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INL Seismic Monitoring Annual Report: January 1, 2007 – December 31, 2007

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R. G. Berg

September 2008

Idaho National Laboratory

The INL is a U.S. Department of Energy National Laboratory
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SUMMARY

During 2007, the INL Seismic Monitoring Program evaluated 2,515 earthquakes from around the world, the western United States, and local region of the eastern Snake River Plain. 671 earthquakes and man-made blasts occurred within the local region outside and within a 161-km (or 100-mile) radius of INL. Of these events, eleven were small to moderate size earthquakes ranging in magnitude from 3.0 to 4.8. 341 earthquakes occurred within the 161-km radius of INL and the majority of these earthquakes were located in active regions of the Basin and Range Province that surrounds the ESRP. Three earthquakes were located within the ESRP at Craters of the Moon National Monument. The earthquakes were of M_c 0.9, 1.4, and 1.8. Since 1972, INL has recorded 36 small-magnitude microearthquakes ($M < 2.0$) within the ESRP.

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ACKNOWLEDGEMENTS

We thank Alan Marley for his continued support. We also thank staff at the University of Utah Seismograph Stations, U. S. Geological Survey, Montana Bureau of Mines and Geology, and BYU-Idaho for their earthworm data shares.

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ACRONYMS

ANL	Argonne National Laboratory
BLM	Bureau of Land Management
CFA	Central Facilities Area
DAAS	Data Acquisition/Analysis System
DOE	Department of Energy
DSL	Digital Subscriber Line
EFS	Experimental Field Station
ESRP	Eastern Snake River Plain
GPS	Global Positioning System
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IP	Internet Protocol
IRC	INL Research Center
LOFT	Loss of Fluid Test
MFC	Materials and Fuels Complex
NEIC	National Earthquake Information Center
NRF	Naval Reactor Facility
PBF	Power Burst Facility
PBO	Plate Boundary Observatory
P-wave	Compressional Wave
RTC	Reactor Technology Complex
RWMC	Radioactive and Waste Management Complex
S-wave	Shear Wave
SMC	Special Manufacturing Complex

SMA	Strong Motion Accelerograph
SSCs	Structures, Systems, and Components
STC	Science and Technology Complex
TA	Transportable Array
TAN	Test Area North
TRA	Test Reactor Area
USGS	United States Geological Survey

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1. Introduction

The Idaho National Laboratory (INL) has accumulated 35 years of earthquake data (1972-2007). This report covers the earthquake activity from January 1, 2007 through December 31, 2007 within a 161-km (100-mile) radius from the center of the INL designated as 43° 39.00' N, 112° 47.00' W (Figure 1). The report is a continuation of previous annual reports on earthquake activity surrounding the eastern Snake River Plain (ESRP) and within and near the INL. It discusses the earthquake activity that has occurred around the local region and within the 161-km radius of the INL. It discusses the seismic station and strong motion accelerograph instrumentation used to record earthquake data and how they were analyzed. It also includes a brief discussion of continuous GPS (Global Positioning System) stations co-located at INL seismic stations.

1.1 History of INL Seismic Monitoring Program

1.1.1 Purpose

The purpose of the INL Seismic Monitoring Program is to provide the INL with earthquake data and staff expertise to support the requirements set forth by Presidential executive orders, DOE directives, orders, and standards, and the Nuclear Regulatory Commission for seismic safety of: Structures, Systems, and Components (SSCs); workers and the public; and operations at INL of reactors and waste management activities. The program supports safety of operations through continuous monitoring of earthquake activity, the development of INL seismic design criteria, assessments of seismic hazards for existing facilities and acquisition of major new programs, and early warning of potential future volcanic eruptions near INL. For example, the earthquake data are used to assess seismic hazards and develop seismic design criteria for the INL as required by DOE Order 420.1A "Facility Safety" (DOE, 2003).

The INL Seismic Monitoring Program operates 27 permanent seismic stations for the purpose of determining the time, location, and size of earthquakes occurring in the vicinity of the INL. The seismic data are compiled to develop an historical database that defines the zones and frequency of earthquake activity. Seismic stations are located within and around the INL near potential earthquake sources that include major range-bounding normal faults and volcanic rift zones (Figure 1). Additionally, thirteen seismic stations have GPS receivers at them for the purpose of determining rates of crustal deformation. GPS velocities are used to identify regions of higher crustal deformation rates (such as Yellowstone, Wyoming) relative to regions of lower deformation rates (Snake River Plain, Idaho).

The INL Seismic Monitoring Program operates 21 strong-motion accelerographs (SMAs) for the purpose of recording strong ground motions from local moderate or major earthquakes. The SMAs are located within INL buildings to determine the response of these buildings to ground motions in the event of a large earthquake. Several SMAs are located at "free-field" sites (not within buildings) at INL facility areas and are used to determine the levels of earthquake ground motions at the ground (rock or soil) surface. SMAs are also co-located with several INL seismic stations to record acceleration data and assess attenuation effects of small to large magnitude normal faulting earthquakes.

1.1.2 Seismic Stations

The INL seismic network has evolved from a single analog station to its current configuration of 27 digital seismic stations. The INL Seismic Monitoring Program also records data from seismic stations owned and operated by other seismic networks. The INL seismic network began with a single station in 1971 and expanded to three stations by October of 1972. In 1977, the INL began monitoring a station operated by BYU-Idaho in Rexburg, Idaho, and the INL installed two additional stations in 1979. From 1979 to 1985, the INL monitored earthquake activity using six seismic stations. In 1985, the INL installed a simulated Wood-Anderson system to improve the capabilities of measuring the magnitude of local earthquakes ($3.0 \leq M_L \leq 5.0$). During 1986, the INL began receiving seismic data from a station located in Pocatello, Idaho and operated by the University of Utah in Salt Lake City, Utah. Also, in 1986, the INL began receiving data from a station located near Palisades Reservoir, Idaho that is operated by BYU-Idaho. A seismic station within the INL boundaries was added to the INL seismic network in 1987.

From 1990 to 1994, INL seismic network under went a major expansion of seismic stations. During 1990, four seismic stations were installed within the INL boundaries. From 1991 to 1992, thirteen new stations were installed in support of construction and operation of the proposed New Production Reactor at INL. Shallow boreholes (<20 m) were drilled for seismic stations located within the ESRP. Also, monitoring of BYU-Idaho seismic station near Palisades Reservoir was terminated in 1991 to accommodate the addition of the new INL seismic stations. In 1994, two new INL seismic stations were installed near Gray’s Lake, Idaho.

Several changes occurred to seismic stations from 1999 to 2003. During 1999, the INL Howe Scarp, Idaho (HWSI) seismic station was relocated further east to a new location now referred to as the Howe Fault, Idaho or HWFI because of a lawsuit filed against the Bureau of Land Management (BLM). With the implementation of the EARTHWORM computer software in 2000, up to 14 stations from several nearby networks were being recorded in real-time along with the INL seismic stations. During 2001-2003, analog seismic instruments at all INL seismic stations were replaced with digital instruments. In 2003, the University of Utah transferred ownership of the Pocatello, Idaho (PTI) seismic station to the INL Seismic Monitoring Program at which time a digital seismic station was installed. With addition of the PTI station, INL currently operates 27 seismic stations.

In 2007, INL began recording data from Transportable Array (TA) seismic stations deployed in Idaho as part of the EarthScope Science program funded under the National Science Foundation. These seismic stations are three-component broadband stations that are temporarily deployed for 18-24 months in a grid that systematically covers the United States. One TA station is co-located at the INL’s Crow’s Nest, Idaho (CNCI) seismic station. Additionally, the INL began acquiring data from the National Earthquake Information Center’s Intermountain West network. As with the TA stations, these stations employ three-component, broadband seismometers.

1.1.3 Strong Motion Accelerographs

The INL began an accelerograph network by installing SMAs in buildings at INL facility areas, and more recently at free-field sites for both rock and soil conditions. In 1973, the INL began an accelerograph network by installing eleven SMAs in critical INL facilities. Three were located within buildings at the Idaho Nuclear Technology and Engineering Center (INTEC) (formerly referred to as Idaho Chemical Processing Plant - ICPP), two within the Materials and Fuels Complex (MFC) facilities (formerly referred to as Argonne National Laboratory – ANL), three within the Power Burst Facility (PBF), two within buildings at the Reactor Technology Complex (RTC) (formerly referred to as Test Reactor Area – TRA), and one at the Old Fire Station (OFS). From 1978 to 1979, four SMAs were installed at Test Area North (TAN) within the Containment Test facility (formerly referred to as Loss of

Fluid Test – LOFT facility). Just prior to the October 1983 M_s 7.3 Borah Peak, Idaho earthquake, one SMA was installed at the INL Research Center (IRC), which is now part of the Science and Technology Complex (STC) in Idaho Falls, Idaho. Following the 1983 earthquake, two SMAs were installed within buildings at the Naval Reactor Facility (NRF). In 1984, two additional SMAs were placed within buildings at INTEC. During 1990, one SMA was installed at the Central Facilities Area (CFA). A digital SMA was co-located with an analog SMA at MFC in 1993. In 1996, two free-field SMA sites were installed, one at NRF and the other at PBF. In 1997, one SMA was installed as a free-field site at the Radioactive Waste Management Complex (RWMC). In 2003, the SMAs were upgraded to digital NetDAS SMAs. At that time, one NetDAS digital SMA replaced two SMAs co-located at Building ANL-767 (Kinemetrics analog SMA-1 and digital SSA-2 accelerograhs). The SMA on the crane beam at PBF-620 was not upgraded, but removed due to decommissioning activities.

Over the years, several SMAs have been relocated because buildings have been decommissioned and demolished. In 1995, the SMA at OFS was moved to a storage building directly behind the fire station because the fire station was decommissioned. In 1997 when the storage building was demolished, this SMA was relocated to the Experimental Field Station (EFS). In 1996, the Containment Test facilities or LOFT facilities were decommissioned. Three of the SMAs from LOFT were moved to the TAN Hot Shop and one was placed at the TAN Air Monitoring building. In 1997, the SMA at CFA was relocated to CFA-1607 Refueling Building. In 2004, the TAN Air Monitoring building was demolished so the SMA was removed and was reinstalled in 2005 as a free-field near the TAN Hot Shop. In 2004, the PBF building was demolished and the three SMAs were removed. The SMAs were reinstalled in 2005 as free-field sites near PBF and RWMC. In 2006, four SMAs at TAN were removed due to demolition of the TAN Hot Shop. In 2007, two of these SMAs were reinstalled; one was installed at the Special Manufacturing Complex (SMC) and the other at a free-field site east of SMC.

Three-component accelerometers were added to some of the seismic stations. In 2002, accelerometers were added to four seismic stations: Gray's Range (GRRI), New Production Reactor (NPRI), HWFI, and Bear Canyon (BCYI). In 2003, accelerometers were added to seismic stations Telchick Spring, Idaho (TCSI), Split Crater (SPCI), and PTI. During 2007, the INL Accelerograph Network operated up to 21 SMAs within or near INL Site facility areas and 6 three-component accelerometers at seismic stations.

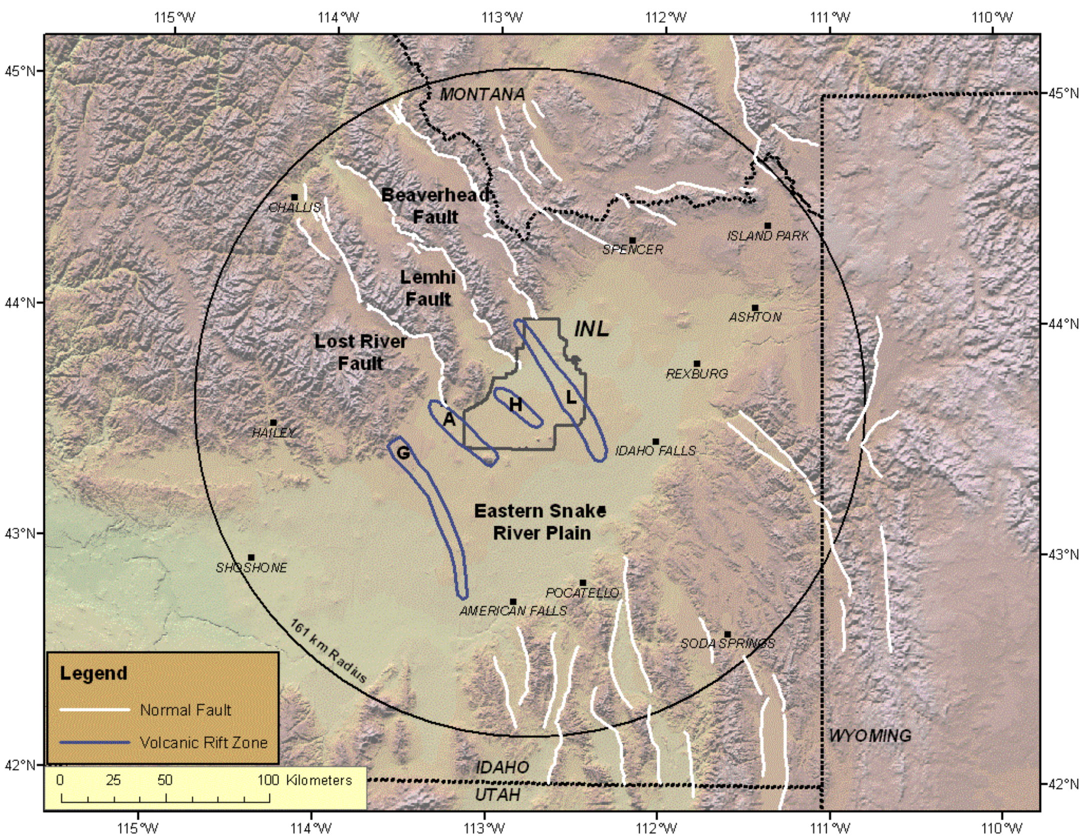

Figure 1. Map shows locations of the earthquake reporting area within the 161-km (100 mile) radius of the INL, Basin and Range normal faults, and volcanic rift zones: G – Great Rift, A – Arco, H – Howe-East Butte, and L – Lava Ridge-Hell's Half Acre.

2. Instrumentation

2.1 Seismic Station Network

During 2007, the INL Seismic Monitoring Program operated 27 permanent seismic stations and monitored up to 65 seismic stations from other nearby seismic networks (Figure 2). Table 1 lists the name, location, and date of installation for the seismic stations owned and operated by the INL Seismic Monitoring Program. Table 2 lists the name, location, and operation dates of seismic stations owned by other agencies. Table A-1 (Appendix A) lists the information for the EarthScope Science Program TA stations. The INL recorded seismic data from these other seismic stations to improve the quality of earthquake locations within the 161-km radius of INL.

Instrumentation for INL seismic stations consists of digital recorders, one- and three-component seismometers, and three-component accelerometers. The digital recorder is a DAQSystems NetDAS field unit, which is an embedded LINUX computer with a GPS clock and Symmetric Research 24 bit digitizer. The NetDAS units have nearly 22 bits of data resolution over ± 20 volts for a four-channel unit or ± 10 volts for an eight-channel unit. Four channel units (NetDAS-CH4) are located at seismic stations that have one or three sensors; eight channel units (NetDAS-CH8) are at seismic stations that have more than three sensors (such as three seismometers and three accelerometers). The seismic stations have pre-amplifiers that improve signal to noise ratios. The NetDAS digitizes data at the seismic station and time stamps the data with accuracies greater than 0.001 seconds. The seismic signals are transmitted by FreeWave Technologies DGR115 900 MHz Wireless Modem radios. These radios use standard IP (Internet Protocol) networking features that are included in the embedded LINUX.

Single-component seismic stations have vertically oriented velocity sensors (or seismometer) that are a Mark Products model L-4C, Teledyne Geotech (TG) model S-13 or TG model S-13 Jr. seismometer buried within 3 m of the ground surface. All seismic stations located within the ESRP have their vertical-component seismometer located at the bottom of 18 m or greater borehole to help dampen wind and cultural noise (Seismic, 1993). Seismic stations with horizontally-oriented velocity sensors have two Teledyne Geotech model S-13 seismometers located within a concrete vault, in addition to the vertically-oriented sensor. Seismic stations with acceleration sensors have Applied MEMs Inc. model SF1500A, SF2500A, or SF3000L tri-axial accelerometers.

Where AC power is not available, seismic stations are powered by batteries, solar panels, and at some locations small wind generators. Radio frequency compatible antennas transmit and receive the seismic signals. Several seismic stations are used as relay stations to allow transmission of seismic signals to the IRC in Idaho Falls. The seismic data are relayed by digital radios or internet Digital Subscriber Line (DSL) links (Appendix A). The data are acquired through EARTHWORM data shares on the Internet (discussed in Section 2.5). Digital seismograms are continuously displayed on three of four computer monitors referred to as "Webicorders." The fourth monitor displays a map of current earthquakes located by the INL Seismic Monitoring Program.

2.2 Strong Motion Accelerographs

The INL accelerograph network has 21 strong-motion accelerographs at INL Site facilities; 20 are located at the INL Site and 1 is located in the IRC at the STC. Table 3 lists the location and date of installation for each of the SMAs in operation. There are 1 to 5 accelerographs at each INL Site facility area (Figure 3). During 2007, earthquakes did not trigger SMAs located within INL facilities.

In 2006, four SMAs at TAN were removed due to demolition of the TAN Hot Shop (TAN-607). Two of the four SMAs removed the previous year from TAN were reinstalled during 2007, one in the cafeteria of the SMC in the TAN facility area and the other at a free-field site east of SMC. The other two SMAs will be reinstalled in 2008. One will be reinstalled at the CRBI seismic station east of TAN. The other will be reinstalled at the NPRI seismic station. This seismic station was chosen since the NPR site is being considered for possible construction of a new power reactor.

INL SMAs are DAQSystems NetDAS digital accelerographs that have Applied MEMS SiFlex SF2500 tri-axial accelerometers. Each SMA is set to trigger and record to compact flash when ground motions exceed 2500 counts, which is equivalent to about 0.005 g. The record lengths are set for 30 s of pre- and post-trigger thresholds. The tri-axial accelerometers have two horizontal components oriented in an orthogonal manner, generally aligned in the north-south and east-west directions. Appendix B lists the accelerometer orientation and instrument response for the horizontal and vertical components of each SMA. SMAs at free-field sites have GPS clocks to synchronize the internal clocks to an absolute time system. For some SMAs at free-field sites and locations within buildings, acceleration data are transmitted to the IRC via digital radios or the Internet. Other SMAs record data on compact flash disks that are retrieved by INL seismic personnel using a laptop PC computer.

