The September 2005 Magmato-tectonic activity along the Manda Harraro rift segment

Ayele[1], A., Keir[2], D., Ebinger[3], C., Wright[2], T., Stuart[2], G., Jacques[4], E., Hammond[5], J., Kendall[5], J-M., Ogubazghi[6], G., Sholan[7], J.

1. Institute of Space Science and Astronomy, Addis Ababa University, e-mail: atalay@geobs.aau.edu.et
2. School of Earth and Environment, University of Leeds
3. Department of Earth and Environmental Sciences, University of Rochester
4. Institut de Physique du Globe de Paris
5. Department of Earth Sciences, University Of Bristol
6. Department of earth Sciences, University of Asmara
7. National Seismological Observatory Centre (NSOC), Yemen

ABSTRACT

In September 2005, a major diking episode occurred in the Manda Harraro rift of the Afar Depression and the associated earthquake swarm was captured by modern seismic instruments in the region. A number of earthquakes (> 300) with magnitude ≥ 3.5 mb occurred associated with the September eruption. Continuous earthquake activity, including a volcanic tremor, was observed on 24–26 September at FURI seismic station in the outskirt of Addis at ~ 450 km away. A minor felsic eruption occurred along a 500-metre-long vent on the flank of the Dabbahu volcano. Local inhabitants reported that a dark column of "smoke" rose high into the atmosphere and spread out to form a cloud which darkened the area for three days and three nights. Results from InSAR and seismology suggest that a rift segment of length > 60 km was activated in September 2005 with a maximum opening of 8 meters. However, seismic data shows that the activity started in April, 2005 and continued until the major eruption in September with 1-2 earthquakes in every previous months of magnitude ~ 4.0 mb.

The early September seismicity is concentrated about the Dabbahu and Gabho volcanoes and the activity migrated southeastwards thereafter which could indicate the dike propagation direction. The preliminary relocation using hypoDD software shows that multiple clusters which may indicate multiple dike sources. Most of the fault plane solutions show normal faults consistent with extensional stress field of the region while two earthquakes around the Dabbahu volcano are stike-slip consistent with reorientation of the stress field near a magma chamber.

Key words: Dabbahu volcano, Seismicity, Dike Propagation, Afar

PRESENTER'S BIOGRAPHY

Atalay Ayele has obtained his PhD in seismology in 1998 from Uppsala University, Sweden. He joined the Geophysical Observatory of Addis Ababa University in 1999 and strongly involved in running the Ethiopian seismic station network of the country. He has been collaborating with several broadband seismic experiments conducted in Ethiopia. Currently he is the staff of the new Institute of Geophysics Space Science and Astronomy in Addis Ababa University.

Seismic anisotropy beneath rifts and role of pre-rift fabric of mantle lithosphere in rift origin

V. Babuška[1]**,** J. Plomerová[2]

1. Geophysical Institute, Czech Acad. Sci., Prague, Czech Republic, v.babuska@ig.cas.cz
2. Geophysical Institute, Czech Acad. Sci., Prague, Czech Republic, jpl@ig.cas.cz

ABSTRACT

Rifting of the continental lithosphere is often connected with a thermal thinning and stretching, and a consequent lithosphere breakup. A mechanism for rupturing of thick, cold, continental lithosphere is less evident, but its breakup along a pre-existing zone of lithospheric weakness is likely. We suggest that mapping 3D seismic anisotropy can help in revealing lithosphere sutures/boundaries and in distinguishing between different models of origin of rifting. 3D analysis of and P- and S-wave anisotropy in the mantle lithosphere of the Eger Rift in the Bohemian Massif (central Europe) and of the Limagne Graben in the French Massif Central revealed that the rifts probably originated above Hercynian sutures between domains of the mantle lithosphere characterized by different, but consistent orientations of seismic anisotropy beneath each of the opposite flanks of both rifts. Our large-scale anisotropic models, based on mantle xenoliths found in both regions, can be characterized by olivine aggregates of hexagonal or orthorhombic symmetry with generally oriented (dipping) symmetry axes. Findings of different and consistent anisotropy, though based only on spatial dependence of relative P residuals, hold also for both flanks of the Garoua Rift in Cameroon (Plomerová et al., GJI 1993). Shear-wave splitting and directional dependence of relative P residuals published by different authors for the Baikal Rift (e.g., Gao et al., JGR 2003) and the Kenya Rift (e.g., Slack et al., Tectonophys. 1994; Kendall et al., Geol. Soc. 2006), which both appear to be localized at the suture zones of Archean and Proterozoic provinces, also indicate different orientations of anisotropy at their flanks. Though a part of anisotropic signals observed along the central parts of the rifts is due to asthenospheric flow and/or aligned magmatic cracks, an important source of anisotropy beneath the flanks, namely that detected far away from the rift boundaries, can be associated with a pre-rift olivine fabric frozen in the mantle lithosphere. Different orientations of the large-scale olivine fabrics at opposite flanks may indicate that the rifts developed along sutures/boundaries of two or more lithospheric domains (microplates) whose fabrics developed at different times and places. The difference in fabrics may help understand commonly observed asymmetric rift architecture and a mechanism for rupturing thick and cold continental lithosphere along old sutures, which have been often rejuvenated and used as the easiest paths for ascent of volcanic products.

Key words: seismic anisotropy, pre-rift fabric of mantle lithosphere

PRESENTER'S BIOGRAPHY

Vladislav Babuška, senior scientist with major research interests in seismic anisotropy and deep structure of continental lithosphere, chairman of the Czech National IUGS Committee. Graduated at Charles Univ., Prague (1960 and 1967), research fellow at Harvard Univ. (1969-70), visiting professor at Nagoya Univ. (1973) and Univ. Louis Pasteur, Strasbourg (1989). From 1992 to 1999 Secretary of the International Geoscience Programme at UNESCO, Paris.

Traveltime Residuals and Implications for Crustal Structure in Ethiopia

Binyam Beyene[1], Atalay Ayele (PhD)[2]

1 Student, Ethiopia, Binyam.Beyene@students.wits.ac.za
2 Head of Geophysical Observatory, Addis Ababa University Ethiopia

ABSTRACT

Earthquake data from Northwest and Southern Afar and Arbaminch was used in this study of the traveltime residuals. The major sources of data were the Ethiopia Afar Geoscientific Lithospheric Experiment (EAGLE) (2001 - 2003), the IRIS/PASSCAL (Incorporated Research Institutes of Seismology/Program for the Array Seismic Studies of the Continental Lithosphere) Experiment (2000 - 2002), and the French Broadband Seismic Experiment (1999 – 2002). The Geophysical Observatory stations also contributed some data.

