Geoscience Initiative Develops Sustainable Science in Africa

PAGES 161–162

AfricaArray (http://www.AfricaArray.org) is a 20-year initiative in the geosciences to meet the African Union's New Partnership for Africa's Development (NEPAD) requirements for continent-wide cooperation in human resources development and capacity building. The name AfricaArray refers to arrays of scientists working on linked projects across the continent, arrays of shared training programs and recording stations, and, above all, a shared vision that Africa will retain capacity in an array of technical and scientific fields vital to its sustainable development.

AfricaArray officially launched in January 2005 and, with support from many public and private partners, has become multifaceted, promoting a broad range of educational and research activities and supporting a multiuser sensor network (Figure 1). Though fostering geophysics education and research in South Africa was its initial focus, AfricaArray has expanded to 17 countries and is now branching out into all areas of the geosciences (Earth, atmosphere, and space).

The First 3 Years: Promoting Geophysical Research and Education in South Africa

AfricaArray was established through a partnership of three organizations: the University of the Witwatersrand (Johannesburg, South Africa), the Council for Geoscience (Pretoria, South Africa; formerly known as the South African Geological Survey), and Pennsylvania State University (University Park, Pa.). These institutions made a wide range of teaching, research, and data acquisition facilities available to launch AfricaArray. To reflect these investments, an organizational structure consisting of codirectors from each institution was put in place. The Incorporated Research Institutions for Seismology (IRIS) also helped in the launch of AfricaArray by providing data management services and refurbished data loggers.

Although the long-term vision for AfricaArray is to support capacity building in all geoscience fields, AfricaArray began with goals of (1) maintaining and expanding geophysical training programs, (2) promoting geophysical research, (3) improving diversity in the geophysical workforce, particularly in South Africa, and (4) establishing a network of seismic stations to obtain data for investigating scientific targets of economic, societal, and academic importance. Establishing a network was also considered important for assisting in the development of the African science community by providing data for student research and collaborative projects, as well as by fostering a culture of data sharing.

During the initial phase of development (2005–2007), efforts focused on improving and expanding the only remaining Ph.D.-granting geophysics program in South Africa, at the University of the Witwatersrand, coupled with the development of a seismic network in eastern and southern Africa. To accomplish this, an annual international geophysics field course was established, a multiproject research program in seismology was initiated, and a program for master's and doctoral students was set up to allow students to spend up to 6 months each year studying and conducting research abroad with a professor at a university affiliated with AfricaArray. In support of these efforts, a chaired faculty research position in seismology was created, seismic recording equipment was purchased, and an information technology technician was hired to help manage the network.

Given that two of the founding partners of AfricaArray are institutions in South Africa, from the outset the initiative has also sought to assist students from historically disadvantaged communities. Many efforts within the South African institutions have been made to attract and support students from diverse backgrounds, and, in addition, a parallel program was initiated in the United States to attract underrepresented minority students into the geosciences.

Expanding Beyond South Africa and Geophysics

A second development phase for AfricaArray (2008–2010) focused on assisting geophysics programs at other African universities and extending the seismic network into western Africa. Students at the University of Yaoundé I in Cameroon and at Addis Ababa University in Ethiopia were supported, and a partnership with the Geophysics Department at Agostinho Neto University in Luanda, Angola, was developed. By the end of 2009 the seismic network included stations in three West African countries: Cameroon, Ghana, and Nigeria. Through this phase of development the number of partners continued to grow, and by 2010 it included 16 African universities; 14 universities in the United States, Europe, and Australia; 17 government agencies in Africa; 8 government agencies outside of Africa; 19 companies; and 6 academic and industrial societies.

