S11D MCC: Level 1 Monday 0830h

Seismic Hazards in the Great Basin I Posters *(joint with G)*

Presiding: **C M Snelson,** University of Nevada,, Las Vegas**; I G Wong,** Seismic Hazards Group, URS Corporation

S11D-0318 0830h POSTER

Kappa at Permanent Stations of the Southern Great Basin Digital Seismic Network

Glenn P. Biasi[1] (775-784-4576; glenn@seismo.unr.edu)

John G. Anderson[1] (jga@seismo.unr.edu)

James N. Brune[1] (brune@seismo.unr.edu)

Kenneth D. Smith[1] (ken@seismo.unr.edu)

Debi Kilb[2] (dkilb@ucsd.edu)

[1]University of Nevada Reno, Seismological Laboratory MS174, Reno, NV 89557-0141, United States

[2]U.C. San Diego, IGPP/SIO MS0225, La Jolla, CA 92093

We have undertaken a systematic study of spectral attenuation parameter kappa at permanent stations of the Southern Great Basin Digital Seismic Network (SGBDSN). Objectives included estimating kappa itself, reconciling disparate small and moderate earthquake estimates, and exploring magnitude and distance dependence of kappa. In seismic engineering, kappa can be the controlling parameter for site-specific seismic design amplitudes. We estimated kappa from the slope of S-wave spectral roll-offs relative to an omega-squared spectral shape, and for reference, an end-member model that assumes corner frequency effects can be ignored. Data include accelerograms and on-scale velocity recordings of over 40 earthquakes ranging in magnitude up to Ml 4.4 in and near the SGBDSN. To extend the magnitude range, a group of small earthquakes was also analyzed. Individual spectral fits exhibit a strong trade-off of corner frequency and kappa. Best-fit corner-frequencies may be identified but chi-squared significance tests and direct examination show that a wide range of corner frequencies and kappas would fit about as well. Fixing the stress drop predictably reduces scatter in kappa estimates. A linear distance correction improves the overall fit to kappa versus distance. However, systematic residuals in this model lead us to prefer a two-slope model where kappa does not increase with distance to 35 km, then increases at about 0.27 msec/km thereafter. Physically the increase beyond 35 km may indicate attenuation for ray paths in the lower crust. Comparing kappa at sites on alluvium, tuff, and Paleozoic limestone does not suggest an obvious correlation with surficial geology. Kappa estimates for moderate earthquakes are roughly consistent with a previous study in the area, and average 19 to 22 msec, depending on how the distance correction is implemented. Slope kappa is generally larger for smallest earthquakes. Site kappa estimates are scattered over a range of +/-10 msec, even for similar source-receiver paths. Disagreement between small and moderate earthquake kappa estimates might be resolved if low kappa events are caused partial stress drop behavior of the source.

S11D-0319 0830h POSTER

Las Vegas Valley Seismic Response Project: Quantification of Basin Response Using 2-D Finite-Difference Ground Motion Simulations

Aasha Pancha[1] (775 784 4251; pancha@seismo.unr.edu)

John N. Louie[1] (775 784 4219; louie@seismo.unr.edu)

John G. Anderson[1] (775 784 4265; jga@seismo.unr.edu)

[1]Nevada Seismological Laboratory and Department of Geological Sciences, Mail Stop 174, University of Nevada, Reno, NV 89557, United States

To improve the ability to predict basin effects, we conducted sensitivity tests using 2-D synthetics to evaluate and quantify the effects of basin properties on ground motion. The initial focus of this work is to aid characterization of the seismic response of Las Vegas Valley (LVV), Nevada to underground nuclear explosions at the Nevada Test Site (NTS). This modeling is part of a larger collaborative effort to characterize the basin and its response to ground shaking. Las Vegas Valley is an asymmetric alluvial basin 50 km wide and up to 5 km deep. We generated suites of 2-D elastic finite-difference simulations of seismic wave propagation for a geometry depicting explosive sources at NTS recorded across LVV. Near surface velocity information, derived from refraction microtremor data collected across LVV (Rasmussen et al., 2003, Fall AGU presentation), constrain velocity gradients within the basin and help us investigate effects of geotechnical layers on low-frequency ground motion. Simulation parameters are varied to determine the sensitivity of basin geometry, seismic velocity, basin velocity gradients, and Pg depth on the duration, amplitude, acceleration response spectra, and spectral amplitude of seismic shaking. The observed basin responses are complex, motivating the construction of a least-squares model to recognize average effects of the velocity-model and basin-geometry parameters on various ground motion measures. The least-squares inversion identifies parameters that significantly reduce the misfit responses. A number of linear forms of the model are considered. We can add additional variables to the model so long as error reductions are significant. Initial results indicate that local basin depth, distance from the basin edge, and velocity contrasts are most significant. Influence of Pg depth suggests that the mix of wave types propagating into the basin is an important factor for ground motion. Additional work will include earthquake sources of varying depth and focal mechanism to derive general basin response characteristics to earthquake motion.

S11D-0320 0830h POSTER

Shallow Shear Velocity and Seismic Microzonation of the Las Vegas Urban Basin

Tiana Rasmussen[1] (tiana@seismo.unr.edu); Shane B. Smith[1] (sbsmith@unr.edu); Matthew Clark[2] (mclark@seismo.unr.edu); Christopher Lopez[1] (ctlopez@unr.edu); Chris Loughner[2] (loughner@seismo.unr.edu); Hyunmee Park[1] (hpark@unr.edu); Jim B. Scott[2] (jscott@seismo.unr.edu); Weston Thelen[2] (wethelen@seismo.unr.edu); Bob Greschke[3] (passcal@passcal.nmt.edu); John N. Louie[2] (775-784-4219; louie@seismo.unr.edu)

[1]Dept. of Geological Sciences, Mackay School of Mines, Univ. of Nevada 172, Reno, NV 89557, United States

[2]Nevada Seismological Lab, Mackay School of Mines, Univ. of Nevada 174, Reno, NV 89557, United States

[3]IRIS-PASSCAL Instrument Center, New Mexico Tech, 100 East Road, Socorro, NM 87801, United States

