T51C-03 0830h

Implications of the 8/21/2003 Mw 7.2 Fiordland New Zealand Earthquake for the Development of the Alpine Fault Plate Boundary

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The transition from subduction of the Australian plate beneath Fiordland to the transpressional Alpine fault represents an abrupt change in plate interactions. Beneath Fiordland, the Australian plate subducts to depths of at least 200 km, with the slip vectors of earthquakes inferred to represent plate interface events aligned in the direction of relative plate motion between the Australian and Pacific plates. To the north, along the Alpine Fault, the eastern edge of the Australian plate serves to define the position of the plate boundary, with the majority of transpressional deformation accommodated by the Pacific plate. Based on plate reconstructions, the eastern edge of the Australian plate that now defines the Alpine fault boundary was previously adjacent to the lithosphere that is currently subducted to depth beneath Fiordland. How this transition occurs has been a point of some debate. The recent Mw 7.2 earthquake (8/21/2003) provides evidence of the lithospheric deformation that allows this change in plate boundary structure. This event is characterized by two thrust planes: one shallowly dipping to the ESE, the other steeply dipping to the WNW. In contrast to subduction interface events further to the east, both fault planes have slip vectors that are nearly pure dip slip, oriented approximately 60 degrees away from the relative plate motion. Although the shallow eastward dipping plane is consistent with the inferred geometry of the slab, its slip vector is incompatible with other subduction events on the plate interface. If however the steeply dipping plane is selected, its orientation, slip vector, and the location of the earthquake are all consistent with it representing an event that occurs as the Australian plate is torn, forming a new eastern edge to that plate. Several other earthquakes with similar mechanisms have occurred on this southwest extension of the Alpine Fault; all with fault planes consistent with a tearing of the plate. This plate edge will translate northward becoming the west side of the Alpine Fault plate boundary. We have previously argued that a tearing of the slab in this way (essentially collinear with the Alpine Fault) was needed to match the patterns of slab deformation, uplift in Fiordland, and the substantial gravity anomaly in the region. This earthquake provides direct evidence of the tearing process and provides constraints on the location within the transition from subduction to translation that the new plate boundary is generated.

T51C-04 0845h

Integrating Seismological Studies of Crustal Structure in the Northern California Coast Ranges to Construct a Regional 3D Strain Model

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The Coast Ranges of California has been the target of a number of recent seismological studies aimed at constraining various aspects of crustal architecture. The combination of techniques used provides a suite of complimentary constraints; the active source Mendocino seismic experiment gave 2D velocity data and delineated interfaces from reflectivity, while tomography provided a smoothed 3D velocity picture. Receiver function studies have characterized crustal interfaces and provide information on the nature of the velocity contrasts across these interfaces. This latter information is key in determining the way in which processes driven by the passage of the Mendocino Triple Junction have driven crustal evolution of the Coast Ranges. Combining the results of these various studies, we test models of thickening and subsequent thinning of the crust in response to the Mendocino crustal conveyor. Specifically we use crustal structure models from receiver functions generated at a number of stations in the region, combined with the 3D tomography of the area, to develop a model of crustal architecture over the entire Coast Ranges. Analyzing these results within the framework of the Mendocino crustal conveyor model allows us to move beyond simply describing the structure; rather it allows us to develop a 3D model of present-day crustal strain that provides constraints on mechanical properties of the Coast Ranges crust, where shear zones develop within that crust, and the role they may play in the evolution of the San Andreas Fault system.

T51C-05 0900h

The last stages of subduction in the South-Central Mediterranean reflected in geodetic and seismic strain rates

