IGCP Project 601 Kick-off Meeting
Windhoek (Namibia), 26 – 29 September, 2011

Seismotectonics and seismic hazards in Africa

http://eost.u-strasbg.fr/~igcp601/Index.html

ABSTRACTS VOLUME

Date and venue: Organised in the frame of the annual meeting of the Organisation of African Geological Surveys (OAGS) http://www.oagsafrica.org/, the IGCP Project kick-off meeting takes place on 26 - 29 of September 2011 in Windhoek (Namibia).

Meeting Programme:
26th September: Scientific sessions
- The sub-Sahara seismotectonic provinces
- The North Africa seismotectonic provinces
- Discussion
27th – 28th September: Field visit to the Erongo geological province
29th September: OAGS – IGCP business meeting
Programme of Monday 26th September 2011 of session on “Seismotectonics and Seismic Hazards in Africa”
UNESCO – SIDA/IGCP Project 601

14 – 14:15  Mustapha Meghraoui (EOST-IPG Strasbourg): Building the seismotectonic map of Africa: procedure, implications and perspectives

14 :15 – 14 :30  Bufelo Lushetile, Norton Titus and Dave Hutchins (Geological Survey of Namibia) : The seismicity in Namibia

14 :30 – 15 :45  Ofonime U. Akpan (Centre for Geodesy and Geodynamics, Toro, Nigeria): The relationship between the September 11, 2009 Southern Benin Republic earthquake and the Atlantic fracture system

15 :45 – 15 :00  Ayele, A. (Addis Abeba Univ.) and 18 authors : Active fault mapping in Illindi (Tanzania) and Karong (Malawi) areas in the East African Rift System and its hazard implication: insights from seismic refraction.

15 :00 – 15 :15  Nathaniel Lindsey (Univ. of Rochester), Cynthia Ebinger, Matthew Pritchard, Hubert Zal : Comparison of seismological, geodetic, and geological observations of rifting in East Africa: Diffuse vs localized deformation

15 :15 – 15 :30  Damien Delvaux (Royal Museum Central Africa), François Kervyn, Eleonor B. Temu : Sismotectonics and active tectonics in the Western rift branch, Tanzania: a review

15 mn  COFFEE BREAK


16 :00 – 16 :15  Abdelhakim Ayadi (CRAAG, Algiers, Algeria), C. Dorbath, M. Meghraoui, S. Maouche and F. Ousadou : The crustal structure and its relation with tectonics in North Africa

16 :15 – 16 :30  Ulrich Achauer (EOST-IPG Strasbourg) : The structure of the crust and mantle beneath East Africa based on seismic and seismicity studies - a review

16 :30 – 16 :45  B. Ateba (IGMR, Buea, Cameroon) Seismicity of Central and West Africa

16 :45 – 17 :00  Vunganai Midzi (Council for Geoscience, Pretoria) : Status of Seismotectonic and seismic hazard studies in South Africa

17 :00 – 17 :15  Ray Durrheim (Witwatersand Univ., S. Africa) and A. Nyblade, T. Mavonga, G. Mulibo & H. Malephane : AfricaArray investigations of active deformation and seismic hazard
Programme of Thursday 29th September 2011
Business Meeting
OAGS and UNESCO – SIDA/IGCP Project 601

08h30 – 09h00 : IGCP Project 601 : Business meeting (IGCP participants only)
  - IGCP Project 601 : Activity report M. Meghraoui
  - Collaboration with OAGS and future actions A. Ayele
  - Working groups on thematic mapping: Draft map for 2012 V. Midzi

09h00 – 10h30 : Discussion of OAGS Project Progress
  - African Input into the Geological Map of the World (OneGeology) G. Schneider
  - Guidelines for Seismotectonic Map Preparation (IGCP Project 601) M. Meghraoui
  - OAGS Bulletin and the IGCP Project contribution L. Bitam

10h30 – 11h00 : Break

11h00 – 11h30 : Invited Speakers
  - EuroGeoSurveys and AEGOS L. Demicheli
  - IGCP Project 601 and the Global Earthquake Model M. El Gabry & A. Ayele

11h30 – 12h30 : New projects and meetings
  - New OAGS Projects and Action Programme for 2012 All
  - OAGS Participation to 34th IGC Meeting - Brisbane All
  - IGCP Project 601 Participation to 34th IGC Meeting - Brisbane All
  - IGCP Project 601 Participation to EGU 2012 - Vienna All

