

Koninklijk Museum voor Midden-Afrika
Verslagen van het departement Aardwetenschappen

Musée royal de l'Afrique centrale
Rapports du département des Sciences de la Terre

Royal Museum for Central Africa
Reports of the Earth Sciences department

2017

Surface environments and collection management

Évolution du personnel

Gijs De Cort, PhD scientist , left the service on December 2017

Projets : de recherche, expositions, activités éducatives, de communication

<u>Projet 1 : Projet « focus » « Pamexea »</u>	
Nom (et acronyme)	Patterns and mechanisms of climate extremes in East Africa (PAMEXEA)
Financement	Source : Belspo (Brain) Budget : 997.000 euros
Partenaires	Responsable interne : Florias MEES Collaborateurs internes : Gijs De Cort Collaborateurs externes : UGent, UCL, Royal Botanical Garden (Meise), University of Twente, Hydrological Research Center (San Diego)
URL site web	
Dates	Début : 2013 Fin : 2017
Description générale du projet	Main components : (i) palaeohydrological reconstruction for specific rift valley lakes to document climate variability during the last 2000 years; (ii) compilation of climate-proxy data for East Africa for the same period, to produce a spatially-resolved history of past East African climate change; and (iii) evaluation and refinement of climate models, ultimately to simulate future climate trends and variability under specific combinations of natural and anthropogenic factors.
Évolution et résultats pour l'année écoulée	Analysis of sediment cores from Lake Bogoria and Nasikie Engida (Kenya).
<u>Projet 2 : Projet « Si-PALEO »</u>	

Nom (et acronyme)	Establishing Silicon Isotopes as Weathering Tracers for Paleoenvironmental Studies (SI-PALEO)
Financement	Source : Marie Curie IEF Fellowship EU Budget : 235000€
Partenaires	Responsable interne : Luc André Collaborateurs internes : Laurence Monin, Collaborateurs externes : S. Bouillon (KU Leuven), A. Borges (Univ. Liège), E. Schefuss, L. Dupont (Univ. Bremen), A. Iaraque (IRD Montpellier)
URL site web	
Dates	Projet terminé en ce qui concerne les analyses mais continuant en 2017 et 2018 par la rédaction des publications
Description générale du projet	Les principaux objectifs du projet SI-PALEO étaient 1) de déterminer les facteurs contrôlant la distribution des isotopes du silicium (Si) dans les sédiments marins, et 2) d'évaluer l'impact des changements climatiques et des activités humaines sur l'altération des roches silicatées en Afrique centrale au cours des derniers milliers d'années.
Évolution et résultats pour l'année écoulée	Les résultats fort originaux font l'objet de publication dans des revues de fort facteur d'impact. La première publication a été soumise en décembre 2017 à la revue Geochimica et Cosmochimica acta.
<u>Projet 3 : Si isotopes in Great Lakes</u>	
Nom (et acronyme)	Establishing Silicon Isotopes as a proxy of Lake dynamic
Financement	Source : MRAC Budget : dotation
Partenaires	Responsable interne : Luc André Collaborateurs internes : Laurence Monin Collaborateurs externes :
URL site web	
Dates	Début : 2013 Fin : 2018

<p>Description générale du projet</p>	<p>Stable Silicon (Si) isotopes (^{28}Si, ^{29}Si, and ^{30}Si) studies offer an efficient proxy for investigating the complex abiotic and biotic controls on continental Dissolved Si fluxes. Significant fractionation of Si isotopes occurs during processes such as secondary mineral formation and biological uptake. In particular, Si is essential for the growth of diatoms, which utilize dissolved silicic acid in lake water and form opaline silica ($\text{SiO}_2 \cdot n\text{H}_2\text{O}$). During the uptake of dissolved silicic acid, there is a preferential incorporation of light silicon isotope (^{28}Si) into biogenic silica, resulting in the enrichment of heavy silicon isotope (^{30}Si) in dissolved silicic acid. Likewise during their precipitation, clays preferentially incorporate the light silicon isotope (^{28}Si) leaving the heavy isotope (^{30}Si) as a residue in the water, but at a different fractionation rate than the diatoms. We report isotopic compositions of dissolved Si in several great lakes in order to quantify the respective roles of diatoms, weathering processes in the Lake catchment and hydrothermal juvenile inputs in the Lake Si cycles. The study is focused on three of the largest lakes in the world (Baïkal, Tanganyika and Kivu) because altogether they represent 35% of the Earth fresh water.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>The observed overall compositions of lake water (sampled at various depth from the surface to the maximum depth) are arranged along non-linear relationship (hyperbola curves) in diagrams plotting the isotopic composition ($\delta^{30}\text{Si}$) in function of the dissolved Si in the water. These hyperbola represent mixtures between two major components. As such they demonstrate the existence of two major controlling factors: (1) the diatoms (high $\delta^{30}\text{Si}$, low dissolved Si) and (2) the origin of Si (low $\delta^{30}\text{Si}$, high dissolved Si). So these compositions help to identify three major types of Si dynamics in large lakes: (1) a dominant control by diatoms (the Baïkal case-study); (2) a balanced control by diatoms and the weathering in the catchment as well (the Tanganyika case study); (3) a leading control by the juvenile hydrothermal inputs (the Kivu case study). We keep on analyzing the collected water $\delta^{30}\text{Si}$.</p>
<p><u>Projet 4 « The suboceanic aquifers »</u></p>	
<p>Nom (et acronyme)</p>	<p>Mg-Si isotopic compositions of suboceanic aquifers: constraints on the oceanic Mg-Si budgets.</p>
<p>Financement</p>	<p>Source : ^dGeosciences Environment Toulouse, CNRS-UPS-IRD-OMP and MRAC Budget : 10.000 €</p>
<p>Partenaires</p>	<p>Responsable interne : Luc André Collaborateurs externes : Christophe Monnin (GET, Toulouse), Camille DELVIGNE (CEREGE, France)</p>
<p>URL site web</p>	
<p>Dates</p>	<p>Début : 01/01/2016</p>

	Fin :31/12/2019
<p>Description générale du projet</p>	<p>The oceanic seafloor alteration is now recognized to act jointly with the continental weathering to significantly change the seawater composition because the global hydrothermal fluid flux through the upper oceanic crust is commensurate with the global riverine flux to the ocean (e.g., German and Seyfried, 2014). The largest part of this fluid circulation involves low temperature off-axis hydrothermal systems where seawater-derived fluids circulate through the permeable basaltic upper layers of the oceanic crust below the sedimentary pile. Every day ~100 billion cubic meters of bottom seawater are transported down into the permeable upper oceanic crust. Within this gigantic aquifer system oxic seawater circulates and reacts with reduced igneous rocks before eventually recharging back into the oceans 10^3–10^4 years later. Consequently, the chemical composition of fluids and rocks are strongly altered, with wide-reaching ramifications throughout the marine system . Strong evidence exist for an abundant microbial community residing within this subsurface crustal basaltic where microbial activity is believed to influence basalt alteration and mineral dissolution rates. with a liquid volume equal to approximately 2% of the ocean’s volume and water fluxes equivalent to the surface continental water runoff, these deep oceanic aquifers have a large impact on the ocean chemical budget in particular on the C cycle. Our project aims to quantify the impact of these aquifers on the Mg and Si oceanic budgets.</p>
<p>Évolution et résultats pour l’année écoulée</p>	<p>We analysed $\delta^{26}\text{Mg}$ of bottom sediment pore waters (taken as proxies of basement fluids) from the ten sites drilled during ODP Leg 168, along a West-East transect in the Juan de Fuca Eastern flank. They are significantly lighter ($-1.0\% < \delta^{26}\text{Mg} < -2.6\%$) than the bottom seawater (-0.82%). They vary correlatively with the gradual changes of Mg concentrations and Sr isotopic compositions from West to East along the transect, asserting the common origin of all these near-basement fluids. $\delta^{26}\text{Mg}$-$^{87}\text{Sr}/^{86}\text{Sr}$ values covary along two distinct trends: one for the fluids close-to-ridge sites and the other one for those sampled at sites farther away from the ridge axis. The low-temperature (15-40°C) fluids from the close-to-ridge sites have their Mg isotopic compositions controlled by reversible reactions linked to the smectite and/or celadonite precipitation from the basement fluids. The observed relationship between the $\delta^{26}\text{Mg}$ and $\delta^{37}\text{Cl}$ values for these proximal sites can be explained by the displacement of water molecules from the Mg hydration shells by the chloride ion, which also accounts for the sensitivity of $\delta^{37}\text{Cl}$ to the Mg dehydration. In the case of the warmer (50-63°C) distal sites, the formation of carbonates along with that of the Mg-phyllsilicates leads to a decoupling of the $\delta^{26}\text{Mg}$ and $\delta^{37}\text{Cl}$ values. The mass balance of the Mg isotopes of the modern ocean requires that a substantial fraction (2.8-8.5 Tmol yr⁻¹) of the continentally-derived Mg flux (rivers + groundwaters) to the ocean is removed through water-rock interactions during ridge-flank circulation. A significant part of it (25-90%) occurs at low temperature (assumed at 7°C) despite low level of Mg</p>

	removal (<1%) from the initial seawater through the Mg-phyllosilicate precipitations. A scenario of evolution of seawater Mg isotopic composition towards lighter values ($dMgSw\delta Sw/dt = -3.4 \text{ Tmol}\% \text{ yr}^{-1}$) is more prone to constrain the secular evolution of the oceanic $\delta^{26}\text{Mg}$ budget than a model of constant Mg isotopic composition because it fits a much larger range of partition of the off-ridge heat flux between cool and warm water transport in the off-axis aquifers and a wider spectrum of continental Mg inputs.
<u>Projet 5« The Trondhjemite-tonalite-diorite » project</u>	
Nom (et acronyme)	The Trondhjemite-tonalite-diorite (TTG)
Financement	Source :dotation Budget : 2.000 €
Partenaires	Responsable interne : Luc André Collaborateurs externes : A. Hoffman (Johanesburg)
URL site web	
Dates	Début : 01/01/2017 Fin :31/12/2020
Description générale du projet	<u>Tonalite-trondhjemite-granodiorite</u> (TTG) series are an aggregation of rocks that are formed by melting of hydrous <u>mafic crust</u> at high pressure. It is widely accepted that most early <u>Archaean granite-greenstones</u> are dominated by TTG, although Late <u>Archaean terranes</u> , such as in the <u>Yilgarn Craton</u> , are dominated by <u>potassium-rich granitoid</u> rocks that are derived through remelting of older <u>felsic</u> TTG-dominated crust. This compositional change was attended by a fivefold increase in the mass of the upper continental crust due to addition of granitic rocks, suggesting the onset of global plate tectonics at ~3.0 billion years ago (Tang et al., 2016). We prospect the $\delta^{30}\text{Si}$ signatures of these rocks to better constrained their origin and check such a model .
Évolution et résultats pour l'année écoulée	We report silicon isotope data on Archaean TTG granitoids from the Barberton granitoid-greenstone terrane (Kaapvaal craton), which range in age from 3.55-3.11Ga. The oldest plutons have Si isotopes in the igneous array ($\delta^{30}\text{Si}$: -0.17 to -0.10‰), whereas younger generations show a significantly heavier isotopic signature ($\delta^{30}\text{Si}$: -0.08 to +0.05‰). These preliminary results are tentatively explained by melting of recycled silicified basalts and cherts ($\delta^{30}\text{Si}$: ~+1‰, Abraham et al., 2011), which were common surface rocks in the oceans at the time, beginning between 3.3 and 3.2 Ga.

Autres activités

Analyses faites en 2017 au sein du laboratoire sur les instruments analytiques (spectromètre de masse, spectromètre d'émission optique, ...) :

- Total = 868 analyses
- Préparation d'échantillons (dissolution, ...) = 359 échantillons
- Analyses à l'ICP-MS (Inductively Coupled Plasma Mass Spectrometer) = 231 échantillons
- Analyses par LA-ICP-MS (Laser Ablation-ICP-MS) = 24 jours
- Analyses au MC-ICP-MS (Multi Collector-ICP-MS) à l'ULB = 18 jours d'analyses
- Analyses à l'ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometer) = 407 échantillons
- Analyses par chromatographie ionique = 230 échantillons

Visiteurs : chercheurs, utilisateurs des bibliothèques, stagiaires, etc.

. [Jakub Plášil, Institute of Physics, Academy of Sciences of the Czech Republic, Prague – mineral collection](#)

. [Isaure Scavezoni, Université de Liège – fossil collection](#)

-Dr Mohammed ALLAN (ULg) : Analyses par Laser Ablation-ICP-MS

-Chunyang ZHOU (VUB PhD Thesis) : Analyses par Laser Ablation-ICP-MS

Communications lors de conférences

. [De Cort, G., Verschuren, D., Ryken, E., Wolff, C., Renaut, R.W., Creutz, M., Van der Meeren, T., Haug, G., Olago, D.O., Sinnesael, M., Goderis, S., Keppens, E. & Mees, F., 2017. A 1,300-year moisture-balance reconstruction from the dry eastern rift valley of East Africa: the sediment record of hypersaline Lake Bogoria. Paleoclimate Modelling Intercomparison Project – Phase 4 \(PMIP4\) Conference, Stockholm, Sweden, September 25-29 2017.](#)

. [De Cort, G., Mees, F., Ryken, E., Wolff, C., Renaut, R.W., Creutz, M., Van der Meeren, T., Haug, G., Olago, D.O. & Verschuren, D., 2017. A 1,300-year moisture-balance reconstruction from the dry eastern rift valley of East Africa: the sediment record of hypersaline Lake Bogoria. 5th PAGES Open Science Meeting, Zaragoza, Spain, May 9-13.2017.](#)

. [André L., Planchon F, Delvigne C, Cardinal, D. & Monnin C. Silicon isotopes of off-axis ridge fluids. Constraints on the oceanic Si budget Goldschmidt Conference Abstracts. 27th V. M. Goldschmidt Conference, 13-18th August 2017, Paris, France](#)

[André L., Abraham K., Foley S.F., and Hofmann A. 2017 Silicon isotopes as markers for the onset of surface products recycling in the Archean. Fukuoka meeting Precambrian World 2, Japan, February 2017.](#)

De Putter, T., **Mees, F.**, Bayon, G., Ruffet, G., Smith, T. & Delvaux, D., 2017. Coupling between tectonics and surface processes in the Congo Basin: Cretaceous-Cenozoic sedimentation and erosion triggered by climatic and tectonic factors. European Geosciences Union General Assembly 2017, Vienna, Austria, April 23-28 2017.

. Dumon, M., Timmermans, E., Vandendriesche, I., Mujinya, B.B., Baert, G., **Mees, F.** & Van Ranst, E., 2017. The Critical Zone in the Haut-Katanga Province, D.R. Congo: combining physico-chemical, mineralogical and micromorphological observations from a 40 m deep weathering profile. 16th International Clay Conference, Granada, Spain, July 17-21 2017.

. Folie, A., De Putter, T., **Mees, F.** & Smith, T., 2017. Un grand serpent palaeophiidé dans le Lutétien marin du Bassin du Bas-Congo, enclave de Cabinda, Angola. Congrès de l'Association Paléontologique Française, Dijon, France, March 28 – April 1 2017.

Wuytack, T., De Cort, G., Van Der Plas, G., **Mees, F.** & Verschuren, D., 2017. The African Anthropocene: land-use history in the central Rift Valley of Kenya based on analyses of clay minerals, particle size and charcoal in a continuous lake-sediment record. 7th Belgium Geography Day, Liège, November 17 2017.

Acquisitions pour les collections

. acquisition of mineral/ore collection of the former Department of Applied Geology (Prof. Dr. I. de Magnée), Université Libre de Bruxelles

. acquisition of several series of mineral specimens

Prêts

. . Les richesses minéralogiques de la R.D. du Congo (Hannut), 5/3/2017

. Ciel ! (Palais Royal, Bruxelles), 22/7-3/9/2017

Made by Children (MIAT, Gent), 20/11/2016- 07/01/2018

Digitalisations et mise en ligne des collections

Paleontology collection – data entry

Development of a new database structure for all department collections

Digitalisations et mise en ligne des collections

Figure 1 Projet « focus » « PAMEXEA »

Le lac Bogoria, lac salin dans la vallée du rift au Kenya. Le long des berges, on observe des arbres et des buissons morts, des suites du niveau du lac exceptionnellement élevé en 2014. D'après les documents historiques, le lac n'avait plus atteint ce niveau depuis plus d'un siècle. Une reconstitution de l'histoire du lac sur base de carottes de sédiment à l'AfricaMuseum a montré qu'un tel niveau est également rare sur de plus longues périodes. Au cours de ces 1000 dernières années, le niveau était généralement plus bas qu'à n'importe quel moment au 20e et 21e siècles, ce qui doit servir de mise en garde quant à un retour possible de sécheresses extrêmes à l'avenir. G.



van der Plas © UGent

Geodynamics and mineral resources

Evolution du personnel scientifique

En 2016 et 2017, le Service de Géodynamique et Ressources Minérales (GRM) a perdu deux chercheurs expérimentés et jeunes : Stijn Dewaele, nommé Professeur à l'UGent et Germain Bayon, qui est reparti vers l'IFREMER à Brest (France), après un séjour dans le Service Environnement et Collections (L. André) et ensuite dans le service GRM (2017). Shana De Clercq, chercheuse junior, a en revanche temporairement renforcé l'équipe en 2017 avant de rejoindre l'UGent elle aussi. Les départs de Stijn et Germain ont affaibli le Service qui dispose toujours de chercheurs qualifiés ou très qualifiés mais relativement âgés. Jacques Cailteux a également rejoint le service en tant que Collaborateur Scientifique.

Etat des lieux 2017 et perspectives 2018 et au-delà

Les perspectives d'évolution du service sont nuancées, principalement sinon exclusivement en raison du contexte institutionnel (tutelle et institution).

Les aspects scientifiques et non institutionnels sont, quant à eux, très positifs :

- le service s'attache à développer une vision intégrées des problématiques géologiques étudiées, du travail de terrain jusqu'à la micro-analyse et la datation ;
- l'intérêt des institutions universitaires belges et étrangères pour les thématiques développées dans le service est réel (voir ci-dessous, projets fedtwin) ;
- la pluridisciplinarité assumée dans les activités du service suscite aussi un intérêt qui va au-delà de la discipline, tant à l'intérieur du MRAC qu'auprès des partenaires externes ;
- les thématiques liées aux ressources minérales ne pourront manquer de revenir au centre des préoccupations et le service sera armé pour répondre aux questions scientifiques *et* sociétales ;
- La productivité scientifique du service est très bonne et sa visibilité augmente également, tant par ses activités scientifiques que de coopération au développement.

Voici quelques thèmes scientifiques qui vont alimenter les recherches et les publications futures du Service :

- Unravelling the Meso-Cenozoic evolution of the Congo Basin and paleosurfaces in the context of tectonic and climatic events in Central Africa;
- Improving governance of natural resources in DR Congo;
- Updating the geological knowledge of the Kivu rift region by cross-border collaboration RDC-Rwanda-Burundi by field data compilation, new field investigations and the promotion and coaching of local studies (memoirs, masters). New rock dating in collaboration with the University of

Johannesburg. New project for updating the geological mapping of Rwanda with DFID (funded by the BTC, now Enabel);

- Finalisation of the investigation of the bimodal magmatism in the West-Congo belt (Congo Central), preparation of publications in collaboration with colleagues from the University of Gent and from Brazil;
- The southern Kasai shield, metacratonic boundary of the Congo craton: field, U-Pb geochronology, geochemistry, geodynamics. Finalisation and publication of the work initiated by Ariel Boven in 2012 on the Kasai Craton;
- Paleoproterozoic manganese and base metals deposits at Kisenge-Kamata (Katanga, D.R. Congo), and the role of the Kasai Block in the genesis of younger mineral deposits surrounding the Kasai, including the Neoproterozoic Katanga Copperbelt;
- The use of mineral materials in pre-colonial times: stone in Ancient Egypt, prestige marbles in Julio-Claudian Rome, copper in precolonial Kongo Kingdom;
- Characterization of the sources of magmas in post-collisional and anorogenic settings, implications for their geodynamic setting: the post-collisional Amsel granite (Hoggar), the metacratonic Ounane and Tisselliline pluton (Hoggar), the accreted Silet magmatism (Hoggar), the post-orogenic Taourirt magmatic province (Hoggar).
- Pan-African continental subduction with eclogites of the Paleoproterozoic LATEA basement and its Neoproterozoic cover (Arechchoum and Egéré groups, Egéré-Aleksod terrane, Hoggar, Algeria), U-Pb zircon ages, geochemistry, Sr-Nd isotopes and metamorphic P-T paths;
- Sedimentology, magmatism, detrital zircon ages of the Ardenne massif, spin-off of the Pan-African belt of Sahara.

Fedtwinn projects (2019? → ?)

Domain 1: “Geodynamics and geofluids in Great Lakes region (Central Africa): magmatic activity, tectonic deformation and associated mineral resources (gold, 3T, REE)”

The geodynamic reconstruction of ancient belts is challenging, especially for long-lived orogenic systems which include complex magmatic suites of contrasting (ultra-)mafic up to felsic compositions. An understanding of the geodynamic processes responsible for magmatism is key to reconstruct the fundamental processes on a lithospheric scale, particularly if magmas are associated with metal-concentration systems. Geological data on a belt-scale, particularly geochemical data, supported by solid geochronological and structural data, provide essential insights into the magmatic and metallogenetic processes involving parts of the upper/lower crust and mantle. The Archean and Paleoproterozoic blocks that constitute Central African Cratons are separated by various Paleoproterozoic (Ubende, Rusizi) and Mesoproterozoic (Kibara, Karagwe-Ankole) belts. Based on the architecture and ages of these belts, it has been postulated that the Central African Cratons were amalgamated into a proto-Congo Craton since at least c. 1380 Ma. An extended purely intracratonic scenario in Central Africa has even been envisaged from ~1800 Ma onwards. The Mesoproterozoic Kibaride orogenic region, composed of the Kibara (KIB)

and Karagwe-Ankole Belts (KAB), separates the Archean to Paleoproterozoic Congo Craton from the Archean to Paleoproterozoic Bangweulu-Tanzania Block. Widespread magmatism occurs throughout this region at ~1375 Ma and around 1000 Ma resulting in associated Nb-Ta-Sn-W, Ni-PGE and Au mineralisation. In the Kibara belt, the 1417–1376 Ma magmatic event is generally interpreted as an active continental margin, while simultaneously an intracratonic basin was proposed for Karagwe-Ankole Belt. However these models mostly focus on specific temporal (cf. 1375 Ma magmatic event) or spatial (cf. Kabanga-Musongati alignment) phenomena and a conclusive model for the entire region during the Mesoproterozoic era is lacking. The contemporaneity of many ultra-mafic and granitic bodies, together with various styles of mineralisation, has major implications for the Mesoproterozoic evolution of the region, and could significantly influence continent-scale Mesoproterozoic plate tectonic reconstructions.