2.3 Continuous GPS Stations

The INL Seismic Monitoring Program has a geodetic network for the purpose of monitoring horizontal crustal deformation in support of INL seismic hazards assessments. GPS data are used to investigate active crustal deformation that is on the order of millimeters of movement per year within the ESRP, the surrounding Basin and Range, and Yellowstone Plateau. GPS data define regions of high velocity gradients (or strain rates) having more frequent damaging earthquakes (e.g., Yellowstone – Hebgen Lake, Montana) than regions of low velocity gradients (e.g., eastern Snake River Plain). The regional spatial patterns of GPS data also help constrain the fundamental geodynamic processes that drive active continental deformation in the western United States.

During 2007, INL collected additional GPS phase data and teamed with Dr. Robert King at the Massachusetts Institute of Technology to process INL GPS phase data. INL personnel installed GPS receivers at eight INL seismic stations bringing the total number of INL continuous GPS sites to thirteen (Table 4). As part of the Plate Boundary Observatory (PBO) under the EarthScope Science Program, there are currently 18 other continuous GPS sites near the Snake River Plain (Figure 4). One of these GPS receivers is co-located at INL’s Great Rift, Idaho (GTRI) seismic station. In addition to continuously operating GPS sites, INL personnel collected GPS phase data at several campaign GPS sites. Dr. King processed all of INL’s GPS phase data acquired up to 2007 and located within the ESRP and surrounding Basin and Range. He combined the INL GPS data with other data in the region to produce a velocity field that encompasses the Pacific Northwest. Locally, the horizontal GPS velocities indicate the Basin and Range is extending at a rate that is an order of magnitude greater than the Snake River Plain, which is thought to explain its relative low seismicity (Payne et al. 2008).

An INL GPS station consists of a Trimble NetRS GPS receiver connected to a L1/L2 dual frequency choke ring antenna. The antenna is attached to a 2.4 m steel rod that is drilled into a rock outcrop to a depth of about 1 m. Above ground the antenna is stabilized using a much larger PVC pipe filled with sand. This reduces the amount of wind noise within the GPS data, improving the accuracy. The NetRS receivers continuously collect GPS phase data. The phase data are relayed along with the seismic station data to DSL links, which are then accessed from the Internet at the IRC. Also, the phase data are downloaded daily from the Internet and archived by University NAVSTAR Consortium (UNAVCO).

2.4 Seismic Data Acquisition and Analysis System

The INL records earthquake data on a computer Data Acquisition/Analysis System (DAAS) at the IRC. INL began recording earthquake data on the DAAS June 8, 1991 using the U. S. Geological Survey (USGS) CUSP processing software. Since 2001, significant upgrades have been made to the DAAS as a result of computer hardware and software advances. The USGS CUSP data acquisition and analysis software that supported use of the TIMIT program were replaced with the earthquake analysis program SEISAN (developed by the University of Bergen, Norway) in 2002 and the USGS EARTHWORM processing software in 2003. From June 1991 to November 2002, earthquake data were analyzed using the USGS TIMIT program. As of December 2002, earthquake data are now being analyzed using the SEISAN program. Use of the SEISAN and EARTHWORM programs facilitated the upgrades of seismic stations and SMAs to the NetDAS digital units, allowing concurrent waveform analyses of both velocity and acceleration data. Instrument responses of the NetDAS units at seismic stations and SMAs are now routinely determined and are integrated into the SEISAN database (see Appendices B and C). All digital earthquake data are also routinely archived to removable media after analysis.

The EARTHWORM program constantly monitors the ratios of the short-term average divided by the long-term average (STA/LTA) of incoming data. This involves comparing the short-term average (1-s window) of the seismic data to a longer-term average, which is the background noise or voltage level determined over a time interval of 20 s. The program determines that an earthquake has occurred when the STA/LTA ratios for several stations within a subnet exceed a threshold value. When an earthquake is detected, the seismograms for all stations within triggered subnets and the time codes are saved in a file on a disk. This file is labeled with a sequential number based on the date and time of the trigger for later reference to the earthquake in the SEISAN database. Each seismogram has 30 s of pre-event data and 20 s of post-event data stored within the file. In some instances, earthquakes have low-amplitude emergent P-waves with larger amplitude S-waves. When this occurs the DAAS may trigger on the S-waves instead of the P-waves, thus, saving 30 s of pre-event time allows recording of the P-waves also.

The earthquake detection software is set up to trigger on earthquakes detected by several stations within a subnet. Subnets contain several stations that are located in a small area and which are likely to detect the same local earthquake. All INL seismic stations usually detect earthquakes of magnitude 1.5. Subnets are specified for stations in close proximity to each other and their relationship to known seismic sources. For the ESRP though, a subnet was created for detection of small magnitude ($M < 0.5$) microearthquakes.

The EARTHWORM program also enables data sharing with other seismic networks in near real time over the Internet. The INL provides data from various seismic stations to the University of Utah, Montana Bureau of Mines and Geology, and National Earthquake Information Center (NEIC), which in return provide data to INL (Table 2). EARTHWORM records seismic data from INL and these other agencies, which are analyzed using the SEISAN program. In 2007, data from EarthScope's TA stations and the NEIC's Intermountain West seismic network were added to the data shares. These data enhanced the azimuth coverage and magnitude determinations of earthquakes within the 161-km radius of INL, particularly for earthquakes in the southern part of the ESRP.

Table 1. Seismic stations operated by INL.

Code	Station Name	Sensors Types	Latitude North (º)	Longitude West (º)	Elevation (m)	Date Installed (Month/Year)
ARNI	Argonne North, Idaho	Borehole Vertical Seismometer; GPS Receiver	43.6667	112.6235	1533	09/1990
BCYI	Bear Canyon, Idaho	Vertical Seismometer; Three-component Accelerometers; GPS Receiver	44.3108	113.4052	2194	05/1992
CBTI	Cedar Butte, Idaho	Borehole Vertical Seismometer	43.3875	112.9115	1734	07/1986
COMI	Craters of the Moon, Idaho	Vertical Seismometer	43.4618	113.5938	1890	03/1992
CNCI	Crows Nest Canyon, Idaho	Vertical Seismometer	43.9283	113.4522	1914	05/1992
CRBI	Circular Butte, Idaho	Borehole Vertical Seismometer; GPS Receiver	43.8303	112.6345	1520	11/1987
ECRI	Eagle Creek, Idaho	Vertical Seismometer	43.0535	111.3705	2086	08/1994
EMI	Eightmile Canyon, Idaho	Vertical Seismometer; GPS Receiver	44.0742	112.9262	1963	04/1992
GBI	Big Grassy Butte, Idaho	Borehole Vertical Seismometer; GPS Receiver	43.9875	112.0633	1541	10/1981
GRRI	Grays Range, Idaho	Vertical Seismometer; Three-component Accelerometers; GPS Receiver	42.9380	111.4217	2207	08/1994
GTRI	Great Rift, Idaho	Borehole Vertical Seismometer; GPS Receiver*	43.2440	113.2410	1522	05/1992
HHAI	Hell's Half Acre, Idaho	Borehole Vertical Seismometer	43.2950	112.3795	1371	06/1992
HPI	Howe Peak, Idaho	Vertical Seismometer; GPS Receiver	43.7113	113.0983	2597	10/1972

Table 1. Continued.

Code	Station Name	Sensors Types	Latitude North (º)	Longitude West (º)	Elevation (m)	Date Installed (Month/Year)
HWFI	Howe Fault, Idaho	Three-component Seismometers; Three-component Accelerometers; GPS Receiver	43.9257	113.0973	1743	10/1999
ICI	Italian Canyon, Idaho	Vertical Seismometer; GPS Receiver	44.3293	112.9412	2463	04/1992
IRCI	INL Research Center, Idaho	Low-gain Three-component Seismometers	43.5153	112.0333	1442	11/1988
JGI	Juniper Gulch, Idaho	Three-component Seismometers	44.0927	112.6768	1657	11/1979
KBI	Kettle Butte, Idaho	Borehole Vertical Seismometer	43.5907	112.3767	1678	05/1992
LJI	Lemhi Junction, Idaho	Vertical Seismometer	43.8208	112.8440	1643	05/1990
LLRI	Little Lost River, Idaho	Three-component Seismometers	43.7230	112.9330	1476	05/1990
NPRI	New Production Reactor, Idaho	Three-component Seismometers; Three-component Accelerometers	43.5975	112.8272	1495	09/1990
PTI	Pocatello, Idaho	Vertical Seismometer; Three-component Accelerometers; GPS Receiver	42.8703	112.3702	1670	10/1984
PZCI	Patelzick Creek, Idaho	Vertical Seismometer; GPS Receiver	44.3410	112.3172	2073	12/1991
SMBI	Sixmile Butte, Idaho	Borehole Vertical Seismometer	43.5022	113.2677	1716	05/1992
SPCI	Split Crater, Idaho	Three-component Seismometers; Three-component Accelerometers	43.4500	112.6370	1553	06/1992

Table 1. Continued.

Code	Station Name	Sensors Types	Latitude North (º)	Longitude West (º)	Elevation (m)	Date Installed (Month/Year)
TCSI	Telchick Spring, Idaho	Three-component Seismometers; GPS Receiver	43.6193	113.4783	1731	05/1992
TMI	Taylor Mountain, Idaho	Three-component Seismometers; GPS Receiver	43.3057	111.9182	2179	10/1972

* - GPS instrumentation is owned by the Plate Boundary Observatory under the EarthScope Science Program.

Table 2. Agencies and stations from which INL receives data shares.

Code	Station Name	Latitude North (°)	Longitude West (°)	Elevation (m)	Operating Dates (Month/Year)	
National Earthquake Information Center, Golden, Colorado						
AHID	Auburn, Idaho	42.7653	111.1003	1960	11/1997	Pres
BW06	Boulder, Wyoming	42.7667	109.5582	2224	05/1996	Pres
DCID1	Drake Creek, Idaho	43.5945	-111.1845	1871	03/2005	Pres
HLID	Hailey, Idaho	43.5625	114.4063	1498	08/1988	Pres
IMW	Indian Meadows, Wyoming	43.8970	-110.9392	2646	07/1980	Pres
LOHW	Long Hollow, Wyoming	43.6123	-110.6037	2121	01/1986	Pres
RRI2	Red Ridge, Idaho	43.3473	-111.3202	2558	07/1986	Pres
TPAW	Teton Pass, Wyoming	43.4902	-110.9507	2512	01/1986	Pres
University of Utah, Salt Lake City, Utah						
BEI	Bear River Range, Idaho	42.1167	111.7823	1859	11/1984	Pres
BMUT	Black Mountain, Utah	41.9582	111.2342	2243	10/1979	Pres
MCID	Moose Creek, Idaho	44.1903	111.1827	2149	12/1995	Pres
MLI	Malad Range, Idaho	42.0268	112.1255	1896	10/1974	Pres
NPI	North Pocatello, Idaho	42.1473	112.5183	1640	04/1975	Pres
YMC	Maple Creek, Wyoming	44.7593	111.0062	2073	12/1983	Pres
YPP	Pitchstone Plateau, Wyoming	44.2710	110.8045	2707	08/1996	Pres
Montana Bureau of Mines and Geology, Butte, Montana						
MCMT	McKenzie Canyon, Montana	44.8277	112.8488	2323	09/1989	Pres
MOMT	Monida, Montana	44.5933	112.3943	2220	10/1995	Pres
TPMT	Teepee Creek, Montana	44.7298	111.6657	2518	10/1992	Pres

Table 3. Strong-motion accelerographs operated by INL.

INL Site Facility Area	Building Number	Location	SMA Code	Year Installed
MFC	ANL-767	Basement	EBR	1973
MFC	ANL-768	Basement	FCF	1973
CFA	CFA-1607	Free-field	CFAF	1996
CFA	EFS	Free-field	EFSF	1997
INTEC	CPP-668	Free-field	CPPF	1992
INTEC	CPP-601	First Floor	CPP1	1973
INTEC	CPP-601	Second Basement	CPP2	1973
INTEC	CPP-666	Second Floor	FAS1	1984
INTEC	CPP-666	Second Basement	FAS2	1984
NRF	NRF-768	Free-field	NRFF	1996
NRF	NRF-A1W	First Floor	A1W	1983
NRF	NRF-S1W	First Floor	S1W	1983
PBF	NA	Free-field	PBFF	2005
PBF	NA	Free-field	ARAF	2005
RTC	TRA-602	Free-field	TRAF	2003
RTC	TRA-670	Basement	TRA2	1996
RWMC	NA	Free-field	RWMC	1997
RWMC	NA	Free-field	RWME	2005
STC	IRC-602	First Floor	IRC	1983
TAN	NA	Free-field	TANA	2007
TAN	SMC	First Floor	SMC	2007

NA – Not within a building.

Table 4. Continuous GPS sites co-located with INL seismic stations.

Code	Station Name	Latitude North (°)	Longitude West (°)	Elevation (m)	Year Installed
ARNG	Argonne North, Idaho	43.6667	112.6235	1533	2005
BCYI	Bear Canyon, Idaho	44.3108	113.4052	2194	2003
CRBG	Circular Butte, Idaho	43.8303	112.6345	1520	2007
EMIG	Eightmile Canyon, Idaho	44.0742	112.9262	1963	2005
GBIG	Big Grassy Butte, Idaho	43.9875	112.0633	1541	2007
GRRG	Grays Range, Idaho	42.9380	111.4217	2207	2007
GTRG*	Great Rift, Idaho	43.2440	113.2410	1522	1998
HPIG	Howe Peak, Idaho	43.7113	113.0983	2597	2005
HWFG	Howe Fault, Idaho	43.9257	113.0973	1743	2007
ICIG	Italian Canyon, Idaho	44.3293	112.9412	2463	2007
PTIG	Pocatello, Idaho	42.8703	112.3702	1670	2007
PZCG	Patelzick Creek, Idaho	44.3410	112.3172	2073	2007
TCSG	Telchick Spring, Idaho	43.6193	113.4783	1731	2005
TMIG	Taylor Mountain, Idaho	43.3057	111.9182	2179	2007

* - Co-located at INL's seismic station GTRI, but operated by the Plate Boundary Observatory under the EarthScope Science Program.

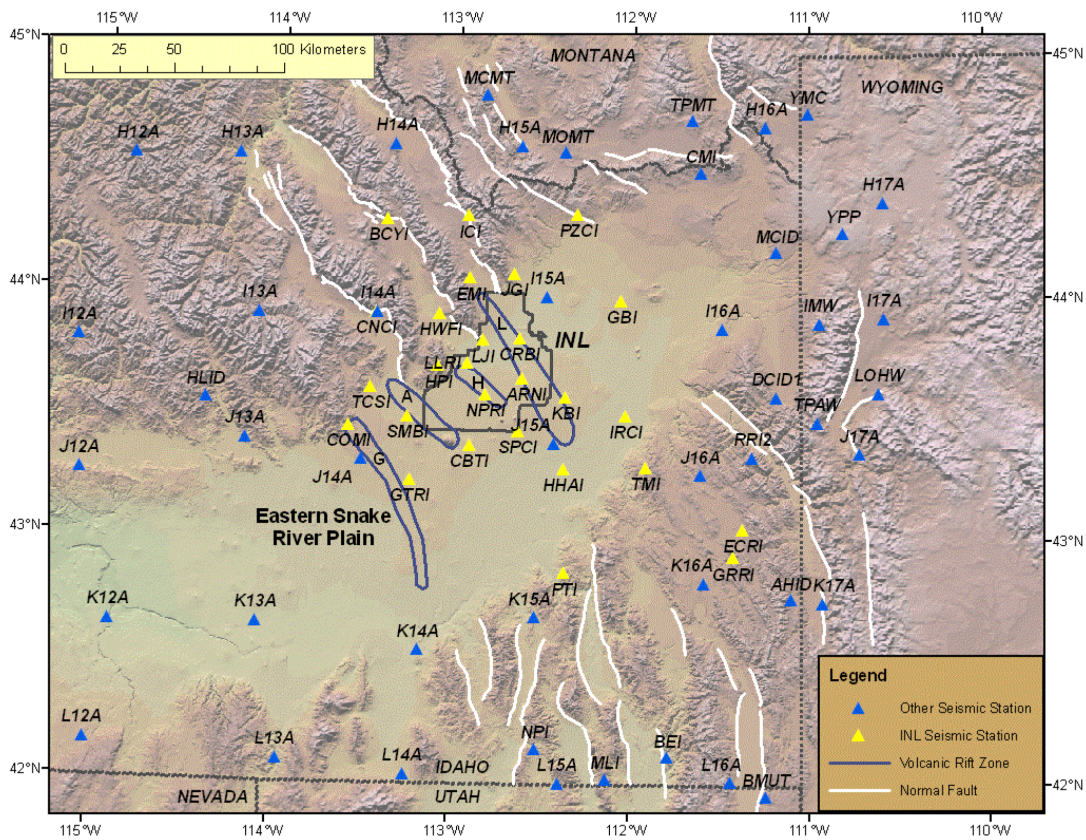

Figure 2. Locations of INL seismic stations and stations monitored by INL that are operated by other institutions. See Figure 1 for names of normal faults and volcanic rift zones.

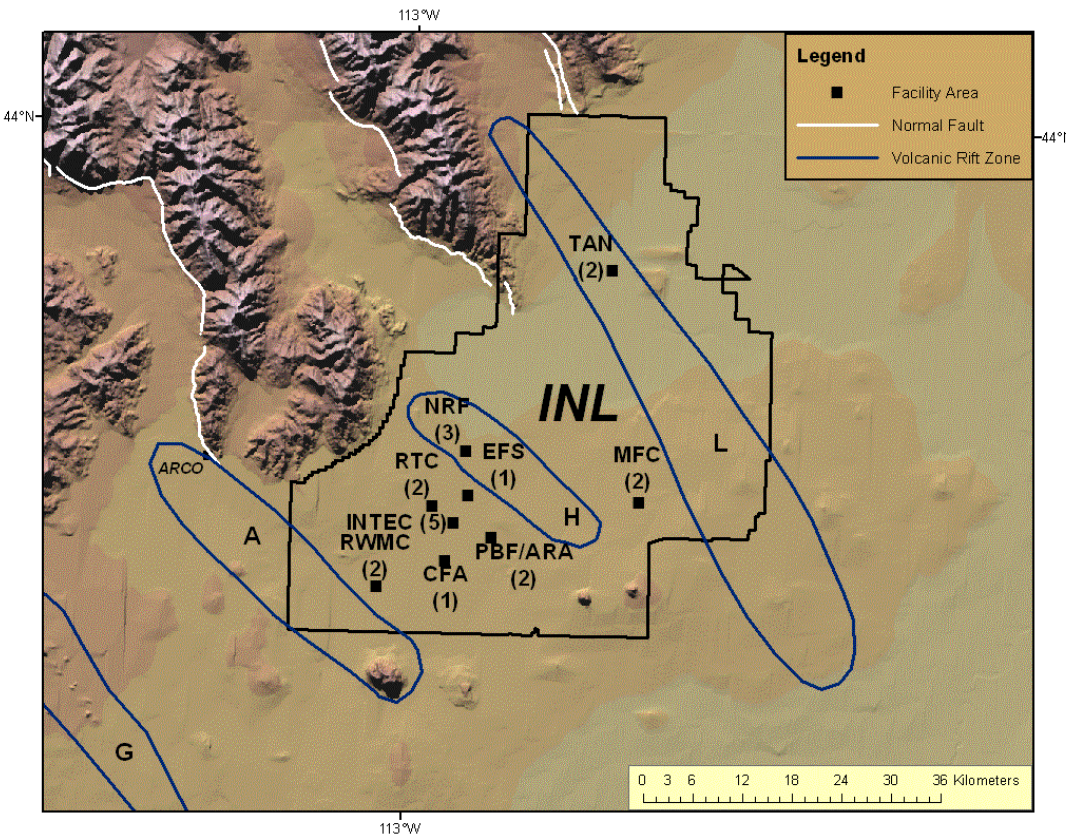

Figure 3. Numbers (in parentheses) of SMAs located at INL facility areas. See Figure 1 for names of normal faults and volcanic rift zones.

