



November 21, 2003

To Whom It May Concern:

Herein please find for your perusal a white paper describing a new AESEDA project called *AfricaArray*. This project will be led by Andrew Nyblade, a member of the AESEDA Leadership Team. The mission of AESEDA (The Alliance for Earth Sciences, Engineering and Development in Africa) is to promote the integration of physical sciences, engineering and social sciences in order to develop human resources, promote economic vitality and enable effective stewardship of georesources in Africa. This mission is being carried out through interdisciplinary, inter-institutional research, education, and outreach initiatives involving strategic partnerships between Penn State University, several Historically Black Colleges and Universities (HBCUs) in the United States, and select African universities. Foundations, international development agencies, and major multinational corporations operating in Africa are major stakeholders in this enterprise.

The partnerships established within AESEDA provide a strong platform for:

- Building contemporary African human capacity to drive economic growth.
- Formulating a greater basis for economic opportunity and sustainable livelihoods.
- Developing a framework to support decision-making and policy development.
- Encouraging Africa's full participation in the global economy.
- Deploying e-Education tools for enhancing human capacity development.

AESEDA has three over-arching strategic goals: 1) to create effective, international, collaborative learning environments that support excellence in education and research; 2) to promote a diverse international milieu that encourages excellence in intellectual inquiry related to promoting sustainable development of georesources in Africa; and 3) to support and build opportunities for disadvantaged populations, while helping to ensure intellectual and cultural diversity in all areas of Alliance activities.

Additional information about AESEDA can be found at <http://www.ems.psu.edu/africa/>, including a description of AESEDA's inaugural symposium held October 12-14, 2003, at Penn State.

Sincerely yours,

Michael Adewumi  
Director, AESEDA  
Professor and Quentin E. and Louise L. Wood  
Faculty Fellow in Petroleum & Natural Gas Engineering

# ***AfricaArray: Training a Scientific Workforce for Africa's Natural Resource Sector***

*(This is a concept paper written to gauge the level of interest on the part of funding agencies for establishing a public-private partnership to support this initiative.)*

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## **Summary**

Highly trained scientists in fields allied to natural resource exploitation are needed in government, industry and academic institutions throughout Africa who are dedicated to building the African scientific community, and who can play pivotal roles in the development and management of Africa's vast mineral and petroleum wealth, and water and geothermal resources. *AfricaArray* will address the limited capacity in the relevant science fields by establishing a unique in-situ education program to help build a scientific workforce for Africa's natural resource sector. At the same time, *AfricaArray* will expand greatly our knowledge of basic earth structure, particularly in areas of economic and societal interest.

*AfricaArray* will do this by tightly coupling education and research programs in seismology with seismic recording stations spread across Africa (*AfricaArray*) over a 20 year period for 1) in-situ training of a new generation of African scientists with BSc (Honors), MSc and Ph.D. degrees, 2) developing facilities within African institutions for conducting and maintaining scientific education and research, 3) promoting community building among African scientists through education and research collaborations and data exchanges, and 4) increasing basic knowledge of earth structure. *AfricaArray* will be run under the auspices of The Alliance for Earth Sciences, Engineering, and Development in Africa (AESEDA), which provides a strong partnership structure between Penn State and several African universities.

*AfricaArray* will be implemented in 4 phases. During **Phase 1 (years 1-3)**, an educational program will be developed at the University of Witwatersrand, South Africa, to provide BSc (Honors) and MSc degree training for one student from each participating country (5 or 6 countries initially), and to train technical personnel how to operate and maintain seismic stations. Three seismic stations will be installed in each participating country as part of a permanent "backbone" seismic network. Data from the seismic stations will be used for BSc (Honors) and MSc thesis research. During **Phase 2 (Years 4-6)**, the in-situ education program will be expanded to include additional BSc and MSc students, and to introduce a Ph.D. program. The backbone network of permanent seismic stations will be expanded into other African countries, and "flexible" seismometer arrays will be installed within the initial member countries, targeted at areas of economic or societal interest. In **Phase 3 (years 7-10)**, the number of students trained at the BSc, MSc and Ph.D. levels will grow to meet the demand for highly trained scientists. A major emphasis will be placed on building sustainable centers of excellence in geophysics at other African universities, and in starting an educational outreach program to secondary schools in areas with earthquake hazards. *AfricaArray* will continue to develop the backbone network in additional countries and to expand further the number of flexible arrays in countries containing established backbone stations. By **Phase 4 (years 11+)**, *AfricaArray* will have attained its design goals of a comprehensive in-situ educational program for BSc (Honors), MSc and Ph.D. students, and an extensive network of permanent and flexible seismic stations. Support (about \$2 million) is being sought for Phase 1 through partnerships with public and private funding agencies.

## **Introduction**

Capacity in science fields allied with natural resource exploitation is extremely limited in much of Africa, and in places where such capacity exists (i.e., South Africa), financial pressures threaten to undermine it. Highly trained scientists are needed in government, industry and academic institutions throughout Africa who are dedicated to building the African scientific community and who can play pivotal roles in the development and management of Africa's vast mineral and petroleum wealth, and water and geothermal resources. The development of Africa's mineral, petroleum, geothermal and water resources is also hindered in many areas of the continent by limited knowledge of earth structure.

The primary goal of *AfricaArray* is to address the problem of limited capacity in science fields allied to natural resource exploitation by establishing a unique in-situ education program that will help build a scientific workforce for Africa's natural resource sector. An additional goal of *AfricaArray* is to help mitigate earthquake hazards in regions where they pose a threat to life and curtail development.

