earthquake may cause great social losses, urges a detailed study of the regional structure and active source under this area. On Oct 1 2001, a digital seismic network was set up and operated to monitor earthquakes in the Capital Circle Region (E38.5 41.0, N114.0 120.0), namely Big Beijing. The network contains 107 seismic stations with continuous records, including 43 broadband seismometers, 59 short-period seismometers and 5 very-broadband seismometers. Four data acquisition centers are located at Beijing, Tianjin and Shijiazhuang, which receive DDN signals from 75 stations and satellite signals from the other 32 stations. Based on this new built seismic network, a research of Broadband Array for Regional Tectonics (BART) is carried on from March this year. The primary scientific goals of BART are: to investigate the crustal and upper mantle structure under Big Beijing area; to construct a detailed 3-D model of the lithospheric structure in the study area; to relocate earthquakes using the new constructed detailed model; with the combined data of relocated earthquakes, high-resolution crustal structures, tectonics and other geophysical data, to delineate the major active tectonics and other active source and try to interpret the mechanism of intra-plate earthquake in North China. From 23 to 24, April, 6 shots with chemical charges of 2000 C 2500kg were conducted near Beijing, with 3 of them along the famous Zhangjiakou C Bohai Sea seismic belt. The distance between every 2 shots are less than 60km. In addition to 107 settled stations, 196 portable short-period seismometers were deployed in the area for these shots, and 96 of them formed a combined array of aperture of 30-40 km within the network, and the other 100 seismographs were deployed along three profiles with one of them across the Zhangjiakou-Bohai tectonic regime. Until now, thousands of records have been obtained and processed. And initial results show that, the structure in the west part of Big Beijing is different from that of East part, and this may be an indicator of the boundary of East Asia Rift.

S71B MCC: Hall C Sunday 0830h

Shake, Rattle, and Roll I: Earthquake Hazard Posters *(joint with PA)*

Presiding: **S H Hickman,** U.S. Geological Survey**; L K Fenton,** California Institute of Technology

S71B-1075 0830h POSTER

Stochastic Finite Fault Modeling of Strong Ground Motions From the 1999 Chi-Chi, Taiwan, Earthquake

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The stochastic method for simulating strong ground motion from finite faults is applied to the case of the 1999 Chi-Chi, Taiwan, earthquake. The method involves discretization of the fault plane into smaller parts (subfaults), each of which is assigned an ω^2 spectrum. The contributions from all subfaults are empirically attenuated to the observation sites and summed to produce the synthetic acceleration time history.
The method is first applied to reproduce strong-motion data recorded at 36 rock sites, located within 7-142 km from the mainshock epicenter. At this stage, the parameters of the synthetic model are calibrated to obtain the best fit between synthetics and observations. The goodness of fit is evaluated through the model bias, which is calculated as the difference between the logarithms of the observed and simulated spectra, averaged over all stations.
The calibrated model for the Chi-Chi event has a near-zero average bias in reproducing ground motions at rock sites in the frequency range from 0.1 to 20 Hz. An unusually low value is found for parameter sfact, which controls the high-frequency radiation, compared to the mean value found for Californian earthquakes. This result reflects the low-PGA character of the examined event, which physically probably means lower-than-usual slip velocities during the rupture.
The calibrated model is subsequently combined with the generic transfer functions for soil sites to simulate the soft-site recordings under the linear-response assumption. This analysis reveals possible reduction in amplification that occurred during the main shock, relative to weak-motion amplification.

S71B-1076 0830h POSTER

Seismic Hazard Increase in Intramountain Basins: the Case Study of Colfiorito, Central Italy

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During the Umbria-Marche seismic sequence (September 1997 to April 1998) two small-aperture array experiments were performed in the Colfiorito basin. The diameter of the basin is 3 km, approximately. The array sites, which are 700 m from each other, are in the middle and at the eastern edge of the basin. Aftershock recordings show a completely different behavior between the two sites. In the middle of the basin, a strong focalisation of energy is observed around 1 Hz. S-wave synchronism lasts for few seconds, then low-apparent-velocity quickly-varying-backazimuth wavetrains cross the array for minutes even at magnitudes as low as 3. The energy increase exceeds a factor of 1,000 compared with a rock reference site. Seismograms of the array at the basin edge show the same predominat frequency, approximately, but smaller amplifications and durations; the low apparent velocity even during direct S waves suggests that the incoming wave field is strongly distorted by interference at the basin edge. Persistent backazimuths from E-SE indicate that, close to the edge, the largest amplitude ground motions are composed of edge-diffracted surface waves.
An attempt is made to interpret observations in terms of source-to-receiver geometry and bedrock topography structure as inferred through seismic and geoelectrical surveys. Since weak and strong motions recorded in the basin indicate a tremendous local increase of the shaking level, the research efforts are now addressed to understand wheter the effects found in Colfiorito are a peculiarity of this basin or can be recognized as a possible common behavior of other intramountain basins.

S71B-1077 0830h POSTER

Uncertainties in Deterministic Earthquake Scenarios

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In areas of low to moderate seismicity, where the overall earthquake hazard is often dominated by a few strong earthquakes in the past, earthquake scenarios are the only way to find out more about possible consequences and impacts on society related to strong earthquakes. One of the most important drawbacks of earthquake scenarios for such areas is however the lack of data. No observational data on damage is available and the only sources of information are historical documents.
In our work we thus concentrate on the sensitivity and uncertainty of input parameters in earthquake scenarios. Using straightforward calculation techniques for deterministic earthquake scenarios we treat the variability of input parameters, such as source location, amplification of ground motion or vulnerability of buildings, with a Monte Carlo approach. The definition of ground motion is based on EMS98 (European Macroseismic Scale) intensities, which has the advantage of bypassing the discussion about linking physical ground motion parameters to damage. In addition it is a method to catch existing historic ground motion information from pre-instrumental times. Being a modern macroseismic scale, EMS98 expresses the probabilistic nature of damage distributions for any intensity, which is important for the transition from hazard to risk.
We present results of earthquake scenarios for sample areas in Basel (Switzerland), where the last stronger earthquake (epicentral intensity IX) dates back to preinstrumental times at 1356. The scenarios are based on a microzonation study and a building inventory assessed on different levels of detail.
The general uncertainty features in our scenario modeling can be applied to other regions where long return period events dominate the overall seismic hazard.

