

## **Seismic Monitoring in Nevada**

**February 2006**

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### **Summary**

Main missions:

- (1) Statewide seismic monitoring (State and USGS funded)
- (2) Intensive monitoring around Yucca Mountain in southern Nevada (DOE-funded).

UNR operates over 180 seismic stations in Nevada and eastern California.

132 ANSS (NN netcode),  
~50 Yucca Mountain (SN netcode).

UNR located ~9800 earthquakes in FY2005. 6,000-9,000 would be typical.

Estimated average magnitude of completeness within the authoritative region: ~M 1.0.

ShakeMaps made automatically; two for earthquakes felt in urban areas of NW Nevada.

Data analysis: Antelope Real-Time System

Analog, digital, and imported data recorded together in real time

Dataloggers: RT72A, RT130, Q330, Guralp, and EWorm digitizer

Strong-motion stations recorded in real-time: K2, Etna, RT130-ANSS, Q330-Episensor

Discrimination, triggering, association, location and magnitude using Antelope modules

All automatic and post-processing work uses an integral relational DataScope database.

Post-processing by dbloc2, dbpick, and dbml (Antelope), local and duration magnitudes  
(UNR local)

Recenteq's automatically updated from database at time of analysis.

(Narrative description adapted from December 2005 status report and renewal proposal)

## **Network Monitoring in FY 2005**

The region monitored is illustrated in the FY 2005 seismicity map of Nevada and eastern California (Figure 1). The UNR authoritative catalog region is also shown. The polygon approximately circumscribes the Western Great Basin (NN) stations. Located earthquakes smaller than  $M_L$  3.5 are shown as red dots. Earthquakes larger than  $M_L$  3.5 are in blue, with the symbols scaled by magnitude. Network average completeness is approximately  $M_L$  1.0, with higher levels east of the Walker Lane fault system. Locally, earthquakes concentrate along mapped faults, but there is a clear secondary tendency for minor faulting activity over most of western Nevada and eastern California. The largest earthquakes,  $M_L$  5.6 and  $M_L$  5.4, occur in the so-called Mina deflection, a NE fault system that relays Owens and Chalfant Valley strike-slip motion to the Central Walker Belt NW trending strike-slip faults and conjugate normal faults of the Central Nevada Seismic Belt (NS trend beginning near 39N, 118W). Western Great Basin network sensitivity in southern and central Nevada is aided by the DOE-funded Yucca Mountain network (network code SN). Other moderate earthquakes ( $M_L$  4.9 to 5.3) occur in the faulting system from north Lake Tahoe NW to the Portola area.

UNR produces:

1. Automatic and reviewed earthquake locations and  $M_d$  and/or  $M_L$ .
2. ShakeMaps for  $M_L$  3.0 and larger earthquakes.
3. QDDS feeds to *recenteqs*.
4. Contributions to the ANSS combined catalog.
5. Waveforms for export to CISN, Utah, NEIC, and IRIS.
6. Web page presentation of recent earthquakes, web links to USGS *recenteqs* for mapped seismicity, "Did You Feel It", and other top-level USGS pages.

## **Partnerships (Institution-Local-State-Federal )**

UNR maintains several partnerships that provide fiscal, facilities, infrastructure, and staff support that contribute to the operation of the network and generation of its products. Partners include the State of Nevada, the U.S. Department of Energy, and the University of Nevada, and support of shorter duration from other public and private grant agencies. Figure 2 shows the distribution of stations in and near the monitoring region.

*State of Nevada:* The State of Nevada established the Nevada Seismological Laboratory in 1974 with a broad mission that can be summarized as to monitor earthquakes, to understand their causes and effects, and to educate the citizens of Nevada on seismic hazards. State funding for network operations to the NSL covers the network engineer, part of the NSL administrative assistant, a portion of the Director, and some non-network-related teaching and research.

*U.S. Department of Energy:* The DOE funds operation of the sensitive network installed for site characterization of Yucca Mountain in southern Nevada, and seismic research of interest to the project. These stations come into a shared Antelope acquisition and analysis system. DOE-supported stations are (now) associated with the SN netcode. DOE funding of their mission amounts to a significant benefit to ANSS.