*AfricaArray* will achieve these goals by tightly coupling education and research programs in seismology with seismic recording stations spread across Africa (*AfricaArray*) over 20 years for:

- 1) In-situ training of a new generation of African scientists with BSc (Honors), MSc and Ph.D. degrees, who will be well positioned to become leaders in government, industry and academic institutions.
- 2) Developing facilities within African institutions for conducting and maintaining scientific education and research.
- 3) Promoting community building among African scientists through education and research collaborations and data exchanges.
- 4) Increasing basic knowledge of earth structure in areas of economic and societal interest, in addition to fundamental geological processes shaping the African continent.

### **Seismology as a tool for building science capacity**

Why use seismology to build science capacity in Africa for the natural resource sector? There are a number of reasons. Seismology students receive training not just in the geosciences, but also in several other fields, including physics, chemistry, mathematics, and information technology (including computer programming). They are broadly trained and can therefore work in several areas of Africa's natural resource sector. In many instances, education and research in seismology requires access to data from seismic recording stations across continents (and oceans). It is a "science without borders", and as such provides a natural mechanism for promoting communication and cooperation between scientists separated by political boundaries. The discipline of seismology forms the core of most academic programs in geophysics and is a cornerstone of many petroleum and some mineral exploration programs. Seismic applications are also important for the exploration and development of water and geothermal resources. The combination of these attributes makes the discipline of seismology an excellent tool for building science capacity for Africa's natural resource sector.

### **The need for African seismologists**

Beyond building science capacity broadly for Africa's natural resource sector, there is also a growing need specifically for African seismologists. Seismologists are needed in the petroleum industry to work in both exploration and production. In the mining industry, seismologists are needed for exploration work as well as in mine safety (hundreds of people are killed each year as

a result of mine induced tremors). The importance of seismic methods in water and geothermal resource exploration and management is growing rapidly. As demand increases for African seismologists, what little capacity there is in Africa for seismology training is disappearing fast, even though the interest from students is high (e.g., 10-15 new BSc honors students at the University of Witwatersrand in 2004; over 100 BSc students currently enrolled at the Agostinho Neto University in Luanda, Angola).

### **The importance of seismic networks in community building**

A unique aspect of this capacity building initiative is the integration of seismic data collection with an educational program. The seismic data provides a common thread that will pull the African science community together and give it a common purpose. Data sharing leads to collaboration on research projects, which in turn has a positive effect on education. In addition, the data component of *AfricaArray* will form an important bridge between African scientists and seismologists in the United States and elsewhere. The seismic network will lead to significant interest and participation in African science by researchers outside of Africa. Because of the seismic network, the global seismology community will have a vested interest in the success and sustainability of *AfricaArray*.

### ***AfricaArray***

*AfricaArray* will be implemented in 4 phases. The components for each phase are outlined to provide a comprehensive, long-term overview of *AfricaArray*. However, the first phase, for which funding is being sought from a broad range of public and private sources (foundations, government agencies, companies), is given primary focus. Details of the educational program are presented below; information about the seismic stations and research products are given in Appendix A.

**PHASE 1 (Years 1-3).** The initial phase is designed to be practical, cost-effective, and to enable growth in subsequent years (Phases 2-4).

1) *AfricaArray* will develop an educational program in conjunction with the School of Geosciences at the University of Witwatersrand, South Africa (details provided in Appendix B), that will:

- a. Provide BSc Honors and MSc degree training at the University of Witwatersrand (over 3 years) for one student from each initial member country (5 or 6). The students will use data from *AfricaArray* for their thesis research. The degree (BSc Honors, MSc) obtained by the students will depend on their previous level of education. The education program will:
  - i. Provide funding for the students
  - ii. Provide funding for a faculty position at the University of Witwatersrand (see rationale in Appendix B)
  - iii. Provide co-thesis advisors at Penn State University to help guide thesis research
  - iv. Provide funding for the students to spend time at Penn State University collaborating with their co-thesis advisors
- b. Train technical personnel to operate and maintain seismic stations. This will involve a series of workshops/training courses in the practical aspects of operating seismic stations and managing data.

2) In the initial member countries (5 or 6), a network of ~3 broadband seismic stations will be installed. These sites will form a permanent “backbone” network. A backbone network is

needed, in part, so that data obtained in Phases 2-4 by “flexible” arrays of seismic stations can be integrated. *AfricaArray* will establish support facilities (i.e., computer networks, repair shops) in each country. The initial 5 or 6 countries will be selected in consultation with funding and other *AfricaArray* partners. A preliminary list would include Angola and Nigeria (supported by oil company interests) and Botswana, Namibia and South Africa (supported by mining company interests). The attached figure illustrates the backbone network and its expansion over time (countries shown with seismic stations in each phase were chosen for illustration purposes).

3) *AfricaArray* will foster community building by hosting an annual workshop that will bring together seismologists and other earth scientists from African countries to present research results, to provide a forum for discussing education issues, and to promote collaboration and data sharing. *AfricaArray* will also foster community building by bringing African and US students together to work collaboratively on research projects.

4) Penn State will need to partner with the School of Geosciences at the University of Witwatersrand to develop *AfricaArray*'s educational program. *AfricaArray* will need to partner with the Incorporated Research Institutes of Seismology (IRIS) to provide data storage and management, to help develop training materials for field operations, and to help establish an instrument facility at Penn State University modeled after the IRIS/PASSCAL Instrument Center. Penn State will need to partner with industry, government agencies and foundations to fund *AfricaArray*. The cost for Phase 1 is about \$2M. Funding agencies possibly interested in supporting the capacity-building components of *AfricaArray* include USAID, private foundations, and companies. Agencies possibly interested in supporting the basic research components of *AfricaArray* include NSF, DOE, and also some companies.