S71B-1078 0830h POSTER

Precarious Rock Evidence for Low Ground Accelerations Associated with Normal Faults and Extensional Strike-Slip Faults

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Preliminary measurements of the quasi-static toppling acceleration of a number of precarious rocks about 5 kilometers from the San Jacinto fault south of Beaumont, California, provide upper limits on ground motions of about 0.4 g, suggesting low ground accelerations associated with the 1899 and 1918 M7 extensional strike-slip earthquakes. Similar observations of the Fort Sage Mountains precarious rocks in the Honey Lake region of northeastern California, suggest an upper limit on ground motions of about 0.2-0.3 g (Intensity VIII), whereas, the recent USGS-CDMG hazard maps predict 2%-in-50yr (5000 yr recurrence times) accelerations of about 0.8 g (Intensity XI). Recent evidence from physical and numerical models and data regressions has indicated that ground motion from extensional strike-slip earthquakes may be considerably lower than for transpressional strike-slip faults and thrust faults. Data from transpressional strike-slip and thrust earthquakes dominate the database used in most determination of regression curves for ground acceleration, and in the calculation of current probabilistic hazard maps. Therefore, estimates of ground accelerations on these seismic hazard maps may be too high for extensional regimes. Verification of these preliminary results might eventually allow reduction of the current estimates of seismic hazard from strike-slip faults in extensional regimes. This could be important for estimates of seismic hazard in cities such as San Jacinto, Hemet, El Centro, Indio, Lone Pine, and Bishop, California, and to any other cities near extensional strike-slip faults.

S71B-1079 0830h POSTER

Gravity and Magnetic Expression of the San Leandro Gabbro with Implications for the Geometry and Evolution of the Hayward Fault Zone, Northern California

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The Hayward Fault, one of the most hazardous faults in northern California, trends NNW and extends for about 90 km along the eastern margin of the San Francisco Bay region. At numerous locations along its length, distinct and elongate gravity and magnetic anomalies correlate with mapped mafic and ultramafic rocks. The most prominent of these anomalies reflects the 16-km long San Leandro gabbroic block. Inversion of magnetic and gravity data constrained with physical property measurements is used to define the subsurface extent of the San Leandro gabbro body and to speculate on its origin and relationship to the Hayward Fault Zone.
Modeling indicates that the San Leandro gabbro body is about 3 km wide, dips about 75-80o northeast, and extends to a depth of at least 6 km. One of the most striking results of the modeling, which was performed independently of seismicity data, is that accurately relocated seismicity, that extends to a depth of about 12 km, is concentrated along the western edge or stratigraphically lower bounding surface of the San Leandro gabbro. The western boundary of the San Leandro gabbro block is the base of an incomplete ophiolite sequence and represented by Late Cretaceous to early Tertiary, a low-angle roof thrust related to the tectonic wedging of the Franciscan Complex. After repeated episodes of extension and attenuation, the strike-slip Hayward Fault probably reactivated or preferentially followed this pre-existing feature in the late Tertiary.
Because earthquakes concentrate near the edge of the San Leandro gabbro but tend to avoid its interior, this massive igneous block may influence the distribution of stress. The microseismicity cluster along the western flank of the San Leandro gabbro leads us to suggest that this stressed volume may be the site of future moderate to large earthquakes. Improved understanding of the three-dimensional geometry and physical properties along the Hayward Fault will provide additional constraints on seismic hazard probability,

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earthquake modeling, and fault interactions that may be applicable to other major strike-slip faults around the world.

S71B-1080 0830h POSTER

Seismic Hazard Evaluation Using Markov Chains

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We design and implement a method for determination of seismic hazard through the application of Markov Chains to the statistical analysis of seismicity reported in catalogues, where seismic hazard is defined as the occurrence probability of one or more earthquakes in a specific geographic area within given time and magnitude intervals. The method is applied to geographic areas that include several seismogenic regions.

The method is limited mainly by the catalogue length (and, in a smaller degree, by its accuracy). The choice of regions, time interval and threshold magnitude is made empirically, so as to obtain optimal definition and coverage. The confidence in the transition probabilities is quantified, and the results of the method are compared with two memory-less probabilistic models (uniform and Poisson).

S71B-1081 0830h POSTER

Threshold of Geomorphic Detectability Estimated from Geologic Observations of Active Slow-Slipping Strike-Slip Faults

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Sources of catastrophic earthquakes include not only major active faults, but also slow-slipping ones. However, geomorphic characteristics and long-term seismic behavior of slow-slipping faults have not been well understood, although intensive paleoseismic studies were carried out after the unexpected 1992 Landers and 1999 Hector Mine earthquakes. Two Japanese surface faulting earthquakes on slow-slipping strike-slip faults (the 1927 Mw=7.0 Kita-Tango and 1943 Mw=7.0 Tottori earthquakes) provided good opportunity to examine these problems. Analysis of coseismic surface slip, cumulative geomorphic expressions, and paleoseismicity for these two events not only supports a characteristic-slip behavior for these faults, but also suggests a concept of threshold of geomorphic detectability for intramontane strike-slip faults, which must be exceeded in order that progressive coseismic surface offsets can be preserved against surface processes as detectable systematic deflections of channels and ridge crests. The determined threshold slip rates for these examples are in the range of 0.06-0.13 mm/yr, which can be a quantitative explanation for an extremely small number of mapped active faults with slip rates of less than 0.1 mm/yr in Japan islands. On the contrary, the threshold of geomorphic detectability is probably negligible in arid regions where denudation rate would be extremely low. To date, the issue of geomorphologically undetectable active faults has been that of blind thrust faults buried beneath thick sediments, but another type of blind active faults or fault segments can exist in humid and mountainous regions. In spite of their low slip rates and long recurrence intervals, their potential presence must be considered, especially in regions under the tectonically undeveloped regime, where regional strain is accommodated by many scattered slow-slipping faults.

S71B-1082 0830h POSTER

Characteristic Fault Rupture: Implications for Fault Rupture Hazard and Distribution of Earthquake Sizes

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Analysis of a global paleoseismic data set shows that event-to-event variability in slip at a point on a fault is much less than that commonly assumed in fault rupture hazard evaluations and less than would be expected from an exponential distribution of earthquakes on a fault. Our database consists of 525 observations from 179 faults having measurements of slip from more than one event. We estimate the coefficient of variation (C.V., defined as the standard deviation divided by the mean) by assuming that the C.V. is constant for all sites in the data set or selected data subsets. We recognize that incompleteness of the data may bias the C.V. to low values. Some displacements may be too small to resolve in the geologic record and even those above the detection threshold (nominally 0.5 m) may be obscured by larger more recent events. Checking the sequence position of the smallest slip observed at a site shows a tendency for the smallest to be the most recent, indicating that some slip events are being obscured by subsequent larger ones. Using sites with mean slip >1.0 m removes most of the bias. We are working to incorporate a formal statistical correction for this type of biased data, but the effect on the estimated C.V. appears to be small. Preliminary results indicate that the average C.V. for strike-slip faults is about 0.35, and the average for dip-slip faults is about 0.45.

