



Annual Report* of IGCP/SIDA Project 594

IGCP project short title: **IMPACT OF MINING ON ENVIRONMENT
IN AFRICA**

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Duration: 2011-2014

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Project Secretary: N/A

Date of submission of the report: 30-08-2012

Signature of project leader(s):

1. Website address(es) related to the project: <http://www.geology.cz/igcp594> and

<http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/international-geoscience-programme/igcp-projects/>

2. Summary of major past achievements of the project

In the course of the first year of the project implementation (2011) its organizational structure has been built up and the project website has been made available. An Inaugural Meeting of the project was organized and took place at the city of Kitwe in Zambia. The first meeting of the Czech group of the project with international participation was held in Prague (Czech Republic).

Results of the assessment of the impact of mining and mineral processing of copper and cobalt ores on the contamination of surface waters and sediments of the River Kafue catchment in the Zambian Copperbelt Province were published in the Journal of Geochemical Exploration. Twenty peer-reviewed extended abstracts were published in: Křibek, B. (ed.) (2011) Mining and the Environment in Africa. - Proceedings of the Inaugural Workshop of the IGCP/SIDA Project No. 594, Kitwe, Zambia, October 17-18, 2011, 71 p. Czech Geological Survey, pp. 7-8. ISBN 978-80-7075-119-0 and in Goldschmidt Conference Abstracts, Mineralogical Magazine 75 (3).

A methodological assistance was provided to non-governmental organization Citizens for Better Environment based at the city of Kitwe. It was focused on resolving the problems linked with the impacts of mining and mineral processing of copper and cobalt ores on the environment in Zambian part of the Copperbelt.

3. Achievements of the project in the year 2012

3.1. List of countries involved in the project (please *indicate the countries active in year 2011)

Algeria, Belgium*, Botswana, Burundi, Croatia*, Czech Republic*, Denmark, Democratic Republic of Congo*, Ethiopia, France, Germany*, Great Britain, Italy*, Mali, Morocco, Mozambique, Namibia*, Poland, Romania, Senegal, South Africa*, Zambia*, Zimbabwe*

3.2. General scientific achievements and social benefits

(Meetings are not considered as scientific achievements, they should be listed under heading 3.3.)

The Belgian-Congolese group studied the impact of cobalt contamination on the environment in the Katanga Province (Democratic Republic of Congo). In order to determine the main pathways of human exposure to metals, especially cobalt, urinary concentrations of metals measured in adults and children living in various locations of Katanga were related to estimated intakes of metals, based on concentrations measured in drinking water, foodstuff and dust. It was found that contamination of locally grown vegetables and locally caught fish represent significant sources of exposure to cobalt, with the contribution of contaminated dust also being substantial, especially for children. Moreover, the concentrations of heavy metals and the forms in which they occur were determined in tailings from deposits and two major ore processing facilities in the Katanga Copperbelt (Kipushi, Likasi), were studied by a combination of various methods. For the Kipushi area, sulfide minerals in tailings ponds were

identified as the source of extractable metals they contain, but the input from an external source rather than local oxidation of substrate components is responsible for high levels of contamination in the Likasi area. Contaminated areas around Likasi are characterized by an abundance of Mg-sulfate efflorescences with high concentrations of cobalt and other metals, acting as an important factor for further dispersion of contaminants by wind and water.

The Czech -Zambian team studied the content of metals and arsenic in tubers of cassava (*Manihot esculenta*) growing on uncontaminated and contaminated soils of the Zambian Copperbelt mining district. Generally, the contents of Cu and Co are much higher in cassava growing in contaminated areas. However, dietary exposure to metals and arsenic through the consumption of these vegetable crops has been identified as a low risk to human health in contaminated areas. Nevertheless, as the surfaces of cassava leaves are strongly contaminated by metalliferous dust in the polluted areas, there is still a significant risk of ingesting dangerous levels of copper, lead and arsenic if dishes are prepared with poorly washed foliage.

The Italian group within the project continued in evaluation of the impact of mining and mineral processing on the environment in the Copperbelt Province. The team from the University of the Witwatersrand studied the capability of biosorbents (the *Penicillium simplicissimum* biomass immobilized on zeolite) for adsorption of metals. The results of investigation revealed that the applied biosorbent displayed good adsorption of metals even at low pH values and as such can be used efficiently in areas contaminated by AMD with high metals concentration. The metal loaded in the biomass can potentially be desorbed in order to regenerate the biosorbent and possibly reclaim valuable metals. The same team studied the possibility to discriminate different geological units of the Witwatersrand Basin gold fields, using remote-sensing of tree canopy spectral reflectance. Their study demonstrated significant disjunctions in foliar spectral data for two native phreatophyte tree species, which link to the changes in parent geology across a savannah in a semiarid region. Whether the differences found in their study are directly related to substrate mineralogy and AMD, including changes in nutrient status or toxicities, among other factors, is still under investigation.