*University of Nevada:* The University of Nevada provides non-cash support in the form of facilities and office space for seismic network operations, administrative and purchasing support, and networking. The NSL arranged for fiber communications with Las Vegas Valley for ANSS strong-motion data flow. The University of Nevada Las Vegas and Cheyenne Community College host routers and multi-point radio access for strong-motion coverage to points around Las Vegas. UNR also "taxes" the USGS network operations cooperative agreement under the "off-campus" rate (26% instead of the usual 45%), which makes ANSS funds go farther toward network operations.

UNR imports waveforms from the CISN, the Anza array, and the NSN. Imports are particularly useful to improve regional locations. UNR stations in eastern California provide the primary station coverage for CISN in the area. CISN receives 61 channels of waveform data from UNR in real time.

### **Data Management Practices and ANSS Data Policy**

UNR is working to achieve standards set forth in the ANSS Data Policy. Locations are forwarded immediately from the real-time system to the QDDS processing stream, and are forwarded by QDM through cron-activated steps. Time to QDDS posting has not been measured, but the expected delay is about five minutes. Delays are related to a legacy software scripting system that also services the web posting. Web postings have an expected delay of ~2.6 minutes after an origin is reported. Local earthquake origin rows are posted with magnitudes to the tables within three minutes, although automatic processes that need that location get it sooner. E-mail and e-mail based pages are sent upon origination of the automatic location, and include a per-recipient configurable boundary and magnitude criteria. Automatic location qualities have not been systematically evaluated. Automatic depths are known to be poor, in part due to the variable velocity structure within the network and in part because we haven't worked on the problem.  $M_L$  magnitudes for felt earthquakes have been within about 0.2 magnitude units of final values in most instances, but have not been systematically evaluated. We do not systematically estimate  $M_w$ , primarily for lack of broadband sensor coverage.

Continuous waveforms for three-component NN stations are archived at the IRIS Data Management Center in SEED format. This archive began with four stations in October 2000. Presently NN digital stations are available at IRIS, with EHZ channels for short-period stations and all three components for broadband data. Event cuts are archived at UNR. Event cuts include analog station data.

Reviewed locations are submitted automatically to QDDS by a system that checks for analyst review. Inputs to the ANSS catalog are submitted in month-sized blocks after analysis and review. This process is typically 3-4 months behind (but worse, of late). UNR has been contributing to the combined catalog since 1982.

### **Earthquake Response**

UNR has tailored its off-hours coverage to the needs of the region and the frequency of significant earthquakes. In-person response availability for significant earthquakes in less than 15 minutes is realistic and has been achieved in practice. On-call seismologist staffing is maintained for both earthquake response and technical troubleshooting reasons. The troubleshooting response has been required to diagnose computer and telemetry problems that cause significant losses of capability or coverage. This duty so overlaps in skills that the addition of duty seismologist duties is very minor. Duty seismologist responsibilities are shared among the members of the professional staff. We

respond to hardware outages according to our assessment of their urgency, our ability to resolve it by interventions at home or at the lab, and to some extent according to the time of day. Overall, duty seismologist demands have been very manageable. On average, an after-hours intervention is required about once every three weeks (almost all due to a 12-year-old modem system that would be replaced with an IP telemetry system), and an after hours earthquake response once or less per year.

A larger group is responsible to help if a significant earthquake has occurred. For these events one or more of the professional analysts, all of the seismologists, and the network engineer are on call, to help with relocations, prompt analysis of aftershocks, media, telephones, and field response planning and aftershock deployment. Based on a 10+ year average, most staff are on site within 10-25 minutes following a significant earthquake. Also, some staff have the ability to confirm earthquake locations and magnitudes from home.

The significance of earthquakes has been treated differently in Nevada than might be in the eastern US or in California. For large rural portions of the state, earthquakes of M4 or larger are often not felt, and even when felt, the automatic solution is sufficient for after-hours (outside 7 a.m. to about 11 p.m. 7 days/week). An in-person response at 2 a.m. would be triggered by an M4+ in the Reno-Carson City area at any hour, but that earthquake 50 miles to the east would not because of the small number of people likely to feel it and the small likelihood of damage. For an earthquake eighty miles east of Reno, we may receive no felt reports. The result is a gap between draft ANSS performance standards, which prescribe human review of all earthquakes above M3.5 within 15 minutes, whether or not they are socially consequential.