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Subduction, collision and back-arc spreading zones within the Africa-European plate boundary meet in the south-central Mediterranean. Strain rate maps based on new geodetic data and existing seismic catalogs document several recent tectonic changes in this region. (1) Current Africa-European convergence around Sicily is localized north of the island, along what we interpret to be a back-arc thrust. This thrusting is a response to collision of the subduction zone with the African continental margin 1-3 Ma. Faults in west and central Sicily may be reactivated in occasional earthquakes, but do not accommodate significant compression anymore. (2) Back-arc extension in the Tyrrhenian is currently not observed. Within 1-2 mm/yr the area behaves like a rigid part of Europe. (3) There is no geodetic evidence of ongoing southeast migration of the Calabrian arc. (4) The Aeolian islands and northeastern Sicily exhibit an unusual and previously unrecognized velocity pattern. With velocities of up to two times Africa-European motions, this area is extending, and rotating relative to Africa. We suggest that mantle flow and gravitational collapse associated with an up-dip tearing between the Ionian and Sicilian portions of the slab are responsible for these unusual velocities. The tear could have developed when the trench collided with the Sicilian part of the African margin while roll-back at the Calabrian trench continued (until about 0.5 Ma). The existence of such a tear may also explain the occurrence of extensional earthquakes and high uplift rates in eastern Sicily, the location of Etna, and recent changes in the geochemical signature of Aeolian volcanism.

T51C-06 0915h

First Constraints On the Slip Rate of the Yammouneh Fault (Levant Fault System) Determined by Cosmogenic ^{36}Cl Exposure Dating of Offset Alluvial Fans

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The most active seismogenic structure along the eastern shore of the Mediterranean is the left-lateral strike-slip Levant fault, plate boundary between Arabia and Africa. To this day there is consensus neither on its present slip rate and segmentation, nor on the exact size and frequence of the earthquakes it generates. Between latitudes 33^{o} N and 35^{o} N in Lebanon, the Levant fault's trace veers eastwards by 24^{o}, forming a 160km-long restraining bend, responsible for the uplift of Mount Lebanon (3083m). Most of the resulting transpressive deformation is partitioned between two main structures: the offshore Tripoli-Beirut thrust and the Yammouneh strike-slip fault, whose degree of seismogenic activity has been questioned (various estimations of its modern slip rate range from 0 to 8mm/yr). Using aerial photographs, satellite images, topographic maps and field observations, we mapped and measured left-laterally offset alluvial fans and gullies along the Yammouneh fault. The measured offsets range from less than 10m to about 3km. To constrain the slip rate of the Yammouneh fault, limestone cobbles were sampled on three alluvial fans, each offset by 40–50m. The concentrations of ^{36}Cl and stable Chlorine in the 48 samples were measured by accelerator mass spectrometry at the LLNL-CAMS. The first results suggest an average slip rate of 5–10mm/yr along the Yammouneh fault in the last 8,000 years.

T51C-07 0930h

Determination of Stress From Fault-slip Data: New Models, Algorithms and Accuracy Evaluation

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Stress tensors are regularly determined from fault-slip and/or earthquake focal mechanism data in structural geology and seismotectonics. The inverse problem is nonlinear, unless empirical rules of rupture and friction are employed. All the methods used to date to determine the stress tensor to this nonlinear inverse problem are of local nature, and thus cannot guarantee that the global optimal stress tensor has been obtained. We apply a hybrid global optimization method developed by Xu (J comput appl Math, 147, 301-314, 2002; J comput appl Math, 155, 423-446, 2003; J comput appl Math, 156, 201-219, 2003) to find the global optimal stress tensor. Although the inverse problem is nonlinear, the effect of nonlinearity on the biases of stress tensors has not been investigated. We will examine the biases of inverted stress tensors and their effect on the principal orientations of stress and the shape parameter of the stress ellipsoid. The biases of stress parameters have been shown to be comparable with the estimated stress parameters numerically. We compare the accuracy of the four stress parameters, with and without taking the errors in fault planes into account. If the errors in fault planes are not taken into account, the stress parameters are too optimistically estimated by a factor of $4 \sim 9$ in the example. We will also mathematically reformulate the assumption that the directions of maximum shear stress represent those of slips on fault planes as two functionally independent but equivalent constraints of equality. The new formulation is computationally more effective and provides a correct method for calculating the accuracy of stress parameters.