5) Data from the seismic stations will undergo some initial processing in each country and will then be sent to the IRIS data management center (<http://www.iris.edu/about/DMC/dms.htm>) for archiving and distribution [via the Internet and other forms of media (i.e., tapes, CDs, DVDs)].

**PHASE 2 (Years 4-6).** In Phase 2, the in-situ education programs will be expanded to include additional MSc and Ph.D. students, as well as training for technical personnel. Opportunities for US students to participate in *AfricaArray* will also be expanded. Participation in the annual workshop will be widened, and a process will be initiated to build sustainable centers of excellence for teaching and research at other African universities as students begin finishing degrees and returning to their home countries.

Phase 2 will be the primary expansion phase for the permanent backbone network of seismic stations into other African countries and for the launching of a “flexible” array of seismometers (5 to 10 stations) within the initial member countries. The flexible arrays will slowly migrate across each country to provide more data coverage, first targeting areas of economic and/or societal interest (i.e., sedimentary basins, ultramafic intrusions, kimberlite fields, active faults) and then eventually filling the remaining gaps in data coverage. The stations comprising the flexible arrays will be moved every 1 to 2 years within each country. The map in the middle of the attached figure illustrates how the flexible arrays could be positioned to investigate areas of potential economic interest (i.e., the Kwanza and lower Congo basins in Angola for petroleum and the edge of the Kalahari Craton in Botswana for diamonds).

**PHASE 3 (years 7-10).** The educational programs will continue to grow to meet the demand for highly trained African scientists. A major emphasis will be placed in this phase on building academic programs in geophysics at other African universities by establishing sustainable centers of excellence with the capacity to maintain high-level research and training programs. By year 7

or 8, the first Ph.D. students should complete their degrees, and there should be a number of MSc students finishing as well. *AfricaArray* will help students taking academic positions build and/or improve geophysics programs at their home institutions. In areas of Africa with seismic hazards, *AfricaArray* will also establish a secondary school outreach program to assist in the mitigation of these hazards by raising the level of awareness and preparedness. In Phase 3, the backbone network will expand into yet more countries, and the number of flexible arrays also will grow (see attached figure).

The design goals of *AfricaArray* will be achieved by the end of this phase. The goals include an extensive educational program, a backbone network with stations in many countries, and flexible arrays in a large subset of the countries with backbone stations.

**PHASE 4 (years 11+).** By year 11, *AfricaArray* will attain a ‘mature’ state. An in-situ training program will be in place that will support the future needs of industry, government agencies and academic institutions for highly trained African scientists. This training program will not only include the University of Witwatersrand, but also several other African universities whose programs will have been strengthened by MSc and PhD students trained through *AfricaArray*’s educational program. The backbone seismic network and flexible arrays will provide quality seismic data from many parts of the African continent, and research conducted using the data will provide a big step forward in our knowledge of African earth structure.

### **Why will *AfricaArray* work?**

There have been many attempts at building science capacity in Africa. There have also been substantial amounts of funding provided by donor agencies and spent by African institutions to purchase and run seismic recording stations. Many of these efforts have not been successful. Why should *AfricaArray* have a greater chance of success than previous programs? There are several reasons.

- 1) The in-situ training program will minimize the brain drain problem experienced by many other capacity building initiatives in Africa.
- 2) *AfricaArray* will develop a long-term (20 yrs) science support system through community building efforts.
- 3) *AfricaArray* will be committed to providing long-term (20 yrs) financial and technical support for the educational programs and for operating the seismic stations.
- 4) The project leader (Andrew Nyblade) has many years of experience working in Africa and has successfully carried out several seismic projects similar to *AfricaArray*.
- 5) Through its seismic networks (backbone and flexible arrays), *AfricaArray* will have long-term support from the global seismology community.
- 6) Through its partnership with the University of Witwatersrand, *AfricaArray* will have long-term institutional support from one of the foremost universities in Africa that has close ties to industry.
- 7) *AfricaArray* is not starting from scratch. The School of Geosciences at the University of Witwatersrand has an established program in geophysics. There are already some 17 permanent seismic stations in operation in Africa.
- 8) *AfricaArray* is about training Africans in Africa to work on African problems using African data.

### **About this project**

Earlier this year (2003), the College of Earth and Mineral Sciences at the Pennsylvania State University launched a new initiative focusing on education and research in Africa called the Alliance for Earth Sciences, Engineering, and Development in Africa (AESEDA; <http://www.ems.psu.edu/africa/index.htm>). During the kick-off symposium for AESEDA

(<http://www.ems.psu.edu/africa/symposium/index.htm>), Andrew Nyblade had many conversations with symposium participants about capacity building in Africa and the kinds of research projects that would be of interest to scientists in Africa. *AfricaArray* is an outgrowth of these conversations.

Andrew Nyblade was born and raised in Tanzania and has conducted geophysical research in eastern Africa for almost 20 years. He has been (is) the lead Principal Investigator on four large seismic projects funded by the National Science Foundation totaling \$2.2M (Tanzania 1994-1995; Ethiopia 2000-2002; Kenya 2001-2002; Cameroon, 2004-2006). Using data from these and other projects, he has published over 30 articles on the geology and tectonics of eastern and southern Africa, many in collaboration with scientists in Africa. Through these projects, he has also provided training for African students and technical personnel, including one MS student and one Ph.D. student (in progress).