## CAPTIONS

Figure 1. Seismicity map for the period from October 1, 2000 to September 30, 2005. Red dots mark earthquakes; magnitude-scaled cyan circles indicate those larger than  $M_L$  3.5. Black lines are faults. The polygon encircling most of the seismicity is the UNR authoritative catalog region. The QDDS boundary coincides on the west with the California-Nevada border. Several fault systems of western Nevada and eastern California can be seen in alignments of seismicity.

Figure 2. Station coverage in Nevada. Small red squares mark short-period analog stations. Larger red squares are digitally recorded at 16 bit resolution but transmitted over the analog microwave telemetry system. Blue triangles are 3-component digital sites, almost all with S-13 short-period seismometers. The concentrated cluster around 37N, 116.3W is the Southern Great Basin Digital Seismic Network installed and funded by the Yucca Mountain Project. Green circles are operated by others (netcodes US, LB, BK). Upside down blue triangles have strong-motion instrumentation; stars are formed where weak and strong motion sensors are co-located. Cyan diamonds are NSMP stations. UNR records one NSMP station in real time, and proposes to add another from those east of Reno in the coming year. Stations WAK and YER in western Nevada and SHP in southern Nevada are proposed for upgrades to broadband sensors and strong-motion recording. SHP will provide regional control on Las Vegas area ShakeMaps; YER and WAK will improve coverage for regional moment tensors and some improvement in strong-motion monitoring.

**Table 1**  
**Summary Statistics for Regional/Urban Seismic Network**  
(as of 30 Sept. 2005)

Total no. of stations operated and/or recorded	194
Total no. of channels recorded	533
No. of short-period (SP) stations	119
No. of short-period (SP) stations with metadata (response information)	44
No. of broadband (BB) stations ( <i>includes BK, AZ, US, LB imports</i> )	23
No. of broadband (BB) stations with metadata ( <i>at UNR</i> )	8
No. of strong-motion (SM) stations	92
No. of strong-motion (SM) stations with metadata	90
No. of stations maintained & operated by network (NN + SN netcodes)	180
No. of stations maintained & operated by network with full metadata	111
No. of stations maintained & operated as part of ANSS (means NN netcode)	132
No. of stations maintained & operated as part of ANSS with full metadata	69
Total data volume (mbytes/day) ( <i>total does not include 1.2 Gb/day of YM special application data</i> )	2.5Gb

**Table 2**  
**Earthquake Data and Information Products**

<b>Network Products</b>		
<b>Primary EQ Parameters</b>	Does the network provide the following?	Comments/Explanation
Picks		Available in real time by orb2orb to any cooperating Antelope operator.
Hypocenters		Available in real-time by orb2orb
Magnitudes (& Amplitudes)		$M_L$ and amplitudes available in real-time by orb2orb
Focal mechanisms		In post-processing stream
Moment Tensor(s)	no	
<b>Other EQ Parameters/Products</b>		
ShakeMap	yes	
Finite Fault	Yes, manually	
<b>Supplemental Information</b>		
Felt Reports	yes	
Event Summary	manually	
Tectonic Summary	Manual assembly	
Collated Maps	See note	Capability developed, in testing; ArcIMS covers, basemaps done
Refined Hypocenters (e.g. double-difference)	no	
<b>Web Content</b>		
Recent EQ Maps	Yes	Use Calif. page
Station Helicorder	Yes	
Station noise PDFs	No	No true BB's to use it on
Station Performance Metrics	No	
Network Description	No	
Station List	Yes	Would be hard to find
Station Metadata	Yes for stations at IRIS	
Email Notification Services	yes	
Contact Info	Not really	Lab main office contact, but not individuals
Region-specific FAQs	no	
Region-specific EQ info	no	
<b>Waveforms</b>		
Triggered	no	
Continuous	Yes, partial	Available. NN digital stations go to IRIS DMC
Processed	no	
<b>Summary Products</b>		
Catalogs	yes	
<b>Metadata</b>		
Instrument Response	partial	Nominal values for most stations available
Site Info (e.g. surface geology, Vs30)	partial	

Key:

## Network Products

Does the network  
provide the  
following?