T51D MCC: Level 1 Friday 0830h

Brittle Deformation and Faulting of the Earth's Crust: Observations and Models II Posters *(joint with G, S, V)*

Presiding: **B Meade,** Massachusetts Institute of Technology

T51D-0186 0830h POSTER

Late Quaternary displacement rate on the Alpine Fault and the timing of glacial advances in southwest New Zealand

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Glacial features in eight river valleys crossing the southern end of the onshore Alpine Fault in South Island, New Zealand, are offset dextrally 435, 1240, or 1850 m and have only small vertical offsets. This is consistent with radiocarbon, surface exposure and speleothem evidence for extensive glaciation followed by retreat at c. 18, 58, and 79 ka. Glacial advances at c. 79 and 60 ka were higher and more extensive than 20 ka advances. Consideration of the three offset-age ranks yields an Alpine Fault slip rate with 95% confidence limit (1.96 sigma) of 22.9 ± 3.3 mm/yr. Consideration of eight sites offset by about 435 m indicates the rank 1 offset has a 95% confidence limit of 51 m, yielding a displacement rate and 95% confidence limit of 24.2 ± 3.3 mm/yr for features of this age. Comparison with geologically determined uncertainties from each site shows that geological estimates of uncertainty in age and offset approximately correspond to confidence limits in the range 90-99%. 36.2 ± 3 mm/yr of total plate motion in southern South Island (NUVEL-1A) is being partitioned into 22.9 ± 3.3 mm/yr of Alpine Fault dextral strike-slip, 12 ± 5 mm/yr of heave on oblique dextral-reverse faults up to 80 km southeast of the Alpine Fault, and 5 ± 3 mm/yr of heave on reverse faults at peripheries of the plate boundary.

T51D-0187 0830h POSTER

Using Three-dimensional Mechanical Models of the Los Angeles Basin, California, to Validate Tectonic Boundary Conditions and Locate Unrecognized Secondary Faults

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Geodetic studies have calculated horizontal strain rates that represent different degrees of vertical thickening vs. escape tectonics in the Los Angeles basin. In this study, three-dimensional mechanical models are used to compare fault slip rates resulting from four representative tectonic boundary conditions for this region to paleoseismic and geologic late-Quaternary slip rates. Resulting best-fit tectonic boundary conditions are applied to the model to identify potential locations of unrecognized secondary faults in the eastern Los Angeles basin. We conclude that north-south contraction in the basin is accompanied by negligible east-west strain, suggesting a vertical thickening, rather than escape tectonics scenario. Under the preferred tectonic boundary conditions, the pattern of strain energy density (SED) of host rock highlights potential areas of unrecognized faulting, and the Navier-Coulomb stress criterion predicts the orientation of potential failure planes at these locations. The non-uniform distribution of SED throughout the model suggests: 1) clustering of secondary faults near intersecting major faults (e.g. hanging wall of the Puente Hills thrusts); 2) linkage of proximal faults (e.g. Whittier and Alhambra Walsh faults); and 3) extension of some fault surfaces (e.g. Chino and Compton faults). Correspondingly, the Navier-Coulomb stress in these locations predicts that fault plane orientations are influenced by the geometry of existing faults rather than by tectonic boundary conditions. Additionally, whereas some areas of low fault density have high SED (e.g. south of the Cucamonga fault), others do not. Moreover, the location and orientation of the proposed Montebello fault predicted by the model results matches that inferred from surface geology.

URL: http://www.geo.umass.edu/faculty/cooke/topics/LA.html

T51D-0188 0830h POSTER

Rupture Areas Of Large Earthquakes In Papua New Guinea In 1971 And 2000

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Two large earthquakes with magnitudes greater than 7.0 (Mw) occurred near New Ireland and New Britain, Papua New Guinea, on November 16-17, 2000. Both earthquakes were thrust events with shallow dip angles in the New Britain subduction zone. Also, another two large earthquakes (both Ms 7.9) occurred in the same area on July 14 and July 26 in 1971, almost 30 years before the 2000 events. Aftershock zones of the 1971 events covered large areas, including the fault zones of the 2000 events. In this study we estimate the rupture areas of the 1971 and 2000 events using teleseismic waveform inversion and investigate their interrelationships. To understand the rupture processes of the 1971 events, waveform inversions using Pdiff waves was carried out. Paper recordings of the Pdiff waveform data at seismic stations for distance between 100 and 140 degree were scanned from microfilm and digitalized. Synthetic seismograms were calculated with theoretical Green's Functions and the best fit between observed and synthetic seismograms was obtained by a least-square method. Fault mechanisms and rupture processes were obtained by the waveform inversion. Results of the waveform inversion showed that both earthquakes were thrust events having shallow dip angles. The July 14 event has two areas with large slip and the July 26 event has a single area of large slip. Teleseismic P wave inversions were previously carried out to understand the rupture processes of the 2000 events. P-wave data from stations at distance between 30 and 90 degree were retrieved from the IRIS data center and used for waveform inversion. As the result of the waveform inversion, both events seem to have fairly simple rupture patterns with a single area of large slip. Based on the result of the waveform inversions, we will discuss the relationships between the rupture areas of the 1971 and 2000 events, and their rupture mechanisms.

