USArray Reference Seismic Station Installed In North Dakota

By Fred J. Anderson

Introduction

At 3:30 in the morning (CDT) of October 6, 2008, while most everyone in the nearby towns of Westby and Maddock were likely sleeping, two earthquake monitoring stations in North Dakota quietly recorded an earthquake that had occurred 14 minutes earlier and nearly 7,000 miles away in Xizang, China. The earthquake occurred at a depth of just over six miles and registered a magnitude of 6.6 on the Richter scale. The earthquake monitoring (or seismic) stations near Maddock and Westby were installed this fall as parts of two national seismic monitoring systems (figs. 1 and 2). Together, these stations mark the coming of the study of modern global seismology to the state of North Dakota.

Figure 2. Photograph of the Maddock station shortly after installation. Image courtesy of EarthScope.

North Dakota Stations

The Maddock facility is a permanent station and is one of more than 70 broadband seismic monitoring stations scattered across the U.S. that currently make up the USArray reference and seismic monitoring network, known as the Reference Array (fig 3). The Westby station is a temporary broadband seismic monitoring station that is part of the USArray temporary seismic monitoring network, known as the Transportable Array. The Transportable Array consists of a series of temporary seismic stations that are traveling across the US in a roll-along fashion from the west coast to the east coast. The Westby station is the first of 37 planned temporary seismic monitoring stations that will be installed across North Dakota during the summer of 2009 (fig. 1). The stations will be spaced 43.5 miles apart and once installed, will each be in operation for a period of 24 months. After this time, the stations will be relocated to Minnesota and will continue moving east until they eventually reach the eastern seaboard.

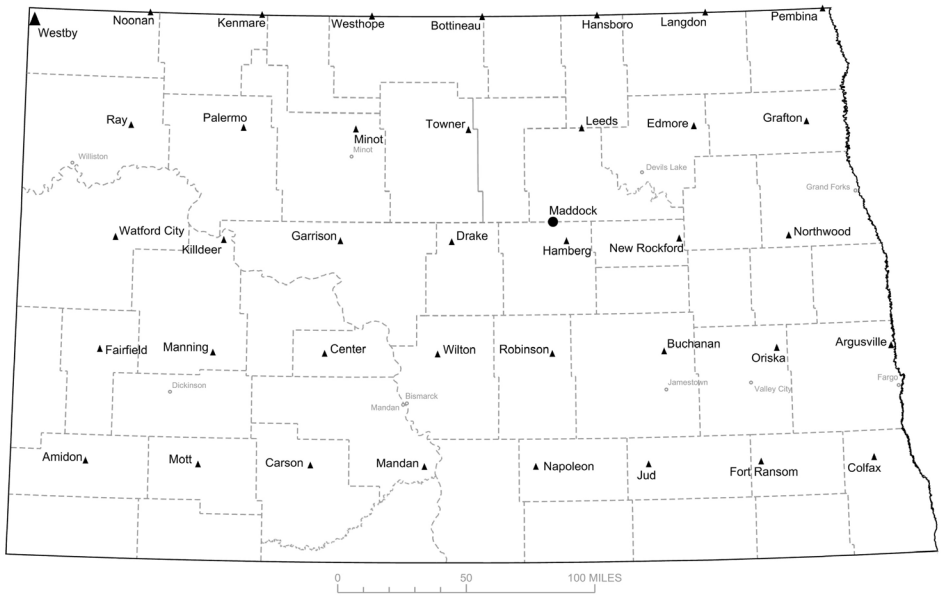

Figure 1. Map of North Dakota showing the approximate locations of the Transportable Array seismic monitoring stations. The station at Westby (large triangle) was installed in October 2008 and is already operational. The remaining 36 temporary stations (small triangles) will be installed in 2009 and will operate for a period of two years. The temporary stations are spaced approximately 43.5 miles apart, which affords an array design of increased resolution appropriate for the investigation of deep earth structures. The Maddock station (black circle) is a permanent station that was also installed this fall and is operational.

The EarthScope Seismic Observation System

Modern global seismology is the field of geological science that uses the wave energy generated from earthquakes to study the internal composition, structure, and dynamics of the whole earth (i.e. core, mantle, crust) (fig. 4). There are differences in the travel and arrival times of seismic wave energy from the source of an earthquake to monitoring stations around the world due to the internal compositional differences in the earth. These differences afford

Figure 3. Locations of current and planned USArray reference seismic monitoring stations in the U.S. The Maddock, ND station is just one of what eventually will be more than 100 permanent stations that form a network that is often referred to as the "backbone." Many of the stations in this system are linked to other multi-element seismic monitoring networks such as the Global Seismographic Network and US Atomic Energy Detection System.

geologists, geophysicists, and seismologists the opportunity to investigate and more fully understand the internal dynamics of the earth. The USArray is part of Project EarthScope, a National Science Foundation-funded study with the objective of imaging and characterizing the earth's crust across the entire US. Similar to astronomers gazing at the night sky in search of astronomical phenomena, the EarthScope project modifies this principle by essentially turning the "telescope" towards the ground to look and listen inwards rather than outwards.