A group of scientists from the University of Pretoria studied the mobilization and transport mechanisms of contaminants in flotation tailings ponds left after mining and mineral processing of platinum ores in South Africa. The results achieved showed that the accumulation and continuous and slow input of chemical species may add to the salinity of the groundwater, degrading its quality and may eventually impact on the health and environment of local groundwater users.

Extensive research carried out by the Czech-Namibian group in cooperation with experts from Germany and Croatia takes place in Namibia. The investigation is focused on the assessment of the impact of a smelter in Tsumeb on local environment. Environment-oriented studies also continue in the area of abandoned mineral deposits of Berg Aukas and Kombat. The investigation in the Kombat area revealed that although the farmland soils in this area are

contaminated at the vicinity of tailings ponds with Pb and Cu, these metals are relatively strongly bound in the soils and there is likely to be only a small danger for their release from soil into surface water and later in to the groundwater. On the other hand, relatively high bioavailability of lead during inhaling and particularly in swallowing contaminated dust particles may pose a problem and health risk.

3.3. List of meetings with approximate attendance and number of countries

Annual Workshop of the IGCP/SIDA Project 594, Windhoek, Namibia, July 5-6, 2012

(51 participants from Croatia, Czech Republic, Democratic Republic of Congo, Germany, Namibia, South Africa, Zambia)

3.4. Educational, training or capacity building activities

Training Course: Applications of geochemical modeling and reactive transport with emphasis on the impact of mining industry on the environment

(20 participants from Namibia, South Africa, Croatia, Czech Republic)

3.5. Participation of scientists from developing countries, and in particular young and women scientists

1) Annual Workshop of the of the IGCP/SIDA Project 594, Windhoek, Namibia, July 5-6, 2012.

Workshop participants:

Amwenyo Hilya (Geological Survey of Namibia), Banza Lubaba Nkulu Celestine (University of Lubumbashi), Braune Matt (SRK Consulting Ltd -South Africa), Cukrowska Ewa (University of the Witwatersrand), Davies Theophilus Clavell (University of Venda, South Africa), Farmer Elizabeth (Navachab Mine), Hangula Simon (Ministry of Mines and Energy, Namibia), Hinsch Manda (SRK-South Africa), Leonard Rosina (Geological Survey of Namibia), Mapani Benjamin (University of Namibia), Matengu Brian (Namibia Water Corporation Ltd), Mupewa Joseph (Geological Survey of Namibia), Moroua Don (CSA Consulting, South Africa), Muyongo Aphary (Geological Survey of Namibia), Nguno Anna (Geological Survey of Namibia), Schneider Gabrielle (Geological Survey of Namibia), Schreck Peter (Geological Survey of Namibia), Shilongo Miriam (Ministry of Mines and Energy, Namibia), Simon Jeremiah (Ministry of Mines and Energy, Namibia), Sutton Malcom (University of the Witwatersrand, South Africa), Tipangandjara Kuir F (Namwater), Tutu Hlanganani, Univeresity of the Witswatersrand, Van Rooy Louis (University of Pretoria) Van Tonder Johan (Ministry of Mines and Energy, Namibia), Oscar S. Shaningwa (Geological Survey of Namibia), Wake Heike (Geological Survey of Namibia), Shivolo N. H. (Aridox Mining and Resources)

Students of the University of Namibia:

Negonga Lisias, Amukwa Lovisa, Shigwenda Silvanus, Shaanika, Giezbertha, Ipinge, Helmi, Hamalwa, Justina, Emvula, Monika, Fanuel Dangarembezi Gideon Francis, Shaningwa Johanna, Uukule Selma, Ijikuza Mannuela

**Students of the University of Pretoria:
Huismanen, Altus**

**Students of the University of Witwatersrand
Makiese Julien, Miranda Muller**

Women scientists: 7, students: 15 (8 women)

(2) Training Course: Applications of geochemical modeling and reactive transport with emphasis on the impact of mining industry on the environment