12h30 – 12h55 : General discussion All

Closure

13h00 – 14h00 : Lunch

14h00 – 16h00 : Windhoek Tour of the City Geol. Surv. of Namibia
Building the Seismotectonic Map of Africa: Procedure, implications and perspectives

Mustapha MEGHRAOUI EOST – IPG Strasbourg, France (m.meghraoui@unistra.fr)
Coordinator of the UNESCO - SIDA/IGCP project 601 http://eost.u-strasbg.fr/~igcp601/

The African continent is made of various geological structures that include zones of active deformation. Seismically active regions are primarily located along rift zones, thrust and fold mountain belts, transform faults and volcanic fields. Several tectonic structures may generate large earthquakes with significant damage and economic losses in Africa. The development of thematic mapping with the identification and characterization of seismically active zones constitutes the framework for the seismic hazard assessment and mitigation of catastrophes. Following the initiation given by the OAGS*, the project titled “Seismotectonics and Seismic Hazards in Africa” is now supported by the UNESCO SIDA/IGCP** (Project 601). Among the objectives previously defined by the OAGS is the preparation and implementation of the “Seismotectonic Map of Africa” with the assistance of the CGMW***. With the geological and geophysical characteristics, we define six seismotectonic provinces (see also the ScTMA-OAGS report) lead by working groups including academics and members of geological surveys that handle multidisciplinary tasks. Our major objective is the constitution of a database in historical and instrumental seismicity, active tectonics, stress tensor distribution, earthquake geology, paleoseismology, active deformation and earthquake geodesy (GPS), crustal structure and seismic tomography, gravity, magnetic and structural segmentation, volcanic fields, rifting processes and geodynamic evolution. Guidelines for the seismotectonic map preparation and related data analysis are here necessary to obtain homogeneous results. An important step is the database harmonization (e.g., earthquake intensities, magnitudes, fault parameters, etc.) at the local, regional and continental level. The data collection and storage are organized under geo-referenced feature using GIS.

A synthesis of earthquake studies exposed in a seismotectonic map hitherto serves as a basis for hazard calculations and the reduction of seismic risks. Any large and small infrastructure project needs a seismic hazard and risk assessment due to its tremendous implications in the socio-economic impact. The Global Earthquake Model**** has set-off regional programs in North Africa and sub-Saharan Africa and provides supports for implementing seismic zoning and probabilistic applications for large ground motions. The NAGET***** for North Africa and AfricaArray****** for sub-Sahara bring the necessary scientific knowledge and expertise to achieving the tasks. Although the grasp of the seismotectonic framework of Africa is a difficult task, several previous and ongoing projects provide wealth of data and outstanding results. The occurrence of large and moderate earthquakes in different geological domains, their related aftershocks and surface faulting revealed the complex nature of the active tectonics in Africa. Rich earthquake catalogues and developed local and regional seismotectonic maps already exist and need to be integrated into a continental framework. Hence, a first draft of the map will be prepared and presented at the 34th IGC (Brisbane, 5 – 10 August, 2012; http://www.34igc.org/ where a session is planned under Theme 34 (Major Geoscience Initiatives, Geosurveys and Maps).

**** The GEM Foundation http://www.globalquakemodel.org/
****** AfricaArray: A program to promote geoscience in Africa http://www.africaarray.psu.edu/
Seismicity in Namibia

Bufelo Lushetile, Norton Titus and Dave Hutchins
Geological Survey of Namibia

Earthquakes have been reported in Namibia since the last century by explorers and the first recorded earthquake occurred in 1910. Since 1910, there have been more than 150 recorded earthquakes as reported by the Council for Geoscience of South Africa (CGS), the United States Geological Survey (USGS), the International Seismological Centre UK and the Bulawayo seismological station. Recently the Geological Survey of Namibia (GSN) has established a Seismological Network consisting of seven seismological stations distributed countrywide to improve seismological records. These seismological data and additional data from Walvis Passive Source Seismic (WALPASS) project will be used to compile a Seismic Hazard Map.