A total of seven earthquakes were used to calculate the residual travel times of Pn and Sn arrivals. The TauP travel time calculator was used to estimate the theoretical traveltime of the different arrivals using local crust and upper mantle velocity structures developed by various authors. An observed arrival time of Pn and Sn phases was picked from the seismograms using the Seismic Analysis Code (SAC) software. The difference between the observed and synthetic arrival times were then plotted using Matlab to observe the systematic variation of the residuals with epicentral distance. The study also helped to compare the crustal and upper mantle velocity models developed from various studies in the area. The analysis was done based on the ray path followed by the wave. The stations were grouped in three categories: event-station pairs where (1) the ray path crosses Afar, (2) for which the ray travels only through the Western Plateaus, and (3) where the ray passes through more than one region, in which case the IASP91 velocity model was used. For ray paths crossing Afar, the Pn residual values are small (+1.10 to -1.96), whereas the Sn arrival is delayed by more than 10 seconds compared to the theoretical value. The Pn residuals for the Western Plateaus range from +1.25 to -1.62, compared to the very high negative residuals obtained for the Sn arrivals (> -14 seconds). Arrival times for ray paths crossing more than one tectonic region were calculated using the IASP91 model. The Pn residual showed a range of 0.26 to 3 seconds delay, while the Sn delay was greater than 15 seconds.

For all the velocity models considered in this study, the Sn delays showed a linear increase with increasing epicentral distance, implying a continuous slow region at depth. Using the slope of the observed Pn and Sn arrival times against epicentral distance, the estimated average Pn velocity for the region is about 7.69 km/s and that of Sn is approximately 3.97 km/s. The very high Vp/Vs ratio of 1.99 suggests the presence of partial melt, which is manifested on the slow shear wave velocity structure.

Key words: Afar, Vp/Vs ratio, TauP

Binyam Beyene

Bachelor of Science degree in physics and Masters in Geophysics specifically in Seismology. The primary area of research was on travel time calculations in the East African Rift system trying to see the implication of rifting process on the velocity of seismic waves. Currently I am a Doctoral Research Fellow at the University of Witwatersrand.

Geodetic constraints on rifting processes in East Africa

E. Calais(1), S. Stamps(1), L. Bennati (1) N. d'Oreye(2), T. Wright(3), I. Hamling(3), E. Saria(4), E. Lewi(5), C. Hartnady(6), R. Fernandes(7), C. Ebinger(8), R. Buck(9)

(1) Purdue University, USA, (2) ECGS, Luxembourg, (3) Univ. of Leeds, UK, (4) Ardhi University, Tanzania, (5) Geophysical Observatory, Ethiopia, (6) Umvoto Africa, South Africa, (7) UBI, CGUL, IDL, Portugal, (8) Univ. Rochester, USA, (9) Lamont-Doherty Observatory, USA

Most passive margins worldwide experienced magmatism prior to breakup, and many continental rifts experience magmatism coincident with rift initiation. This is the case for the East African Rift (EAR), the 5000 km-long series of seismically active structures that marks the divergent boundary between the Somalia and Nubia plates. Although the EAR is often cited as a modern archetype for rifting and continental breakup, its current kinematics is the least well-known of all major plate boundaries. We will present an updated model for the present-day kinematics for the EAR. The model is derived space geodetic data, including new campaign measurements in Tanzania earthquake slip vector directions, and 3.2 Myr-average spreading rates and transform-fault azimuths along the Southwest Indian Ridge. The combined data set supports a model that includes three subplates (Victoria, Rovuma, and Lwandle) between Nubia and Somalia, with total opening increasing from ~1 mm/yr in southern Mozambique to 7 mm/yr in northern Ethiopia. This far-field plate divergence is generally thought to drive lithospheric stretching which, in turn, leads to upwelling and adiabatic decompression melting of asthenosphere. However, the role of rising melt on the plate rheology and on the force balance that governs continental extension remain poorly understood. We will use two case studies to show that far-field plate divergence in the EAR is accommodated during rifting events that involve a significant amount of strain accommodation by magma intrusion. The first one is the on-going Dabbahu rifting event in the Afar region of Ethiopia, in a quasi-oceanic rift setting. It in 2005 started with a 60 km-long dike intrusion, followed since by 6 additional (smaller) dikes. The second one is the July-August 2007 Natron seismic crisis (northern Tanzania), dominated by the first dike intrusion captured geodetically in a continental rift. The dike was triggered then accompanied by slip on normal faults. We will discuss how these events may help better understand rifting mechanisms in East Africa.

Stress in the East African Rift System in a Global Context

Paul M. Davis

Department of Earth and Space Sciences, UCLA CA90095, USA
pdavis@ess.ucla.edu

Of the forces that act on the lithosphere, calculation of ridge-push is most straightforward. The Africa plate, which is geometrically symmetrical, with ridges both east and west, is believed to be nearly stationary with respect to the underlying mantle. This allows us to neglect any viscous drag of the asthenosphere, or the effect of subduction zones, simplifying the calculation of internal stresses. The ridges are assumed to be spreading symmetrically, so that they are retreating from the continent and leaving fresh oceanic lithosphere essentially stationary with respect to the underlying mantle. The African continent is compressed by ridge push stresses. The extension along the east African rift zone indicates that, that part of the continent is in tension. The average state of stress in isostatically compensated lithospheric blocks floating on an inviscid asthenosphere depends on the geoid with high values corresponding to tension. The very long wavelength features of the geoid are attributed to density variations in the lower mantle and are believed to indicate residua of past subduction. These effects must be subtracted before the geoid features related to lithospheric/asthenospheric structure can be recognized. Only the long wavelength density variations in the lower mantle are gravitationally apparent at the surface as the higher harmonic terms are geometrically attenuated. The geoid features of intermediate wavelengths can be interpreted in terms of topography and density variations in an isostatically balanced lithosphere-asthenosphere system. We show that a plot of the geoid, with harmonic degrees of six and less subtracted, correlates well with the stress map. Regions of high elevation, plateaus and mountain ranges, are in tension and correspond to positive anomalies in the filtered geoid. The most dramatic effect of filtering is in seen in the plateau of East Africa, where the world's largest continental rift is found. Without harmonic filtering East Africa is in a geoid low, but when low harmonics are subtracted it appears in a high (Stacey and Davis, 2008). This suggests rifting in Africa is caused by dynamic uplift from convection in the mantle

The relocation and rupture process of Machaze, Mozambique 2006 (Mw7.0) earthquake

Paulino Feitio[1], Nobuo Hurukawa[2], Toshiaki Yokoi[3]

1. National Directorate of Geology, Ministry of Mineral Resources, Mozambique, pfeitio@hotmail.com
2. International Institute of Seismology and Earthquake Engineering, Japan, hurukawa@kenken.go.jp
3. International Institute of Seismology and Earthquake Engineering, Japan, tyokoi@kenken.go.jp

ABSTRACT

In the present study the 2006 Machaze, Mozambique (Mw7.0) earthquake and respective foreshocks and aftershocks are relocated. The main purpose of the relocation is to determine the fault plane related to that earthquake. Phase data used for relocation were retrieved from National Earthquake Information Center (NEIC) within the period between January 1, 2005 and December 31, 2007. The Machaze earthquake cluster is located in the southern end of western branch of East African System. The Modified joint Hypocenter Determination technique is used to relocate simultaneously the mainshock, foreshocks and aftershocks of Machaze event. Aftershock distribution of that event permitted the identification of the fault plane. The result indicates that the strike and dip of the Machaze fault plane is about 172° and 65° westward, respectively and it represents a normal faulting. This result is consistent with field observation of the surface rupture caused by the event. The rupture process of the Machaze earthquake is also determined in the present study. P-arrivals were retrieved from the seismograms obtained from global network operated by Data Management Center (DMC) of Incorporated Research Institute of Seismology (IRIS). The result of the slip inversion shows that two asperities characterize the Machaze earthquake. The maximum slip is not located on the initial break point. The maximum slip is 3.4 m located in the south asperity near the initial break point and the asperity in the north of initial break point has a slip of about 2.5 m. The last asperity is located at surface and generated the most prominent offset observed at the surface. The aftershocks are located near the two asperities. Both analyses show a size of the fault plane corresponding to the mainshock about 50 km in length.