T51D-0189 0830h POSTER

A Quantitative Analysis of Rift Processes in the Northern North Sea and Central Greece.

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Actively extending sedimentary basins provide a snapshot of the way in which basins evolve. Our observations from such regions are temporally limited: we have little understanding of the long-term processes involved but an excellent understanding of the short-term motions (10^0-10^2 years). The converse is true of tectonically dead basins where the deformation has ceased and only the end product can be observed. Studies of active basin formation in central Greece have provided a quantitative understanding of the kinematics of extensional tectonics. The use of GPS, SAR interferometry and geomorphological analysis has constrained the rate of extension and fault kinematics and geometries. Central Greece has often been cited as a present-day analogue for formation of the now inactive East Shetland Basin (ESB) in the northern North Sea. A large 3D seismic dataset has been compiled giving complete coverage of the ESB, a region comparable in size to central Greece ($\sim$10,000 km^2). A quantitative comparison between Greece and the ESB will close the gap in knowledge between short-term and long-term motions. Whilst the two regions have many features in common, such as tilted fault blocks, fault segments of comparable length and similar fault geometries, there are also important differences. For example, one difference between Greece and the northern North Sea is the rate of extension. The North Sea had a peak strain rate that was an order of magnitude slower than the rate at which Greece is currently extending across the gulfs of Corinth and Evia. Another difference is that the distance between large active faults in Greece appears to be significantly longer than in the ESB. A specific example of this difference in scale is the Tern-Eider ridge, which is a horst block in the ESB that appears superficially similar to the island of Evia in Greece. However, the rigid island of Evia is significantly wider than the Tern-Eider ridge. A link between this inter-fault distance and strain rate is currently being investigated, along with an evaluation of elastic thickness in the areas concerned.

T51D-0190 0830h POSTER

Regional Moment Deficits in Southern California

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We present a novel method for detecting regions of seismic moment deficit. These are areas where the moment release associated with large historical earthquakes does not balance the moment accumulation rate observed today. The total deformation field for the last two centuries is calculated by converting estimated focal mechanisms to rupture lengths, depths and displacements using empirical scaling relationships. We estimate the total amount of accumulated surface deformation over the same time period based on estimates of fault slip rates from a block model. These slip rates are then scaled to displacements by multiplying by the time since the start of the earthquake catalog ($\sim$200 years). Total surface displacements for both cases are calculated with an elastic dislocation model. The residual (accumulation minus release) deformation field allows us to clearly identify regions of seismic moment deficit. Finally, the residual displacements in each zone of moment deficit are inverted for the best fitting single event source. We find three regions of significant moment deficit in southern California: the Southern San Andreas and San Jacinto Faults, the gap between the 1872 Owens Valley and 1992 Landers earthquakes, and the offshore faults to the south of Los Angeles.

T51D-0191 0830h POSTER

Predicting Fractures Using an Elastic Dislocation Model of the 1980 El Asnam, Algeria, Earthquake

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We present a forward elastic dislocation model of the predicted fractures due to the Ms 7.3 earthquake at El Asnam, Algeria in October 1980. Using a new fault model based on parameters from previous seismological studies that fits the benchmarked geodetic data, we compare the predicted distribution, mode and orientation of fractures with the observed surface deformation in the area following the 1980 earthquake. Geodetic data are limited to measurements of the vertical component of surface deformation and by using the surface fractures caused by the coseismic stress perturbation to constrain our models we can indirectly sample all three components of the near-surface displacement field. In addition, the surface fracture observations are spatially more widely distributed than the geodetic measurements. By combining the redistributed elastic dislocation stress due to slip on the major faults and the overburden stress, the models successfully predict normal faults and tensile fractures in the hangingwall of the reverse fault system. With a pre-1980 oblique sinistral-reverse slip increment, the model can reproduce the observed oblique NNE striking normal faults along the north-central section of the main reverse fault. Long-term regional stresses cannot be sustained by fractured and weathered near-surface rocks, consistent with the results of our forward modelling which are not sensitive to the magnitude or direction of a regional tectonic stress. The predicted fractures are predominantly controlled by the near-field, short-term redistributed stresses due to coseismic slip. The agreement between modelled and measured deformation patterns adds confidence in the use of elastic dislocation theory to accurately predict small faults generated by coseismic slip on large faults.