In July 2003 we performed a seismic microzonation study of the Las Vegas basin along a 15 kilometer transect. Using 120 Reftek RT-125 “Texans” on loan from PASSCAL, we completed this transect in two days. 4.5-Hz geophones collected Rayleigh-wave data for dispersion analysis and velocity-profile modeling. Only passive urban seismic noise sources are needed for this refraction microtremor analysis; freeway and commuter traffic are used in this case. Using a geophone spacing of 20 meters, fifty 260-m array sections were analyzed to create a transect of 30-m shear velocity measurements 15 km long. The transect runs approximately parallel to Interstate 15 from Cheyenne Avenue at the north to Tropicana Avenue at the south, passing most of The Strip and downtown Las Vegas. We added a few refraction lines, with a sledgehammer source, to augment the microtremor dispersion data with P velocities. The lowest shear velocities observed in Las Vegas are in the NEHRP class D range, at 230 m/s, well above the NEHRP class E range. These lower velocities are found near Interstate 15 and Lake Mead Blvd. Velocities then rise smoothly southward to the middle of the NEHRP-C range (450-600 m/s) near Sahara Blvd. to the south. There appears to be a slight decline further south to Tropicana Blvd. Our results from only 3 km out of the 15-km-long transect have velocities near or below the NEHRP-C/D boundary at 350 m/s. This survey suggests a medium-scale study with a limited budget can be completed in a short time. The study is a crucial new step in the characterization of the effects of ground shaking due to a seismic source in the surrounding region. Similar studies have been completed in the Reno area basin and in the Los Angeles Basin. All of these studies suggest that shallow shear velocity does not correlate well with geologic map units. The range of velocities within one map unit is greater than the average difference between units.

URL: http://www.seismo.unr.edu/hazsurv

S11D-0321 0830h POSTER

Crustal Velocity Model of Watusi and Legacy Seismic Refraction Data, Clark County, Nevada

Shelley A Zaragoza[1] (702-525-3620; szargo@physics.unlv.edu)

Catherine M Snelson[1] (702-895-2916; csnelson@unlv.edu)

Darlene McEwan[1] (mcewand@unlv.edu)

John Sandru[1] (sandru@unlv.edu)

Aaron C Hirsch[2] (achirsch@csbsju.edu)

[1]Department of Geoscience, University of Nevada Las Vegas, 4505 Maryland Parkway MS 4010, Las Vegas, NV 89154-4010, United States

[2]Department of Geology, St. John’s University, Box 745, Collegeville, MN 56321, United States

Clark County, Nevada is located in the southern portion of the Basin and Range Province. As such, it has undergone tremendous extensional forces that produced numerous north-trending ridges and basins. Little is known regarding the crustal structure of the southern Basin and Range. Extension along the Las Vegas Valley Shear Zone (LVVSZ) has produced a northwest-trending corridor of particular interest that may channel seismic energy into the Las Vegas basin. Potential sources include energy produced by earthquakes as well as nuclear testing, should the Nevada Test Site (NTS) become active in the future. Previous studies include a crustal velocity model in the form of a fence diagram by Prodehl (1979) based on Legacy data, seismic refraction experiments performed when the NTS was active. Legacy data were collected on seismometers placed at intervals greater than or equal to 500 m. Seismic sources included chemical blasts and nuclear test shots. To examine whether structures along the corridor would cause seismic energy to dissipate or to transmit into the basin, in September 2002 we utilized 400 seismic instruments to record the Watusi chemical blast at the Nevada Test Site. The profile extended from Ann Road and I-95 northwest to the town of Indian Springs, where the station spacing was 125 m. The blast was located 65 km away from the first station and was expected to have the energy equivalent to 40,000 tons of TNT. However, most of the energy was lost into the air. In addition, falling debris produced diffractions in the data. We picked first arrivals and analyzed these data with forward modeling utilizing MacRay ray-tracing software, integrating these with Prodehl’s model to produce an updated, higher resolution crustal velocity model. The model indicates velocities of the upper to lower crust, into the Moho, with average velocities of approximately 6 km/s. Further studies will include integrating data from the Seismic Investigation of the Las Vegas Valley Evaluating Response (SILVVER) experiment, performed in August 2003, into a 3-D crustal velocity model.

S11D-0322 0830h POSTER

Comprehensive Analysis of Broadband Seismic Data in Las Vegas Valley

Hrvoje Tkalcic[1] ((925) 422-7332; tkalcic1@llnl.gov)

Arthur Rodgers[1] (rodgers7@llnl.gov)

Catherine Snelson[2] (csnelson@unlv.edu)

Darlene McEwan[2] (mcewand@unlv.edu)

[1]Lawrence Livermore National Laboratory, Earth Science Division, P.O. Box 808, L-206, 8000 East Avenue, Livermore, CA 94551, United States

[2]University of Nevada, Las Vegas, Department of Geosciences, 4505 Maryland Parkway, Las Vegas, NV 89154, United States

The city of Las Vegas is one of the fastest growing metropolitan areas in the world. Its urban area is located in a relatively broad sedimentary basin in the Basin and Range Province. Acknowledging that Las Vegas of 2003 is drastically different from Las Vegas of a decade ago, our objectives are to understand and predict ground motions and evaluate the effects of possible future earthquakes and nuclear tests at Nevada Test Site (NTS) on buildings in Las Vegas. A model of the basin depth was derived from gravity data in an independent study, while a model of compressional velocity structure of the basin was derived from seismic refraction studies. We are using strong motion accelerometers regional data, as well as newly acquired broadband teleseismic data to evaluate these models, and predict ground motions at the surface. Delay times of about a dozen analyzed teleseismic P-waves show variation of up to 0.5 seconds across relatively short distances (15 km or less), providing some valuable information on basin shape and thickness. Teleseismic P-waves have favorable signal-to-noise for low frequencies (0.1 to 1.0 Hz). This provides complementary site response measurements to those obtained from regional earthquakes and explosions. Our results indicate a clear difference

S

in site response between hard-rock and basin stations, with amplification reaching factor 5 for the basin stations. The measured P and S wave energies for the recorded data also corelate well with the existing basin depth model, providing additional constraint in modeling the basin shape and structure. We use time domain deconvolution receiver functions to constrain the position of basin boundaries and main crustal discontinuities. Finally, we simulate low frequency ($f < 1$ Hz) theoretical ground motion in Las Vegas Valley by an elastic finite difference code. Preliminary results show that we can predict relative amplification, as well as some of the complexity in the waveforms, even without invoking complex (and computationaly expensive) three-dimensional structural models. This work is in progress.