The standard practice in fault-rupture hazard evaluations is to use empirical relations of fault displacement as a function of earthquake magnitude developed from global earthquake data. The Wells and Coppersmith (1994) model for average displacement (averaged over the length of rupture) gives standard deviations (σ) of 0.28 and 0.33 log10 units for strike-slip and normal faults, respectively. Usually, in hazard evaluations, σ is assumed to represent aleatory variability in displacement as a function of magnitude. Factoring the variability of slip along strike into the variability of slip at a point gives a total σ of the logarithm of the slip at a point of 0.32 and 0.36 for strike-slip and normal faults, respectively (assuming for this purpose that the maximum slip represents two σ above the median). The corresponding C.V. for earthquakes of a single magnitude is 0.86 to 0.97, much larger than the values derived from paleoseismic data. If variability in earthquake magnitude is incorporated into the model, the C.V. is even larger (> 1.0). If we assume an exponential distribution of magnitudes, such as specified by the Gutenberg-Richter relation, then slip at a point for any given magnitude must be highly characteristic (σ < 0.10 log10 units) to be consistent with the empirical observations. For a characteristic earthquake model, σ can be up to 0.20 log10 units.

An important implication of these results is that global empirical models of fault displacement vs. earthquake magnitude are not applicable to estimating fault rupture hazard at a point. Instead of the large aleatory variability from the global models, the amount of displacement at a point should have small aleatory variability. If no observations of past displacements are available near the site, then the epistemic variability in the median slip for a given magnitude is large. If even a few observations are available, then the epistemic uncertainty is greatly reduced. This difference significantly impacts the computed fault rupture hazard at a site.

S71B-1083 0830h POSTER

Earthquake Potential Models for China

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We present three earthquake potential estimates for magnitude 5.4 and larger earthquakes for China. The potential is expressed as the rate density (probability per unit area, magnitude and time). The three methods employ smoothed seismicity-, geologic slip rate-, and geodetic strain rate data. We tested all three estimates, and the published Global Seismic Hazard Assessment Project (GSHAP) model, against earthquake data.

We constructed a special earthquake catalog which combines previous catalogs covering different times. We used the special catalog to construct our smoothed seismicity model and to evaluate all models retrospectively. All our models employ a modified Gutenberg-Richter magnitude distribution with three parameters: a multiplicative "a-value," the slope or "b-value," and a "corner magnitude" marking a strong decrease of earthquake rate with magnitude. We assumed the b-value to be constant for the whole study area and estimated the other parameters from regional or local geophysical data.

The smoothed seismicity method assumes that the rate density is proportional to the magnitude of past earthquakes and approximately as the reciprocal of the epicentral distance out to a few hundred kilometers. We derived the upper magnitude limit from the special catalog and estimated local a-values from smoothed seismicity. Earthquakes since January 1, 2000 are quite compatible with the model.

For the geologic forecast we adopted the seismic source zones (based on geological, geodetic and seismicity data) of the GSHAP model. For each zone, we estimated a corner magnitude by applying the Wells and Coppersmith [1994] relationship to the longest fault in the zone, and we determined the a-value from fault slip rates and an assumed locking depth. The geological model fits the earthquake data better than the GSHAP model. We also applied the Wells and Coppersmith relationship to individual faults, but the results conflicted with the earthquake record.

For our geodetic model we derived the uniform upper magnitude limit from the special catalog and assumed local a-values proportional to maximum horizontal strain rate. In prospective tests the geodetic model agrees well with earthquake occurrence.

The smoothed seismicity model performs best of the four models.

S71B-1084 0830h POSTER

Earthquake recurrence parameters from seismic and geodetic strain rates in the Mediterranean

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Knowledge about long-term seismic strain rates is essential to determine the seismic hazard of a region. Probabilistic seismic hazard analyses implicitly make an estimate of long-term seismic strain rates. But the strain rate fields implied by the seismic hazard data are generally not checked against other strain rate data. Our project aims at determining earthquake recurrence parameters for the Mediterranean consistent with seismic, tectonic and geodetic information. We use the method of *Haines and Holt* [JGR, 1993] to map seismic data and geodetic velocities into a strain rate field. In the central Mediterranean area, seismicity rates are low and geodetic velocity gradients are relatively small (up to 10^{-8}/y). A long-term strain rate field is obtained by merging seismic and geodetic data. Moment tensors provide constraints on the type of the deformation. Seismicity rates from historical and instrumental catalogs and geodetic velocities yield estimates of the magnitude of strain. We show preliminary results and discuss the potential to define a strain rate map for an area of slow deformation like the central Mediterranean region. Comparison with the eastern Mediterranean is done where the dense data coverage allows an independent determination of the seismic and geodetic strain rate field.

S71B-1085 0830h POSTER

Paleoseismological Study of the Sekiya Fault in Tochigi Prefecture, NE Japan -Part II-

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The Sekiya fault is an NS-striking E-side-down thrust fault, extending for 30 km in the northern part of Tochigi Prefecture, NE Japan. We excavated three trenches in Momura area, northern part of the Sekiya fault in 2000 and two trenches in Sekiya area, middle part of the fault in 2001. The trenching survey in Momura area has revealed that the last rupture event on the northern part of the Sekiya fault occurred in or after the 14th to 15th century, and that the penultimate event occurred 4000 to 5000 years ago. In addition, the trenching survey in Sekiya area has revealed that three fault rupture events had occurred on the middle part of the fault. The last two events occurred simultaneously with the last rupture event and the penultimate event

recognized on the northern part of the fault, Momura area. And newly found event in Sekiya area occurred about 8000 to 8400 years ago. The recurrence interval between the last two events is in the range of 3200-4530 years and it between the prior two events is in the range of 3100-4500 years, respectively.

URL: http://unit.aist.go.jp/actfault/english/activef.html

S71B-1086 0830h POSTER

A Practical Space-Time Model for Regional Seismicity

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Regional earthquake occurrence rate is modeled as a function of previous activity whose specific form is based on empirical laws such as the modified Omori formula and the Utsu-Seki scaling law of aftershock area against magnitude. Its parameters, including the p-value of the aftershock decay rate, can vary from place to place. This model is used to visualize features of the regional seismic activities in and around Japan. Among the five parameters of the model, the present paper is particularly concerned with spatial variation of the K-parameter to compare the spatial aftershock intensity with asperity locations and stress changes estimated by seismic waves and GPS observations, respectively. Furthermore, the model enables us to enhance the regions where the actual occurrence rates deviate systematically from the modeled one. In particular, the so-called relative quiescences or the seismic gaps of the second type are of great concern.

URL: http://www.ism.ac.jp/~ogata

S71B-1087 0830h POSTER

Slip Along the Brawley Fault, Imperial Valley, California, During the Past 300-400 Years

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The Brawley fault zone, including the "Brawley Seismic Zone," is the principal transfer zone accommodating strain between the San Andreas and Imperial faults in southernmost California. The Brawley fault ruptured along with the Imperial fault in the 1979 M 6.6 earthquake and may have been involved in larger Imperial fault events in 1940 or earlier. We have opened two trenches across the Brawley fault at Harris Road and found that the lacustrine clay deposits associated with the most recent filling of Lake Cahuilla in about A.D. 1680 are faulted far more than can be explained by slip in the 1940 and 1979 earthquakes. In 1979, dip-slip across the fault strands exposed in our trenches totaled 7.5 cm, and across the entire half-kilometer-wide Brawley fault zone at Harris Road, dip-slip totaled about 16 cm; there was also about 8 cm of strike-slip. In 1940, if there was any rupture across this portion of the fault, the slip was not significant enough to be noted and documented. In contrast, the base of the most recent lake clay exposed in our trench drops a minimum of 2.3 m across the Brawley fault, and the actual drop may be appreciably higher. Of course, the lacustrine clay was probably deposited over a preexisting scarp, and we are currently in the process of resolving the details of the slip, but much of the 2.3 m of (minimum) vertical separation appears to have been produced in a single large displacement during or very soon after deposition of the bulk of the lacustrine deposits, *i.e.* ca. 1680. This is precisely the time frame during which one or more large events ruptured both the southern San Andreas and Imperial faults. In addition to the ca. 1680 event, we have found evidence for at least two later events, one of which was 1979.

