A public-private partnership supporting training and research in earth, atmospheric and space sciences in Africa
http://africaarray.psu.edu/

8th Annual AfricaArray Workshop

School of Geosciences
University of the Witwatersrand,
Johannesburg, South Africa

15-18 January 2013

Programme & Abstracts

International Committee on Global Navigation Satellite Systems

8th Annual AfricaArray Workshop – 15-18 January 2013

School of Geosciences, University of the Witwatersrand, Johannesburg, South Africa

15 January	***8h00-15h00***	***Training course on the operation of AfricaArray stations***
15 January	***15h30-17h00***	***Global Earthquake Model (GEM) workshop: report on the activities of the Regional Programme for sub-Sahara*** *Presented by Prof Atalay Ayele*
16 January	***8h00-14h30***	***Training course on the operation of AfricaArray stations*** *Presented by Prof Andy Nyblade, Dr Damien Delvaux & Dr Alain-Pierrre Tokam Kamga*
16 January	***15h00-17h30***	***Computer Code for Seismic Hazard assessment in the Case of Incomplete and Uncertain Data*** *Prof Andrzej Kijko, Aon Benfield Natural Hazard Centre*
17-18 January	***8h00-17h00***	***AfricaArray Scientific Meeting***

GLT Lecture Theatre, Geosciences Building, Wits **Thursday January 17**

08:00 - 08:30	REGISTRATION – Tea and Coffee
08:30 - 08:40	WELCOMING REMARKS **Roger Gibson** *(Head, School of Geosciences, University of the Witwatersrand)*
08:40 - 09:10	AFRICAARRAY STATUS REPORT - network activities and development plan **Andy Nyblade** *(Penn State Univ., USA)* & **Damien Delvaux** *(AfricaArray)*
09:10 - 09:30	EDUCATIONAL & COMPLEMENTARY ACTIVITIES **Ray Durrheim** *(University of the Witwatersrand/CSIR, SA)*

Theme: Structure and Tectonics of the African Plate

09:30 - 10:00	KEYNOTE: Rifting and basin formation in Central Africa **DELVAUX, Damien** *(AfricaArray, University of the Witwatersrand, SOUTH AFRICA & Royal Museum for Central Africa, BELGIUM)*
10:00 – 10:20	Study of the lithosphere beneath Cameroon, West Africa **TOKAM KAMGA, Alain-Pierre** (*Post-doctoral Fellow, University of the Witwatersrand, SOUTH AFRICA*)
10:20 - 10:40	Geophysical study of the Mamfe basin, south-eastern extension of the Benue trough beneath Cameroon, West Africa **NGUIYA, Severin** *(University of Doula, CAMEROON)*

10:40 – 11:00	***Tea break***
11:00 - 11:20	Structure of the Precambrian in Uganda **TUGUME, Fred (***Geological Survey Department, UGANDA*)
11:20 - 11:40	Tectonic history of the Kaapvaal craton: constraints from rheological modeling **KGASWANE, Eldridge** (*PhD candidate, University of the Witwatersrand & Council for Geoscience, SOUTH AFRICA*)
11:40 - 12:00	Crustal structure beneath three seismic stations in the south flank of volcano Nyiragongo in the Western Rift valley of Africa from receiver function analysis **MAVONGA TULUKA, Georges,** (*Goma Volcano Oberservatory, DR Congo*)
12:00 - 12:20	Computer-assisted seismogram analysis and source parameter determination: case of the short period seismic network at the Karthala Volcano Observatory, Grand Comoro **MOUSSA, Abdoulkarim** (*Centre National de Documentation et de la Recherche Scientifique (CNDRS), COMOROS*)
12:20 - 12:40	Upper mantle and transition zone structure beneath Tanzania and Zambia: Is the African superplume a through-going mantle structure? MULIBO, Gabriel and **NYBLADE, Andy** *(both at Penn State University)*
12:40 - 13:00	Toward ambient noise interferometry in South Africa **MANGONGOLO, Azangi** *(PhD candidate, University of the Witwatersrand & Council for Geoscience, SOUTH AFRICA)*
13:00- 14:00	***Lunch break***
14:00 - 14:20	3D geophysical modelling of the Karoo basin - Preliminary results **SCHEIBER-ENSLIN, Stephanie** (*PhD candidate, University of the Witwatersrand, SOUTH AFRICA*)
14:20-14:40	Potential field modelling of the Bushveld Complex **COLE, Janine** (*PhD candidate, University of the Witwatersrand & Council for Geoscience, SOUTH AFRICA*)
14:40 - 15:00	Observational studies to mitigate rockbursts in South African gold mines **DURRHEIM, Ray** (*CSIR & University of the Witwatersrand)* & **OGASAWARA, Hiroshi** (*Ritsumeikan University, JAPAN*)
15:00 - 15:20	Rockburst damage mechanisms at Impala platinum mine **LEDWABA, Lesiba** (*MSc graduate, University of the Witwatersrand, SOUTH AFRICA*)
15:20 - 15:40	***Tea break***
15:40 - 16:00	Reflection seismic investigations of the structure and tectonics of the Witwatersrand basin **MANZI, Musa** (*PhD candidate, University of the Witwatersrand, SOUTH AFRICA*)
16:00 - 16:20	Development of a potential field forward modelling system for Python **COLE, Patrick** (*Council for Geoscience, SOUTH AFRICA*)
16:20 - 16:50	AfricaArray International Field School **WEBB, Sue & STUDENTS** (*University of the Witwatersrand, SOUTH AFRICA*)
17:00 - 19:00	**POSTERS & Fin*ger Supper in the Bleloch Museum, sponsored by AfricaArray***

GLT Lecture Theatre, Geosciences Building, Wits **Friday January 18**

Theme: African Geodesy, Hydrology and Tectonics

08:00 – 08:30 KEYNOTE: Geodesy and hydrology
PLAG, Hans-Peter *(Global Change & Sustainability Research Institute, University of the Witwatersrand, SOUTH AFRICA*)

08:30-08:50 Crustal thickness in Africa from satellite gravity data
VAN DER MEIJDE, Mark (ITC, *University of Twente, THE NETHERLANDS*)

08:50-09:10 Contribution of tectonic solutions for the seismotectonic map of Africa
FERNANDES, Rui (SEGAL, *PORTUGAL*)

09:10-09:30 Validation of geoid models for Tanzania with GNSS levelling
DAUD MASUNGULWA, Ntambila (ARDHI University, *TANZANIA*)

09:30-09:50 Developing preliminary velocity field for Madagascar by measuring 9 geodetic markers with high-precision GPS instruments
RAJAONARISON, Tahiry *(MSc candidate, Institute and Observatory of Geophysics, University of Antananarivo (IOGA), MADAGASCAR)*

09:50 - 10:10 Stability monitoring of the Nigerian Permanent GNSS Network (NIGNET)
DODO, Joseph (*Centre for Geodesy and Geodynamics, NIGERIA*)

10:10 – 10:30 ***Tea break***

Theme: Seismic hazard

10:30 - 11:00 KEYNOTE: Post-Gondwana stress distribution in South Africa – helping to understand seismic hazards in the subcontinent.
ANDREOLI, Marco *(NECSA & University of the Witwatersrand, SOUTH AFRICA*)

11:00 - 11:20 Seismicity of the arid regions of western South Africa
MALEPHANE, Hlompho (*PhD candidate, University of the Witwatersrand, SOUTH AFRICA*)

11:20 - 11:40 Earthquake disaster risk reduction in Ghana: efforts, challenges and mitigation strategies
AMPONSAH, Pauline (*Atomic Energy Commission, GHANA*)

11:40 - 12:00 Malawi's current seismicity and rifting
KAPANJE, Winstone (*Geological Survey Department, MALAWI*)

12:00 - 12:20 The 2009 Karonga Earthquake Sequence: Revisiting the Seismic Performance of Buildings in the area
CHINDANDALI, Patrick Rafik (*Geological Survey Department, MALAWI)*

12:20 - 12:40 Current capability of the Ethiopian Seismic Station network to understand earthquake and volcano hazards in the region and mitigate risks
AYELE, Atalay (*GEM sub-Sahara and University of Addis Ababa, ETHIOPIA)*