Amukwa Lovisa (University of Namibia), Kaundikiza G (F and G Mineral Resources), Shigwedha S. R. (Student, University of Namibia), Tjikuzu Manuella (Student, University of Namibia), Muroua Don (CSA), Ipinge Helmi (Student, University of Namibia), Hijamutiti Michelle (Student, University of Namibia), Huisamen Althus (Student, University of Pretoria), Shaningwa Johanna (Student, University of Namibia), Uukulev Selma (Student, University of Namibia), Jeremiah Simon (Geologist, Ministry of Mines, Namibia), Simubah Gloria (Geologist, Geological Survey of Namibia), Hamakwa Justina (Student, University of Namibia), Nesonga Lisias (Student, University of Namibia), Emwula Monika (Student, University of Namibia), Benjamin Mapani, University of Namibia, Shivoko N.H (Geologist),

Students: 11 (7 women)

*3.6. List of most important publications (including maps)
Distinguish between peer review literature and other (no abstracts)*

(1) Publications submitted to international journals:

Křibek, B, Majer, V, Knésl, I, Nyambe I, Mihaljevič, M, Ettler, V, Sracek, O. (2012) Metals and arsenic in cassava and sweet potatoes: Indicators of contamination in the Zambian Copperbelt mining district. – Submitted to the journal Environmental Geochemistry and Health.

Mees, F, Masalehdani, MNN, De Putter, T, D´Holander C, Van Biezen, E, Mujinya, BB, Potdevin, JL, Van Ranst, E (2012) Concentrations and forms of heavy metals around two ore processing sites in Katanga, DR. Congo.- Submitted to the Journal of African Earth Sciences

Křibek B, Mapani, B, Nyambe I (2011) Mining and the Environment in Africa.- Inaugural Workshop of the IGCP/SIDA 594, Kitwe, Zambia, October 17-19, 2011.- Submitted to Episodes.

(2) Peer-reviewed extended abstracts

- Bakatula, EN, Cukrowska, EM, Tutu, H, Straker, CJ, Weiersbye, IM (2012) Biosorption of metals from gold mine wastewaters by *Penicillium simplicissimum* immobilized on zeolite: Kinetic, equilibrium and thermodynamic studies. - *In: Mapani, B, Křibek, B (eds.) Environmental and health impacts of mining in Africa.- Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 7-11. Czech Geological Survey, ISBN 978-80-7075-781-9.*
- Banza Lubaba Nkulu, C, Asosa, JN, Ngombe, LK, Mwanza, AM, Numbi, OL, Ilunga, BK, Kimpanga, CM, Cheyns, K, Smolders, E, Haufroid, V, De Putter, Th, Nemery, B (2012) Pathways of exposure to cobalt in populations living in Katanga, D.R. Congo.- *In: Mapani, B, Křibek, B (eds.) Environmental and health impacts of mining in Africa.- Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 12-13. Czech Geological Survey, ISBN 978-80-7075-781-9.*
- Cukrowska, EM, Lusilao-Makiese, J, Tutu, H, Chimuka, LK (2012) The impact of gold mining on mercury pollution in the Witwatersrand Basin, South Africa.- *In: Mapani, B, Křibek, B (eds.) Environmental and health impacts of mining in Africa.- Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 14-15. Czech Geological Survey, ISBN 978-80-7075-781-9.*
- Davies, TC (2012) Advances in mitigation and rehabilitation technology in major and abandoned mines in Sub-Saharan Africa.- *In: Mapani, B, Křibek, B (eds.) Environmental and health impacts of mining in Africa.- Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 16-20. Czech Geological Survey, ISBN 978-80-7075-781-9.*
- Ettler, V (2012) Environmental impact of ore smelting: the African and European experience.- *In: Mapani, B, Křibek, B (eds.) Environmental and health impacts of mining in Africa. - Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 21-22. Czech Geological Survey, ISBN 978-80-7075-781-9.*
- Ettler, V, Mihaljevic, M, Šebek, O, Křibek, B, Majer, V (2012) Mobility and bioaccessibility of inorganic contaminants in soils in the vicinity of copper smelters, Copperbelt, Zambia. - *In: Mapani, B, Křibek, B (eds.) Environmental and health impacts of mining in Africa.- Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 23-24. Czech Geological Survey, ISBN 978-80-7075-781-9.*
- Huisamen, A, van Rooy, JL (2012) Contaminant mobilisation by fluid-rock interaction and related transport mechanisms in platinum tailings. - *In: Mapani, B, Křibek, B (eds.) Environmental and health impacts of mining in Africa.- Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 25-27. Czech Geological Survey, ISBN 978-80-7075-781-9.*
- Křibek, B, Majer, V, Knésl, I., Nyambe, I, Mihaljevič, M, Ettler, V, Sracek, O (2012) Metals and arsenic in cassava: Indicators of contamination in the Zambian Copperbelt mining district. - *In: Mapani, B, Křibek, B (eds.) Environmental and health impacts of mining in Africa.- Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 28-33. Czech Geological Survey, ISBN: 978-80-7075-781-9.*