S71B-1088 0830h POSTER

Integrated Web-based Oracle and GIS Access to Natural Hazards Data

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The National Geophysical Data Center (NGDC) catalogs information on tsunamis, significant earthquakes, and volcanoes including effects such as fatalities and damage. NGDC also maintains a large collection of geologic hazards photos. All of these databases are now stored in an Oracle relational database management system (RDMS) and accessible over the Web as tables, reports and interactive maps.

Storing the data in a RDMS facilitates the search for earthquake, tsunami and volcano data related to a specific event. For example, a user might be interested in all of the earthquakes greater than magnitude 8.0 that have occurred in Alaska. If the earthquake triggered a tsunami, the user could then directly access related information from the tsunami tables without having to run a separate search of the tsunami database. Users could also first access the tsunami database and then obtain related significant earthquake and volcano data.

The ArcIMS-based interactive maps provide integrated Web-based GIS access to these hazards databases as well as additional auxiliary geospatial data. The first interactive map provides access to individual GIS layers of significant earthquakes, tsunami sources, tsunami effects, volcano locations, and various spatial reference layers including topography, population density, and political boundaries. The map service also provides ftp links and hyperlinks to additional hazards information such as NGDC's extensive collection of geologic hazards photos. For example, a user could display all of the significant earthquakes that have occurred in California and then by using a hyperlinks tool, display images showing damage from a specific earthquake such as the 1989 Loma Prieta event.

The second interactive map allows users to display related natural hazards GIS layers. For example, a user might first display tsunami source locations and select tsunami effects as the related feature. Using a tool developed at NGDC, the user can then select a specific tsunami event and automatically display the tsunami effect locations related to that event. The user could also select significant earthquake events and display tsunami events related to specific quakes.

URL: http://www.ngdc.noaa.gov/seg/hazard/hazards.shtml

S71B-1089 0830h POSTER

Probabilistic Seismic Hazard assessment in Albania

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Albania is one of the coutries with highest sesimicity in Europe.The history of instrumental monitoring of seismicity in this country started since 1968 with the setting up of the first seismographic station of Tirana and more effectively after the beginning of the operation of the Albanian Seismological Network in 1976. There is a rich evidence that during two thousands years Albania has been hit by many disastrous earthquakes. The highest magnitude estimated is 7.2.

After the end of Communist era and opening of the country, a boom of constructions started in Albania continuing even now. It makes more indispensabile the producing of accurate seismic hazard maps for preventing the damages of future probable earthquakes. Some efforts have already been done in seismic hazard assessment(Sulstarova et al., 1980; Kociu, 2000; Muco et al., 2002).

In this approach, the probabilistic technique has been used in one joint work between Seismological Institute of Tirana, Albania and Department of Geophysics of Aristotle University of Thessaloniki, Greece, into the framework of NATO SfP project "SeisAlbania".

The earthquake catalogue adopted was specifically conceived for this seismic hazard analysis and contains 530 events with magnitude M>4.5 from the year 58 up to 2000. We divided the country in 8 seismotectonic zones giving for them the most representative fault characteristics. The computer code used for hazard calculation was OHAZ, developed from the Geophysical Survey of Slovenia and the attenuation models used were Ambraseys et al., 1996; Sabetta & Pugliese, 1996 and Margaris et al., 2001. The hazard maps are obtained for 100, 475, 2375 and 4746 return periods, for rock soil condition.

Analyzing the map of PGA values for a return period of 475 years, there are separated 5 zones with different escalation of PGA values: 1)the zone with PGA (0.20 - 0.24 g) 1.8 percent of Albanian territory, 2)the zone with PGA (0.16 - 0.20 g) 22.6 percent of Albanian territory, 3)the zone with PGA (0.12 - 0.16 g) 26.5 percent of Albanian territory, 4)the zone with PGA (0.08 - 0.12 g) 28.2 percent of Albanian territory and 5)the zone with PGA (0.04 - 0.08 g) 21.9 percent of Albanian territory.

The new maps of probabilistic seismic hazard for Albania would be a basic tool for the strategies of seismic hazard mitigation in this country.

S71B-1090 0830h POSTER

Paleoseismological Findings on the Penultimate Faulting of the Arifiye Segment; 1999 Izmit Earthquake, North Anatolian Fault, Turkey

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The four segments of the northern strand of the North Anatolian Fault ruptured in the August 17, 1999 Izmit earthquake (Mw 7.4). The Arifiye segment is located central part of 1999 Izmit rupture, 30 km length, and maximum lateral displacement along the Izmit rupture was observed on this segment as 4.9 meters. The surface rupture has vertical component with maximum 0.50 meters at the eastern part of the segment that was triggered ruptured also in 1967 Mudurnu Valley earthquake, according to local people memory. We excavated two cross trenches at the Caybas1 site on the segment. The right lateral and vertical displacements were measured just after the earthquake 2.80 and 0.35 meters at this site respectively. Stratigraphy consists of five units, which are recent soil, clay, silty clay, silty sand and sand units from top to bottom on the trench walls. Lower two units probably formed as channel and flood plain deposits of Sakarya river. Unit 3 consists of two sub-layers and an oxidation zone developed between them; lower part includes ceramics and horseshoe. An erosional surface between unit 3 and 4 on the upthrown and downthrown side of the fault was defined. Second unconformity was between units 2 and 3 which was parallel to the recent topographic surface. Different fault patterns have been identified on all of the trench walls. Two faulting events including 1999 earthquake identified, and penultimate event horizon was within the upper part of the Unit 3. Amount of the vertical offset is around 0.90-1.00 meters. Although the 1999 faulting the vertical separation appeared to be 0.35-0.40 meters at the surface, total vertical separation was about 0.45-0.50 meters above the penultimate event horizon. These data indicate that triggered rupture might have been developed at the eastern part of Arifiye segment during the 1967 Mudurnu Valley earthquake as noted by local people. Amount of the vertical offset of the penultimate event, which has similar faulting geometry with that of the last event, is 0.45-0.50 meters. It can be said that magnitude of the penultimate event might be similar that of 1999 Izmit earthquake. However, we do not have enough data to discuss as to whether the similar triggered mechanism has occurred during the penultimate event.