Key words: Mozambique earthquake, relocation, slip inversion.

PRESENTER'S BIOGRAPHY

Paulino Cristovao Feitio, Mozambican, born on June 4, 1976, in Quelimane, capital of Zambezia Province. In 2003 after graduation in Geology by Eduardo Mondlane University, joined National Directorate of Geology, Ministry of Mineral Resources in Mozambique. From that time worked in the project of national geological mapping. Member of disaster management team and National Technical Council for Disaster Mitigation since 2006. Lecturer of Structural Geology and Geological Mapping at Department of Geology, Eduardo Mondlane University (UEM) – Mozambique. In 2007 started its studies in joint master program between International Institute of Seismology and Earthquake Engineering (IISEE) and Graduate Institute for Police Studies (GRIPS) in Japan, where concluded Master in Disaster Management Polices in September 2008.

The uppermost mantle beneath the East African Rift System: Results from surface wave tomography of the African continent

Stewart Fishwick[1]

1. Department of Geology, University of Leicester, United Kingdom, sf130@le.ac.uk

ABSTRACT

This study focuses on the structure of the uppermost mantle and provides an overview of how the shear wavespeed varies beneath different sections of the East African Rift, and how this region compares to the rest of the African continent.

Surface wave tomography is one of the ideal tools for investigating the upper mantle. Data from both permanent stations and a large number of temporary deployments in Africa and the surrounding regions are used to provide sufficient path coverage to obtain reliable tomographic results. In the first stage a waveform inversion procedure is used to calculate 1D path-average models for over 8000 source-receiver pairs. These models are then combined within a tomographic inversion scheme to obtain the variations in velocity at depths between 75 and 300km.

It is important to illustrate that the results of tomographic inversions are very dependent on the choices made by the user. For example, the choice of parameterization will influence the images produced. Models with fine parameterisations and minimal smoothing or damping have high resolution, but much greater uncertainty due to both limitations in path coverage and in the methodology used. Smooth models are likely to be a sensible starting point as *a priori* information for more detailed local studies, while high resolution models can be of interest to the exploration industry, although finding ways to suitably illustrate the uncertainty in the velocity variations remains a challenge.

At shallow depths (75-100km), as might be expected, the Ethiopian section of the EARS has the slowest velocities – also significantly slower than other regions within the African continent. Further south, for example beneath parts of Tanzania, wavespeeds are faster than the global reference model ak135, and more typical of cratonic regions. By 125-150km depth the transition between fast and slow velocities in this region occurs in central Tanzania, and will be compared with the location of diamondiferous deposits from the Consorem database. At 175km depth there is a very distinct change in shear wavespeed that follows the boundary of the western branch of the rift system. From tomography alone the question of 'cause of' or 'consequence of' cannot be answered, and must come from a multidisciplinary approach. At depths greater than 200km the reliability of the models is limited by the lack of higher mode information in the present data-set. This lack of resolution may limit our present understanding of the interaction between large scale convection (deep mantle processes?) and smaller scale processes that may be operating within the upper mantle. Further work integrating global, regional and local studies is likely to give the most improvement in our understanding of these questions.

Key words: Upper mantle, Tomography, Africa, Lithosphere

PRESENTER'S BIOGRAPHY

Stewart Fishwick completed a PhD at the Research School of Earth Sciences, Australian National University in 2005, then following a post-doctoral position (2006-2007) at the University of Cambridge (UK), took up a New Blood Lectureship in Geophysics at the University of Leicester (UK) in October 2007.

Seismic observations from the Afar Consortium Experiment: Preliminary results

J. Hammond[1], M. Guidarelli[2], J-M. Kendall[1], G. Stuart[2], D. Keir[2], C. Ebinger[3], M. Belachew[3] and A. Ayele[4]

1 Department of Earth Sciences, Wills Memorial Building, Queen's Road, Bristol, BS8 1RJ, UK, email: j.hammond@earth.leeds.ac.uk
2 School of Earth and Environment, Earth Science,University of Leeds,Leeds,LS2 9JT,UK,
3 University of Rochester, Department of Earth and Environmental Sciences, Rochester, 14627, United States.
4 Geophysical Observatory, Addis Ababa University, PO Box 1176, Addis Ababa, Ethiopia

In March 2007, 41 stations were deployed throughout Afar and the adjacent rift flanks as part of a large multi-national, collaboration involving universities and organisations from the UK, US and Ethiopia. This abstract describes the crustal and upper mantle structure results of the first 19 months of data. Crustal structure has been determined using the H-k stacking of receiver functions and thickness varies from ~45km on the rift margins to ~16km beneath the Afar stations closest to the Red Sea. Estimates of V_p /V_s show normal continental crust values (1.7-1.8) on the rift margins, and very high values (2.0-2.2) in Afar, similar to results for the Main Ethiopian Rift (MER). This supports ideas of high levels of melt in the crust beneath the Ethiopian Rift.

A study of seismic noise interferometry is in early stages, but inversions using 20 s Green's function estimates, with some control from regional surface waves, show evidence for thin crustal regions around the recently rifted Dabbahu segment.

To improve our understanding of the physical and compositional properties of the crust and locate regions of high attenuation (an indicator of melt), we determine attenuation (Q) using t* values measured from spectra of P wave arrivals. We present whole path attenuation from source to receiver, which will provide a starting point for a future tomographic inversion.

SKS-wave splitting results show similar patterns to that observed in the MER with sharp lateral changes over small lateral distances (40º over <30 km), with fast directions overlying the Dabbahu segment aligning parallel with the recent diking. This supports ideas of melt dominated anisotropy beneath the Ethiopian rift. The magnitude of splitting in this region is smaller than that seen at the MER, suggesting a thinner region of melt, or less focused melt is causing the anisotropy.

Seismic tomography inversions show that in the top 150 km low velocities mimic the trend of the seismicity in Afar. The low velocity anomalies extend from the main Ethiopian rift NE, towards Djibouti, and from Djibouti NW towards the Dabbahu segment. Outside of these linear regions the velocities are relatively fast. Below ~250km the anomaly broadens to cover most of the Afar region with only the rift margins remaining fast.