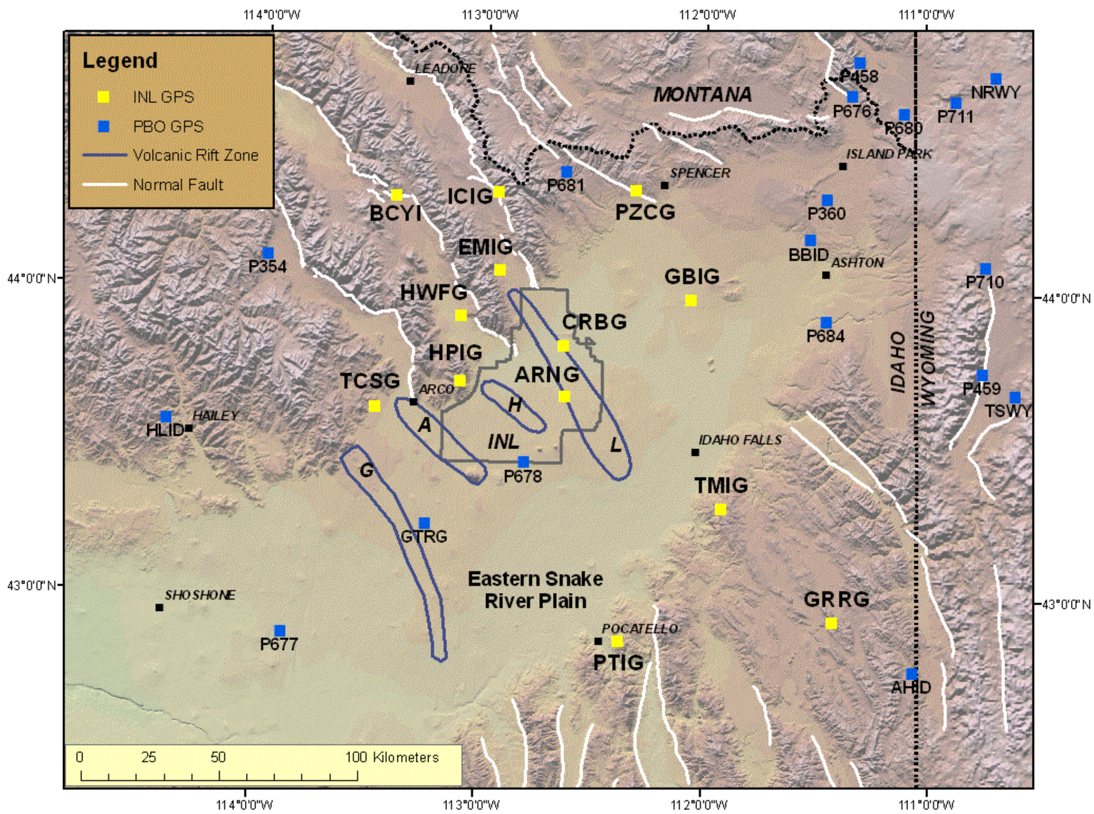

Figure 4. Locations of the continuous GPS stations co-located at INL seismic stations and operated by the Plate Boundary Observatory (PBO) under the EarthScope Science Program. See Figure 1 for names of normal faults and volcanic rift zones.

3. Data Analysis

Digital seismograms are analyzed using the SEISAN program to determine the earthquake's location, magnitude, and peak ground accelerations. SEISAN displays multiple seismograms on a computer screen with corresponding time codes having accuracy of ± 0.001 s. P- and S- wave arrival times of the seismograms are selected at an accuracy of 0.01 s. Duration and/or amplitude of a seismic signal is selected and then used to calculate the magnitude of an earthquake. The arrival times, durations, and amplitudes measured for an earthquake are saved in a computer file directly from the SEISAN program. The HYPOINVERSE program is used to compute the location. Two methods may be used to calculate the final magnitude of an earthquake depending on its size. The locations and magnitudes of the earthquakes are plotted on maps to assess seismically active regions near the INL. Amplitudes of the accelerograms are also measured using the SEISAN program, then processed using a separate program that outputs peak horizontal and vertical accelerations.

3.1 Location Method

The HYPOINVERSE computer program (Klein, 1989) is used to determine locations for all local earthquakes recorded. Phase data files (arrival times of the earthquake) from the output of SEISAN are input into the HYPOINVERSE location program. According to Zollweg and Sprenke (1995), stable locations are usually obtained from about seven to ten arrival times (P- and S-waves combined) for recorded events that are not surrounded by INL seismic stations. Within the INL network, stable locations can be obtained with a minimum of six arrival times. Because of the density and sensitivity of the INL seismic network, the majority (usually more than 90%) of earthquakes located within the 161-km radius have a minimum of six arrival times. However, some earthquakes are located with fewer than six arrival times and, thus, their locations have larger errors. Seismic stations from other agencies monitored by the INL provide coverage outside the INL network and phase arrivals from these stations supplement phase data from INL stations in an attempt to reduce location errors.

Four P-wave velocity models are used in the HYPOINVERSE location program depending on the location of the earthquakes (Table 5). The "ESRP" velocity model is used for locating earthquakes that occur within the ESRP including the mountainous terrain on the northern and eastern edge of the Plain (Olsen et al., 1979; Sparlin et al., 1979; Braile and Smith, 1979; and Ackerman, 1979). The "INL ESRP" velocity model is used to locate earthquakes that occur on the ESRP and are near or within the INL Site boundaries. This model was developed from Sparlin et al. (1982) and Braile et al. (1982) and checked with respect to a few microearthquakes located within the ESRP (Jackson et al., 1989). The "BPEAK" velocity model is used for locating earthquakes that occur in the Borah Peak aftershock area and the mountainous terrain northwest of the Plain (Richins et al., 1987). Finally, the "SMT" velocity model is used to locate earthquake in southwestern Montana (Stickney, 1997). For all velocity models, a P-wave velocity to S-wave velocity ratio of 1.75 is used (Bones, 1978; Greensfelder and Kovach, 1982; and Richins et al., 1987).

Other notable parameters used in the HYPOINVERSE location program are the starting focal depth, set to 5 km, and the distance cutoff for arrival weighting, set to 50 km. Zollweg and Sprenke (1995) evaluated the parameters chosen for the HYPOINVERSE program used by INL. They determined that the parameters chosen yield good location results despite the poor coverage in azimuth of earthquakes outside the network. An evaluation of the difference between the observed and computed latitude and longitude was less than 0.25 km.

3.2 Magnitude Calculations

Magnitudes are determined using two methods 1) coda magnitudes using signal duration of digital seismograms and 2) local magnitudes using amplitudes from digital seismograms. A coda magnitude (M_c) is calculated for an earthquake using several signal durations measured from the seismograms of different seismic stations. A local magnitude (M_L) is calculated using the largest peak-to-peak trace amplitude measured from digital waveforms and the Richter magnitude equation. If a magnitude cannot be determined for a local earthquake, then magnitudes determined by other seismic networks may be used. These include the University of Utah, Montana Bureau of Mines and Geology, NEIC, Boise State University, and the U.S. Bureau of Reclamation. The summary list of earthquakes in Appendix D lists the type of magnitude calculated and what institution reported the magnitude.

For the signal duration method, the following expression is used to calculate coda magnitude at a station (Arabasz et al., 1979):

$$M_c = -3.13 + 2.74 \log \tau + 0.0012 \Delta \qquad [1]$$

Where:

τ = Total signal duration recorded at the station in seconds;

Δ = Epicentral distance from the station in km.

The duration is measured at the start of the earthquake signature (P-wave arrival) to the end of the coda, where the signal fades into the background noise of the trace. The final magnitude is determined by averaging the coda magnitude calculated for each seismogram. The SEISAN program automatically selects the duration of the earthquake when the P-wave arrival time is selected. Equation (1) is usually used to estimate magnitudes for events located by the HYPOINVERSE location program.

Local magnitudes calculated from the digital seismograms are based on the Richter magnitude scale. Richter (1958) defined the local magnitude scale from the following equation:

$$M_L = \text{Log } A - \text{Log } A_o \qquad [2]$$

Where:

A = Recorded maximum trace amplitude from the zero-line measured in millimeters on a standard seismogram;

A_o = Maximum trace amplitude from the zero-line in millimeters for a selected standard earthquake.

Dr. Richter developed the scale for a standard earthquake of magnitude 3.0 at 100 km for A_o = 0.001 mm and amplitude of 1.0 mm measured on the standard seismogram. He constructed a table of magnitudes based on distance and -Log A_o for maximum trace amplitudes recorded on the standard Wood-Anderson seismogram.

SEISAN has a program that uses equation [2] with amplitudes measured on a synthetic Wood-Anderson digital seismogram. The program allows the user to convert waveforms recorded on the horizontal channels of accelerometers and seismometers at INL seismic stations to synthetic Wood-Anderson seismograms. The SEISAN program uses the instrument response information contained in

Appendix B for accelerograms and Appendix C for seismograms to calculate synthetic Wood-Anderson seismograms at a magnification of 2800. The user then selects the largest peak-to-peak amplitude (or A) in millimeters from the digital display of the synthetic Wood-Anderson seismogram. The SEISAN program then uses the distance of the simulated Wood-Anderson station to the earthquake's epicenter and one-half the peak-to-peak amplitude to determine local magnitude using Richter's table. The program determines the local magnitude for each amplitude selected.

3.3 Peak Accelerations

Peak horizontal and vertical accelerations are determined for accelerograms (or acceleration time histories) using the SEISAN program (Section 2.4). SEISAN displays the horizontal and vertical accelerograms for some free-field SMAs located at the INL and accelerometers co-located with the seismic stations. The SEISAN program allows the user to correct the accelerograms by removing the instrument responses listed in Appendices A and B. A separate program is used to measure the largest zero-to-peak acceleration amplitude from the corrected acceleration time history.

3.4 Location Quality

Comparisons between earthquake locations determined by the INL and locations determined by other temporary networks or NEIC have been used to approximate locations errors of earthquake epicenters (Jackson et al., 1993a). This method was very general and yielded an approximation of the quality of the INL earthquake locations. In 1995, the State of Idaho requested Zollweg and Sprenke (1995) to perform an independent assessment of the INL Seismic Monitoring Program. Zollweg and Sprenke (1995) evaluated the location accuracy of the INL seismic network by two methods: 1) directly comparing INL locations to well-located earthquakes; and 2) indirectly by evaluating the network bias or non-random error through varying independent permutations (or combinations) of recording stations.

For the first method, twenty-two earthquakes having high-quality locations determined from a temporary seismic network installed near Challis, Idaho from July 1, 1992 to July 12, 1992 (by Boise State University) were compared to INL locations for these earthquakes. The earthquakes were located about 120 km from the center of INL, had varying magnitudes ranging from 1.9 to 4.5, and had absolute errors less than 1 km. The epicenters determined by INL seismic stations for these events differed by 1.6 to 11.5 km with an average of 7.1 km. The differences in locations were dependent on magnitude, with the smaller magnitude earthquakes tending to have greater differences in locations (Zollweg and Sprenke, 1995). These results are similar to the earlier estimates of an error radius of 5 km for a comparison to high-quality locations of the aftershocks from the M_s 7.3 October 28, 1983 earthquake (Jackson et al., 1993a). However it is noted that this estimate for an error radius was based on having five stations in the INL seismic network at that time. The closest station to the aftershocks was at a distance of 50 km or more.

The second method used by Zollweg and Sprenke (1995) evaluates the network bias. Unless all earthquakes are located using exactly the same groups of stations and phases (P- and S-waves), the relative locations will be affected by a non-random error or network bias. The network bias is important for the smaller earthquakes that make up the majority of the events in a catalog since fewer stations usually record smaller earthquakes. Five earthquakes located northwest of the INL seismic network and ranging in magnitude from 1.8 to 3.8 were used in the analysis. Because INL operated 26 seismic stations at the time of the assessment, there were millions of possible combinations of recording stations. Zollweg and Sprenke (1995) chose to vary the combination of the ten most influential phase arrivals for the permutation analysis. The locations for most of the permutations clustered about radii ranging from 6.5 to 11 km. For the magnitude 3.8 earthquake, 8% of the permutations resulted in a linear band extending 100 km. Zollweg and Sprenke (1995) suggested that earthquakes located with fewer S-wave arrival times have less well-constrained locations. Some of the larger earthquakes, like the magnitude 3.8 earthquake, have fewer S-wave arrival times because the signals saturate the instrumentation and onset of the S- wave is indistinguishable from the P-waves. Earthquakes with more than three S-wave-arrival times resulted in better-constrained locations.

3.5 Depth Quality

The HYPOINVERSE location program also calculates depth to the hypocenter. Focal depths calculated by this program are not accurate for many of the earthquakes recorded by the INL seismic network for two reasons: 1) the station spacing is usually greater than twice the focal depth of the earthquake recorded; and 2) the earthquake usually occurs outside of the network. To calculate accurate focal depths, the earthquake must occur within the seismic network and at a distance equal to or less than its focal depth. Although focal depths are listed in Appendix D, they should be interpreted within the context of the limitations discussed in this section unless otherwise indicated.

3.6 Data Completeness

Local earthquakes are easily discriminated from other seismic data such as local mine blasts, air blasts (or sonic booms), and distant (worldwide) and regional earthquakes occurring far outside of the INL seismic network. For example, man-made blasts are easily discriminated from earthquakes on the basis of waveform characteristics, the time the event occurred, and the location of the event. The NEIC earthquake website listing is regularly inspected to confirm consistency with the INL earthquake catalog for magnitudes 2.5 and greater (the cutoff magnitude for NEIC earthquake locations).

Detection threshold can provide a measure of completeness for the INL earthquake catalog. It is defined as the magnitude level at which the seismic network will nearly always locate an earthquake. Zollweg and Sprenke (1995) evaluated the detection threshold by plotting the cumulative number of earthquakes as a function of magnitude to determine the lowest magnitude point that the curve begins to flatten. Zollweg and Sprenke (1995) determined the detection threshold to be a magnitude 1.3 anywhere within a 100-mile radius around INL. Their conclusion was based on a plot of 1360 earthquakes for an 18-month period. Since the seismic stations are all located within 90 km of the center of INL, they suggested that the detection threshold is magnitude 0.8 within the network on the ESRP. The analysis of Zollweg and Sprenke (1995) suggests that the INL earthquake catalog is complete for magnitudes above 1.3 within a 100-mile radius of INL and may be complete for magnitudes as low as 0.8 within the network. Hardware and software upgrades for the current DAAS have increased detection sensitivities on the order of magnitude 0.0 which allow recording of small magnitude microearthquakes within ESRP.

Table 5. P-wave velocity models used in location programs.

Velocity Model Code	Velocity (km/sec)	Depth to Top of Layer (km)	Layer Thickness (km)	References
ESRP	4.90	0.00	2.00	Olsen et al., 1979; Sparlin et al., 1979; Braile & Smith, 1979; Ackerman, 1979.
	6.00	2.00	15.00	
	6.70	17.00	23.00	
	7.90	40.00	Half-space	
INL ESRP	3.30	0.00	1.00	Sparlin et al., 1982; Braile et al., 1982; Jackson et al., 1989.
	4.90	1.00	2.00	
	5.30	3.00	2.00	
	6.15	5.00	2.00	
	6.53	7.00	10.00	
	6.80	17.00	23.00	
	8.00	40.00	Half-space	
BPEAK	4.75	0.00	1.64	Richins et al., 1987.
	5.59	1.64	5.31	
	6.16	6.95	11.05	
	6.80	18.00	22.00	
	8.00	40.00	Half-space	
SMT	5.52	0.00	5.86	Stickney, 1997.
	6.12	5.86	12.78	
	6.74	18.64	20.05	
	8.00	38.69	Half-space	

4. 2007 Earthquake Activity

During 2007, INL recorded 2,515 independent triggers from earthquakes that occurred worldwide, in the western United States, and in the local region of the ESRP. Within the local region, INL located 671 earthquakes and man-made blasts outside and within a 161-km (or 100-mile) radius of INL. Of these, eleven were small to moderate size earthquakes ranging in magnitude from 3.0 to 4.8 and 341 earthquakes occurred within the 161-km radius of INL.

4.1 Regional Earthquake Activity

Eight earthquakes of magnitudes from 3.0 to 4.8 occurred in the region outside the 161-km radius of INL (Figure 5). Five of these earthquakes occurred in western Wyoming. The first earthquake of M_L 3.9 occurred on February 25, 2007 in southwestern Wyoming. Some residents in Jackson, Wyoming reported that they felt this earthquake. The next two earthquakes occurred closer to Jackson, Wyoming: one earthquake of M_L 3.1 occurred on October 28, 2007 east of Jackson and residents did not feel the earthquake. The other earthquake of M_L 4.0 on October 31, 2007, three days later, occurred closer to Jackson and was felt by many residents. The last two earthquakes occurred near the end of the year in Yellowstone Park, Wyoming. An earthquake of M_L 3.0 on November 5, 2007 was not felt. The earthquake of M_L 3.6 on December 31, 2007 occurred near West Yellowstone, Montana and was felt by local residents. Two earthquakes occurred in southern Montana, one of M_L 3.7 on March 29, 2007 near Dillon, Montana and the other of body-wave magnitude (m_b) 4.8 on May 8, 2007 northeast of Dillon. Local residents did not report feeling either of these earthquakes. Finally, one earthquake occurred in central Idaho, northwest of Stanley, Idaho. The earthquake of M_L 3.8 occurred on December 13, 2007 and was not felt by local residents.

4.2 Local Earthquake Activity

There were 341 earthquakes located within the 161-km radius of INL, which occurred within the ESRP and in the surrounding Basin and Range Province (Figure 6). Three of these earthquakes exceeded magnitude 3.0. The first earthquake of M_L 3.1 occurred on February 15, 2007 north of Spencer, Idaho in southwest Montana. Throughout the year, earthquakes of smaller magnitudes occurred near the epicenter of this earthquake. The second earthquake of M_L 3.1 occurred on February 23, 2007 near Challis, Idaho and was felt by local residents. The third earthquake of M_L 3.1 occurred on September 4, 2007 southwest of Challis, Idaho. Over the year, 31 earthquakes of smaller magnitudes occurred near the September 4 epicenter within a small cluster. Earthquakes of smaller magnitudes occurred outside the Snake River Plain in the surrounding Basin and Range is southeastern Idaho, southwestern Montana, and central Idaho.