12:40- 14:00 ***Lunch break***

14:00 - 14:20 Seismicity of an volcanic area in the center of Madagascar
RAMAROLAHY RINA, Andrianasolo *(Institute and Observatory of Geophysics Antananarivo (IOGA), MADAGASCAR)*

14:20 - 14:40 Modeling crustal structure beneath the Ubendian Belt in southern Tanzania using a genetic algorithm applied to regional waveforms
EL TAHIR, Nada *(PhD candidate, University of the Witwatersrand)*

withdrawn Vp/Vs ratio and Moho depth determination beneath the crust of Tal El-Amarna area, El-Minya, Middle Egypt, using the receiver function method
EL-SHARKAWY, Amr (*National Research Institute of Astronomy and Geophysics, EGYPT*)

Theme: Initiatives allied to AfricaArray

14:40 - 15:00 Geodetic infrastructure and UNAVCO's role in supporting AfricaArray and other geodesy projects in Africa
MATTIOLI, Glen (*UNAVCO, USA*)

15:00 - 15:20 ISC mission and current development
SHUMBA, Blessing (*International Seismological Centre, ISC*)

15:20 - 15:40 ***Tea break***

15:40 – 16:00 GEM Sub-Saharan Africa and current status of developing earthquake hazard model
AYELE, Atalay (*GEM sub-Sahara and University of Addis Ababa, ETHIOPIA*)

16:00 – 16:20 Wits Global Change and Sustainability Research Institute
PLAG, Hans-Peter *(University of the Witwatersrand, SOUTH AFRICA*)

16:20 – 16:40 IASPEI & African Seismological Commission
GROBBELAAR, Michelle (*Council for Geoscience, SOUTH AFRICA*)

16:40 – 17:00 American Geophysical Union (AGU) & Society of Exploration Geophysicists (SEG)
WEBB, Sue (*University of the Witwatersrand, SOUTH AFRICA*)

17:00 - 19:00 **POSTERS & Finger *Supper in the Bleloch Museum, sponsored by he Global Earthquake Model (GEM) Foundation***

Posters: on display on 17-18 January in the Bleloch Museum

Ghana National Seismic Networking & the Seismicity of the Country
AHULU, Sylvanus Tetteh (*Ghana Geological Survey Department, Accra, GHANA*)

Seismic noise cross correlation and the structure of the mantle in Cameroon
ATEBA, Bekoa (*Institute of Geological and Mining Research, CAMEROON*)

Seismicity in Zambia
CHILESHE, Miriam (*Geological Survey Department, ZAMBIA*)

Existing and proposed location of seismic station in Sudan
EL-KHIDIR, Amani *(Ministry of Minerals - Geological Research Authority of Sudan, GRAS)*

Crustal structure of the Khartoum basin, Sudan
EL TAHIR, Nada (*PhD candidate, University of the Witwatersrand & Geological Authority, SUDAN*)

Seismic network of the Goma Volcanic Observatory
ETOY OSODUNDU, Modeste (*Goma Volcanic Observatory, DRC*)

Tectonic model of the Limpopo belt: constraints from magnetotelluric data
KHOZA, David *(Dublin Institute for Advanced Studie*s, IRELAND *s & University of the Witwatersrand, SOUTH AFRICA)*

Recent activity of the Aon Benfield Natural Hazard Centre, University of Pretoria
KIJKO, Andrzej *(Aon Benfield Natural Hazard Centre, University of Pretoria)*

Seismicity of the arid regions of western South Africa
MALEPHANE, Hlompho (*PhD candidate, University of the Witwatersrand, SOUTH AFRICA*)

Diurnal variation of total electron content at Makerere University in the ascending solar phase
MUTONYI D'UJANGA, Florence (*Makarere University, UGANDA*)

Assessment of Onistar DGPS against precise point positioning in Tanzania
NGAILO, Elly Gerson (*ARDHI University, TANZANIA*)

The Malawi seismic network
SHABA, Pearson *(Geological Survey Department, MALAWI)*

CTBT link to the ISC database
ISC-GEM global reference earthquake catalogue 1900-2009
SHUMBA, Blessing (*International Seismological Centre, ISC*)

The Seismicity of the Northern Province of Malawi
SHABA, Pearson (*Geological Survey, MALAWI)*

Geological and structural mapping of the northwestern part of the prolific gold producing Ashanti gold belt of Ghana using magnetic and radiometric data
WEMEGAH, David Dotse (*Kwame Nkrumah University of Science Technology, GHANA*)

Earthquake disaster risk reduction in Ghana: Efforts, challenges and mitigation strategies

P.E. AMPONSAH[1, 2] and N.K. Allotey[1]

1. Ghana Atomic Energy Commission, P.O.Box LG 80, Legon-Accra, Ghana.
2. Graduate School of Nuclear and Allied Sciences, P.O.Box AE1, Atomic Energy, Ghana.

Several megacities in the developing world are faced with the threat of devastating earthquakes. Most of these are close to tectonic boundaries and receive requisite national and international attention. Ghana's case, and for that matter, Accra, the capital city, is an interesting one, since it is far away from the major earthquake zones of the world. However, the southern part of the country, in which Accra is located is seismically active and has been affected by moderate to large earthquakes over the years. Historical records of earthquakes in Ghana date as far back as 1615. Notable among these is the 22 June 1939 earthquake in which seventeen lives were lost with extensive damage done to structures and properties. The seismic risk confronting the country has not been given the needed attention. This is being fuelled by a myriad of problems including, continuous haphazard development, poor enforcement of building codes and poor knowledge of earthquake-resistant construction. This study seeks to present a holistic view of the problem and to suggest feasible ways of ameliorating the problem. The study focuses on what is currently being done, and also points out other measures that need both immediate and long term attention. In summary, the study seeks to draw both national and international attention to Ghana's earthquake risk and also find plausible solutions to mitigate earthquake disaster in the country.

Keywords: Ghana, earthquakes, safety measures, earthquake risk reduction.

Post-Gondwana stress distribution in South Africa Helping to understand seismic hazards in the subcontinent

M A G ANDREOLI[1, 2], Z Ben-Avraham[3, 4], D Delvaux De Fenffe[2, 5], R Durrheim[6, 2], A Fagereng[7], A O Heidbach[8], M Hodge[7], A Le Roux[7], A Logue[1,7],H Malephane[2],N v d Merwe[2], J Muoka[2], K Saalmann[2] and I Saunders[9]

1. South African Nuclear Energy Corporation, South Africa, marco@necsa.co.za
2. University of the Witwatersrand, South Africa
3. Tel Aviv University, Israel, zviba@tau.ac.il
4. University of Haifa, Israel
5. Royal Museum for Central Africa, Belgium, damien.delvaux@africamuseum.be
6. CSIR, South Africa, RDurrhei@csir.co.za
7. University of Cape Town, South Africa, Ake.Fagereng@uct.ac.za
8. GFZ Potsdam, Germany, heidbach@gfz-potsdam.de
9. Council for Geoscience, South Africa , ians@geoscience.org.za

A persistent weakness in assessing the seismic hazards in South Africa originates from the under-representation of much of the subcontinent in the World Stress Map database. As a consequence, it is generally difficult to determine the reactivation potential of known faults, permissible only if they line up close to the direction of *maximum horizontal compressive stress* (σ_H). To obtain this datum, or even better the orientation of the principal compressive stresses ($\sigma_1>\sigma_2>\sigma_3$), we installed 3 compact Trillium stations across the Grootvloer seismic cluster (Bushmanland, Northern Cape) whose data will be integrated with those from the national network to obtain focal mechanism solutions. These neotectonic stress tensors are then combined with σ_H parameters obtained from caliper logs of off-shore wells and from the geometry of joints, faults and sheared fractures in palaeosols (Bushmanland), soils and calcrete (NW Free State) and aeolianites (southern Cape). We also include underground rock engineering phenomenological observations and measurements (Witbank coal field), and data in the public domain. Our data consistently indicate a NNW-SSE oriented σ_H (Wegener Stress Anomaly or WSA) prevailing across most of central, southern and western South Africa/Namibia

not further than southern Angola. We also found that the WSA is the last of at least 7 successive tectonic regimes to leave their brittle imprints along the SE Atlantic seaboard since the break-up of W Gondwana. In conclusion, the state of stress in South Africa holds many uncertainties, including the strike-slip to transpressional character of the WSA, its rapidly changing strength and stain rate and the influence of the E African Rift System.