### **Key Personnel (CVs in Appendix C)**

#### **At Penn State University:**

**Andrew Nyblade**, Associate Professor, research interests include applied seismology, tectonics, heat flow

**Charles Ammon**, Associate Professor, research interests include theoretical seismology, inverse theory, signal processing

**Eliza Richardson**, Assistant Professor, research interests include theoretical seismology, earthquake source physics, mining seismicity

**Sridhar Anandakrishnan**, Associate Professor, research interests include active source seismology, earthquake seismology, glaciology

#### **At the University of Witwatersrand:**

**Paul Dirks**, Professor, Head, School of Geosciences, research interests include structural, geology, tectonics, economic geology

**Sue Webb**, Lecturer, research interests include potential fields and seismology

**Mike Jones**, Senior Research Officer, interests include heat flow and tectonics

**Gordon Cooper**, Senior Lecturer, research interests include inverse theory, wavelets, image processing

**John Hancox**, Senior Lecturer, interests include sedimentology, basin analysis, oil geology.

**Roger Gibson**, Associate Professor, interests include structural-metamorphic geology tectonics

**Lew Ashwall**, Professor, interests in geodynamics, geochemistry, Precambrian tectonics

## Appendix A. Seismic Stations and Research Products

The seismic stations will consist of a ground motion sensor (seismometer), digitizer, data logger, GPS clock and power supply. The seismic waves recorded by the seismic stations will come from earthquakes at many different distances from the stations. The seismic data will be used with a variety of proven modeling techniques to extract information about earth structure at many scales. A sampling of research products that will come from *AfricaArray* is provided below and is indexed according to the funding partners that might be interested in these products (\* denotes petroleum companies, <sup>x</sup> denotes mining companies, <sup>^</sup> denotes power generating companies, <sup>o</sup> denotes agencies funding basic research, for example NSF and DOE). As a further example of the kinds of information about earth structure that can be obtained from the seismic data, a list of publications is provided from a seismic project in Tanzania.

**Sedimentary Basins<sup>\*,o</sup>:** Depth to basement, mean shear wave velocity of sediments, location of major basement uplifts, insights into basin formation and evolution, reactivation of basement structures.

**Intrusive Complexes<sup>x</sup>:** Thickness of lithosphere surrounding kimberlite fields and other igneous intrusions, depth extent of ultramafic bodies, anisotropy of basement fabrics.

**Seismicity<sup>x,^,o</sup>:** Seismicity patterns, including event locations, magnitudes, and source characteristics.

**Crust and Mantle Structure<sup>x,o,\*</sup>:** Variations in crustal and lithosphere thickness for various geologic terrains, variations in the thermal structure of the lithosphere, strain patterns in the lithosphere and convecting mantle, lower mantle structure and dynamics.

### Publications from the Tanzania Broadband Seismic Experiment

Nyblade, A.A., C. Birt, C.A. Langston, T.J. Owens, and R.J. Last, Seismic experiment reveals rifting of craton in Tanzania, *Eos, Trans. AGU*, 77, 517-521, 1996.

Zhao, M., C.A. Langston, A.A. Nyblade, and T.J. Owens, Lower crustal rifting in the Rukwa Graben, East Africa, *Geophysical Journal International*, 129, 412-420, 1997.

Last, R.J., A.A. Nyblade, C.A. Langston, and T.J. Owens, Crustal structure of the East African Plateau from receiver functions and Rayleigh wave phase velocities, *Journal of Geophysical Research* 102, 24,469-24,483, 1997.

Langston, C.A., R.A. Brazier, A. A. Nyblade, and T.J. Owens, Local magnitude scale and seismicity rate for Tanzania, East Africa, *Bulletin Seismological Society of America*, 88, 712-721, 1998.

Ritsema, J., A. A. Nyblade, T.J. Owens, and C. A. Langston, Upper mantle seismic velocity structure beneath Tanzania: Implications for the stability of cratonic lithosphere, *Journal of Geophysical Research*, 103, 21,201-21,214, 1998.

Zhao, M., C.A. Langston, A.A. Nyblade and T.J. Owens, Upper mantle velocity structure beneath southern Africa from modeling regional seismic data, *Journal of Geophysical Research*, 104, 4783-4794, 1999.

Owens, T.J., A.A. Nyblade, H. Gurrola, and C.A. Langston, Mantle transition zone structure beneath Tanzania, East Africa, *Geophysical Research Letters*, 27, 827-830, 2000.

Nyblade, A.A., T.J. Owens, H. Gurrola, J. Ritsema, and C. Langston, Seismic evidence for a deep upper mantle thermal anomaly beneath East Africa, *Geology*, 28, 599-602, 2000.

Brazier, R.A., A.A. Nyblade, C.A. Langston, and T.J. Owens, Pn wave velocities beneath the Tanzania Craton and adjacent rifted mobile belts, East Africa, *Geophysical Research Letters*, 27, 2365-2368, 2000.

Nyblade, A.A., Crust and upper mantle structure in East Africa: Implications for the origin of Cenozoic rifting and volcanism and the formation of magmatic rifted margins, in *Volcanic Rifted Margins*, edited by M.A. Menzies, S.L. Klemperer, C.J. Ebinger, and J. Baker, *Geological Society of America, Special Paper 362*, 15-26, 2002.