Three earthquakes occurred within the ESRP at Craters of the Moon National Monument (COM in Figure 6). On February 3, 2007 two earthquakes of M_c 0.9 and 1.8 occurred within 1 minute of each other, respectively. Another earthquake of M_c 1.4 occurred on June 3, 2007. In total, INL has recorded 36 small-magnitude microearthquakes ($M < 2.0$) within the ESRP since 1972.

5. 1972 – 2007 Earthquake Activity

Earthquakes in 2007 were located in areas around the ESRP that have been active in the past. Figure 7 also shows that the 2007 earthquakes occurred in active regions of the Basin and Range Province surrounding the ESRP. Even though microearthquakes ($M_L \leq 2.0$) have occurred within the ESRP, earthquake monitoring by the INL seismic network for the last 35 years indicates that the ESRP has been seismically inactive relative to the surrounding Basin and Range Province (Jackson et al., 1993b).

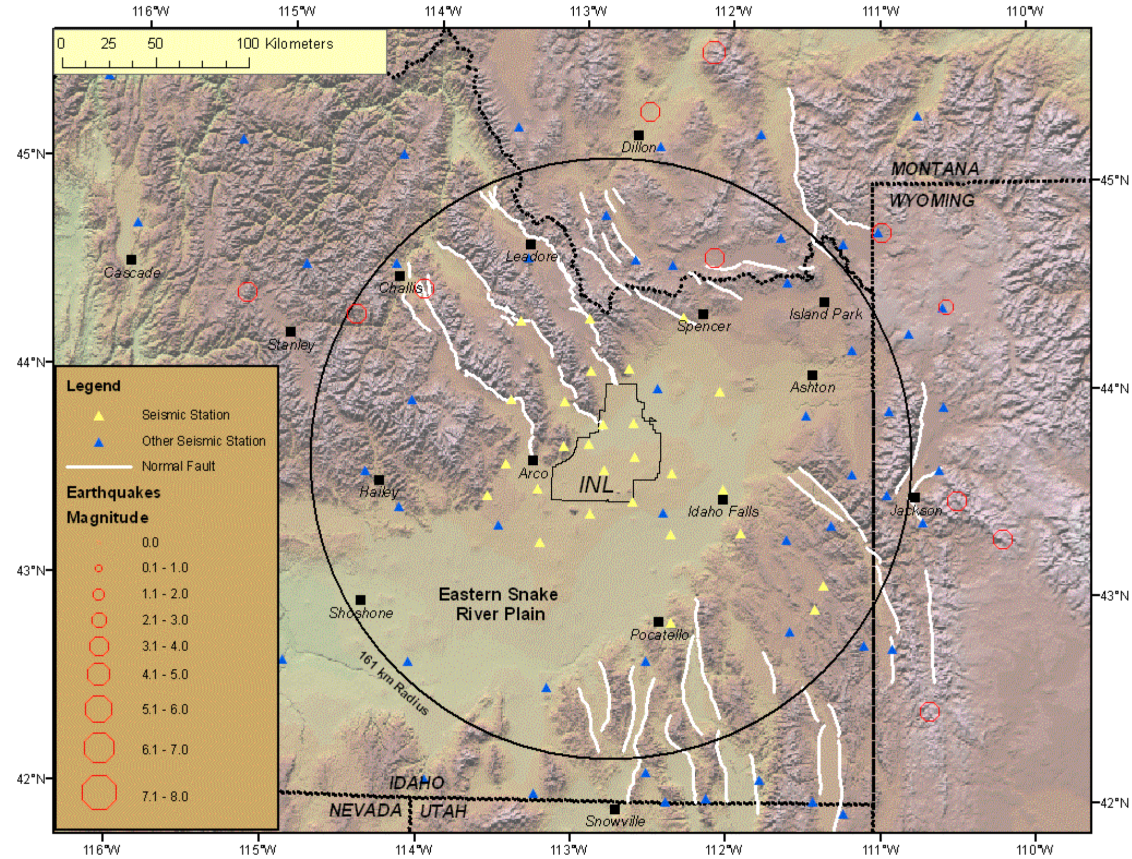

Figure 5. Map shows epicenters of earthquakes for magnitudes greater than 3.0 during 2007.

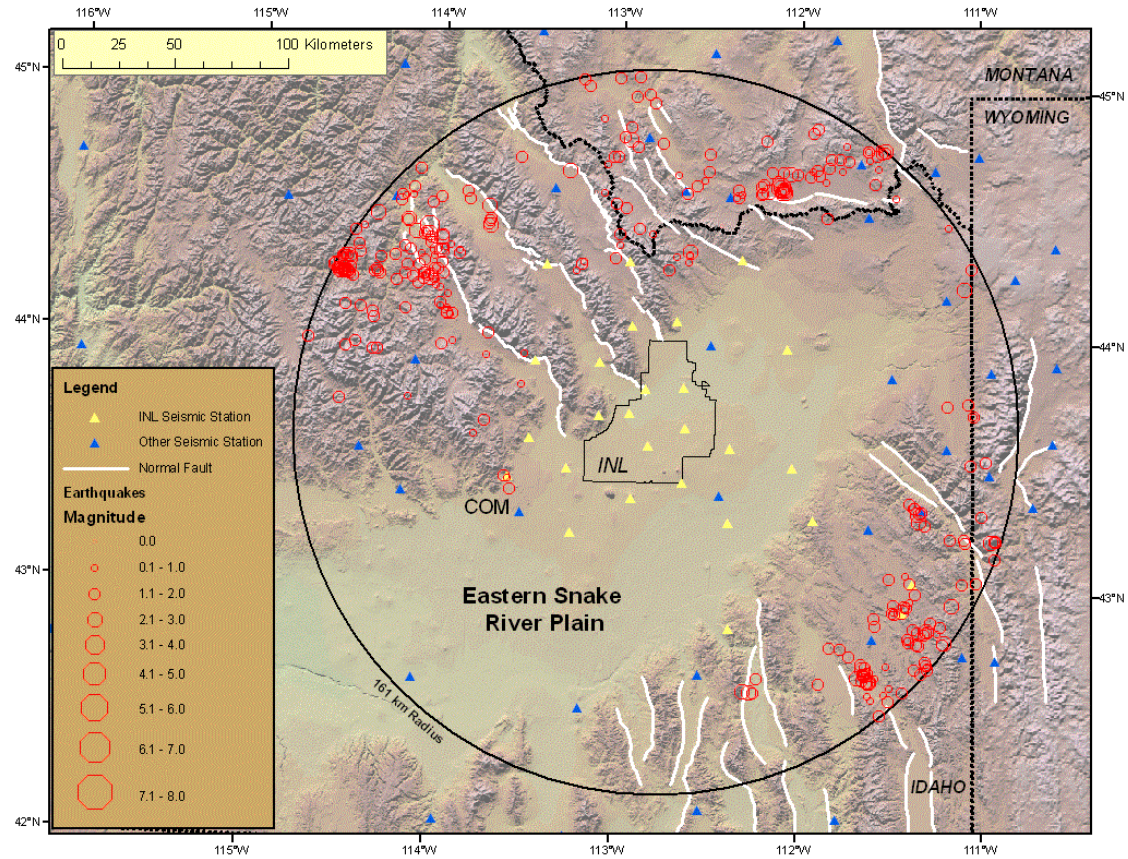

Figure 6. Map shows epicenters of earthquakes within the 161-km radius of INL from January 1, 2007 to December 31, 2007.

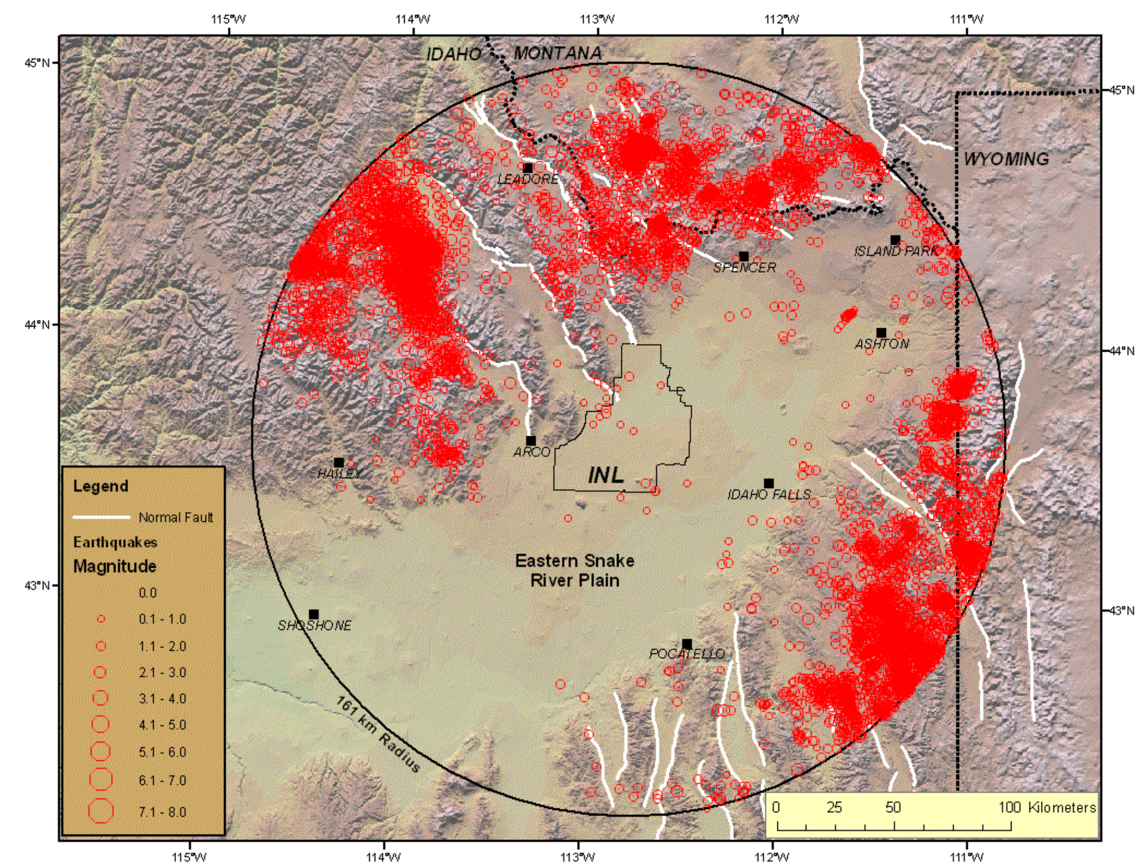

Figure 7. Map shows epicenters of earthquakes from 1972 to 2007 within the 161-km radius of INL.

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Appendix A

Seismic Network Information

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Appendix A

Seismic Network Information

EarthScope Science Program

USArray is a component of the EarthScope Science Program to capture high-resolution images of structure of the continental lithosphere and deeper mantle using passive seismic events such as earthquakes that occur worldwide. Broadband seismometers are being deployed in N-S transects across the United States for 18-24 months. While installed in Idaho, the USArray's Transportable Array (TA) stations enhance detection and coverage of local earthquakes for the INL Seismic Monitoring Program. The TA stations that were recorded by the INL and used to compute earthquake locations during part of 2007 are listed in Table A-1.

Table A-1. EarthScope Science Program Transportable Array seismic stations monitored by INL.

Code	Longitude West (º)	Latitude North (º)	Elevation (m)
G11A	-116.2680	45.3997	1343
G12A	-115.3257	45.1285	1780
G13A	-114.2329	45.0931	1538
G14A	-113.4604	45.2432	2140
G15A	-112.4887	45.1660	1857
G16A	-111.8046	45.2285	1769
G17A	-110.7398	45.3212	1574
H10A	-116.7474	44.5890	882
H11A	-116.0127	44.7035	1525
H12A	-114.8554	44.5494	1777
H13A	-114.2545	44.5642	1563
H14A	-113.3674	44.6165	1933
H15A	-112.6439	44.6173	1957
H16A	-111.2478	44.7038	2080
H17A	-110.5762	44.3951	2400
I10A	-116.8029	44.0860	782
I11A	-115.9578	43.9121	1288
I12A	-115.1328	43.7945	1849
I13A	-114.1169	43.9146	2104
I14A	-113.4518	43.9286	1897
I15A	-112.4850	43.9997	1470
I16A	-111.4868	43.8756	1744
I17A	-110.5759	43.9200	2134
J10A	-116.7670	43.4275	748
J11A	-115.8278	43.4151	1302
J12A	-115.0980	43.2500	1587
J13A	-114.1742	43.3979	1552
J14A	-113.5178	43.3234	1649
J15A	-112.4334	43.3998	1497
J16A	-111.6119	43.2741	2004
J17A	-110.7118	43.3629	1975
K10A	-116.8705	42.7779	1701
K11A	-116.0323	42.7713	914
K12A	-114.9029	42.6360	1091
K13A	-114.0840	42.6493	1222
K14A	-113.1760	42.5452	1387
K15A	-112.5305	42.6852	1566
K16A	-111.5884	42.8321	1885
K17A	-110.9201	42.7507	1922
L10A	-116.4711	42.0773	1537
L11A	-115.7541	42.1669	1511
L12A	-115.0162	42.1460	1756
L13A	-113.9444	42.0886	1482
L14A	-113.2398	42.0343	1528
L15A	-112.3860	42.0041	1645
L16A	-111.4319	42.0149	2013

INL Seismic Network Telemetry

Digital radios, Internet, or DSL links transmit seismic data from INL seismic stations and free-field SMAs to the IRC. Some seismic stations are used as relay links to transmit several seismic stations to a DSL drop point or directly to the IRC. Figure A-1 shows the telemetry configuration during 2007.

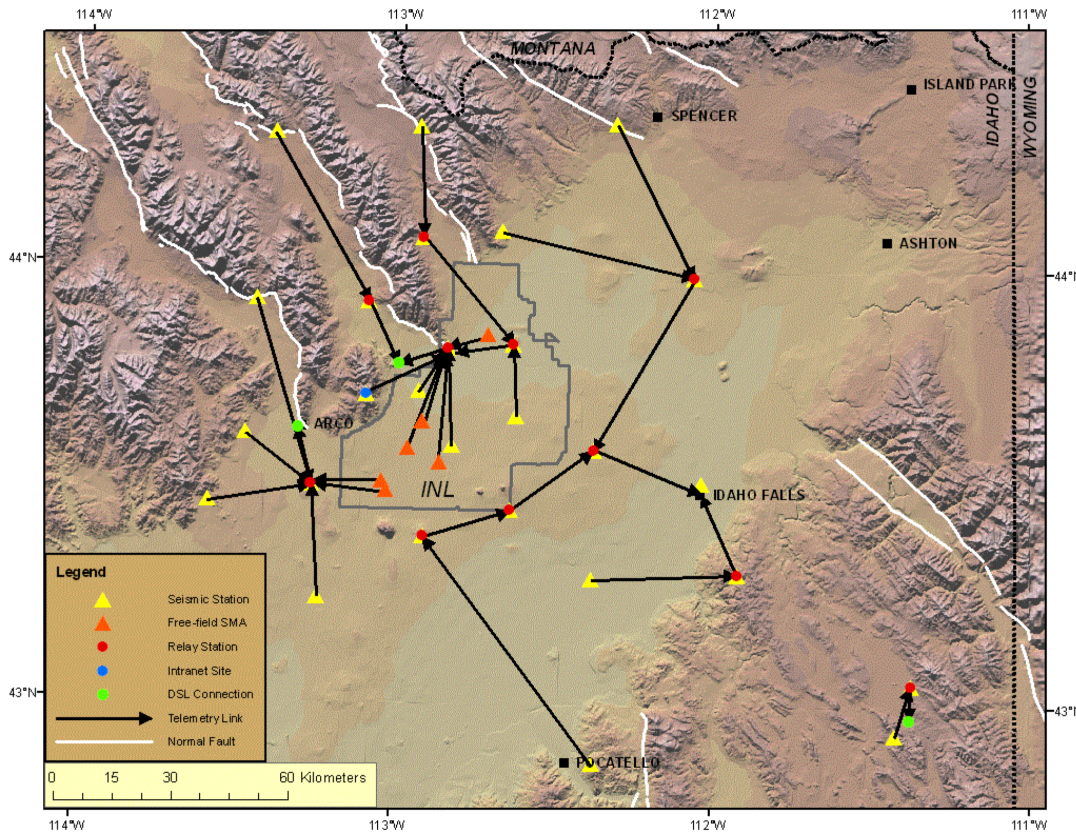

Figure A-1. Telemetry configuration of INL seismic stations and free-field SMAs during 2007.

Appendix B

Instrument Response of NetDAS SMAs

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Appendix B

Instrument Response of NetDAS SMAs

B.1 Method for Determining Amplitude Response

The instrument response of the NetDAS-SMA is used to convert the measured counts of ground motion amplitude to units of g. Instrument responses for NetDAS units that have accelerometers mounted within the unit are determined by conducting 1-g (acceleration of gravity) tilt tests. These tests are done on a leveled pad at the IRC seismic lab or on the actual leveled pad at their physical location listed in Table 3. These 1-g tilt tests provide a relationship between the number of digitizer counts and the 1-g offset. Equation B-1 provides the conversion from the measured count level to actual g level for the recorded motion. Trigger threshold accelerations and counts/g are listed for NetDAS units with SMAs in Table B-1 using equation:

$$\text{Acceleration (g)} = \text{Counts}_{\text{(Measured or target)}} / \text{(Counts/g)} \qquad \text{[B-1]}$$

For accelerographs without internally installed accelerometers within the NetDAS units, Equation B-1 does not apply; there is a frequency dependent amplitude response, which is discussed further in Appendix C. The frequency response information for the NetDAS-4CH should be applied to the acceleration data recorded by these external type accelerometers. Table B-2 lists the instrument response for these accelerometers using the methods discussed in Appendix C.

Tables B-1 and B-2 list the beginning and ending dates for the time periods that the instrument responses are applicable. If changes occurred to SMA or seismic station instrumentation (such as accelerometer or NetDAS unit) during the year, then more than one range of dates are listed for a location. Also, note that the building numbers and locations for the SMA codes are listed in Table 3.

Table B-1. Instrument responses for strong-motion accelerographs.

