S33B CC: 220 C-E Wednesday 1330h

Studies from Eurasia and the Circum-Pacific Posters *(joint with G, T)*

Presiding: **P M Rouleau,** Memorial University of Newfoundland**; I Morozov,** University of Saskatchewan

S33B-01 1330h POSTER

Initial results from the RETREAT seismic deployment in the Northern Apennines.

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The paradox of how horizontal contraction and extension can occur simultaneously in convergent mountain belts remains a fundamental and largely unresolved problem in continental dynamics. The Apennines represent one of the most accessible "type locality" areas of syn-convergent extension. Rollback - which describes the tendency of a subducting plate to retreat from the orogenic front - is commonly invoked as an explanation for syn-convergent extension, but this idea does not address how the retrograde motion of the subducting plate, which is a mantle-based process, causes horizontal extension in the overlying zone of crustal convergence, especially in light of the large accretionary fluxes typically associated with continental subduction. The goal of the multidisciplinary project RETREAT is to develop a self-consistent dynamic model of syn-convergent extension, using the Northern Apennines as a natural laboratory. In the context of this larger study, a passive seismological experiment got underway in the fall of 2003. At present the project is a collaboration between the Istituto Nazionale di Geofisica e Vulcanologia (INGV), the Geophysical Institute in Prague (GIP) and US universities (Rutgers and Yale). The project aims at developing a comprehensive understanding of the deep structure beneath the Northern Apennines, with particular attention on inferring likely patterns of mantle flow. Specific objectives of the project are the crustal and lithospheric thicknesses, the location and geometry of the Adriatic slab, and the distribution of seismic anisotropy laterally and in depth. The project will collect teleseismic and regional earthquake data for 3 years. The first phase of the project, successfully deployed in October of 2003, utilizes 10 broad-band stations from GIP, together with permanent installations operated in the region by INGV. This year a 25-node array of seismographs from the US PASSCAL pool will be deployed, densifying an already existing 2D grid, and also forming two tightly spaced linear transects across the Apennines. In addition, installing of several French stations is envisaged. This contribution reports on the goals, analytic tools and some initial results of the deployment.

S33B-02 1330h POSTER

The Stress Fields due to Recent Seismic Events in the Central Apennines, Italy.

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The Central Apennines, Italy, are characterized by moderate seismic activity on normal faults, oriented in directions parallel to the Apenninic chain. The subject of this study is the Umbria-Marche Apennine, a segment approximately 200 km long, where three main seismic events occurred in the last three decades. The 1979 Norcia earthquake was a M=5.8 event, taking place at the south end of the considered segment. The 1984 Gubbio earthquake was a M=5.3 event which took place at the north end. The 1997-98 Colfiorito sequence was made of 8 main shocks with magnitudes between 5 and 6 and epicentres comprised between the Gubbio and the Norcia earthquake areas. A model made of an elastic half-space is considered, where the seismic sources are represented by rectangular dislocations having the appropriate values of source parameters, and the stress field produced by each event is calculated. The superposition of the different stress fields and of an assumed regional tensile stress gives the time evolution of the stress field in the area. The analysis of Coulomb failure stress as a function of time gives information as to the role played by coseismic stress transfer and fault interaction during the past three decades in the region.

S33B-03 1330h POSTER

Seismic Quiescence Test For Earthquakes In The Caucasus

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This paper represents probabilistic assessment of seismic quiescence for Caucasus. The high quality earthquake catalogue compiled by the Armenian National Survey for Seismic Protection Government of Armenia, has been used. The catalogue is representative for earthquakes with magnitude of Msd=2.5, for the time period since 1962 and for the area located within 38N to 42N and 42E to 47E. As a parameter of the seismic quiescence, quantity of earthquakes has been used Wyss and Habermann 1988, which is described by the Poisson distribution quite well. This feature allows to compare probabilistic assessments of different temporal and spatial scales. To study the time history of seismicity change in the region, we used probabilistic approach, where an occurrence probability for a given number of earthquakes is estimated. The background seismicity is calculated on the base of data for last 40 years. Calculated probabilistic Z-level maps using sliding window technique allow to follow the dynamics and specification of seismic regime in the region. Active and passive zones are defined according to definite confidence levels of probability, and in the preparing phase the confidence level for characterizing the seismic quiescence is given in Z-values scales. All strong earthquakes of the Caucasus have been tested, using above- mentioned approach. Investigating all known models, which more or are less proved by laboratory experiments and by situations of theoretical physics for an explanation of physical bases of predictions seismic quiescence was chosen dilatancion-diffusion (DD) model, which in all of seismic cycle of a mode of the source precisely allocates a phase of a seismic quiescence prediction. The result we have found that before all strong seismic events in the Caucasus very well pronounced seismic quiescence has been observed.