Comments/Explanation

### **Descriptions:**

*Tectonic Summary:* Text and/or figures describing the tectonic setting of the event and related activity

*Event Summary:* Text and/or figures (press releases, collated media/disaster agencies info) that describes the earthquake and its effects

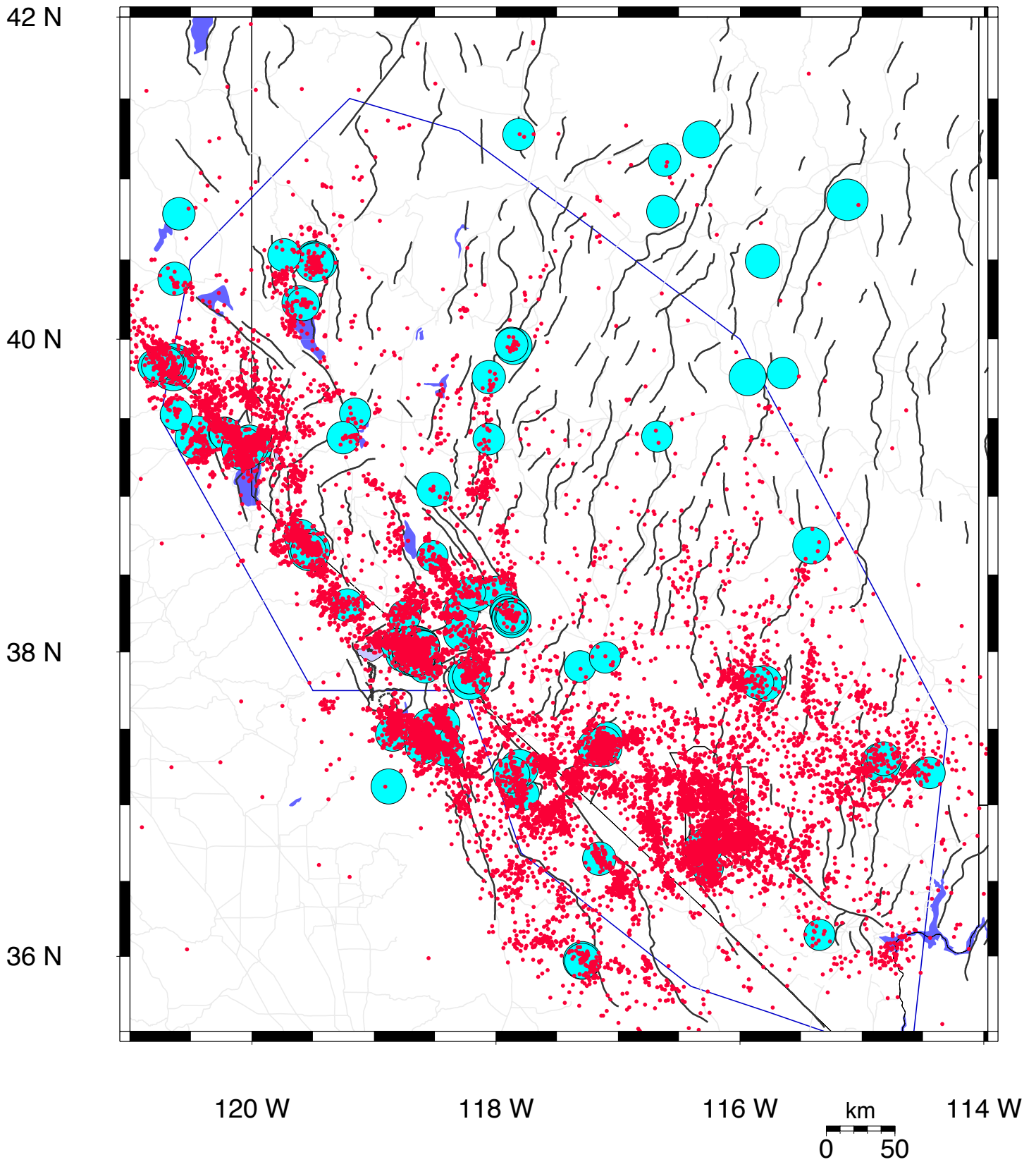
*Collated Maps:* Any map or set of maps that illustrates the event properties, tectonics, hazards, etc

*Processed Waveforms:* Specialized processing that is required by some portion of the community, e.g. processed strong motion records for the engineering community

*Catalogs:* Lists of parameters that describe an earthquake(s) or information used to describe an earthquake (e.g., picks, locations, amps,...)