The seismicity of Namibia is considered moderate with earthquakes concentrated along the coastal escarpment and topographically high zones of the Namaqua and Damara Orogenic belts. Other earthquakes are mainly associated with major fault systems in the country.
The relationship between the September 11, 2009 Southern Benin Republic earthquake and the Atlantic fracture system

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An earthquake occurred on Friday, 11th September, 2009 and was felt in parts of Abeokuta, Ago-Iwoye, Ajambata, Ajegunle, Imeko, Ijebu-Ode, Ilaro and Ibadan all in South-western Nigeria. The event was recorded by three seismological stations operated by the Centre for Geodesy and Geodynamics, Toro. The stations are equipped with 24-bit recorders and 30 seconds period seismometers. Data was recorded in the MiniSEED format at a sampling rate of 40 samples per second (sps). The data was analyzed using the SEISAN earthquake analysis software where the arrival times of the primary waves (P-wave) and secondary waves (S-wave) were picked for the three stations. A flat six-layered earth model was used in the location of the event. The result showed an epicentral location of latitude 6.611° and longitude 2.433° i.e. close to Allada in Southern Benin Republic (about 128 km west of Lagos, Nigeria), focal depth of 10.0 km and an origin time of 3:10.18.60 GMT. The local magnitude was 4.5 and moment magnitude 4.2. The P-wave to S-wave velocity ratio was 1.72. Analysis of the event provided a normal fault mechanism with median solution of strike 325°, dip 40° and rake -90°. The epicenter of this earthquake lies along a fracture zone thought be a continental extension of an Atlantic transform.
Seismicity of Central and West Africa

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Seismicity in Africa is mostly associated with plate boundaries and the East African Rift System. Central and West Africa, is generally considered as aseismic or having low seismicity. In this study we review the geological, tectonic setting, and historical seismicity of Central and West Africa. One station of the global seismic network has been installed in Central Africa Republic, Senegal, Ivory Coast and Ghana. Afterwards, small networks of short period sensors have also been operated for shorter or longer periods in some countries: Cameroon, Senegal, Ivory Coast and Ghana. Then, the region is not well covered by seismic stations. The Africa Array project since 2005 is improving the situation by installing broad band seismic stations in Ghana, Nigeria and Cameroon. The results of the data collected so far from all the stations show that the seismicity in Central and Western Africa is associated with main lineaments, craton borders, transform faults and volcanism. The biggest magnitude recorded is 6.5 in Ghana and 6 in Cameroon. The most active region is linked to Mount Cameroon, an active volcano. Other earthquakes of magnitude 4 to 5 are felt in the region and must be taken into consideration for seismic hazard assessment.
Active fault mapping in Illindi (Tanzania) and Karong (Malawi) areas in the East African Rift System and its hazard implication: Insights from seismic refraction

1Ayele, A., 2Marohbe, I., 2Ferdinand, R.W., 3Hlatywayo, J.D., 4Goitom, B., 5Chapola, L.S., 6Tumwikirize, I., 7Barongo, J., 8Macheyeki, A., 9Manhiça, V.J., 10Mdala, H., 10Chisambi, J., 11Mwano, J.M., 12Shumba B., 7Kianji, G.K., 2Feitio, P., 13Mulowezi, A., 13Mutamina D.

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In October 2010 the ESARSWG (Eastern and Southern Africa Regional Seismological Working Group) undertook a field campaign to map active faults in Illindi village (south western Tanzania) and Karonga (northern Malawi) as part of the ongoing hazard assessment program along the EAR region. During the campaign the targeted faults were fractures caused by the occurrence of the November 16, 1994, magnitude 5.0 event in Illindi Village and the 2009, magnitude 6.2 earthquake in Karonga, respectively. For the case of Illindi, it wasn’t possible to uncover fractures using seismic refraction technique at spots where deformation/fractures were observed during the occurrence of the event. We inferred a 14 meters thick low velocity volcanic ash of velocity 347 m/second on top of another relatively higher velocity (787 meters /second) but still a low velocity layer. We interpret this either the observed fractures are denuded by floods after several raining seasons or possibly the observed fracture during the occurrence of the event is due to the site effect response by the thick volcanic sediment while the event could actually occurred elsewhere in the neighborhood.

In the case of Karonga, several fractures are mapped after sealed by flood during the raining season and observations of the fractures during the occurrence of the event were witnessed by residents in many villages. This mapping is made in the area where the Karonga fault is thought to be discontinuous by stepping west in the northern part. We also inferred that the area is covered by unconsolidated low velocity sediments.