Langston, C.A., A.A. Nyblade and T.J. Owens, Regional wave propagation in Tanzania, East Africa, *Journal of Geophysical Research*, 107, 10.1029/2001JB000176, ESE 1-1 – 1-18, 2002.

Nyblade, A.A., and R.A. Brazier, Precambrian lithospheric controls on the development of the East African rift system, *Geology*, 30, 755-758, 2002.

## **Appendix B. Geophysics Programs at the University of Witwatersrand and Penn State University**

The University of the Witwatersrand is the only university in South Africa that offers an internationally accepted BSc(Hons) degree in Geophysics. Geophysics training at the University of the Witwatersrand has traditionally been organized through 2 separate groupings: 1. A teaching department in Geophysics with the responsibility to provide BSc(Hons) and undergraduate teaching; and 2. The Bernard Price Institute of Geophysics with a mandate to do research and post-graduate training. During reviews in 2003, it was decided that from 2004 onwards all teaching and research in Geophysics should be collapsed into a single entity housed within the School of Geosciences. The Bernard Price Institute of Geophysics will be closed, leaving 3 full-time geophysicists in place.

Geophysics teaching at Wits University is done at Undergraduate (years 1 to 3), Honors (Year 4) and Post Graduate (MSc and PhD by research) levels. Undergraduate teaching is limited to 2<sup>nd</sup> and 3<sup>rd</sup> year service teaching in Geology and Physics Programs. The main Geophysics course is taught as a one year Honors level degree program. Access to the BSc(Hons) Geophysics course is through Physics, Applied Mathematics or Geology. The BSc(Hons) degree provides training for fourth year students in Solid Earth Geophysics, and the main components of the course are: Mathematical and Computational Geophysics, Potential Field Methods, Geo-electrical Methods, Exploration, Earthquake and Mine Seismology, Heat Flow, and Global Geophysics. In addition, students have to attend a field school and complete a research project.

Wits Geophysics graduates are well sought after by the South African mining industry, and they find employment in many branches of geophysics. Many do well obtaining higher degrees at overseas universities. There are currently 8 honors students and the expected number for 2004 is 10-15. Most of the students are from South Africa, but there are currently 2 Namibians, and applications for 2004 from several other African countries (Botswana, Zimbabwe, Zambia) have been received.

Post-graduate programs in Geophysics consist of research degree programs at MSc and PhD levels. Normally there are between 5 and 8 students enrolled at each level and research has concentrated on computational geophysics, seismic studies, potential field methods and heat flow. Staff have actively participated in large international projects such as the Kaapvaal Craton seismic project and the Kaapvaal magneto-telluric project, and many opportunities exist for post-graduate projects.

In order to provide training for larger honors classes and to supervise increased numbers of M.Sc. and Ph.D. students supported by AFRICAARRAY, it will be necessary to increase the staff complement above the current level (three) and broaden the research and expertise base. **Therefore, funding for one faculty position is included in the budget for *AfricaArray*.**

The graduate program in geophysics at Penn State offers MSc and Ph.D. degrees with specialization in seismology (earthquake and refraction/reflection), rock mechanics, geodynamics, and heat flow. Affiliated with the geophysics program are active research groups in tectonics, structural geology, basin analysis, and geomorphology. There are six faculty in geophysics at Penn State, and course offerings at the graduate level include introductory seismology, environmental geophysics, reflection seismology, geodynamics, rock mechanics, heat flow and thermal modeling, advanced seismology, inverse theory, digital filtering and time series analysis. There are about 20 geophysics graduate students (MSc and Ph.D.) currently enrolled at Penn State.

## Appendix C. Curriculum Vitae

### ANDREW A. NYBLADE

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Tel. (814) 863-8341 Fax (814) 863-7823 e-mail: andy@geosc.psu.edu

#### EDUCATION

|              |                         |      |                        |
|--------------|-------------------------|------|------------------------|
| <b>B.A.</b>  | Geology                 | 1982 | Wittenberg University  |
| <b>B.A.</b>  | Earth Science Education | 1982 | Wittenberg University  |
| <b>M.S.</b>  | Geophysics              | 1985 | University of Wyoming  |
| <b>Ph.D.</b> | Geology                 | 1992 | University of Michigan |

#### PROFESSIONAL EXPERIENCE

|              |   |
|--------------|---|
| 2002-present | Associate Professor, Department of Geosciences, Pennsylvania State University                             |
| 2001-present | Faculty Affiliate, Graduate Program in Acoustics, Pennsylvania State University                           |
| 2003         | Cox/Blaustein Visiting Professor, Department of Geophysics, Stanford University                           |
| 1997-2002    | Assistant Professor, Department of Geosciences, Pennsylvania State University (tenure-track)              |
| 1994-1997    | Assistant Professor, Department of Geosciences, Pennsylvania State University (fixed term appointment)    |
| 1995         | Visiting scientist, US Geological Survey, Branch of Seismology, Menlo Park, CA                            |
| 1992-1993    | National Science Foundation Postdoctoral Fellow, Department of Geosciences, Pennsylvania State University |
| 1988-1991    | Teaching and Research Assistant, Department of Geological Sciences, University of Michigan                |
| 1986-1988    | Math and Physics Instructor, grades 9-12, International School Moshi, Moshi, Tanzania                     |
| 1985-1986    | Exploration Geophysicist, Exxon Co. U.S.A., Denver, Colorado  |
| 1982-1985    | Teaching and Research Assistant, Department of Geology and Geophysics, University of Wyoming              |