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S71B-1091 0830h POSTER

Aftershock Observation of the 22 June 2002 Changoureh-Avaj Earthquake (Mw 6.5), NW Iran

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Iran is located in Alps-Himalayan belt with a high seismicity. On 22 June 2002, a shallow earthquake (Mw6.5) occurred in northwest of Iran, latitude 35.67N and longitude 48.93E (NEIC), for about 225 km west of Tehran, the capital of Iran. This earthquake caused a lot of damages, 1466 wounded and 230 killed persons in the villages with adobe constructions. It is very important to study this earthquake not only for seismological interests but also for knowing fault activity around Tehran with about 7 million population. Taking instruments from Japan one month after the main shock, we installed seismographs in four temporal stations around the damaged area in order to observe aftershocks of this earthquake. The four stations were laid out as a triangle pattern with sides long about 20 km for getting the accurate hypocenters of aftershocks. We decided to put the central station of the triangle near surface fissures caused by the main shock because of no accurate hypocentral data of the mainshock. In each station we installed a high sensitive seismograph (Lennartz-LE3Dlite) with three components. And in one station we installed an acceleration seismograph (Akashi-JEP6A3) with three components. Seismic wave data were recorded in 100Hz sampling by using 16 bit digital recorders (Datamark- LSH8000SH-HD) with 2Gbyte hard disk card and GPS. We observed continuously from July 24 to 29 and succeeded getting good continuous data of all stations during about three days.

We started to pick the P and S phase of each event observed in all stations and calculated hypocenter and magnitude of each event by using WIN software in Unix system. By processing of 113 aftershocks, we suggest that most of those epicenters distributed in a square with 25km side in the damaged area. By using NS vertical projection of the hypocenters we can imagine the reverse fault surface with 35 degrees dip to the south from 0 to 15 km depth. Our result is comparable with focal mechanism solutions of USGS and ERI of the University of Tokyo, and preliminary report of BHRC (Building and Housing Research Center of Iran). This fault could reach to the surface between Abdarreh and Changoureh villages where most of houses were destroyed. More investigation and data processing will be need to have a better imagine of fault and sub-fault structures of this earthquake.

S71B-1092 0830h POSTER

Paleoseismic Resolution Analyses Using Synthetic Earthquakes

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Comparison of synthetic paleoseismic data (input) with calculated event timing and recurrence intervals (output) provides a means of quantifying the uncertainties of real paleoseismic data. Characterization of these uncertainties can provide guidelines for determining what site conditions, such as deposition rates and carbon dating uncertainties, are necessary to describe fault behavior. We implement a Monte Carlo correlation method (Hilley and Young, in review) that effectively trims earthquake ages by calculating event ages from a probability distribution and discards events chosen out of stratigraphic order. The synthetic earthquake events (input) and ages of layers that bracket those events were generated in two steps: 1) select radiocarbon dates at random from a specified distribution using the mean carbon deposition rate and its uncertainty; 2) select earthquake ages from a specified distribution using the recurrence interval and its uncertainty. The event ages (output) were retrieved from a specified probability distribution using the bracketing input ages from step one (Monte Carlo based correlation method). The event ages are first determined by exhaustive sampling (50,000) of pairs of randomly selected bracketing radiocarbon dates, mapping them through the radiocarbon calibration curve, discarding those out of stratigraphic order. The resulting constant probability distributions for individual trial are then summed for each event. Stratigraphic ordering with respect to all events additionally refines the individual event ages (500,000 trials). We compared the input (synthetic events) ages to the retrieved output ages as well as the event recurrence to the calculated output event recurrence to determine how the varied site condition parameters affect resolution of earthquake timing. Our analyses indicate that synthetic earthquake ages were approximated by the calculated average trimmed ages. However, low carbon deposition and high earthquake recurrence rates lead to large mis-prediction of individual event ages, and therefore inaccurate recurrence interval estimations. For recurrence intervals less than 200 years, the mis-estimation of event ages resulted in high recurrence interval uncertainties of $\pm$ 40% (1σ). The determination of earthquake recurrence is predominately controlled by the production rate of the dated ^{14}C samples, and their analytical and calibration uncertainties.

S71B-1093 0830h POSTER

Tectonic stress and dip-slip faults

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Dip-slip faults in a plane strain approximation are loaded by tectonic stress fields superimposed to the lithostatic loading. The subsequent dislocations are computed by a finite element numerical model. The fault surfaces are modeled by contact elements and slip according the Coulomb friction criterion. This model does not take into account the full dynamics of an earthquake source, but the computed fault dislocations are mechanically consistent with the imposed stress, in contrast to widely employed models characterized by a-priori imposed slip distribution. This study focuses on the following points: 1) the comparison between our approximation and previous results based on prescribed fault slip, including cases in which the faults approach or cross the Earth surface; 2) the interplay between tectonic stress and lithostatic loading for normal and reverse faults; 3) the effects of lithospheric rheology including the post-seismic relaxation due to linear and non-linear creep in the lower crust. We show that the numerical modeling of single faults or fault systems is a very useful tool to understand how the tectonic stress is released by earthquake dislocations and how fault systems may interact.

S71B-1094 0830h POSTER

Paleoseismological study along the Magome-toge fault, central Japan

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Kiso-sanmyaku-seien fault zone, extending for 60 km along the Kiso River, consists of three echelon faults which trend in the N-S to NE-SW direction. We trenched the southernmost of these faults, the Magome-toge fault, at Kudaritani and Fukutochizawa. Though only 16 km apart along the same fault, these two sites differ greatly in their earthquake histories.

In trench walls of Kudaritani, we recognized three faulting events: one in the Holocene and two in the Late Pleistocene. Another older event is also inferred from a prismatic gravelly clay bed deposited in front of the fault plain. Our precise sequential 14C dating of the humic soils revealed that the latest faulting event occurred 5,000 - 3,800 cal yr BP. The penultimate event occurred after the fall of AT tephra (25,000 - 27,000 cal yr BP) and before 11,000 cal yr BP, and the third recent event predated the fall of the AT tephra. Faulting intervals are therefore estimated to be around 10,000 to 23,000 years.

At Fukutochizawa, geological evidence of two faulting events in the late Holocene was detected at an outcrop and four hand-dug pits. We conclude that the latest event occurred in or after 13th century because the youngest radiocarbon age of humus displaced by the latest faulting is 720-650 cal yr BP (AD 1230-1300). An earlier event was recognized by a colluvial wedge intercalated in the gravel beds. Since the layers above and below the colluvial wedge were dated to 1860-1690 cal yr BP and 2290-2270 / 2160-1990 cal yr BP, respectively, we estimate that the penultimate event occurred 1690-2290 cal yr BP. The interval between the two dated events is thus about 1000-2000 years.

The northern part of the Magome-toge fault appears more active than the southern part, and a segment boundary probably exists somewhere between the two sites.

S71B-1095 0830h POSTER

Characterization of recent Lake Tahoe fault activity: Combining Sub-Meter Resolution Seismic Imagery with AMS C-14 Dated Submerged Paleo-Surfaces.