S33B-04 1330h POSTER

Active Tectonics And Modern Geodynamics Of Sub-Yerevan Region

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The given work is dedicated to active tectonics and modern geodynamics of Sub-Yerevan region. This region is interesting as a one of regions with maximal seismic activity in Armenia. The high level of seismic risk of this region is conditioned by high level of seismic hazard, high density of the population, as well as presence of objects of special importance and industrial capacities. The modern structure of Sub-Yerevan region and the adjacent area, as well as the Caucasus entirely, has mosaic-block appearance, typical for collision zone of Arabian and Eurasian plates. Distinctively oriented active faults of various ranges and morphological types are distinguished. These faults, in their turn, form various-scale active blocks of the Earth's crust and their movement defines seismic activity of the region. The researches show, that all strong earthquakes in the region were caused by movements by newest and activated ancient faults. In order to reveal the character of Earth's crust active blocks movement, separation of high gradients of horizontal and vertical movements and definition of stress fields highest concentration regions by GPS observations, high-accuracy leveling and study of earthquake focal mechanisms a new seismotectonic model is developed, which represents a combination of tectonic structure, seismic data, newest and modern movements. On the basis of comparison and analysis of these data zones with potential maximal seismic hazard are separated. The zone of joint of Azat-Sevan active and Yerevan abysmal faults is the most active on the territory of Sub-Yerevan region. The directions relatively the Earth's crust movement in the zones of horizontal and vertical movement gradients lead to conclusion, that Aragats-Tsakhkunian and Gegam active blocks undergo clockwise rotation. This means, that additional concentration of stress must be observed in block corners, that is confirmed by location of strong earthquakes sources. Thus, on the North 1988 Spitak (M=7.0), on the East Garni-Dvin and on the South-West Ani and Tekor strong earthquakes' sources are adjacent to the corners of Aragats-Tsakhkuniats active block.

S33B-05 1330h POSTER

Constraints on the Vertical Variation of Seismic Anisotropy Beneath the Nanga Parbat Haramosh Massif From S and SKS Splitting

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To constrain the magnitude and direction of seismic anisotropy beneath the Nanga Parbat region at the western end of the Himalaya collision zone, we measure shear wave splitting in teleseismic and regional shear phases recorded by the Nanga Parbat Seismic Experiment. At stations outside the Nanga Parbat Haramosh Massif (NPHM), SKS and related core phases produce delay times, δt, between 1.5 and 2.3 s with WNW-ESE fast directions. In contrast, regional S phases originating from the Hindu Kush with source depths of 200 km to 300 km produce similar fast directions, roughly E-W, but their delay times are significantly smaller ($\delta t \leq 0.5$ s). The depth range sampled by the regional S phases largely lies within high velocity lithosphere imaged by regional shear wave tomography studies of East Asia which extends to more than 200 km depth in the Nanga Parbat region. We thus conclude that anisotropy within the lithosphere only contributes ~0.5 s to the total splitting observed for the teleseismic phases and that the sub-lithospheric mantle is responsible for 1.0 - 1.5 s. Within the interior of the NPHM, SKS paths from a wide range of back-azimuths produce null measurements. Laboratory studies of gneiss samples from Nanga Parbat suggest that as much as 21% shear wave anisotropy with a N-S fast axis may exist in the crust. In addition, deformation in the mantle lithosphere consistent with the roughly E-W compression of the Nanga Parbat orogen could also contribute to shallow N-S anisotropy. The null observations in the NPHM interior may therefore be explained by a two layer anisotropic model with N-S anisotropy in the crust and lithosphere that cancels splitting from roughly E-W sub-lithospheric anisotropy. At stations surrounding the NPHM, the dominant WNW-ESE fast directions in the SKS phases are aligned with the least principal stress direction of the India-Asia collision zone. However, the regional S phases indicate that lithospheric compression can only account for approximately 0.5 s of splitting. Therefore, to explain the bulk of the splitting seen in the teleseismic phases, strong anisotropy due to asthenospheric flow parallel to the orogen is required.

S33B-06 1330h POSTER

The seismic experiment around Eastern Tibet

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Knowledge of the seismic structure of the upper mantle would be of tremendous help in unraveling the post-collision geodynamic history of the Tibetan plateau in general and the eastern Himalayan syntaxis in particular. We are conducting a seismic experiment as part of a multidisciplinary study to place additional constraints on the relationship between crustal and mantle structure, to test the decoupling hypothesis, and to provide a structural framework of the mantle to constrain the geodynamic evolution of the region. In October 2003 we deployed a 25 station broadband array across eastern Tibet and the array will record local, regional, and teleseismic events over a 9 month period. We have obtained first group data already. The regional broadband array will be used to provide important constrains on the stress field in the crust (earthquake locations and source characteristics), the depth to Moho beneath eastern Tibet (receiver functions and high-frequency surface wave dispersion), the presence of absence of a weak lower crustal layer (propagation speed and attenuation of seismic waves), the level of the mechanical coupling between crust and mantle (tomgraphic imaging and seismic anisotropy), and the presence of lithosphere scale faults and the off set across them.

