour l’environnement et la santé, réduit les dépenses domestiques et la charge de travail des femmes et des filles, leur laissant du temps pour l’éducation et le développement. La capacité du système à produire de l’eau et de

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\*Speaker

l'énergie peut également réduire la charge de travail des hommes et des garçons, par exemple grâce à la fourniture d'eau qui peut être utilisée pour faire pousser des pâturages dans le cas des populations pastorales, habitat vert dans le cas des populations agricoles ou pisciculture dans le cas des populations de pêcheurs. L'énergie peut être utilisée dans les processus de conservation des produits des activités pastorales, agricoles et de pêche. Ce programme permet d'alimenter deux des étapes de démonstration que sont : L'identification des sites, leur caractérisation et l'élaboration d'un plan générique de système énergétique en intégrant les éléments techniques et sociaux, La faisabilité et la conception du site. La troisième étape, qui ne fait pas partie de ce projet, serait la construction de systèmes de démonstration. 4 sites ont été pré-sélectionnés en fonction de critères géologiques et sociétaux, il s'agit du Lac Abhé, République de Djibouti, Homa Hills, Kenya ; Lac Kivu, Rwanda ; Era Boru, Ethiopie. Des données ont été acquises sur les deux premiers sites.

**Keywords:** geothermie, population, appropriation

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# From paleoecology of crocodilians to paleoenvironments in the Shungura Formation (Plio-Pleistocene, Ethiopia), an interdisciplinary ballad using the oxygen stable isotopes.

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## Abstract

*Axelle Gardin and collaborators (including Géraldine Garcia and Olga Otero, awaiting the consent of the other co-authors)*

The evolution of the Turkana Depression is geologically constrained by the East African Rift, but it is characterized by complex environmental, and more particularly hydrological, change that has been recently questioned by new sedimentological data. In the context of the Shungura Formation (Plio-Pleistocene, Ethiopia), these hydrographic changes are only documented by sedimentological studies and freshwater invertebrate assemblage analyses, while terrestrial environments are by far more widely studied. However, water retains information about aquatic environment and its interactions with climate and geodynamics and, as an essential resource and habitat, about aquatic communities and ecosystems.

With an application in the Shungura Formation, we explore a new approach using the oxygen isotopic composition ( $\delta^{18}\text{O}$ ) of fossil crocodilian teeth to describe environmental change between 3 and 1 million years ago. This powerful geochemical tool informs on water resources and is used by both paleo-biologists and geologists with different aims, i.e., respectively to document either paleoecology or paleoenvironment. When most studies using  $\delta^{18}\text{O}$  to characterize paleoenvironments neglect paleoecological aspects or information, and vice versa, we propose to integrate both when studying  $\delta^{18}\text{O}$  of fossil crocodilian teeth, allowing to go further and gain precision and relevance in our interpretation through the integration of the animal in its environment. This contribution will present the results obtained on the crocodilians of the Shungura Formation from the article Gardin et al. (in prep) and will open the discussion on these interdisciplinary concerns in the use of the  $\delta^{18}\text{O}$  in fossil crocodilian

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teeth.

Gardin A., Pucéat E., Garcia G., Boisserie J.-R., Schuster M., Nutz A., Otero O.  $\delta^{18}\text{O}$  in crocodilian teeth apatite documents the diversity of aquatic environments and suggests their relative stability in the Turkana Depression between 3.0 and 2.6 Ma (Shungura Formation, Plio-Pleistocene, Ethiopia). In prep.

**Keywords:** Stable oxygen isotopes, Shungura Formation, Crocodilians, Aquatic environments, Paleoclimate



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# Fluoride Contamination and Distribution in Cultivated and Uncultivated Soils along the Rift Valley Landscape