The seismic studies will be integrated with results from other areas of the consortium project (e.g., Magneto-tellurics, GPS, insar, gravity, petrology, geochemistry), enabling us to develop a greater understanding of rifting beneath an area of incipient oceanic spreading.

The plate-kinematic context of Miocene-Recent neotectonism, seismicity and volcanic activity in Comoros and Madagascar

Chris J.H. Hartnady[1], Gerard Rambolamanana[2], Eric Calais[3], D. Sarah Stamps[4], Elifuraha Saria[5].

1. Umvoto Africa (Pty) Ltd, Muizenberg, South Africa, chris@umvoto.com
2. IOGA, University of Antananarivo, Madagascar, rambolamanana_gerard@yahoo.fr
3. EAS Department, Purdue University, West Lafayette, IN 47907, USA, ecalais@purdue.edu
4. EAS Department, Purdue University, West Lafayette, IN 47907, USA, dstamps@purdue.edu
5. UCLAS, Univ. of Dar Es Salaam, P. O. Box 35176, Dar Es Salaam, Tanzania, sariah@aru.ac.tz

ABSTRACT

A new kinematic model for the East African Rift System (EARS) provides rates and directions of tectonic extension along the active margin between the Somalia (SO) and Lwandle (LW) plates within the wider Nubia (NU)-SO boundary zone. The SO-LW boundary extends from the Rovuma (RV) plate near East African coastline around the Tanzania-Mozambique border (diffuse RV-SO-LW triple junction), through the Comoros Archipleago and Madagascar, along then along the submarine Madagascar Ridge to a wide zone between 48°-53E along the SW Indian Ridge (diffuse LW-SO-Antarctica [AN] triple junction). From the current SO-NU and LW-NU angular velocity estimates, the SO-LW angular velocity (35.517°S, 46.388°E, 0.070°/Myr clockwise) implies that the separation rate of SO from fixed LW is 3.1 mm/yr towards N089°E in the volcanically active western Comoros area (12°S, 44°E), and 2.95 mm/yr towards N098°E in the Nosy Be area of Northern Madasgascar (13.5°S, 48°E), where the major volcanic activity commenced in the Late Miocene (K/Ar age determinations of ~9 Ma for basal lava flows at Diego Suarez, <1 Ma for a flow from the central part of the Mont D'Ambre Complex). At both Nosy Be and Mt D'Ambre, cinder cones and craters (the latter often with crater lakes) commonly appear as the youngest, nearly Recent (Holocene) manifestations. The Comores and Nosy Be region (Ambohitra) volcanics are both supposed to have formed from the migration of the SO plate over a postulated Comores hotspot; alternatively by the NW-ward propagation of deep-seated, rift-related faults from Madagascar acting as conduits for magmas to reach the surface from the mantle. The apparent W-ward younging of the volcanics between Diego Suarez, Ambohitra and Grande Comore (Karthala) is cited as support for hotspot track model. The latter model, however, fails to account for the younger cinder cones and crater lakes farther south in Madagascar; e.g., the seismically and geothermally active Itasy Volcanic field (19°S, 47°E) of over 100 discrete cones 200 km SW of Antananarivo, which is thought to range in age from Pliocene to ~8000 years (Holocene). The current EARS kinematic model predicts a present-day SO-LW separation rate of 2.2 mm/yr towards N097°E in the Itasy area.

The Comoros volcanic archipelago falls within a seismically active belt on Jurassic oceanic crust. Since the expansion of seismographic monitoring, mainland Madagascar is known to experience hundreds of earthquakes annually, ranging in magnitude between M 2 and M5.5. Numerous minor earthquakes have occurred at lower-crustal depths (15–30 km) beneath the Ankaratra plateau, including M 5.2 and M 5.5 events in 1985 and 1991. These earthquakes delineate several prominent areas of activity, including NNW and WNW trends that parallel neotectonic structures, such as the Ankay–Alaotra graben. Near the southern end of the Madagascar ridge SO-LW relative motion is characterized by NE–SW compression, reflected in the thrust-faulting mechanisms of strong earthquakes near the southern termination of the Madagascar Ridge. In this zone of incipient subduction within the diffuse LW-SO-AN triple junction (37°S, 48°E), the very slow SO-LW convergence rate is only 0.5 mm/yr towards N210°E.

.

Key words: Somalia-Lwandle, plate kinematics, Madagascar, Comoros, seismicity, volcanicity

PRESENTER'S BIOGRAPHY

Chris Hartnady; b. 04 Jul 1945, Cape Town, South Africa; M.Sc., University of Cape Town (UCT), 1969; British Council scholar, Royal School of Mines, Imperial College, London, 1970-71; Junior Lecturer, Dept of Geology, UCT, 1972-1974; Research Officer, Chamber of Mines Precambrian Research Unit (PRU), UCT, 1974-1980; PhD, Dept of Geology, UCT, 1978; Senior Research Officer, PRU, UCT, 1980-86; Director, PRU, UCT, 1987-91; Associate Professor, Dept of Geological Sciences, UCT, 1987-2000; Research & Technical Director, Umvoto Africa (Pty) Ltd, Cape Town, 2000-; Member, Geol. Soc. S. Afr., 1971-; Life member, Geol. Soc. Afr.,. 2004-.

The Two Recent destructive Earthquakes in the Lake Kivu Area: Intensities and aftershock sequences.

K.Kavotha[1], N.Lukaya[2], N. D'Oreye[3], O. Etoy[4] and A.M.Syavulisembo[5]

1. CRSN-Lwiro, D.R. of Congo, deokavotha@yahoo.fr
2. CRSN-Lwiro, D.R. of Congo, lukayan@yahoo.fr
3. M.N.H.N., Luxembourg, nicolas.doreye@ecgs.lu
4. CRSN-Lwiro, D.R. of Congo, etoyoso@yahoo.fr
5. CRSN-Lwiro, D.R. of Congo, adal12@yahoo.fr

ABSTRACT

Within the Western Rift Valley of Africa, the Lake Kivu area is peculiarly characterized by the highest uplift and a complex dislocation of the Crust marked by a NE-SE trending system of faults that transect the faults bordering the well defined Rift zone. Despite this complex dislocation, the Lake Kivu province has been for several decades free of destructive earthquakes.

Recently, two seismic events spaced only 20Km from each other with magnitudes Mb ± 6 shaked this area on October 24, 2002 and on February 03, 2008 causing louse of lives and damages to buildings. From the field observation of the damages and of the aftershock sequences, the following results stand out clearly.

(1) The two earthquakes are assigned maximum intensities of VIII =IX on the Mercalli-modified scale.
(2) The hypocenter distribution cluster within 0 to 15 Km depth and shows an elliptically epicentre distribution with the main axis of 25 Km long. This axis has the trend of N34 ^{0}O similar to that of the faults that transect the Rift axis.
(3) The aftershocks of the 2008 earthquake are still going an and a preliminary location of these aftershocks suggests that the main shock was associated with a normal faulting along the Eastern side of the Rift zone at the border between D.R. Congo and Rwanda.

Key words: Lake Kivu, Recent, Earthquakes.