S11D-0323 0830h POSTER

Initial Results From the Las Vegas Valley Broadband Array Based on Differential Travel Time Residuals and Interstation Phase Velocities

Darlene J McEwan[1] (702-895-4633; mcewand@unlv.nevada.edu)

Catherine M Snelson[1] (csnelson@unlv.nevada.edu)

Hrvoje Tkalcic[2] (tkalcic1@llnl.gov)

Arthur Rodgers[2] (rodgers7@llnl.gov)

[1]Department of Geoscience, University of Nevada Las Vegas, 4505 Maryland Parkway, 4010, Las Vegas, NV 89154-4010, United States

[2]Lawerence Livermore National Laboratory, P.O. Box 808, L-206, 800 East Avenue, Livermore, CA 94551, United States

Eight broadband seismometers, collectively known as the Las Vegas Valley Broadband array (LVVBB), were deployed by Lawerence Livermore National Laboratory (LLNL) and the University of Nevada Las Vegas (UNLV) in September 2002. The LVVBB array recorded data continuously from local and regional earthquakes as well as global teleseisms through late January 2003. The coverage area extends throughout the northeastern regions of the Las Vegas Valley; the area estimated to be the deepest portion of the Las Vegas basin based on gravity data. Differential travel time residuals were calculated through the cross-correlation of P-wave arrivals from global teleseisims to better constrain basin geometry and depth to basement. The calculated delay times show variations up to 0.5 s over distances of 15 km or less. The residual pattern is consistent across the basin and is associated with zones of thicker basin fill. This supports earlier models of the basin. A number of regional earthquakes originating in southern California are linearly aligned with the LVVBB array. Interstation phase velocities of Rayleigh wave propagation from these events are being used to create surface wave dispersion curves to assist in modeling the shear wave velocity structure of the region. Given the current models, average shear velocities of 0.96 km/s and 1.25 km/s characterize the change from shallow to deep sediments. These new results will further constrain the shear wave velocity in the study area, and aid in evaluating the behavior of basin fill for building construction. These studies contribute to the modeling of ground-motions in Las Vegas Valley and can be used to assess the Valley's response in the event of an earthquake or future nuclear testing at the Nevada Test Site.

S11D-0324 0830h POSTER

Geologic Interpretation of the Las Vegas Valley Based on Industry Seismic Reflection Data

Aaron Hirsch[1] (952-239-7243; achirsch@csbsju.edu)

Catherine M Snelson[2] (csnelson@unlv.nevada.edu)

[1]St. John's University/College of St. Benedict, Department of Geology; Pengle Science Center, Collegeville, MN 56321, United States

[2]Univeristy of Las Vegas Nevada, Department of Geoscience, University of Nevada Las Vegas, 4505 Maryland Pkwy, MS 4010, Las Vegas, NV 89154-4010, United States

Las Vegas Valley, NV is located in the southern Basin and Range Province where the basin was formed by the Las Vegas Valley Shear Zone as well as by several thrust and normal faulting events that occurred by Cenozoic time. The geology and tectonic setting in the Las Vegas region is poorly understood given the fact that many structures have been covered by the constant growth of the City. National studies of ground motion and amplification of seismic energy placed Nevada third in the list of states having the potential for loss of life and property due to earthquakes. The Las Vegas area has a high potential for strong ground shaking due its thick basin fill and associated amplification. Due to the amplification effects within the Valley, moderate nearby quakes or large distant quakes will produce a large amount of damage in the Valley. Las Vegas, though not known for its earthquakes, has numerous micro quakes and an active seismic history. In a study using HAZUS to predict damage associated with a M6.9 earthquake, the loss would be billions of dollars with thousands of lives lost. Long-term economic loss would be in the several billions of dollars. Recently, several normal faults, which have the potential to produce a M6.5 to 7.0 earthquake, were reclassified as active tectonic fault with Quaternary movement. As a result, there has been increased effort to understand the Las Vegas Valley and to assess its potential for seismic hazards. One such effort included acquiring industry reflection profiles that cross the Valley. In the 1980's, north/south and east/west trending reflection lines with intersecting tie points were placed between Frenchman Mountain to the East and Spring Mountains to produce seismic profiles using Vibroseis. The profiles, which are over 200 kilometers in length and extend down to 5 s in time or approximately 15 km depth, will provide a tie between the surface work that is currently being conducted and the crustal velocity models that are being calculated to produce a seismic hazard potential for the Las Vegas Valley. The quality of the Vibroseis data is very high. We have been able to locate the basin/bedrock contact as well as several faults that cut the sections. All of which have been mapped on the shot point map. Most of the faults appear to be normal faults listric in character that trend north-south paralleling the structure of the southern Basin and Range. Basin geometry and associated minor folding, which have been truncated by minor faulting, can be seen across the profiles. Some faults can be seen as tectonic in origin while others are merely subsidence faulting from basin settling. With this new data we will identify structures that could potentially focus energy in the sub-surface adding to our growing knowledge of the basin geometry. In addition, this data will be incorporated into the seismic hazard model that is being developed for the Las Vegas Valley and will provide very detailed geologic information that has not been previously available.