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Domain 2: “Geodynamics of the Congo Basin, vertical movements of the Congo Craton and mobile belts, rifts and regional Meso-Cenozoic paleo-environment evolution”

The Congo Basin is one of the major river basins of the world, covering some 2,500,000km². The basin outline results from a 500 million years-long “shaping” process of the Congo Craton (substrate of the Basin) and the surrounding Proterozoic mobile belts, after the Pan-African orogeny. Most of these mobile belts have been thoroughly studied for their genesis, age, associated mineral resources. Less attention has been paid to the role played by these Proterozoic terranes as landforms, thresholds, borders for the future Congo Basin. Further, the combined opening and stress regimes of the two Mid-Atlantic and East African Rifts is structuring the upper portion of the Central African crust. However, evidence on the internal dynamics of the Basin itself, and of its intermittent waterbody, remains scarce. Adding to these geodynamics uncertainties, the paleoclimate prevailing over the basin is also loosely constrained. It seems likely that the Congo basin experienced long-lasting arid and desert conditions, with major eolian sand deposition, during most of the Cenozoic era. In the last 10 Myr (Mio-Pliocene) the onset of the present-day climate pattern and its intertropical convergence zone (ITCZ), allowed massive rainfall over both Northern and Southern parts of the basin throughout the year, and the growth of a unique rainforest. The vertical evolution of the hilly borders of the Congo Basin included periodical uplift and denudation phases of Proterozoic fold belts, which brought mineral resources to the surface. Weathering either generated ore (Eocene? bauxite) or allowed ore enrichment within secondary, oxidized deposits, in the Paleogene-Neogene. The huge Cenozoic plateau made of eolian sand in the Bandundu area possibly records several episodes of silicification, whose regional meaning is not precisely known. A comprehensive geodynamic approach of the post-pan-African orogeny is needed to provide a regional understanding of this major river basin and its natural resource endowment.

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Domain 3: “From ‘resource curse’ to sustainable development: multidisciplinary and regional approach in the Great Lakes Region (Central Africa)”

The Great Lakes Region of Central Africa is a land-locked, overpopulated area, which suffers from recurrent conflicts since decades. These conflicts have several causes, most of them with roots in the access to land and productive resources (land, water) issue. To the West, the mineral-rich Congolese hinterland, a huge area stretching from the Ituri (North) to Northern Katanga (South), is a major source of tin, tantalum, tungsten and gold (3TG), which is ransomed by various armed groups and altogether constitute a stronghold for illegal ore smugglers and a major regional barrier for economic development. Various attempts have been put forward to regulate the illegal ore trade (certification, traceability, etc.), with little positive effect. A likely hypothesis is that of a tacit consensus for maintaining a status quo, as neighbouring countries take advantage of the export of illegal Congolese ore, feeding a globalized downstream market (tantalum to Germany and USA; gold to the Emirates, India and China). Economic powers should however balance the benefits they derive from cheap minerals with the persistence of instability, the westward infiltration of Islamic groups, and the risk for further unmonitored migration. Therefore, enforcing sustainable development in the Great Lakes Region is a global strategic priority and requires an holistic approach.

Practically, the area needs improved governance, the development of basic infrastructure – roads, bridges, railway, lake harbours, power plants – and an extensive virtual communication network (including banking). An integrated view of the productive resources (land, agriculture, power, minerals) in the Great Lakes Region and of the needs of surrounding areas is key to the regional development. Credible solutions have to integrate the existence of failed states (DR Congo, Burundi) and possibly to build on reliable regional champions. Bottom-up actions, supported by credible multilateral organizations, and a strong political involvement of economic powers, might constitute a way forward.

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GRM-Natural Risks – transversal theme: “Rifts and volcanism in the Western branch of the East African Rift System – a window on the deep mantle?”

The Great Lakes Region in Central Africa experiences, since the Eocene, a major uplift which is associated to mantle buoyancy, at the subcontinental scale. These deep processes possibly benefited from the existence of major weakness zones, along cratons margins and boundaries, which were periodically reactivated since at least the Mesoproterozoic (1.6-1.0 Ga). The regional buoyancy and topographic bulge resulted in increased tectonic stress, which is at the origin of the aperture and collapse of the Western branch of the East African Rift System (EARS), some 25 millions of years ago (late Oligocene). One of the most striking features of the western branch of the EARS is that it is overall magma-poor, safe for the Virunga volcanic fields. The Virunga area has several active volcanoes, among which the Nyiragongo, which has K-rich fluid lava in a permanent lava lake, and the neighbouring Nyamulagira volcano, with basaltic lava and a newly created lava lake which suggests resumption of the central vent activity (previous activity was associated to dike-fed flank eruptions). The historical activity of these volcanoes is recorded in the RMCA rock collection since the beginning of the 20th century, and allows a diachronic study of the changing activity and magma types for both volcanoes over more than 100 years. Newly emitted material, the hydrothermal fluids circulation and the gases in the volcanic field, will allow

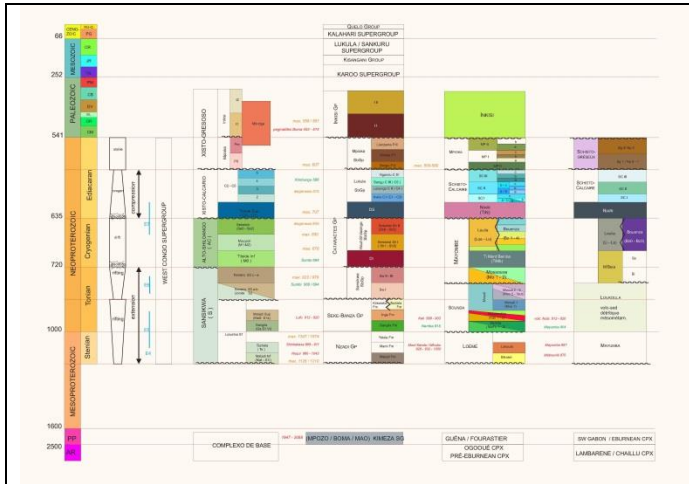
a better understanding of the complex relationship of the active volcanism with the deep-seated magma reservoir.

Projets – Projecten

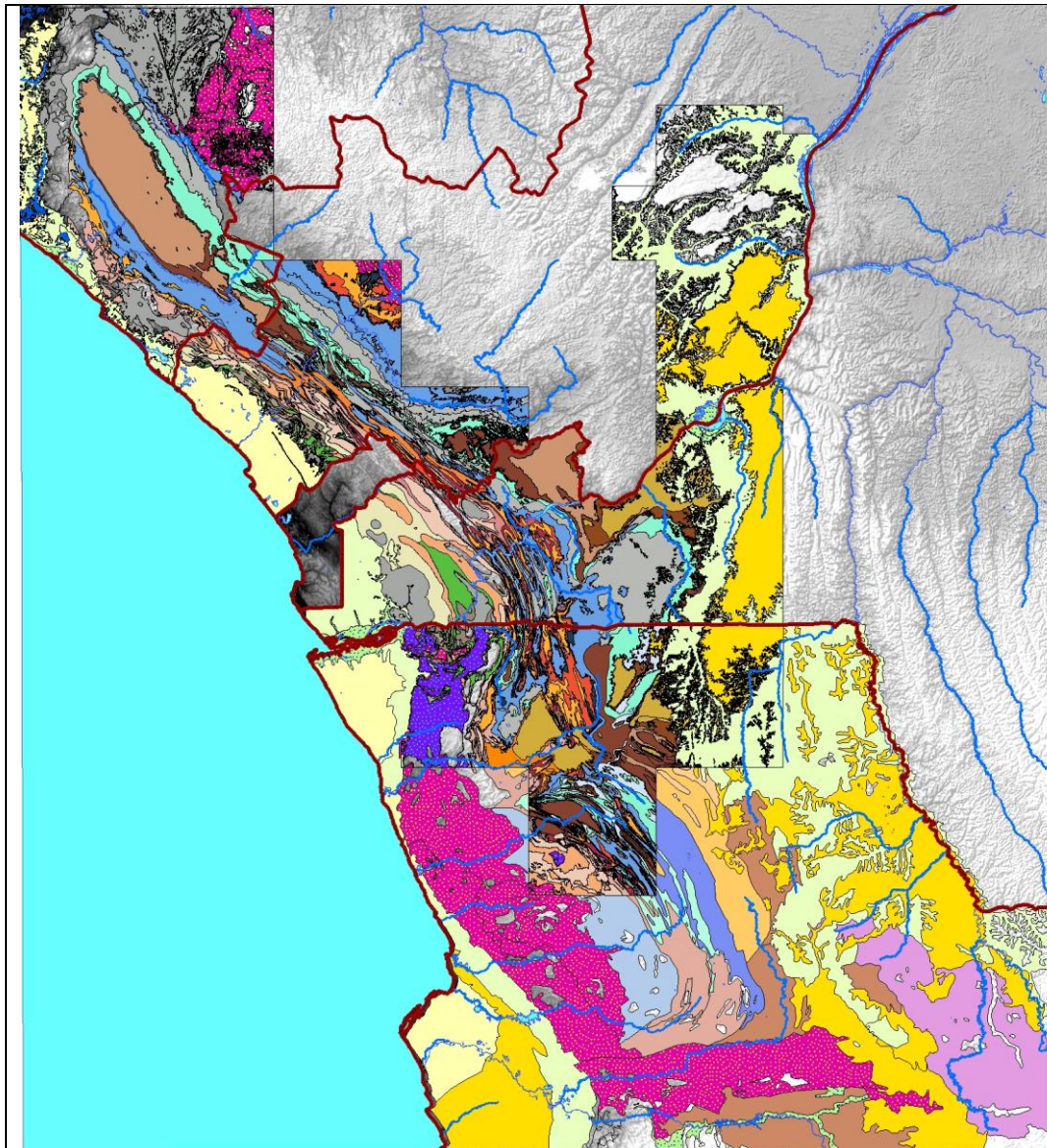
Projet 1 Focus 2017 : des algues vieilles d'un milliard d'années en RDC	
Nom (et acronyme)	Etude du Supergroupe de la Mbuji-Mayi (Kasai, RDC)
Financement	Source : ULg, interne Budget :
Partenaires	Responsable interne : Daniel Baudet Collaborateurs internes : M. Fernandez, D. Delvaux, L. Tack Collaborateurs externes : ULg : E. Javaux, B. Baludikay, C. François, J.Y. Storme Unikin : B. Baludikay
URL	http://
Dates	Début : 2009 Fin :
Description générale du projet	<p>Le Supergroupe de la Mbuji-Mayi occupe une région entre le Kasai et le Katanga (entre les degrés carrés S5E23 et S8E26) s'allongeant suivant un axe Nord-Ouest sur 500Km et large de 250Km. Il comporte deux régions, l'une occidentale (région de Mbuji-Mayi) structuralement peu compliquée, l'autre orientale (vallée de la Lomami) plissée à fortement faillée.</p> <p>Il est composé de deux groupes, le groupe inférieur, BI, est essentiellement détritique et le groupe supérieur, BII, est essentiellement carbonaté et contient des stromatolites. Le magmatisme est présent avec des laves basaltiques chapeautant le sommet stratigraphique dans la partie occidentale mais des masses volcaniques et de dolérite ont aussi été reconnues près de la limite BI/BII dans la partie orientale.</p> <p>Cahen et al (1984) trouvèrent un âge de 948 ± 20Ma (K-Ar sur RT) pour les laves sommitales de la stratigraphie et un âge de 1055Ma ($^{207}\text{Pb}/^{206}\text{Pb}$ sur galène syngénétique ; 1954) au sommet du BI.</p> <p>Des travaux miniers (1953) ont conduit à faire des sondages dans la partie ouest de la région et ces sondages font partie des collections du Musée. Ils permettent de consulter pratiquement l'entièreté des 1500m de stratigraphie du Supergroupe en principalement 3 sondages. La région occidentale a ainsi pu être plus facilement étudiée.</p>

Évolution et résultats pour l'année écoulée	<p>Deux articles ont été publiés durant 2017 sur les résultats concernant la géochronologie (François <i>et al.</i>, 2017) et la spectrographie Raman (Baludikay <i>et al.</i>, 2017).</p> <p>Un âge sur les laves sommitales a été mesuré et est en voie de publication. Les travaux continuent sur l'évolution des isotopes du carbone et de l'oxygène.</p>
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<u>Project 2</u>	
Naam (en acroniem)	GEOSUDESTE2017
Financiering	<p>Bron: intern</p> <p>Budget:</p>
Partners	<p>Intern verantwoordelijke: <u>Max Fernandez-Alonso</u></p> <p>Interne medewerkers: Daniel Baudet, Luc Tack</p> <p>Externe medewerkers: A. Pedrosa-Soarez (Univ. Minas Gerais); D. Thieblemont & Y. Callec (BRGM)</p>
URL website	
Data	<p>Begin: september 2016</p> <p>Einde: november 2019</p>
Algemene beschrijving van het project	<p>Geosudeste2017 took place as scheduled. The project itself is extended with 2 years till end 2019 to enable all to provide the necessary updated and edited GIS layers for the integration of the West Congo and Araçuai belts according to a uniform stratigraphy, valid for the entire Pan-African "belt".</p> <p>A first version of the integrated West-Congo belt stratigraphy is attached. It correlates the stratigraphy from Angola, DR Congo, R. Congo and Gabon using the most recent published works.</p>
Evolutie en resultaten voor het afgelopen jaar	<p>de digitalisatie in GIS van de betreffende delen van de geologie op 1/200.000 van Gabon, de Republiek Congo, de Democratische Republiek Congo en Angola is beëindigd. Eind 2017 alle kaartbladen afgewerkt in GIS in de loop van 2017. Het werk focust daarna voornamelijk op het opstellen van een uniforme chronostratografie voor de ganze Keten.</p>



chronostratigrafische
correlatie over de 4
landen: Angola -
DR Congo - R. Congo -
Gabon



draft (2017)
geologische
kaart van de
West-Congo
keten na
Gondwana
amalgamatie

<u>Projet 3</u>	
Nom (et acronyme)	PROJET S1_RDC_CRGM: Renforcement de la capacité de recherches et de service géologique du Centre de Recherches géologiques et minières en RDC
Financement	Source : Coopération au développement via l'accord cadre Budget : 64.965 euros pour l'année de projet 2017.
Partenaires	Responsable interne : <u>P. Lahogue</u> Collaborateurs internes : D. Baudet, D. Delvaux, S. Dewaele Collaborateurs externes : CRGM-RDC, Université Marian Ngouabi-Congo Brazzaville, ULiège- Belgique, U. Gent-Belgique, Université de Minas Gerais (Brésil), Université de Rio de Janeiro (Brésil), Université d'Adelaïde (Australie)
URL site web	
Dates	Début : 1/03/2016 Fin : 28/02/2018
Description générale du projet	<p>Ce projet constitue les deux dernières années du projet de renforcement de la capacité de recherche et de service géologique du CRGM au travers de recherches scientifiques communes avec le MRAC de plus haut niveau scientifique que précédemment. Les activités de recherches pour ce projet portent sur quatre sujets géologiques.</p> <p>Etude du contexte géologique de la région transfrontalière du Pool Malebo (côté Kinshasa et Brazzaville) et cartographie – détails voir ce sous projet.</p> <p>Etude minéralogique et géochimique des pegmatites dans la région de Boma – détails voir ce sous projet.</p> <p>Etude du massif de Mao (Bas-Congo, RDC) – détails voir ce sous projet.</p> <p>Etude de la diamictite inférieure : comparaison entre les régions de Kimuaka, Sansikwa et Kasi (Bas-Congo, RDC) – détails voir ce sous projet.</p> <p>Le projet prévoit aussi la constitution d'une base de données avec des fonctionnalités de recherche reprenant l'ensemble des données collectées dans le cadre du projet – détails voir ce sous projet.</p>
Évolution et résultats pour l'année écoulée	Cette deuxième année de projet (en cours) a permis des collectes complémentaires de données via des travaux de terrain et le traitement de celles-ci afin de compléter de les résultats de l'année précédente. La base de données est fonctionnelle au MRAC et au CRGM pour l'encodage et la consultation. Des publications sous forme de cartes et d'articles sont en élaboration pour être finalisées en fin de projet, soit début 2018.

<u>Projet 4</u>	
Nom (et acronyme)	Etude du contexte géologique de la région transfrontalière du Pool Malebo (côté Kinshasa et Brazzaville) et cartographie
Financement	Source : Coopération au développement via l'accord cadre et le projet PROJET S1_RDC_CRGM

	Budget : 27478 euros (partie du budget du PROJET S1_RDC_CRGM, année de projet 2017)
Partenaires	Responsable interne : <u>P. Lahogue</u> Collaborateurs internes : D. Delvaux, F. Mees. Collaborateurs externes : Guylain Fukiabantu (CRGM), Dim Mbolokala (CRGM), Elvis Kongota (CRGM), Aimé Luboya (CRGM), Florent Boudzoumou (Univ Marian Ngouabi), Timothée Myouna (Univ Marian Ngouabi), Frédéric Boulvain (ULiège).
URL site web	
Dates	Début : 1/03/2016 Fin : 28/02/2018
Description générale du projet	Les causes de l'élargissement du fleuve Congo au niveau du Pool Malebo restent encore non élucidées actuellement même si diverses hypothèses ont été formulées à ce jour. En outre les cartes géologiques réalisées de part et d'autre de la frontière restent partiellement incompatibles. L'étude du contexte géologique de la région transfrontalière du Pool Malebo (côté Kinshasa et Brazzaville) est menée afin d'harmoniser les interprétations géologiques et d'améliorer la compréhension de la formation du Pool. L'étude devra permettre sur base de nouvelles données de terrain et de nouvelles comparaisons de part et d'autre du Fleuve Congo de valider ou au contraire de remettre en question certaines hypothèses actuelles. Cette étude est menée avec le CRGM à Kinshasa et l'Université Marien NGOUABI de Brazzaville. Une carte géologique sera produite au terme du projet. Elle sera le fruit de deux axes de recherches complémentaires : une étude structurale et une étude des processus sédimentaires.
Évolution et résultats pour l'année écoulée	Cette seconde année a permis la collecte de données via des travaux de terrain complémentaire ciblés en fonction des résultats de 2016 tant sur la partie Brazzaville moins bien connue de nos chercheurs que sur de nouvelles zones autour de Kinshasa. Les échantillons récoltés ont été analysés. Ils ont aussi permis d'étudier le contexte stratigraphique et structural du Pool et établir les relations entre les deux rives du Pool. Ce travail a permis de consolider la collaboration avec les géologues de l'Université de Brazzaville. Une attention particulière a été portée aux niveaux silicifiés dans les grès tendres pour évaluer leur possible utilisation comme repère pour l'étude de la déformation tectonique ainsi qu'à la fracturation dans le grès de l'Inkisi afin de préciser le modèle d'évolution de la fracturation et sa cinématique. Des publications sous forme de cartes et d'articles sont en élaboration pour être finalisées en fin de projet, soit début 2018.

<u>Projet 5</u>	
Nom (et acronyme)	Réalisation d'une base de données de points d'observation et informations connexes au CRGM.
Financement	Source : Coopération au développement via l'accord cadre et le projet PROJET S1_RDC_CRGM

	Budget : 2855 euros (partie du budget du PROJET S1_RDC_CRGM, année de projet 2017).
Partenaires	Responsable interne : <u>P. Lahogue</u> Collaborateurs internes : Collaborateurs externes : Aimée Love Pay (CRGM).
URL site web	
Dates	Début : 1/03/2016 Fin : 28/02/2018
Description générale du projet	Extension de la base de données existante à l'ensemble des données du CRGM avec création des modules d'encodage et de recherche et intégration des données dans un SIG
Évolution et résultats pour l'année écoulée	Cette année a permis de finaliser l'adaptation prévue de la base aux données collectées via les archives et les différents projets en cours ainsi que d'améliorer la standardisation des données de terrain et d'analyse d'échantillons à y intégrer. L'encodage des données est en cours.