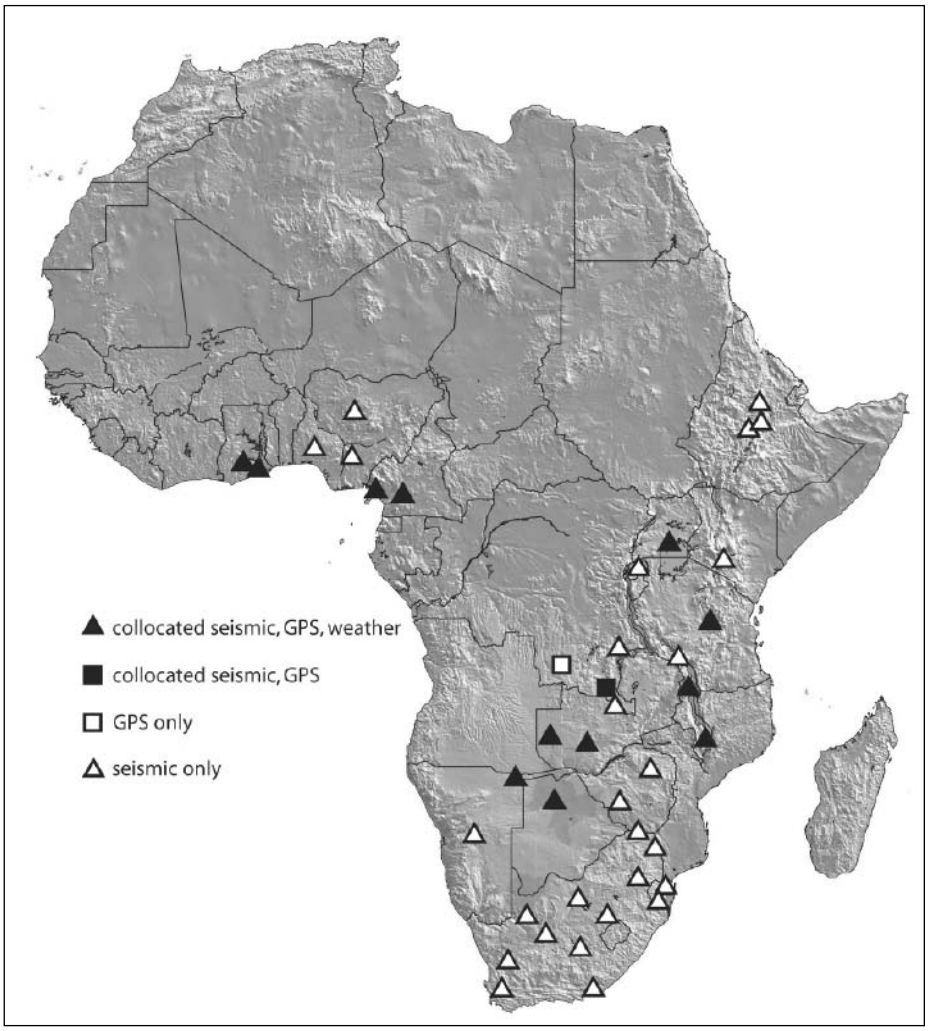

Fig. 1. Map showing the AfricaArray network as of May 2011. GPS is the Global Positioning System.

With the successful development of a geophysics program and seismic network extending into eastern, southern, and western Africa, further expansion of AfricaArray is now under way to include other areas of the geosciences. Current efforts are also focused on building science capacity more broadly, especially in fields relevant to solving problems associated with global change, the sustainable use of natural resources, and other pressing environmental issues.

To this end, in January 2010 funding was obtained from the U.S. National Science Foundation to upgrade the network by adding Global Positioning System (GPS) receivers and automated weather stations to many of the seismic stations, and in August 2010 installation of the new equipment began. In addition, workshops were held in Washington, D. C. (June 2010), and Johannesburg (November 2010) to obtain community input on a new science plan for AfricaArray that includes the areas of atmospheric science, climate science, geodesy, geography, hydrology, and space science, in addition to geophysics.