S11D-0325 0830h POSTER

Preliminary Results From SILVVER '03 - Seismic Investigations of the Las Vegas Valley: Evaluating Risk

Catherine M Snelson[1] (702-895-2916; csnelson@unlv.nevada.edu); John Sandru[1]; Darlene J McEwan[1]; Aaron Hirsch[2]; Shelley A Zaragoza[1]; Anna Draa[1]; Andrew D Hanson[1]; Galen Kaip[3]; Steven H Harder[3]; Steve Azevedo[4]; William McKibben[4]; Arthur Rodgers[5]; J. Patrick Lewis[5]; Duane Smith[5]; Donald Rock[5]; Dave McCallen[6]

[1]Department of Geoscience, University of Nevada Las Vegas, 4505 Maryland Pkwy, MS 4010, Las Vegas, NV 89154-4010, United States

[2]Department of Geology, St. John's /College of St. Benedict, Pengle Science Center, Box 745, Collegeville, MN 56321, United States

[3]Department of Geological Sciences, University of Texas at El Paso, 500 University Ave., El Paso, TX 79968, United States

[4]IRIS PASSCAL Instrument Center, New Mexico Tech, 100 East Road, Socorro, NM 87801, United States

[5]Seismology Group, Earth Science Division, Lawrence Livermore National Laboratory, L-205, Livermore, CA 94551, United States

[6]Laser Science Engineering Division, Lawrence Livermore National Laboratory, Livermore, CA 94551, United States

In August 2003, the University of Nevada Las Vegas (UNLV) with the assistance of the several other institutions acquired seismic refraction data and broadband data across the Las Vegas basin, NV. The SILVVER '03 (Seismic Investigations of the Las Vegas Valley: Evaluating Risk) project is in part a continuing effort to characterize the Las Vegas basin for strong ground motion. The objectives of this phase of the Las Vegas Valley Seismic Response (LVVSR) project were to acquire 3-D seismic data across the basin to define the geometry and structure in the sub-surface; to identify subbasins, which can focus energy in the basin; and test the current basin model, which shows that the northeastern portion of the basin is as deep as 5 km of unconsolidated basin fill and has increased amplification. The experiment consisted of two seismic refraction profiles of about 55 km in length each. One profile extended from the northeast, across the Las Vegas Valley Shear Zone and the transition from the deep to shallow portions of the basin to the southwest. The second profile extended from the southeast from Frenchman Mountain to the northwest towards the Nevada Test Site along a corridor that is thought to focus energy into the Las Vegas Valley. Station spacing along the profile was nominally 100 to 200 m and shot point spacing was on the order of 10 km. There were 8 shots that were successfully recorded ranging in size from 50 to 1000 lb. The overall quality of the data is very high, especially since the majority of the instruments were deployed in the urban area. Initial results show that the basin can be characterized by an average velocity of 4 km/s while the transition into the crust indicates there is a dramatic velocity increase to 6 km/s at the basin/bedrock contact. The data from this experiment will be used to produce a 3-D tomographic velocity model of the Las Vegas basin. In addition to the seismic refraction profiles, we set out 6 broadband stations across the Valley in an effort to record the chemical blasts. These instruments are currently deployed and recording continuously. Only the larger shots were captured by the broadband array. These data will be used to further our understanding of the Las Vegas basin and the potential seismic hazards that the region faces. In addition, these newly acquired datasets will be integrated into a 3-D community model that is being developed by the working group that will identify areas in the Valley where there could be an increase of amplification due to strong ground motion.

URL: http://geoscience.unlv.edu/pub/snelson/SILVVER

S11D-0326 0830h POSTER

Preliminary Assessment of Basin-Induced Amplification of Weak Ground Motion in Pahrump Valley, Nevada-California

Robert E. Abbott (reabbot@sandia.gov)

Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM 87185-1168, United States

Sedimentary basins can increase the magnitude and extend the duration of seismic shaking. This potential is investigated for Pahrump Valley, Nevada-California, by comparing the waveforms and spectra of weak ground motion recorded in the city of Pahrump, Nevada, to those recorded in the nearby mountains. Preliminary results, based upon a few events, suggest significant amplification (5x or more relative to a rock site) at frequencies ranging from 4 to 15 Hz, depending on the location of the basin station. The Pahrump Valley is located approximately 50 km WNW of Las Vegas. Gravity data suggest that the city of Pahrump sits atop a narrow, approximately 5 km deep sub-basin in the valley. The city of Pahrump has seen tremendous growth in recent years (over 200% population increase in 10 years) and the growth rate is increasing. Several nearby fault systems represent a seismic hazard to the population of Pahrump and its neighboring communities; the most notable hazard is from the Pahrump Valley Fault Zone which runs along the western edge of Pahrump Valley. Proximity to the more active Death Valley and Furnace Creek Fault Zones, both less than 50 km distant, and possible future underground nuclear tests at the Nevada Test Site, 75 km to the north, also represent a potential hazard.

S11D-0327 0830h POSTER

Late Quaternary Surface Rupture and Associated Transpressive Uplift on a Section of the State Line Fault in the south-central Amargosa Desert Basin, Southwestern Nevada

Christopher M. Menges[1] ((520-670-5022); cmmenges@usgs.gov)

Chris Fridrich[2]

Richard J. Blakely[3]

Ren A. Thompson[2]

[1]USGS, 520 N. Park Ave, Tucson, AZ 85719, United States

[2]USGS, Denver Federal Center, Denver, CO 80225, United States

[3]USGS, 345 Middlefield Rd, Menlo Park, CA 94025, United States

New geomorphic, geophysical, and structural data indicate that a section of the Pahrump-Stewart Valley (State Line) fault on the northern piedmont of the Resting Spring Range is associated with late Quaternary surface rupture and related transpressive domal uplift. Detailed aeromagnetic and gravity data clearly image this northwest-trending strike-slip fault in the subsurface as a continuous multi-strand fault system that continues >35 km further northwest into the south-central Amargosa Desert basin than previously established. This continuation of the fault consists of a sigmoidal bend characterized by a constraining bend on the north flank of the Resting Spring Range, paired with a releasing bend on the north flank of the southeastern Funeral Mountains. Bedrock mapping in the Amargosa Desert indicates a cumulative late Cenozoic right-lateral displacement of ∼15 km across the entire fault zone. In the Resting Spring area, the major central strand of the State Line fault zone is inactive but offsets playa facies of the Artists Drive Formation