Current capability of the Ethiopian Seismic Station Network (ESSN) to understand Earthquake and Volcano Hazards in the region and mitigate risks

Atalay Ayele

Institute of Geophysics Space Science and Astronomy, Addis Ababa University; atawon@yahoo.com

Ever since earthquake recording started in Ethiopia in 1959, the monitoring facility has evolved over the last half a century. Three component digital seismogram recording with GPS time stamping started in Ethiopia in 1994 which was a big leap in routine data analysis. In 1999 and 2000, several remote stations were upgraded to be digital seismic stations. Currently more than 9 state of the art broadband seismic stations are running in the country, which are backbone to the Ethiopian Seismic Station Network (ESSN). The installation of real-time-data access at least for three seismic stations namely DESE, ARBA and HARA is in progress. This will bring the number of stations with real-time-data access in Ethiopia to five together with AAE and FURI. The seismic data from ATD (Djibouti), KMBO (Kenya) and MBAR (Uganda) global stations are made to be accessible for the Institute of Geophysics Space Science and Astronomy (IGSSA) near real-time. This will empower the Institute to listen to earthquakes of interest that may burst in the active rift segments and volcanic source in the region. The improvement & advance of this monitoring facility will have significant national relevance in mapping hazard and mitigating risk as the country is already in progress of building mega development structures like buildings and Dams. On the other hand the seismic data will boost basic science research and the graduate program that Addis Ababa University is vigorously pursuing.

Earthquake Hazard and Risk in Sub-Saharan Africa: current status of the Global Earthquake model (GEM) initiative in the region

Atalay AYELE[1], Vunganai Midzi[2] , Bekoa Ateba[3], Thifhelimbilu Mulabisana[2], Kwangwari Marimira[4], Dumisani J. Hlatywayo[4], Ofonime Akpan[5], Paulina Amponsah[6], Georges Mavonga Tuluka[7] and Ray Durrheim[9]

1. Addis Ababa University, Ethiopia, e-mail:*atalayayele@gmail.com*
2. Council of Geosciences, South Africa
3. Institute of Geological and Mining Research, Cameroon
4. National University of Science and Technology, Zimbabwe
5. Centre for Geodesy and Geodynamics, Nigeria
6. Atomic Energy Commission, Ghana
7. Goma Volcano Observatory, DRC
8. University of Witwatersrand, South Africa

Large magnitude earthquakes have been observed in Sub-Saharan Africa in the recent past, such as the Machaze event of 2006 (Mw, 7.0) in Mozambique and the 2009 Karonga earthquake (Mw 6.2) in Malawi. The December 13, 1910 earthquake (Ms = 7.3) in the Rukwa rift (Tanzania) is the largest of all instrumentally recorded events known to have occurred in East Africa. The overall earthquake hazard in the region is on the lower side compared to other earthquake prone areas in the globe. However, the risk level is high enough for it to receive attention of the African governments and the donor community.

The latest earthquake hazard map for the sub-Saharan Africa was done in 1999 and updating is long overdue as several development activities in the construction industry is booming allover sub-Saharan Africa. To this effect, regional seismologists are working together under the GEM (Global Earthquake Model) framework to improve incomplete,

inhomogeneous and uncertain catalogues. The working group is also assessing all possible sources of data for the catalogue as well as for the seismotectonic model that will help to develop a reasonable hazard model in the region. In the current progress, it is noted that the region is more seismically active than we thought. This demands the coordinated effort of the regional experts to systematically compile all available information for a better output so as to mitigate earthquake risk in the sub-Saharan Africa.

The December 2009 Karonga Earthquake Sequence Revisiting the Seismic Performance of Buildings in the area

Patrick R.N. CHINDANDALI

Geological Survey of Malawi, P.O. Box 27, Zomba, Malawi, rafikiwanga@gmail.com

A review on why several buildings performed poorly during the December 2009 earthquake sequence in Karonga District, northern Malawi is carefully presented in this paper. A total of 26 earthquakes of 4.5<M <6.0 were recorded between December 6 and 19, 2009. The main shock (Mw 6.0), occurred on December 19, 2009 at 0145Hrs (UTC). Four people were killed, 300 wounded, over 1000 houses collapsed and 2900 houses damaged. Most of the buildings suffered damage largely due to substandard construction practices and their location across the fault or proximity to fault rupture. In a country like Malawi where majority of the population live without knowledge of earthquake awareness, human loss and property damage could be more in future events due to substandard construction practices and awareness resulting in millions of dollars in economic loss. There is therefore need for proper earthquake mitigation programs by implementing National building code which could be pivotal in addressing the shortfalls in the design, construction and implementation of building requirements, but its absence only advances vulnerability of the communities in Karonga and the whole nation. Lessons learned from the 2009 Karonga earthquakes should improve the nation's understanding and awareness of earthquakes and mitigation.

Keywords: Earthquake Mitigation, Karonga earthquakes, Malawi earthquake sequence, Malawi Rift, National Building Code, Risk Assessment, Seismicity of Malawi, Vulnerability.

3D Potential Field Modelling of the Bushveld Complex

Janine COLE[1], Susan J Webb[2], Carol A Finn[3]

[1]Council for Geoscience, Pretoria, South Africa, jcole@geoscience.org.za
[2]University of the Witwatersrand, Johannesburg, South Africa, susan.webb@wits.ac.za
[3]USGS, Denver, Colorado, cfinn@usgs.gov

Three conceptual geophysical models of the Bushveld Igneous Complex have been published over the years (Cousins, 1959; Du Plessis and Kleywegt, and Meyer and De Beer 1987; Cawthorn et al., 1998 and Webb et al., 2004). Only the third model incorporated isostatic adjustment of the crust in response to the weight of the dense mafic material using results from the Southern African Seismic Experiment (SASE) (Nguuri, et al., 2001; Webb et al., 2004). All of the models published up to now have been done in 2 or 2.5 dimensions which is not well suited to modelling the complex geometry of the Bushveld intrusion. The main question is how the new knowledge of the increased crustal thickness, as well as the complexity of the Bushveld Complex, will impact on the gravity fields calculated for the existing conceptual models, when modelling in three dimensions. The three published geophysical models were remodelled using full 3D potential field modelling software, and including crustal thickness obtained from the SASE in order to test the existing conceptual models. Including the thicker crust underneath the Bushveld Complex necessitates the presence of dense material in the central area between the eastern and western lobes. The simplest way to achieve this is to model the mafic component of the Bushveld Complex as a single intrusion. This is similar to what the first students of the Bushveld Complex suggested. Conceptual models are by definition simplified versions of the real situation, and the geometry of the Bushveld Complex is expected to be much more intricate.

References

Cawthorn, R.G., Cooper, G.R.J., Webb, S.J. (1998). Connectivity between the western and eastern limbs of the Bushveld Complex. SAJG, 101, 291-298.

Cousins, C.A. (1959). The structure of the mafic portion of the Bushveld Igneous Complex. Trans. G. Soc. S A, 62, 179-189.
Du Plessis, A., Kleywegt, R.J. (1987). A dipping sheet model for the mafic lobes of the Bushveld Complex. SAJG, 90, 1-6.
Meyer, R., De Beer, J.H. (1987). Structure of the Bushveld Complex from resistivity measurements. Nature, 325, 610-612.
Nguuri, T.K., Gore, J., James, D.E., Webb, S.J., Wright, C., Zengeni, T.G., Gwavava, O., Snoke, J.A. and Kaapvaal Seismic Group. (2001). Crustal structure beneath southern Africa and its implications for the formation and evolution of the Kaapvaal and Zimbabwe cratons. GRL, 28, 2501-2504.
Webb, S.J., Cawthorn, R.G., Nguuri, T., James, D. (2004). Gravity modelling of Bushveld Complex connectivity supported by Southern African Seismic Experiment results, SAJG, 107, 207-218.