<u>Projet 6</u>	
Nom (et acronyme)	The structure of the Tuareg Shield depicted by its magmatism and geophysics; spin-off in Tibesti and in Anti-Atlas [TUAREGMAG]
Financement	Source : Own resources, USTHB Alger, University of Strasbourg, IPGP Paris Budget : nd
Partenaires	Responsable interne : <u>Jean-Paul Liégeois</u> Collaborateurs internes : Collaborateurs externes : A. Ouabadi, N. Abdallah, N. Fezaa, A. Bendaoud, R. Ben El Khaznadj, S. Zerrouk (USTHB Algiers, Algeria); A. Benhallou, D. Derder (CRAAG, Algiers, Algeria); A. Azzouni-Sekkal (Tlemcen University, Algeria)

	<p>B. Bonin (Orsay University, France) B. Henry (IPGP, Paris, France) S. Brahim, J.F. Ghienne, M. Munsch (Strasbourg University, France) S. Belkacim, M. Ikenne (Agadir University, Morocco) D. Gasquet (Savoie-Mont Blanc University, France) O. Bruguier (Montpellier University, France) B. De Waele (SRK Consulting, Australia) C. Nkono, D. Demaiffe (ULB, Belgique)</p>
URL	
Dates	<p>Début : 2015</p> <p>Fin : 2020</p>
Description générale du projet	<p><i>Description générale du projet:</i> The structure of the Tuareg Shield (Central Sahara) has been mainly acquired during the Pan-African orogeny at the end of the Neoproterozoic. But, the Archean and Paleoproterozoic heritage is of paramount importance for its understanding (metacratonic evolution) and the current swell, result of the Africa-Europe collision, reactivated some structures, which allowed Cenozoic volcanism to appear, and enhanced some features. A comprehensive study of the magmatism, from different periods and from terranes contrasted by their rheology, with the help of geophysics, can lead to the understanding of the complex structure of the Tuareg Shield, with far-reaching consequences, for the shield itself but also elsewhere, the processes depicted here being exportable.</p>
Évolution et résultats pour l'année écoulée	<p>(1) The Cenozoic volcanism in Hoggar has for long been attributed to a mantle plume. Auscultation of the basement geology showed that it is actually the result of far-distant intraplate stress due to the Africa-Europe collision. Detailed studies of this volcanism combining field, petrology, geochemistry and geochronology have been performed these last years for constraining that finding. One paper has been published in 2017 on that subject (Ben El Khaznadj et al., 2016, Journal of African Earth Sciences).</p> <p>(2) The In Ouzzal Pan-African granitoids. We dated this magmatism at 601 ± 4 Ma (zircon U-Pb age, LA-ICPMS and SHRIMP). These high-level subcircular plutons, intrusive in the In Ouzzal terrane, made of c. 2 Ga granulites having Archean protoliths, are thus contemporaneous to large batholiths intrusive in ductily deformed terranes around. Their chemistry and Sr-Nd signature point to a mixed mantle/granulitic origin. All these observations relates to a metacratonic evolution of the In Ouzzal rigid terrane within the general northern tectonic escape of the Tuareg terranes due to the collision with the West African craton. An article has been accepted at the end of 2017 (Fezaa et al.) in a book entitled "Lithospheric Architecture and Precambrian Geology of the Hoggar and Adjacent Areas- A reference case for mapping and modeling in Geosciences", published by Springer in the Regional Geology Review Series.</p> <p>(3) Cartography of surface and deep structures through geophysics.</p> <p>(a) Surface cartography. Mapping and discriminating the Pan-African granitoids in the Hoggar (southern Algeria) using Landsat 7 ETM data and airborne geophysics allowed to to discriminate and map different types and generations of Pan-African granitoids in the Hoggar in close correlation with previous works and established geological maps. The studied area (200*350 km) extends over four contrasted Pan-African terranes (In Tedeini, Iskel, Tefedest and Laouni terranes, the two latter belonging to the LATEA metacraton. This study led to the establishment of a more accurate geological map where the geochemical characteristics of the Pan-African granitoids are determined, including plutons not yet studied, especially in the poorly known In Tedeini terrane, and brings new constraints for the</p>

	<p>geodynamic development of the Tuareg Shield, which includes the Hoggar. This study has been published in 2017 in the Journal of African Earth Sciences (Zerrouk et al., 2017).</p> <p>(b) Deep structures. Using new data for potential methods (magnetism, gravimetry) allow to have an overall view of the geological structure of the Tuareg Shield and to decipher the Hoggar terrane prolongation to the north under the large Algerian sedimentary basins. This would allow a better understanding of the nature of these different terranes both in the Tuareg shield and to the north and a better understanding of the Pan-African orogen especially its relations with the Saharan metacraton. An article will be submitted early 2018 (Brahimi et al.).</p> <p>(4) Tifnoute Ediacaran volcanism in Anti-Atlas. This is the first spin-off project. The northern boundary of the West African craton has been metacratonized during the Pan-African orogeny. A main consequence is the huge Ouarzazate volcanic province (800 * 100 km), 580-545 Ma in age. We studied it in the Tifnoute valley, in a rigid Anti-Atlas salient within High Atlas. Due to the alteration of these volcanic rocks, we focused the composition of the clinopyroxene (LA-ICP-MS). This helped understanding the whole-rock geochemistry and Sr-Nd isotopes. These volcanic rocks have a mostly depleted Neoproterozoic source either the young lithospheric mantle (alkali-calcic series) or the asthenosphere (younger alkalic series). These rocks emplaced in transtensive post-collisional environment that evolved towards the major rifting event that will give rise to the Rheic ocean (see project Ardenne). A paper has been published on this subject: Belkacim et al 2017 (Journal of African Earth Sciences).</p> <p>(4) Tibesti Cenozoic volcanism and Pan-African structure. This is the second spin-off project. Based on SRTM, DEM and Landsat image, this study demonstrates that the emplacement of the Tibesti volcanic province results from the reactivation of inherited structures of the Saharan metacraton. An article will be submitted early 2018 (Nkono et al.)</p>
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Projet 7	
Nom (et acronyme)	Magmatism linked to mega-shear zones [MAGSHEAR]
Financement	Source : Own resources, Tehran Universities, Western Australian University Budget : nd
Partenaires	Responsable interne : Jean-Paul Liégeois Collaborateurs internes : Collaborateurs externes : O. Wane (Bamako University, Mali) N. Thébaud (Western University, Australia) R. Deevsalar (Tarbiat Modares University, Tehran, Iran) J. Ahmadian (Payam Noor University, Tehran, Iran)
URL	
Dates	Début : 2014

	Fin : 2017
Description générale du projet	Large magmatism intrusions can be linked to mega-shear zones and can appear similar while actually in different environments. A first focused region was the Massigui area in southern Mali where c. 2.1 Ga granitoid batholiths intruded along the Banifin shear zone. The second focused region was Western Iran where the Malayer-Boroujerd plutonic complex (MBPC) that intruded along the Sanandaj-Sirjan zone.
Évolution et résultats pour l'année écoulée	<p>(1) The Massigui area in Mali. Located to the west of the Man Shield, close to the Kenema Archean nucleus, this is a key area, which is confirmed by its younger age (c 2.1 Ga) than most of the Birimian segment. Magmatic rocks are organized along the Banifin shear zone that is the northern prolongation of the shear zone marking the eastern boundary of the Archean nucleus. Shrimp dating on magmatic and detrital zircons demonstrate the contemporaneity of the sediments, the extrusions and the intrusions, within an uplifting transpressive environment. This magmatic medium to high-K event can be related to the continental subduction of the Archean Kenema nucleus responsible for the Massigui transpression and corresponding to the metacratonic margin of the Sarmatia craton, now in Eastern Europe. An article is accepted in Precambrian Research and will be published in January 2018 .</p> <p>(2) The Malayer–Boroujerd plutonic complex (MBPC) in Iran is a portion of a Middle Jurassic magmatic arc built by the northeast verging subduction of the Neo-Tethys plate beneath the Central Iranian Microcontinent. Our geochemical and Nd and Hf isotopic data reveal that the MBPC was triggered by mantle–crust interaction during subduction inputs from Neo-Tethys oceanic slabs. Its emplacement occurred in two locus: (1) in a deep mantle–crust interplay zone and (2) in a shallow level upper crustal magma chamber. Geochemical modeling indicate that the MBPC S-type granites are products of upper crustal greywacke while I-type granites formed by partial melting of amphibolitic lower crust and mixing with upper crustal greywacke melt in shallow level magma chamber. Small amounts of mafic magmas escaped the mixing process at mantle–crust boundary zone and emplaced close to the surface, forming the rare gabbroic intrusions and dykes. As a whole, this is hydrous melting of metasomatised mantle in Neo-Tethys subduction zone. An article has been accepted in the Swiss Journal of Geosciences and will be published in January 2018 (Deevsalar et al.)</p>

<u>Projet 8</u>	
Nom (et acronyme)	Dispersal of the African Gondwana margin recorded in Ardenne Cambro-Ordovician sediments and in Romanian granitoids[PERIGOND]
Financement	Source : Own resources, Dresden Museum für Mineralogie und Geologie Budget : nd
Partenaires	Responsable interne : <u>Jean-Paul Liégeois</u> Collaborateurs internes : Collaborateurs externes :

	A. Herbosch (ULB, Belgique) U. Linnemann, A Gärtner, M. Hofmann (Dresden Museum)
URL	
Dates	Début : 2016 Fin : 2019
Description générale du projet	The formation of Gondwana c.600 Ma ago was followed by the dispersal of some of its margins in terranes that moved at variable distance. Some of them moved at rather medium distance and are now located in southern or eastern Europe (e.g. the Romanian terranes here studied) while others moved far away on the other side of the Rheic Ocean and came back to Europe when the ocean closed leading eventually to the Variscan orogeny (e.g. the Avalonia terrane that includes the Ardenne region here studied). Understanding the evolution of such terranes imposes, in addition to the detailed study of the terrane itself, to be able to correlate them with West Africa from where they originated and so to have a good knowledge of this area, which is the case of the RMCA scientist of this project.
Évolution et résultats pour l'année écoulée	<p>(1) The Romanian South Carpathians Danubian granitoids. Initially considered to be all of Pan-African ages, the Danubian are actually either Pan-African or Variscan intrusion. Understanding the behavior of these formerly Pan-African terranes imposes this study of both generations. The pre-Alpine basement of the Lower Danubian nappes in the South Carpathians in Romania is made up of two Precambrian terranes (Drăgșan and Lainici-Păiuș). We focus here on the major and trace element geochemistry (1) in the Drăgșan terrane, of the Variscan Retezat and Parâng intrusions; (2) in the Lainici-Păiuș terrane, of the Variscan Furcătura, Petreanu and Frumosu intrusions and of the Pan-African Vârful Pietrii, Șușița and Olteț granites and granitic leucosomes of migmatites; and (3) in the Upper Danubian nappes basement, of the Variscan MunteleMic, Sfârdin, Cherbelezu and Ogradena intrusions. For each intrusion, in which a range of composition is observed, we decipher the differentiation mechanisms (fractional crystallization, hybridization, melt laden with restite minerals, etc.) in order to define the parental liquid compositions and the P-T conditions under which they intruded. The source rock composition is dominated by a variety of mafic igneous compositions or metasediments rich in volcanic components. We confirm a Variscan age (c. 300 Ma) for the Frumosu intrusion granite and inherited Precambrian ages (c. 1.7–1.9 and 2.6–2.9 Ga) for the Motru dyke swarm. Thus, both Drăgșan and Lainici-Păiuș together with the Upper Danubian basement terranes were affected by Variscan post-collisional granitic plutonism. In the South Carpathians, both Pan-African and Variscan granites were generated in a crust thickened by stacking of terranes. The source of the Pan-African granites in Lainici-Păiuș is different from that of the Variscan granites (from Lainici-Păiuș and Drăgșan terranes and from the Upper Danubian nappe basement), but all these sources were notably depleted in metapelite component. This study has been published in 2017 in Lithos (Duchesne et al., 2017). Further study for building a geodynamical model from the late Neoproterozoic to present times for this area is envisaged.</p> <p>(2) The Stavelot-Venn Massif in Ardenne, Belgium. The Brabant and Ardenne massifs belong to East Avalonia, a terrane that detached from NW Africa at the Cambrian-Ordovician boundary. During the Variscan orogeny, these two massifs were stacked and so their relative position during their formation is highly</p>

	<p>discussed in Belgium. We already studied the origin of the Brabant Massif (Linnemann et al., 2011) and focused the Rheic Ocean opening in Ardenne when studying the coticule (Herbosch et al., 2016). We now study through sedimentology, geochemistry and detrital zircon dating of the sediments of the Stavelot-Venn massif in Ardenne and through zircon dating and geochemistry of the SVM magmatic rocks, the paleoposition of the SVM for reconstituting its detachment from West Africa and its relative position respectively to the Brabant Massif and, as a whole, its Cambrian-Ordovician evolution. The Stavelot-Venn Massif (SVM) corresponds to the northwestern part of the Rheno-Hercynian Belt, close to the Variscan front. It has undergone Variscan folding and very low (anchizone) to low-grade (epizone) metamorphism during Upper Carboniferous times. An earlier Caledonian folding is highlighted by an angular unconformity between the SVM and the overlying Pridoli-Lochkovian series. The SVM corresponds to an allochthonous nappe disconnected from the basement and transported at least 20 to 30 km northwestwards during the Variscan Orogeny onto the Brabant. The SVM shows a continuous sedimentation from the lower Cambrian to the Middle Ordovician, which is mainly terrigenous with minor volcanic episodes and even rarer small magmatic intrusions. Estimated thickness of the different units of the Lower Palaeozoic of the SVM inlier is more than 3000 to 3500 m. We show that there are strong correlations between the sedimentation and the sources determined by the detrital zircon signature between Brabant and SVM but that important differences impose that they deposited on different basements. Dating of magmatic rocks allows their correlation with that of Brabant but here also differences arise. A geodynamical model is being currently built for showing the relative position of Brabant, Ardenne and NW Africa and to represent their Cambrian-Ordovician evolution. An article should be submitted to an international journal in 2018.</p>
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<u>Projet 9</u>	
Nom (et acronyme)	The geology of the Kasai Block (Congo Craton), its mineral wealth and contribution to the genesis of surrounding mineral deposits
Financement	Source : Own resources Budget : nd
Partenaires	Responsable interne : <u>Thierry De Putter</u> Collaborateurs internes : Jean-Paul Liégeois, Florias Mees, Stijn Dewaele, Max Fernandez, Jacques Cailteux Collaborateurs externes : Adrian Boyce (Glasgow)
URL	
Dates	Début : 2016 Fin : non fixée

<p>Description générale du projet</p>	<p>The Kasai Block (KB) is a major geodynamic unit, which belongs to the Congo Craton. This huge area, located West to the Neoproterozoic Copperbelt and its foreland, has considerable mineral deposits, most of them largely unexplored and unpublished. Manganese carbonate ore is abundant at Kisenge-Kamata, but also present at Kasekelesa and Mwene-Ditu. At Kisenge, ore lenses are hosted in Paleoproterozoic (PP) marine sediments unconformably deposited on the granitogneissic Archean basement. Current mining activity also focuses on gold reserves in this area. Besides, the metal content in PP shale metasediments and manganese lenses (Mn, Cr, Co, Cu, Ni, Zn) is significant.</p> <p>To understand the genesis of these mineral deposits and the role the KB has possibly played in the formation of younger surrounding mineral deposits (e.g. the Katanga Copperbelt), it is necessary to investigate the geology and geodynamic evolution of the KB over ~3 billion years. Questions as (1) the internal structure of the KB; (2) its behaviour in the Eburnian orogeny (~2 Ga); (3) its relations with Meso- and Neoproterozoic mobile belts are crucial to unravel the KB “mineral heritage” across Central Africa.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>A research paper has been submitted to Ore Geology Reviews in 2017, on the genesis of the Kisenge manganese carbonate ore deposit. This paper brings new data on questions mentioned above: the KB had intracratonic PP east-west trending marine-connected basins where Mn-rich chemical sediments precipitated, in restricted environments (De Putter <i>et al.</i>, submitted). It is likely that part of the manganese and associated metals deposited in the PP were later remobilized and trapped in the Neoproterozoic Roan basin, and hence fed the Central African Copperbelt (ongoing investigation).</p> <p>Another research axis (led by Max Fernandez and Jean-Paul Liégeois) focuses on the lithology and ages of the granitogneissic rocks in the KB and their geodynamic evolution, in the Eburnian orogeny but also in connection with the formation of the Mesoproterozoic Kibaran belt. This research will shed new light on the complex “triple point” (west to Kolwezi) where the KB, the Kibaran terranes (or supposed so) and the Neoproterozoic Roan Basin come in mutual contact. The geological map of the area could be substantially improved, at the light of new data.</p>

<p style="text-align: center;"><u>Projet 10</u></p>	
<p>Nom (et acronyme)</p>	<p>Kimberlites</p>
<p>Financement</p>	<p>Source : Own resources</p> <p>Budget : nd</p>
<p>Partenaires</p>	<p>Responsable interne : Thierry De Putter</p> <p>Collaborateurs internes :</p> <p>Collaborateurs externes : Phil Janney (Cape Town, RSA) ; D. Demaiffe (ULB)</p>
<p>URL</p>	
<p>Dates</p>	<p>Début : 2016</p> <p>Fin : non fixée</p>

<p>Description générale du projet</p>	<p>Dans le cadre de ses études sur les kimberlites, Phil Janney (Cape Town) a demandé à pouvoir accéder au matériel congolais conservé dans nos collections. Nous lui avons fourni l'accès aux échantillons de 3 zones kimberlitiques, le Kasai, le Nord de l'Angola voisin et les champs kimberlitiques des Kundelungu. Les analyses sont en cours et l'apport du musée se situera dans le contexte géologique régional, que ce soit au Kasai ou dans les Kundelungu. Dans les deux cas, les kimberlites se mettent en place dans des intervalles chronologiques assez mal connus au Sud de la RDC.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>Echantillonnage et analyses en cours en 2017.</p>

Projet 11	
<p>Nom (et acronyme)</p>	<p>Structure, evolution and natural resources of the Congo Basin</p>
<p>Financement</p>	<p>Source : Fonds propres, Accord-Cadre MRAC-DGD projets RDC-CRGM et RDC-GEODYN</p> <p>Budget : non défini, selon disponibilités et synergies avec autres projets en cours ; participation possible dans un projet ERC, à soumettre en 2017</p>
<p>Partenaires</p>	<p>Responsable interne : <u>D. Delvaux, T. De Putter</u></p> <p>Collaborateurs internes : D. Baudet, F. Mees</p> <p>Collaborateurs externes :</p> <p>Université de Liège (E. Javaux) Université de Lubumbashi (E. Kadima, S. Sebagenzi) Université de Utrecht (M. Tesazuro, F. Beekmans, S. Cloetingh) ITC, Université de Twente, Enschede (M. van der Meirwe) Université RWTH Aachen (V. Sachse) Université de Rennes-1 (G. Ruffet) Université de Bourgogne, Dijon (É. Pucéat) IFREMER, Brest (G. Bayon)</p>
<p>URL site web</p>	
<p>Dates</p>	<p>Début : 2010</p> <p>Fin : non déterminée</p>
<p>Description générale du projet</p>	<p>The Congo basin is one of the major river basins in the world. Its history over the last 100 Myr records a series of geological events with a worldwide significance: the opening of the Atlantic Ocean; the greenhouse-gas (GHG) rich Cretaceous period; the Cretaceous/Tertiary (K/T) boundary at 65 My; the Paleocene-Eocene thermal maximum (PETM) at ~55 My; the Miocene aperture of the Western branch of the East African Rift System (EARS) on its eastern border at 25 My. In a nutshell, the river basin experiences two major drainage regime in this time</p>

	<p>interval: (1) a continental lake and starving basin (desert conditions?) in the Mid-to Late Cretaceous and the Paleogene; (2) a powerful river with a massive drainage in the Neogene, and the deposition of a large offshore Tertiary sedimentary fan, whose diagenesis led to the formation of offshore oil deposits. The internal structure of the Basin is a major constrain influencing the sedimentation therein. A multidisciplinary research has shed new light on this structure, and on the geometry of the sediments deposited at different periods in the evolution of the basin. This study (yet to be published) provides a series of transects within the basin, allowing for a much better understanding of its progressive sedimentary infilling.</p> <p>This history of the Basin also owes much to the vertical movements that affect the basin itself and its rims, from the East African Plateau (EAP) down to the Atlantic shelf margin. Stacked uplifts of this large sub-continental landmass create paleo-surfaces that, under various climate regimes, led to the formation of major economic ore deposits: Paleogene bauxites; Mio-Pliocene secondary deposits in the Katanga (Cu-Co, Mn) and the Kivu (Sn-Ta-W, Au, REE) regions, where there is a direct link with the aperture of the EARS; diamonds in the Kasai; most probably also secondary Cu deposits in the Bas-Congo and Congo-Brazzaville regions.</p> <p>The purpose of the proposed working group is to better constrain the paleo-environmental conditions in which the Upper Cretaceous and Cenozoic sediments were (or were not) deposited in the Congo basin and offshore fan. Classical sedimentology, structural geology, geochemistry, argon dating, zircon dating and paleontology are coupled with new provenance and climate proxies that are used to decipher sediment deposition and cycling at the basin scale, the link between geodynamics, climate, weathering and the formation of paleosurfaces and economic ore deposits.</p> <p>Major milestones were reached in 2016 (see below) and it is expected that 2017 will still bring new and important results (a.o. published papers) on the evolution of the Congo Basin in the last 100Myr.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>Une révision multidisciplinaire de l'évolution du bassin de la Cuvette centrale a débuté 2010 et se poursuit, avec des partenaires nouveaux. Elle combine des approches géophysique, stratigraphique, géochimique/isotopique et tectonique, avec des études thermochronologique, pétrographique et de géochimie des sédiments. En 2017, les activités suivantes ont été réalisées/poursuivies:</p> <ul style="list-style-type: none"> • Etude stratigraphique et tectonique du Stanley Pool/Pool Malebo dans les environs de Kinshasa (RDC) et de Brazzaville (RD) en collaboration avec le CRGM et l'Université de Brazzaville dans le cadre du projet RA_RDC_CRGM (D. Delvaux, P. Lahogue) • Nouveaux âges Ar-Ar permettant de contraindre la dynamique verticale des marges sud du bassin, du Campanien au Miocène (avec G. Ruffet, Rennes ; publication en préparation) • Révision complète de l'étage paléogène du bassin, incluant une évaluation du forçage paléoclimatique de l'altération

Projet 12	
Nom (et acronyme)	Origin of the European modern faunas through Palaeogene Central Africa collections (Paleurafrica)
Financement	Source : BELSPO Brain

	Budget : 892.385€
Partenaires	Responsable interne : <u>Thierry De Putter</u> Collaborateurs internes : Florias Mees, Daniel Baudet Collaborateurs externes : <ul style="list-style-type: none"> - Thierry Smith, IRScNB, PI - Stephen Louwye, Universiteit Gent - Johan Yans, Université de Namur - Gregg Gunnell, Duke University (USA) † - Nancy Stevens, Ohio University
URL site web	http://www.paleurafrica.be/
Dates	Début : 2014 Fin : 2017 (accord signé la présidence de Belspo sur une prolongation jusque fin 2018, pour cause de départ retardé)
Description générale du projet	<p>Knowledge about the evolution of the earliest modern vertebrates has made giant leaps during the last two decades thanks to important studies and discoveries by researchers in North America, Europe, North Africa and Asia. In this context, Belgian scientists have contributed to the study of modern vertebrates from western Europe, analyzing the historical Paleogene key collections of the Royal Belgian Institute of Natural Sciences in two previous projects (Belspo MO/36/011 and 020). Collaboration of Belgian scientists with leading experts from 8 different countries has resulted in joint projects in North America, China (Belspo BL/36/ C54) and most recently Vastan in India (five fieldwork grants from the National Geographic Society). These Belgian initiatives led to the publication of more than 50 scientific A1 papers in the last 10 years concerning, what the great paleontologist George Gaylord Simpson termed “The Beginning of the Age of Mammals”.</p> <p>Recent advances made in the study of vertebrate evolution suggest that the earliest modern mammals such as primates, perissodactyls (odd-toed ungulates) and artiodactyls (even-toed ungulates), which appeared suddenly in all three Northern hemisphere continents at the Paleocene-Eocene Thermal Maximum (PETM 55.8 my ago), likely originated during the late Paleocene in tropical habitats farther south.</p> <p>The PETM is the first and most prominent of a series hyperthermals, short-lived events of extreme global warming, and is considered among the most important analogues for current global warming. Using isotopic data, PETM studies have demonstrated its effect on past mammal dispersal, evolution and ecology and highlighted potential biotic effects of future climate change.</p> <p>Numerous international expeditions have been carried out on all northern continents and high quality collections exist from the PETM key period, among which is the Belgian Dormaal collection at the RBINS, recognized as the international reference level for Europe. Nevertheless, only two fossil localities in the tropics have yielded vertebrates from around this time interval, the Cerrejon coal mine in Colombia and the Vastan lignite mine in India. Extraordinary discoveries and progress have been made on early primates, bats, artiodactyls and other modern vertebrates but their direct ancestors have not been identified so far. Africa may well represent an</p>