(equivalent), internally folded into a giant southeast-plunging chevron syncline, against fluvial and playa margin facies of the same formation that are folded into a broad northwest-plunging anticline. These deformed Tertiary strata are exposed in the core of a large (10 x 18 km) domal Quaternary uplift, centered on the northern piedmont of the range, that coincides with a major transpressive left-step in the adjoining active trace of the fault zone. The domal uplift is indicated by persistent incision into Tertiary bedrock (1-5^{+} m deep) beneath stepped sequences of straths capped by thin and locally warped mid-Pleistocene to Holocene alluvial-gravel veneers. Quaternary activity on the fault zone in this area is now focused on a strand along the northern and eastern border of the uplifted area marked by a discontinuous, 8-10 km long series of aligned, en-echelon, or anastomosing fault scarps that commonly bound linear pressure ridges cored by internally deformed Tertiary strata. These scarps dip steeply up to 20°-30° downslope at the base of the uplifted ridges, vary in height from 0.2-2.7 m, and are associated with persistent right-lateral gully offsets of 0.5-5.2 m. The geomorphic data indicate varying amounts of lateral and vertical (reverse) surface displacements, depending on location and orientation within the overall left-stepping fault zone. Combined measurements of vertical and lateral displacement at 10 sites yield estimates of right-oblique net slip for the most recent faulting event that range from 1.9-5.2 m (averaging 3.1 m). A latest Holocene (<2ka) age is estimated for this surface rupture based on both stratigraphic relations to surficial deposits and scarp morphology. Geomorphic evidence for prior ruptures is absent or poorly constrained, but generally suggests recurrence intervals at least on the order of 10^4 yrs. Paleoseismic interpretations of the net-slip displacement data suggest that the fault scarps are probably associated with a **M** 7.1-7.3 paleoearthquake along a rupture zone on the State Line fault that, although not studied in detail, most likely continued ~ 35-40 km to the southeast from the Resting Spring area through Stewart and northwestern Pahrump Valleys. The Holocene surface rupture at the Resting Springs area is unlikely to extend northwest along the northeastern flank of the southeastern Funeral Mountains because upper to middle Pleistocene surfaces are only locally warped, with no detectable fault scarps, in that area.

S11D-0328 0830h POSTER

Using Precision Gravity Survey To Locate Faults Within The Southern Mesilla Bolson, Rio Grande Rift.

Salma Khatun[1] (915-204-5400; khatun@geo.utep.edu)

Diane Doser[1] (915-307-5851; doser@geo.utep.edu)

Ekal Imana[1] (915-747-5401)

[1]Department of Geological Sciences, University of Texas at El Paso., 500, University Av., El Paso, Tx 79968

The southern Mesilla bolson of west Texas and southern New Mexico is a rapidly growing portion of the El Paso-Juarez metropolitan area. Faulting within the bolson is difficult to trace due to intensive urban and agricultural activities. Prior to channelization of the Rio Grande in the 1930's the river also frequently altered its course, rapidly depositing or eroding sediment within the bolson, also making the tracing of faults or offset surfaces difficult. We have used the precision gravity technique (digital precision gravity meter, station spacing of 60 m or less, elevation known to 30 cm or less) as an inexpensive method to map possible locations of faults within the bolson. We analyze the gravity data using 3-D modeling techniques that can account for known geology and topography, which are then subtracted from the observed gravity data. The residual gravity map is then examined for sharp gradients and bends in gravity contours that may indicate the presence of faults. Once suspected faults are identified we have conducted follow-up geophysical surveys (DC resistivity sounding, spectral analysis of surface waves) over the structures to determine if grain size or sediment compaction changes (often indicative of faults) are associated with the gravity anomalies. Water well logs have also aided in our interpretations. Our results suggest there are at least 3 faults within the bolson that parallel the range bounding fault that separates the eastern bolson from the western edge of the Franklin Mountains. If these faults are currently seismogenic, they represent a significant hazard to the urban areas located on the thick (1500 m), water saturated sediments of the bolson. We feel the precision gravity technique could serve as a useful reconnaissance tool to help identify faults in other regions where urbanization or other factors limit surface exposure of recent geologic processes.

S11D-0329 0830h POSTER

Strong Motion Prediction Within a Basin Located Above the Teton Fault in Wyoming

Daniel R.H. O'Connell[1] (303-445-3176; geomagic@seismo.usbr.gov)

Robert W. Graves[2] (626-449-7650; robert_graves@urscorp.com)

Lisa V. Block[1] (303-445-3171; lblock@do.usbr.gov)

[1]USBR, PO Box 25007 D-8330, Denver, CO 80225-0007, United States

[2]URS Corporation, 566 El Dorado St., 566 El Dorado St., CA 91101, United States

Strong motion estimates were developed for a site near the center of a basin located above the Teton fault near Jackson, Wyoming for scenario M 6.9 to 7.1 normal-faulting earthquakes. A 3D velocity-hypocenter inversion using 1150 earthquakes recorded by the Jackson Lake Seismic Network resolves velocity variations down to a scale of several km and delineates a 4-km-deep low-velocity basin located above the east-dipping Teton fault. Details of basin boundary and internal velocity structure was derived from reinterpretation of existing seismic refraction data, and 2D finite-difference waveform modeling of three microearthquakes (MEQ) located near the perimeter of the basin and recorded on broadband stations near the middle of the basin. The refraction data and MEQ waveform modeling indicate nearly linear vertical velocity gradients within the basin. Published interpretations of the refraction data used constant velocity layers with strong velocity discontinuities within the basin which fail to reproduce strong broadband arrivals that follow direct S-waves by 4-6 s; these arrivals are composed of S-waves and surface waves produced at the basin margins. Reciprocity 3D finite-difference viscoelastic Green's functions were used to synthesize motions for frequencies <1 Hz and eight empirical Green's functions (EGF) were used to synthesize > 1 Hz motions. Kinematic finite-fault rupture models were generated with self-similar slip distributions and variable rupture and rise times. A 3D eikonal equation solver was used to calculate first S-wave arrival times for point-source summations of EGF's. The dip of the Teton fault is not well constrained; dips of 35, 45, and 60 degrees where used to synthesize ground motions. For a 35-degree fault dip, directivity produces factor of two stronger peak responses on the fault perpendicular component than the fault parallel component for all periods. For periods > 0.7 s and a 60 degree fault dip, peak motions were stronger on the fault parallel component than the fault perpendicular component; the strongest arrivals on the fault parallel component are associated with basin-edge waves. The top 5 km of the Teton fault is located within 2-3 km of the western edge of the basin. The western edge of the basin acts as a strong secondary seismic source for sites within the basin; basin-edge S-waves close to the fault are nearly critically reflected for sites near the center of the basin and produce large acceleration and velocity responses that extend the duration of strong shaking by > 10 s within the central portion of the basin.