PRESENTER'S BIOGRAPHY:

KAVOTHA: Researcher involved in the observation of the seismic activity of the Western Rift valley of Africa and the seismic monitoring of Volcano Nyiragongo and Nyamulagira since 1980.

Constraints on continental rifting from seismology: Highlights from the EAGLE experiment in the Main Ethiopian Rift.

J-Michael Kendall[1] , Ian Bastow[1], Graham Stuart[2], Derek Keir[2], Cindy Ebinger[3], Atalay Ayele[4].

[1]Department of Earth Sciences, University of Bristol, UK.
[2]School of Earth and Environment, Univerisity of Leeds, UK.
[3]Department of Earth and Environmental Sciences, University of Rochester, USA.
[4]Geophysical Observatory, Addis Ababa University, Ethiopia

The rifting of continents and eventual formation of ocean basins is a fundamental component of plate tectonics, yet the mechanism for break-up is poorly understood. The East Africa Rift system (EARS) is an ideal place to study this process as it captures the initiation of a rift in the south through to incipient oceanic spreading in north-eastern Ethiopia. Seismological investigations can be used to test models of rifting. I will summarise results of the recent EAGLE project, which has provided detailed seismic images of the portion of the Ethiopian Rift that spans the transition from continental rifting to incipient oceanic spreading. Seismic data were acquired in 3 phases of the EAGLE project, two of which were designed to record passive seismicity. In Phase I, 29 broad-band seismometers were deployed for 16 months with a nominal station spacing of 40 km and covering a 250 km x 350 km region centred on the transitional part of the rift. In Phase II, a further 50 instruments were deployed for 3 months in a tighter array (nominal station spacing of 10 km) in the rift valley. A variety of techniques have been used to study velocity structure and anisotropy beneath the Main Ethiopian Rift. Travel-time tomography and receiver function analysis illuminate a magamatic rift zone with little crustal stretching. Studies of seismic anisotropy from SKS splitting and surface waves are best explained by oriented melt pockets aligned parallel to magmatic segments in both the crust and uppermost mantle, and not the simple lattice preferred orientation of mantle olivine. Cumulatively, these observations support models of magma assisted rifting, rather than those of simple mechanical stretching.

SEISMICITY AND SEISMIC HAZARD OF LESOTHO

Malephane Hlomphe

Lesotho Highlands Development Authority

Lesotho is a small country surrounded by South Africa and is characterized by a low level of intraplate seismicity which trends in a north-west to south-east direction. Recently scientists have identified this zone as a possible link to the extension of the East African Rift System into the Indian Ocean thereby forming a plate boundary. By use of data from three different agencies, a seismic catalogue for Lesotho is compiled and the seismicity is investigated. A probabilistic seismic hazard assessment is made based on the compiled catalogue. The results from this study indicate that the postulation of a boundary zone that accommodates the southward extension of the EARS is possible.

Stratification of Upper Mantle Anisotropy beneath East Africa

Jean-Paul Montagner[1], Mathias Obrebski[2], Lev Vinnik[3], Eleonore Stutzmann[1]

1. Laboratoire de Sismologie, Institut de Physique du Globe de Paris, France, jpm@ipgp.jussieu.fr
2. Seismological Laboratory, UC Berkeley, Berkeley, CA, USA, mathiasobrebski@yahoo.fr
3. Institute of Physics of the Earth, Moscow, Russia, vinnik@ifz.ru

ABSTRACT

Africa is characterized by extensive intraplate volcanism. The Afar area is one of the biggest continental hotspots active since about 30Ma. At around the same time (30Ma), volcanic activity re-started in several regions of the African plate and since then, hotspots such as Darfur, Tibesti, Hoggar and Mount Cameroon, are characterized by a significant though modest volcanic production. Imaging of seismic anisotropy can help investigating the complex interactions of mantle upwellings and related hotspots with asthenosphere, lithosphere and crust. The interpretation of anisotropy makes it possible to relate surface geology and plate tectonics to underlying mantle convection processes. Different physical processes (cracks or fluid inclusions, lattice preferred orientation of crystals, fine layering) give rise to observable seismic anisotropy (S-wave splitting, surface wave radial and azimuthal anisotropy) and can act together in different depth ranges.
Surface waves provide an almost uniform lateral and azimuthal coverages and are used to image large scale ($>$500km) lateral heterogeneities of velocity and anisotropy in the upper mantle (0-400km depth), whereas body wave S-wave splitting data provide a better lateral resolution of anisotropy.
Our anisotropic tomography results suggest that the Afar hotspot has a different and deeper origin than the other African hotspots (Darfur, Tibesti, Hoggar). These latter hotspots can be traced down to 200km from S-wave velocity but have no visible effect on radial and azimuthal anisotropy. Additional constraints on the geometry of anisotropy beneath the East African Rift and other places on the African continent are found by performing the joint inversion of receiver functions (RF) and SKS waveforms at several permanent broadband stations where receiver functions and SKS waves are clearly indicative of anisotropy. So far, the splitting of SKS waves was reasonably accounted for by models with a single homogeneous layer. However, in complex tectonic environments, several different processes create a complex stratification of anisotropy. By simultaneously taking account of effects of anisotropy on body waves and surface waves, we demonstrate how to unravel this complex stratification of anisotropy beneath the Horn of Africa.

Key words: mantle plumes, hotspot, anisotropy, tomography, East Africa.

PRESENTER'S BIOGRAPHY

Jean-Paul Montagner

Education : Ecole Normale Supérieure Cachan, 1974. Masters in Physics, University of Paris XI, 1976. Agregation of Physics, 1979. Doctorat d'Etat, Univ. Paris VI, 1986. Post-Doc fellow, California Institute of Technology (1986-1988).
Positions held: C.E.A.(Atomic Energy Council) Research Fellowhip (1981-1984). Scientist C.N.R.S. (1984-1989) Consultant of the Ministry of Education and Research (1991-1994). Professor of Geophysics, Univ. Paris VII- Denis Diderot, IPG Paris (1989-present) and at I.U.F (1994-1999) Director of the Seismolab (UMR CNRS7580) (1996-2003) Scientific Director of Earth, Environment, Universe Sciences in the Research Direction of the Ministry of Research (2003-2006).
Seismological contributions :
(1) Geophysical instrumentation : seismometry, concept of multiparameter station applied to ocean bottom stations and to global seismic networks (GEOSCOPE).
(2) Theoretical Seismology : effect of seismic anisotropy on free oscillations, surface waves, body waves.
(3) Mantle, Inner core structure and large-scale Tectonics. Relationship with mineralogy, geochemical anomalies. Inversion of seismic data. First global anisotropy 3D tomography. First observations of seismic anisotropy in the transition zone (400-900km), of correlation between plate motion, continental root and seismic anisotropy.