INL Site Facility Area	SMA Code	Instrument Response Begin Date	Instrument Response End Date	NetDAS Serial #	Accelerometer Model	Accelerometer Serial #	Orientation	Counts/g	Trigger Level (g)
MFC	EBR	2/8/2006	12/31/2007	1095	SF2500A	46	Vertical	533228	0.0046
							North	555864	0.0045
							East	543393	0.0046
	FCF	6/2/2003	12/31/2007	1079	SF2500A	61	Vertical	549212	0.0046
							North	559404	0.0045
							East	558307	0.0045
CFA	CFAF	2/8/2006	12/31/2007	1097	SF2500A	37	Vertical	530620	0.0046
							North	547301	0.0045
							East	560906	0.0045
	EFSF	5/6/2004	12/31/2007	1096	SF2500A	49	Vertical	553390	0.0045
							North	526189	0.0048
							East	549747	0.0045
INTEC	CPPF	2/2/2006	12/31/2007	2000	SF2500A	42	Vertical	559216	0.0045
							North	569302	0.0044
							East	556137	0.0045
	CPP1	5/19/2004	12/31/2007	1099	SF2500A	NA	Vertical	522025	0.0048
							North	563402	0.0044
							East	569090	0.0044

Table B-1. Continued.

INL Site Facility Area	SMA Code	Instrument Response Begin Date	Instrument Response End Date	NetDAS Serial #	Accelerometer Model	Accelerometer Serial #	Orientation	Counts/g	Trigger Level (g)
INTEC	CPP2	5/19/2004	12/31/2007	1078	SF2500A	NA	Vertical	615499	0.0041
							North	647203	0.0039
							East	628378	0.0040
	FAS1	2/2/2006	12/31/2007	1084	SF2500A	48	Vertical	573249	0.0044
							North	573389	0.0044
							East	546041	0.0045
	FAS2	2/2/2006	12/31/2007	1083	SF2500A	52	Vertical	544357	0.0046
							North	549370	0.0045
							East	565218	0.0044
NRF	NRFF	1/31/2005	12/31/2007	1098	SF2500A	55	Vertical	540182	0.0046
							North	553738	0.0045
							East	551745	0.0045
	A1W	1/31/2005	12/31/2007	1091	SF2500A	53	Vertical	541217	0.0045
							North	570002	0.0044
							East	564995	0.0044
	S1W	1/31/2005	12/31/2007	1088	SF2500A	45	Vertical	561125	0.0044
							North	558488	0.0045
							East	558473	0.0045
PBF	PBFF	6/7/2005	12/31/2007	1089	SF2500A	NA	Vertical	559223	0.0047
							North	553304	0.0045
							East	557374	0.0045

Table B-1. Continued.

INL Site Facility Area	SMA Code	Instrument Response Begin Date	End Date	NetDAS Serial #	Accelerometer Model	Serial #	Orientation	Counts/g	Trigger Level (g)
PBF	ARAF	6/8/2005	12/31/2007	1086	SF2500A	56	Vertical	530586	0.0045
							North	553243	0.0044
							East	550731	0.0042
RWMC	RWMC	11/9/2004	9/21/2007	1081	SF2500A	NA	Vertical	556615	0.0045
							North	550661	0.0043
							East	572485	0.0048
	RWMC	9/21/2007	12/31/2007	1081	SF2500A	NA	Vertical	552610	0.0045
							North	554529	0.0043
							East	572590	0.0048
	RWME	4/14/2005	9/21/2007	1077	SF2500A	NA	Vertical	558903	0.0045
							North	564951	0.0043
							East	557551	0.0048
	RWME	9/21/2007	12/31/2007	1077	SF2500A	NA	Vertical	552358	0.0045
							North	540927	0.0043
							East	556424	0.0048
RTC	TRAF	9/1/2005	12/31/2007	1094	SF2500A	41	Vertical	526114	0.0048
							North	574035	0.0043
							East	549477	0.0045
	TRA2	5/6/2004	12/31/2007	1085	SF2500A	38	Vertical	543172	0.0046
							North	556212	0.0045
							East	568860	0.0044

Table B-1. Continued.

INL Site Facility Area	SMA Code	Instrument Response Begin Date	Instrument Response End Date	NetDAS Serial #	Accelerometer Model	Accelerometer Serial #	Orientation	Counts/g	Trigger Level (g)
STC	IRC	12/16/2002	8/21/2007	NIR	SF2500A	NIR	Vertical	NIR	NIR
							North	NIR	NIR
							East	NIR	NIR
TAN	TANA	6/7/2005	12/31/2007	1090	SF2500A	40	Vertical	553849	0.0044
							North	564675	0.0044
							East	530791	0.0045
	SMC	NA	12/31/2007	1087	SF2500A	39	Vertical	NIR	0.0044
							North	NIR	0.0042
							East	NIR	0.0045

NIR – No instrument response due to problems with the SMA.

NA – Not available.

Table B-2. Instrument responses of accelerometers located at seismic stations.

	Instrument Response			Accelerometer					
Seismic Station	Begin Date	End Date	NetDAS Serial #	Model #	Serial #	Orientation	Datalogger Counts/Volt	Sensor Volt/g	Station Counts/g
BCYI	3/23/2005	9/6/2007	1068	SF3000L	185	Vertical	833601	1.220	1016993
						North	837596	1.200	1005115
						East	833104	1.220	1016387
BCYI	9/06/2007	12/31/2007	1068	SF3000L	185	Vertical	833043	1.220	1016312
						North	837181	1.200	1004617
						East	831948	1.220	1014977
GRRI	8/4/2005	8/24/2007	1013	SF2500A	57	Vertical	804275	1.396	1122768
						North	872679	1.345	1173753
						East	863351	1.412	1219052
GRRI	8/24/2007	12/31/2007	1013	SF2500A	57	Vertical	838085	1.396	1169967
						North	846390	1.345	1138395
						East	843067	1.412	1190411
HWFI	11/3/2005	12/31/2007	1069	SF2500A	62	Vertical	804003	1.378	1107916
						North	805254	1.371	1104003
						East	809573	1.352	1094542
NPRI	10/21/2005	12/31/2006	1065	SF2500A	36	Vertical	810927	1.427	1157193
						North	802533	1.376	1104286
						East	808520	1.371	1108481
PTI	9/7/2006	8/23/2007	1071	SF3000L	188	Vertical	839813	1.230	1032970
						North	833415	1.194	995098
						East	847947	1.244	1054846
PTI	8/23/2007	12/31/2007	1071	SF3000L	188	Vertical	834190	1.230	1026054
						North	833375	1.194	995050
						East	834469	1.244	1038079

Table B-2. Continued.

	Instrument Response			Accelerometer					
Seismic Station	Begin Date	End Date	NetDAS Serial #	Model #	Serial #	Orientation	Datalogger Counts/Volt	Sensor Volt/g	Station Counts/g
SPCI	6/13/2005	8/28/2007	1070	SF3000L	186	Vertical	806336	1.216	980505
						North	806668	1.237	997848
						East	809144	1.215	983110
SPCI	8/28/2007	12/31/2007	1070	SF3000L	186	Vertical	834485	1.216	1014734
						North	834508	1.237	1032286
						East	835579	1.215	1015228

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Appendix C

Instrument Response of Seismic Stations

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Appendix C

Instrument Response of Seismic Stations

C.1 Method for Determining Amplitude Response

The INL determines instrument responses for both the four (4CH) and eight channel (8CH) NetDAS units. The INL establishes a DC counts/volt level by measuring a known voltage level for a specified duration of time for each channel on the NetDAS units and recording the mean and standard deviation in counts for this duration. The input voltage polarity is often reversed in order to obtain a greater measurement range. The mean provides the method to produce the DC counts/volt level (Equation C-1a and C-1b) and the standard deviation provides an idea of the measurement uncertainty and system noise.

Single ended:

$$\text{Counts/Volt} = \mu / v_i \qquad \text{[C-1a]}$$

Reversed Polarity:

$$\text{Counts/Volt} = (\mu + - \mu^-) / (v_i + - v_i^-) \qquad \text{[C-1b]}$$

Where:

μ is mean counts

v_i is input voltage

Subscript "+" is positive polarity

Subscript "– " is negative polarity

C.2 NetDAS-4CH Frequency Response

The response of the Symmetric Research PAR4CH (4CH) digitizer used in the NetDAS-4CH was calculated at the INL to establish the instrument response of NetDAS units and the methods incorporated vendor information. The DAQSystems, Inc., manufacturer of the NetDAS units, reviewed INL's frequency response results and methods, which is discussed in the following steps.

The NetDAS-4CH frequency response was determined empirically by measuring the output counts resulting from a known input signal. Trials were conducted using a constant-amplitude sine wave with frequencies varying between 0.1, 5, 10, 15, 20, 25, 30, and 35 Hz. The frequency sweep was performed twice for representative frequencies of 0.1, 5, 10, 15, 20, 25, 30, and 35 Hz. The averages of the measured counts at each frequency were then converted into decibel responses relative to the average response at 0.1 Hz, because the vendor data sheets list a gain of 1 at this frequency. A 2nd order polynomial was then fit to the data creating a simple amplitude response in frequency. The perfectly matched response (R-squared of one) is shown here as described by Equations C-2 and C-3 (conversion to decibels).

$$Y_{dB} = -0.0045f^2 + 0.0074f - 0.014 \qquad \text{[C-2]}$$

$$dB = 20 \log (E_2/E_1) \qquad [C-3]$$

Where:

f – frequency (Hz)

E_1 – original signal level

E_2 - modified signal level

E_2/E_1 – commonly referred to as gain

This relationship was then used to calculate the gains out to the Nyquist frequency (1/2 the sample rate). The INL samples all data at 100 samples per second or 0.01 Hz. The information was then entered into MATLAB, which has a function to determine poles and zeros. Poles and zeros notations are the form that many seismic applications use to remove the instrument response. The NetDAS-4CH frequency response in dB and poles and zeros are shown in Figure C-1.

Equations C-2 and C-3 can be used in conjunction with the DC counts/volt measurement to generate a count based frequency response for short hand calculations or spectral deconvolution to remove the frequency response.

$$Ycounts = Counts/Volt \times 10\text{^}((-0.0045f^2 + 0.0074f - 0.014)/20) \qquad [C-4]$$

Where:

^ - Indicates 10 to the power of the number calculated in parentheses.

However, the preferred method for removing the frequency response from a recorded waveform is to use a seismic analysis package, such as SEISAN. This program recognizes the poles and zeros representation of instrument response, which quickly and accurately corrects recorded waveforms to actual ground motions.

C.3 NetDAS-8CH Frequency Response

The response of the Symmetric Research PAR24B (8CH) digitizer used in the NetDAS-8CH was based on vendor provided information, and calculated in the same method as described above for the PAR4CH. A 2nd order polynomial was fit to the data creating a simple amplitude response in frequency that matched the amplitude response (R-squared of 0.999). Equation C-5, listed below, is similar to Equation C-3 used for the response of the NetDAS-4CH. The NetDAS-8CH frequency response in dB and poles and zeros are shown in Figure C-2.

$$Y_{dB} = -0.0045f^2 + 0.0071f - 0.0158 \qquad [C-5]$$

C.4 Short-period high-gain seismic stations

In the fall of 2002, INL seismic personnel began tracking instrument response of the seismic stations. These response values, in combination with the instrument frequency responses (see C.2 and C.3), are used to create site- and date-specific system response files for the INL seismic stations. These response files are used in SEISAN to correct waveforms for further analyses such as calculating magnitudes by measuring amplitudes. Table C-1 lists the measured responses (including any system amplification) for the seismic stations that have been measured for instrument responses (in counts/volt).

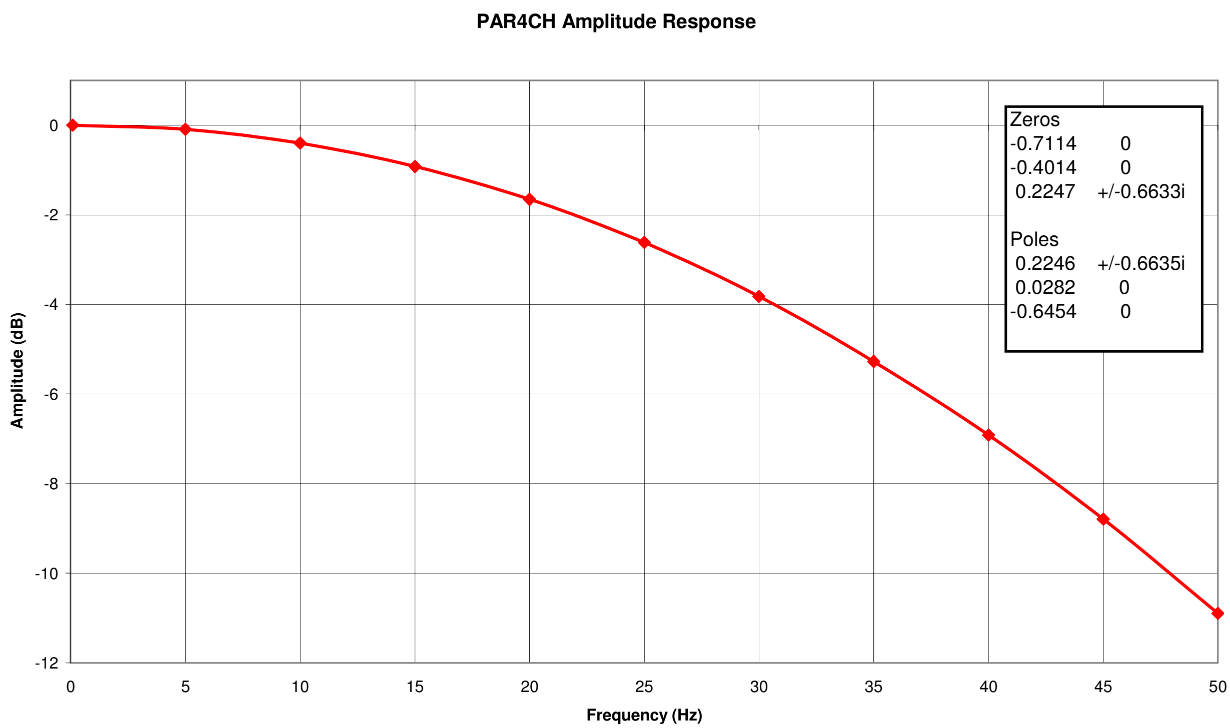

Figure C-1. Amplitude verses frequency system response of the Symmetric Research PAR4CH digitizer used in the NetDAS-4CH.

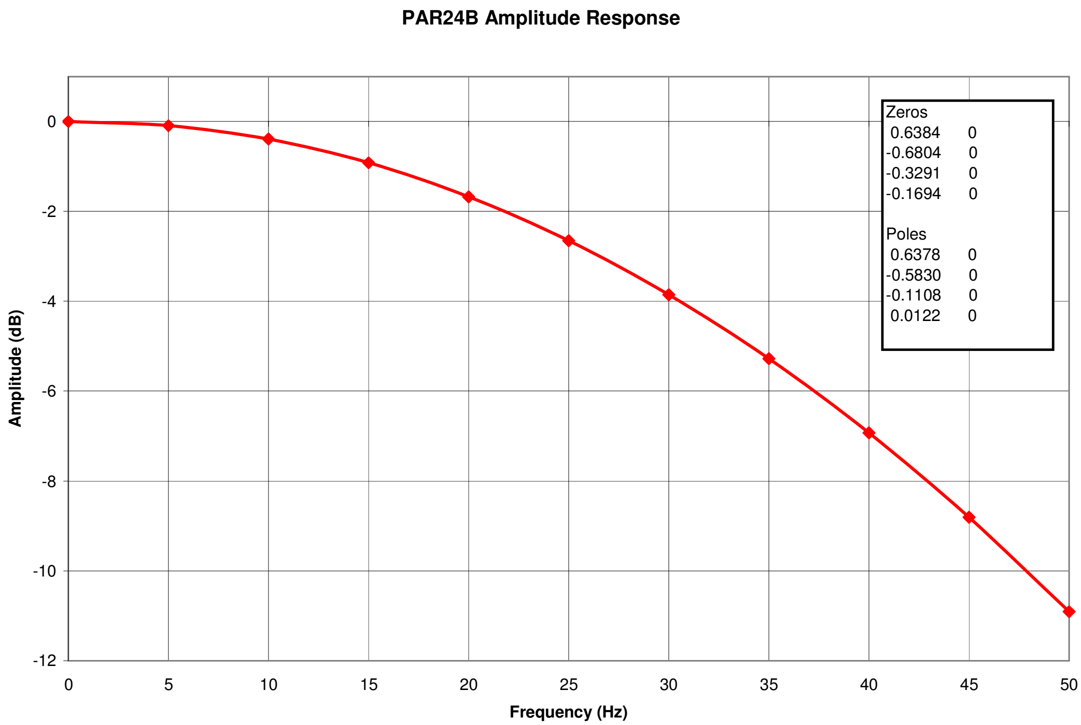

Figure C-2. Amplitude verses frequency system response of the Symmetric Research PAR24B digitizer used in the NetDAS-8CH.

Table C-1. Instrument responses of seismometers located at seismic stations.

Seismic Station	Instrument Response Begin Date	End Date	NetDAS Serial #	Digitizer Model	Orientation	Datalogger Counts/Volt	Seismometer Model
Single-component seismic stations							
ARNI	8/29/2006	8/28/2007	1017	4CH	Vertical	488042[a]	S13J
ARNI	8/28/2007	12/31/2007	1017	4CH	Vertical	47977741	S13J
BCYI	3/23/2005	9/6/2007	1068	8CH	Vertical	835518	S13J
BCYI	9/6/2007	12/31/2007	1068	8CH	Vertical	835518	S13J
CBTI	8/29/2006	8/29/2007	1024	4CH	Vertical	494794[a]	S13J
CBTI	8/29/2007	12/31/2007	1024	4CH	Vertical	48948934	S13J
CNCI	8/30/2006	9/6/2007	1066	4CH	Vertical	492673[a]	L4C
CNCI	9/6/2007	12/31/2007	1066	4CH	Vertical	48587278	L4C
COMI	10/6/2004	9/21/2007	2005	4CH	Vertical	387088[a]	S13
COMI	9/21/2007	12/31/2007	2005	4CH	Vertical	36022837	S13
CRBI	8/28/2006	12/31/2007	1027	4CH	Vertical	401458	S13J
ECRI	9/12/2006	8/24/2007	1051	4CH	Vertical	324557[a]	S13
ECRI	8/24/2007	12/31/2007	1051	4CH	Vertical	46797192	S13
EMI	8/28/2006	9/13/2007	1019	4CH	Vertical	445625[a]	L4C
EMI	9/13/2007	12/31/2007	1019	4CH	Vertical	48487157	L4C
GBI	5/18/2005	9/13/2007	30802	24USB5V	Vertical	7679384	S13J
GBI	9/13/2007	12/31/2007	30802	24USB5V	Vertical	2833423	S13J
GRRI	8/24/2007	12/31/2007	1013	4CH	Vertical	7965667	L4C

Table C-1. Continued.