S11D-0330 0830h POSTER

Colluvial Wedge Study at the Provo Segment of the Wasatch Fault Zone

Maike Liselotte Buddensiek[1] (801-585-1538; maikeb@geophys.utah.edu)

Susan S Olig[2] (510-874-1729; susan_olig@urscorp.com)

Ann Mattson[1] (801-587-7699; amattson@mines.utah.edu)

Ronald L Bruhn[1] (801-581-6619; rlbruhn@mines.utah.edu)

Gerard T Schuster[1] (801-581-4373; schuster@mines.utah.edu)

[1]University of Utah, Department of Geology and Geophysics, 135 South 1460 East Room 719, Salt Lake City, UT 84112, United States

[2]Seismic Hazards Group URS Corporation, 500 12th Street, Suite 200, Oakland, CA 94607, United States

Measuring the size and depth of colluvial wedges by paleoseismic trenching is valuable in estimating the past history of a fault. Unfortunately, trenching is very costly, time consuming and causes environmental damage. A complementary investigation method is seismic trenching, i.e. inverting traveltime data from refraction experiments to produce trench-scale tomograms. Here, we show the preliminary results for inverting three seismic lines collected next to the Mapleton Megatrench, which crosses the Provo Segment of the Wasatch Fault Zone, Utah. The seismic data were collected along an 83.5 m high-resolution line along a USGS trench site and two 595 m long low-resolution lines parallel and perpendicular to the high-resolution line. The low-resolution lines were used to image the Lake Bonneville sediment horizon (LBS) in order to establish an upper LBS datum on the tomograms; and the high-resolution data were used to find colluvial wedges. The LBS horizon interpreted from the tomograms agreed with the actual location determined from three sediment cores. The pending results of the trench, that intersected the high-resolution line, show that the faulting is more complex than seen in the smoothed tomograms. However, some of the faults and three possible colluvial wedges were interpreted in the tomogram. It is also clear that some important geologic features seen in the trench are too finely detailed to be resolved in the tomogram. Due to the complexity of the fault geometry encountered in the paleoseismic trench, we see a need to increase the resolution of the geophysical method to a scale of 0.5 meter.

S11D-0331 0830h POSTER

Shaking Hazard Predictors in the Reno, Nevada Area Basin

Jim B. Scott[1] (775-784-4251; jscott@seismo.unr.edu); Matthew Clark[1] (775-784-4251; xv1100mc@aol.com); Thomas W Rennie[1] (775-784-4976); Aasha Pancha[1] (775-784-4251; pancha@seismo.unr.edu); Hyunmee Park[1] (775-784-6465; hpark@unr.edu); Matthew Purvance[1] (775-784-4251; mdp@seismo.unr.edu); John N. Louie[1] (775-784-4219; louie@seismo.unr.edu)

[1]Nevada Seismological Laboratory, Dept. of Geological Sciences, University of Nevada, Reno, University of Nevada MS 174, Reno, NV 89557, United States

We investigated several known and potential predictors of earthquake hazard in the Reno basin including: 1) refraction microtremor shear velocity averaged over 30 m depth (V30); 2) gravity-depth modeling; 3) surface geology and soil type; and 4) a precarious rock limit on maximum historic shaking. We combined the results of a V30 transect across 16 km of the basin performed in October and November, 2001 with a gravity-depth modeling study reported in 2000 to produce a shear-velocity model applicable to the shallow basin. The shallow shear-velocity transect was completed using our refraction microtremor method. Shallow shear velocity predicts earthquake ground motion amplification and potential hazard in similar alluvium-filled basins, and is the basis of site hazard classification under NEHRP-UBC provisions (BSSC, 1998). A geologic map-based classification of nearly all of our transect line would be NEHRP-D. Our measurements of V30 revealed that, in fact, most (82%) of the transect is classified NEHRP-C. No correlation of V30 with most mapped surface geology or agricultural soil type was found. A precarious rock site on the northwestern side of the basin placed a 0.5 g limit on historic shaking. Anomalous sediments having unusually high V30 were discovered filling a western sub-basin and will be the subject of further study. We conclude that: 1) The Reno basin has stiff Tertiary sediments underlying the surface at shallower depths than do other urban basins such as the Los Angeles basin. Weaker soils appear to occur east of downtown Reno in the broad floodplain of the Truckee River. 2) Surface geology is a poor predictor of V30 in the Reno basin. 3) Very large earthquakes have probably not occurred in the Reno area in geologically recent times.