#### AWARDS AND HONORS

|      |   |
|------|---|
| 2003 | Cox/Blaustein Visiting Professorship, Department of Geophysics, Stanford University |
| 1991 | National Science Foundation Postdoctoral Fellowship                                 |
| 1983 | Hill Foundation and Conoco Fellowships, University of Wyoming                       |
| 1981 | Wittenberg University Honor Society   |

#### MEMBERSHIP IN PROFESSIONAL SOCIETIES

- American Geophysical Union
- Seismological Society of America
- Geological Society of America

#### EDITORIAL POSITIONS

- **Tectonics Editor**, Books Board, American Geophysical Union, 2003-2005
- **Associate Editor**, Journal of Geophysical Research, 1997-2000

## PEER REVIEWED PAPERS IN PAST FIVE YEARS

- Zhao, M., C.A. Langston, **A.A. Nyblade** and T.J. Owens, Upper mantle velocity structure beneath southern Africa from modeling regional seismic data, *Journal of Geophysical Research*, 104, 4783-4794, 1999.
- Rudnick, R. L., and **A.A. Nyblade**, The thickness and heat production of Archean lithosphere: constraints from xenolith thermobarometry and surface heat flow, in *Mantle Petrology: Field observations and high-pressure experimentation: A Tribute to Francis R. (Joe) Boyd*, edited by Y. Fei, C. Bertka, and B. Mysen, The Geochemical Society, 3-12, 1999.
- Nyblade, A.A.**, Heat flow and the structure of Precambrian lithosphere, *Lithos*, 28, 81-91. Also published in: *Composition, Deep Structure, and Evolution of Continents*, edited by R. Van der Hilst and W. McDonough, Elsevier, 81-91, 1999.
- Owens, T.J., **A.A. Nyblade**, H. Gurrola, and C.A. Langston, Mantle transition zone structure beneath Tanzania, East Africa, *Geophysical Research Letters*, 27, 827-830, 2000.
- Nyblade, A.A.**, R.P. Knox, and H. Gurrola, Mantle transition zone thickness beneath Afar: Implications for the origin of the Afar hotspot, *Geophysical Journal International*, 142, 615-619, 2000.
- Nyblade, A.A.**, T.J. Owens, H. Gurrola, J. Ritsema, and C. Langston, Seismic evidence for a deep upper mantle thermal anomaly beneath East Africa, *Geology*, 28, 599-602, 2000.
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- Nyblade, A.A.**, Crust and upper mantle structure in East Africa: Implications for the origin of Cenozoic rifting and volcanism and the formation of magmatic rifted margins, in *Volcanic Rifted Margins*, edited by M.A. Menzies, S.L. Klemperer, C.J. Ebinger, and J. Baker, *Geological Society of America, Special Paper 362*, 15-26, 2002.
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- Nyblade, A.A.**, and N.H. Sleep, Long lasting epeirogenic uplift from mantle plumes and the origin of the Southern African Plateau, *Geophysics, Geochemistry and Geosystems*, in press, 2003.

**Academic Staff at the Pennsylvania State University** (in addition to A. Nyblade)

**Prof. C. J. Ammon**

Qualifications: BSc (Penn State), MA (SUNY, Binghamton), PhD (Penn State)

Honors: Program Committee Chair for Seismology, American Geophysical Union Fall & Spring Meetings (1994 – 1996); Member of Board of Directors, Seismological Society of America, 1997-1999.

Editorships: Associate Editor of Bulletin of the Seismological Society of America, 1993-1996.

Refereed papers published: 36

Main fields of specialization: earthquake seismology, tomography, waveform modeling, inverse modeling methods.

Main research interests: Earthquake processes, seismic wave propagation, seismic imaging, evolution of continental lithosphere.

**Prof. E. Richardson**

Qualifications: A. B. Honors (Princeton University), PhD (Massachusetts Institute of Technology)

Refereed papers published: 5

Main fields of specialization: earthquake physics, seismology

Main research interests: earthquake nucleation, stress-triggering, fault dynamics, rupture mechanics, mining-induced seismicity

**Prof. S. Anandakrishnan,**

Qualifications: BS, MS (Columbia University), PhD, (U. of Wisconsin, Madison)

Refereed papers published: 33

Main fields of specialization: active-source seismology, glaciology, earthquake seismology

Main research interests: high-resolution seismic imaging, sediment properties, sediment/fluid interactions, glacier dynamics, upper-crustal structure.

**Academic Staff at the University of Witwatersrand, School of Geosciences:**

**Prof P. H.G.M. Dirks**

Qualifications: BSc Hons, MSc (Univ. of Utrecht, Netherlands), PhD (Univ. of Melbourne, Australia).

Awards: Phaup award of the Geological Society of Zimbabwe (1999, 2000). Associate of SRK, mining engineering department, Fellow of the Geological Society of South Africa.

Editorships: Regional editor of Gondwana Research and J. African Earth Sciences.

Refereed papers published: 67

Substantive Professional Reports written: 32

CD-ROMS developed (mineral and investment data bases): 3

Main fields of specialization: Structural geology, tectonics, economic geology

Main research interests: gold and basemetal mineralization in greenstone terranes, Tectonics of Archean greenstone terrains, mineralization distribution patterns and applications to GIS, granulites, Pan-African mobile belts.

**Prof R L Gibson** (Associate Professor)

Qualifications: BSc Hons (Natal), PhD (Cambridge)

Awards: Jubilee Medal of the Geological Society of South Africa; Wits University Young Researcher's Award; several scholarships for study at Cambridge University; Fellow of the Geological Society of South Africa

Editorships: Guest editor, South African Journal of Geology 99(2); Member of editorial boards of *Geology* (1997-1999) and *Geological Magazine* (2000-present)

Refereed papers published: 40

Main fields of specialization: Structural geology, tectonics, metamorphic petrology, impact processes.