This is also a point to note for any development structures to be erected both in Illindi (Umalila) and Karonga areas be aware of the amplification effect of low velocity and thick sediments during ground motions that will possibly be caused by future earthquakes in both areas.
Comparison of seismological, geodetic, and geological observations of rifting in East Africa: Diffuse vs localized deformation

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The rift valleys of eastern and central Africa transect cratons, Precambrian orogenic belts, and oceanic lithosphere, and show profound differences in the volume and composition of magmatic products, the timing of rift initiation, the pre-rift plate structure, and rift morphology exist between rift sectors. The growing evidence of frequent and sometimes volumetrically large magma intrusions, combined with the historic-recent record of damaging earthquakes, motivates our systematic comparison of seismic and geodetic moment release along the length of the East African rift system. We use NEIC and historic seismicity catalogues and published sparse geodetic data, and we invert well-determined CMTs for strain rate vectors within distinct rift sectors, allowing for finite width deformation zones. The maximum fault length within each sector is used to predict a maximum earthquake magnitude, providing some evaluation of the completeness of the earthquake catalogue. The spatial pattern of moment release shows significant deformation outside the fault-bounded rift valleys and across the uplifted plateaus, extending from South Sudan through Botswana. Seismic moment rate is everywhere less than geodetic moment rate, and the discrepancy increases with increasing degree of magmatism within the rift sectors. Thus, much of the plate boundary deformation is accommodated aseismically over the time period of observations, and short term patterns suggest magma intrusion accounts for much of the discrepancy. Opening rates are much lower than predicted from models of geodetic data that assume deformation in narrow zones between plate rigid plates, consistent with broad zones of deformation and aseismic strain. Comparison of seismic moment release and effective elastic thickness shows that seismic moment release is greatest where the rift transects strong lithosphere, as in the Western and Southwestern rift arms. Our results indicate that plate boundary deformation is not restricted to the fault-bounded rift valleys, motivating a re-evaluation of hazards throughout eastern and southeastern Africa, and highlighting the need for widely distributed GPS networks. The broad deformation zone provides new insights into rift initiation processes, including the role of metasomatic modification of thick, cold cratonic lithosphere beneath Africa.
Sismotectonics and active tectonics in the western rift branch, Tanzania: a review

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The Rukwa region in the Western Highlands of Tanzania is one of the most seismically active segments of the western branch of the East African rift system. This region contains evidence for past strong earthquakes as recorded in the neotectonic morphology, paleoseismic trenches and outcropping recent lacustrine deposits in the paleo-shorelines and abandoned floor of Lake Rukwa. It was hit by an Ms 7.4 earthquake on December 13, 1910. Together with the Mw 7.1 May 20, 1990 Sudan earthquake and the Mw 7.0 February 22, 2006 Machaze earthquake in Mozambique, they are the only three M >= 7.0 events instrumentally recorded yet in the East African Rift. The Ms 7.4 Rukwa earthquake was part of a seismic crisis that lasted about 20 years and affected the Ufipa Plateau between Lakes Tanganyika and Rukwa and the Mbozi block, between Lakes Rukwa and Malawi. The epicentre of the Ms 7.4 Rukwa earthquake was located near Sumbawanga town along the Kanda normal fault system that cut longitudinally the Ufipa plateau. Lake Rukwa is also in an old but still active rift graben, with active faulting affecting its lake floor, far from the major border faults. In the Katavi paleo shore line at the north-western extremity of Lake Rukwa, morphostructural analysis and paleoseismic trenching evidenced also an active sismogenic fault. The Songwe depression with forms the southern extremity of the Rukwa depression has been affected since 300 Ka by intense tectonic activity in a transtensional context that controlled the deposition of the Songwe travertine deposit, caused pull-apart deformation of the former lacustrine deposits and was responsible for soft sediment deformation in the late Quaternary lake beds.
Recent tectonic stress regime in Egypt