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## Abstract

Fluoride pollution in soil is often overlooked in comparison to heavy metals and organic pollutants, but it has negative impact to human health and plants when it exceeds the limits. Fluoride consumption beyond 1.5 mg/L in water can induce a variety of bone disorders, including tooth mottling and lesions of the endocrine glands, thyroid, liver and other organs to humans while on plants it causes necrosis and chlorosis. It is often overlooked because of its ability to affect humans and animal slowly compared to other pollutants like heavy metals. Once fluoride is accumulated in soils, it can appear in different forms and the soluble fluoride is up-taken by plants and finds its way into the food chain imposing health risks on higher trophic levels. The aim of this study was to investigate the spatial distribution of fluoride in cultivated and uncultivated soils and the effects of farming practices on fluoride availability and distribution along the slopes of Mount Meru – a volcanic mountain. The study area lies in the rift valley zone and its waters is largely used for irrigated agriculture (horticultural crops) is rich in fluoride. Samples from cultivated land were collected from smallholder farms and samples from uncultivated land were collected from Arusha National Park. Soil and water samples were randomly collected from the study area and were analyzed for fluoride content. Results indicate that concentration of fluoride in water and soil samples are higher for cultivated land when compared to uncultivated land. Research is however, ongoing to understand the magnitude of contamination and distribution of fluoride along the landscape.

**Keywords:** Fluoride, Rift Valley, Tanzania

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# le programme ”geothermal village” : les démonstrateurs

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## Abstract

Dans le cadre du programme GV, 4 sites ont été retenus et se caractérisent par la des manifestations hydrothermales de surface et par la présence de communautés locales en demande de ressources énergiques, et éventuellement en eau potable.

- Le projet Abhé se situe au sein du vaste graben de Tendaho en Ethiopie et du Gobaad à Djibouti. On observe sur ce site de nombreuses cheminées de travertins hydrothermaux, déposées sur les basaltes faillés de la série stratoïde (4 à 1 Ma). Une communauté semi-nomade bénéficie en cet endroit de zones de pâture développées à la faveur des zones irriguées par ces sources thermales. Le projet devrait bénéficier au village en formation autour d’une école créée en 2001, aujourd’hui dépourvu d’électricité et d’eau potable, et soutenir le développement touristique du site incluant des applications thermales. Il est mené en partenariat avec l’ODDEG.

- Le projet Era Boru se situe en Afar Ethiopien, dans un ensemble à dominance pantelleritique (rhyolite hyper-alcaline) situé au pied du volcan Dabbahu dans la zone relais (leaky transform fault) entre les chaînes axiales actives de Alayta et Manda Harraro. Sur ce plateau (700m d’altitude moyenne) on observe de nombreuses sources de vapeur développées le long de failles et fissures ouvertes NNW-SSE, qui sont utilisées par les populations locales comme source d’eau, captée par condensation de la vapeur au sein de puits artisanaux. Le projet vise ici à fournir eau potable, électricité et autres commodités à cette population située hors de tout réseau. Il est mené en partenariat avec AGAP (Afar Geothermal Alternative Power) une compagnie gérée par des populations locales.

- Le projet Homa Hills se situe au Kenya sur la rive SE du lac Victoria sur l’extrémité occidentale du rift de Nynza, de direction E-W. Il se caractérise par un volcanisme de nature carbonatitique développé depuis l’âge miocène. Plusieurs sites hydrothermaux ont été retenus, au pied nord du volcan, se caractérisent par des sources chaudes et des émanations gazeuses, dans une zone peuplée, avec une population rurale (polyculture et élevage) et d’importants sites de pêche sur les rives du lac. Le projet vise ici, outre une production

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\*Speaker

électrique, des usages thermiques directs (séchage de produits agricoles et de la pêche) et une production d'eau (potable et thermalisme).

- Le projet Bugarama a été sélectionné avec EDCL (la compagnie de production d'énergie du Rwanda) dans l'extrémité sud du pays, près des frontières avec le Burundi et la RDC. Il se situe sur un segment de la branche ouest du grand rift entre les lacs Kivu et Tanganyika. Les températures attendues ne permettront pas une production électrique. Des usages directs sont envisagés : séchage du riz ou du thé, de fruits et légumes, et thermalisme (bains, piscines et tourisme).

Nous présenterons les résultats acquis en géosciences et sciences sociales sur trois de ces sites. En effet la situation en Ethiopie (guerre entre Tigré et armée Fédérale) n'a pas permis à ce jour de travailler sur le site d'Era Boru.