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Deformational strain within the Lake Tahoe Basin was mapped during previous campaigns using a combination of high resolution seismic CHIRP, multi-beam swath bathymetry, and airborne laser altimetry. These previous campaigns identified submerged paleo-shorelines of Pleistocene to early Holocene age, which act as a tectonic strain marker due to fault related disruptions of this once flat surface, as well as significantly offset fault scarps. Building upon this previous work, specific sites were selected for additional investigation with seismic CHIRP and AMS C-14 dated vibra and piston cores. The combination of these three techniques is ideally suited for quantifying recent fault activity through the correlation of paleo-surfaces and accurate age determinations. Initial analysis of seismic CHIRP and piston coring conducted in Emerald Bay shows a complex normal fault system with a sedimentation rate much higher than other parts of the lake. Seismic CHIRP conducted near Zephyr Cove was able to image multiple paleo-shorelines. Vibra coring of these same surfaces recovered sands of the same consistency as beach sand. Additional piston cores were collected at various lake locations below 400 m depth, including two cores taken across the Stateline Fault. Core analysis and AMS C-14 dating combined with site-specific seismic CHIRP, and previous mapping, will improve chronological control on the fault activity within the Lake Tahoe Basin.

S71B-1096 0830h POSTER

Relationship Between Regional Strain and Microseismicity in Japan

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It is generally thought that the level of activity of small earthquakes is related to the regional stress or strain field. In this study, we compare the observed strain field in Japan with the rates of shallow crustal earthquakes, to see how well the microearthquake activity correlates with the regional strain field.

With the installation of over 1000 continuous GPS stations of GEONET in Japan, we are able to observe the deformation field to a resolution of several tens of kilometers. We used the average horizontal displacement rates measured over the last 5 to 7 years at each station. The average rates were calculated by fitting linear trends to the data with periods of large earthquakes or other large deviation removed. These displacement rates were interpolated onto a 50 km grid and horizontal strains were calculated for the region of the Japanese Islands.

Using earthquake locations from the Japan Meterological Agency catalog, we calculated yearly rates of shallow earthquake activity for the same grid and same

time period that was used for the GPS observations. For the comparisons with the strain field, we tested several depth ranges from 10 to 30 km and magnitude thresholds of M1.0 to M3.0.

We compared the rates of earthquake activity with the rates of maximum shear strain for the region covering the 4 major islands of Japan. Areas that had the very highest strain rates 1x10^{-6}, such as the region of inferred dike injection near Kozushima had the highest rates of seismicity. However, in the strain rate range of 10^{-8} to 10^{-7}, which includes over 90% of the data, there were no clear correlations between strain rate and earthquake activity. Using different depth ranges and magnitudes of earthquakes or varying the grid the size did not produce significantly different results.

S71B-1097 0830h POSTER

Fault geometry and segmentation of the MTL active fault system in the Iyo—nada Sea, western Shikoku, in Japan

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The Median Tectonic Line (MTL) active fault system is one of the most active fault system in Japan, which is an east-west trending, 190 km-long fault system and consists of several rupture segments in Shikoku. A long active fault system such as the MTL active fault system may not rupture along its entire length in a single earthquake but instead consists of multiple seismic segments that rupture independently of one another. Therefore, the identification of the active segment for an each earthquake is very important subject for estimating ground motion. We investigated the detailed submarine topography, subsurface structure and fault activity of the MTL active fault system in the Iyo-nada Sea (Iyo-nada MTL active fault system), in Shikoku, Japan, by using echo sounder, single-channel seismic profiler and all-core boring in 2000 and 2001, in order to reveal the fault distribution and activity. We obtained the detailed fault trace with geometric discontinuities such as en echelon steps, bends, changes in strike, and gaps in this study area. These data are very precise compared with previous data, and permit us to consider fault segmentation and continuity to the Beppu Bay fault system and Iyo fault zone. The high-resolution core analysis revealed three or more seismic events and recurrence interval with 2500 to 3500yrs. The main fault trace and Holocene activity revealed in this study are apparently different from these of the Beppu Bay fault system. This result suggests that activity of these two fault systems depend on different tectonic setting one another. In contrast, the Iyo fault zone that distributes on land continues to the MTL active fault system in the Iyo-nada Sea as forming positive flower structure accompanied with compressional bend. We tried to conduct fault segmentation for the Iyo-nada MTL active fault system based on the 3-D fault geometry because we can easily consider the relationship between the surface trace and the subsurface structure of fault. Moreover, we also took into account of gravity data that may reflect basement structure, since it is suggested that basement structure may control the surface fault geometry, in recently. The Iyo-nada MTL active fault system is divided into three segments, which are the Iyo segment, the Iyo-nada segment and the Hoyo-kaikyo segment, on the basis of the 3-D fault geometry. These segment boundaries indicate the extensional right lateral steps with basin structure, respectively. In particularly, the extensional step at the eastern Iyo-nada Sea constructs pull-apart basin. We recognized these extensional right steps as the gExtensional Jogh in this study. These extensional jogs correspond to the changing parts of gravity anomaly trend. Therefore, deep crustal structure may be closely related with the fault geometry and segmentation.

S71B-1098 0830h POSTER

Seismicity of the Jalisco Block

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In April 2002 began to transmit the stations of the first phase of Jalisco Telemetric Network located at the northwest of Jalisco Block and at the area of Volcan de Fuego (Colima Volcano), in June were deployed four additional MarsLite portable stations in the Bahia de Banderas area, and by the end of August one more portable station at Ceboruco Volcano. The data of these stations jointly with the data from RESCO (Colima Telemetric Network) give us the minimum seismic stations coverage to initiate in a systematic and permanent way the study of the seismicity in this very complex tectonic region. A preliminary analysis of seismicity based on the events registered by the networks using a shutter algorithm, confirms several important features proposed by microseismicity studies carried out between 1996 and 1998. A high level of seismicity inside and below of Rivera plate is observed, this fact suggest a very complex stress pattern acting on this plate. Shallow seismicity at south and east of Bahia de Banderas also suggest a complex stress pattern in this region of the Jalisco Block, events at more than 30 km depth are located under the mouth of the bay and in face of it, a feature denominated Banderas Boundary mark the change of the seismic regime at north of this latitude (20.75°N), however some shallow events were located at the region of Nayarit.

URL: http://sisvoc.cuc.udg.mx

S71B-1099 0830h POSTER

Damage From the Nahrin, Afghanistan, Earthquake of 25 March, 2002

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On 25 March, 2002, a destructive earthquake of m_b = 6.1 struck the city of Nahrin and nearby villages in Baghlan Province in northeastern Afghanistan. The earthquake occurred on a southeast-dipping reverse fault that parallels the linear northeast-trending range front of the Hindu Kush Mountains, east of Nahrin. Field reconnaissance showed no disturbance of the ground by surface rupture, liquefaction, or lateral spreading, and virtually no evidence of landsliding or rockfall. United Nations and Afghan authorities estimate the death toll from the earthquake to be over 2000, with about 20,000 families impacted by the earthquake. We conducted a survey of damage in 68 villages affected by the earthquake and found that areas within 25 km of the epicenter experienced modified Mercalli intensities of between VI and VII. Shaking intensities were strong enough to cause complete building collapse in many villages.