S33B-07 1330h POSTER

A Crustal Fluid Based Interpretation of the Frequency Dependent Shear Wave Attenuation Observed in the Lithosphere Beneath the Kanto Area, Japan.

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Seismic attenuation measurements in the band 0.01 - 10 Hz have now been reported for a large number of tectonic areas. For tectonically active regions, the measured attenuation appears higher and more frequency-dependent than for passive regions. It has been hypothesised that such an observation reflects the presence of a high density of fluid-saturated fractures along the paths of the seismic waves used to estimate the attenuation. In order to quantitatively test this hypothesis, both a seismic attenuation data set that spans a large band of frequencies and a quantitative seismic absorption model that involves fluids are needed. This hypothesis is tested here using the set of shear-wave attenuation data reported for the Kanto Area, which shows a clear maximum in attenuation near one Hz, and the squeeze-flow mechanism model (i.e. squirt-flow adapted to the field-based fracture-porosity scale and crustal hydraulic attributes), which predicts well-defined attenuation maxima. The modelling results show that the squeezing of fracture-bound saline fluid produces shear-wave Q values that match the magnitude and frequency dependence of the data-inferred shear-wave Qs. In particular, the depth-distribution of squeeze-flow Qs for the sampled area shows a zone of very high absorption and pronounced frequency dependence that correlates well with a zone of impedance contrast imaged via body wave tomographs reported for the same area. Thus, the squeeze-flow mechanism supports the hypothesis that viscous flow of crustal fluids effectively attenuates high-frequency seismic waves in the crust and so suggests a cause for the shear-wave Q versus frequency trend observed in the Kanto area.

S33B-08 1330h POSTER

Constraints on the Shallow Velocity Structure from Wide-Angle P/S mode Conversions in the First Arrivals: Application to ACCRETE Data

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P/S mode conversions identified in the first arrivals could provide valuable information about S-wave velocity contrasts within the shallow subsurface. Near-receiver P/S conversions are routinely employed to constrain the crustal thickness in teleseismic seismology, in a technique known as receiver functions. Recently, Morozov et al. (2002) applied this method to recordings from an ultra-long-range refraction profile in Northern Eurasia and showed that travel-time lags between the direct P- and converted P/S waves could be utilized to map the thickness of the sediments along the profile. However, in wide-angle crustal, as well as in exploration seismology, mode conversions in the first-arrival coda has still not been utilized. In this study, we use the P/S phases to constrain the shallow subsurface in the records from a crustal ACCRETE profile acquired in 1994 across the Coast Plutonic Complex in SE Alaska and Coastal British Columbia. The dataset included 1700 km of marine multichannel profiling in BC fjords that were also recorded by 60 three-component Reftek seismographs deployed at 3-5 km spacing on land. To date, this dataset provides some of the best-quality S-wave recordings, including consistent reflections and conversions from the Moho. Three-component particle motion analysis and receiver-function-type deconvolution reveal P/S mode conversions in the first arrivals in almost all the receiver gathers. Particle motion changes from linear (primary P-wave) to circularly-polarized transverse (P/S converted mode) within 100-200 ms milliseconds of the first arrivals. The delay between the P/S and P waves is independent of shot locations and is indicative of a P/S conversion on S-wave velocity contrasts near the receiver. The locations of these contrasts were estimated from the time delay and polarization of the P/S waves. These results suggest that in the ACCRETE area, mode conversions take place on the sediment-basement contact. Therefore, identification of mode conversions in the coda of the first arrivals helps constraining the shallow near-receiver structure. In future experiments with dense three-component recording, this technique could provide a valuable tool for mapping the three-dimensional shallow subsurface using remote seismic sources.

S33B-09 1330h POSTER

Study of resent seismic activity in the basin and transform faults of the Gulf of California