T51D-0192 0830h POSTER

Elastic Dislocation Models of Listric Normal Faults

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We model the deformation in the hangingwall and footwall of listric normal faults using elastic dislocation theory. Our models simulate intra-basinal listric normal faults (e.g. growth faults) wholly within a sedimentary succession, with no basement involvement. We seek to provide a physical understanding for previously published geometrical models of deformation around listric faults in which graphical methods are used to determine the geometry of beds in the hangingwall from a known fault shape. Simple elastic dislocation models of faults in a uniform elastic half-space predict a displacement field of variably inclined simple shear, when viewed in the hangingwall reference frame. Listric fault models with constant heave result in steeper inclined shear when compared to equivalent models with constant slip. Elastic dislocation models of listric faults with a relaxed viscoelastic rheology predict a displacement field almost identical to purely elastic models. A significant prediction from the elastic dislocation models of listric normal faults is the relative lack of footwall uplift when compared to planar faults with a similar depth, dip and slip. Elastic dislocation theory provides a physical explanation for the success of previous geometrical models that implement inclined simple shear.

T51D-0193 0830h POSTER

Possible Connections Between the Coronado Bank Fault Zone and the Newport-Inglewood, Rose Canyon, and Palos Verdes Fault Zones Offshore San Diego County, California.

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High-resolution multichannel seismic-reflection and deep-tow Huntec data collected by the USGS were interpreted to map the Coronado Bank fault zone (CBFZ) offshore San Diego County, California. The CBFZ is comprised of several major strands (eastern, central, western) that change in both orientation and degree of deformation along strike. Between Coronado Bank and San Diego, the CBFZ trends N25W and occupies a narrow 7 km zone. Immediately north of La Jolla submarine canyon (LJSC), the easternmost strand changes orientation to almost due north and appears to be offset in a right-lateral sense across the canyon axis. The strand merges with a prominent fault that follows the base of the continental slope in about 600 m water depth. The central portion of the CBFZ is mapped as a negative flower structure and deforms seafloor sediment as far north as 15 km north of LJSC. Farther north, this structure is buried by more than 400 m of basin sediment. Along the eastern edge of the Coronado Bank, the western portion of the CBFZ is characterized by high angle normal faults that dip to the east. North of the Coronado Bank, the western segment follows the western edge of a basement high; it cuts through horizontal basin reflectors and in places deforms the seafloor. We mapped an additional splay of the CBFZ that trends N40W; it is only observed north and west of LJSC. Although the predominant trend of the CBFZ is about N40W, along strike deviations from this orientation of some of the strands indicate that these strands connect with other offshore fault zones in the area. Based on the limited data available, the trend of the CBFZ south of Coronado Bank suggests that it might connect with the Rose Canyon fault zone (RCFZ) that has been mapped in San Diego Bay. North of Coronado Bank, the CBFZ is a much broader fault zone (about 25 km wide) composed of diverging fault strands. The westernmost strand may merge with the western strand of the Palos Verdes fault zone (PVFZ) south of Lasuen Knoll. The eastern strand trends toward the Newport-Inglewood fault zone (NIFZ) as imaged offshore near Dana Point. These connections suggest that the CBFZ is linked at depth with other prominent fault zones to the north (PVFZ and NIFZ) as well as to the south (RCFZ).