Development of a 3D Potential Field Forward Modelling System in Python

Patrick COLE

Council for Geoscience, South Africa pcole@geoscience.org.za

The collection of potential field data has long been a standard part of geophysical exploration. The interpretation of such data can be a daunting task, especially when 3D models are becoming more necessary. The current trend in modelling software is to follow either the modelling of individual profiles, which are then "joined" up into 3D sections, or to model in a full 3D using polygonal based models (Singh and Guptasarma, 2001). Unfortunately, both techniques have disadvantages. When modelling in 2.5D the impact of other profiles is not truly available on your current profile being modelled, and vice versa. The problem is not present in 3D, but 3D polygonal models, while being easy to construct the initial model, are not as easy to make fast changes to. In some cases, the entire model must be recreated from scratch. The ability to easily change a model is the very basis of forward modelling.

The solution was to adopt a voxel based approach, rather than a polygonal approach. The solution for a cube (Blakely 1996) was used to calculate potential field for each voxel. The voxels are then summed over the entire volume. The language used was Python, because of its huge capacity for scientific development. The interface to the program works similar to a Paint program. The model is simply drawn into the side views or top views of the volume of interest. Relevant voxels are either activated or deactivated in this way. The software has proved to be extremely successful. It has enabled faster modelling of anomalies in a non-complex manner – implying little or no training to prospective users.

References

Blakely, R.J., Potential Theory in Gravity and Magnetic Applications (1996), pp 200 - 201
Singh, B., Guptasarma, D., (2001). New method for fast computation of gravity and magnetic anomalies from arbitrary polyhedral, Geophysics, 66, pp. 521 - 526

Validation of Recent Geoid Models for Tanzania

Ntambila DAUD

School of Geospatial Sciences and Technology**,** Ardhi University**,** Box 35176, Dar es Salaam, Tanzania

Geoid is an equipotential surface of the Earth's gravity field very close to mean sea level. It is a datum for orthometric heights, height system widely used globally for daily activities of people. Determination of orthometric height in hilly terrain levelling is cumbersome, tedious, time consuming and expensive. The method that can solve the problem is GPS leveling depends on the geoid. Many developing countries do not have dedicated regional gravimetric geoid models in place. Tanzania had its first regional geoid model in 2007 (TZG07). The second dedicated precise gravimetric geoid model of Tanzania is TZG08. Four recent gravimetric geoid models were validated by (a) comparison of geoid heights computed from the four geoid models at 23 GNSS/levelling benchmarks in mainland Tanzania (b) comparison of sea surface topography from the differences between the mean sea surface and geoid heights of the four models in the ocean

area (c) individual comparison of the geoid models to one another. The four geoid models are, TZG07, AGP07, TZG08 and EGM08. Findings show that, their relative and absolute accuracy is 39.4cm and 38.1cm for TZG07, 42.3cm and 41.1cm for AGP07, 24.9cm and 22.7cm for TZG08, and 33.0 cm and 31.4cm for EGM08. The main conclusion is that TZG08 performs better in the area of interest and thus qualifies to be gazetted as the official National geoid model of Tanzania

Keywords: Tanzania, Geoid model, GNNS/GPS levelling, Orthometric height

---

Rifting and basin formation in Central Africa

D. DELVAUX

Royal Museum for Central Africa, Tervuren, Belgium
University of the Witwatersrand, Johannesburg, South Africa

The Congo-Tanzania plate was assembled in the Paleoproterozoic by orogenic welding of a series of Archean cores. It was affected by Pan-African collisional orogenic processes at its margins during the Gondwana amalgamation in late Neoproterozoic - early Paleozoic. It hosts the intracratonic Congo basin and several successive rift systems that testify for a long geological evolution. The dislocation of Gondwana started in Permo-Triassic with the Karoo rifting period. Rifting stages also occurred in the Cretaceous and Paleogene while modern rifting started in the Miocene and is still active today.

Active tectonism in Central and East Africa is shown by the distribution of historical and instrumental and seismicity, thermal springs and neotectonic faults. The distribution of thermal (warm) springs matches well that of the seismicity in the East African rift system, confirming the idea that thermal springs are also a good indicator for active tectonism.

The geometry of half grabens which form the building blocks of rift basins is particularly well illustrated by the Livingstone/Karonga basin at the northern end of Lake Nyasa/Malawi. On the Tanzanian side, the border fault accommodated most of the slip between the top of the basement under the basin and the rift shoulder and forms the Livingstone fault scarp. On the Malawi side, the Karoo to recent sediments dip gently towards the basin, with an increasing inclination with the age of the sediments.

The Rungwe volcanic province which lies at the intersection between the eastern and western branches of the east African rift system in the region of Mbeya has a long and complex evolution. It hosts a recently recognized geothermal system and the late Quaternary sediments of Lake Rukwa have recorded the interaction between climatically driven lake level fluctuation, volcanism and faulting.

Vp/Vs ratio and Moho depth determination beneath the crust of Tal El-Amarna area, El-Minya, Middle Egypt by applying the Receiver Function Method

Ahmed Hosny[1,2], Mostafa Toni[1], Mohsen M. Attia[3], Awad Hassoup[1] and **Amr EL-SHARKAWY**[1]

1. Seismology Department, National Research Institute of Astronomy and Geophysics, Helwan, Egypt
2. ICTP North Africa Group for Earthquake and Tsunami studies, NAGET.
3. Geology department, Faculty of Science, Sohag University, Egypt.

The receiver function method was applied on the teleseismic data of the earthquakes recorded by the TAMR station, which is installed at Tal El-Amarna area, 50 km south of El-Minya province, in the central part of the eastern desert of Egypt. TAMR station is equipped with a very broad band trilium seismometer and it is recently deployed as an important element of the national seismic network of Egypt (ENSN). Data of the converted P waves to S waves (Ps phase) at TAMR station indicates that, the depth average of Moho discontinuity is at 35 km. They demonstrate also about 6-7 km thickness of the sedimentary cover at that site. The analysis of the TAMR data shows Vp/Vs ratio of about 2.05 ± 0.05, which is remarkably high, particularly at a normal thickness of the crust (35 km). The high Vp/Vs

ratio reflects sometimes the presence of saturated sedimentary layer (limestone) with water, which might be the case at Tal El-Amarna area due to its location very close to the River Nile and presence of many faults and fractures. Due to the historical interest of Tal El-Amarna area, a more detailed study focusing on the seismic hazard assessment is needed, such as deterministic and probabilistic seismic hazard.

Validation of Recent Geoid Models for Tanzania

Ntambila DAUD

School of Geospatial Sciences and Technology**,** Ardhi University**,** Box 35176, Dar es Salaam, Tanzania

Geoid is an equipotential surface of the Earth's gravity field very close to mean sea level. It is a datum for orthometric heights, height system widely used globally for daily activities of people. Determination of orthometric height in hilly terrain levelling is cumbersome, tedious, time consuming and expensive. The method that can solve the problem is GPS leveling depends on the geoid. Many developing countries do not have dedicated regional gravimetric geoid models in place. Tanzania had its first regional geoid model in 2007 (TZG07). The second dedicated precise gravimetric geoid model of Tanzania is TZG08. Four recent gravimetric geoid models were validated by (a) comparison of geoid heights computed from the four geoid models at 23 GNSS/levelling benchmarks in mainland Tanzania (b) comparison of sea surface topography from the differences between the mean sea surface and geoid heights of the four models in the ocean area (c) individual comparison of the geoid models to one another. The four geoid models are, TZG07, AGP07, TZG08 and EGM08. Findings show that, their relative and absolute accuracy is 39.4cm and 38.1cm for TZG07, 42.3cm and 41.1cm for AGP07, 24.9cm and 22.7cm for TZG08, and 33.0 cm and 31.4cm for EGM08. The main conclusion is that TZG08 performs better in the area of interest and thus qualifies to be gazetted as the official National geoid model of Tanzania

Keywords: Tanzania, Geoid model, GNNS/GPS levelling, Orthometric height

---

Stability Monitoring of the Nigerian Permanent GNSS Reference Network (NIGNET)

Joseph Danasabe DODO[1], Lazarus Ojigi[2] and Yakubu Tahir[1]

1. Centre for Geodesy and Geodynamics, National Space Research and Development Agency, P.M.B. 11 Toro, Nigeria
2. Department of Strategic Space Application, National Space Research and Development Agency, Abuja, Nigeria

The recent establishment of the state-wide, network of Global Navigation Satellite System (GNSS) continuously operation reference station in Nigeria has the potential to significantly increase the number and diversity of users making decisions on the basis of instantaneous positions derived from the GNSS. In utilising this service, GNSS users place increasing reliance on the network of Continuously Operating Reference Stations (CORS) that generate the real time information used to correct their GNSS receiver data, thereby enabling sub-meter levels of positioning accuracy. Theoretically, the overall quality of the solution obtained by the GNSS mobile user should reflect a combination of the quality of the data collected within the CORS network and that measured by the roving receiver. However, in reality this is not the case and users often accept the overly optimistic quality estimates generated by GPS receivers. In order to accurately describe the quality of the Nigerian Permanent GNSS Station positional solutions, the Centre for Geodesy and Geodynamics has initiated a project to determine the stability of the CORS stations. This paper presents the approach and results obtained from the first phase of this project, the continuous stability monitoring of the Nigerian Permanent GNSS Network (NIGNET) through the computation of daily network solutions. The paper discusses the role of stability monitoring within the existing NIGNET quality control activities.