S11D-0332 0830h POSTER

Holocene Fault Activity Beneath the Great Salt Lake: Correlating Near-Surface Faults with Bathymetric Surface Gradients

Andrew M Hennes[1] (520-621-4890; ahennes@geo.arizona.edu)

Roy A. Johnson[1] (520-621-4890; johnson@geo.arizona.edu)

[1]University of Arizona, Department of Geosciences 1040 E. 4th St., Tucson, AZ 85721, United States

Fault scarps along the Wasatch Front are evidence of seismically active normal faults that have accommodated east-west extension along the eastern margin of the Basin and Range province since the Tertiary. These well-defined, large-offset normal faults juxtapose Precambrian rocks of the Wasatch Range against thick syntectonic Tertiary and younger strata in the Salt Lake Basin. A system of similar listric normal faults with large offsets are imaged in industry seismic reflection data from beneath the Great Salt Lake just to the west of the Wasatch Front. Offsets near the surface on these listric faults are evident in several seismic profiles from the Great Salt Lake and suggest that displacement has continued at least through the Tertiary. Some of these young faults may have movement recent enough to breech the surface and produce a scarp. Interpretation of high-resolution seismic data (Colman et al., 2002) reveals episodes of major faulting since 13.5 ka that offset the surface. Fathometer-recorded water

depths collected during the dense industry seismic program cover approximately 70 percent of the Great Salt Lake and allow a unique opportunity to construct a detailed bathymetric map of part of the Great Salt Lake. Geostatistical analysis of the water depth reveals the expected relatively smooth overall bathymetric surface of the floor of the Great Salt Lake, but also shows that it is disrupted by several abrupt changes in the bathymetry. A plot of the gradient magnitude, or rate of change of the bathymetry, indicates several linear features with steep surfaces much like fault scarps that trend along the regional fault fabric. Areas of highest gradient magnitude may indicate areas of most recent offset and may delineate the aerial extent of more recent fault activity. These anomalous surface gradients correlate well with seismically defined normal faults that run along the western margin of Promontory Point and Antelope Island, as well as along the northern side of Carrington Island, suggesting that major intra-basin and basin-bounding normal faults do breach the surface over much of their lengths. Development of laterally continuous fault scarps in a flat, internally drained basin indicates very recent fault activity beneath the Great Salt Lake.

URL: http://www.geo.arizona.edu/∼/ahennes/Research.htm

S11D-0333 0830h POSTER

Geophysical Studies of Seismic Hazard in the Tahoe City Sub-basin, Lake Tahoe, California

J. M. Muehlberg[1] (775-784-1093; muehlber@unr.nevada.edu)

R. A. Schweickert[1] (richschw@unr.edu)

J. McHugh[1] (jmchugh@unr.nevada.edu)

T. Rasmussen[1] (tiana@seismo.unr.edu)

J. N. Louie[1] (775-784-4219; louie@seismo.unr.edu)

[1]Department of Geological Sciences, Mackay School of Mines, Univ. of Nevada 172, Reno, NV 89557, United States

The Lake Tahoe basin has the potential for serious earthquakes and earthquake-related tsunamis. The history of lake level fluctuations should be recorded in sediments beneath the Lake's outlet at Tahoe City. Borehole data show the sediments consist primarily of a thick sequence of lacustrine silts and clays with interbedded sands. Beneath this unit is an older Q-T (?) sand and gravel sequence of unknown origin. The lacustrine deposits locally rest upon 2.0 Ma latites, which in turn rest upon the older sand and gravel sequence. Near the outlet, several fault scarps displace units less than 2.0 m.y. old. These scarps may influence the stability of the dam across the outlet and the sequence and extent of lake level high stands. Our project is integrating geophysical and stratigraphic data to further define and describe the Tahoe City sub-basin. We collected new gravity data to provide an estimate of basin depths across the outlet and help define subsurface faults. Preliminary data suggest the maximum basin depth is 180 m, near the outlet. Refraction microtremor surveys yielded information about stratigraphy and shear velocities of the Quaternary deposits. The average shear wave velocity to 30-m depth obtained for this area is 334 m/s. These values correspond to a NEHRP soil hazard class of D, similar to that found in other lacustrine basins of the region. Soils in this NEHRP class tend to show a significant amplification of shaking, posing increased hazard to structures. We are combining stratigraphic with gravity and seismic data to produce geologic cross sections having information on basin depths and Quaternary faults.

S11E MCC: Level 1 Monday 0830h

Novel Ways of Analyzing the Seismic Coda I Posters

Presiding: **R Snieder,** Center for Wave Phenomena/Colorado School of Mines; **M Campillo,** Universite Joseph Fourier

S11E-0334 0830h POSTER

Passive Seismic Imaging

Brad W Artman (650 723 6007; brad@sep.stanford.edu)

Stanford University, Geophysics Mitchell Bldg, Stanford, CA 94305, United States

Traditionally, passive seismology connotes the use of earthquake signals from continuously recording receivers. Small time windows around the arrivals of earthquakes are then analyzed in myriad fashion. I will distinguish from this body of work, the notion of passive seismic imaging, which requires no knowledge of the time or characteristics of a source event. Instead, by using the ambient noise in the subsurface with all orders of scattering and thus randomized directionality, passive seismic imaging can produce results analogous to conventional controlled source experiments. Mathematical proof of the concept of passive seismic imaging has been presented in the literature from several foundations. The results reduce to the simple concept of cross-correlating many long recordings within a simultaneously deployed array. This generates panels with the kinematics of a shot-gather from a standard reflection seismic acquisition effort. Results from synthetic data sets show the validity of the method for point diffractor, and layered earth models. Noting the similarity of form of the standard approach to produce shot-gathers with the imaging condition of shot-profile migration, I then show that migrating the raw passive seismic data without the correlation step produces the the correct image. The synthetic data from above is used to demonstrate the technique. By comparison, this image is of better quality, and demands less compute time, than migrating the data having been cross-correlated first. Finally, both techniques are used to process a 2x2 meter, 72-channel array recorded on the beach sand of Monterey Bay, California. Approximately one meter below the sand, a six inch diameter plastic pipe was buried to serve as a target.