Seismic Station	Instrument Response Begin Date	End Date	NetDAS Serial #	Digitizer Model	Orientation	Datalogger Counts/Volt	Seismometer Model
GTRI	8/16/2006	8/28/2007	1021	4CH	Vertical	250192[a]	S13J
GTRI	8/28/2007	12/31/2007	1021	4CH	Vertical	49147158	S13J
HHAI	8/23/2007	12/31/2007	1014	4CH	Vertical	460431	S13J
HPI	8/31/2005	9/13/2007	1015	4CH	Vertical	474874[a]	L4C
HPI	9/13/2007	12/31/2007	1015	4CH	Vertical	47682925	L4C
ICI	8/28/2006	9/13/2007	1020	4CH	Vertical	492964[a]	L4C
ICI	9/13/2007	12/31/2007	1020	4CH	Vertical	48888117	L4C
KBI	8/28/2007	12/31/2007	1018	4CH	Vertical	45839400	S13J
LJI	2/24/2004	8/5/2007	1052	4CH	Vertical	477522[a]	S13J
LJI	8/5/2007	12/31/2007	1052	4CH	Vertical	48539000	S13J
PTI	9/12/2006	8/23/2007	1071	8CH	Vertical	833485[a]	S13
PTI	8/23/2007	12/31/2007	1071	8CH	Vertical	79944873	S13
PZCI	6/16/2004	9/13/2007	1023	4CH	Vertical	399981[a]	S13J
PZCI	9/13/2007	12/31/2007	1023	4CH	Vertical	50322662	S13J
SMBI	8/16/2006	8/29/2007	1064	4CH	Vertical	495995[a]	S13J
SMBI	8/29/2007	12/31/2007	1064	4CH	Vertical	48952563	S13J
Three-component seismic stations							
HWFI	11/3/2005	11/16/2007	1069	8CH	Vertical	856478[a]	S13
					North	857063[a]	S13
					East	853611[a]	S13

Table C-1. Continued.

Seismic Station	Instrument Response Begin Date	End Date	NetDAS Serial #	Digitizer Model	Orientation	Datalogger Counts/Volt	Seismometer Model
HWFI	11/16/2007	12/31/2007	1069	8CH	Vertical	86285415	S13
					North	86332010	S13
					East	83363500	S13
IRCI	6/3/2005	12/31/2007	1012	4CH	Vertical	469890	S13
					North	461125	S13
					East	467680	S13
JGI	8/28/2006	9/13/2007	30801	24USB5V	Vertical	2876376	S13
					North	2867906	S13
					East	2881375	S13
JGI	9/13/2007	12/31/2007	30801	24USB5V	Vertical	2823772	S13
					North	2837383	S13
					East	2834625	S13
LLRI	8/29/2006	9/20/2007	1029	4CH	Vertical	489950[a]	S13J
					North	493268[a]	S13
					East	483647[a]	S13
LLRI	9/20/2007	12/31/2007	1029	4CH	Vertical	48337000	S13J
					North	48888449	S13
					East	48725117	S13
NPRI	10/21/2005	12/31/2007	1065	8CH	Vertical	836486	S13J
					North	837155	S13
					East	839175	S13

Table C-1. Continued.

Seismic Station	Instrument Response Begin Date	End Date	NetDAS Serial #	Digitizer Model	Orientation	Datalogger Counts/Volt	Seismometer Model
SPCI	6/13/2005	8/28/2007	1070	8CH	Vertical	827660[a]	S13J
					North	827077[a]	S13
					East	829743[a]	S13
SPCI	8/28/2007	12/31/2007	1070	8CH	Vertical	83330000	S13J
					North	83376700	S13
					East	83485300	S13
TCSI	8/16/2005	9/20/2007	1010	24USB5V	Vertical	2642927	S13
					North	2642368	S13
					East	2635268	S13
TCSI	9/20/2007	12/31/2007	1010	24USB5V	Vertical	2838206	S13
					North	2840762	S13
					East	2839697	S13
TMI	8/1/2005	11/6/2007	2004	24USB5V	Vertical	2226262	S13
					North	2198172	S13
					East	2194452	S13
TMI	11/6/2007	12/31/2007	2004	24USB5V	Vertical	2837736	S13
					North	2843957	S13
					East	2839995	S13

a. Gain not included.

Appendix D

2007 Earthquake List

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Appendix D

2007 Earthquake List

The summary list of earthquakes includes those located within a 161-km (100-mile) radius of the INL centered at 43.0° 39.00' N, 112° 47.00' W. Table D-1 provides an explanation of the headings listed in Table D-2 for the earthquake list. The format for this table has been modified from previous years. The earthquake identification number is no longer reported since the SEISAN analysis package identification number is simply the origin data and time. The listing also includes the distance of the earthquake epicenter from the center of INL.

Table D-1. Explanation of the earthquake summary table headings.

Heading	Example	Explanation
ORIGIN	1/3/2007 5:58	Date of the earthquake: month/day/year (1/3/2007); origin time of the earthquake: hour and minute in UTC (5:58)
LAT N	44.6115	Latitude of epicenter in degrees North
LONG W	112.2127	Longitude of epicenter in degrees West
MAG	1.6	Magnitude of the earthquake.
TYPE	Mc INL	Type of magnitude reported and reporting agency. Magnitude types: Coda magnitude (Mc); Local magnitude (ML); Moment magnitude (Mw); and Body wave magnitude (mb). Reporting agencies include: Idaho National Laboratory (INL); NEIC (US); University of Utah (UU); and Montana Bureau of Mines and Geology (MB). NM with a magnitude of 0.00 indicates that no magnitude was calculated as a result of multiple earthquakes, which obscures the coda of the first event or the record length was insufficient to include the full coda of the earthquake.
DIST	116.3	Distance in km from center of INL at: 43° 39.00' N, 112° 47.00' W.
Z	3.54	Calculated focal depth in km. Not all earthquakes have appropriate seismic station geometry for calculating a reliable focal depth, thus the errors (ERZ) are typically large.
NO	5	Number of station readings used in locating the earthquake with weights above 0.1. P- and S-wave arrival times for the same station are regarded as two readings.
GAP	338	Largest azimuthal separation in degrees between stations.
DMIN	101.3	Distance in km from the epicenter to the nearest station.
RMS	0.04	Root mean square error of arrival time residuals in second using all weights as calculated by: RMS=SQRT(ΣR_i^2/N)
		Where: SQRT is the square root; ΣR_i is the sum of the time residuals for the i^{th} station; and N is the number of residuals.
ERH	5.7	Standard horizontal error of the epicenter in km.
ERZ	11.6	Standard vertical error of the focal depth in km.

Table D-2. Earthquakes located within 161-km radius of INL in 2007.

ORIGIN TIME	LAT N	LONG W	MAG-TYPE	DIST	Z	NO	GAP	DMIN	RMS	ERH	ERZ
1/3/2007 5:58	44.6115	112.2127	1.6 Mc INL	116.3	3.54	5	338	101.3	0.04	5.8	11.6
1/4/2007 11:39	44.6138	112.1797	2.1 Mc MB	117.6	14.81	14	137	17.2	0.25	0.9	0.7
1/4/2007 23:41	43.9528	114.3295	1.4 Mc INL	128.9	6.71	9	262	43.8	0.33	5.5	8.0
1/6/2007 2:05	44.6023	113.1417	0.0 NM	109.8	7.65	6	307	61.1	0.30	2.0	26.9
1/10/2007 22:11	42.8077	111.3343	1.4 Mc INL	150.4	4.85	6	229	19.7	0.03	7.7	5.7
1/14/2007 13:54	43.7723	111.0665	2.0 Mc INL	138.9	8.56	11	261	109.8	0.09	1.9	3.7
1/15/2007 5:51	43.7222	111.0367	2.0 Mc INL	141.0	7.94	10	255	53.3	0.08	0.6	1.1
1/18/2007 4:25	43.9552	114.3538	1.5 Mc INL	130.8	7.29	9	256	43.8	0.10	2.4	1.6
1/19/2007 15:43	44.2592	114.1860	1.7 Mc INL	131.4	0.02	12	279	69.3	0.19	5.9	5.6
1/22/2007 17:34	42.6180	112.2272	1.2 Mc INL	123.4	9.99	6	132	57.5	0.08	0.7	2.3
1/23/2007 0:19	44.6853	112.0612	2.3 Mc INL	128.8	7.76	11	219	84.0	0.10	1.1	1.8
1/24/2007 9:24	42.9703	111.4747	1.3 ML INL	130.3	7.96	12	162	38.1	0.05	0.5	1.0
1/25/2007 21:50	42.7257	111.2878	0.9 ML INL	159.2	7.77	8	111	16.0	0.11	0.6	1.9
1/26/2007 0:51	42.7927	111.7625	1.4 ML INL	126.4	3.37	10	135	54.3	0.08	0.4	1.5
1/27/2007 18:23	43.3755	111.3847	1.6 Mc INL	117.1	6.39	12	170	109.9	0.07	0.6	1.6
1/27/2007 21:12	43.3352	111.3333	1.8 Mc INL	122.3	5.32	18	141	47.6	0.11	0.3	1.4
1/28/2007 0:21	43.2990	111.3380	2.1 Mc INL	123.2	14.63	22	140	47.1	0.05	0.5	0.4
1/28/2007 4:18	43.3310	111.3462	2.1 Mc INL	121.5	11.63	20	140	46.5	0.07	0.5	1.0
1/28/2007 5:43	43.3382	111.3227	1.7 ML INL	123.1	4.98	17	143	48.4	0.09	0.5	10.9
1/28/2007 5:57	43.2880	111.3042	1.4 Mc INL	126.2	11.39	13	267	99.0	0.13	2.4	4.3
1/28/2007 10:42	44.7118	111.8420	1.5 Mc MB	140.0	10.24	10	161	14.1	0.04	0.6	0.9
1/31/2007 5:53	44.6055	112.2145	1.9 Mc MB	115.6	4.96	6	330	100.7	0.07	6.0	12.3
2/1/2007 5:59	44.6347	112.2187	1.3 Mc INL	118.5	6.48	8	219	33.6	0.16	1.9	15.6
2/1/2007 7:48	44.6425	112.2070	1.3 Mc INL	119.6	9.47	10	191	34.6	0.08	1.2	1.6
2/3/2007 4:46	43.4542	113.5937	0.9 Mc INL	69.0	20.72	16	134	0.9	0.12	0.5	1.1
2/3/2007 4:47	43.4118	113.5793	1.8 Mc INL	69.0	21.24	19	64	5.7	0.16	0.6	0.8
2/3/2007 10:41	44.2783	114.0287	1.9 Mc INL	121.9	1.31	11	244	60.4	0.12	1.4	1.8
2/5/2007 20:49	44.5338	113.7363	2.9 ML MB	124.5	0.31	9	286	36.2	0.18	5.4	8.1
2/5/2007 20:52	44.4790	113.7243	1.4 ML INL	119.1	1.44	6	277	31.6	0.11	6.1	6.1
2/5/2007 22:06	42.8318	111.3913	0.7 Mc INL	145.1	2.37	6	134	12.0	0.04	1.3	12.0
2/5/2007 22:47	44.4673	113.7295	1.5 Mc INL	118.4	0.04	9	274	31.2	0.15	4.7	5.0
2/5/2007 23:57	44.4890	113.7188	1.6 Mc INL	119.7	0.05	5	327	31.9	0.10	6.5	7.8
2/6/2007 12:46	44.4553	113.7273	2.3 ML MB	117.2	0.04	10	272	30.3	0.11	4.6	5.5
2/6/2007 17:20	44.2188	114.1165	1.3 Mc INL	124.3	2.19	5	273	62.3	0.16	4.7	9.7
2/6/2007 22:12	42.8602	111.3428	1.5 Mc INL	146.2	2.50	5	122	10.8	0.12	1.1	14.3
2/8/2007 19:49	43.9818	113.9762	1.6 Mc INL	102.8	5.00	4	237	42.5	0.07	11.8	13.8
2/11/2007 1:32	43.5260	111.0530	1.2 Mc INL	140.3	0.02	9	111	84.6	0.04	0.6	2.1
2/11/2007 19:02	44.4258	114.4737	1.8 Mc INL	160.6	1.70	7	254	86.1	0.15	3.2	4.8
2/13/2007 8:15	42.6132	111.5200	0.2 ML INL	154.4	5.01	6	139	38.3	0.15	1.1	15.5
2/13/2007 12:15	44.2433	114.1455	1.7 Mc INL	127.7	7.51	6	246	59.6	0.21	3.2	7.2
2/14/2007 6:23	44.6937	112.1542	1.2 Mc INL	126.5	6.53	6	232	41.3	0.09	1.6	13.5
2/15/2007 3:44	44.6297	112.1153	3.1 ML US	121.4	8.52	24	188	35.9	0.16	0.7	1.0
2/15/2007 3:48	44.6578	112.1255	1.9 Mc INL	123.8	9.29	9	192	38.4	0.11	1.4	2.9
2/15/2007 9:42	44.6227	112.3415	1.4 Mc MB	113.8	1.81	9	271	31.4	0.08	1.3	0.9

ORIGIN TIME	LAT N	LONG W	MAG-TYPE	DIST	Z	NO	GAP	DMIN	RMS	ERH	ERZ
2/15/2007 10:56	44.6318	112.1145	2.2 Mc MB	121.6	8.80	17	188	36.1	0.15	0.6	1.6
2/15/2007 14:42	43.7232	111.0340	0.9 Mc INL	141.2	4.21	7	222	53.3	0.08	1.1	5.1
2/18/2007 2:01	44.2902	113.2392	1.0 Mc MB	80.1	2.24	4	236	13.4	0.08	0.9	7.0
2/20/2007 4:17	44.8947	113.1022	1.0 Mc INL	140.8	3.85	6	269	21.4	0.05	2.5	2.9
2/21/2007 21:27	44.8172	112.1893	1.5 Mc MB	138.2	11.93	5	325	111.8	0.13	6.7	14.3
2/22/2007 22:20	44.2633	114.5097	1.6 Mc INL	154.4	0.08	7	273	78.3	0.17	3.8	7.8
2/23/2007 13:06	44.4027	113.9953	2.5 ML MB	128.3	0.31	11	300	48.1	0.30	7.5	9.5
2/23/2007 14:39	44.4480	114.0645	3.1 ML US	135.7	1.75	12	305	54.7	0.18	1.9	4.1
2/23/2007 14:43	44.5428	114.0450	1.1 Mc INL	141.7	10.03	5	331	57.1	0.12	3.1	1.5
2/24/2007 22:08	42.9552	111.4090	1.0 Mc INL	135.6	4.99	7	175	32.9	0.11	1.1	11.1
2/25/2007 4:32	42.9597	111.3985	1.3 Mc INL	136.0	9.47	7	178	32.6	0.11	3.6	5.9
2/25/2007 18:43	42.9437	111.4288	2.6 ML US	135.1	1.75	13	118	33.4	0.08	0.6	2.6
2/26/2007 22:53	44.2748	114.5247	1.7 Mc INL	156.0	0.12	6	251	79.7	0.09	1.7	2.6
2/27/2007 20:49	44.3337	114.0283	0.9 Mc INL	125.5	7.22	5	252	49.8	0.14	2.0	17.3
2/28/2007 0:49	44.2670	114.5342	1.9 Mc INL	156.4	0.02	7	252	78.9	0.14	2.6	11.1
3/1/2007 2:59	44.3417	113.0248	1.3 Mc MB	79.4	0.33	7	261	30.5	0.08	1.6	2.5
3/2/2007 8:10	42.9637	111.4145	1.2 Mc INL	134.7	4.93	6	176	33.8	0.14	1.9	13.7
3/3/2007 0:15	44.2517	114.5192	1.7 Mc INL	154.5	1.27	6	272	77.1	0.13	4.1	16.4
3/5/2007 21:00	44.2545	114.5537	2.2 Mc INL	157.2	0.04	7	253	77.8	0.27	4.2	14.3
3/6/2007 4:15	42.9820	111.3808	0.9 Mc INL	135.8	11.57	7	186	33.2	0.10	1.3	1.3
3/7/2007 12:08	44.5570	113.0257	1.1 ML MB	102.8	6.94	8	283	40.8	0.17	1.5	19.1
3/8/2007 22:30	44.2638	114.5243	1.5 Mc INL	155.5	0.04	7	251	78.5	0.22	3.3	5.9
3/12/2007 4:08	44.3673	114.1923	1.5 Mc INL	138.3	2.39	5	264	63.1	0.00	3.4	6.5
3/12/2007 19:37	44.7637	112.5040	1.4 Mc MB	125.9	9.02	5	164	20.8	0.04	1.2	2.5
3/13/2007 16:18	44.6883	113.2942	2.6 ML US	122.5	0.36	16	234	38.5	0.07	1.9	4.5
3/15/2007 1:25	42.9673	111.1555	2.2 Mc INL	152.3	4.98	12	99	22.9	0.40	3.0	10.2
3/15/2007 11:08	44.3132	111.0450	1.3 ML INL	157.7	5.01	7	116	17.5	0.20	2.0	19.7
3/15/2007 13:29	44.4263	114.0765	1.2 Mc INL	134.9	2.83	6	228	55.0	0.11	2.2	6.9
3/15/2007 17:01	43.7518	114.5253	1.5 Mc INL	140.8	8.71	8	259	23.1	0.09	1.6	5.5
3/15/2007 20:03	44.2685	114.5658	1.3 Mc INL	158.7	1.25	8	254	79.5	0.20	3.7	10.8
3/15/2007 20:17	44.2802	114.5755	2.1 Mc INL	160.0	0.04	9	255	80.9	0.14	2.9	8.2
3/15/2007 20:34	43.1532	110.9220	1.2 Mc INL	160.5	14.52	12	195	45.5	0.10	2.6	4.4
3/19/2007 0:58	42.7138	111.3553	1.3 Mc INL	155.9	7.14	6	169	75.1	0.10	1.3	2.0
3/19/2007 10:23	44.8685	111.9040	1.4 Mc MB	152.6	2.07	8	192	24.4	0.24	1.8	2.8
3/19/2007 21:25	42.8828	111.2918	0.0 Mc INL	148.1	5.68	7	126	20.4	0.08	0.8	2.1
3/21/2007 19:59	44.2640	114.5260	1.3 Mc INL	155.6	0.31	8	252	78.5	0.24	3.8	14.3
3/22/2007 7:08	44.5908	112.3542	0.9 Mc INL	110.1	6.84	6	215	3.2	0.03	1.6	0.8
3/22/2007 16:31	44.0300	113.7203	1.8 Mc INL	86.4	5.01	8	170	40.1	0.11	1.0	15.3
3/22/2007 22:20	42.6157	112.2545	2.6 Mc INL	122.8	1.44	9	151	56.4	0.04	0.9	12.4
3/23/2007 20:29	42.6178	112.2873	2.2 Mc INL	121.7	9.87	10	134	55.6	0.07	0.8	1.1
3/25/2007 13:08	44.4262	114.1372	2.1 Mc INL	138.7	0.16	7	232	59.7	0.15	2.1	10.7
3/27/2007 20:05	44.2818	114.0110	1.6 Mc INL	121.0	5.01	7	257	48.5	0.04	2.9	11.6
3/30/2007 1:00	44.6918	112.5123	1.2 ML MB	117.9	4.61	5	199	14.4	0.05	8.5	9.5
3/31/2007 0:27	44.2957	114.5573	2.0 Mc INL	159.4	0.04	7	254	82.4	0.19	3.7	12.5
3/31/2007 5:26	42.8747	111.3627	1.8 Mc INL	144.0	4.98	11	162	24.7	0.06	0.5	5.8