Keywords: Continuously operation reference station, daily network solution, Nigerian Permanent GNSS Network, coordinate repeatability

---

Observational Studies of Earthquake Nucleation, Triggering and Rupture in South African Mines

Ray DURRHEIM[1,2,3] and Hiroshi Ogasawara[1,4]

1. JST-JICA Science and Technology Research Partnership for Sustainable Development (SATREPS)
2. CSIR Centre for Mining Innovation, South Africa
3. University of the Witwatersrand, South Africa
4. Ritsumeikan University, Japan

Mining-induced earthquakes pose a risk to workers in deep mines, while natural earthquakes pose a risk to people living close to plate boundaries and even in stable continental regions. A five-year ca. US$3 million Japan-SA collaborative project "Observational studies in South African mines to mitigate seismic risks" was launched in August 2010. The project has three main aims: (1) to learn more about earthquake preparation and triggering mechanisms by deploying arrays of sensitive instruments in mines where mining-related stresses are likely to induce significant seismic activity; (2) to learn more about earthquake rupture and damage phenomena by deploying strong ground motion sensors close to potential rupture zones and on the walls of stopes; and (3) to upgrade the South African national surface seismic network in the mining districts. Acoustic emission sensors, accelerometers, strainmeters, and controlled seismic sources are being installed at sites in Ezulwini, Moab-Khotsong and Driefontein gold mines to monitor the deformation of the rock mass, the accumulation of damage during the earthquake preparation phase, and dynamic stress as the rupture front propagates. These data will be integrated with measurements of stress, stope closure, stope strong motion, and seismic data recorded by the mine-wide network. Here we describe the design of experiments that seek to identify reliable precursors of damaging seismic events.

Seismic Network of the Goma Volcanic Observatory

O. ETOY, T. Mavonga, M. Fikiri and J.P. Wilonja

Department of Seismology, Goma Volcanic Observatory, Democratic Republic of Congo

The seismic network of Goma Volcanic Observatory [GVO] was obtained in 1983 from the principal network of Geophysical Department of the Centre de Recherche en Sciences Naturelles of Lwiro. The network has 3 analogical seismic stations located around the Nyamulagira and Nyiragongo volcanoes and located at KTL, LBG and BLG up to 2002. After the Goma January 17th 2002 Nyiragongo eruption a Telemetered Digital Seismological Network was installed with the collaboration of the Istituto Nazionale di Geofisica e Vulcanologica [INGV] of ITALY in October 2003 and has 6 stations KNN, RSY, GOM, KBT, KBB and BLG. The seismic stations are concentrated in the south part of Nyiragongo volcanoes for the monitoring of his volcanic activities and for the reduction of the risk hazard of the lava flow in the Goma City witch the population estimated was 700.000 peoples in 2003. Some of seismic stations worked up to 2006. After 2007 they stopped several time due to the insecurity conditions caused by the groups army and movement of the rebels operating around the Virunga National Park.
During 2011 two non telemeter digital seismic stations using the Data logger recorders was installed at RGB and BOBN with the collaboration of MRAC-AFRICA ARRAY because the direct transmission signal from each station to Goma office was not possible. The GVO network are using the broadband 5, 40,120 seconds and short period 1.0 second type seismometers and the different software's for the data acquisition, to analyze and for the processing.

MRAC: Africa Museum of Central Africa

KTL: Katale	LBG: Luboga	BLG: Bulengo	KNN: Kunene
RSY: Rusayo	GOM: Goma	KBT: Kibati	KBB: Kibumba
BOBN: Bobandana	RGB: Rumangabo		

Seismic Equipment and Earthquake Monitoring in Malawi

Winstone KAPANJE

Geological Survey Department, MALAWI

Ever since the earthquake observation started in Malawi in 1962, Malawi has never procured seismic equipment. The only equipment that was being used was the ones installed in Southern Rhodesia (Zimbabwe) and Northern Rhodesia (Zambia) by Federal Government of Rhodesia and Nyasaland (Malawi). In 1962, one analogue three-component station was installed at Chileka Airport. After the Salima earthquake of March, 1989, Malawi was given three single-component portacoders, one in each of the three regions. These were given and being maintained by Council for Geoscience. In December, 2009, Malawi was hit by series of earthquake in the Northern Region. Malawi Government through Geological Survey relied on AfricaArray data from Zomba and Mzuzu and the NDC-MW(CTBTO). Other stations were down. In 2010, Malawi procured Ten Seismic Equipment from REF TEK. With this new equipment plus the Africa Array, now Malawi is able to monitor earthquakes (micro-, micro-earth tremor). Now Geological Survey Department is able to see the variation of seismicity in Malawi; and recent seismic activity happening in the western side of Zomba district.

Tectonic history of the Kaapvaal Craton: constraints from rheological modelling

E.M. KGASWANE[1,2]

1. Council for Geoscience, Pretoria, Private Bag X112, 0001, South Africa
2. School of Geosciences, University of the Witwatersrand, Private Bag 3, Johannesburg, South Africa

The lithospheric strength of the Kaapvaal Craton has been to first order, estimated using rheological flow laws governing brittle and ductile failure of rocks at lithospheric depths and geotherms (some computed and others adopted from past studies). The resulting rheological models for the 64 broadband seismic stations spread across the craton were further analysed using strength formulations for the lower crust and lithospheric mantle and the results of this analysis show that the craton can be delineated approximately into three strength domains. These strength domains are consistent with SKS splitting observations from previous and recent studies. A major portion of the Kimberley terrain and minor parts elsewhere in the craton has an upper lithospheric structure that is weak corresponding to strength ratios that are less than 0.5, most parts of the Witwatersrand terrain show a moderate strength ratio between 0.5 and 1.0, and the eastern shield of the craton shows an upper lithospheric structure that is mechanically strong and corresponds to a strength ratio greater than 1.0. The low strength ratio across the Kimberley terrain correlates with a strong mantle anisotropy (deduced by studies of SKS splitting measurements) and is suggestive of a weak lithosphere. The high strength ratios in the eastern shield of the KC correlate with a weak mantle anisotropy and is suggestive of a stable lithosphere. The strength ratio parameter tends to be linearly related to crustal thickness and surface heat flow, however these relationships are apparent and are dependent on the deformation history of the region.

Keywords: Brittle deformation, ductile deformation, geotherm, strength ratio parameter, Kaapvaal Craton

Tectonic model of the Limpopo belt: constraints from magnetotelluric data

D. KHOZA[1,2], A. G. Jones[1], M. R. Muller[1], R. L. Evans[3], S. J. Webb[2], M. Miensopust[4], and the SAMTEX Team[1]

1. Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin, Ireland
2. University of the Witwatersrand, 1 Jan Smuts Avenue, Johannesburg, South Africa
3. Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, MA 02543-1050, USA
4. Institut fur Geophysik, Westfalische Wilhelms Universitat, Munster, Germany

Despite many years of work, a convincing evolutionary model for the Limpopo belt and its geometrical relation to the surrounding cratons is still elusive. This is partly due to the complex nature of the crust and upper mantle structure, the significance of anatectic events and multiple high-grade metamorphic overprints. We use deep probing magnetotelluric data acquired along three profiles crossing the Kaapvaal craton and the Limpopo belt to investigate the crust and upper mantle lithospheric structure between these two tectonic blocks. The 20-30 km wide composite Sunnyside-Palala-Tshipise-Shear zone is imaged in depth for the first time as a sub-vertical conductive structure that marks a fundamental tectonic divide interpreted here to represent a collisional suture between the Kaapvaal and Zimbabwe Cratons. The upper crust in the Kaapvaal Craton and the South Marginal Zone comprises resistive granitoids and granite-greenstone lithologies. Integrating the magnetotelluric, seismic and metamorphic data, we propose a new tectonic model that involves the collision of the Kaapvaal and Zimbabwe cratons circa 2.6 Ga, resulting in high-grade granulite Limpopo lithologies. This evolutionary path does not require a separate terrane status for each of the Limpopo zones, as has been previously suggested.