**Keywords:** géothermie développement durable, énergies hors réseau

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# Insights on sedimentation in lake Turkana from numerical modelling: revealing the trajectory of sediments from deltaic river mouths to the deep basin

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## Abstract

Lake Turkana, the largest lake of the eastern branch of the East African Rift System, has a strong terrestrial influence, as indicated by the ratio of lake Turkana area to its watershed area of around 0.06, which is the lowest among the East African Great Lakes. The Omo river plume which extends up to 100 km from the river mouth during the flood season, discharges in Lake Turkana a quantity of sediments estimated at 47 million tons/year, a few times larger than the quantity of suspended sediments delivered by the Rhone river to the Mediterranean Sea. The end result is a large delta, frequently exposed to the variable nature of the lake water level, and simple basin-fill sedimentation, gradually decreasing in thickness from the river mouth sources.

Through a series of numerical experiments employed with Delft3D, we aim to understand the riverine sediment dispersal delivered to the lake. The first series of experiments, focused on the annual basin-fill sedimentation, investigate the impact of wind-driven hydrodynamic circulation coupled with the wave-induced resuspension of sediments. By selecting different processes to model, the respective contribution in resuspending and transporting sediment along the lake of either waves and currents or the buoyant river plume could be investigated. Additionally, future hypothesised lake levels at -25m and -35m are tested for basin-fill sedimentation and sediment focusing. Another set of experiments concerns the sedimentation in the Omo delta. Flooding of deltas and sediment trapping processes under new conditions of water level in lake deltas is rarely studied in the field although recognized in the stratigraphic record, and represents a challenge for the future adaptation of marine deltas. To this end, a series of realistic and idealized experiments test the effects of modulation of water level on

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deltaic sediment trapping and resulting stratigraphy. One tentative simulation focused on the recent flooding of the Omo delta, which shows the sediment trapping mechanisms that can act close to the river mouths during lake level rise.

This study provides insights into sediment transport in Lake Turkana, and similarly in large lakes in general, supporting waves as the main agent of sediment transport away from river mouths into deeper areas, and shows the impact of water levels on lake sediment depocenters.

**Keywords:** Lakes, Delft3D, numerical modeling, hydrodynamics

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# Greening the Maasai: The Deterritorialization of Local Pastoral Landscape in the Greater Olkaria Geothermal area, Kenya

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## Abstract

Ch. Adongo (LAP, EHESS) & B. Hazard (LAP, CNRS) Since the 1950s, the Greater Olkaria Geothermal Area (GOGA) has been an experimental field for geothermal resources development. The massive acceleration in geothermal development is seen from about 2007 onwards, coinciding with the period of a highly popularized green growth discourse, carbon trade and climate financing. The Kyoto protocol, 1997, Paris COP 21, 2015 and the recent one planet summit, 2018 prescribe green growth as the remedy to an increasing green house gases concentration. Consequently, the attractive climate funding and lucrative carbon markets have created new experimental fields for climate adaptation, making Africa a lab for renewable energy projects. National policies on the other hand continue to conform to this green growth discourse. For instance, both the Kenya Vision 2030 and Kenya National Climate change response strategy policy state "following a low carbon development path will result in significant economic and huge environmental and social benefits". Kenya's geothermal industry is therefore not only a climate resilient strategy but also a pathway to economic development. Accordingly, the Kenyan government has outlined plans that will not only catapult Kenya to a middle-income country, but also do so following a green path. One of these is the Least Cost Power Development Plan 2017–2037 that encompasses the development of geothermal resources. Moreover, the expansion of the geothermal industry is a major strategy for meeting Kenya's Nationally Determined Contributions (NDC) as required by the Paris accord of 2015. Summarily, green growth promises a triple win scenario: for the environment, society and economy. However, this triple win scenario obscures the experiences of local communities, who besides having to adapt to the adverse consequences of climate change, are today forced to also adapt to the climate adaptation interventions themselves. Through the example of the Greater Olkaria Geothermal Area, this thesis uses a multi-scale approach to show how global discourses interact with local socio-political relations. Specifically, I expose the discursive frames of how geothermal as a green energy development is promoted, its consequences, the emergent socio-political relations at the local level and how the local inhabitants mobilize resistance to or support for the project. The intention on the one hand, therefore, is to illuminate impending issues of livelihoods, social processes (access, exclusion and alienation), cultural transition and ultimately economic change. On the other hand, it demonstrates how contemporary global sustainability narratives percolate

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to the local levels, where their interactions with the local landscapes coproduce outcomes in resource appropriation. This paper illuminates how "green growth" is today used as a tool for deterritorializing local communities and local spaces.