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A focal mechanisms catalogue for Egypt is compiled from the previous works. A critical evaluation of the data quality for all focal mechanisms was achieved using the adaptive Neuro-Fuzzy system. Five attributes are used to describe the quality of data: range of solution, reversed polarity station, azimuthal distribution, critical stations and the constraint of the nodal planes. Different weights are assigned for the focal mechanisms based on the checked attributes. The selected mechanisms do not reflect a simple uniform pattern of seismic dislocation. To resolve this ambiguity, the weighted focal mechanisms were used to invert the stress tensor of six seismotectonic zones. The tectonic stress orientations are estimated along the northern part of the Gulf of Suez, southern Gulf of Suez, Gulf of Aqaba, Cairo-Suez district, Dahshour zone and the Aswan Zone. The entire Gulf of Suez indicates an extensional stress field, with NE-SW horizontal extension axis $\sigma_3$. The best fitting solution for the Gulf of Aqaba is a strike-slip regime with sub-horizontal $\sigma_1$ and $\sigma_3$ axes trending NNW and ENE, respectively. A normal dip slip with small strike slip component due to a nearly sub-vertical $\sigma_1$ and sub-horizontal NNE striking $\sigma_3$ characterized Cairo-Suez district and Dahashour zone. Aswan seismic zone shows mainly strike slip stress regime with a slight extension component (sub-horizontal NW $\sigma_1$ and NNE $\sigma_3$). Generally, extensional and/or extensional-strike slips are dominating the Egyptian territory. These regimes are in good correlation with dominant extension due to the Red Sea-Gulf of Suez rifting and the left lateral shear along the Gulf of Aqaba.

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The structure of the crust and its relation with tectonics in North Africa

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In North Africa, Algeria is known as one of the most active region because several large and shallow depth (0-30km) seismic events have occurred in the last six decades (Orléanville, (1954, Ms=6.0), El Asnam, (1980, M 7.3), Constantine (1985, Ms 6.0), Tipasa-Chénoua (1989, Ms 6.0), Mascara, (1994, M 6.0) and Zemmouri, (2003, M 6.8)). These events were associated with major active thrust and strike-slip faults affecting the Tell Atlas and characterizing the Africa-Eurasia plate boundary in the western Mediterranean. Taking into account mainshock and aftershocks for all events, we performed event relocations using handpicked P and S phases located with the tomoDD in a detailed 3D velocity structure of epicentral areas. Furthermore, the travel-times of the selected aftershocks and the corresponding hypocenter catalogue were used for a tomographic inversion using the double-difference tomography. In spite of the high tectonic complexity of northern Algeria, some correlations may be highlighted between geological units and velocity structures. Based on velocity structures across active zones and earthquake areas, we observe that fault segmentation and geometrical discontinuities observed along strike are controlled by pre-existing structures imaged by tomography. Basement outcrops in the Tell Atlas region are related to higher P velocities in the upper crust. At the same depths, lower velocities correspond to Quaternary filling of tectonically active basins. The high resolution study of seismic events and related velocity structure allows for a better constraint of the fault geometry and structure in the Tell Atlas.

Our seismotectonic study also addresses a special attention to the Hoggar “stable” shield in the Sahara (southern Algeria) where an earthquake m_b 4.0 occurred in 2010. The tomographic results indicate a high velocity of seismic waves due to young volcanic fields. The results of our previous works including the compilation of the available tomographic studies will be integrated in the OAGS/SeTMA – IGCP 601 project for a better construction of the seismotectonic map of Africa.
The structure of the crust and mantle beneath East Africa based on seismic and seismicity studies - a review

by U. Achauer,
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East-Africa is well known for the East African rift system and its connected volcanic activity along and across both graben systems. Since a long time it is suggested that the source of the earthquake activity as well as the strong volcanic activity in parts of the East African rift is related to one or two large scale plumes originating at the core-mantle boundary (CMB).

Over the last couple of decades quite a number of collaborative large-scale seismic projects have been carried out across East Africa to decipher the crust and upper mantle structure and to search for the source regions and reason of the wide-spread earthquake activity.