- Mihaljevič, M, Ettler, V, Šebek, O., Sracek, O, Kříbek, B, Majer, V, Veselovský F, Kyncl, T (2012) Dendrogeochemical record of pollution from mining and smelting in Copperbelt, Zambia. - *In: Mapani, B, Kříbek, B (eds.) Environmental and health impacts of mining in Africa .- Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 34-35. Czech Geological Survey, ISBN: 978-80-7075-781-9.*
- Mileusnić, M, Ružičić, S, Mapani, BS, Kamona, AF, Mapaure, I, Chimwamurombe, PM (2012) Trace elements dispersion from a tailings impoundment (dam) and speciation study in surrounding agricultural soils: A Case study from Kombat Mine area, Otavi Mountainland, Namibia. - *In: Mapani, B, Kříbek, B (eds.) Environmental and health impacts of mining in Africa.- Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 36-39. Czech Geological Survey, ISBN: 978-80-7075-781-9.*
- Muller, MH, Weiersbye, IM, Tongway DJ, Hardwick, D (2012) Discrimination of three geologies on the Witwatersrand Basin gold fields, South Africa, using remote-sensing of tree canopy spectral reflectance- *In: Mapani, B, Kříbek, B (eds.) Environmental and health impacts of mining in Africa - Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 40-45. Czech Geological Survey, ISBN: 978-80-7075-781-9.*
- Quinger, J, Mischo, H (2012) Mobilization processes of As, Cd and Pb in soils in the Tsumeb Area, Namibia.- *In: Mapani, B, Kříbek, B (eds.) Environmental and health impacts of mining in Africa - Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 46-47. Czech Geological Survey, ISBN: 978-80-7075-781-9.*
- Schneider, GIC (2012) Mining & exploration in protected areas in Namibia.- *In: Mapani, B, Kříbek, B (eds.) Environmental and health impacts of mining in Africa - Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 48-50. Czech Geological Survey, ISBN: 978-80-7075-781-9.*
- Sracek, O, Kříbek, B, Majer, V, Mihaljevič M (2012) The impact of mining activities on the environment and surface drainage in the Copperbelt, Zambia.- *In: Mapani, B, Kříbek, B (eds.) Environmental and health impacts of mining in Africa - Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 51-52. Czech Geological Survey, ISBN: 978-80-7075-781-9.*
- Sracek, O, Lefévre, R (2012) Acid rock drainage and pyrite oxidation rate in waste rock pile at Mine Doyon site, Québec, Canada.- *In: Mapani, B, Kříbek, B (eds.) Environmental and health impacts of mining in Africa - Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 53-54. Czech Geological Survey, ISBN: 978-80-7075-781-9.*
- Vaněk, A, Penížek, V, Chrástný, V, Teper, L, Cabala, J (2012) Thallium geochemistry in soils affected by Zn smelting.- *In: Mapani, B, Kříbek, B (eds.) Environmental and health impacts of mining in Africa - Proceedings of the Annual Workshop IGCP/SIDA No. 594, Windhoek, Namibia, July 5th-6th, 2012, p. 55-57. Czech Geological Survey, ISBN: 978-80-7075-781-9.*

3.7. Activities involving other IGCP projects, UNESCO, IUGS or others

A close cooperation with IGCP/SIDA 606 Project has been established. Professor Davis attended the Annual Meeting of the IGCP/SIDA 594 Project held in Windhoek. Both projects will organize a joint meeting in the frame of 24 Colloquium of African Geology (CAG24) and 14th Congress of the Geological society of Africa (GSAf14) in Addis Ababa, Ethiopia on JANUARY 8-14, 2013.

Members of the UNESCO/IGCP Project 594 participated in the preparation of a new project AMIRA No.P1085 - Artisanal and Small-Scale Mining in Africa (AMA): finding a way forward. This project is focused on the assessment of impacts of these kinds of mining on the environment and health of the population in Africa. Participants of the Annual Meeting of the IGCP/SIDA 594 in Windhoek were informed about preparatory works on the project. The project was proposed by Professor Kim HEIN (Ncube-Hein) School of Geosciences, University of the Witwatersrand, Johannesburg, phone: +27 11 717 6623, Email: kim.ncube-hein@wits.ac.za and by Kriba Reddy, AMIRA International, Email: kriba.reddy@amirainternational.com, Phone: +27 11 498 7201, Fax: +27 11 498 7203