Site conditions were an important factor in the distribution of damage in the Nahrin area. Houses built on the narrow crests of ridges eroded in loess suffered major damage due to the focusing of near-surface seismic waves on ridge-tops. Houses on low fluvial terraces along the Nahrin River also suffered major damage, likely due to their close proximity to the water table. Structures built on metamorphic bedrock and alluvial fans along the range front of the Hindu Kush Mountains or on high terraces along the Nahrin River suffered comparatively less damage.

Building failure was predominantly caused by the mud-block construction, characteristic of much of Afghanistan and adjacent countries. Most houses are built of mud blocks made from reworked loess, which contains a relatively low percentage of clay. The walls contain no bracing against lateral shear, and wall corners are not tied together, leading to failure at corners and roof collapse. In several villages, mosques were constructed to a higher standard and suffered significantly less damage than surrounding mud structures. The mosques often had concrete foundations and structural supports tied to the foundations. Had houses been built to the same standards as most mosques, loss of life would have been greatly reduced.

S71B-1100 0830h POSTER

Seismic Map of Mongolia and Site Effect Microzoning at the Capital, Ulaanbaatar

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Mongolia lies thousands of kilometres away from the India-Asia collision front. However, during the last century, it suffered four earthquakes with magnitude larger then 8. Given the small slip rates on these faults, about 1 mm/year, such events have return period of about 5000 years. In that context, the knowledge of the seismic hazard at Ulaanbaatar, capital of Mongolia where 35 to 40 % of the population live, is of first importance. We have undertaken a total revision of the seismicity of Mongolia in the aim to obtain an homogeneous catalogue, which will participate to assess seismic hazard at Ulaanbaatar. Local seismic monitoring, set up since 1994, has revealed dense seismic activity around Ulaanbaatar. The map of seismicity we built with these new data will be shown and published end of 2002. It reveals the first image of high microseismicity of this region either associated with large fault or with regional widespread activity. It tell us new information about seismic cycle in Mongolia. It seems that the micro seismicity associated with aftershocks or post-seismic activity on large fault decrease very slowly. We see still clear seismic activity on the faults that ruptured in 1905 during Bolnay and Tsetserleg earthquakes with magnitude 8 and more. We can notice the very low micro activity on large active faults that did not break during the two last centuries. It suggests that during the interseismic period, that could reach 5000 years, there is quite no activity. Ulaanbaatar is located several hundreds kilometres east of these large faults but could be affected by smaller events in its vicinity. For example, the September 24 in 1998, an earthquake of Mw = 5.3 at 190 km from Ulaanbaatar has been felt in the city. Moreover, some quaternary fault scarps were recognised at a distance of 40 to 200 km from the capital. We estimate that they could produce magnitude 6.5 to 7 earthquakes and may cause damage in the city. Concerning seismic hazard, key questions are whether high seismicity rate is representative of what we may expect in the future and what is the hazard assessment with smaller, but more frequent, events. We have also undertaken a microzoning to estimate site effects from seismic measurements within the Ulaanbaatar sedimentary basin. More then 100 sites have been measured in the city and its vicinity using 3 component seismometers. The results are deduced from H/V and site/rock reference applied either on noise or earthquakes recording. It shows, using different methods, stable amplified frequencies but variable amplification factors.

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S71B-1101 0830h POSTER

Improving our Knowledge on Seismic Hazard in the Algarve (Portugal)

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A seismic hazard project known under the CAPSA acronym is reaching its final stages. The most relevant geophysical results are presented.

The Algarve is located in the SW edge of the Iberian Peninsula, bordered by the Atlantic Ocean, on the West and South, near the border between the Eurasian and

the African plates. This particular tectonic setting, despite the diffuse but noteworthy seismicity, poses concerns as to the possibility of high magnitude events being generated and affecting the area. In fact, Zitelini (1999) put into evidence the Marques de Pombal structure, which is thought to be responsible for the 1755 earthquake that hit Lisbon and produced considerable damage in the Algarve. Historical seismicity provides evidence that several near-shore and inland events of large magnitude occurred in the Algarve in the last centuries.

Comprehensive geological field work, partly conducted under the aegis of CAPSA, unravelled a remarkable paleoseismicity, affecting the Plio-Pleistocene sediments, and pointed out to the importance of some major N-S and NW-SE striking faults, with dominant strike-slip movement as well as ENE-WSW inverse faults. Some of those structures are considered to be the surface expression of deeper reactivated variscan structures.

From a geophysical perspective, project activities were developed along those lines:

a)Compilation of potential field data, execution of small scale seismic reflection profiling and preparation of digital elevation models, to get the geophysical signature of the known complex fault systems, which affect the sediments, and are thought to be rooted. Seismic images of neotectonic deformation, and their probable extension into deeper levels have been obtained. Striking lineaments and a better delineation of salt domes and associated tectonics, resulted. b)By a reappraisal of the seismic catalogue data and analysis of the spatial distribution of events, correlations with known lineaments or faults, were sought. As a rule a diffuse pattern emerges, but two alignments are apparent. Deployment of a temporary seismic network around the subvolcanic Monchique massif, which is the siege of frequent microtremors, allowed collection of new events. Standard spectral analysis and calculation of the most relevant parameters (hypocentre, magnitude, etc.) was undertaken and is providing new insights on the nature of such microseismicity. Simultaneously, research on rupture mechanisms and analysis of Q dependency on frequency, took place, using mine induced seismic events, from Driefontein Mine (South Africa), as recorded on the near-source network deployed in the mine, which now reaches depths greater than 3.5Km. c)A gravity survey around Monchique to obtain a model of the massif, and merging with existing regional gravimetric and aeromagnetic surveys. Global processing and interpretation of such datasets, shed some light into the structure of the upper crust and is used as input for improved velocity models. d)Collection of new data to assess the importance of site effects, by: recording ambient seismic noise in urban areas settled on soft sediments and calculating spectral ratios by Nakamura techniques; collecting info on P and S wave velocities, from refrecation data at sites where lithological control from boreholes is available.