S11E-0335 0830h POSTER

Wave-equation Imaging of Teleseismic Body-wave Coda

Jeffrey C Shragge[1] (jeff@sep.stanford.edu)

Brad W Artman[1] (brad@sep.stanford.edu)

[1]Stanford University, Geophysics, Mitchell Bldg., Stanford, CA 94305, United States

Historically, characterization of the lithosphere with information in teleseismic body-wave coda has been realized with collections of 1-D receiver functions. However, the promise of larger, fully 3-D teleseismic data sets with finer spatial sampling (e.g. the US-ARRAY project) motivates the investigation of industry-oriented imaging algorithms in the context of crustal/upper mantle studies. In this milieu, we present a multi-dimensional structural imaging method based on wave-equation migration of multi-component teleseismic array data for v(x,y,z) media. Although the advantages of wave-equation methods are well known to explorationists, these methods are rarely used in teleseismic investigation. Possible reasons for their disuse are unconventional source characteristics, and the heretofore limited number, and irregular distribution, of receivers. However, given sufficient receiver density teleseismic body-wave coda may be readily imaged with a wave-equation processing strategy through the use of a modified shot-profile migration algorithm. Shot-profile migration requires separate depth extrapolation of source and receiver wavefields. The source wavefields are modeled using the slowness vector of the incident body-wave that dictates the time-slope of the impulsive line (in 2-D) or plane sources (in 3-D). The receiver wavefield is the scattered energy in the body-wave coda after a deconvolution with the estimated source-signature. The two wavefields are then independently extrapolated through separate velocity models according to the wave-equation, and an imaging condition is applied at each model location to generate the image. The presence of forward- and backscattered arrivals of P,SV and SH polarity within the coda requires various combinations of migration parameters to independently focus different scattering modes. Accordingly, seven different images can be produced through appropriate permutations of velocity models and source wavefield propagation direction. Importantly, the application of this imaging technique to 3-D data sets needs only a 3-D velocity model. We present multi-event, stacked, migrated images of all possible scattering modes for both synthetic and field data sets. The imaging strategy is tested on a 2-D, finite-difference modeled data representing a subduction/suture earth model. The method is then applied to the IRIS-PASSCAL CASC93 data acquired in central Oregon, USA, and generates interpretable images of the Cascadia subduction zone.

URL: http://sepwww.stanford.edu/sep/people/jeff/agu2003SHRAGGE.txt

S11E-0336 0830h POSTER

Breakdown of wave diffusion in 2D due to loops

Matthew Haney[1] (mhaney@dix.mines.edu)

Roel Snieder[1] (303.273.3456; rsnieder@mines.edu)

[1]Dept. of Geophysics and Center for Wave Phenomena, Colorado School of Mines 1500 Illinois Str., Golden, CO 80401, United States

There is a growing interest in incorporating the multiply-scattered coda into our understanding of the earth's interior using energy transport theory. Using energy transport, the envelopes of seismograms are modeled and interference effects between individual arrivals in the coda are ignored. Also known as radiative transfer, this picture of the coda leads to the so-called diffusive regime at late times. There are several novel applications at this level, among them obtaining the Vp/Vs ratio from the partitioning of P- and S-energies and the ability to separate scattering and intrinsic Q. However, that individual wave arrivals in the coda may interfere constructively, and the underlying wave character of the multiply-scattered seismic energy emerges. Constructive interference in the coda renders the usually diffusive regime "non-diffusive", most notably in the presence of a coherent backscattering peak at the source position. Here, we test the validity of the diffusion approximation for the average intensity (squared envelope) of multiply-scattered waves with numerical simulations in a strongly scattering 2D medium of finite extent. We show that the diffusion equation underestimates the intensity and attribute this to both the neglect of recurrent scattering paths and interference within diffusion theory. We present a theory to quantify this discrepancy based on counting all possible scattering paths between point scatterers. Interference phenomena, due to loop paths, are incorporated in a way similar to coherent backscattering. This may ultimately help to bridge the conceptual gap between the regimes of "weak" and "strong" localization. In addition, the work suggests a new way in which the microstructure of a discrete random medium can become imprinted in the average transmitted intensity. This could lead to sample size dependencies as have been previously reported for coherent backscattering. [Haney, M. and R. Snieder, R., Breakdown of diffusion in 2D due to loops, Phys. Rev. Lett., 91, doi:10.1103/PhysRevLett.91.093902, 2003.]

S11E-0337 0830h POSTER

Volcano monitoring using continuous data

Roel Snieder[1] (303.273.3456; rsnieder@mines.edu)

Mike Hagerty[2] (64-7-376-0149; m.hagerty@gns.cri.nz)

[1]Dept. of Geophysics and Center for Wave Phenomena, Colorado School of Mines 1500 Illinois Str. Golden CO 80401-1887, Golden, CO 80401, United States

[2]Inst. Geological Nuclear Science, Private Bag 2000, Wairake 0000, New Zealand

Mt. Arenal is a volcano that has been heavily instrumented. In this study we used continuous recordings of air pressure and ground motion to monitor Mt. Arenal. The pressure record shows a sequence of distinct pulses. The time interval between these pulses changes with time. The associated ground motion resembles a superposition of overlapping exponentially decaying signals. We carried out a deconvolution of the ground motion with the pressure for a number of non-overlapping time intervals. Under the assumption that the pressure pulses are related to the excitation of the seismic waves, this should give the seismic impulse response of Mt. Arenal. The deconvolved signals obtained from the different time intervals display the typical character of coda waves with a diffusive character. Even though the waveforms are complex, they are highly reproducible. The deconvolved waves from adjacent time windows have a high correlation with a correlation coefficient of about 0.95 or more. This correlation coefficient decreases to about 0.80 for the deconvolved waveforms that are from time windows with a separation in time of about 10 minutes. On the basis of the employed data, the cause of the change in the waveforms cannot be established unambiguously. However, the de-correlation of the deconvolved waves can be explained by a change in the location of the seismic source over about 60 meters during a 10 minute interval. The reproducible character of the deconvolved signals and their gradual and systematic change with time open up the possibility of passive volcano monitoring using coda wave interferometry [Snieder, R., A. Gret, H. Douma, and J. Scales, Coda wave interferometry for estimating nonlinear behavior in seismic velocity, Science, 295, 2253-2255, 2002].

S11E-0338 0830h POSTER

Volcano Monitoring with Coda Wave Interferometry at Mount Erebus, Antarctica

Alexandre Gret[1] (303.273.3733; agret@dix.mines.edu)

Roel Snieder[1] (rsnieder@mines.edu)

Rick Aster[2] ((505)835-5924; aster@dutchman.nmt.edu)

[1]Dept. of Geophysics and Center for Wave Phenomena, Colorado School of mines 1500 Illinois str., Golden, CO 80401, United States