Keywords: Limpopo belt, Archean, magnetotelluric

Rockburst Damage Mechanism at Impala Platinum Mine

Lesiba S LEDWABA[1], Johann Scheepers[1], Ray Durrheim[2,3] and Steve Spottiswoode[4]

1. Impala Platinum Holdings Limited
2. CSIR Centre for Mining Innovation, South Africa
3. University of the Witwatersrand, South Africa
4. 24 Mail Street, Florida Park, 1709, South Africa

Impala Platinum Mine (Impala), situated north of the town of Rustenburg in the North West Province of South Africa, has experienced an increase in seismicity from ~841 seismic events in the year 2005 to ~1588 seismic events in 2008. The Seismologists and Rock Engineers need to understand the underlying mechanisms and driving forces responsible for seismicity to develop and design mining layouts and support strategies to eliminated or mitigate the risks posed by rockbursts. However, most previous studies of seismicity conducted on Impala and other Bushveld Complex mines in the Rustenburg area provided limited information regarding the source parameters and mechanism due to insufficient data.

The study is designed to investigate the seismic hazard on Impala Platinum Mine by means of two approaches: an investigation of seismic spatial distributions and the study of the rockburst damage mechanism of seismic events. A number of detailed investigations of rockbursts were conducted whereby damage was mapped and photographed. The investigations include reviews of the seismic history, short-, medium- and long-term seismic hazard assessment methods, and an analysis of the source parameters of the seismic event and associated ground motions. The study has revealed that most of the seismic events occur close to the reef plane, and are the result of the failure of a volume of rock that includes a pillar and the host rock that forms the foundation of the pillar.

Seismic Hazard Assessment of the Western Arid Regions of South Africa: a Preliminary Study

H R MALEPHANE[1], R Durrheim[1, 2], M A G Andreoli[1, 3], A Kijko[4], V Midzi[5], I. Saunders[5] and F Scherbaum[6]

1. University of the Witwatersrand, South Africa, hlompho.malephane@students.wits.ac.za
2. Council for Scientific and Industrial Research, South Africa, rdurrhei@csir.co.za
3. South African Nuclear Energy Corporation, South Africa, marco@necsa.co.za
4. University of Pretoria, South Africa, andrzej.kijko@up.ac.za
5. Council for Geosciences, South Africa, vmidzi@geoscience.org.za
6. Council for Geosciences, South Africa, ians@geoscience.org.za
7. University of Potsdam, Germany, fs@geo.uni-potsdam.de

The study is a contribution to other studies conducted for understanding the general stress pattern of southern Africa. The Vaalputs radioactive waste disposal facility lies within the study area. It is currently the only such facility in South Africa that was found suitable for low- and intermediate-level radioactive waste, in the mid 1980s. A seismic hazard assessment greatly benefits the suitability assessment for a future high-level radioactive waste disposal facility in the area. A two-station seismic network established in 1989 monitored seismicity around this facility. Data collected shows that the Vaalputs site is seismically stable, yet sporadic activity including seismic swarms has occurred across Namaqualand and Bushmanland in recent years. From this data a preliminary probabilistic seismic hazard assessment is conducted using two different approaches for comparison and verification of results. The seismic source zones are clearly identified and defined, recurrence relations derived and ground motion estimates, in terms of Peak Ground Acceleration (PGA) computed. The area is characterised by a maximum magnitude M<5.5. A new seismic network consisting of three stations, forming a triangular layout at about 100km apart has recently been established with the aim of expanding and linking it to the South African National Seismological Network. The network consists of one broadband, compact Trillium sensor at Stofkloof near the Vaalputs site and two Mark 4.5Hz geophones at Aggeneys and Koffiemeul farm. The new data will be incorporated to the existing data in order to achieve the aim of this study..

Keywords: Vaalputs, radioactive waste, seismic hazard assessment, seismic source zone

Toward ambient noise interferometry in South Africa

Azangi **MANGONGOLO**

Council for Geoscience (CGS), P/Bag 001, Pretoria, South Africa

Ambient noise interferometry is now widely used for earth structure and monitoring using the impulsive response between pair of stations. Well recovered Green's functions from daily ambient noise cross correlations are presented. Using Bensen et al. (2007), a computer code was made to process ambient noise and recover Empirical Green Function (EGF) between pair of stations. The processing steps consist of: (1) running absolute-mean normalization and (2) whitening for spectral domain normalization, before (3) time-domain cross correlation. Using waveform ambient noise recorded by the South African National Network and the Kaapvaal craton experiment, daily ambient noise filtered between 0.2 and 40s were cross correlated and stacked to produce Green functions. For the area between latitude 26S and 30S and longitude 24E to 28E, Green functions calculated show prominent Rayleigh waves with apparent velocity of 3.106 km/s. Before the Rayleigh waves, seismic waves with apparent velocity of 3.603 km/s were also identified. We suggested that these waves are the Moho reflected SmS phases. Slightly higher than the SmS identified by Zhan et al., (2010) in the area. Results presented here is just the first step of ambient noise interferometry studies in South Africa.

Keywords: Ambient noise interferometry, Green functions, seismic waves, tomography, monitoring.

3D Reflection seismic investigations of the structure and tectonics of the Witwatersrand basin

M. S. D. MANZI[1], K. A. A. Hein[1]; R. J. Durrheim[1,2]

1. School of Geosciences, University of the Witwatersrand Johannesburg, PBag 3, WITS, 2050, RSA.
2. Council for Scientific and Industrial Research (CSIR), Johannesburg, RSA.

The study is a contribution to other studies conducted to understand the general stress pattern of southern Africa and to constrain the nature of the seismic sources therein. The Vaalputs low- and intermediate-level radioactive waste disposal site, which lies at the core of the study area, is the only facility of its kind in Africa and has been in operation since the mid1980s. A two-station TELS seismic network established in 1989 monitored seismicity around this facility almost continuously for a period of 20 years. The data collected show that the Vaalputs site is seismically stable, though sporadic activity (including at least 2 seismic swarms) tends to occur further away across Namaqualand and Bushmanland. From these data we conducted a preliminary probabilistic seismic hazard assessment (PSHA) using two different approaches for comparison and verification of results. The seismic source zones were clearly identified and defined, recurrence relations derived, ground motion estimated, and Peak Ground Acceleration (PGA) computed. Accordingly, we obtained a maximum magnitude value M<5.5. We also recently replaced the old TELS system with a new seismic network consisting of three stations, forming a triangular layout at about 100km apart across Bushmanland, with the aim of linking it to the South African National Seismological Network. The network is solar-powered, remotely-accessed via cellphone, and consists of one broadband, compact Trillium sensor at Stofkloof, near Vaalputs, and two Mark 4.5Hz geophones, at Aggeneys and Koffiemeul farm, near Bosluispan, respectively The new data will be incorporated to the existing catalogue in order to achieve the aim of this study, including a more advanced PSHA also applicable to a future high level radioactive waste disposal facility if it were located in the same region..

Keywords: Neoarchaean, Witwatersrand Basin, seismics, structure, tectonics

Crustal structure beneath five seismic stations revealed from teleseismic P wave receiver function analysis in the Virunga volcanic area, Western Rift Valley of Africa

Georges MAVONGA TULUKA[1], Damien Delvaux[2,3] and Ray Durrheim[2,4]

1. Goma Volcanic Observatory, Goma, D.R. Congo
2. University of the Witwatersrand, Johannesburg, South Africa
3. Royal Museum for Central Africa, Bruxelles, Belgium
4. Council for Scientific and Industrial Research, Johannesburg, South Afica

The shear velocity structure beneath the Virunga volcanic area was estimated by using an average solution in the time domain inversion of stacked teleseismic receiver functions provided by two seismic broadband stations KUNENE (KNN) and KIBUMBA (KBB) and three others equipped with Lennartz (LE-5sec). The bradband stations are 29 km apart and located at the Eastern and Western escarpment of the Western Rift in the Virunga area, respectively, while the other stations, namely: Rusayo (RSY), Bulengo (BLG) and GOMA, are located in the south flank of volcano Nyiragongo.