References:

Zitelini, N., et alt. 1999, The tectonic source of the 1755 Lisbon earthquake and tsunami, Ann. Geofisica 42: 49-55

S71C MCC: Hall C Sunday 0830h

Earthquake Source Studies I Posters

Presiding: **J J McGuire,** Woods Hole Oceanographic Institution; **N A Ratchkovski,** University of Alaska, Fairbanks

S71C-1102 0830h POSTER

Automatic Moment Tensor Inversion in the European-Mediterranean Region

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We automatically determine source parameters (M_w, depth and focal mechanism) for all moderate to strong earthquakes (magnitude $M \geq 4.8$) that occur in the European-Mediterranean region. Since April 2000, we run a procedure, that automatically collects and inverts waveforms for the seismic moment tensor. We retrieve broadband data recorded at regional epicentral distances from several networks and data centers (Switzerland, Austria, Czech Republic, Germany, Israel, Slovenia, USGS, Geofon, MedNet, ORFEUS), that provide waveforms via AutoDRM in near-real time. Moment tensor inversion is performed at long periods (60 to 125sec) with complete three-component seismograms. Data are first inverted for a fixed depth and traces with low signal-to-noise ratio are removed. Then, the remaining traces are inverted for several trial depths to find the best fitting depth. Moment tensor solutions are produced within 90 minutes after the event origin time. Solution quality is automatically assessed with empirically derived rules, that are based on number of stations and components used and formal error estimates of the moment tensor elements. Quality **C** solutions are rejected; quality **B** have well resolved moment magnitude M_w; quality **A** have well resolved M_w, depth and focal mechanism. Within two years, the automatic procedure resulted in 93 moment tensor solutions: 29 solutions have quality **A**, 33 quality **B** and 31 quality **C**. The non-homogeneous station and event distribution, and additional varying noise levels, affect the solution quality. However, the quality assessment correlates with event magnitude. Solutions with accurate M_w are produced already for earthquakes with $M_w \geq 4.5$, and quality **A** solutions are obtained for earthquakes with $M_w \geq 4.9$.

S71C-1103 0830h POSTER

Spectral-Element Centroid-Moment Tensor Inversions

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The recently developed spectral-element method (SEM) accurately simulates wave propagation in 3-D global and regional Earth models. In general, these 3-D synthetics significantly improve the waveform fit to the data. In this study, we use the SEM to calculate Fréchet derivatives for earthquake source parameters in fully 3-D Earth models. This enables us to perform Centroid-Moment Tensor (CMT) inversions for global and regional events. We use a variety of misfit criteria to obtain a robust estimate of the source parameters.

On a global scale, we test the method for the deep 1994 Bolivia earthquake and the shallow 2001 Buj, India, event. We use 3-D model S20RTS (Ritsema et al. 1999) and crustal model CRUST2.0 (Bassin et al. 2000). The synthetics incorporate effects due to ellipticity, topography & bathymetry, attenuation, the oceans, rotation, and self-gravitation. In Southern California, we test the CMT algorithm for several small local events by using the new 3-D LA basin model developed by Süss et al. We use a local version of the SEM that honors the deep geometry of the basement and incorporates topography & bathymetry, attenuation, and shallow sediments.

S71C-1104 0830h POSTER

Characteristics of the Nicoya Peninsula, Costa Rica Seismogenic Zone From Focal Mechanism Determinations

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Most of the world's great earthquakes occur along the seismogenic portion of the thrust interface at subduction zones. This region is formally defined by its frictional properties, characterized by unstable slip or stick-slip behavior, but observationally by the location of thrust earthquakes. The precise geometry of the seismogenic zone beneath the Nicoya Peninsula, Costa Rica, including the dip of the planar interface and its up and down-dip limits, has recently been imaged by the northern transect of the Costa Rica Seismogenic Zone Experiment (CRSEIZE). This experiment consisted of a network of 34 seismic stations on and offshore of the Nicoya Peninsula, 14 ocean bottom seismometers that operated for 6 months and 20 land stations that operated for 18 months. Approximately 650 out of over 3000 detected events locate along the shallow plate interface between the subducting Cocos and overriding Caribbean plates. These events reveal a sudden shallowing of the updip limit of seismicity where origin of the subducted plate changes from Cocos-Nazca Spreading center (CNS) to East Pacific Rise (EPR), coincident with an increase in heat flow measurements. Focal mechanisms for many of these events have been determined from a combination of P-wave first motions and P,SV, and SH amplitude ratios. Results reveal a plate interface with a complicated geometry; focal mechanisms of underthrusting events vary along the plate interface and intraplate events with diverse faulting geometries occur within the upper and lower plates near the plate boundary. We test for any systematic changes in faulting geometry as a function of subducting plate origin (CNS versus EPR) and depth to help us better understand the mechanical behavior of the seismogenic zone.

S71C-1105 0830h POSTER

Nonlinear Inversion of Body Waveforms of the June 2001 Earthquakes in Southern Peru.

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We report on the non-linear inversion of broad band body waves of the Mw=8.4 June 23, 2001 earthquake in Southern Peru. This tsunamigenic intraplate event occured in the nothern part of a well identified seismic gap of southern Peru, but it did not fill it completely. We use a non-linear inversion technique which combines two algorithms proposed earlier by Courboulex and colleagues: simulated annealing combined with heat-bath. The former is a Monte-Carlo technique consisting in a random exploration of parameter space, whereas heat-bath is a meticulous search of small final ajustments. The quality of waveform inversion is evelauted with a cost function based on the χ^2 test (L^2 norm). Our approach does not depend on a priori models, it can skip local minima and invert any number of parameters in reasonable time. The distribution in time and space of the aftershock population suggest that the rupture propagated unilaterally to the south-east. We confirm this from the inversion of body wave data. We obtain excellent fit between observed and synthetic seismograms using a linear source model in which rupture is constrained to propagate at constant speed towards the south-east. The STF reveals a rather complicated rupture history with a broad peak lasting about 50 s and a stronger second peak centered at about 80 after the initial shock. Like many other earthquakes the main source of energy (asperity) was not situated at the hypocenter but almost 100 km away from it. The focal mechanism was calculated using both P-wave polarity and our inversion algorithm. In the latter approach, the lack of good data on the Pacific side is compensated by the joint inversion of P and SH waves. Using similar technique for the three major aftershocks (the Mw=6.8 of June 26, the Mw=6.8 of July 5 and the Mw=7.5 of July 7 events) we find similar thrusting focal mechanism, but simpler STF.

S71C-1106 0830h POSTER

Observed Weather Satellite Thermal IR Responses Prior to Earthquakes

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A number of observers claim to have seen thermal anomalies prior to earthquakes, but subsequent analysis by others have failed to produce similar findings. It was the purpose of this study to determine if thermal anomalies could be found in association with known earthquakes by systematically co-registering weather satellite images at the sub-pixel level and then determining if statistically significant responses had occurred prior to an event. Earthquakes associated with plate movement (strike-slip and thrust faulting), rather than volcanism, were to be considered. A new set of automatic co-registration procedures were developed for this task to accommodate all properties particular to weather satellite observations taken at night. Spacecraft and sensor ephemeris and the horizontal displacement due to elevation were all factored in, and final adjustment for minor satellite deviations (related to roll, pitch, and yaw) were made by using image-to-image tiepoint correlations. Reliance upon visual clues in an image (frequently the subject of debate in the past) is not required. The technique relies on the general condition where ground cools after sunset. The technique applies best to the use of the geosynchronous weather satellites (GOES, Meteosat, and GMS), where images are taken every thirty minutes. Use of the