Main research interests: Interaction between thermal, magmatic, fluid and tectonic processes in metamorphic terranes including the Witwatersrand basin and its mineralization, the Vredefort dome, the Limpopo belt and the Bushveld aureole, and the deformation and metamorphic effects of impacts.

**Prof. L D Ashwal**

Qualifications: BSc (State Univ. New York), M.Sc. (Univ. Massachusetts), Ph.D. (Princeton Univ.), Pr. Sci. Nat

Awards: Academy of Science of South Africa- elected to membership March 1998; A1-rated scientist, National Research Foundation, 1996-2001; Fellow, Geological Society of South Africa, elected March 2000;

Refereed papers published: 62; 2 books (Anorthosites, 1994; Greenstone Belts, 1997)

Main fields of specialization: Petrology, mineralogy, geochemistry, tectonics, meteoritics.

Main research interests: Origin of anorthosites and related rocks, layered mafic intrusions, origin and evolution of planetary crusts, Precambrian geologic history, origin of magmatic ore deposits, role of fluids in igneous and metamorphic processes; meteorites and their parent bodies, thermal and palaeomagnetic studies, geology of Madagascar and other Indian Ocean continental fragments, Gondwana assembly and break-up.

**Dr P J Hancox** (Senior Lecturer)

Qualifications: BSc Hons, PhD (Witwatersrand)

Awards: Best paper at the 1999 SAIMM Heavy Minerals conference; Friedel Sellschop Award for research excellence.

Books written: Co-authored "The Tswaing meteorite Crater" (1999, Council for Geoscience); Chapter on Wetlands for "The Cainozoic Geology of Southern Africa" with T.S.McCarthy; Chapter on Sub-Saharan Africa for the Encyclopedia of Palaeontology; "Karoo – A Palaeontological Wonderland" for An Introduction to South Africa's Geological and Mining Heritage, with B.S.Rubidge.

Refereed papers published: 26

Main fields of specialization: Sedimentology, stratigraphy, palaeontology and basin analysis

Main research interests: Karoo Basin development including the nonmarine Permo-Triassic boundary; Rovuma Basin development; palaeodrainage history of the Vaal river; sedimentary processes in wetlands of southern Africa; alluvial fan sedimentation in the eastern Bushveld.

**Dr G R J Cooper** (Senior Lecturer)

Qualifications: BSc Hons (Manchester), MSc (Newcastle upon Tyne), PhD (Witwatersrand)

Awards: Best paper, 16<sup>th</sup> Annual Conference of the South African Society for Atmospheric Sciences.

Editorships: Editorial Board, *Computers and Geosciences*

Refereed papers published: 21

Main fields of specialization: Geophysics and applied mathematics

Main research interests: geophysical inverse theory; geophysical signal processing; applications of fractals and wavelets to geophysical data sets; gridding algorithms; pattern recognition and textural filtering of geophysical data; data compression; chaos theory; image processing; geophysical software development

**Ms S J Webb** (Lecturer)

Qualifications: BSc (SUNY, Binghamton), MSc (Memorial), Ph.D. (Witwatersrand, expected 2004)

Awards: Predoctoral Fellow, Carnegie Institution of Washington, 2000-present

Books edited: Abstracts of the 5th SAGA Geotechnical Meeting; Co-editor of Southern African Geophysical Review, Volume 2; Editorial board of *South African Journal of Geology*

Refereed papers published: 7

Main fields of specialization: Potential fields, seismology

Main research interests: Structure of the Kaapvaal Craton, determined using seismology and potential fields; large-scale geophysics of the Bushveld Complex

**Dr M Q W Jones** (Senior Research Officer)

Qualifications: BSc Hons (Rhodes), PhD (Witwatersrand)

Books written: "Heat flow in South Africa" (1992, Geological Survey of South Africa)

Refereed papers published: 15

Main fields of specialization: Terrestrial heat flow

Main research interests: Thermal structure of the crust and upper mantle; geodynamics and plate tectonics; recent climatic history; heat flow applications in mine refrigeration

## Appendix D. Letter of support

University  
of the Witwatersrand,  
Johannesburg



### School of Geosciences

Private Bag 3, Wits 2050, Johannesburg, South Africa • Fax: +27 11 717 6579 • Telephone: +27 11 717-6547 • school@geosciences.wits.ac.za

To: Dr. Andrew A. Nyblade,  
Department of Geosciences,  
Pennsylvania State University,  
University Park, PA 16802, USA

Date: 11 November 2003

The School of Geosciences at the University of the Witwatersrand fully supports the programme objectives outlined in the AFRICAARRAY proposal.

Geophysics has been taught at Wits since the founding of the Bernard Price Institute in 1937. In the 1980's the Department of Geophysics was founded, with a focus on applied research into exploration and mining, and the School currently offers the only comprehensive, internationally recognized, geophysical training programme in southern Africa. Current Geophysics staff members are involved in research programs with universities across the world, and the department is active in both applied exploration related research and global geophysical problems.

During a recent restructuring exercise at Wits, Geophysics has been down-sized, and in 2004 there will be only three full-time academic staff members remaining. We will no longer have a seismologist, which is of grave concern to us, and as a consequence, guest lecturers from industry and government organisations will have to be used wherever possible. Support for building capacity in seismology is therefore of critical importance to us.