A re-appraisal of magnitude equal to and greater than $4.0m_b$ earthquake locations in Central Southern Africa and the implications of data to faulting in the area

Nkosilathi R. Mpofu[1], Blessing Shumba[2]

[1]Physics Department, Midlands State University, Gweru, Zimbabwe, rayanvd@yahoo.co.uk.
[2]Goetz Observatory, Meteriological Services Department, Bulawayo, Zimbabwe, shumbamajachani@yahoo.co.uk

ABSTRACT

Central Southern Africa lies over the southern tip of the East Africa Rift System. It covers Zimbabwe, Zambia, Malawi and parts of Mozambique, Botswana and the Transvaal (South Africa). The main tectonic features in the area include the Mid-Zambezi basin - Deka fault zone, the Luangwa rift, Lake Malawi rift and the Eastern highlands of Zimbabwe which form the western flanks of the extreme southern tip of the Western arm of the East Africa rift that passes southwards through Lake Malawi. Event relocations have been carried out using the Modified Joint Hypocenter Determination (MJHD) method. The study covers a period from 1958 to 2008. Results show errors within 0.1 degree and better accuracy in the determined epicentres compared with those globally determined by ISC and USGS. The depths were not fixed. Results of hypocentral depths confirm that the majority of events occurring in the area are of shallow depth. A number of fault-plane solutions were determined with the help of aftershock distributions. Several earthquake clusters were observed. These clusters appear to be associated with the global faulting along the East Africa Rift System. Relatively large events of magnitude greater than 5.0 m_b were relocated and their fault-plane solutions determined. Normal faulting dominates these mechanisms. The results indicate a general northeasterly fault strike which is synonymous with the mechanisms found in the East Africa Rift System, confirming suggestions that the entire region lies within the rift system where rifting is only apparent from earthquake activity.

Key words: Earthquake relocation, rift system, fault-plane solution, earthquake clusters, Modified Joint Hypocenter Determination (MJHD).

Biography of Nkosilathi R. Mpofu

In 2006 Nkosilathi Mpofu was admitted for a Bsc Honorary degree in Physics at Midlands State University. The author considers himself to be privileged in getting an opportunity to be a regular contributor in geophysical research in the region. He also aspires to further his studies in seismology and be able to carry out vital work and publications which are currently lacking in Southern Africa, in particular fault plane mapping. He is currently a trainee seismologist at Goetz Observatory in Bulawayo as part of a work related learning programme done in conjunction with the fore mentioned University.

AfricaArray research on mantle structure beneath the East African Rift System: What is the depth extent of the upper mantle low velocity anomaly?

Andrew A. Nyblade[1], Angela Marie Reusch[1], Fred Tugume[1], Gabriel Mulibo[1], Aubreya Adams[1], Richard Ferdinand[2]

1. Penn State University, USA, andy@geosc.psu.edu
2. University of Dar es Salaam, Tanzania, rf@udsm.ac.tz

ABSTRACT

The nature of anomalous upper mantle structure beneath East Africa and its geodynamic link to the East African rift system has long been debated. To advance our understanding of mantle processes beneath East Africa, AfricaArray research projects have focused on combining datasets from new temporary broadband seismic deployments with datasets from previous deployments to image details of crust and upper mantle structure. AfricaArray has also established a network of permanent seismic stations across eastern and southern Africa to provide data from imaging African Earth structure. A variety of methods have been used to analyze the datasets, including body and surface wave tomography, receiver function inversions, shear wave splitting analyses, and stacking receiver functions to image the 410 and 660 km discontinuities. All of these studies are aimed at determining the spatial and depth extent of the low velocity anomaly in the upper mantle beneath East Africa, and in particular to ascertain if the anomaly extends through the mantle transition zone connecting to anomalous lower mantle structure under central and southern Africa.

Results obtained so far indicate that the anomaly extends to at least 500 km depth, and is very broad. It is found at uppermost mantle depths beneath the rift valleys but under the Tanzania Craton it is only present below about 150-200 km depth. The low wave speeds that characterize the anomaly are primarily caused by rock temperatures elevated by a few hundred degrees. Evidence for this comes from a 20-30 km depression of the 410 km discontinuity that coincides with the lowest wave speeds at the top of the transition zone. The breadth and depth extent of the anomaly suggests that it is not associated with a single plume. Multiple plumes or else a superplume are alternative possibilities under consideration.

Key words: East Africa, upper mantle, seismic tomography

PRESENTER'S BIOGRAPHY

Anderw Nyblade is a professor in the Department of Geosciences at the Pennsylvania State University, and is a co-Director of AfricaArray. His interests are in using broadband seismic data from local, regional and teleseismic earthquakes to investigate mantle processes in regions of active tectonics. He has been working on problems of African tectonics and geology for over twenty years, and has conducted many seismological field projects throughout Africa.

Earthquake source parameters of the Nyamandlovu Earthquakes

Blessing T Shumba[1], Dumisani J Hlatywayo[2]

1. Goetz Observatory Box AC 65 Ascot Bulawayo, Zimbabwe, shumbamajachani@yahoo.co.uk
2. Physics Department, National University of Science and Technology, Zimbabwe, djhlatywayo@gmail.com

ABSTRACT

Focal mechanisms of earthquakes occurring in the Nyamandlovu area, northwest of Bulawayo, Zimbabwe, have been determined. Synthetic P-waveforms compared with observed data from CTBTO stations were employed. All events used were of shallow depth, no more than 15km. A threshold magnitude of 4.5m_b was chosen. Results show normal faulting in the area. Events have tended to occur either after some significant drought or some wet season of considerable length. The area is known to be underlain by thick karroo sandstones that form an aquifer of high potential water storage. These events are probably induced by pore-pressure differentials in the underlying rock. The earthquake mechanism in the area however bears a signature that is synonymous with that for events in incipient rifting zone of the East Africa Rift system.

Key words: focal mechanisms, Karroo sandstones, P-wave polarities

---

BLESSING SHUMBA'S BIOGRAPHY

Blessing Tawanda Shumba (Seismologist) is a young scientist with Goetz Observatory in Zimbabwe. He holds an MSc degree in Earthquake disaster mitigation from the Graduate Institute for Policy Studies (GRIPS) in Tokyo, Japan. He also obtained a post graduate diploma in Seismology from the International Institute of Seismology and Earthquake Engineering in Tsukuba, Japan and a BSc honors degree in Applied Physics from the National University of Science and Technology in Zimbabwe. His research interest is on Earthquake Source Processes. He has worked on research studying the seismicity with the main focus on determining fault plane solution of large earthquakes.

Interpretation of the Gravity Field of the northern portion of the East African Rift: Implication for Crustal Extension

A Tessema

Geophysics Unit, Council for Geoscience, Private Bag X112, Pretoria 0001,
Tel. +27 (012) 841 1459, email: atessema@geoscience.org.za

New Bouguer gravity data acquired by the Ethiopian Geological Survey and existing gravity data obtained from the Geophysical Exploration Technology (GETECH) were compiled to assess the nature of the crust beneath the East African Rift. Filtering techniques were applied in order to extract and display gravity anomalies of crustal origin, and the results are discussed in terms of the structure of the rift system.