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Deployment of broad-band seismic stations around the Gulf of California since 2002 have greatly improved the location of small to medium size earthquakes. This is the result of a joint project between CICESE, Utrecht University and Caltech. This network consists of the RESBAN-CICESE network (eight broad band stations and five short period stations) and the NARS-Baja network from the Utrecht University (thirteen broad-band stations). For example, an earthquake of magnitude 5.6 occurred on November 12, 2003 and it was located east of the Bahia de los Angeles town at 29.034° Latitude North and 113.251° Longitude West, over the North Salsipuedes Basin. Fault geometry was obtained with the body waveform modeling using Herrmann (1987) reflectivity code. A preliminary fault geometry with a strike of 320°, a dip of 70°, a slip of $-100°$ and a focal depth of 5 km was calculated. Seismic station BAHB located at about 22 km west of the epicenter showed a clear triangular source time function of 4.5 seconds. Over the southern end of the Gulf of California occurred bursts of earthquake activity on January 13 and 14, 2004 with events in the magnitude range from 3.5 to 4.4 over the Pescadero Basin at the average geographic coordinates of 24.634° ± 0.011° Latitude North and 109.296° ± 0.10° Longitude West. Again on February 9, 2004 another earthquake swarms occurred with events in the magnitude range from 4.0 to 5.3. Preliminary locations of the events indicated that the events are located in the Pescadero Basin. Focal depths of the earthquakes are uncertain. We will show the best-located events that we have been able to locate with the RESBAN-NARS-Baja network of the Gulf of California.

S33B-10 1330h POSTER

A Synthesis of Anisotropy Measurements in New Zealand

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New Zealand (NZ) straddles the boundary between the Australian and Pacific plates; a large number of recent anisotropy studies there allows us to gain insights into processes of plate boundary deformation. The tectonics of the north island of NZ is dominated by oblique subduction at the Hikurangi margin, which gives way to transpression along the Alpine fault in the south island. In the southernmost south island there is a transition to oblique subduction again (Puysegur subduction zone). The fast directions obtained from shear wave splitting of teleseismic phases (such as SKS) are remarkably consistent throughout the variety of tectonic regimes in NZ. In the north island, trench parallel fast directions are found both above and below the slab, suggesting trench parallel asthenospheric flow in both these regions. Anisotropy in the lithosphere is likely to be due to shear deformation. Throughout the south island, the fast directions from Pn and teleseismic phases are subparallel to the Alpine Fault, suggesting widespread (at least as wide as the south island) shear deformation of the underlying mantle. Results from local phases suggest that in the crust and uppermost mantle, the shear zone is narrower than in the deeper mantle. Throughout much of NZ fast directions measured from both local and teleseismic phases are subparallel to the geological features. This suggests that the crust and mantle deform coherently and that there is vertical coupling. However, there are variations in some locations in the fast directions obtained using local phases, probably reflecting shallow structure. The teleseismic delay times in NZ are amongst some of the highest in the world. Results from local phases suggest that anisotropy exists to at least 200 km depth throughout much of NZ. Petrophysical analysis of mantle xenoliths suggests that for the north island a significant portion of the anisotropy must reside in the asthenosphere. Many regions have been studied in detail and show a departure from the general observations above. Preliminary results from the tip of the north island show little splitting. The Central Volcanic Region (CVR) in the north island is a zone of active back arc extension. In the western CVR fast directions from local phases are perpendicular to the trench, suggesting asthenospheric flow in the extension direction. In the eastern CVR there is a mixture of fast directions, suggesting a transition between the western CVR and trench parallel fast directions further east. There is also a back azimuthal dependence from teleseismic phases. At Mt Ruapehu (southernmost CVR) temporal changes in anisotropy appear to be related to a volcanic eruption, which could eventually lead to an eruption monitoring tool. In the lower north island lateral variations in anisotropy are measured with teleseismic S and ScS phases. A large number of splitting measurements at the permanent station SNZO in Wellington show significant variations with propagation and incoming polarization directions, as well as waveform frequency. This suggests that the anisotropic structure here is complicated. The northern south island (Marlborough region) is a transition between subduction and oblique transform faulting; here the shallow anisotropy is attributed to a thick layer of subducted crust (metamorphosed schist). In southernmost NZ the fast directions are not fault parallel, but are consistent with crustal strain extension directions. However, the smaller strain in this region is not consistent with the delay times. The Puysegur subduction zone could also be affecting the splitting measurements in this region.

S43A CC: 516 D Thursday 1330h

Seismology From Crust to Core: The Science of the Global Seismographic Network I *(joint with G, T)*

Presiding: **L Wen,** State University of New York at Stony Brook**; J Park,** Yale University

S43A-01 1335h

Earth Noise: A survey of the Global Sesimographic Network stations

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The IRIS Global Seismographic Network (GSN) consists of widely distributed, similarly equipped, and well-calibrated stations. Using data from the 118 GSN stations operating during the year July 2001 through June 2002, we have made over 738,000 hourly spectral estimates of the observed ground motion in seventh-decade (approximately half-octave) bands for periods between 1000 and 0.07 seconds. From these estimates we have developed a robust earth noise model and characterized the performance of the network. We note the differences in vertical and horizontal component of the noise and in the performance of the 4 models of seismometers used in the network. In addition to the well known microseismic noise peaks, at many stations there is an additional peak at about 125 seconds. At longer periods, the vertical component of earth noise is considerably quieter than previously reported. Indeed, these lowest noise levels can only be observed on one of the GSN sensors - the STS-1.

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