Reference Seismic System

Each reference network seismic monitoring station in the USArray consists of a buried seismometer and vault which houses auxiliary sensors and power and data management components (fig. 5). Stations are continuously reckoned with a permanent GPS receiver. The data collected from regional and teleseismic earthquakes is communicated via satellite or cellular communications through the internet or direct connection to the internet to a computerized data management center located at the University of Washington in Seattle. This station configuration provides secure and continuous real-time seismic monitoring and telemetered data to the global seismological community and the interested everyday user via the internet.

The seismometer installed at the Maddock reference station is a Streckeisen STS-2 three-component broadband seismometer that is capable of sensing ground motions over a frequency band of 0.01 Hz to 15 Hz (fig. 6). The seismometer at the Westby temporary station is a Gurlap CMG3T broadband seismometer with similar ground motion sensing capabilities as the Streckeisen STS-2 but has a more durable design suitable for temporary monitoring locations (fig. 7).

Recorded Earthquakes

The TA network station near Westby and the USArray reference station near Maddock have recorded the wave energy released from four earthquakes since their installation (fig. 8). The first event was the earthquake that was centered in China and mentioned at the beginning of this article. The second event recorded was a magnitude 6.1 event with an epicenter located in the Virgin Islands on Saturday, October 11, 2008 at 5:40 A.M. CDT. This earthquake is reported to have occurred at a depth of 18 miles. The seismic wave energy from this earthquake was recorded in North Dakota at 5:48 A.M., just under

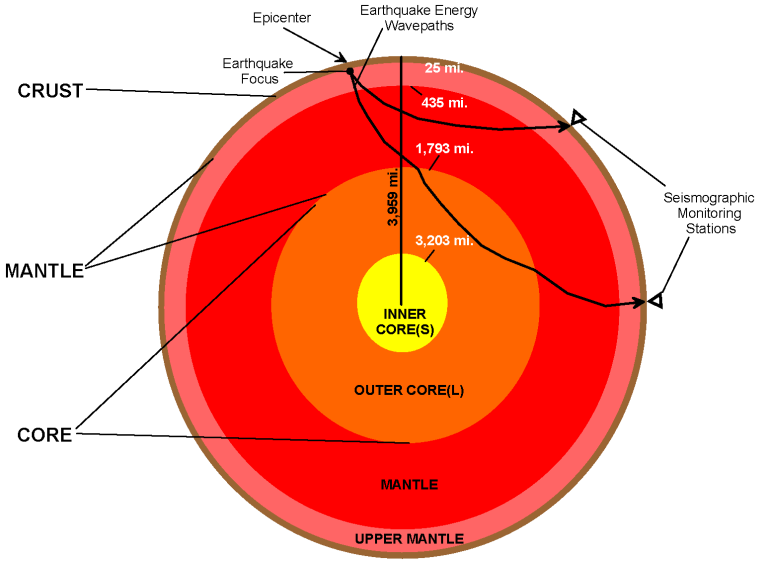

Figure 4. Generalized internal structure of the earth. The earth's solid metallic inner core is surrounded by a liquid metallic outer core. A rocky mantle surrounds the core and is capable of flow. The earth's crust is the thin outer shell of the planet and consists of continental and oceanic crust. These seismic stations detect and measure the energy waves released during earthquakes that travel through the earth.

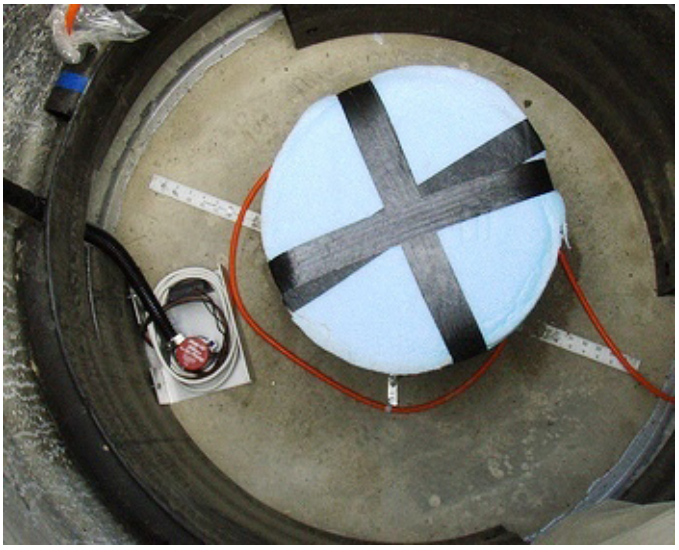

Figure 5. On the left: instrumentation and auxiliary sensors installed in the upper vault section of the Maddock station. On the right: seismometer installed on a concrete pad at a depth of about six feet in the lower vault section of the Maddock station. Images courtesy of EarthScope, 2008.

eight minutes after the earthquake had occurred. The third event was a magnitude 6.5 earthquake with an epicenter near the west coast of Mexico at Chiapas on Thursday, October 16, 2008 at 2:41 P.M. CDT. This earthquake is reported to have occurred at a depth of just over 46 miles. The energy released from this earthquake, in the form of seismic waves, was recorded in North Dakota at 2:48 P.M. CDT, approximately six-and-a-half minutes after the earthquake occurred. The fourth event was a magnitude 7.1 earthquake with an epicenter near Fiji and the Tonga Islands in the southern Pacific Ocean. This earthquake occurred on Sunday, October 19, 2008 at 12:10 A.M. CDT at a depth of nearly 27 miles. The event was recorded in North Dakota at 12:23 P.M. CDT approximately 13 minutes after the earthquake occurred.