The down-sizing of geophysics is a reflection of a more general trend in higher education in South Africa, and indeed in Africa in general, namely the increasing pressure to maintain training capacity in highly specialized fields that train relatively small student numbers at comparatively large expense. Because geophysics is very relevant to the country and local Industry, the School is committed to maintain the current staff compliment.

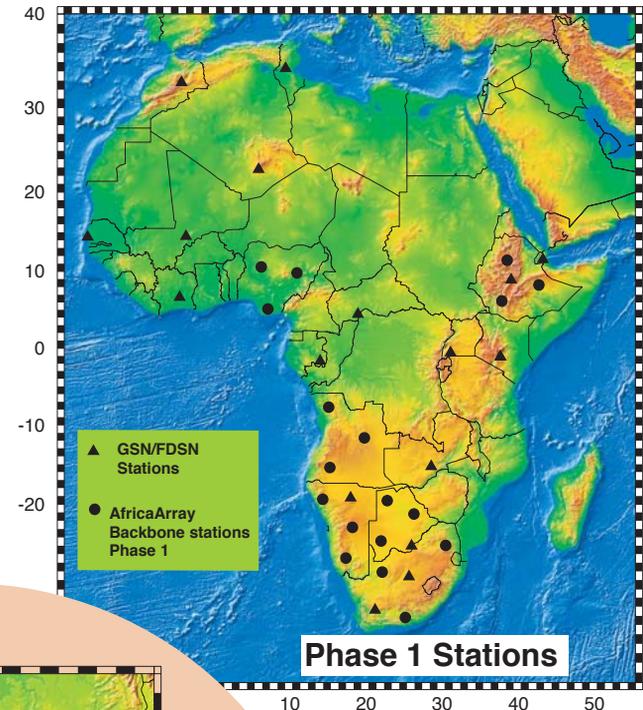
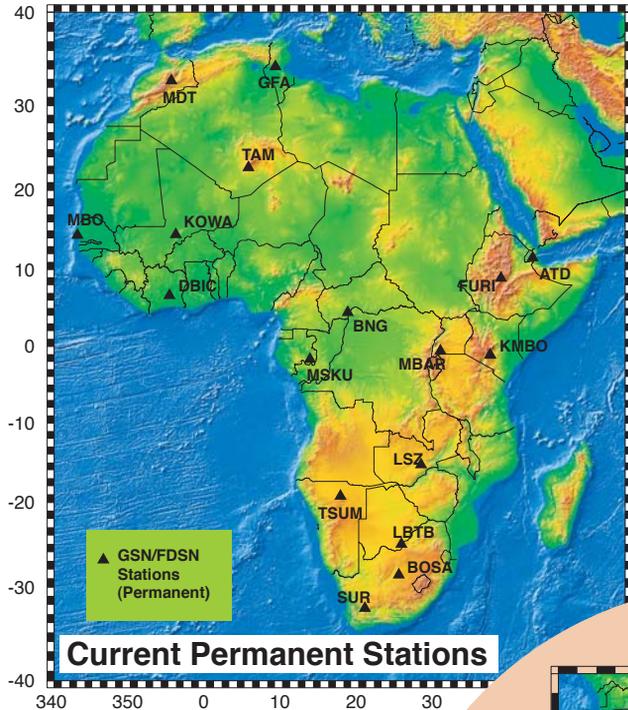
Within Africa, South Africa is one of the few countries with the infrastructure and financial capacity to maintain a full teaching capacity in Geophysics. Wits is therefore ideally positioned to assume the role of regional training centre, or Centre of Excellence, through which a partnership with Penn State, aimed at building geophysics capacity in the region, can be coordinated.

It is critical that at least one regional training centre is preserved and supported, to ensure that Africa retains expert capabilities in Geophysics. It is with this in mind that the School of Geosciences fully supports the proposal of establishing an AFRICAARRAY programme, in which we will endeavor to accommodate graduates from participating countries and offer them the opportunity to study towards BSc Hons and Post-graduate degrees in association with Penn State University. In so doing we hope that in the long-term we can contribute substantially towards the establishment of a viable, and self-sustainable geophysics research community which will be based principally within Africa.

Sincerely Yours,

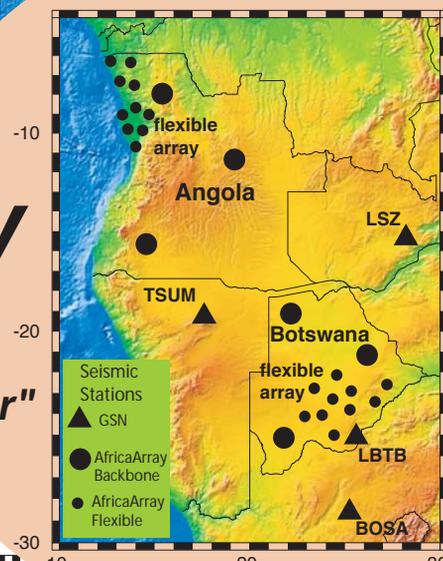
A handwritten signature in blue ink, appearing to read 'P. Dirks', with a horizontal line underneath.

Prof. Paul Dirks  
Head, School of Geosciences



# AfricaArray

*"Training a Scientific Workforce for Africa's Natural Resource Sector"*



## Components

- BSc MSc Ph.D. Programs*
- Technical Training*
- Community Building*
- Seismic Networks*
- Data Management*
- Data Exchange*
- Research*
- High School Outreach*