	<p>important source area for the origin of many modern mammal groups but its Paleogene record is poorly sampled, especially from sub-Saharan Africa.</p> <p>Interestingly, there is a unique collection of Paleocene vertebrates from Central Africa in the federal heritage resulting from Belgian expeditions of the Royal Museum of Central Africa by Edmond Dartevelle in the Democratic Republic of Congo and Angola. Therefore, the aim of this project is to identify the Paleogene vertebrate faunas of Central Africa and to look for ancestors of modern mammals from Europe and elsewhere.</p> <p>Our international and multidisciplinary team will study and digitize the Belgian Paleogene collections from earlier expeditions in Belgium (RBINS) and in Congo and Angola (RMCA). The history of earlier African expeditions will be traced and the excavation sites will be relocated through the use of archives. New excavations will be organized to complete the existing collections, using modern screen-washing techniques that will enable the team to find small vertebrates. A partnership will be developed with international specialists in Central African fieldwork and faunas (a consortium including Duke University, Ohio University, and Wake Forest University, all in the USA). Targeted sampling of these sites will also enable the team to date and characterize them in detail, based on microfossils (Ghent Univ.) and isotopic data (Namur Univ.). Faunal turnovers and the influence of dispersals during the Palaeogene, especially the early Paleogene, will be analysed by comparison with European faunas, North American faunas, and Chinese and Indian faunas in order to elucidate which modern vertebrate groups originated in Africa.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>En 2017, l'étude sédimentologique et minéralogique des coupes du Bas-Congo a été réalisée par Shana De Clercq ; ces coupes permettent de compléter la vision sédimentologique et paléoenvironnementale des bassins littoraux dont coupe-type de Landana est l'exemple le plus connu. La question qui se pose en arrière-plan est celle d'une possible connexion (ou non-connexion) entre les bassins littoraux et le bassin continental du Fleuve Congo. Il n'est pas exclu que cette connexion n'ait pas existé au Paléogène et qu'elle ne soit rétablie qu'au Miocène.</p> <p>En parallèle, les travaux pluridisciplinaires sur la coupe de Landana se sont poursuivis : ils font notamment apparaître une lacune de tout l'étage Danien (base du Paléocène) ; un article a été soumis en 2017 à Geoscience Frontiers (Solé <i>et al.</i>, soumis).</p> <p>Les travaux de 2017 viennent apporter des contraintes importantes sur les zones côtières du bassin du fleuve. Ces dernières fourniront un jalon supplémentaire entre les dépôts du cône sous-marin du fleuve, les informations sédimentologiques au centre du bassin et la dynamique des marges sud de celui-ci (paléosurfaces nouvelles, attestées par les âges Ar-Ar obtenus sur cryptomélane, au Campanien, à l'Éocène et au Miocène ; publication en préparation).</p>

Projet 13	
Nom (et acronyme)	Egyptian and African Copper Metallurgy in Federal Collections: Contextualisation, Preservation, Patrimonial Value (EACOM)
Financement	Source : BELSPO Brain

	Budget : 689.007 €
Partenaires	Responsable interne : <u>Thierry De Putter</u> Collaborateurs internes : Alexandre Smith Collaborateurs externes : <ul style="list-style-type: none"> - Luc Delvaux, Musées Royaux d'Art et d'Histoire, PI - Patrick Degryse, Katholieke Universiteit Leuven - Nicolas Nikis, Université Libre de Bruxelles
URL site web	http://eacom.be/wp/
Dates	Début : 2014 Fin : 2017
Description générale du projet	<p>The main goals of this project are to re-contextualise and increase the qualitative value of the material linked to copper metallurgy in two Belgian federal scientific institutions, through a multidisciplinary study of copper <i>chaînes opératoires</i> in Ancient Egypt and in sub-Saharan Africa, especially in the Congo Basin, one of the world's richest copper exploitation areas. The researchers involved in the project have identified technological and material similarities between ancient Egypt and the Congo Basin, reason for which the two federal collections in which the material related to copper metallurgy from these two areas is kept, the Royal Museums of Art and History (RMAH) and the Royal Museum for Central Africa (RMCA), chose to collaborate on this project. This collaboration will increase the scientific and societal impact of their collections by giving a better understanding of the context of early production and use of copper. The aim is to gain a more accurate image of this process, drawing on all potential information, archaeological, ethnographical and archaeometrical.</p> <p>The Egyptian collections related to copper metallurgy in the RMAH have been left dormant because of the lack of specific expertise and information on these metallurgy-related artefacts.</p> <p>These collections were developed through the so-called subscription system of the museums to British excavations in the 1930's. This practice led to the dispersion of lots of objects throughout several countries. To accurately re-contextualise the artefacts in the RMAH belonging to these scattered assemblages, and to understand their archaeological meaning, it will be necessary to retrace the lots to which they belong.</p> <p>The ethnographic and archaeological collections of the RMCA that include archival material (films, photographs, etc.) and objects from the Congo Basin were begun as early as the 1930's. These collections have also suffered from neglect, despite their considerable scientific potential as witnesses to traditional metallurgical techniques. Through the study of these RMCA collections, a reconstruction of metallurgical <i>chaînes opératoires</i> may thus accurately and thoroughly be done.</p> <p>The project will bring together all these artefacts (ceramics, waxes, ore fragments, copper-based artefacts, etc.) related to metallurgy in one coherent set for the first time. These will be re-contextualised by re-assembling the lots to which they belonged, that were dispersed throughout Europe at the time of their discovery, and through external data from several disciplines,</p>

	<p>archaeology, archaeometry, ethnography and experimental archaeology. There is much to be gained from the comparative study of these two rich and diverse collections. Not only will it be possible to bring to light rich contextual data, but also to reconstruct the technical context of some long “forgotten” artefacts.</p> <p>The comparisons between the various types of objects associated to metalworking in the two collections will allow to better comprehend the similarities and differences in the use of metallurgical techniques in Pharaonic Egypt and in Sub-Saharan Africa. Furthermore the numerous depictions of metalworking on the walls of Egyptian tombs will be confronted to the ethnographic documentation kept in the RMCA (films, photographs, etc.). The joint parallel study of these two “sleeping” collections will increase their qualitative value by identifying their societal and technical context.</p> <p>This will enhance the relevance of these data sets making them reference collections for any further research on copper metallurgy in Africa and on metallurgical processes in general. Finally, in terms of the public perception of these two federal collections, this project will also permit to contribute to a different view on past societies by revealing the techniques behind the objects and by emphasising the importance of seemingly less spectacular artefacts, that however do offer deep insight into everyday life and the organisation of extinct cultures.</p>
Évolution et résultats pour l'année écoulée	<p>En 2017, poursuite des analyses isotopiques et LA-ICP-MS sur divers échantillons en vue de finaliser le papier « <i>Copper production and trade in the Niari Basin (Republic of Congo) during the 13th to 19th centuries CE: chemical and lead isotope characterization</i> » soumis cette même année à Archaeometry, accepté fin 2017 et actuellement sous presse (Rademakers et al., in press).</p> <p>Poursuite de l'étude géologique des gisements de la région de Mindouli, dans le cadre de la préparation d'une publication de ces derniers.</p>

Projet 14

Nom (et acronyme)	Project Congo – Brazil (CoBra)
Financement	Source : University of Gent, Museum Budget :
Partenaires	Responsable interne : D. Baudet Collaborateurs internes : D. Delvaux, L. Tack Collaborateurs externes : U Gent : G. Van Ranst, J. De Grave University of Minas Gerais (Brazil): A. Pedro-Suares, University of Rio de Janeiro (Brazil): I. Dussin
Dates	Début : 2015 Fin : 2019

Description générale du projet	<p>The Araçuaí-West Congo Orogenic belt (AWCO) situated mainly in eastern Brazil and partly in western Africa (D.R. Congo, R.P. Congo, Gabon and Angola) is a good field for the study of the reactivation of inherited structures, and particularly for the Gondwana break-up and the opening of the Atlantic Ocean.</p> <p>For a better understanding of the tectonic movements, they will be studied in an absolute time-frame given by low temperature methods (apatite fission track and apatite U-Th-Sm)/He). The studies will be held in East Brazil and West-Africa (Kongo-Central, DRC)</p>
Évolution et résultats pour l'année écoulée	<p>A complementary sampling has been performed in Bas-Congo. Samples are in processing at UGent and the first results are in production. A first presentation of these results have been made in Bangkok conference on Gondwana (2017) and will be also presented at the CAG27 (Aveiro, Portugal; July 2018)</p>

<u>Projet 15</u>	
Nom (et acronyme)	Etude du socle du Kongo central (RDC)
Financement	<p>Source : Université de Minas Gerais, Université de Gent, Museum</p> <p>Budget :</p>
Partenaires	<p>Responsable interne : Daniel Baudet</p> <p>Collaborateurs internes : M. Fernandez, D. Delvaux, L. Tack</p> <p>Collaborateurs externes : Université de Minas Gerais : A. Pedro-Suares Université de Rio de Janeiro : I. Dussin Université de Gent : J. De Grave CRGM : A. Love, P. Nseka</p>
URL	http://
Dates	<p>Début : 2016</p> <p>Fin :</p>
Description générale du projet	<p>Lors des travaux sur la région de Shinkakasa il est apparu que les roches du socle avaient été mal estimées et qu'un travail d'étude en profondeur était absolument nécessaire en particulier avec les outils isotopiques modernes.</p>

Évolution et résultats pour l'année écoulée	Des échantillons complémentaires ont été prélevés en particulier lors des travaux dans le massif de Mao. Les traitements sont en cours à l'UGent et à Belo Horizonte.
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Projet 16	
Nom (et acronyme)	Etude du massif de Mao (Kongo central, RDC)
Financement	Source : DGD-MRAC Budget : 33000€
Partenaires	Responsable interne : Daniel Baudet Collaborateurs internes : M. Fernandez, D. Delvaux, L. Tack Collaborateurs externes : CRGM : A. Love, P. Nseka, E. Kongota Université d'Adelaïde (Australie): S. Glorie , A. Donnelly
URL	http://
Dates	Début : 3/2016 Fin : 3/2018
Description générale du projet	Après l'étude de Boma Ouest et les découvertes importantes faites sur le socle, il est devenu important de voir la géologie de Boma Est dans le massif de Mao peu visité dans le passé mais important pour la compréhension de la géologie de Boma et du Kongo central. Référence aux projets 5(AWCO) et 12 (CRGM)
Évolution et résultats pour l'année écoulée	Une deuxième incursion a permis de pénétrer (en pirogue et à pieds) le massif avec établissement de deux camps au cœur de celui-ci. De nombreuses données ont pu être récoltées mais la forêt primaire a bloqué les équipes dans la progression vers le nord du massif. Des travaux structuraux ont permis d'élaborer un nouveau modèle géodynamique de la région du Kongo Central. De ce nouveau modèle géodynamique du Kongo Central et des nouvelles données du massif deux publications sont en cours et seront présentées au CAG27 (Aveiro, juillet 2018)

<u>Projet 17</u>	
Nom (et acronyme)	Etude de la diamictite inférieure dans la région de Kimuaka (Kongo central, RDC)
Financement	Source : DGD-MRAC Budget : 30000€
Partenaires	Responsable interne : Daniel Baudet Collaborateurs internes : M. Fernandez, D. Delvaux, L. Tack Collaborateurs externes : CRGM : P. Muanza, P. Nseka Université d'Adelaïde (Australie): S. Glorie , A. Donnelly
URL	http://
Dates	Début : 3/2016 Fin : 3/2018
Description générale du projet	Après l'étude de la diamictite inférieure sur l'avant pays, au massifs de Kimbundu et de la Sansikwa, c'est dans la zone plissée qu'il fallait poursuivre l'étude de cette diamictite et comparer avec les observations des études précédentes. Kimuaka et Isangila représentent les deux meilleurs lieux pour l'étude la diamictite inférieure, l'un pour la constance de sa coupe et l'autre pour la qualité de ses affleurements. Référence aux projets 5(AWCO) et 12 (CRGM)
Évolution et résultats pour l'année écoulée	Des travaux complémentaires ont eu lieu sur le terrain cette année et une publication est en cours de rédaction sur cette diamictite en particulier avec les nouvelles données géochronologiques.
<u>Projet 18</u>	
Nom (et acronyme)	Etude minéralogique et géochimique des pegmatites dans la région de Boma (Kongo central, RDC)
Financement	Source : DGD-MRAC Budget : 15000€
Partenaires	Responsable interne : Stijn Dewaele Collaborateurs internes : D. Baudet

	Collaborateurs externes : CRGM : D. Ilito Université d'Adelaïde (Australie): S. Glorie
URL	
Dates	Début : 3/2016 Fin : 3/2018
Description générale du projet	Les études récentes de la région de Boma Ouest (Shinkakasa) en regard des données anciennes font suspecter la présence de pegmatites panafricaines et un inventaire de ces pegmatites revêt une grande importance. Référence aux projets 5 (AWCO) et 12 (CRGM)
Évolution et résultats pour l'année écoulée	De nouveau des travaux ont été préparés pour échantillonner l'île de Mateeba mais la société présidentielle du GEL n'a pas donné les autorisations. Le projet est en stand-by.

Autres activités – Andere activiteiten

Max Fernandez-Alonso, samen met Daniel Baudet

Bijdrage aan andere lopende onderzoeksprojecten in de DRC in samenwerking met D. Baudet; zie uitgebreide informatie daarover in het rapport van dhr. Baudet en het rapport van de Dienst Geodynamica en Minerale Rijkdommen.

- The Neoproterozoic West-Congo belt and its place in the Gondwana continent
- Etude du Supergroupe de la Mbuji-Mayi
- Etude du socle du Kongo Central

Bijdrage aan het Raamakkoord project "GEOKIVU" voor wat betreft het luik regionale geologie van Kivu. Zie uitgebreide informatie daarover in het rapport van de dienst Natuurlijke Risico's.

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Theodore Trefon

Sabbatical from MRAC working at the **World Resources Institute** in Washington DC. This provides significant visibility to MRAC's Congo expertise in central Africa because participation in frequent

meetings at World Bank, USAID, the world's major environmental NGOs (such as WWF and WCS) and the University of Maryland's forest cover monitoring team. Main tasks at WRI are writing project proposals for the Green Climate Fund and assisting team in USAID forest governance deliverables.

Missions: Yangambi Reserve in DRC with ERAIFT, Kinshasa and Brazzaville with WRIs central Africa forest team, Kinshasa for a USAID/CARPE planning meeting, Central African Republic for WRI/Green Climate Fund.

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Thierry De Putter

- Membre du Comité de Rédaction de la Revue Internationale de Géologie, Géographie et d'Ecologie Tropicales (Géo-Eco-Trop)
- Co-organisateur du Theme Day 2017 de la l'Académie Royale des Sciences d'Outremer « *Disasters and resilience in the 21st century – a multidisciplinary workshop* » (11 décembre 2017)
- Membre titulaire de l'Académie Royale des Sciences d'Outremer
- Membre du Conseil National des Sciences Géologiques (Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique)

Missions : Madagascar (Mai 2017) avec les collègues de l'Université de Rennes-1 (France) : étude des paléosurfaces de cette région de l'Afrique ; Alba Fucens (Italie ; août 2017), dans le cadre de la fouille ULB-MRAH : étude des *crustae* de marbres colorés du 1^{er} siècle AD ; Medamoud (Égypte ; octobre 2017), dans le cadre de la fouille IFAO-Sorbonne : étude de la provenance des calcaires en œuvre dans le temple de Montou.

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Damien Delvaux

Damien Delvaux as Editor-in-Chief of the Journal of African Earth Sciences: refreshing of the Editorial Board and improvements of the quality and speed of then journal. This offers a significant visibility of the MRAC expertise on the geology of Africa.

Missions:

- Investigation of the bimodal magmatism in the West-Congo belt (Congo Central), its relations with the crystalline basement and tectonic evolution.
- Investigation of supergene formations around the Pool (Kinshasa/Brazzaville) and evidence of an important fault zone along the Congo River between Kinshasa and Brazzaville, formed during the opening of the Atlantic and which could be reactivated under the present-day stress field and generate earthquakes. This was an opportunity to establish cross-border collaborations with the University of Brazzaville

- Geological field investigations in the South Kivu region, RDC, for improving the knowledge of the regional geological and tectonic evolution. Evidence of a new carbonatite complex at Idjiwi Island.
- Edition of a special issue of GeoEcoTrop on Geohazards in the Great Lakes Region of Central Africa (volume 41/2) containing 10 articles issued from the RGL_Georisk capacity building project in the Kivu rift region.
- Reconnaissance mission to the Sinda-Mohari region of the lower Semliki in the late Miocene—Pliocene sediments of the Lower Semliki basin (Albertine Graben, DRC), for their potential of paleo-anthropological studies. This was the first scientific visit in this key region since the 1989-1990 Japan expedition.
- Organisation of a course as invited lecturer on the Geology of the East African Rift at the new School of Mining and Geology of the University of Rwanda.

Bezoekers: onderzoekers, gebruikers van bibliotheken, stagiairs, enz.

- Quatre chercheurs du CRGM ont été reçus au MRAC en 2017 dans le cadre des projets PROJET S1_RDC_CRGM : Aimée Love Pay, Guylain Fukiabantu, Elvis Kongota et Patty Nseka
- Visite de F. Boudzoumou (RP Congo) et réunion de travail sur la géologie du Pool (décembre 2017).
- Visite de A. Pedro-Suares et F. Da Silva avec réunion de travail avec J. De Grave et G. Van Ranst sur l'évolution des travaux de CoBra.
- Geodoc : quelques visiteurs

Voordrachten tijdens conferenties

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Bouzeguella-Talimat, S., Bonin, B., **Liégeois, J.P.**, Benmerzoug-Bechiri, F., Khaloui, R., 2018. Interactions between dioritic and granodioritic magmas within the Pan African Amsel batholith (Central Hoggar, Algeria): an approach through the study of plagioclase crystals. 27th Colloquium of African Geology, Oviedo, Portugal.

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Andere

Max Fernandez-Alonso, Thierry De Putter: reviewers van peer-review journals: Precambrian Research (IP 3.843); Journal of African Earth Sciences (IP 1.420); Tectonophysics (IP 2.693); Lithos (IP 3.677); *Mineralium Deposita*; *Acta Geologica Sinica*; Journal of Egyptian Archeology (TDP); *Bibliothecas Orientalis* (TDP)

Jean-Paul Liégeois :

- top 1% reviewer in Earth and Planetary Sciences; reviewer pour Precambrian Research (6); International Journal of Earth Sciences (3); International Geology Review (3); Terra Nova (2); Journal of African Earth Sciences (2); Arabian Journal of Geosciences (2); Earth-Science Reviews (1); Gondwana Research (1); Geological Society of America Bulletin (1); Lithos (1); G-Cubed (1); Geologica Belgica (1); 1 review pour 3 contributions pour le livre Geology of the Arab World (Springer); 1 rapport de thèse (Emma Gulen, Université Complutense de Madrid);
- Éditeur Associé du Journal of African Earth Sciences;
- Member Editorial Board of Estudios Geologicos (Spain); Lithos; Geologica Belgica; International Geology Review; Arabian Geofrontiers.

Damien Delvaux de Fenffe: Reviews de 7 manuscripts, pour Natural Hazards, Tectonophysics, Geology, Precambrian Research, Arabian Journal of Geosciences, Tectonics

External Reviewer de la thèse de doctorat d'Anna Traforti, Università degli Studi di Padova.

Digitalisaties en online zetten van de collecties

<u>Project 1</u>	
Naam (en acroniem)	Earth Sciences Geodata Information System - EARTHGIS
Financiering	Bron: intern – Knowledge Center Budget:
Partners	Intern verantwoordelijke: <u>Max Fernandez-Alonso</u> Interne medewerkers: Pascale Lahogue, Florias Mees, Philippe Vignaux, Externe medewerkers:
URL website	
Data	Begin: juni 2017 Einde: november 2017

Algemene beschrijving van het project

The Earth Sciences Department manages 23 collections covering (central-) African geology, ranging from old/historic field notes of geological and scientific expeditions in the late 19-th century to present-day geochemical ICPMS analysis results on geological samples and telemetric seismic and differential GPS data collected along the East-African rift. Some of these collections are unique and/or original (see appendix last page), as RMCA is probably the only place in the world where all this information pertaining central-African Earth and Environmental Sciences can be found together.

For most of these collections (meta)databases exist, as data digitizing and capture started already more than 20 years ago and still continues with ups and downs according to the changing personnel means of the department. Most databases are however still incomplete (see appendix), either due to the sheer size of the collection (thousands of items), and/or its complexity or due to the lack of scientific and/or technical personnel required for pre-encoding work.

This on-going activity results today in a series of databases that already contain - although uncomplete - large amounts of information that unfortunately remains often difficult in access for the non-specialized, hence under-exploited. This is mainly due to having started almost 2 decades ago with (meta)database development, while at the time a technical solution was found for each individual collection that mostly mimicked the management of the original paper-based procedures. Today it is realized that this was not always according to best-practices, and the department is confronted to the situation of having a variety of non-standardized (meta)databases running on different versions / generations of software and language (excel, access, xml,) that cannot be inter-connected and are prone to lose functionality with each future upgrade/ update of operation systems.