**Keywords:** Geothermal resource, pastoral landscape, deterritorialization, green growth, green energy, climate change, Maasai, Kenya

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# Water places, "Tulla" and "Cinna" of the Chalbi in the understanding of past and present socio-ecological changes.

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## Abstract

In many Arid and Semi-Arid Lands, ecosystem services are often correlated with natural resources on which the livelihoods of the inhabitants depend. Most of the inhabitants have developed specific systems of production to allow an efficient use of scarce resources available. Although these local societies and ecological systems have from the past to present responded to the variability of climatic condition, they have recently experienced a shift from the implementation of various models for protection of natural resources in order to conserve biodiversity and scarce resources (water, soil, pasture, forest) to the merging of megaprojects. Current political and economic changes led international institution, government and investor development to invest in global water reform and on building infrastructure to extract new energy sources (oil, wind, hydroelectric) to the exclusion of pastoralist rangelands and water points. These processes contribute to the merging of competitive vision of nature and the erosion of their environmental consciousness, and in fine to the conservation of some specific ecological niches. Adopting a landscape approach and an interdisciplinary perspective crossing anthropology, GIS and archaeology, the contribution aims to show how the wetland (oases, "tulla wells system", etc.) in arid areas inform us about temporal and spatial dynamics of human-landscapes interactions. Focusing on the past and present socio-ecological changes of specific ecological niches (oases, water points, rivers, riverine forest, etc.) located in arid east African landscapes. From a set of watering places connecting important cultural, archaeological and ecological features, we explain how an ethnography of the "Tulla system" led us to mobilise GIS in order to understand the relationship between some specific social and cultural values of water, archaeological and ecological data. With regards to the state of the art, a better knowledge of the socio-ecological changes, including vegetation changes, that happened in the rift valley over the period from 1800 to today is required. As such the paper explore some vital functionality of the protected wetland such as the socio-cultural values and practices (transhumance road, place for trade, land uses...) of pastoralists' livelihood.

**Keywords:** Tulla, Water places, Wells, interdisciplinarity, landscape approach, anthropology, archaeology, GIS

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# The 2017 Moiyabana, Botswana earthquake suggest the EARS extension in southern Africa

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## Abstract

The 3 April 2017 MW 6.5, Moiyabana (Botswana) earthquake occurred in the continental interior of the African plate and in a seismogenic region previously considered as stable. We analyse the mainshock and aftershock sequence based on a local seismic network and local seismotectonic characteristics. The earthquake rupture geometry is constrained with more than 1,000 aftershocks recorded over a period of three months, field investigations and from the InSAR analysis of Sentinel-1 images (ascending orbit). The mainshock (25.134 E, 22.565 S; depth  $22 \pm 3$  km) and the largest aftershock (MW 4.6 on the 5 April 2017) were followed by more than 500 events of magnitude  $M_l \geq 0.8$  recorded in April 2017. The aftershock distribution at depth and focal mechanisms of mainshock and aftershocks display predominance of NW-SE trending fault geometry with NE and antithetic SW dipping normal faulting that reveal a graben like structure. Stress inversion of focal mechanisms obtained from the mainshock and aftershock database are compatible with a NE-SW extension under normal faulting regime. The InSAR study shows fringes with two lobes with 4 to 6 cm coseismic slip on a NW-SE elongated and 30-km-long surface deformation consistent with the mainshock location and normal faulting mechanism. The modelling of surface deformation provides the earthquake rupture dimension at depth with  $\sim 1$  m maximum slip on a fault plane striking  $315^\circ$ , dipping  $45^\circ$ ,  $-80^\circ$  rake and with  $M_0$  7.12  $10^{18}$  Nm. Although the seismic strain rate is of low level, the occurrence of the 2017 Moiyabana earthquake, followed by an aftershock sequence in the central Limpopo belt classifies the intraplate region as an active plate interior. We demonstrate a graben structure modelled from the mainshock and aftershock sequence; as well as the ENE-WSW extensional stress regime associated with the Moiyabana earthquake sequence. Our results suggest the seismotectonic deformation as the extension of the EARS in southern Africa.

**Keywords:** Seismotectonics, Earthquake, Normal Faulting, Graben, like deformation, mainshock, aftershocks

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