Now that we have a seismic monitoring station in North Dakota, it will be possible to answer very specific questions related to earthquakes and seismology in the state. These questions range from a more accurate understanding of earthquake wave arrival times to a greater understanding of the deeper structure of the earth beneath the Williston Basin and the entire state. We have always said that North Dakota is located in an extremely stable part of the North

Figure 6. Streckeisen STS-2 three-component broadband seismometer. This type of seismic monitoring instrument has been installed at the Maddock USArray reference network station and is currently operational. Image courtesy of EarthScope, 2008.

Figure 7. Gurlap CMG3T broadband seismometer. This more durable type of seismic monitoring instrument has been installed at the Westby station as part of the Transportable Array (TA) network and is also currently operational. Image courtesy of EarthScope, 2008.

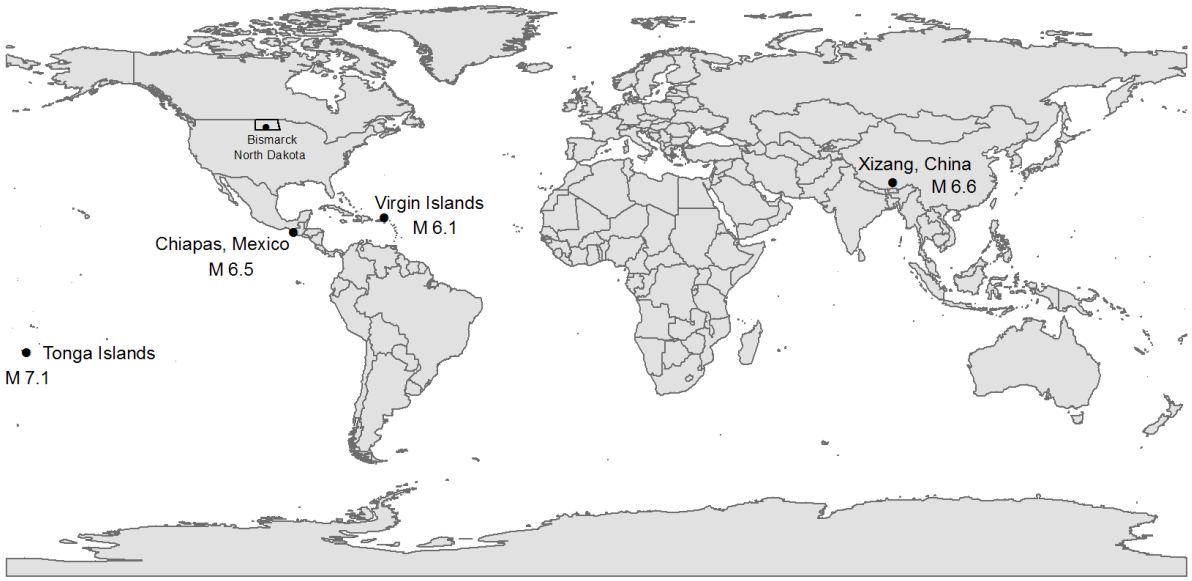

Figure 8. Location of earthquakes recorded by seismic monitoring stations in North Dakota during their first month of operation in October of 2008.

American Continent. The detailed information that will be recorded by both the permanent and temporary seismic stations will be able to provide a greater understanding of seismicity in the state.

Web Sites of Interest

Incorporated Research Institutions for Seismology (IRIS): http://www.iris.edu/hq/

USGS Earthquake Hazards Program: http://earthquake.usgs.gov/

Rapid Earthquake Viewer: http://rev.seis.sc.edu/index.html

Earthquake – The vibrations of the earth caused by the passage of seismic waves radiating from some source of elastic energy.

Epicenter – The point on the earth's surface directly above the focus (or hypocenter) of an earthquake.

Seismic Array – An arrangement of seismographs into a network that act collectively to collect seismic data that is enhanced from background microseismic noise by increasing the overall signal to noise ratio.

Comings and Goings

Richard Suggs

Regular visitors to the Wilson M. Laird Core and Sample Library may recognize Richard as one of the graduate students hired as a temporary employee to assist with the core and thin section photo project (January 2006 Newsletter). He joined the DMR full-time in September as an engineering technician with the Oil & Gas Division at its Bismarck office. Having obtained a B.S. in geology at UND's Department of Geology and Geological Engineering Richard, who was born and raised in Grand Forks, is currently in the final stages of completing his master's degree – a formidable task, as anyone who has done this while in full-time employment will know.

Richard's wife, Shannon, is also a geologist and works for the ND Department of Health's Division of Water Quality.