Subsets of some of these (meta)databases are today successfully being publicized for the professional public through on-line internet applications that use present-day standard data-encoding rules and software (e.g. rdcmining, geokivu, cartesius, libis, museum website, OneGeology, ...). However the Earth Sciences department itself does not possess until now a unified, standardized, quick and user-friendly in-house (intranet)application and/or database system that caters to its own needs and provides access to the information that is available in its own collections. This proposal aims at providing a solution for this shortcoming by developing for the Earth Sciences department an in-house geodata system that will open up its existing databases for its own scientific research and –services purposes.

To achieve this, we proposed to build on the experience acquired during the development of the existing internet applications OneGeology, RDCMining, Geokivu, Cartesius, Museum Website (mineral database), to design a single in-house intranet portal that will allow data consultation through tabular (SQL / XML) and/or map (GIS) -based queries. Data will be exported from the existing databases and stored on a central database server system according to the type of collection; each database architecture designed in accordance to the present-day international standards for digital geodata (INSPIRE, OpenGIS, GeoSciML, ...) and using Open-Source languages and systems.

Priority will be given to these collections that were earmarked of high importance (P4) in a recent survey carried out by the Earth Sciences department (see

	<p>appendix). It is envisaged that on the medium to long term, all the collections earmarked P3-P1 must become accessible through the geodata portal.</p> <p>EARTHGIS development started with 5 priority databases: minerals, geology, mineral deposits, maps+airphoto, archives. This development is based on the existing "rdcmning" internet application, which is being adapted / converted to an intranet tool to provide access for (in the future all) data repositories of the geology department. Access / queries are / will be possible either text-based or through a WebGIS map interface.</p>
Evolutie en resultaten voor het afgelopen jaar	The EARTHGIS will be operational first quarter 2018.

<u>Project 2</u>	
Naam (en acroniem)	Natural Heritage (luik Geologie)n
Financiering	<p>Bron: Belspo</p> <p>Budget:</p>
Partners	<p>Intern verantwoordelijke: <u>Max Fernandez-Alonso</u></p> <p>Interne medewerkers: Pascale Lahogue, Florias Mees, Philippe Vignaux,</p> <p>Externe medewerkers:</p>
URL website	
Data	<p>Begin: mei 2017</p> <p>Einde: december 2019</p>
Algemene beschrijving van het project	<p>European natural science collections contain the largest and most significant part of the world's scientific knowledge of the earth's structure, environment and biosphere. They constitute a key international research infrastructure for tackling major socio-economic and scientific challenges. The Belgian collections cover all the fields of Natural History including Zoology, Botany, Geology, Palaeontology and Anthropology. Belgian scientific institutions house some 55 million specimens and is one of the most important collections relating to Natural Sciences worldwide. The 3 collection partners of this project are members of CETAF, the Consortium of European Taxonomic Facilities, which contributes to Europe's knowledge-base by enhancing synergy between the collections and research capabilities of its members. CETAF facilitates the normalization of data and metadata in Natural Sciences databases as well as the implementation of unique identifiers for collection specimens, which is essential data aggregation. Several European Natural History Institutions are presently working on a proposal for the coming ESFRI Roadmap 2018. This initiative, called DiSSCo (Distributed System of</p>

Scientific Collections), is a long-term project aiming to ensure open access to European natural history collections thereby broadening the user community and finding innovative solutions through the use of natural science related data. As partner of NaturalHeritage CETAF will be the interface between the project and the other European institutions active in the domain. The three Belgian institutions RBINS, RMCA and APM have a long history of collaboration and have for the past 15 years formed the informal yet solid Be-TAF consortium. The directors and middle management of the 3 institutions take strategic decisions for joint activities as well as defining Belgium's position in the national and international arena. They also form the National Task Force (NTF) for the Belgian participation in DiSSCo, write proposals together and represent each other at key meetings where relevant. The three institutions have appointed staff members to play the role of facilitators and following up the Be-TAF joint activities, namely Patricia Mergen for RMCA and APM, and Carole Paleco for RBINS. Despite Be-TAF not being a legal entity, the 3 partners regularly sign more formal Memoranda of Understanding or Collaboration Agreements where objectives are clearly stated and the roles of each partners defined. The intention to sign a 5 year MoU for a joint digital collection management agreement including this Natural Heritage.be activity, if it is funded. More than a decade ago, RBINS decided to develop an "in-house" solution, called DaRWIn. The current version, still used by RBINS and more recently also by RMCA, is an Open Source system. However, it was built as a system predominantly taxonomically based to accommodate information for RBINS Natural History collections. The recent ratification of the Nagoya Protocol by the EU members and its implementation, as well as the impact of other European protocols related to access to public data (INSPIRE, Open Data, Open Science) define also a new framework of collaboration where interoperability between different data sources are crucial. The fast evolution in programming and data exchange together with the exponential development of web- and cloud-based applications can provide distributed access to a wide variety of geo-coded or geo-referenced natural sciences information. This imposes now the use of a totally new architecture, with the interconnection of separate modules covering the different disciplines in the Natural Sciences at its core. This interoperability both within the NaturalHeritage.be portal, as well as outside with other sources of references and/or with other similar on-line collection systems will help scientists and decision makers to address Belgian Natural History Collections using cross-linked and big-data approaches. The project will research and evaluate how a modular architecture can address these new requirements. This architecture will be based on two levels of interoperability between small modules and with international authority files. Based on this research, the project will develop a new database system and search portal so that there is an interoperation between all the Belgian natural history collections. The consortium will valorise the long term existing in-house expertise in Open Source systems in the three collection-based institutions in order to reach the expected goals, respecting the workflow in each institution. Open source technologies allow resource sharing for development and maintenance, thus ensuring sustainability. Proven functionality in the existing version of DaRWIn will be transferred to the new system with enhancements. New modules will be developed for geological, botanical and living collections. The rendering of embedded multimedia files hosted by external specialized platforms will be added. A common search portal overlaying the local query interfaces with interoperable databases that use compatible technologies will reinforce synergy between partners by establishing links between data which are unconnected at present (e.g. relationship between soil/substrate, vegetation and associated fauna). This approach will also improve cross-validation of data

	and avoid multiple encoding, which is time-consuming and a source of error. To achieve modularity of NaturalHeritage.be and to insure independence of each module, we will implement all of them by extending the principle of dependency injection based on a service container (or dependency injection container). Each module will therefore be a service provided by the application, which can stand alone or in combination with others as required. The dependency between modules is therefore dynamically constructed and unique to each installation or to each “orientation” in the application (Zoology, Botany, Geology and Palaeontology)
Evolutie en resultaten voor het afgelopen jaar	Het project is in mei 2017 opgestart. In de loop van oktober 2017 is er een aanvang genomen met het deelluik geologie met de ontwikkeling van het datamodel voor de geologische collecties.

Project 3	
Naam (en acroniem)	Mirror CRGM - rdcmining
Financiering	Bron: intern – RAAC Knowledge Centre Budget:
Partners	Intern verantwoordelijke: <u>Max Fernandez-Alonso</u> Interne medewerkers: Pascale Lahogue, Florias Mees, A. De Muêlenaere, F. Theeten Externe medewerkers: Trésor Kadima, Toutou Ibia (CRGM Kinshasa)
URL website	
Data	Begin: februari 2015 Einde:
Algemene beschrijving van het project	Te CRGM in Kinshasa werd een spiegel website van RDC mining, een on-line databank van geologische en mijnbouwdocumentatie in DRC (www.rdcmining.cd) en een spiegel website van het CABIN project geïnstalleerd (http://cabin.ebale.cd/CABINPortal/).
Evolutie en resultaten voor het afgelopen jaar	In 2017 werd een conventie opgemaakt en ondertekend tussen KMMA en CRGM voor de periode 2016-2018, voor update en onderhoud van de ICT infrastructuur waarop deze spiegelwebsite geïnstalleerd is.

Natural hazards and cartography

Évolution du personnel

A la fin de l'année 2017, le service Risques Naturels comprenait 11 scientifiques et 3 techniciens ; soit un scientifique de plus que l'an dernier. Il faut noter qu' Evelyne GILLES (Géodynamique et ressources minérales) est actuellement partiellement mise à disposition du Service et contribue au projet 8. Pascale LAHOGUE (Géodynamique et ressources minérales) contribue également à la réalisation du projet 8. Théodore Tréfon reste pour 1/5 de son temps membre de l'équipe Risques Naturels, ce qui s'est matérialisé par sa contribution au projet 2 (GeoRisCA).

Départ	Arrivée
Didier VAN AUBEL (30 juin) Liesbet JACOBS (30 septembre)	Fils MAKANZU IMWANGANA (01 mai)

Projets : de recherche, expositions, activités éducatives, de communication

Projet 1 : Projet « focus »	
Nom (et acronyme)	Focus on the PhD researchers
Financement	Source : Various sources (BELSPO being the principal one) Budget :
Partenaires	Responsable interne : François KERVYN and Olivier DEWITTE Collaborateurs internes : Caroline MICHELLIER, Liesbet JACOBS, Elise MONSIEURS, Adalbert MUHINDO SYAVULISEMBO, Antoine DILLE
URL site web	h
Dates	Début : Fin :
Description générale du projet	This project is the focus project for the 2017 annual report. It highlights the contribution of the five PhD students who have been active in the Service in 2017. Their involvement is highly connected to the research project described below

<p>Évolution et résultats pour l'année écoulée</p>	<ul style="list-style-type: none"> • Caroline Michellier a réalisé sa thèse de doctorat dans le cadre du projet GeoRisCA (http://georisca.africamuseum.be). Ses recherches avaient pour objectif de contribuer à la prévention des géorisques en évaluant la vulnérabilité de la population des villes de Goma et de Bukavu en RD Congo. Caroline a défendu sa thèse en 2017. • Liesbet Jacobs mène des recherches sur la prédiction spatiotemporelle des glissements de terrain, en utilisant différentes méthodes allant de la récolte de données sur le terrain et du crowdsourcing à la modélisation statistique. Liesbet réalise sa thèse dans le cadre du projet AfReSlide (http://afreslide.africamuseum.be/) et la défendra début 2018. • Elise Monsieurs étudie l'influence des précipitations sur les glissements de terrain en région tropicale, dans le contexte du changement climatique. Elle a entamé sa thèse dans le cadre du projet RESIST (http://resist.africamuseum.be/), puis avec une bourse du F.R.S.-FNRS. Grâce à une bourse de la Belgian American Educational Foundation (BAEF), elle a effectué un séjour d'un an à la NASA. • Adalbert Muhindo Syavulisembo étudie la vulnérabilité spatiotemporelle de la population de Goma face aux risques volcaniques. Réalisé dans le cadre des projets GeoRisCA et RESIST, son travail est soutenu par la Coopération belge au Développement (DGD). • Antoine Dille a entamé sa thèse en 2017. Grâce aux techniques de télédétection, il étudie les dynamiques des glissements de terrain en environnement urbain, en particulier à Bukavu, à l'est de la RD Congo. Ses travaux sont financés à travers le projet RESIST.
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<p>Projet 2 :</p>	
<p>Nom (et acronyme)</p>	<p>Geo-Risk in Central Africa: integrating multi-hazards and vulnerability to support risk management (GeoRisCA)</p>
<p>Financement</p>	<p>Source : BELSPO - Science for a Sustainable Development (SSD) programme</p> <p>Budget : 471.543 EUR (total 998.158 EUR)</p>
<p>Partenaires</p>	<p>Responsable interne : François KERVYN (coordinateur projet)</p> <p>Collaborateurs internes : Damien DELVAUX, Olivier DEWITTE, Caroline MICHELLIER, Adriano NOBILE, Benoît SMETS, Philippe TREFOIS, Théodore TREFON</p> <p>Collaborateurs externes :</p> <p>Nicolas D'OREYE^{1,2} BENOÎT SMETS² ¹Musée National d'Histoire Naturelle du Luxembourg / ²European Centre for Geodesy and Sismology (ECGS)</p> <p>Hans-Balder HAVENITH (WP leader) Université de Liège (ULg)</p> <p>Matthieu KERVYN (WP leader) Sam POPPE</p>

	<p>Vrije universiteit Brussel (VUB)</p> <p>Eléonore WOLFF (WP leader) Caroline MICHELLIER Université Libre de Bruxelles (ULB)</p>
URL site web	http://georisca.africamuseum.be/
Dates	<p>Début : 01/05/2012</p> <p>Fin : 28/02/2017</p>
Description générale du projet	<p>La région autour des lacs Kivu et Tanganyika est soumise à différents types d'aléas qui menacent la population densément distribuée dans toute cette zone. Les séismes touchent régulièrement toute la région, et peuvent être à l'origine de dégâts importants, autant matériels qu'humains. La chaîne volcanique des Virunga, qui s'étend dans la province du Nord Kivu en République Démocratique du Congo (RDC) et dans le Nord du Rwanda, comptent deux volcans actifs, le Nyiragongo et le Nyamulagira, qui menacent en permanence la population des villes de Goma (RDC) et de Gisenyi (Rwanda). Enfin, les glissements de terrain, dont les processus variés peuvent être soudains, sont à l'origine des plus fréquentes catastrophes d'origine géologique qui surviennent dans cette zone. En outre, la région souffre d'un faible niveau économique et de conflits armés récurrents qui contribuent à affaiblir encore davantage la population menacée.</p> <p>Le projet GeoRisCA (http://georisca.africamuseum.be) réalisé dans le cadre du programme SSD (SD/RI/02A) de la Politique Scientifique belge (Belspo) avait pour objectif global de répondre à la nécessité d'étudier les risques d'origine géologique dans la région du lac Kivu, afin de contribuer à la prévention des risques, à l'échelle régionale et locale.</p> <p>L'étude a été menée à l'échelle régionale (principalement pour l'étude de l'aléa sismique) et également à l'échelle de deux sites urbains : Bukavu, chef-lieu de la province du Sud Kivu qui compte environ 870.000 habitants, une ville affectée par des mouvements de terrain fréquents, et Goma, chef-lieu de la province du Nord-Kivu où vivent environ 775.000 personnes sous la menace des coulées de lave du volcan Nyiragongo dont la dernière éruption date de 2002.</p> <p>Pour combler le manque de données fiables, de nombreux instruments de mesure ont été déployés et des méthodologies adaptées à ce contexte particulier ont été développées. Plusieurs bases de données ont été construites au cours du projet. Ces données ont constitué la base de la réalisation de cartes détaillées, aussi bien pour le suivi de l'évolution des aléas en présence, que pour la densité de population et ses caractéristiques démographiques jusque-là méconnues. La dernière étape du projet consistait à combiner spatialement l'évaluation de la vulnérabilité et la densité de la population aux analyses de susceptibilité aux glissements de terrain et de probabilité d'invasion des coulées de lave développées par les experts dans le cadre du projet GeoRisCA.</p> <p>Les cartes de risques obtenues constituent de nouveaux outils d'aide à la décision ; elles ont été transmises aux autorités locales et permettent d'une part le renforcement des politiques de réduction des risques de catastrophes et des programmes de prévention des catastrophes, et d'autre part, une nouvelle</p>

	<p>approche de l'aménagement du territoire. Enfin, il est important de souligner que cette recherche n'aurait pu être réalisée sans un étroit partenariat avec les institutions scientifiques et les autorités locales, et a significativement contribué à améliorer les interactions entre ces différentes parties prenantes.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>L'année 2017 a marqué la clôture du projet GeoRisCA. Après la restitution en décembre 2016, auprès des autorités des provinces du Nord et du Sud Kivu (RDCongo) des principaux résultats du projet GeoRisCA, des recommandations ont été formulées. En mai 2017, les représentants de la Protection civile du Nord et du Sud Kivu sont venus en Belgique pour une semaine de travail sur les cartes de risque de GeoRisCA, ainsi que des discussions sur la suite prévue pour la prise en compte de ces documents dans les plans de contingence et d'évacuation face aux risques d'origine géologique auxquelles sont soumises les villes de Goma et de Bukavu. Bien que l'avis de ces représentants ait été positifs, ces démarches pour l'intégration des documents sont toujours en cours.</p> <p>Le rapport final du projet a été rédigé et sera prochainement publié par Belspo (qui a financé le projet). En parallèle, un film d'une dizaine de minutes a été réalisé et est en cours de finalisation. Il sera mis en ligne sur YouTube prochainement. Tout en rappelant les principaux résultats de ce projet, il met en évidence son impact au niveau local, ainsi que le rôle des résultats dans le domaine de la prévention des catastrophes et de la gestion des risques naturels. GeoRisCA a posé les bases des connaissances sur les risques d'origine géologique dans la région et a permis de construire un large réseau de collaboration Nord-Sud, mais aussi Sud-Sud. C'est sur ces acquis que d'autres projets ont pu se développer et venir compléter les connaissances scientifiques obtenues dans GeoRisCA.</p>

<p>Projet 3</p>	
<p>Nom (et acronyme)</p>	<p>REmote Sensing and In Situ detection and Tracking of geohazards (RESIST)</p>
<p>Financement</p>	<p>Source : BELSPO – Research programme for earth observation "STEREO III"</p> <p>Budget : 370.393 (total = 978.713 EUR)</p>
<p>Partenaires</p>	<p>Responsable interne : François KERVYN (coordinateur du projet)</p> <p>Collaborateurs internes : Olivier DEWITTE (WP leader), Liesbet JACOBS, Elise MONSIEURS, Adriano NOBILE, Antoine DILLE, Benoit SMETS</p> <p>Collaborateurs externes :</p> <p>Nicolas THEYS (WP leader) Hugues BRENOT Belgian Institute for Space Aeronomy (IASB-BIRA)</p> <p>Dominique DERAUW (WP leader) Ludivine LIBERT Université de Liège (ULG)</p> <p>Nicolas D'OREYE (WP leader) Julien BARRIERE</p>

	<p>Gilles CELLI Halldor GEIRSSON Adrien OTH Benoît SMETS European Center for Geodynamics / Seismology (ECGS)</p> <p>Dalia KIRSCHBAUM (WP leader) National Aeronautics and Space Administration (NASA)</p>
URL site web	http://resist.africamuseum.be/
Dates	<p>Début : 01/12/2014</p> <p>Fin : 30/11/2018</p>
Description générale du projet	<p>The Kivu rift area is part of the East African rift system. It is also the most-populated region of Central Africa and exposed at the same time to the highest level of geohazards on the continent. This region includes the Virunga Volcanic Province (VVP) in eastern Democratic Republic of the Congo (DRC), the western part of Rwanda and Burundi, as well as southwest Uganda. A rare combination of seismic, volcanic and landslide hazards (with highly variable recurrence rates and potential impact) in conjunction with increased demographic pressure makes Kivu particularly threatened by natural disasters.</p> <p>The source mechanisms underlying the eruptive activity of the VVP's volcanoes as well as landslide triggering and dynamics in the region of interest are still poorly understood, even though in recent years, some progress has been made towards appropriate monitoring of these geohazards: Earth Observation (EO) tools are used for ground deformation monitoring, and the region was provided with its first GPS network. However, this geodetic network set apart, a serious lack of ground-based monitoring capabilities still exists. At the same time, new (expected) EO sensors (will) offer unprecedented capabilities and opportunities. RESIST will contribute to the understanding of the source mechanisms driving volcanic eruptions and landslides in the region by 1) filling the gap of knowledge on ground-based level through the installation of the densest seismic and infrasound network ever deployed in the region and first UV camera for SO₂ monitoring and 2) combining this information with innovative EO approaches, using both archived data and new space-born acquisition possibilities in radar, optic, gas and precipitation monitoring. RESIST will exploit ground-based instrument networks, field surveys and modern EO techniques (Split Band and MSBAS InSAR time-series, SO₂ flux, TRMM, GPM) to study and characterize the changes in the monitored parameters that could/should be considered as significant in terms of volcanic and landslide (LS) processes. The locations of ground based measurement stations will be chosen in order for the network not to be jeopardized as a whole by possible political unrest.</p> <p>Concerning volcanic signals, RESIST aims at gaining scientific insights into the mechanisms that lead to an eruption and what types of measurable phenomena and signals can be robustly considered as precursory information for eruptive activity. With respect to LS processes, the project will aim at gaining scientific insights into the rainfall characteristics that trigger the different types of LS at the regional scale. Both core objectives require measuring and monitoring ground deformations and benefit from the new dense seismic network.</p>

	<p>All methods used for InSAR time series, GPS, seismic location and event characterisation and classifications, high resolution optical imagery, SO₂ flux computation and determination of rainfall thresholds (TRMM, GPM) are based upon well-established techniques to be improved with novel approaches, providing a good balance between risk and reward. The excellent complementarity and long experience of RESIST partners already involved in previous projects in that region will warrant the feasibility of the ground-based segment.</p> <p>Through this multidisciplinary combination of these multiple data sets and methodologies, RESIST will contribute to an unprecedented understanding of deep and shallow earth processes responsible of critical geohazards in a highly sensitive region.</p> <p>By addressing the understanding of two of the mains hazards in the Kivu rift zone using complementary RS and ground-based measurement techniques and implying both local partners and an international partner, RESIST proposes innovative quality research. It furthermore capitalizes on a highly experienced consortium and successful projects.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>The project started 1st of December 2014. 2017 is therefore to be considered as the third effective year of the project.</p> <p>RESIST is framed around several monitoring networks unprecedented for this studied region that are now installed and operational. For the study of ground deformation linked to volcano-tectonic seismicity we now have the KIVU-G-NET (Kivu Geodetic Network) network which is composed of 15 GPS/GNSS permanent stations. The data processing chain has been made fully automated. The volcano-tectonic seismicity is also studied through a network of 13 seismic and 3 infrasound permanent stations providing near-real-time data. Processing of the data from these networks show first and promising results, notably in the location and characterization of the recent seismic events that stroke the region. SO₂ emissions by volcanoes are now being studied by a UV SO₂ camera that is installed a few kilometres from the city of Goma (DRC). For the study of the rainfall conditions behind the landslide processes, a network of 12 automatic raingauges (of which two are weather stations) is now installed along the rift flanks west of Lake Kivu (DRC).</p> <p>The other pillar of RESIST is framed around satellite remote sensing. For Radar data processing new tools and software are being developed. In parallel first applications on ground deformation linked to volcano and landslide processes have been studied. Results already allow to better characterize those processes. Very high resolution satellite optical remote sensing and UAV acquisition are also used. At this stage, only preliminary results are obtained and more data need to be acquired for further analysis. For SO₂ emissions, first time-series of SO₂ total masses over the Kivu Rift zone have been generated for the 2004-2014 period. Several eruptive events were clearly identified as well as increasing SO₂ emissions over the last years (presumably for recent activity at Nyiamulagira). For rainfall characterisation, a big step forward in the validation of the TRMM product has been made. This validation used, a.o. the rain gauge data from the RESIST network.</p> <p>For the volcanic study SAR images were acquired to study the 2011-2012 Nyamulagira eruption and the unrest episodes occurred at Nyragongo during the 2016. The displacement time series for the Nyamulagira eruption allowed to</p>