ORIGIN TIME	LAT N	LONG W	MAG-TYPE		DIST	Z	NO	GAP	DMIN	RMS	ERH	ERZ
4/1/2007 14:51	44.3173	113.2082	1.4	Mc INL	81.7	11.35	6	126	15.7	0.06	1.3	4.4
4/3/2007 11:44	44.8668	112.9493	1.7	Mc INL	136.0	9.15	8	271	9.1	0.07	2.5	0.7
4/4/2007 23:25	44.2543	114.5465	2.1	Mc INL	156.6	0.04	9	253	77.7	0.20	3.1	12.0
4/5/2007 16:11	42.6912	111.6295	1.7	Mc INL	142.0	2.62	9	87	44.1	0.09	0.6	14.3
4/7/2007 22:50	44.1238	113.9517	0.9	Mc INL	107.7	5.01	5	213	45.6	0.13	1.8	16.4
4/9/2007 15:34	44.2370	114.0860	1.8	Mc INL	123.3	1.07	10	215	55.0	0.12	1.4	13.7
4/11/2007 22:22	44.2423	114.4808	1.5	Mc INL	151.3	1.32	6	247	75.8	0.04	2.4	9.8
4/12/2007 23:57	44.2625	114.5390	2.0	Mc INL	156.5	0.31	9	252	78.5	0.13	1.9	10.5
4/13/2007 4:17	43.2307	111.0867	1.5	Mc INL	145.0	4.43	8	109	106.9	0.08	0.6	4.2
4/13/2007 17:33	42.6957	111.6365	1.8	Mc INL	141.3	2.50	12	97	44.6	0.08	0.5	14.3
4/14/2007 5:46	44.6227	112.0928	1.4	Mc INL	121.5	2.19	5	138	24.2	0.06	0.9	1.3
4/14/2007 10:35	44.1033	113.9183	1.4	Mc INL	104.2	6.91	8	192	42.1	0.26	1.1	14.3
4/14/2007 14:54	43.9960	113.9150	1.0	Mc INL	98.8	5.02	7	182	37.9	0.21	1.6	18.4
4/14/2007 22:46	44.6163	112.1152	1.3	Mc INL	120.0	3.31	6	146	62.7	0.25	1.3	9.7
4/17/2007 0:41	43.3583	111.3550	1.6	Mc INL	119.9	3.22	7	139	69.1	0.15	0.8	3.9
4/17/2007 0:51	43.3577	111.3628	1.7	Mc INL	119.3	6.29	10	181	82.8	0.19	1.1	1.7
4/18/2007 22:20	42.6558	111.8785	1.1	Mc INL	132.8	4.99	7	107	60.4	0.10	0.7	14.7
4/19/2007 8:33	44.7640	111.5740	1.2	Mc INL	157.1	3.90	6	207	8.2	0.01	1.5	3.0
4/19/2007 12:09	44.7722	111.5115	0.0	NM	160.9	6.84	6	202	13.1	0.04	1.7	5.2
4/19/2007 16:18	44.6367	112.5787	1.1	Mc INL	111.0	4.90	4	153	15.4	0.09	5.4	9.4
4/19/2007 18:42	44.2562	114.5258	1.5	Mc INL	155.2	0.16	8	251	77.7	0.13	2.3	9.8
4/20/2007 1:42	42.8177	111.1985	2.2	Mc INL	158.5	5.77	10	171	91.5	0.08	0.9	1.4
4/22/2007 8:37	44.7083	111.5675	0.4	Mc INL	152.6	0.05	4	154	8.1	0.05	0.6	8.5
4/22/2007 14:02	44.3535	114.1630	1.1	Mc INL	135.5	5.40	6	267	60.6	0.10	3.1	10.3
4/23/2007 17:01	44.3015	112.9463	0.0	Mc INL	73.7	4.85	4	142	3.1	0.06	9.0	10.1
4/25/2007 3:17	43.9918	114.7095	1.1	Mc INL	159.5	0.62	7	308	101.2	0.12	7.8	6.2
4/25/2007 9:47	43.9547	113.5167	0.4	ML INL	68.1	1.78	4	330	6.0	0.02	11.9	2.7
4/26/2007 2:55	44.2160	114.0158	1.0	Mc INL	117.3	6.84	6	256	49.9	0.11	2.5	6.6
4/26/2007 7:47	44.6782	112.6823	0.7	Mc INL	114.7	4.37	5	217	21.2	0.13	5.4	15.2
4/26/2007 21:06	42.8345	111.3920	1.3	Mc INL	144.9	2.11	4	196	11.8	0.03	3.2	12.7
4/27/2007 0:04	44.3202	114.3280	1.5	Mc INL	144.6	2.17	6	300	73.6	0.23	11.6	11.6
4/29/2007 10:47	44.2345	114.0162	0.6	Mc INL	118.4	4.17	5	288	56.6	0.17	6.2	12.8
4/30/2007 1:38	44.3430	113.8917	1.1	Mc INL	117.7	8.04	5	250	39.0	0.11	1.8	14.3
4/30/2007 21:05	42.8210	111.3895	1.3	Mc INL	146.0	2.47	4	134	13.3	0.18	1.6	18.6
5/1/2007 6:09	44.3587	113.8922	0.9	Mc INL	118.8	5.04	5	314	39.2	0.11	6.1	12.4
5/1/2007 10:16	44.7773	111.5308	1.5	Mc INL	160.4	11.21	10	178	11.9	0.15	0.9	1.5
5/2/2007 1:09	44.6128	112.0862	2.1	Mc INL	120.7	12.74	23	136	24.6	0.08	0.4	1.1
5/3/2007 11:38	44.3680	113.9718	1.0	Mc INL	124.3	5.01	5	256	64.1	0.17	3.9	19.0
5/4/2007 11:42	42.6407	111.4908	1.0	Mc INL	153.8	4.99	8	110	34.9	0.10	1.1	13.5
5/4/2007 14:29	44.7022	111.9077	1.3	Mc INL	136.4	5.25	5	159	19.4	0.04	1.8	3.4
5/6/2007 2:39	44.4932	114.3508	2.1	Mc INL	156.7	1.25	6	281	78.0	0.30	6.8	19.0
5/7/2007 0:55	42.5302	111.5467	1.1	Mc INL	160.1	5.00	5	171	45.0	0.08	1.9	13.2
5/7/2007 19:36	42.5912	111.5923	0.5	Mc INL	152.5	4.98	5	186	44.7	0.20	2.7	19.3
5/8/2007 0:42	44.2742	114.4897	2.0	Mc INL	153.5	0.16	7	283	86.7	0.11	3.9	8.5
5/9/2007 0:04	44.3830	114.0528	1.7	Mc INL	130.4	0.92	6	262	52.3	0.05	2.7	13.1

ORIGIN TIME	LAT N	LONG W	MAG	TYPE	DIST	Z	NO	GAP	DMIN	RMS	ERH	ERZ
5/9/2007 11:26	44.7463	111.6142	0.9	Mc INL	153.6	3.30	4	172	4.5	0.00	1.3	1.9
5/10/2007 19:50	44.6575	112.5352	0.8	Mc INL	113.8	12.08	6	174	13.3	0.04	1.7	2.8
5/11/2007 0:38	44.6028	114.1522	1.2	Mc INL	152.4	5.10	4	275	93.5	0.08	5.6	11.5
5/17/2007 10:18	44.4695	114.1848	2.1	Mc INL	144.6	0.31	13	272	64.6	0.22	3.6	10.4
5/17/2007 20:35	44.2318	114.2370	1.3	ML INL	133.4	0.31	7	270	71.3	0.20	4.6	12.8
5/18/2007 10:10	44.1192	114.1817	1.5	Mc INL	123.9	8.75	6	299	62.2	0.09	9.0	2.0
5/20/2007 0:01	42.7150	111.2878	1.2	Mc INL	159.9	4.08	6	143	16.3	0.06	1.1	13.3
5/22/2007 23:22	42.7983	111.8190	2.0	Mc INL	122.9	4.99	8	114	46.3	0.19	0.8	18.5
5/24/2007 4:52	44.7935	111.5610	0.9	Mc INL	160.3	12.84	5	181	10.9	0.15	1.6	2.6
5/24/2007 8:01	44.1008	114.3635	1.5	Mc INL	136.5	0.16	8	277	75.6	0.21	3.2	5.8
5/24/2007 8:58	44.1192	114.4293	1.2	Mc INL	142.2	0.31	7	280	81.2	0.16	4.7	10.7
5/24/2007 10:24	44.5943	113.8528	1.2	Mc INL	135.5	2.51	6	275	47.6	0.22	6.1	22.2
5/24/2007 21:23	44.2477	114.4957	1.9	Mc INL	152.7	0.62	9	249	76.5	0.19	3.8	10.7
5/26/2007 17:30	44.7883	112.9133	2.0	Mc INL	127.1	4.56	12	192	6.7	0.06	2.1	2.3
5/28/2007 0:43	42.7295	111.2933	1.5	Mc INL	158.5	6.26	8	101	16.3	0.05	0.9	5.4
5/28/2007 22:46	44.2838	114.5777	1.6	Mc INL	160.3	0.08	5	277	81.3	0.21	7.5	12.7
5/29/2007 7:36	44.1180	113.9625	0.5	ML INL	108.1	7.94	6	213	46.0	0.21	1.1	19.9
5/29/2007 12:03	44.1327	113.9878	0.4	Mc INL	110.7	7.78	5	217	48.6	0.10	0.8	14.8
5/30/2007 19:25	42.7402	111.2918	0.0	Mc INL	157.9	5.00	7	132	15.9	0.22	1.5	4.7
5/31/2007 18:19	42.6888	111.6338	1.5	Mc INL	142.0	5.00	6	130	45.9	0.09	1.1	14.3
6/3/2007 16:21	43.4633	113.6108	1.4	Mc INL	70.0	16.77	25	76	1.4	0.12	0.6	0.5
6/3/2007 20:14	43.9605	114.5013	1.1	Mc INL	142.5	6.93	4	282	44.9	0.13	3.3	16.4
6/4/2007 23:45	44.8245	112.9832	1.6	Mc INL	131.6	5.17	6	240	66.2	0.10	2.2	14.6
6/5/2007 2:11	44.8112	112.9525	2.1	Mc MB	129.9	0.08	12	237	66.2	0.20	3.2	11.2
6/5/2007 20:52	44.2593	114.0443	1.5	Mc INL	121.8	5.01	7	242	51.3	0.09	2.0	14.4
6/6/2007 1:18	44.2625	114.0843	1.1	Mc INL	124.7	5.07	4	245	54.5	0.10	2.5	14.9
6/6/2007 21:14	42.7283	111.2812	0.0	Mc INL	159.4	5.05	6	138	15.4	0.03	1.3	9.5
6/7/2007 21:34	42.7323	111.2962	0.0	Mc INL	158.2	5.53	7	99	16.4	0.04	0.9	6.0
6/10/2007 18:51	44.1087	113.9490	1.7	Mc INL	106.7	6.70	10	195	44.6	0.14	0.8	4.4
6/12/2007 17:10	42.6767	111.6688	2.1	Mc INL	141.2	4.98	6	90	47.6	0.19	1.2	19.6
6/13/2007 11:06	43.0542	111.1005	1.5	Mc INL	151.6	2.93	11	254	22.0	0.03	1.8	10.8
6/13/2007 15:29	44.2978	112.7275	1.3	Mc INL	72.2	11.75	9	131	17.4	0.28	1.6	4.9
6/15/2007 16:24	44.2532	114.3282	1.2	Mc INL	141.0	1.10	9	235	74.0	0.11	1.9	2.1
6/17/2007 13:14	44.6002	113.0905	1.0	Mc INL	108.5	7.69	8	178	31.7	0.25	1.0	20.8
6/18/2007 0:24	43.9797	114.4505	1.6	Mc INL	139.0	7.15	7	250	46.5	0.06	2.1	13.6
6/20/2007 0:11	43.2185	111.0825	1.4	Mc INL	145.7	11.14	7	186	29.7	0.13	1.6	3.3
6/20/2007 3:51	44.4780	112.4375	0.0	NM	96.2	4.35	7	133	13.3	0.05	2.2	3.2
6/20/2007 11:34	43.3225	110.9945	2.0	Mc INL	149.1	5.00	9	135	132.3	0.48	2.1	42.1
6/21/2007 22:27	44.3672	114.4520	1.1	Mc INL	155.8	0.18	5	250	83.7	0.07	3.1	8.0
6/23/2007 15:39	43.2337	111.1633	1.8	Mc INL	139.0	2.67	10	168	106.3	0.24	2.8	7.2
6/24/2007 9:30	43.0580	111.0208	1.6	Mc INL	157.3	6.38	9	286	135.9	0.04	4.2	3.8
6/24/2007 13:19	44.6290	112.1005	1.6	Mc INL	121.8	13.47	17	140	23.7	0.11	0.4	0.8
6/24/2007 14:07	44.5968	112.1133	0.5	Mc INL	118.2	4.57	5	211	22.3	0.09	6.5	8.5
6/24/2007 19:31	44.6285	112.0875	1.1	Mc INL	122.3	5.02	5	148	24.7	0.02	0.9	12.6
6/26/2007 19:11	44.2695	114.3468	1.3	Mc INL	143.1	0.04	9	237	75.3	0.19	2.5	11.7

ORIGIN TIME	LAT N	LONG W	MAG-TYPE	DIST	Z	NO	GAP	DMIN	RMS	ERH	ERZ
6/27/2007 15:05	45.0642	112.9042	1.3 Mc INL	157.6	2.71	8	279	26.6	0.04	4.5	1.4
6/28/2007 3:01	44.9612	112.8152	1.1 Mc INL	145.9	0.02	11	308	15.1	0.08	3.0	3.6
6/28/2007 21:13	42.6982	111.3212	1.5 Mc INL	159.1	4.97	5	144	19.6	0.04	1.2	12.8
6/28/2007 21:45	44.2702	114.5575	1.9 Mc INL	158.2	0.16	10	253	79.6	0.11	2.5	7.3
6/30/2007 19:06	44.9870	112.9233	1.1 Mc INL	149.2	0.03	8	268	18.7	0.30	3.4	6.5
7/4/2007 2:27	44.2548	114.5197	1.9 Mc INL	154.7	0.16	7	250	77.5	0.12	2.6	11.0
7/5/2007 5:03	44.4185	114.0658	2.3 Mc INL	133.7	0.59	14	264	54.0	0.11	2.1	9.5
7/5/2007 17:16	44.2518	114.0637	2.0 Mc INL	122.6	2.11	10	260	53.0	0.03	2.5	12.7
7/6/2007 0:55	44.2753	114.5267	1.7 Mc INL	156.2	0.04	10	251	79.8	0.19	3.6	9.4
7/7/2007 3:15	44.4757	111.1715	0.7 Mc INL	158.4	6.04	5	105	31.7	0.05	0.6	13.0
7/7/2007 16:57	44.6500	111.5800	1.6 Mc INL	147.1	3.74	6	229	11.2	0.04	10.8	6.5
7/8/2007 6:36	44.7812	111.5287	2.2 Mc INL	160.9	12.76	10	179	12.3	0.13	0.8	1.2
7/8/2007 13:39	44.7727	111.5470	1.8 Mc INL	159.2	10.78	11	177	10.5	0.17	0.8	1.7
7/10/2007 0:10	44.8007	111.7428	1.0 Mc INL	152.6	14.88	6	181	10.0	0.15	1.4	1.0
7/10/2007 20:08	42.8143	111.3478	1.5 Mc INL	149.1	6.72	5	231	21.0	0.02	6.3	5.1
7/11/2007 19:30	44.4177	114.0912	1.3 Mc INL	135.2	5.04	5	228	56.0	0.20	2.5	20.8
7/12/2007 6:21	43.0152	111.3543	1.8 Mc INL	135.6	5.58	11	160	4.5	0.20	1.1	1.8
7/13/2007 2:34	42.7275	111.5118	0.6 Mc INL	145.6	4.99	3	295	24.5	0.08	3.4	12.1
7/16/2007 1:19	44.1253	114.5130	1.4 Mc INL	148.7	1.25	6	264	63.1	0.14	4.6	11.7
7/17/2007 6:16	44.2398	114.0498	2.1 Mc INL	121.0	7.45	20	214	52.1	0.19	1.2	4.3
7/18/2007 4:21	44.6980	111.9323	0.9 Mc INL	135.0	6.32	5	158	21.4	0.20	1.8	18.0
7/18/2007 5:52	44.2613	114.0827	1.5 Mc INL	124.5	1.23	11	217	54.4	0.11	1.5	4.1
7/18/2007 6:29	44.4063	114.0513	1.5 Mc INL	131.9	3.12	8	225	52.6	0.11	1.7	6.9
7/19/2007 17:55	42.7070	111.6273	0.0 Mc INL	140.8	4.99	5	210	43.6	0.13	1.8	16.0
7/20/2007 5:44	42.5870	111.5000	1.2 Mc INL	157.7	5.04	8	147	38.3	0.07	0.9	11.5
7/21/2007 9:10	44.2048	113.9897	0.7 Mc INL	114.9	7.63	5	250	52.9	0.07	2.8	13.7
7/23/2007 15:55	44.4425	114.4267	0.8 Mc INL	158.5	1.28	6	251	82.7	0.05	2.4	9.3
7/24/2007 8:54	44.6998	111.7677	1.0 Mc INL	142.2	7.00	3	278	8.7	0.06	2.5	2.0
7/24/2007 18:32	42.6800	111.6013	0.5 Mc INL	144.5	5.02	8	151	42.1	0.17	1.1	17.6
7/25/2007 22:37	44.2550	114.5377	1.3 Mc INL	156.0	1.25	7	252	77.7	0.19	3.3	14.9
7/26/2007 10:02	45.0272	113.1895	1.5 Mc INL	156.6	1.53	8	296	34.9	0.05	3.8	4.4
7/26/2007 10:49	45.0493	113.2188	1.9 Mc INL	159.5	0.31	12	299	38.2	0.12	5.9	4.6
7/27/2007 14:41	44.4700	114.1832	1.2 Mc INL	144.6	0.31	9	237	64.5	0.17	2.4	9.6
7/28/2007 3:13	44.2938	114.1792	1.1 Mc INL	132.9	4.58	10	227	61.8	0.17	2.1	5.2
7/28/2007 17:15	44.3290	114.2455	1.5 Mc INL	139.5	5.75	9	233	67.1	0.07	2.3	4.0
7/31/2007 9:44	44.6583	111.8555	1.0 Mc INL	134.5	10.46	6	138	17.0	0.05	1.4	5.1
7/31/2007 14:45	44.2642	114.5493	1.3 Mc INL	157.3	7.87	6	253	78.8	0.04	1.9	1.6
7/31/2007 23:55	44.1048	113.9505	1.1 Mc INL	106.6	7.17	12	210	44.5	0.21	0.9	21.7
8/1/2007 14:32	44.2607	114.3562	1.1 Mc INL	143.3	0.56	7	238	77.7	0.08	1.5	2.6
8/4/2007 1:22	44.2540	114.5085	1.9 Mc INL	153.9	0.16	8	250	77.3	0.21	3.4	12.8
8/5/2007 6:47	44.5503	114.2232	1.7 Mc INL	152.7	0.31	8	245	70.4	0.08	1.9	7.4
8/5/2007 16:45	44.4160	113.9873	1.6 Mc INL	128.7	5.00	6	322	47.9	0.13	12.9	16.4
8/6/2007 16:23	42.6882	111.6307	1.8 Mc INL	142.2	4.92	13	79	32.6	0.10	0.6	10.9
8/13/2007 20:14	44.3115	114.0823	1.1 Mc INL	127.6	2.67	6	221	66.0	0.15	1.7	12.6
8/15/2007 17:55	44.1467	113.9887	1.1 Mc INL	111.5	6.07	9	201	49.4	0.07	0.7	2.6