Members of the Italian, Czech and Belgian groups of the UNESCO/IGCP Project 594 also participated in preparation and compilation of the project "Integration of Geological and other Environmental Information with Medical Data for a Human Exposome". The project was not approved in 1011 and will be resubmitted in 2012. Coordinator of the Project: Professor Benedetto De Vivo, Università Federico II, Napoli, Italy, phone: + 393 92077298, E-mail: bdevivo@unima.it

Members of the Italian, Czech and Spanish groups of the IGCP/SIDA project participated within the program FP7-ENV-20130/Environment in the preparation and compilation of a sub-project: Turning waste into a resource through innovative technologies, processes and services in Sub-Saharan Africa.

Members of Polish, Czech, Danish and Italian groups participate in the preparation of the new EuroGeoSurvey project in Africa.

The scope of the project involves:

- Economic geology and management of mineral resources
- (methodological assistance).
- Small-scale mining.
- Information on infrastructure of mineral resources.
- Geo-environmental studies and rehabilitation (revitalization) of mining and post- mining areas.
- Water resources sustainable management and health.
- Mitigation of geohazards and land-use planning.
- Geoheritage protection and promotion (geo-sites and geo-parks and education).
- Human resources and capacity building and training of OAGS members and their partners through innovative case studies.

- Dissemination of information about the project and building and running database of the obtained results.

4. Activities planned for year 2013

4.1. General goals

General goals of the project in 2013 are (1) to correlate and integrate the results of multidisciplinary studies performed in contaminated areas using the best contemporary procedures for statistical analysis, management and compilation of geochemical data in Africa; (2) to strengthen the capacity of African institutions in environmental geochemistry by cooperation with foreign experts and organizations, (3) to raise the public awareness about the impacts of mining on the environment and human health and, (4) to facilitate cooperation among geoscientists and medical scientists.

The project in the following period will be focused not only on the mechanisms controlling the attenuation of pollutants impact on soils and waters, but also on the use of best-available technologies for reclamation and remediation works (sorbents and bioremediation methods). Appropriate attention will be paid to the possibility of reusing the mine wastes (slag and flotation tailings) as a source of metals. This reworking of mine wastes can bring not only an economic benefit to mining companies, but also contribute to solving environmental problems.

4.2. Tentative list of specific meetings and field trips (please list the participating countries)

(1) The second Annual meeting of the IGCP/SIDA Project 594 will be organized in cooperation with the IGCP/SIDA project 606 within the 24 Colloquium of African Geology (CAG24) and the 14th Congress of the Geological society of Africa (GSAf14) in the United Nations Conference Center (UNCC) in Addis Ababa, Ethiopia on JANUARY 8-14, 2013.

The session 5.3: Environmental and Health Impacts of Mining in Africa will be organized under the auspices of both IGCP/SIDA Projects.

Conveners of the section: Theo C. Davies, University of Venda, South Africa (daviestheo@hotmail.com), Benjamin Mapani (University of Namibia, bmapani@unam.na), Bohdan Křibek, Czech Geological Survey (bohdan.křibek@geology.cz)

(2) Training course in Environmental Geochemistry will be organized either at the University of the Witwatersrand or at the University of Pretoria, South Africa.

5. Project funding requested

USD 12 000 for year 2013

6. Request for extension, on-extended-term-status, or intention to propose successor project N/A

7. Financial statement (\$ USD only) See certified financial statement and originals of invoices.

Additional funding in 2012: Czech Geological Survey (funding of Bohdan Kříbek's and Vladimír Majers's travels to Namibia), Charles University, Prague (funding of Martin Mihaljevič's and Vojtěch Ettler's travels to Namibia), Czech University of Life Sciences (funding of Vít Penížek's and Aleš Vaněk's travels to Namibia), Palacký University Olomouc, Czech Republic (funding of Ondra Sracek's travel to Namibia), University of the Witwatersrand (funding of Ewa Cukrowska's and Mirana Miller's travels to Namibia). University of Namibia (rental of a bus for field trip), Geological Survey of Namibia (rental of the conference room, logistics).

8. Attach any information you may consider relevant

Attachments:

- 1. Certified financial statement and originals of invoices**
- 2. Meeting Report Form: Annual Workshop held in Windhoek, Namibia and relevant materials**
- 3. Meeting Report Form: Training Course: Applications of geochemical modeling and reactive transport with emphasis on the impact of mining industry, Windhoek, Namibia and relevant materials**
- 4. Publications of the IGCP/SIDA 594**