	<p>detect a very fast (one day) magmatic intrusion below the Eastern flank of the caldera two days prior to the eruption. It also allowed the detection of the subsequent intrusion that brought the magma up to the two eruptive vents located 11 km ENE from the caldera.</p> <p>Preliminary results for the inversion suggest that the eruption is a complex sequence of a deflation of a shallow magma chamber (~3km below the caldera) that fed a sill intrusion toward the ENE direction that twisted into a dyke and brought the magma up to the surface. During the two 2016 unrest episodes at Nyiragongo, InSAR data show small ground deformations inside the crater possibly associated to the emplacement and intermittent activity of the new spatter cone and to the lava lake fluctuations. However, due to the loss of coherence on the steep vegetated flank of the volcano, we was no able to detect ground deformations in the Northeastern area interested by the seismic swarm in November neither with Cosmo SkyMed (X-Band) or Sentinel-1 (C-Band) images.</p> <p>For the landslide study, inventories are still being compiled. We have been working on (1) collecting information on the timing of landslide occurrence (2) updating existing inventories, (3) extending our investigation to new regions, and (4) building regional susceptibility models. In total, we have mapped more than 5000 landslides Concerning the temporal data, we have an inventory counting up to now 200 localized and timed landslide events. The landslide inventory for Bukavu is now completed. This inventory based on intensive field work will serve for the validation of the remote sensing methods used to monitor some landslides. To improve our understanding of the processes and the remote sensing analysis, five DGPS field campaigns were carried out in Bukavu this year. Furthermore, InSAR time series were processed with different techniques to evaluate the deformation rate in this area. Results show that the landslide is divided into blocks that move with different velocities (up to 20 cm/yr), which is consistent with field observations and DGPS measurements. For two landslides (Funu and Ikoma), UAV acquisitions have been done, allowing high resolution characterization of the processes. Field observation is indispensable regarding ground truth collection and interpretation of geomorphological processes which only had been observed by remote sensing prior to a field campaign. This year, a total of four field campaigns were carried out.</p>
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Projet 4	
Nom (et acronyme)	Landslides in Equatorial Africa: Identifying culturally, technically and economically feasible resilience strategies (AfReSlide)
Financement	<p>Source : BELSPO- Belgian Research Action through Interdisciplinary Networks (BRAIN-be)</p> <p>Budget : 157.500 (total = 919.447 EUR)</p>
Partenaires	<p>Responsable interne : Olivier DEWITTE (WP leader)</p> <p>Collaborateurs internes : Liesbet JACOBS, Elise MONSIEURS, Adriano NOBILE</p> <p>Collaborateurs externes :</p> <p>Matthieu KERVYN (coordinator)</p>

	<p>Jan MAES Vrije Universiteit Brussel (VUB)</p> <p>Liesbet VRANKEN (WP leader) Kewan MEERTENS Katholieke Universiteit Leuven (KUL)</p> <p>Véronique JOIRIS (WP leader) Astrid de HONTHEIM Université Libre de Bruxelles (ULB)</p> <p>Jean POESEN (WP leader) Katholieke Universiteit Leuven (KUL)</p>
URL site web	http://afreslide.africamuseum.be/
Dates	<p>Début : 01/10/2014</p> <p>Fin : 30/10/2018</p>
Description générale du projet	<p>Landslides (LS) cause significant impacts in many equatorial regions. Their impact depends on their size and speed, the elements at risk and the vulnerability of these elements. This problem is particularly acute in Equatorial Africa characterized by mountainous topography, intense rains, deep weathering profiles, high population density and high vulnerability to geohazards. Every year LS cause fatalities and result in structural and functional damage to infrastructure and properties. Losses from LS are expected to increase in the future in response to the demographic pressure causing more development in landslide-prone areas (LSPA), deforestation and associated changes in land use and land cover, and the changing climate causing higher or more intense rainfalls.</p> <p>Many studies investigated how natural factors and human activities control the occurrence or re-activation of LS. These studies typically deliver susceptibility maps but these are insufficient to lead to efficient risk management. Building resilience requires to have a true hazard estimate, accounting not only for the spatial distribution of future LS but also for their temporal occurrence and the hazard intensity, to quantitatively analyse the socio-economic consequences of LS and to identify effective resilience strategies that are cost-effective, technically efficient and that are culturally acceptable and adapted to the livelihoods of the vulnerable population. Such an analysis is crucial as it enables to provide practical recommendations for households and policy makers to mitigate LS-related damages.</p> <p>This project focuses on 4 representative study areas known for having suffered severely from rainfall-triggered LS in Uganda (Mount Elgon, Mount Rwenzori) and SW and NW Cameroon (Mount Cameroon, Bamenda). In two of these regions, some preliminary studies on LS characteristics and susceptibility mapping have been carried out, while hazard maps, a socio-economic impact analysis and resilience strategies are completely lacking. This project follows a bottom-up approach where the specific research questions, scientific data and research outputs are designed in collaboration with, and according to the needs of, the local communities and stakeholders via stakeholder meetings and participatory data collection approaches.</p>

	<p>Information on LS is far more limited in Equatorial Africa compared to other continents. There are very few data at the continental and regional scale and it is difficult to have a clear picture of the total area affected. One of the challenges and objectives of this project is therefore to develop a methodology for resilience analysis adapted to this data-poor environment. The project will combine detailed field and remote sensing characterization of LS, socio-economic surveys of LS impact on household's livelihood, and anthropological approaches of LS perception and possible resilience strategies.</p> <p>The specific objectives of the present project are:</p> <ol style="list-style-type: none"> 1. to produce LS susceptibility maps and identify return periods of LS-triggering rainfall events to estimate hazards for 4 representative study areas; 2. to analyse the types of elements at risk (immaterial and material) and their exposure, and to develop a methodology to economically value the consequences; 3. to assess current and potential resilience strategies at household and at policy levels; 4. to analyse the cultural premises underlying perceptions of environmental threats, to describe land rights and land management, and to identify culturally acceptable resilience strategies; 5. to produce risk maps and provide recommendations for the most effective resilience strategies. <p>The output of the project will take the form of GIS databases for each study area, together with quantitative datasets and written recommendations for stakeholders. Based on results from several case study areas in the different target regions in Cameroon and Uganda, a <i>Manual of Do's and Don'ts for Enhanced Landslide Resilience: Lessons learned from Failures and Successes</i> will be produced with and for local stakeholders managing LS risk and local development.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>This report documents the achievements of the AfReSlide consortium in the fourth year of the project which effectively started in January 2014.</p> <p>Here we describe only the tasks and results linked to RMCA contribution in the project. The fourth year of the project was mostly dedicated to data analysis and valorisation. However, we remained present in the field with field work and surveys carried out in the Rwenzori Mountains, one of the key study areas within AfReSlide.</p> <p>For the LS hazard analysis (WP1), the results of extensive field work conducted in the Mt. Rwenzori was valorised in two peer-reviewed international publications. Quantitative susceptibility analysis have been at the core of this. Several approaches tailored on the AfReSlide study areas were developed. As a result, the first landslide susceptibility assessments for the Rwenzori mountains are now available. Meanwhile, the collection of rainfall data in both the Rwenzori Mountains as well as the Bamboutos is ongoing in the framework of the final task, the hazard assessment. Together with this rainfall data collection, a geo-observer network made of 20 local observers directly active in the field was set up in the Rwenzori region, allowing to collect numerous accurate data on various processes in a very short period of time.</p>

	<p>Finally, with regard to the valorization (WP6) of the AfReSlide project, regular 3-month meetings allow the discussion of the research strategy, preliminary results and interactions between the different WPs. The scientific results of AfReSlide have been regularly presented at national and international conferences and in 2017,. Dissemination of the project results towards policymakers and stakeholders is made through the biannual newsletter and the project website.</p> <p>During this year, Liesbet Jacobs wrote here PhD manuscript (thesis defence 09 January 2017).</p>
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Projet 5	
Nom (et acronyme)	Développement des capacités en observation et étude des géorisques dans la Région des Grands Lacs (S1_RGL_GEORISK)-suivi
Financement	<p>Source : DGD</p> <p>Budget : suivi</p>
Partenaires	<p>Responsable interne : Damien DELVAUX et François KERVYN (coordinateurs)</p> <p>Collaborateurs internes :</p> <p>Olivier DEWITTE, Caroline MICHELLIER</p> <p>Collaborateurs externes :</p> <p>Katcho KARUME, Directeur Général Observatoire Volcanologique de Goma (OVG), Goma, RDC</p> <p>Sivanos FIAMA BONDO, Chercheur Centre de Recherches en Sciences Naturelles (CRSN), Lwiro, RDC</p> <p>Jean Berckmans MUHIGWA, Professeur Université Officielle de Bukavu (UOB), Bukavu, RDC</p> <p>Rigobert BIRHEMBANO, Professeur Institut Supérieur Pédagogique (ISP), Bukavu, RDC</p> <p>Pascal NKURUNZIZA, Professeur Université du Burundi, Bujumbura, Burundi</p>
URL site web	
Dates	<p>Début : mai 2016</p> <p>Fin : avril 2018</p>
Description générale du projet	La région du lac Kivu et du Nord-Tanganyika en Afrique centrale (RDC, Burundi, Rwanda ; région dite des Grands Lacs), est soumise à une combinaison d'aléas géologiques (volcanisme, séismes, mouvements de masses, émanations de dioxyde de carbone, éruption limnique..) dont la concentration exceptionnelle en une même région combinée à une forte densité de population en constante

	<p>augmentation rend le problème des géorisques particulièrement aigu. Ces aléas sont liés à l'activité géodynamique particulièrement intense de cette région du rift est-africain. D'autre part, cette région manque de spécialistes qualifiés en mesure de comprendre et d'étudier ces processus. Les institutions scientifiques et universitaires locales n'ont pas non plus les capacités suffisantes pour les étudier et former des spécialistes en la matière. Elles manquent aussi de moyens modernes d'observation et de surveillance de cette manifestation de la géodynamique (sismicité et déformation crustale) ainsi que du facteur climatique qui peut influencer les mouvements de masse. En conséquence, ces aléas ne sont pas pris en compte dans la politique de développement régionale par les autorités et société civile (bénéficiaires finaux du projet).</p> <p>Le projet S1_RGL_GEORISK vise à renforcer les capacités des instituts scientifiques et universitaires locaux (groupes cibles) à la formation, la recherche et le monitoring dans le domaine des géorisques. L'objectif est de former des scientifiques et de produire des informations utiles à même de pouvoir conscientiser, conseiller et aider les bénéficiaires finaux à prendre en compte ces facteurs dans leur politique de développement régional, au bénéfice de la population. Il s'étend sur 3 années et permettra de donner à une vingtaine de spécialistes une formation de base et une pratique de la recherche dans le domaine des géorisques. Il s'appuie en outre sur l'installation de 3 nouvelles stations d'observation (comprenant chacune sismomètre, GPS et senseur météo) afin d'améliorer les capacités des 5 institutions de recherche et d'enseignement pour l'observation et d'étude des géorisques.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>Les activités liées à ce projet ont été essentiellement liées à la publication d'un volume spécial dans la revue Geo-Eco-Trop rassemblant les contributions liées aux résultats obtenus durant la première phase de RGL. Chacune des publications a été réalisée avec les participants locaux. Cet exercice nous a permis de leur montrer la manière avec laquelle une publication se met en place ; renforçant ainsi leur capacité d'analyse, de synthèse, d'écriture et de communication. Le volume est disponible en open access : http://www.geoecotrop.be/index.php?page=numero-41</p>

<p>Projet 6</p>	
<p>Nom (et acronyme)</p>	<p>Projet Monographies des provinces de la DR Congo</p>
<p>Financement</p>	<p>Source : DGD/accord cadre Budget : N/A</p>
<p>Partenaires</p>	<p>Responsable interne : Mohamed LAGHMOUCH Collaborateurs externes : Jean Omasombo (MRAC) (coordinateur du projet)</p>
<p>URL site web</p>	
<p>Dates</p>	<p>Début : 2009 Fin : 2018</p>

Description générale du projet	La contribution de la Section au projet PROVINCES consiste en l'appui cartographique –création, mise à jour– des cartes des 26 nouvelles provinces de la RDC. Par son approche systématique, et la confrontation des informations à celles fournies par les équipes locales de terrain, ce travail est une avancée importante pour la cartographie de la RDC. Pour les besoins des monographies, différents types de cartes sont produits : administratives, occupation du sol, géologique, et orographique. Le projet a été étendu jusqu'à 2018.
Évolution et résultats pour l'année écoulée	Les documents passent par une étape intermédiaire qui aboutit dans un premier temps à la production de cartes provisoires, validées ensuite avant l'édition finale grâce aux informations fournies par les équipes locales. En 2017, les cartes suivantes ont été publiées : Carte administrative et routière de Kasai (version 2), RDC au 1 : 750.000 Carte administrative et routière du Haut-Katanga (version 2), RDC au 1 : 750.000

<u>Projet 7</u>	
Nom (et acronyme)	Rwenzori Ice Dynamics and Environmental Changes (RIDECE)
Financement	Source : Commission Européenne : projet postdoc "Marie Curie" Budget : 172.800 EUR
Partenaires	Responsable interne : François Kervyn (promoteur) et Denis SAMYN (coordinateur et principal acteur du projet) Collaborateurs internes : Liesbeth JACOBS Collaborateurs externes : E. BERTHIER (LEGOS-CNES, Toulouse, FR) T. MÖLG (Friedrich-Alexander Univ., Nuremberg, GER) A. KLEIN (Texas A&M Univ., USA) B. KULESSA (Swansea Univ., UK) L. NICHOLSON (Innsbruck Univ., AUT) G. KASER (Innsbruck Univ., AUT) J. UETAKE (NIPR, JAP) S. LAMBOT (UCL, BEL) D. VERSCHUREN (UGent, BEL) F. PATTYN (ULB, BEL) UNESCO (Div. Environment)
URL site web	http://www.africamuseum.be/home/contact/staff/SAMYN_Denis/project_view
Dates	Début : 07/09/2015 Fin : 031/01/2018
Description générale du projet	At the border between Uganda and the D.R. of Congo, the Rwenzoris form a remote and high-altitude mountain range stretching through the East African Rift System. With heights of 4-5 km, they include Africa's third highest peak (Mt. Stanley, 5109 m) as well as some of the last African glaciers. The combined area of

	<p>the Rwenzori glaciers declined by more than 75% during the 20th century, and halved between 1987 and 2006. This extreme mass loss may have strong implications for the local hydrology, ecosystems and communities, and recent estimates suggest that the glaciers will disappear in the next decade(s).</p> <p>This trend correlates well with similarly dramatic glacier retreats on Mt Kilimanjaro (Tanzania) and Mt Kenya (Kenya) during the same period, and is attributed to increased air temperature or reduced humidity/cloud cover. Despite recent work on the evolution of glacier extent in the last decades, the measured glacier retreat, as well as the interpretation of the driving climatic factors responsible since the 1980's, remain controversial and are limited to available data.</p> <p>In order to better understand the dynamics of this recession, we will survey the current state of the two largest Rwenzori glaciers, Stanley and Speke glaciers, using a panel of remote sensing, geophysical and geochemical methods. These include, first, surveying of glacier extents over the last decades using satellite imagery, mapping of the current glacier extent and main features using differential GPS, and assessing the glacier thicknesses using ice-penetrating radar. These three steps will allow for further ice flow modeling. Second, the use of weather station data in the glacier vicinity as well as ice/water sampling for geochemical analysis will allow investigating the glacier sensitivity to the changing climate and its (palaeo-)environmental potential.</p> <p>These results will be compiled with a view to provide a first estimate of modern, past and future ice budgets in the area of interest.</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>L'année 2017 a débuté avec la seconde expédition RIDEC dans le massif des Rwenzoris (Ouganda/R.D. Congo), avec pour finalité la cartographie des glaciers principaux (Speke Glacier et Stanley Glacier) en conjonction avec des mesures géophysiques (de type GPR, Ground-Penetrating Radar) afin d'en quantifier le volume de glace restant. Pour cette seconde expédition, la technique utilisée de mesure par GPR a été optimisée afin de pallier aux effets d'atténuation du signal électromagnétique en raison du fort contenu en eau dans les glaciers étudiés ainsi qu'à leur faible épaisseur. Ces effets complexes et peu documentés d'absorption par l'eau limitent fortement la compréhension de la structure interne des glaciers en zone équatoriale. L'instrumentation GPR 'low-cost, low-energy, low-weight' développée et testée au cours du projet RIDEC fait toujours l'objet d'expérimentations en vue de trouver le meilleur compromis entre les aspects liés à la puissance, la résolution, la portabilité et la fréquence centrale de l'instrument.</p> <p>-Malgré les conditions peu clémentes rencontrées au sommet du Rwenzori ainsi que le caractère 'low-cost' des instruments utilisés, il s'est avéré que la station météorologique ainsi que l'appareil photo de type 'time-lapse' installés en février 2016 aux abords des glaciers étudiés ont fonctionné correctement. Une année de données météorologiques et d'évolution physique des glaciers ont ainsi pu être récoltés. Ces données serviront à alimenter un modèle d'écoulement glaciaire 3D (en cours de développement), et pourront également être utilisées pour la validation des modèles de circulation globale et de pluviosité en région tropicale (voir projet MIRACCLe).</p> <p>D. Samyn a également travaillé sur le traitement de données satellitaires optiques disponibles en 'open access' (Landsat, Aster) recouvrant la région des Rwenzoris. Des algorithmes spécifiques de reconnaissance des corps neigeux et de glace ont</p>

	<p>été utilisés et développés de manière à cartographier, de manière semi-automatique, l'évolution de l'étendue glaciaire dans la région depuis l'époque des premières images acquises (1984) à nos jours. Les résultats de ces analyses ont fait l'objet d'une présentation orale à New Orleans (USA) lors de l'assemblée annuelle de l'AGU en décembre 2017, ainsi que d'une publication en cours.</p> <p>Un drone équipé d'une caméra optique à haute résolution a également été déployé lors de cette seconde expédition RIDEC. Bien que le survol des glaciers Stanley et Speke n'ait pu être réalisé comme prévu en raison des conditions météorologiques extrêmement difficiles rencontrées cette année sur le terrain (en raison du cycle 'El Niño'), deux vols ont pu être effectués dans le secteur du Lac Bujuku (4000 m asl) au niveau des couloirs d'éboulements rocheux localisés en 2016 sur les pentes du Mont Baker. Les images recueillies ont permis d'une part la création d'un modèle numérique de terrain à haute résolution des profils étudiés. Ces données ont servi d'autre part à l'élaboration d'une série de simulations 3D d'avalanches rocheuses à l'aide du modèle physique STONE (développé par l'équipe de F. Guzzetti à Perugia, Italie). Ces simulations ont été réalisées en collaboration avec N. Hisette lors d'un stage (avril-juin 2017) en partenariat avec L. Jacobs et O. Dewitte, dans le cadre de son master (<i>Postgraduate Programme in Innovation and Entrepreneurship in Engineering</i>) et des projets AfReSlide et RIDEC. Les résultats de ces travaux ont donné lieu à un séminaire au MRAC de la part de N. Hisette (juin 2017), et font l'objet d'une publication en cours de rédaction.</p>
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<u>Projet 8</u>	
Nom (et acronyme)	Valorisation et exploitation de Géo-données aux Kivu (S1_RGL_GEOKIVU)
Financement	Source : DGD/accord cadre Budget : ~380.000€
Partenaires	Responsable interne : François KERVYN Collaborateurs internes : Mohamed LAGHMOUCH, Caroline MICHELLIER Collaborateurs externes : <ul style="list-style-type: none"> • Robert WAZI (UOB, BUKAVU, RDC) • Rigobert BIRHEMBANO (ISP/BUKAVU, RDC) • Prince KALEME (CRSN/BUKAVU, RDC) • Gustave MUBANGA (IGC/BUKAVU – GOMA)
URL site web	
Dates	Début : 01/03/2016 Fin : 28/02/2019
Description générale du projet	Le projet « Valorisation et exploitation de Géo-données aux Kivu (S1_RGL_GEOKIVU) » a pour objectif l'amélioration de la connaissance régionale et locale dans les domaines des sciences de la Terre et de la géographie – avec un focus particulier sur les risques naturels et l'occupation du sol – par la valorisation des géo-données existantes dans les institutions partenaires et le renforcement de l'expertise en matière de gestion de la géo-information. Le projet vise l'inventaire des géo-données existantes au sein de chaque