ORIGIN TIME	LAT N	LONG W	MAG-TYPE	DIST	Z	NO	GAP	DMIN	RMS	ERH	ERZ
8/17/2007 12:35	45.0577	113.0158	1.9 Mc INL	157.7	0.02	15	260	28.8	0.23	2.5	7.1
8/17/2007 16:58	44.3922	114.0318	0.5 Mc INL	129.7	5.01	5	223	50.8	0.16	2.2	18.2
8/18/2007 3:43	44.5637	113.8393	1.2 Mc INL	132.2	0.02	11	266	44.6	0.13	1.9	3.2
8/18/2007 8:03	44.6160	112.0833	1.5 Mc INL	121.2	11.99	13	136	24.8	0.06	0.6	1.4
8/19/2007 7:17	43.6273	113.7830	0.6 ML INL	80.7	1.59	7	135	23.9	0.11	0.7	3.3
8/20/2007 17:09	42.6917	111.6312	1.8 Mc INL	141.9	5.42	10	156	32.3	0.09	1.0	13.2
8/22/2007 10:43	44.3360	114.4420	1.1 Mc INL	153.4	0.14	6	248	86.0	0.13	2.2	10.8
8/22/2007 16:21	42.7197	111.6240	1.5 Mc INL	139.9	4.99	8	103	29.4	0.19	1.0	16.6
8/22/2007 21:29	42.6725	112.2137	1.7 Mc INL	118.2	4.98	7	126	25.4	0.10	0.6	12.4
8/25/2007 6:17	44.3250	114.5273	1.5 Mc INL	158.7	7.10	9	253	85.3	0.12	1.8	3.1
8/27/2007 23:08	44.2593	114.5010	1.6 Mc INL	153.6	0.08	7	249	77.8	0.16	3.2	12.5
8/28/2007 4:45	43.7657	114.1480	1.0 Mc INL	110.7	0.54	6	181	30.7	0.02	1.2	2.2
8/28/2007 10:55	42.8643	111.2912	2.2 Mc INL	149.3	3.48	18	142	13.4	0.07	0.5	4.1
8/28/2007 11:03	42.8665	111.2847	1.4 Mc INL	149.6	2.45	8	144	13.7	0.04	0.8	9.9
8/28/2007 12:18	42.8477	111.3150	0.6 Mc INL	148.9	11.71	4	203	13.3	0.05	1.5	2.6
8/28/2007 16:22	42.8517	111.3070	1.7 Mc INL	149.1	9.39	9	131	13.4	0.09	1.0	1.8
8/29/2007 14:08	42.8622	111.2963	1.2 ML INL	149.1	4.61	6	187	13.3	0.05	1.3	4.1
8/29/2007 19:36	42.6950	111.6257	1.9 Mc INL	141.9	4.99	9	99	31.7	0.16	0.9	16.1
8/31/2007 1:19	42.6643	111.6117	2.3 Mc INL	145.2	3.55	19	84	34.1	0.20	0.5	16.1
8/31/2007 1:23	42.6668	111.6433	1.3 Mc INL	143.3	5.00	5	180	35.2	0.14	1.6	15.6
8/31/2007 2:01	42.6070	111.6092	0.6 Mc INL	150.3	5.01	5	230	39.8	0.02	1.6	11.8
8/31/2007 2:19	42.6588	111.6040	2.4 ML US	146.1	6.96	20	85	34.4	0.16	0.5	5.1
8/31/2007 2:58	42.6593	111.6100	2.5 Mc INL	145.7	2.86	17	84	34.6	0.13	0.4	14.7
8/31/2007 3:14	42.6582	111.6013	1.4 Mc INL	146.3	2.50	8	149	34.4	0.23	1.1	21.6
8/31/2007 3:55	42.6618	111.6197	1.2 Mc INL	145.0	5.00	7	119	34.7	0.30	1.0	20.7
8/31/2007 18:16	42.6363	111.6108	0.0 Mc INL	147.7	5.01	7	124	36.9	0.18	1.1	18.4
8/31/2007 18:39	42.7348	111.6475	1.2 Mc INL	137.4	0.03	9	107	29.2	0.28	1.1	4.0
8/31/2007 18:45	42.7122	111.6385	2.2 Mc INL	139.8	6.04	14	76	30.7	0.14	0.5	4.9
8/31/2007 18:50	42.6780	111.5710	0.5 Mc INL	146.3	4.98	3	191	31.4	0.05	9.4	7.9
9/1/2007 4:24	42.6620	111.6133	1.4 Mc INL	145.3	2.50	8	120	34.4	0.23	0.9	21.2
9/2/2007 4:55	44.7492	111.7783	1.3 Mc INL	146.3	7.48	10	171	9.2	0.10	0.9	1.0
9/3/2007 8:32	44.4352	113.0033	1.1 Mc INL	89.1	11.25	11	130	12.8	0.13	0.6	1.4
9/4/2007 9:34	44.3178	114.5142	1.5 Mc INL	157.5	7.34	13	252	84.4	0.10	1.9	1.7
9/4/2007 11:17	44.3100	114.5103	3.1 ML US	156.8	3.63	20	251	83.5	0.14	1.5	2.3
9/4/2007 12:43	43.0882	111.4050	1.0 Mc INL	127.9	7.36	7	217	4.8	0.10	1.6	0.7
9/4/2007 23:13	44.2368	114.0293	1.0 Mc INL	119.4	5.59	11	211	50.5	0.09	1.3	9.7
9/8/2007 17:09	42.9000	111.2730	1.4 Mc INL	148.2	9.68	13	160	12.8	0.11	0.7	1.0
9/10/2007 5:25	44.3142	114.5242	1.0 Mc INL	158.0	8.21	7	253	84.0	0.13	1.9	2.8
9/10/2007 6:11	44.3188	114.5020	0.7 ML INL	156.6	6.65	7	252	84.4	0.28	2.4	7.1
9/10/2007 12:02	44.3155	114.4938	1.1 Mc INL	155.9	6.28	7	250	84.0	0.24	3.2	5.4
9/10/2007 13:15	44.3163	114.5295	1.0 ML INL	158.5	1.61	7	253	84.3	0.28	4.4	7.8
9/11/2007 10:06	44.2270	111.0872	2.2 Ml UU	150.5	0.03	8	254	128.0	0.06	2.0	5.2
9/12/2007 15:11	44.3928	113.0018	0.6 Mc INL	84.5	9.75	5	312	8.6	0.09	1.1	1.3
9/12/2007 17:25	42.6997	111.6138	1.6 Mc INL	142.1	5.00	7	114	30.8	0.10	0.9	13.9
9/13/2007 3:08	44.2508	114.0787	0.9 Mc INL	123.6	6.67	9	216	54.2	0.35	2.2	4.6

ORIGIN TIME	LAT N	LONG W	MAG-TYPE	DIST	Z	NO	GAP	DMIN	RMS	ERH	ERZ
9/13/2007 16:43	44.3077	113.9875	1.4 Mc INL	121.2	7.31	11	214	46.5	0.18	1.2	19.5
9/16/2007 9:18	44.5738	114.1553	0.5 ML INL	150.4	7.12	5	243	66.5	0.16	3.9	3.1
9/16/2007 11:37	44.5442	112.9695	1.2 Mc INL	100.6	5.19	14	142	24.0	0.12	0.4	1.1
9/17/2007 20:18	44.3758	113.9420	1.0 Mc INL	123.1	7.55	6	278	63.3	0.22	4.7	22.4
9/21/2007 9:13	43.6818	113.7278	1.2 Mc INL	76.3	3.69	13	141	26.7	0.08	0.5	1.2
9/21/2007 10:37	44.8038	112.7690	1.9 Mc INL	128.4	11.13	18	161	6.9	0.06	0.6	1.1
9/23/2007 7:41	42.8880	111.5720	1.5 Mc INL	129.8	0.05	10	160	13.5	0.12	0.5	1.4
9/25/2007 14:44	44.1823	113.9517	1.0 Mc INL	111.0	5.01	7	201	49.0	0.09	1.2	14.5
9/26/2007 13:10	44.0998	113.9303	0.9 Mc INL	104.9	4.85	6	237	42.8	0.12	3.2	6.4
9/26/2007 21:26	44.7383	111.7323	1.1 Mc INL	147.3	14.11	4	183	5.4	0.03	1.6	1.9
9/27/2007 9:03	44.2937	114.1110	1.3 Mc INL	128.3	7.21	8	221	56.4	0.12	1.5	3.8
9/27/2007 16:31	42.8590	111.2332	0.4 Mc INL	153.5	12.85	4	167	15.0	0.00	2.2	3.7
9/27/2007 23:37	44.5698	113.9995	1.2 Mc INL	141.2	1.32	6	267	83.6	0.24	4.4	18.0
9/29/2007 7:40	44.6823	111.8938	1.1 Mc INL	135.1	5.01	4	206	28.7	0.17	2.8	18.5
9/30/2007 22:53	42.7445	111.3007	1.6 Mc INL	157.0	4.96	5	129	16.6	0.19	1.4	15.6
10/1/2007 15:29	43.8288	113.5298	1.0 Mc INL	63.3	5.93	8	201	12.7	0.09	1.4	1.0
10/2/2007 10:18	44.5692	114.2170	1.4 Mc INL	153.7	0.31	9	246	70.7	0.11	1.9	10.5
10/2/2007 10:48	44.4607	112.8925	1.3 Mc INL	90.6	6.96	12	115	15.1	0.10	0.6	12.4
10/7/2007 10:27	44.5895	112.3417	1.9 Mc INL	110.3	5.63	15	129	4.2	0.08	0.4	0.3
10/7/2007 20:26	44.6258	112.0945	2.2 Mc INL	121.7	13.12	22	140	24.1	0.08	0.4	1.3
10/9/2007 2:25	44.5680	114.1982	0.9 Mc INL	152.5	5.01	4	245	92.7	0.23	3.7	22.9
10/10/2007 7:25	44.6938	112.0948	1.4 Mc INL	128.5	12.66	15	158	26.3	0.09	0.6	1.4
10/10/2007 8:58	44.6043	112.3277	0.8 ML INL	112.2	2.98	8	138	5.4	0.08	1.0	0.5
10/13/2007 7:13	44.6787	111.9430	1.2 Mc INL	132.7	5.48	11	151	22.7	0.06	0.9	13.4
10/14/2007 0:05	44.3303	112.6140	0.6 Mc INL	76.9	1.15	5	177	23.7	0.01	2.6	10.0
10/14/2007 1:42	44.3710	112.6092	2.1 Mc INL	81.4	9.99	22	75	23.5	0.09	0.3	1.8
10/14/2007 1:56	44.3610	112.6085	0.6 Mc INL	80.3	2.70	6	192	23.3	0.04	0.9	1.6
10/15/2007 20:54	44.2642	113.9757	1.1 Mc INL	117.6	5.00	7	209	45.8	0.12	1.5	11.8
10/18/2007 17:06	44.3585	112.6085	0.3 Mc INL	80.1	5.04	4	190	23.3	0.10	7.0	10.7
10/20/2007 8:08	43.7642	111.1755	1.4 Mc INL	130.1	5.00	5	165	63.7	0.05	5.7	11.8
10/20/2007 12:23	44.3575	114.0267	1.3 Mc INL	127.0	1.25	11	260	49.8	0.16	3.2	7.4
10/24/2007 1:50	43.2175	110.9468	2.6 ML US	156.2	5.26	36	108	39.0	0.08	0.6	2.8
10/24/2007 6:30	42.7647	111.7123	2.0 Mc INL	131.4	8.96	16	80	30.6	0.28	0.8	4.2
10/24/2007 14:54	42.9377	111.4778	1.9 Mc INL	132.2	6.38	18	55	4.6	0.10	0.3	0.9
10/24/2007 15:17	42.9417	111.4723	0.3 Mc INL	132.3	8.02	6	96	4.2	0.09	0.7	1.1
10/24/2007 17:08	42.9362	111.4650	1.1 Mc INL	133.2	9.69	8	100	3.5	0.17	0.7	1.2
10/25/2007 14:20	44.0773	114.3538	1.5 Mc INL	134.9	6.92	20	124	26.2	0.11	0.3	15.3
10/26/2007 6:44	44.7813	111.6232	1.7 Mc INL	156.3	9.30	24	149	6.6	0.22	0.6	0.9
10/28/2007 22:57	44.3230	113.1982	1.0 Mc INL	81.9	6.94	18	75	16.6	0.16	0.4	8.1
10/29/2007 15:59	44.7815	111.6218	1.0 Mc INL	156.4	9.43	15	149	6.7	0.16	0.7	1.0
10/30/2007 15:54	43.0720	111.4965	1.5 ML INL	122.5	4.77	5	265	10.5	0.07	2.7	10.8
10/31/2007 2:08	42.6230	111.4230	1.4 Mc INL	159.0	9.07	13	163	26.9	0.11	0.8	2.3
10/31/2007 14:18	44.7467	111.8308	1.1 Mc INL	143.8	9.24	19	135	13.2	0.11	0.6	1.5
10/31/2007 15:32	44.3408	114.1033	0.9 Mc INL	130.8	1.31	15	130	47.4	0.14	0.5	3.6
11/1/2007 6:36	44.7158	113.0783	1.0 Mc INL	120.9	5.64	12	157	22.0	0.12	0.9	1.6

ORIGIN TIME	LAT N	LONG W	MAG-TYPE	DIST	Z	NO	GAP	DMIN	RMS	ERH	ERZ
11/1/2007 18:16	43.0570	111.3835	1.6 Mc INL	131.2	9.05	15	81	1.1	0.06	0.4	0.6
11/3/2007 13:26	42.8143	111.2043	1.1 Mc INL	158.3	8.46	12	149	29.8	0.07	0.7	3.6
11/5/2007 1:41	44.3493	112.6840	0.8 ML INL	78.2	7.00	13	102	20.6	0.05	0.5	13.0
11/5/2007 8:01	44.8525	111.9283	1.2 Mc INL	150.2	5.01	10	148	24.9	0.11	0.8	15.5
11/5/2007 20:15	44.3173	114.5393	1.7 Mc INL	159.2	0.02	15	134	36.0	0.10	0.8	9.7
11/6/2007 15:48	44.6037	112.6327	1.5 Mc INL	106.8	6.75	15	95	1.8	0.13	0.5	0.3
11/13/2007 14:00	43.9432	113.7288	0.2 Mc INL	82.8	1.57	10	173	22.3	0.22	9.0	2.5
11/14/2007 18:23	44.3598	113.9868	1.3 Mc INL	124.7	7.26	22	72	31.1	0.10	0.3	5.8
11/20/2007 3:40	44.9960	112.8493	2.0 ML INL	149.8	7.56	16	116	34.1	0.03	0.4	3.7
11/20/2007 10:02	44.5105	111.8520	2.0 ML INL	121.3	0.94	17	92	52.5	0.11	0.5	1.9
11/22/2007 1:39	44.3515	113.9950	2.7 ML INL	124.6	3.67	25	97	31.4	0.08	0.3	1.5
11/23/2007 11:09	42.8825	111.2148	1.7 ML INL	153.2	8.41	11	177	16.0	0.03	1.1	3.4
11/24/2007 15:40	44.7345	113.5643	2.0 Mc MB	135.9	7.28	10	265	48.7	0.09	2.4	14.4
11/25/2007 4:56	44.6852	112.0150	1.1 Mc MB	130.5	5.02	12	72	50.4	0.13	0.5	1.9
11/27/2007 14:37	44.6760	114.1228	1.7 Mc INL	156.5	2.80	6	280	70.0	0.11	4.3	11.5
11/29/2007 6:11	44.7458	113.0405	1.1 Mc INL	123.6	4.27	11	126	17.7	0.07	0.7	1.3
11/29/2007 11:10	43.5418	110.9705	1.4 Mc INL	146.8	12.85	15	97	28.9	0.09	0.4	0.9
12/1/2007 16:25	44.5927	111.4648	1.0 Mc INL	148.7	4.96	8	108	14.8	0.08	0.6	1.4
12/2/2007 8:47	43.2228	110.9163	1.4 Mc INL	158.4	14.57	21	135	22.7	0.14	0.6	1.4
12/4/2007 3:45	44.4415	112.8188	0.8 Mc INL	88.1	6.20	6	104	24.0	0.10	1.0	2.1
12/4/2007 5:06	43.2225	110.9223	1.7 Mc INL	157.9	7.33	26	132	23.1	0.15	0.3	2.2
12/4/2007 16:40	43.2277	110.9190	1.1 Mc INL	158.0	11.67	15	149	22.5	0.13	0.5	2.1
12/5/2007 12:53	44.7460	113.0190	1.8 Mc INL	123.4	10.96	34	108	16.2	0.14	0.4	0.9
12/8/2007 6:02	44.6397	112.0922	1.0 Mc INL	123.2	12.94	16	55	24.5	0.20	0.6	2.8
12/10/2007 20:42	44.2635	114.3408	1.6 Mc INL	142.4	0.04	18	156	42.7	0.21	0.9	3.3
12/12/2007 12:14	44.7808	111.6203	1.1 Mc INL	156.4	10.40	14	108	6.7	0.13	0.5	1.0
12/14/2007 12:09	42.9182	111.5763	1.9 Mc INL	127.3	2.18	23	73	9.6	0.11	0.4	13.8