*Region-specific earthquake information:* Description (text and/or maps) of historical earthquakes, faults/geology, etc.

# Nevada Seismicity, Oct 1, 2000 to Sep 30, 2005





# Nevada Station Coverage

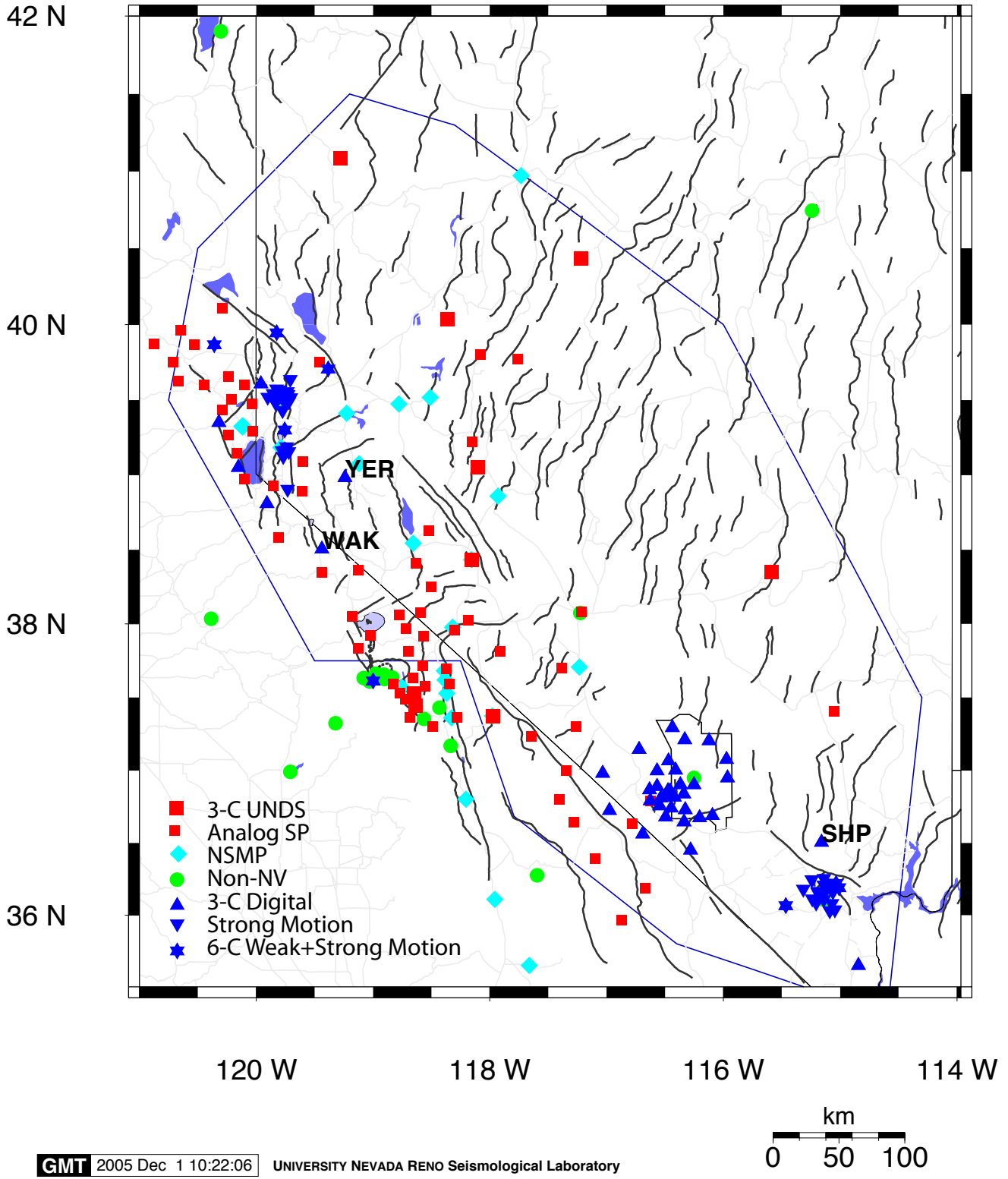


Figure 2