T51D-0194 0830h POSTER

Neotectonics of the Panamint Valley fault zone: Active slip on a low-angle normal fault system

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The mechanical feasibility of active normal-sense displacement on low-angle ($< 30^\circ$) fault systems has been the subject of debate for the past quarter-century. Although the significance of these fault systems has now been recognized in both extensional and collisional orogens across the globe, relatively few have been shown to be presently or recently active. Rather, observations of high-angle normal faults which displace young alluvial deposits near or at the range front are commonly interpreted to indicate that low-angle faults observed within the range have been abandoned in favor of newly-formed structures. Here we assess this hypothesis with new mapping and observations of late Pleistocene - Holocene alluvial deposits and fault scarps along ~60km of the central and southern Panamint Valley fault zone. Four lines of evidence indicate that slip on these young fault scarps is a direct consequence of displacement on a low-angle master detachment. First, the geometry of fault scarps within alluvium mimics range-scale variations in strike on the curviplanar, low-angle detachment fault, suggesting that scarps merge with the detachment at depth. Second, the kinematics of recent faulting inferred from displaced geomorphic markers suggests oblique-normal slip, consistent with the long-term slip vector inferred from piercing lines across the Hunter Mountain fault (e.g., Burchfiel et al., 1987). Third, alluvium of late Pleistocene age (inferred from soil and surface characteristics) is juxtaposed against bedrock across a ~25-30° fault surface characterized by well-developed fault gouge. Finally, direct observations of 3-5 meter fault scarps at the intersection of the low-angle range-front fault with the valley floor indicate recent (probably seismogenic) slip on the detachment system itself. We are forced to conclude that the neotectonics of the Panamint Valley fault zone reflect active slip above a low-angle detachment fault.

T51D-0195 0830h POSTER

Combined seismic and magnetotelluric imaging of the Dead Sea Transform

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Coincident seismic and magnetotelluric data, collected as part of the international DESERT (DEad SEa Rift Transect) project, have provided high-resolution velocity and resistivity images of the upper-crustal structure of the Dead Sea Transform. While changes in velocity or resistivity may signal geologic, tectonic, or hydrologic boundaries, looking at these properties in tandem allows for more precise resolution of such boundaries. A combined statistical analysis of the DESERT resistivity and velocity models will be presented. Data from both local and regional profiles exhibit a strong correlation between velocity and resistivity. Cluster analysis can be further used to 'map' out regions of uniform physical properties, and the borders between these regions are often sharply defined. Preliminary results suggest the Dead Sea Transform forms a sharp vertical boundary within the upper 5 km of the crust.

T51D-0196 0830h POSTER

A System for Evaluating Earthquake Driven Stress Changes in the Los Angeles Region.

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Studies of Coulomb stress changes associated with large earthquakes (greater than M6.0) demonstrate that aftershocks commonly fall within zones of increased stress and that seismic hazard from additional large events increases within these zones. We are developing a system that will automate stress change calculations and integrate the results with ever-changing assessments of seismic risk in the Los Angeles region. One problem that arises in stress analysis is that it is difficult to determine stress changes on regional faults following earthquakes as fault geometries are often poorly constrained. For this reason, we integrate calculations of stress changes associated with 'scenario' earthquakes with the SCEC Community Fault Model (CFMA). By determining the stress change on each triangular patch of a fault, a clear picture of triggered earthquake hazard emerges. Here, we model ruptures on the San Andreas Fault and examine the resultant Coulomb stress change on the Sierra Madre Fault. A second motivation for the system is the desire to view the time-evolution of the regional stress field as it is altered by the numerous small (less than Mw5.0) earthquakes that occur in and around Los Angeles. Our system is also designed to access, query, and filter earthquake focal-mechanism catalogs and do summations of resultant stress changes.