The residual gravity derived from high-cut filtering technique reveals density contrast associated with the crustal structure of the rift system. The patterns of positive anomalies coincide with the axis of the northern part of the rift system. These anomalies are exhibited by large amplitude and linear features, which can be interpreted in terms of a zone of crustal thinning through which relatively dense materials have intruded the overlying crust. In contrast, south of the Main Ethiopian Rift, the anomalies are characterized by random patterns and low amplitude. The along-rift-axis variation in gravity anomalies implies that the style of crustal deformation have changed progressively, beginning with regionally distributed crustal extension, such as the one which is observed within the juvenile and wider southern segment of the rift to localized deformation within the active and narrow rift zones of the northern sector of the Ethiopian rift. These suggest that the key parameters controlling along-rift-axis variation in gravity anomalies are the rate of crustal extension, faulting and magmatic activities.

The removal of the short wavelength anomalies from the Bouguer gravity field of the East Africa revealed a broad wavelength gravity low (~1000 km wide), which coincides with the East African swell. This broad gravity low highlights the presence of low-density astenosphere and thinned lithosphere resulting in from an elevated thermal perturbation in the upper mantle.

Linking Africa's surface to its deep interior

Trond H. Torsvik[1], Kevin Burke[2], Bernhard Steinberger[3]

1. NGU, Norway, Trond.Torsvik@ngu.no
2. MIT, USA, kburke1@MIT.EDU
3. NGU, Norway, Bernhard.Steinberger@ngu.no

ABSTRACT

Practically all Large Igneous Provinces (LIPs) and many hotspots are correlated with the edges of the Large Low Shear wave Velocity Provinces (LLSVPs) in the deep mantle near the core-mantle boundary (CMB). These provinces, concentrated beneath portions of the Pacific and African plates, are associated with broad upwelling and positive geoid anomalies. Africa was at the heart of Gondwana (550 Ma) and later of Pangea (320 Ma), and since then Africa has been dominated by slow northward drift over the African LLSVP — For that reason the deep mantle below Africa differs radically from all other continents and numerous deep plumes have impinged the African plate and its margins. Plume-derived LIPs include the 200 Ma Central Atlantic Magmatic Province (CAMP, affecting NW Africa), the 182 Ma Karroo LIP (South Africa), the 130 Ma Etendeka (Namibia, South Africa), the 87 Ma Madagascar LIP, the offshore 73 Ma Sierra Leone Rise LIP, and finally the 31 Ma Afar LIP that was instrumental in the development of East African Rift. Based on novel absolute plate reconstructions and global tomography models we demonstrate that ALL African LIPs and deep-plume sourced hotspots (Azores, Canary; Cap Verde, Ascension, Tristan, Reunion and Afar) are directly related to the LLSVP margins (the Plume Generating Zones; PGZs) in the deep mantle. This remarkable correlation between surface and deep mantle features indicates that deep mantle heterogeneities must have remained essentially stable in their present positions for at least several hundred of millions of years. It remains unclear how deep plumes have been triggered and sourced in the PGZ at the LLSVP edges, but temporal variations in the passage of subducted slabs into the lower mantle and, in the extreme case, mantle avalanches, may explain the episodicity and sporadicity in plume generation. The time lag between subduction and LIP eruption would depend on slab sinking speed and later plume ascent speed from the CMB. Based on usual assumptions of speeds in the mantle, one can estimate ≥ 120 Myr time difference. CAMP may thus be related to the subduction of Palaeozoic ocean floors, whilst the large concentration of Cretaceous LIPs (e.g. Etendeka) can be linked to Peri-Pangean, mostly inward plunging, subduction zones.

Key words: Africa, Large Igneous Provinces, Large Low Shear wave Velocity Provinces, plumes, core-mantle boundary.

PRESENTER'S BIOGRAPHY

Trond Torsvik is a senior scientist with the Geological Survey of Norway (Centre for Geodynamics) and a Professor of Geodynamics at the University of Oslo (Physics of Geological Processes). My interests include all aspects of geoscience, from the Precambrian to present, and from the core-mantle-boundary to the surface of the entire Earth.

Seismic Energy Mapping between 3° S and 6° N in the Western Rift of East Africa

Isaiah Tumwikirize [1] Ray Durrheim[2]

1Department of Geological Survey and Mines, P.O. Box 9, Entebbe, UGANDA. E-mail: isaiah.tumwikirize@gmail.com, isaiah_tumwikirize@hotmail.com
2 University of the Witwatersrand Johannesburg, School of Geosciences. E-mail: rdurrhei@csir.co.za

Abstract
Using magnitude-energy relation, a moving block method is implemented to compute total energy released by earthquakes from 1840 to 1999 earthquake catalogue period, covering 3° S and 6° N of the western rift. After unifying earthquake magnitude into surface wave magnitude, because this type of magnitude does not suffer saturation, seismic energy was computed. The results all natural earthquakes in the catalogue show that most of the seismic energy is released in the western branch of the EARS. The high seismic energy centres reflect areas of weakness in the EARS, because seismic energy release in an earthquake is caused by a fault motion driven by dynamic stress. The low seismic energy centres show areas of low stress and stable cratonic nuclei of the basement complex, for example, Tanzanian craton and the basement complex in eastern Uganda. These may however be affected by static stress due to volcanic activity at localised centres. This finding is expected because of very low seismic activity observed from the seismological data, which provides evidence for very little stress variation or deformation. Moreover during an earthquake, stress changes very rapidly due to seismic energy release and decreases in most places of the fault plane but may increase at some places especially at the edge of the fault where stress concentration occurs.

The findings in this paper further show that seismic energy release, and rupture length are related by scaling laws on earthquake magnitude scale. There are rupture yielding transition windows and a steady increase in rupture by a small change in earthquake magnitude. This trend is progressively followed by a change in gradient between earthquake magnitude and a fast increase in rupture length on the onset of sharp gradients. The fast increases in rupture length were observed by the onset of sharp gradients between M_s 5.0 to 5.4; M_s 5.4 to 6.0, M_s 6.0 to 6.6 and M_s 6.6 to 7.1. This relationship correlates in terms of energy release as follows: a rupture length of 5 km is caused by seismic energy of 10^{19} ergs generated by an earthquake of magnitude M_s 5.0. Likewise a 15 km rupture is affected by seismic energy of 10^{21} ergs from an earthquake magnitude M_s 6.0, and a 30 km rupture is caused by Ms 6.6 earthquake, which has an energy budget of 10^{22} ergs. And an earthquake of magnitude 7.0 releases 1.6x 10^{22} ergs and a rupture of approximately 50 km. The findings from seismic energy release and rupture length in this paper together with other geological and geotechnical information can be used in seismic hazard, risk mitigation and land use planning.

Key words: Seismic Energy, East Africa, Rift

PRESENTER'S BIOGRAPHY

Acting Coordinator Uganda National Seismological Network, Geophysicist, over 10 years experience in Geosciences work especially in seismic network operation, data processing analysis and interpretation and geothermal exploration. Education: B. Development Studies; BSc. (Hon) Geophysics, PGD Seismology. Membership: Eastern and Southern Africa Regional Seismological Working Group (ESARSWG); Uganda Seismic Safety Association and Society of Exploration Geophysicists (SEG).