The velocity model was presented as P-wave velocity models. From these models, the crust mantle transition zone beneath the area sampled by KNN, KBB, RSY, BLG and GOMA in the Virunga area was determined at depth from about 39 to 43 km, 30 to 39 km, 28 to 39 km, 26 to 32 km and 28 to 37 km, respectively. The V_p/V_s in the south flank of volcano Nyiragongo area varied from 1.74 to 1.90.

A low velocity zone was observed below stations KNN, KBB, GOMA, BLG and RSY at depths between 20 to 30 km, 18 to 28 km, 10 to 16 km, 10 to 15 km and 8 to 18 km, respectively, and with average velocity 6.1 km/s, 5.9 km/s, 5.8 km/s, 5.5 km/s and 4.9 km/s. This low velocity zone may sample the conduit containing partial melt. The models show

also high velocity material (6.9, 7.3 and 7.8 km/s) lying beneath stations KNN, KBB and GOMA at depths 3 to 20 km, 3 to 10 km and 3 to 10 km , respectively, which is indicative of magma cumulates within the volcanic edifice. The result obtained in this study was applied to the determination of epicenters during the period prior to the 27 November 2006 Nyamuragira eruption. This eruption was preceded by a swarm of hybrid volcanic earthquakes with clear P-waves onset. It correlates well with the location of the eruption site and data provided by the InSAR observations of surface deformation associated with the eruption.

Computer-assisted seismogram analysis and source parameter determination: case of the short-period seismic network at the Karthala Volcano Observatory, Grand Comoro.

Abdoulkarim MOUSSA

Karthala Volcano Observatory, Centre National de la Documentation et de la Recherche Scientifique, PO. Box 169 , Moroni, Grand Comoro, Union of Comoros

Grand Comoro Island is dominated by the presence of the Karthala shield volcano. The monitoring of this volcano is assured by the Karthala Volcano Observatory which is under the control of the Centre National de la Documentation et de la Recherche Scientifique (CNDRS). This observatory was established in 1988. It's a great challenge for the Karthala Volcano Observatory (KVO) to better monitor this volcano since it's still active and remains a danger for the Comorian population. The monitoring of the Karthala volcano is mainly based on seismic data analysis. We also use other techniques but those ones are secondary. A short period seismic network composed by 8 seismic stations exists in the central part of Grand Comoro at the summit zone of the Karthala. After data acquisition, we use SISMALP to proceed to computer-assisted seismogram analysis and source parameter determination. After that, we proceed to the plotting of the hypocenters on a map of Grand Comoro using MATLAB. The Karthala Volcano Observatory is a young observatory so naturally some improvements have to be done in order to improve his efficiency. Indeed technical and material improvements are required.

Keywords: Grand Comoro, Karthala volcano, Karthala Volcano Observatory, seismic data analysis.

Hydrogeodesy and Water Management at River Basin Scale

Hans-Peter PLAG

Global Change and Sustainability Research Institute (GCSRI),
The University of the Witwatersrand, Johannesburg, South Africa.

Sustainable water management is essential for meeting the growing demands for potable water and for reducing current and projected shortages. Regional water management is hampered by a lack of sufficient observations of terrestrial water storage, particularly on local to river basin scales. In many countries, water scarcity is going to worsen, and for African countries, projections are dire. The lack of efficient decision support through monitoring and modeling can lead to inappropriate water management with the consequence of severe human and ecological disasters. A much improved observation system providing information on all terrestrial reservoirs of the water cycle from local to regional scales is needed in support of water resource management.

Geodetic observations capture signals of all mass transport within the Earth system. On time scales from days to decades, the main redistribution of mass in the Earth system takes place in the water cycle. Changes in the Earth's gravity field, shape, and rotation relate to the changes in water distribution in the atmosphere, oceans, on the land surface, and in the subsurface. The dramatic increase over the last three decades in accuracy of geodetic techniques for the monitoring of regional and local changes in gravity and surface displacements facilitates more accurate measurement of water mass as it is stored and cycles from one reservoir to another. The integrated global geodetic observation infrastructure has the potential to close some of the current gaps in our monitoring system for the water cycle, particularly on regional scales. Increasingly, hydrogeodetic data products are available for use in regional water

management. The public availability of these data products derived from the geodetic observations creates the opportunity to integrate these products into decision support tools for water management.

Hydrogeodetic products help to constrain changes in land water storage from local to global scales. Particularly at river basin scale, they provide a basis to monitor changes in water storage, both below and above the surface, and they allow the detection of trends caused by unsustainable water resource management. Improved data access, documented data applicability, and better access to hydrogeodetic products for non-experts are key to a wider use of hydrogeodetic products as decision support for water management. A web-based hydrogeodesy workbench would be an important step in this direction. The geodetic and hydrometeorological stations of AfricaArray could provide a core observation network for the development of a hydrogeodetic community in Africa.

The Global Change and Sustainability Research Institute (GCSRI) and its relation to AfricaArray

Hans-Peter PLAG

Global Change and Sustainability Research Institute (GCSRI),
The University of the Witwatersrand, Johannesburg, South Africa.

The GCSRI is one of six "21st Century Institutes" under establishment at the University of the Witwatersrand. The Exxaro Chair on Global Change and Sustainability leads the GCSRI. This chair has a research focus on climate policy at national, regional, and international levels, including the transition to a low carbon economy, energy and climate nexus, and integrated reporting on climate and global change. The development and quantification of indicators for sustainability, environmental and societal health, and global change provides a basis for the integrated reporting.
The 1st order process outcomes facilitating progress towards sustainability have to develop the human and social capital upon which other sustainability processes can be built. Consequently, the current research projects contributing to the GCSRI focus on the next generation of African scholars and thinkers, leadership training in climate change mitigation and adaptation, and sustainable cities. Masters students, PhD students, and post-doctoral researchers work on a wide range of global change and sustainability topics in an integrated and interdisciplinary environment. The development of a curriculum for a Masters degree in Global Change is under way in coordination with several Faculties and Schools at Wits.

The draft research plan of the GCSRI defines sustainability research and emphasizes the importance of an improved linkage of transdisciplinary science with societal stakeholders in order to create the knowledge and facilitate the innovation required to build sustainable communities. To make progress towards a metrics for the sustainability of a community, four characteristics of sustainability are identified: (1) the disaster risks a community faces and the temporal changes in the risks due to changes in the hazards, the sensitivity of the community and built environment to the hazards, and the exposure; (2) resilience, i.e., the ability of the community to withstand external shocks, as well as slow changes; (3) adaptive capacity, i.e., the ability to respond successfully to, for example, climate variability and change; and (4) sustainable livelihood. The GCSRI aims to research these characteristics in selected focus areas.
The food-water-energy nexus is one of the 'frontlines' in the sustainability crisis of humanity and so is the resilience of the growing urban environment. These are key candidates for GCSRI research focus areas. Earth observations are fundamental for answering many of the questions related to the sustainability and the impacts of global change in these areas. AfricaArray provides valuable observations, particularly if integrated into broader information systems such as model webs for food-water-energy and urban resilience applications. In developing these systems, the GCSRI will make use of AfricaArray data and products.