The current network (Figure 1) consists of 12 stations with collocated broadband seismometers, GPS receivers, and automated weather sensors; 1 with a collocated broadband seismometer and GPS receiver; 27 with broadband seismometers; and 1 with just a GPS receiver. An additional nine stations with collocated broadband seismometers, GPS receivers, and automated weather sensors will be added to the network by the end of 2011. Near–real time data transmission is available for some of the stations, primarily in southern Africa, while data are manually downloaded from data loggers at the majority of stations.

Information about the seismic equipment and access to the seismic data can be obtained from the IRIS data management facility under AfricaArray's network code of AF (http://www.iris.edu/mda/AF). Information about the GPS and meteorological equipment and access to the data are available through the UNAVCO data management facility (http://facility.unavco.org/data/data.html) by searching on AfricaArray.

Opportunities for Involvement

New partners are sought to help with the expansion of the network and research and education programs into all areas of the geosciences. With new partners the network can be made more dense, expanded geographically into other parts of Africa, and diversified through the addition of other environmental sensors to selected stations. Although the network has been constructed as a research facility, through new partnerships it could be upgraded into a real-time network for supporting disaster risk reduction.

New partners are also sought to promote the use of the network to build human scientific infrastructure in Africa. The network provides opportunities for existing programs to expand their activities through on-site technical training and the use of data for student and postdoctoral research; any efforts to strengthen and expand this are welcome. Information about becoming an AfricaArray partner can be found at http://www.AfricaArray.org.

Acknowledgments

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NEWS

Perspectives on More Than 3 Decades of the Voyager Mission

PAGE 163

Voyager 1 and Voyager 2, twin NASA probes that were launched from Cape Canaveral, Fla., in the summer of 1977 during a once-every-175-year alignment of the solar system's giant outer planets, changed our understanding about those planets—Jupiter, Saturn, Uranus, and Neptune—as well as the 4 dozen moons the spacecraft have flown by and the shape of the solar system itself. Today these 722-kilogram probes, whose instruments mostly are still operating after almost 34 years in space, are helping to rewrite the textbooks about the outer edge of our solar system as they continue to race outward from Earth. Voyager 1, currently 17.4 billion kilometers from Earth, and Voyager 2, 14.2 billion kilometers from Earth, are on their way to becoming the first human-made objects to leave the solar system and enter interstellar space, the medium between stars.

In exclusive interviews with *Eos* and during a 27 April news briefing at NASA headquarters in Washington, D. C., Voyager project scientist Ed Stone and several others who have worked on the project discussed mission highlights and the probes' journeys through the heliosheath. This is the final outer layer of a kind of bubble the Sun creates around itself called the heliosphere, a margin where the solar wind is slowed by the pressure of interstellar gas. All the while, the spacecraft, still responsive to ground commands, are sending back data about the solar wind, the magnetic field carried out by the wind, charged particles, and plasma waves.

Voyager 2 is moving at 3.3 astronomical units (494 million kilometers) per year at 48° out of the ecliptic plane (the plane of the Earth's orbit around the Sun) to the south. Voyager 1, which is speeding along at about 3.6 astronomical units (538.5 million kilometers) per year at 35° out of the ecliptic plane to the north, could in 4–5 years be the first object to cross into interstellar space.

"To be quite honest, nothing has ever been there before. So these [dates] are all estimates," said Stone, who has been project scientist since 1972. Stone, an AGU Fellow, is a professor of physics at the California Institute of Technology (Caltech), Pasadena, and a former director of the NASA Jet Propulsion Laboratory (JPL), which built the Voyagers

NASA/Carla Cioffi

Voyager project scientist Ed Stone.

and continues to operate both probes. Crossing through the heliosphere boundary "will not be exactly what we think," Stone told *Eos*, noting that current models may be only partially helpful in understanding Voyager's environs. He said the boundary will not be a discrete, abrupt interface and that it could be "puzzling" at first as to whether or not Voyager 1 has indeed entered interstellar space.

"Time after time, you have the most to learn when it's not what you expect," Stone said. "On Voyager, it's been very characteristic right from the beginning that the things which we have learned the most about were the things which we had not really thought