Constraints on the seismic structures for the Rwenzori region in western Uganda local and teleseismic events

I. Wölbern [1], G. Rümpker [2], M. Lindenfeld[3], A. Jakovlev[3]

1. Goethe University Frankfurt am Main, Germany, woelbern@geophysik.uni-frankfurt.de
2. Goethe University Frankfurt am Main, Germany, rumpker@geophysik.uni-frankfurt.de
3. Goethe University Frankfurt am Main , Germany, mirzar@geophysik.uni-frankfurt.de
4. Goethe University Frankfurt am Main, Germany, jakovlev@geophysik.uni-frankfurt.de

ABSTRACT

Within the framework of the multidisciplinary RiftLink research group we have carried out a passive-source seismological experiment in order to study the Rwenzori mountains in western Uganda close to the Congo border. Local and teleseismic events have been recorded during a period from May 2006 to September 2007. Our aim was to map local seismicity and to derive the velocity structure of the crust and the uppermost mantle to constrain the development and uplift of the 5000 m high mountain range.

The microseismic activity in the region is unexpectedly high. On average 800 events have been located per month, but only a few of which are located within the Rwenzori massive itself. In the northwestern part focal depths have been revealed to between 10 and 20 km, whereas on the eastern side hypocenters go as deep as 30 km. East of the ridge a cluster of seven events has been determined which occurred at a depth of about 60 km within 20 days. We have used P-wave polarities to determine fault plane solutions for selected events. Most of them revealed normal faulting with strike directions roughly parallel to the rift axis and extension forces perpendicular to it. A small group of events shows strike directions which are systematically tilted counter-clockwise. This supports a numerical model describing the Rwenzori block as a micro plate that is captured between two rift segments and rotates clockwise.

In order to resolve the 3D velocity structure of the crust down to about 20 km local earthquake tomography has been applied based on P and S arrival times. We have found a pronounced negative velocity anomaly in the upper five kilometers near the western flank of the Rwenzori mountains related to the Buranga hot springs at the surface. We also attempted to derive the 3D anisotropic velocity structure. For the inversion we assume a simplified form of transverse anisotropy defined by four parameters: a fast and a slow velocity and two angles to determine the orientation of the fast velocity axis. In the northern part the fast axes are dominantly oriented NS, roughly parallel to the strike direction of the major faults.

Receiver functions computed from teleseismic events reveal a rather simple crust beneath the eastern rift shoulder. The Rwenzori range, however, is characterized by a complex inner crustal structure. We utilized different techniques based on travel time and waveform information to derive the depths to Moho. Our results provide evidence for the absence of a deep crustal root underneath the mountain range. In the southeastern part of our network, a pronounced negative phase is detected which we interpret as the top of a low velocity layer at about 15 km depth. The strong velocity decrease in this layer may be indicative for partial melt. Splitting parameters derived from SKS phases exhibit fast-polarization directions that are parallel to the rift with delay times of about 1.2 seconds. This indicates that rifting in this region may probably assisted by magmatic intrusions.

Key words: East African Rift System, local seismicity, tomography, receiver functions, shear wave splitting

PRESENTER'S BIOGRAPHY

Ingo Wölbern studied Geophysics at the University of Kiel, Germany, where, he participated in the seismological TOR project finishing with a master's thesis about crustal influences on travel time residuals of teleseismic earthquakes in the Tornquist zone area. Following, he worked on receiver functions at the GeoForschungsZentrum in Potsdam and received his Ph.D. in December of 2003. This work focused on the investigation of the crust and upper mantle beneath Hawaii to determine anomalies and structures related to the Hawaii plume. A further receiver function study concentrated on the central Andes and the related subduction zone. Since 2005 he is working at the University of Frankfurt mainly focusing on field work and data evaluation of the seismic study in Uganda within the RiftLink research group, and further involved in a passive source experiment on the Cape Verde islands.

The Magma Plumbing System of Dabbahu and Gabho volcanoes (Afar Rift, Ethiopia) from InSAR, GPS and Seismicity data

Tim Wright[1], Atalay Ayele[2], Manahloh Belachew[3], Laura Bennati[4], Cindy Ebinger[3], Ian Hamling[1], Derek Keir[1], Elias Lewi[2], Carolina Pagli[1], Gezahegn Yirgu[2]

1. University of Leeds, UK, t.wright@see.leeds.ac.uk
2. Addis Ababa University, Ethiopia
3. University of Rochester, USA
4. Purdue University, USA

ABSTRACT

In September 2005, a 60-km-long dike, up to 8 meters thick, was intruded into the Dabbahu rift segment, a nascent seafloor spreading centre on the Nubia-Arabia plate boundary in the Afar Depression of Northern Ethiopia. Localized subsidence of 2-3 meters at Dabbahu and Gabho, measured by InSAR, indicated that some of the intrusion was fed from shallow magma chambers beneath Dabbahu and Gabho volcanoes, two centers of focused silicic volcanism at the northern end of the rift segment. An array of 9 seismometers recorded seismicity from October 2005 to April 2006 – three were located in the area between Dabbahu and Gabho, where an explosive, rhyolite eruption took place on 26 September 2005. Ten continuously-recording GPS receivers were installed in January 2006, including one on the flanks of Dabbahu and one on Gabho. In addition, Envisat was programmed to acquire SAR data on every overpass since September 2005, enabling us to build time series of recent deformation.

The data show that:

(i) Gabho began to uplift aseismically in November/December 2005. Uplift was most rapid initially, with 25 cm in the first six months, and continued until summer 2007. Since then it has been stable.

(ii) The southern flank of Dabbahu began subsiding immediately after the main dyke intruded, continuing until ~March 2006, and reaching a maximum of ~10 cm. This occurred above a band of seismicity that dips to the north beneath Dabbahu.

(iii) The centre of Dabbahu began to uplift in ~March 2006, and has continued steadily for at least 2 years. The total uplift (by July 2008) was ~50 cm. Seismicity in the first six months was concentrated at 3 km depth beneath the uplifting area.

(iv) Gabho and Dabbahu did not subside during the dyke injections that have occurred in the southern half of the rift segment since 2005 (nine by July 2008).

Despite the remarkably similar behavior to the Krafla system in Iceland, which underwent a rifting episode from 1975 to 1984, these observations require a more complex magma plumbing system. In contrast to the single inferred shallow chamber beneath Krafla, multiple magmatic sources are required in the Dabbahu rift.

Key words: Rifting, Volcanism, Tectonics, Geodesy, Seismicity

PRESENTER'S BIOGRAPHY

Tim Wright is a Royal Society University Research Fellow at the University of Leeds. He graduated from Cambridge University in 1995, received an MSc from the University of London in 1997 and a D.Phil. from the University of Oxford in 2000. He specializes in research into active tectonics using InSAR, and is currently the PI of the Afar Rift Consortium, a major NERC-funded project investigating the splitting of continental lithosphere and the creation of new crust in the Afar region of Northern Ethiopia (http://www.see.leeds.ac.uk/afar).