	<p>institution partenaire, la digitalisation des cartes qui enrichiront cet inventaire, l'apport de données numériques disponibles au MRAC, la création d'une base de données contenant l'ensemble des informations (métadonnées) répertoriées.</p> <p>Ces métadonnées encodées dans une base de données se présentent sous la forme d'un géo-catalogue accessible en ligne créé par le MRAC, qui facilite la recherche et l'exploitation des données existantes chez les différents partenaires</p> <p>Afin de pérenniser les activités développées au cours du projet, GeoKivu inclut également la formation en gestion de la géo-information et manipulation des Systèmes d'Informations Géographiques (SIG) pour permettre aux chercheurs de ces institutions d'exploiter les géo-données identifiées dans des projets de collaboration entre institutions partenaires notamment. Faisant suite au lancement de l'inventaire initié au cours de la première année, les méthodologies et techniques acquises au cours du projet seront renforcées dans le cadre d'applications spécifiques ; ces dernières seront développées au sein de chaque institution, en partenariat avec les chercheurs du MRAC (2017 – 2019).</p>
<p>Évolution et résultats pour l'année écoulée</p>	<p>Les tâches réalisées par les quatre institutions partenaires et le MRAC en 2017 sont les suivantes :</p> <ol style="list-style-type: none"> 1. En 2017, les archives géologiques du musée géologique de Bukavu sont inventoriées et numérisées. <ol style="list-style-type: none"> 1. En collaboration avec le MRAC, nos partenaires travaille depuis janvier 2017 sur 4 applications scientifiques : l'Université Officielle de Bukavu travaille à la réalisation d'une carte géologique régionale inédite sur base de compilations de données existantes ; l'Institut Supérieur Pédagogique de Bukavu travaille à la réalisation d'un nouvel atlas pour la ville de Bukavu ; l'Institut Cartographique du Congo réalise une carte détaillée et multi-couches de la Ville de Goma 2. - Le Centre de Recherche en Sciences Naturelles travaille à la compilation des données cartographiques anciennes des espèces de mammifères de RDC pour créer des cartes de répartition 3. L'encodage des métadonnées a été effectué dans le respect des normes INSPIRE. Le MRAC contribue aujourd'hui au géocatalogue avec 5563 métadonnées et les partenaires de Geokivu avec 1081 métadonnées, dont 891 correspondent à des documents cartographiques et 190 correspondent à des documents d'autres types (mémoires, thèses, , rapports...). 4. L'encodage des cartes du CRSN/IGC et des mémoires en relation avec les géo-données de l'UOB/ISP a été en partie réalisée et se poursuivra en 2018. 5. Le MRAC a installé un Scanner A0 au CRSN en mars 2018 pour la digitalisation systématiques des documents cartographiques des 4 institutions partenaires. 280 documents scannés en 2017. 6. La conformité des métadonnées encodées par nos partenaire est analysée au MRAC et les erreurs identifiables sont corrigées. La méthodologie mise en place servira de base à la poursuite des activités d'encodage prises en charge par nos partenaires. 7. Le MRAC a créé et mis en ligne un géo-catalogue dynamique qui facilite les consultations et les commandes des géo-documents et prochainement le téléchargement des géo-données. Ce géo-catalogue abrite, à ce jour, 6.643 documents dont 5.562 documents encodés par le MRAC : http://geocatalogue.africamuseum.be. <p>Quatre missions de suivi ont été organisées au cours de cette deuxième année de projet, afin de vérifier la réalisation des tâches, consolider les acquis et surtout superviser les applications développées par nos quatre partenaires.</p>

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<u>Projet 9</u>	
Nom (et acronyme)	Modelling regional rainfall controls on landslides in the tropics in the context of climate change (MiRACCLe)
Financement	Source : F.R.S_FNRS Budget : 4 year PhD fellowship
Partenaires	Responsable interne : Elise MONSIEURS Collaborateurs internes : Olivier DEWITTE Collaborateurs externes : Dr. Alain DEMOULIN, ULg (Promotor) Dr. D. KIRSCHBAUM. NASA Goddard Space Flight Center, Greenbelt, USA. Prof. Dr. N. VAN LIPZIG. KU Leuven, Leuven, Belgium. Dr. W. THIERY. ETH Zurich, Zurich, Switzerland. Prof. Dr. M. KERVYN. Vrije Universiteit Brussel, Brussels, Belgium.
URL site web	
Dates	Début : 01/10/2016 Fin : 30/09/2020
Description générale du projet	<p>Landslides (LS) present the most widespread natural hazard in the world, causing billions of dollars in damages and thousands of deaths each year. In the tropical climate zone, rainfall is the primary trigger for LS. However, timing of LS initiation is still poorly understood due to lack of adequate rainfall ground monitoring networks and spatiotemporal data on LS occurrence. Moreover, emerging scientific evidence indicates that climate change affects the intensification and increasing frequency of natural hazards. A thorough understanding of its impact on LS is however currently lacking.</p> <p>The aim of this PhD study is to model the control of rainfall on LS triggering on a regional scale and to apply this model to project future changes in LS hazard induced by climate change. In particular, the proposed project will contribute to (i) improved rainfall detection and characterization in the tropics, using state-of-the-art rainfall satellite data, (ii) a better representation of the tropics in global LS inventories, (iii) the development of a novel LS prediction algorithm for the tropics using rainfall thresholds, and (iv) an efficient integration of climate projections into this LS prediction algorithm. The western branch of the East African Rift is chosen as a case study, representative of many other mountainous regions in the tropics.</p>

Évolution et résultats pour l'année écoulée	<p>This research is based on the first outputs of the RESIST project, of which the following are still of relevance for the MiRACCLE project: an operational rain gauge network in the study area, a collection of additional rain gauge data from different sources (e.g., local universities, research institutes), a regional landslide inventory, and the systematic monitoring of a slow-moving landslide in Bukavu (DR Congo) using Differential GPS (DGPS). During the first months of the project Fieldwork in the study area is conducted to gather more information on landslide activities and maintain the rain gauge network.</p> <p>In December 2016, Elise Monsieurs moved to the Hydrological Sciences Laboratory at NASA Goddard Space Flight Centre (Maryland, USA), where she stayed until the end of December 2017. She worked closely with Dr. Dalia Kirschbaum and Thomas Stanley on satellite precipitation validation and rainfall thresholds for landslides. Where the original plan was to start with the comparison of the two rainfall products TRMM and GPM (Tropical Rainfall Measuring Mission; Global Precipitation Measurement), GPM analyses are shifted to mid-2018. This deviates from the proposed research plan, because of an unforeseen delay in satellite data availability. GPM's reprocessed product for 1998-present, was expected to be available in 2017 when writing the research proposal. This only affects the order of planned activities, not the activities itself.</p> <p>So far the TRMM Multi-satellite Precipitation Analysis (TMPA) 3B42 Research Derived Daily Product and Near Real-time product have been validated from 1998 to 2017, at 0.25° x 0.25° spatial and 24 h temporal resolution. The sparse and heterogeneous temporal coverage in a region with high rainfall variability poses challenges for validation. In addition, the discrepancy between local-scale gauge data and spatially averaged (~775 km²) TMPA data in the context of local convective storms and orographic rainfall is a crucial source of uncertainty. The data-poor context makes validation a challenging task. Therefore time is invested in searching for suitable validation approaches. A flexible framework was adopted for SRE validation that fosters explorative research in a remote context. Results show that TMPA performs reasonably well during the rainy seasons for rainfall intensities <20 mm/day. TMPA systematically underestimates rainfall, but most problematic is the decreasing probability of detection of high intensity rainfalls. TRMM is found relevant in mapping regional-scale rainfall-triggered hazards that are in any case poorly covered by the sparse available gauges. A paper on these findings is in progress.</p> <p>A conference paper has been published on the practical aspects of conducting fieldwork in the study area, and a paper is in progress on the spatiotemporal landslide inventory that has been assembled, and on the TRMM validation results.</p>
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<u>Projet 10</u>	
Nom (et acronyme)	Belgian American Education Foundation (BAEF) funded research stay
Financement	Source : B.A.E.F. Budget : \$12.000
Partenaires	Responsable interne : Elise MONSIEURS

	<p><u>Collaborateurs internes</u> : Olivier DEWITTE</p> <p><u>Collaborateurs externes</u> : Dr. D. KIRSCHBAUM. NASA Goddard Space Flight Center, Greenbelt, USA.</p>
URL site web	
Dates	<p><u>Début</u> : 01/12/2016</p> <p><u>Fin</u> : 30/11/2017</p>
Description générale du projet	<p>Landslides (LS) present the most widespread natural hazard in the world, causing billions of dollars in damages and thousands of deaths each year. In the tropical climate zone, rainfall is the primary trigger for LS. However, timing of LS initiation is still poorly understood due to lack of adequate rainfall ground monitoring networks and spatiotemporal data on LS occurrence. Moreover, emerging scientific evidence indicates that climate change affects the intensification and increasing frequency of natural hazards. A thorough understanding of its impact on LS is however currently lacking.</p> <p>Considering that there is no long term ground rainfall data available for the proposed study area, remote sensing is the only way to acquire rainfall information. NASA offers state-of-the-art remote sensing rainfall products with high temporal and spatial resolution. Furthermore, NASA has the only research group worldwide working on this data for landslide prediction. Therefore a research stay at the NASA Goddard Space Flight Center (Greenbelt, USA), under guidance of Dr. Dalia Kirschbaum (partner of this PhD proposal) are foreseen in the research project of Elise Monsieurs (MiRACCLe). The unique expertise of the ULg and RMCA with NASA, i.e. geohazards in Central Africa and rainfall remote sensing respectively, will enhance a novel understanding of landslide triggering in the study area.</p> <p>The specific goals of this one-year research stay at NASA were to get insights in NASA's satellite rainfall estimates and to validate them over the study area.</p>
Évolution et résultats pour l'année écoulée	<p>The research stay has enforced the collaboration between the partners NASA and the RMCA. Elise Monsieurs spent one year at the Hydrology Lab at NASA Goddard Space Flight center to validate TRMM rainfall estimates. She continues these analyses on her return at the RMCA and will be turning to GPM rainfall estimates once available mid-2018.</p>

<u>Projet 11</u>	
Nom (et acronyme)	MUZUBI – Multi Zone phase Unwrapping using advanced Split Band Interferometry
Financement	<p><u>Source</u> : Belspo STEREO-III Programme</p> <p><u>Budget</u> : 90.808€ (Total = 223.260€)</p>
Partenaires	<p><u>Responsable interne</u> : François KERVYN</p> <p><u>Collaborateurs internes</u> : Benoît SMETS</p>

	<p>Collaborateurs externes : D. DERAUW (Centre Spatial de Liège, Belgium) N. D'OREYE (ECGS/MNHN, Luxembourg) Y. RUBIO (Camahue National University, Argentina) S. SAMSONOV (Natural Resources Canada)</p>
URL site web	
Dates	<p>Début : 01/12/2015 Fin : 30/11/2017</p>
Description générale du projet	<p>The current MUZUBI project is aiming at developing a novel methodology to improve the phase unwrapping in SAR interferometry (InSAR). The methodology is based on the results of a former project (Vi-X). The innovative method to be developed here will be tested on two case studies in Argentina and DRC. Results will be compared with the results from a state-of-the-art method (MSBAS) currently used in the frame of a running project (RESIST) in order to assess and quantify the benefit of the proposed methodology.</p> <p>The task attributed to RMCA in the MUZUBI project corresponds to the validation of absolute phase unwrapping for the production of a digital elevation model of the Nyiragongo lava field.</p>
Évolution et résultats pour l'année écoulée	<p>In order to validate the project outputs on Nyiragongo volcano, we need a topographic reference. As the volcanic activity recurrently modifies this topography, an update in the Nyiragongo volcanic field was required. In 2016, RMCA used a Remotely Piloted Aircraft System (RPAS or commonly "drone") and Structure-from-Motion photogrammetry to create a 3D model of the Nyiragongo crater. The 3D model of the crater was georeferenced using both the geotagging of photographs and ground control points measured with a differential GPS. Both the SRTM-1 and the TanDEM-X Digital Elevation Models (DEM), the latter being produced by RMCA in the frame of the the Vi-X project (Belspo STEREO-II Programme), were updated with the newly created crater DEM. These two updated topographic layers will be next used to validate topographic information coming from absolute phase unwrapping.</p> <p>In 2017, the project was paused because the PI (D. Derauw), was not able to carry out his tasks for several months. From the RMCA side, the objectives have been reached.</p>

<u>Projet 12</u>	
Nom (et acronyme)	Historical aerial Photographs and ArchiveS to assess Environmental Changes in Central Africa (PASTeCA)
Financement	<p>Source : BELSPO – Belgian Research Action through Interdisciplinary Networks (BRAIN-be)</p> <p>Budget : 229,685 (total = 597,560 EUR)</p>
Partenaires	<p>Responsable interne : Olivier DEWITTE (Project coordinator)</p> <p>Collaborateurs internes : François KERVYN, Caroline MICHELLIER, Benoît SMETS, Mohamed LAGHMOUCH</p>

	<p><u>Collaborateurs externes :</u></p> <p>Arthur DEPICKER Liesbet JACOBS Anton Van ROMPAEY (WP leader) Gerard GOVERS (WP leader- KU Leuven</p> <p>Eléonore WOLFF (WP leader) Nicholus ODHIMABO MBOGA Université Libre de Bruxelles (ULB)</p>
<p>URL site web</p>	<p>http://pasteca.africamuseum.be/</p>
<p>Dates</p>	<p><u>Début :</u> 01/10/2017</p> <p><u>Fin :</u> 30/09/2021</p>
<p>Description générale du projet</p>	<p>The conversion of natural lands into human-dominated landscapes is a major component of global environmental change. This conversion has been substantial during the past few centuries, but dramatically accelerated during the last decades and is expected to continue. This human-induced transformation of environments can have impacts for example on biodiversity, climate and land surface feedbacks, soil and landscape degradation, and also alter ecosystem services. Assessing the processes of land use and land cover (LULC) changes and possible future scenarios is of paramount importance if we are to embed sustainability in development strategies, ecosystem management, and land use planning, particularly for developing countries where rates of LULC changes are highest.</p> <p>To quantify and understand the complexity of changes and subtle modifications in LULC, an accurate account of past LULC conditions and recent changes over a multidecadal time scale has an important added value. However, sufficiently long, multidecadal records of LULC changes are almost inexistent for the least developed areas of the globe. Here we propose to make use and valorise the Royal Museum for Central Africa (RMCA)'s unique collection of historical black and white aerial photographs over the entire DR Congo, Burundi and Rwanda. These photographs are an important but hitherto poorly exploited archive that has the potential to reveal key information on the state of the environment in that region of Central Africa at the mid of the 20th century. Additionally to these photographs, archives such as relevant maps also available at RMCA (rural cadastre, urban cadastre, etc.) can provide supplementary information on historical LULC.</p> <p>The general objective of the PASTeCA project is to evidence the importance and the added value of archive documents in studies addressing present day issues in areas lacking baseline studies. In the present case, aerial photographs and archives from RMCA will support present day environmental change studies in target tropical environments of Central Africa. The focus of the environmental topics relies on the spatio-temporal dynamics of LULC changes. The project deals with land occupation and demography, land degradation, slope processes, geohazards, and geomatics and remote sensing issues. The first specific objective</p>

	<p>is to produce geolocalised digital products of the historical photographs and archives that can be used for LULC studies in general. The second specific objective of this project is to explore the causes, impacts, scales and trends of the LULC and its changes in the context of environmental degradation with the help of these digital products. The third specific objective is dedicated to improve accessibility of digital products derived from historical photographs, archives and LULC changes for both the international scientific community and the public at large to foster their exploitation.</p> <p>In order to carry out the project in the most efficient way, research is focused on a well-defined study area located in the tropical mountain environments of the western branch of the East African Rift. The region of interest extends from the North Tanganyika rift zone in the south to the Virunga Volcanic Province in the north. Its LULC evolution is very interesting to study because of the combination of various natural and human characteristics (i.e. high population densities, border between three countries, diversity in landscape, recent land degradation, various conflicts, urban sprawl, numerous occurrences of landslides, very active volcanoes, etc.). For the region of interest, most questions related to LULC and the changing environments remain unclear and research outputs will be directly relevant to society. It is hoped also that the new knowledge that this project will bring will not be limited only to a local and regional perspective. It is expected that PASTeCA brings insight of the core basics that explain the studied environmental processes in general so that it serves for other assessments in many other places too.</p>
Évolution et résultats pour l'année écoulée	<p>Project has started as expected. Two new PhD students are now involved. Processing of aerial photo digitization has started</p>

Projet 13	
Nom (et acronyme)	A Multi-sensOr approach to characterize ground Displacements in Urban Sprawling contexts (MODUS)
Financement	<p>Source : BELSPO – Research programme for earth observation “STEREO III”</p> <p>Budget : 181.807 (total = 204.907 EUR)</p>
Partenaires	<p>Responsable interne : François KERVYN and Olivier Dewitte (project coordinators)</p> <p>Collaborateurs internes : Antoine DILLE, Adriano NOBILE, Benoit SMETS, Elise MONSIEURS</p> <p>Collaborateurs externes :</p> <p>Jean-Philippe MALET (WP leader) Belgian Institute for Space Aeronomy (IASB-BIRA)</p> <p>Dominique DERAUW (WP leader) Université de Liège (ULG)</p>

	Nicolas D'OREYE (WP leader) Musée national d'histoire naturelle (Mnhn) / European Center for Geodynamics and Seismology (ECGS)
URL site web	
Dates	Début : 01/12/2017 Fin : 30/11/2020
Description générale du projet	Ground deformations in urban areas are environmental constraints that need to be considered in planning and risk management. Characterization of such deformations requires combination of several techniques, adapted to the deformation dynamics and urban context. Here, the city of Bukavu (DR Congo) is chosen as experimental test site for comparing and integrating deformation monitoring by multiple sensors and techniques. This rapidly expanding city is set in a landslide-prone environment. In the mother-RESIST project, the InSAR PSI, SBAS and MSBAS techniques provided promising preliminary results on landslide displacements within Bukavu. Here, in the framework of a PhD research, we will continue using these techniques with additional image acquisitions allowing us to extent deformation time series, in combination with techniques using optical imageries. Satellite COSMO-SkyMED, Sentinel-1, Pléiades and SPOT-6, SPOT-7 data will be used in combination. Targeted ground-based stereo time-lapse photogrammetry, UAV, ground-based LiDAR and repeated DGPS measurement campaigns using the RESIST GPS reference network will provide topographic data at higher spatial and temporal resolutions to complement these time series and validate displacement results. Image correlation methods will be applied on both SAR (amplitude images) and optical data (high-resolution satellite, time-lapse and UAV images). The time series will be complemented with old aerial photographs (digital photogrammetry) to assess the changes over the last 60 years, enabling to compare long- and short-term trends with climatic and land use change data. All these dynamics data, together with high topographic elevation models derived from optical data and LiDAR will be used to better characterize the landslide mechanisms and forecast the evolution of hazard in space and time. We expect the comparison of methods to provide insights into the most suitable (combination of) techniques according to the landslide type, dynamics and urban context.
Évolution et résultats pour l'année écoulée	Project has started as expected. A new PhD student (Antoine DILLE) is now involved

Projet 14	
Nom (et acronyme)	MIGRADAPT
Financement	Source : BELSPO – Belgian Research Action through Interdisciplinary Networks (BRAIN-be) Budget : 370.393 (total = 978.713 EUR)

Partenaires	<p>Responsable interne : Theodore TREFON (WP leader)</p> <p>Collaborateurs internes : Caroline MICHELLIER</p> <p>Collaborateurs externes : François GEMENNE (ULg, Coordinateur du projet) Edwin ZACCAI (ULB) Christiane TIMMERMAN (UA)</p>
URL site web	
Dates	<p>Début : 01/01/2017</p> <p>Fin : 12/12/2020</p>
Description générale du projet	<p>In the dichotomy between migrants and refugees/asylum-seekers, the former are typically cast as economically motivated, and set apart from refugees, fleeing war and persecution. Yet environmental changes are increasingly part of migration journeys, and count amongst the factors that call into question the distinction made between migrants and refugees. At the same time, in the international negotiations on climate change, migration is increasingly mooted as a possible adaptation strategy to the impacts of climate change. But only few studies exist as to how migration could actually work for adaptation, and none of them addresses migration in Belgium. This is the goal of this project, delineated into two parts.</p> <p>First, MIGRADAPT will look at the role of the environment as a driver for recent migration to Belgium. While it is unlikely that one could single out environmental changes as a key driver of migration to Belgium, except in exceptional cases, the project will rather attempt to provide an assessment on how migrants perceive the environment to have influenced their migration journey as well as how they perceive current environmental disruption in their countries of origin. Indeed, many countries of origin or of transit of migrants to Belgium are affected by significant environmental disruptions. How are such disruptions perceived by the migrants?</p> <p>Through its innovative theoretical and empirical approach MIGRADAPT will provide scientific evidence on the role of environmental drivers in migration decisions and on how perceived and observed environmental changes exacerbate pre-existing migration flows to Belgium through its impacts on the other most commonly addressed drivers of migration, such political and economic factors.</p> <p>Moreover, the project will show how environmental disruptions not only affect the first stage of human mobility from their countries of origin, but also how environmental stressors intervene throughout migrants 'fragmented journeys', including their potential to alter migratory routes and destinations entirely.</p> <p>Second, MIGRADAPT seeks to understand how migrants can support the adaptation and resilience of their communities of origin. How and under which conditions can migration support the adaptation and resilience of communities affected by environmental changes?</p> <p>MIGRADAPT will provide evidence on how and under which conditions migration to Belgium can support the adaptation and resilience of origin communities and</p>

	<p>also on how the perception that migrants have on environmental shocks in their origin communities can impact the amount, form, and use of the socio-economic remittances that they send. Through its transnational and multi-sited methodology that captures both the drivers and impacts of migration, MIGRADAPT will address the multifactor aspect of the dynamics of environmental migration and its implications for both migrants and those remaining in communities of origin.</p> <p>The evidence from the project, both in Belgium and in three different countries of origin of the selected migrants, will be translated into policy recommendations that should allow policy makers to tailor and mainstream the environmental component of migration into migration policies, including bilateral migration agreements. The project will also seek to inform Belgian climate and development policies, so that they can better incorporate migration into the strategies. Overall, the project will seek the maximise the potential of migration for adaptation to environmental changes, building on its appraisal of the migration-environment nexus in Belgium.</p>
Évolution et résultats pour l'année écoulée	

Projet 15	
Nom (et acronyme)	Developing strategies for natural hazard data collection in a poorly developed region with very low capacity
Financement	<p>Source : BELSPO - RESEARCH FELLOWSHIPS to NON – EU POSTDOCS – Call 2016</p> <p>Budget : ~60,000€</p>
Partenaires	<p>Responsable interne : François KERVYN, Olivier DEWITTE</p> <p>Collaborateurs internes : Fils MAKANZU IMWANGANA</p> <p>Collaborateurs externes :</p>
URL site web	
Dates	<p>Début : 01/05/2017</p> <p>Fin : 30/04/2018</p>
Description générale du projet	<p>The general objective of this proposal is to investigate strategies for natural hazard data collection in a poorly developed country and a context of very low capacity. The aim is to investigate this topic at the regional scale. The region of interest lies within the East African Rift. The aim is to focus on geophysical (earthquake, volcanic eruption, landslide), hydrological (flood), biophysical (wildfire) and atmospheric (thunderstorm) hazards.</p> <p>More specifically we aim to test and validate several data acquisition approaches as well as collect new data on natural hazards in the region. We also aim to</p>

	develop a method of data collection that can be used in other regions with similar context.
Évolution et résultats pour l'année écoulée	Ont été réalisés : Analyse de la littérature, mise en place d'outils de collecte de données par téléphonie mobile (avec campagne de terrain pour a mise en place de l'outil), récolte de données via Internet, récolte de données via réseau de partenaires locaux et stakeholders. Les premières analyses ont été initialisées.