In this paper we shall review some of the seismic work carried out by international groups, discuss the results in the light of their geodynamic implications and if time permits give some ideas for new projects.
Status of seismotectonic and seismic hazard studies in South Africa

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Though South Africa is considered to lie in a stable continental region, earthquakes are recorded and located daily. Large events have been recorded that resulted in severe damage to infrastructure in nearby towns, farms, underground mines and even death in some circumstances. Therefore, it is necessary that we consider the effects of these events in the design of our infrastructure. This mitigation is done by carrying out reliable seismic hazard and risk studies of our regions using state of the art methodologies. In South Africa, several regional seismic hazard studies have been carried out and published. Continental wide studies that include the South African region were also published by various scientists from the continent (e.g. GSHAP). However, to ensure that we conform to international best practice in such studies, more studies need and are being done to improve data, knowledge and methodologies used in the assessments. We continue to collect and improve collection methods of historical and instrumental seismicity data. Available geological information is being used to identify and characterize active or capable faults. With this information and other previous and ongoing studies, a seismotectonic model for South Africa can be developed.
AFRICAARRAY investigations of active deformation and seismic hazard

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AfricaArray is a long-term initiative that promotes linked observational, research and training programs to build geoscience capacity in Africa. The observational stations are positioned to provide data that can enable exploration for minerals, groundwater and hydrocarbons, and help to forecast natural hazards such as earthquakes, volcanic eruptions, and changes in climate. AfricaArray has established a backbone network of 41 seismic stations in sub-Saharan Africa, and currently also operates temporary networks to monitor mining-induced seismicity in South Africa, seismicity associated with the East African Rift System, and a seismic network designed to image the boundary of the Congo craton. In this contribution we present three recent studies conducted by post graduate students in Tanzania, DR Congo and South Africa pertinent to active deformation, seismic hazard assessment and volcanogenic seismicity.

Seismicity within two earthquake swarms (mb 1.0-4.0) in northern Tanzania recorded by the 1994-1995 Tanzania Broadband Seismic Experiment were investigated by Mulibo. Events were relocated, regional depth phases were modelled and focal mechanisms were examined. In the Manyara swarm, seismicity is distributed over a region ~20 km wide and extends to >30 km depth. Hypocenters correlate well with the Manyara rift, and focal mechanisms of many events show normal faulting with nodal planes having the same NNE orientation as the Manyara rift border fault. This result indicates that the events are consistent with slip along the border fault and related faults beneath the Manyara rift, and shows that the faults extend into the lower crust. Seismicity in the KwaMtoro swarm is distributed over a region ~10 km wide but extends only to ~12 km depth. There are no mapped faults above the swarm, but a strong correlation between the N-S orientation of the swarm, the N-S orientation of nodal planes in focal mechanisms, and N-S striking extensional structures nearby, suggest that events in this swarm could be caused by slip on a system of rift faults. However, a magma-driven origin for either swarm cannot be ruled out either.

Seismic data gathered and analysed by Tuluka Mavonga as part of an effort to monitor the active volcanoes Nyiragongo and Nyamuragira and quantitatively assess the earthquake hazard in the Democratic Republic of Congo and surrounding areas. In order to investigate volcanic processes in the Virunga area, a local seismic velocity model was derived and used to relocate earthquake hypocenters. It was found that swarm-type seismicity, composed mainly of long-period earthquakes, preceded both the 2004 and 2006 eruptions of Nyamuragira. A steady increase in seismicity was observed to commence ten or eleven months prior to the eruption, which is attributed to the movement of magma in a deep conduit. In the last stage (1 or 2 months) before the eruption, the hypocenters of long-period earthquakes became shallower. Seismic hazard maps were prepared for the DRC using a 90-year catalogue
compiled for homogeneous Mw magnitudes. The highest levels of seismic hazard were found in the Lake Tanganyika Rift seismic zone, where peak ground accelerations (PGA) in excess of 0.32 g, 0.22 g and 0.16 g are expected to occur with 2%, 5% and 10% chance of exceedance in 50 years, respectively.

Seismicity is one of several factors that need to be considered in selection of nuclear waste disposal sites. The seismic history of the western arid regions of South Africa is being evaluated by Malephane with the aim of assessing the long-term stability of the region, which has many characteristics favourable for the disposal of high-level radioactive waste. This study’s catalogue is compiled from two sources: namely, the Council for Geosciences (CGS) starting from 1908 to 2010 with a total of 1159 events and a minimum magnitude of M=1.1 for the study area; and the South African Nuclear Corporation (Necsa) Vaalputs network, which covers the period 1989 to 2010, with a total number of 501 events, some as low as magnitude M=0.4. Necsa is in the process of deploying three additional 3-component stations that will be positioned across Bushmanland. One of these will be equipped with a broadband sensor and the others with 1Hz sensors. These will supplement the national network’s coverage of the area, therefore increasing sensitivity and accuracy of hypocentre location. These stations will become part of the Africa Array network.