Developing a preliminary Malagasy velocity field using mm-precision GPS observations

Tahiry RAJAONARISON[1],D. Sarah Stamps[2], Gerard Rambolamanama[1]

1. Institute and Observatory of Geophysics, University of Antananarivo, MADAGASCAR
2. Perdue University

In this work we develop the first country-wide preliminary velocity field for Madagascar using high-precision Global Positioning System (GPS) instruments capable of detecting millimeter precision deformation. In 2010, 8 geodetic markers were installed and initially observed for the first position epoch in Madagascar and remeasured in 2012. These markers are strategically positioned across the island to capture potential displacements in any direction. In a first step we calculate positions (1 position per 24 hours) from the initial 2010 and the follow-up 2012 GPS campaigns with millimeter precision and incorporate GPS data from a continuous GPS site established in 2008 (ABPO) using GPS processing software package GAMIT-GLOBK. We correct for deformation due to the Earth's rotation, oceanic loading and zenith delays, precession, and nutation, lunar tides, solar tides, small changes in time and antenna phase fluctuations. To obtain the lowest positions uncertainties, we test 3 atmosphere loading models, atmospheric zenith delay modeling errors and variations in the angle of elevation. We find the lowest position uncertainties using the otl FES2004.grid atmospheric loading model, solving for 3 zenith delays per hour, and using an elevation cut-off angle of 20. In the last step we use GLOBK to apply a kalman filter and combine the 2010 and 2012 positions and establish the first country-wide preliminary velocity field based
on 2 years of observations.

Keywords: Madagascar, GPS , geodetic markers, GAMIT-GLOBK

STUDY OF A VOLCANIC AREA IN THE MIDDLE WEST OF MADAGASCAR

Andrianasolo RAMAROLAHY RINA

Institute and Observatory of Geophysics, University of Antananarivo (IOGA), Madagascar

Nowadays, Madagascar does not know any volcanic eruption even if there are two volcanic areas in Madagascar which are in the center and in the north. Itasy is one of these volcanic areas (Quaternary volcanoes) in the center (middle west), while there is an other one in the south of the center of Madagascar. All of the volcanoes in Madagascar are formed from its separation with India. This study concerns the volcanic field of Itasy which is located in the center , coordinates 19.00°S and 46.77°E, and seismically active. The last eruption was around 6050 BC and generally quiet now (no eruption). In this area, there are many hot spring and some of them are from the magmatic heat flow and the other from the active faulting (some of faults were formed from the formation of the volcanoes) according to the previous geologic study. According to the seismic study, since July 1988 to July 2012, there were 2707 earthquakes and 183 events with local magnitude above 3 Richter (around 5 or 6 earthquakes per year). The data seismic showed that there are two repartitions of the epicenters which are those above the faults and there are also around the main volcanic field. Taking into account the geological and seismic study together, the faults in Itasy are still active and about the volcanoes maybe active, too but we need another study like GPS to confirm that there is a rising of magma beneath the domes.

Geophysical 3D Modelling of the Karoo Basin and Beattie Magnetic Anomaly, South Africa – Preliminary Results

Stephanie SCHEIBER-ENSLIN[1,2], Jörg Ebbing[3,4], Detlef G. Eberle[1] and Susan J. Webb[2]

1. Council for Geoscience, Pretoria Street, Pretoria, South Africa (sscheiber@geoscience.org.za)
2. School of Geoscience, University of the Witwatersrand, Johannesburg, South Africa
3. Geological Survey of Norway, Trondheim, Norway
4. Department for Petroleum Engineering and Applied Geophysics, Norwegian University of Science and Technology, Trondheim, Norway

Declining natural gas production worldwide has caused a shift in focus to unconventional sources such as the Karoo Basin, the broad arid plateau that covers much of the interior of South Africa. The plateau is supported by the stable Archean Kaapvaal Craton in the north and several surrounding Proterozoic basement blocks in the south, and formed within the continental interior of Gondwana during the Late Carboniferous (300 Ma) to Middle Jurassic (125 Ma). No clear tectonic model exists for the Karoo Basin, with several hypotheses regarding the nature of the subsidence resulting in basin formation, which in turn has implications for shale gas formation within the basin.

The aim of this study is to develop a 3D model of the southwestern Karoo Basin. This model will be used to carry out isostasy and flexure studies on the lithosphere in this region in an attempt to gain new insight into the possible evolution of the Karoo Basin on- and off-craton. Here we present 2D gravity and magnetic models across the southwestern Karoo along with a combined preliminary 3D model. The models presented here are based on seismic and potential field data, along with geological and structural information that cover the entire basin. Information about the Moho structure was derived from teleseismic data. The models have been further constrained using deep boreholes, as well as on- and off-shore seismic lines, magnetotelluric (MT) data, and magnetic depth-to-basement estimates. Density and susceptibility values are based on borehole and hand sample data, as well as on the conversion of p-wave seismic velocity to densities.

Potential field models over the southwestern Karoo would be incomplete without including a source for the Beattie magnetic anomaly (BMA), which stretches east to west for ~1000 km across a large portion of South Africa. Seismic data over the western section of the anomaly place the source in the mid-crust (10-15km). We present here modeling of aeromagnetic profiles over the eastern portion of the anomaly, where the source is at its shallowest. Magnetic modelling parameters were determined from exposed Natal basement granite-gneisses further north of the anomaly. Our analysis supports the idea that the BMA is part of the tectono-metamorphic Namaqua-Natal Mobile Belt (NNMB) and associated shear zones, while earlier studies have attributed the anomaly to partially serpentinized oceanic lithosphere possibly linked to a suture zone, or to massive disseminate magnetite-sulphide bodies within the basement.

Crustal thickness in Africa from satellite gravity data

Mark VAN DER MEIJDE[1]

1. Faculty for Geo-Information Science and Earth Observation (ITC), University of Twente, The Netherlands

The Gravity field and steady-state Ocean Circulation Explore (GOCE) satellite gradiometer has been launched in 2009 and the first gravity models have been released July 2010. GOCE maps the Earth's gravity field with unprecedented accuracy and spatial resolution. The final map, model and derivatives of the earth gravity field will provide a better understanding of the physics of the Earth's interior and will lead to new insights into geodynamics especially in areas where limited information is available till date.

An updated crustal model will be presented based on newly released GOCE data. The new model will be compared with an earlier derived crustal model for Africa based on the predecessor of GOCE, GRACE. The crustal thickness estimates using data from the GRACE satellite indicate that the average crustal thickness of the majority of the Precambrian terrains is 40 +/- 5 km. Crustal values, however, are not well resolved in narrow tectonic provinces and in regions where there is a gradational Moho. The higher resolution and higher accuracy of GOCE gravity data will enable

us to model narrow Phanerozoic and Proterozoic mobile belts, rifts and basins that cannot be well resolved with the GRACE data.

The high reliability of the derived crustal thickness models is proven through comparison with receiver function and seismic reflection based estimates of crustal thickness. Our crustal models provide new insights about African geodynamics, including mantle processes, regional seismicity and lithospheric stresses. The tectonic and geodynamic implications of our models will be discussed with emphasis placed on less studied regions.

Keywords: satellite gravity, GOCE, crustal structure, Africa

Geological and structural mapping of the north-western part of the prolific gold producing Ashanti Gold Belt of Ghana using airborne magnetic and radiometric data

D. D. WEMEGAH, B. Boadi, K. Preko

Geophysics Section, Department of Physics, Kwame Nkrumah University of Science and Technology, Kumasi-Ghana

Integrated airborne geophysical methods namely magnetic and radiometric were used to investigate the Konongo area located at the north-western boundary of the prospective Ashanti Gold Belt in south-eastern Ghana. These datasets provided useful information on the various lithological units and geological structures within the area. The data processing approach employed concentrated on enhancing the geophysical data quality and this aided in tracing accurate positioning of geological boundaries, the responses related to mineralization and geological structures that may be of vital economic importance. The magnetic image enhancing technique such as reduction to the pole, analytical signal and first vertical derivative helped delineate folds, fractures, lithological boundaries and the two main Birimian tectonic structural deformation events (D1-NE / D2–NNW) which are potential hydrothermal gold mineralization zone. The contacts between Birimian meta-sedimentary and meta-volcanic rocks noted to host gold mineralization in the belt were also delineated. The radiometric data provided geochemical information of potassium (K), thorium (Th) and uranium (U) that proved valuable in delineating bedrock lithology of the area such as the Banso Batholith, Birimian meta-volcanic, Tarkwaian formation and alteration zones within the lithology and contact zones. High K, Th and U concentration were mapped in the meta-sediments and the Banso batholith. The high-resolution airborne magnetic and radiometric data of the study area resulted in better definition of both geological structures and lithological boundaries. This work shows the usefulness of geophysical data in mapping possible geological structures that host hydrothermal gold mineralization within the upper part of this gold belt.

Keywords: aeromagnetic, gamma ray, geological structures, hydrothermal gold mineralization

---