<u>Projet 16</u>	
Nom (et acronyme)	Prevention and mitigation of urban gullies: lessons learned from failures and successes (PREMITURG)
Financement	<u>Source : ARES - Research Project for Development (RPD)</u> <u>Budget : 499 928.66 €</u>
Partenaires	<u>Responsable interne : Olivier DEWITTE</u> <u>Collaborateurs internes :</u> Theodore TREFON <u>Collaborateurs externes :</u> Matthias VANMAERCKE (project coordinator North) Université de Liège (ULg) Fils MAKANZU IMWANGANA (project coordinator South) Université de Kinshasa (UNIKIN) Serge COGELS David JAMAR Université de Mons (UMons) Charles BIELDERS Université catholique de Louvain (UCL) Jean POESEN KU Leuven (KUL) Lucile GRETY Responsable Plateforme Afrique Centrale Université de Liège (ULg) Robert WAZI NANDEFO Université Officielle de Bukavu (UOB) Willy MBALANDA LAWUNDA Université de Kinshasa (UNIKIN)

	<p>Valentin KANDA NKULA Centre des Recherches Géologiques et Minières (CRGM)</p> <p>Jean-Marie BWISHE HABARI Protection Civile du Sud-Kivu (PCSK)</p>
URL site web	
Dates	<p>Début : 01/12/2017 (01/05/2018)</p> <p>Fin : 30/04/2023</p>
Description générale du projet	<p>Intense rainfall, inappropriate city infrastructure and lack of urban planning lead to the formation of large gullies in many Congolese cities. These urban gullies are often formed in a matter of hours due to the concentration of rainfall runoff. Once formed, they mostly continue to expand during subsequent years. Given their nature and location in densely populated areas, they often claim casualties, cause large damage to houses and infrastructure and impede the development of many (peri-) urban areas. These problems directly affect the livelihood of perhaps more than a million of mainly poor people in DRC and may strongly aggravate as a result of rapid urban growth and climate change. Several initiatives already exist to stabilize existing gullies, but an estimated 50% of these measures fail. Furthermore, prevention receives very little attention.</p> <p>This project aims to contribute to the prevention and mitigation of urban gullies by strengthening the research and decision-making capacity of Congolese universities and members of the national Disaster Risk Reduction (DRR) platform. For this, we aim to (i) study the factors controlling this erosion process; (ii) identify the most effective/efficient prevention and mitigation measures (iii) study the societal and governance context of urban gullies and its influence on the prevention and mitigation of urban gullies; and (iv) valorize and appropriate the obtained research results.</p> <p>This will mainly be done by the training of 3 MSc and 3 PhD students of DRC. Their research will focus on urban gullies and prevention and mitigation initiatives in Kinshasa, Bukavu and Kikwit. In Kinshasa, also the societal context of urban gullies will be investigated. Apart from the training of these students, the project will support local MSc studies and provide a range of prediction tools, field manuals, trainings, seminars and workshops to assist decision makers and other stakeholders in addressing this issue.</p>
Évolution et résultats pour l'année écoulée	<p>Project administrative issues started in 2017. Actual research will start in 2018.</p>

Projet 17	
Nom (et acronyme)	Reducing land degradation through and for sustainable rural land use in the South Ethiopia Rift Valley
Financement	Source : VLIR-UOS-IUC

	Budget : ~370.000€
Partenaires	<p>Responsable interne : Olivier DEWITTE</p> <p>Collaborateurs externes :</p> <p>Matthieu KERVYN (project coordinator) Margaret CHEN Ann VAN GRIENSVEN VUB</p> <p>Gert VERSTRAETEN Jean POESEN Jan DIELS KU Leuven</p> <p>Ann VERDOODT Universiteit Gent</p> <p>Arba Minch University (Ethiopia)</p>
URL site web	http://www.vliruos.be/en/ongoing-projects/overview-of-ongoing-projects/iuc/institutional-cooperation-with-arba-minch-university-(amu)-ethiopia/
Dates	<p>Début : 01/03/2017</p> <p>Fin : 28/02/2022 (2027)</p>
Description générale du projet	This project aims at increasing capacities within Arba Minch University (Ethiopia) to understand and address land degradation processes, including soil fertility loss, sediment production by gullies and landslides and sediment delivery to the lakes. Outcomes include PhD theses, an integrated geodatabase and a meteo-hydrological monitoring network. The Elgo-Sile and Basso-Shafé catchments are used as case study sites. Attention is given to integrate indigenous practices and to develop outreach tools.
Évolution et résultats pour l'année écoulée	Project started in 2017 with first field mission and selection of PhD students. From Sept onwards, the student have started a per-doctoral programme in Belgium (KUL and VUB). Main task was to supervise them. RMCA is directly involved in one PhD supervision.

Projet 18	
Nom (et acronyme)	Thèse Adalbert Muhindo SYAVULISEMBO Titre de la thèse : Analyse spatio-temporelle de l'exposition de la population face à l'aléa volcanique : le cas de Goma, République démocratique du Congo.
Financement	<p>Source : Accord-cadre</p> <p>Budget :</p>

Partenaires	<p>Responsable interne : François KERVYN (promoteur)</p> <p>Collaborateurs internes : Adalbert MUHINDO, Caroline MICHELLIER (co-promoteur)</p> <p>Collaborateurs externes : Eléonore WOLFF, ULB (Promoteur)</p>
URL site web	
Dates	<p>Début : 01/12/2015</p> <p>Fin : 30/11/2017</p>
Description générale du projet	<p>Le doctorat de Adalbert Muhindo Syavulisembo a commencé le en mai 2016. Il est encadré par Eléonore WOLFF (promoteur, ULB), et Caroline MICHELLIER et François KERVYN (co-promoteurs, MRAC). Le président du jury est Jean Michel DECROLY (ULB). Ce doctorat devrait se terminer au cours de l'année académique 2019-2020. Une telle étude constituera un apport scientifique essentiel au plan de contingence de gestion des risques volcaniques, ainsi qu'au plan d'évacuation élaboré pour la région. Les cartes produites à partir de notre recherche seront en premier lieu destinées à servir de support de réflexion aux autorités municipale et provinciale pour leurs politiques de planification de développement territorial et de réduction des risques</p>
Évolution et résultats pour l'année écoulée	<p>Ce doctorat s'intéresse à la gestion des risques liés aux coulées de lave volcaniques dans les Virunga, en se focalisant sur la distribution spatio-temporelle et la vulnérabilité de la population par le biais de sa mobilité.</p> <p>Concrètement, ceci implique une localisation des zones de concentration de la population en fonction du temps, une identification/localisation des ressources essentielles (éducation, eau, santé, vivres, énergie, sécurité, etc.) et une évaluation de l'accessibilité de la population à ces ressources.</p> <p>En effet, le nombre des personnes localisé dans une zone potentielle d'un aléa naturel ne reste pas constant en fonction du temps. En outre, la mobilité de la population renvoie à une grande variété de déplacements habituellement de courte durée, répétitifs ou cycliques, mais qui ont tous en commun l'absence de toute intention déclarée d'un changement de localisation. Or, l'heure à laquelle se produira l'éruption volcanique n'est pas connue. C'est pourquoi, nous estimerons les variations de l'effectif de la population qui se localise dans les zones potentielles des coulées de lave volcaniques.</p> <p>Par ailleurs, dans le contexte des zones urbaines isolées par des coulées de lave volcaniques, la perte d'intégrité du réseau routier peut devenir une cause de risque indirect en réduisant l'accès aux ressources essentielles et en retardant les opérations de secours. Ainsi, nous nous intéressons aux principales dynamiques de la population sur le réseau routier et nous cherchons à déterminer les itinéraires les plus sûres et les plus rapides.</p> <p>Un travail de terrain intense a été mené entre février et septembre 2017, avec la collecte de beaucoup de données qui seront directement utiles pour répondre aux questions de recherche mentionnées ci-dessus.</p>

<u>Projet 19</u>	
Nom (et acronyme)	Orthoimage Goma
Financement	Source : Budget :
Partenaires	Responsable interne : François KERVYN Collaborateurs internes : Benoît SMETS, Caroline MICHELLIER Collaborateurs externes :
URL site web	
Dates	Début : 01/12/2015 Fin : 30/11/2017
Description générale du projet	In order to answer to the need of a Very-High Resolution (VHR) image of the city of Goma, the Natural Hazards Service decided to investigate, out of the frame of a funded project, the feasibility of using images acquired with classical cameras to image a large area (i.e., > 100 km ²).
Évolution et résultats pour l'année écoulée	In the absence of the appropriate conditions and funding to develop long-range drone-based solutions, we took advantage of the support offered by the United Nations (MONUSCO) to the Goma Volcano Observatory (OVG) and the Congolese Geographical Institute (IGC) to fly over Goma with a helicopter and test the feasibility of acquiring an orthophotomosaic of the whole city at a resolution of 10-20cm per pixel, with consumer-grade cameras and Structure-from-Motion Multi-View Stereo (SfM-MVS) photogrammetry. This 5-hour long flight was made on June 6 th , 2017. The flight plan and camera configuration for sharp imaging and adequate image overlapping were planned by making a balance between the flight limitations (i.e., duration, speed and elevation), the camera's characteristics (i.e., image resolution, lens, field of view) and the targeted spatial resolution (i.e., 10-20cm). The image pre-processing and most of the photogrammetric processing workflow was realized in 2017. The latter workflow includes classical steps corresponding to the tie point detection and image matching for the calculation of interior and exterior orientations, the use of ground control points for the scaling and georeferencing of the photogrammetric results and the dense matching for the production of a dense point cloud. The final version of the orthomosaic and digital elevation model of Goma will be produced in 2018.

<u>Projet 20</u>	
Nom (et acronyme)	Introduction to Physical Geography
Financement	Source : Budget :
Partenaires	Responsable interne : Olivier DEWITTE Collaborateurs internes :

	<p><u>Collaborateurs externes :</u></p> <p>Gert VERSTRAETEN KU Leuven</p>
URL site web	
Dates	<p><u>Début :</u> 01/10/2017</p> <p><u>Fin :</u> 30/09/2018</p>
Description générale du projet	<p>Olivier Dewitte is invited professor at KU Leuven for the academic year 2017-2018. He will be teaching from February to May 2018 a course entitled "Introduction to Physical Geography". The audience is made of 3rd year bachelor students in geography, geology, biology and archaeology. The audience is around 100. This course is an opportunity to advertise RMCA and reinforce current collaboration with KU Leuven.</p>
Évolution et résultats pour l'année écoulée	<p>Course preparation</p>

<u>Projet 21</u>	
Nom (et acronyme)	Scholarly peer-review – scientific edition
Financement	<p><u>Source :</u></p> <p><u>Budget :</u></p>
Partenaires	<p><u>Responsable interne :</u></p> <p><u>Collaborateurs internes : staff from the service</u></p> <p><u>Collaborateurs externes :</u></p>
URL site web	
Dates	<p><u>Début :</u> 01/01/2017</p> <p><u>Fin :</u> 31/12/2018</p>
Description générale du projet	<p>Peer-review activities carried out by Service staff</p>
Évolution et résultats pour l'année écoulée	<p>Olivier Dewitte : 12 reviews in the following journals : Catena, Earth-Science Reviews, Earth Surface Processes and Landforms, Geomorphology, Natural Hazards and Earth System Sciences, Geologica Belgica, Land Degradation & Development, International Journal of Geographical Information Science</p>

	<p>Elise Monsieurs : 4 reviews for Springer, Land Degradation & Development, Journal of African Earth Sciences, World Development.</p> <p>Adriano Nobile: 5 reviews in the following journals: Remote Sensing, Geosciences</p> <p>Benoît Smets: 2 reviews in the following journals: Earth-Science Reviews, Geology</p>
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Autres activités

Accueil cartothèque : plusieurs dizaines de visiteurs se sont présentés en 2017 pour recourir à notre collection cartographique

Expertise et formation : le Service a été régulièrement sollicité pour son expertise en matière de cartographie pour diverses questions spécifiques.

International conferences:

Researchers from the Service took part in several international conferences:

- EGU General Assembly (Vienna, Austria)
- World Landslide Forum (Ljubljana, Slovenia)
- 3rd North American Symposium on Landslides, Roanoke, VA, USA
- ESA – Fringe 2017, Helsinki, Finland
- Third International workshop on Monitoring and Development of Lake Kivu Gas Resources, Kigali, Rwanda
- IAVCEI 2017 (Portland, USA)
- 5ème Journée Aléas Gravitaires, Besançon, France
- 99th Journée Luxembourgeoises de Géodynamique, Luxembourg, Luxembourg
- The Geological Society of America 129th Annual Meeting (Seattle, USA)
- AfricaGIS 2017 Conference, Addis Ababa, Ethiopia
- ASI – COSMO-SkyMed workshop – Rome - Italy
- European Volcanoes' Night – Europe
- Disasters and Resilience in the 21th Century, Multidisciplinary workshop of the RAOS, Brussels, Belgium
- AGU Fall Meeting (New Orleans, USA)

External training/research stay

- Elise MONSIEURS 1 December 2016 – 19 December 2017: Research stay at the Hydrology Laboratory at NASA Goddard Space Flight Center (Greenbelt, MD, USA)BAEF
- Benoît SMETS: 1-day training in UAV applied to Volcanology (IAVCEI, Portland, USA)

Visiteurs : chercheurs, utilisateurs des bibliothèques, stagiaires, etc.

- Bibentyo Toussaint MUGARUKA (MSc. in Geography, VUB - KU Leuven, Belgium). “Landslide spatio-temporal distribution in a changing environment: focus on the Ruzizi gorges at the DR Congo – Rwanda border”. Supervision: Olivier DEWITTE
- Sascha WIJESINGHa (Advanced master in Disaster and Risk Management, University of Liège, Belgium). “Debris flows in the Kalehe region (DRC): (spatial) distribution and simulation”. Supervision: Olivier Dewitte with Antoine Dille)
- Benjamin, VAN ROOZENDAEL (BSc. in Geography VUB). Deep-seated landslides in the Rwenzori Mountains : detection, morphology and spatial controls. Bachelor thesis geography. Finished, August 2017, Supervision: Liesbet JACOBS
- Rachel ABELA. Spatial prediction of soil variables for landslide susceptibility optimisation. Master Thesis, Physical Land Resources (VUB). Ongoing. Supervision : Liesbet JACOBS
- Hisette Noémie (MSc., KU Leuven). “Modelling rock falls in the upper Rwenzori catchment with STONE”. 12-week internship at RMCA within the framework of the “Postgraduaat innoverend ondernemen voor ingenieurs” degree at KU Leuven. (Supervision with Denis Samyn and Liesbet Jacobs).
- Josué Muhindo Subira (Goma Volcano Observatory), Analysis of seismic data associated to the 2011-2012 Nyamulagira eruption and their correlations with ground deformation. Supervision : Adriano Nobile
- Dans le cadre de GEOKIVU, le MRAC a organisé un stage en 2017 pour 5 partenaires de Bukavu et Goma : Jacques Mwangi (CRSN/ Lwiro), Ilombe Mawe Guy (UOB), Christian Kalikone Buzera (UOB), Sylvain Kulmushi (ISP/ Bukavu), Jean-Baptiste MULENGEZI, Gustave Munganga Byabuze (IGC/ Goma)

Suivi de thèses et défenses

Doctorant 1	
Prénom et nom	Caroline MICHELLIER
Titre doctorat	Contribuer à la prévention des risques d'origine géologique : l'évaluation de la vulnérabilité des populations dans un contexte de rareté de données. Les cas de Goma et Bukavu (RD Congo)
Université	Université Libre de Bruxelles (ULB) / Vrije Universiteit Brussel (VUB) (thèse conjointe)
(Co-)Promoteur(s) (MRAC et externes)	Eléonore WOLFF (ULB) (promoteur) Matthieu KERVYN (VUB) (promoteur) Comité d'encadrement / Co-promoteurs : François KERVYN (MRAC) Jean Michel DECROLY (ULB) Fabio VANIN (VUB) Marius GILBERT (ULB) Théodore Trefon (MRAC) Natalia DELIGNE (GNS,

	Nouvelle Zélande) Patrick PIGEON (Université Savoie Mont Blanc, France)
Date défense de thèse	Septembre 2017

Doctorant 2	
Prénom et nom	Liesbet JACOBS
Titre doctorat	Landslides in the Rwenzori Mountains: field-based characterisation and susceptibility assessments in a data-scarce tropical environment
Université	Vrije Universiteit Brussel (VUB)
(Co-)Promoteur(s) (MRAC et externes)	Olivier DEWITTE (MRAC) et Matthieu KERVYN (VUB) (promoteurs) Jean POESEN (KU Leuven), co-promoteur
Date défense de thèse	Janvier 2018

Doctorant 3	
Prénom et nom	Elise MONSIEURS
Titre doctorat	Modelling regional rainfall controls on landslides in the tropics in the context of climate change
Université	Université de Liège (ULg)
(Co-)Promoteur(s) (MRAC et externes)	Olivier DEWITTE (MRAC) et Alain DEMOULIN (ULg)(supervisors) PhD committee Dalia KIRSCHBAUM (NASA) Matthieu KERVYN (VUB), François KERVYN (RMCA)
Date défense de thèse	2020

Doctorant 4	
Prénom et nom	Adalbert Muhindo SYAVULISEMBO
Titre doctorat	Etude de la mobilité de la population dans la ville de Goma. Ce travail s'inscrit dans la suite des activités du projet GeoRisCA et contribue à une meilleure caractérisation de la vulnérabilité de la population exposée au risque coulées de laves.
Université	Université Libre de Bruxelles (ULB)
(Co-)Promoteur(s) (MRAC et externes)	Eléonore WOLFF (ULB) (promoteur), François Caroline MICHELLIER (co-promoteur).
Date défense de thèse	2019

Doctorant 5	
Prénom et nom	Antoine DILLE
Titre doctorat	A multi-sensor approach to characterize ground deformations in urban sprawling contexts
Université	Vrije Universiteit Brussel (VUB)
(Co-)Promoteur(s) (MRAC et externes)	Co-supervisors: François KERVYN (RMCA) and Olivier DEWITTE (RMCA)
Date défense de thèse	2021

Doctorant 6	
Prénom et nom	Frédéric GNAGNE
Titre doctorat	Landslides in Abidjan (Ivory Coast) : from process characterization to prediction
Université	Université de Liège (ULg)
(Co-)Promoteur(s) (MRAC et externes)	Alain DEMOULIN (ULg) et Olivier DEWITTE (MRAC) (promoteurs) Yves CORNET (ULg) et Jean BIEMI (Houphouet-Boigny University) (co-promoteurs)
Date défense de thèse	Thèse commencée en octobre 2015.

Doctorant 7	
Prénom et nom	Clairia KANKURIZE
Titre doctorat	Unravelling soil conditions and human activities linked to landslide occurrence in a tropical environment: the Murmiwa region in Bujumbura
Université	Université Catholique de Louvain (UCL)
(Co-)Promoteur(s) (MRAC et externes)	Supervisors: Bruno DELVAUX (UCL) and Gervais RUFYIKIRI (Université Polytechnique de Gitega). PhD committee: Olivier DEWITTE (RMCA).
Date défense de thèse	2020

Doctorant 8	
Prénom et nom	<u>Williams MUKENGA</u>
Titre doctorat	Spatial analysis of landslide hazard in the Cameroon volcanic line
Université	Université de Liège (VUB)
(Co-)Promoteur(s) (MRAC et externes)	Supervisors: Hans-Balder HAVENITH (ULg) and Eko

	ROBERT (Université de Yaoundé). PhD committee: Nathalie FAGEL (ULg) and Olivier DEWITTE (RMCA)
Date défense de thèse	2020

<u>Doctorant 9</u>	
Prénom et nom	<u>Nick ESTRADA</u>
Titre doctorat	Landslide susceptibility prediction in a mountainous catchment: the Naranjo Basin, Western Guatemala
Université	Université de Liège (ULg)
(Co-)Promoteur(s) (MRAC et externes)	Supervisors: Alain DEMOULIN (ULg) and Olivier DEWITTE (RMCA)
Date défense de thèse	2017

<u>Doctorant 10</u>	
Prénom et nom	<u>Jean-Claude MAKI MATESO</u>
Titre doctorat	Landslides and land use at the heart of the anthropisation of a rural world: focus on the Lake Kivu region in DR Congo
Université	Université catholique de Louvain (UCL)
(Co-)Promoteur(s) (MRAC et externes)	Supervisors: Charles BIELDERS (UCL) and Olivier DEWITTE (RMCA)
Date défense de thèse	2021

<u>Doctorant 11</u>	
Prénom et nom	<u>Arthur DEPICKER</u>
Titre doctorat	Earth surface processes and land degradation in the Kivu Rift
Université	Université catholique de Louvain (UCL)
(Co-)Promoteur(s) (MRAC et externes)	Supervisors: Gerard GOVERS (KUL) and Olivier DEWITTE (RMCA). Co-supervisor : Anton Van ROMPAEY
Date défense de thèse	2021

<u>Doctorant 12</u>	
Prénom et nom	<u>Liulsegad BELAYNEH</u>
Titre doctorat	Landslide and gully erosion hotspots and their contribution to land degradation in the South Ethiopia

	Rift Valley
Université	Université catholique de Louvain (UCL)
(Co-)Promoteur(s) (MRAC et externes)	Supervisors: Matthieu KERVYN (VUB) and Olivier DEWITTE (RMCA).
Date défense de thèse	2021

Digitalisations et mise en ligne des collections

La numérisation systématique des cartes de la cartothèque du service se poursuit et profite du cadre de Geokivu. Le géocatalogue a été mis en ligne pour faciliter l'accès au public de notre collection <http://geocatalogue.africamuseum.be/>

Il implique un inventaire, un tri, une réorganisation des archives, la numérisation et le stockage des documents numériques et le géoréférencement des documents prioritaires.

Il y a 6642 documents cartographiques encodés sur le géocatalogue dont 5562 encodés par le MRAC et 1081 encodés par nos partenaires de GEOKIVU