T51D-0197 0830h POSTER

NEW SIMULATION OF THE 1755 TSUNAMI SOURCE USING A COMPOSITE SUBDUCTION SOURCE

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A recent marine seismic survey, together with tomographic data, provides compelling evidence for an active east dipping subduction zone beneath the Gibraltar Arc, which can be thought as a candidate for the 1755 Lisbon earthquake. If we consider a convergent rate of 1 to 2 cm/yr and a co-seismic slip of 20 m (to account for the 1755 earthquake magnitude), we get a recurrence interval between 1000 and 2000 years, that seems compatible with available geological information. Previous attempts to model the tsunami wave that could be generated by such structure concluded that synthetic amplitudes are lower and arrival times longer than observed, particularly for locations along the west coast of Portugal. This suggested a second source segment, closer to the Portuguese margin, which should have also contributed to the tsunami waves that ravaged the coast of SW Portugal and the Gulf of Cadiz, and were reported as far as the Lesser Antilles and SW England. This possibility is also reinforced by some historic documents that report the occurrence of at least a second large shock. In this paper we present the simulation of a composite 1755 source, where the main shock is attributed to dipping subduction beneath the Gibraltar Arc, modelled as a 180 km (N-S) x 210 km (E-W) rectangular fault with a 20 m co-seismic slip, followed by a second shock, 10 minutes later, beneath the southern flank of Gualdalquivir Bank, modelled as a 250 km (WNW-ESE) x 71 km (WSW-ESE) rectangular fault with 5 m co-seismic slip. Tsunami wave heights are computed for all locations where reliable historical information is available and comparison is made between synthetic values and observations.

T51D-0198 0830h POSTER

Moment tensor mechanisms from Iberia

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New moment tensor solutions are presented for small and moderate earthquakes in Spain, Portugal and the westernmost Mediterranean Sea for the period from 2002 to present. Moment tensor inversion, to estimate focal mechanism, depth and magnitude, is applied at the Instituto Andaluz de Geofísica (IAG) in a routine manner to regional earthquakes with local magnitude larger then or equal 3.5. Recent improvements of broadband network coverage contribute to relatively high rates of success: Since beginning of 2002, we could obtain valuable solutions, in the sense that moment tensor synthetic waveforms fit adequately the main characteristics of the observed seismograms, for about 50% of all events of the initial selection. Results are available on-line at http://www.ugr.es/ iag/tensor/. To date, the IAG moment tensor catalogue contains 90 solutions since 1984 and gives a relatively detailed picture of seismotectonics in the Ibero-maghrebian region, covering also low seismicity areas like intraplate Iberia. Solutions are concentrated in southern Spain and the Alboran Sea along the diffuse African-Eurasian plate boundary. These solutions reveal characteristics of the transition between the reverse faulting regime in Algeria and predominately normal faulting on the Iberian Peninsula. Further we discuss the available mechanisms for intermediate deep events, related to subcrustal tectonic processes at the plate contact.

T51D-0199 0830h POSTER

Evidence for Late Pleistocene-Holocene Activity along a Potential Seismic Source in southern Apennines (Italy)

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The Lucanian Apennines in southern Italy has experienced major and destructive earthquakes (Intensity * VIII) in 1561, 1694, 1826, 1857, 1980. Except for the 1980 Irpinia event for which coseismic faulting has been observed, no fault-event relationship has been definitely established for the rest of the mentioned earthquakes.Immediately south to the 1980 event zone and north to the 1857 one, a noteworthy area, where no clear relationship between seismogenic structures and historical seismic activity, has been identified. Structural and geomorphological analysis based on spot images, DEM, aerial photos interpretation and field observations, helped to point out 20 km length normal

fault running on the western edge of two basins named Melandro and Pergola. The fault is composed by two main NNW-trending, ENE- dipping segments, showing an en-echelon pattern. The fault affects recent soft sediments, producing scarps up to 10 m high. Evidence for Late Pleistocene-Holocene tectonic activity along the trace were also observed at several outcrops and quarries, such as tilted and deformed colluvial and alluvial deposits. Radiocarbon dating from deformed sediments revealed a faulting age of at least 12 ka old. The far- and near- field data analysis and interpretations lead to consider this fault as a potential large earthquake source in this area.

T51E MCC: Level 1 Friday 0830h

Ground and Space Methods for Monitoring EM Preearthquake Phenomena I Posters *(joint with GP, S, SA, SM, MR)*

Presiding: **S Pulinets,** Universidad Nacional Autónoma de México**; M Parrot,** Laboratoire de Physique et Chimie de l'Environnement, CNRS, Universit dOrlans

T51E-0200 0830h POSTER

STIMULATED IR EMISSION FROM THE SURFACE OF ROCKS DURING DEFORMATION

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Studying the IR emission from rocks placed under stress may lead to a better understanding of the reported pre-earthquake "thermal anomalies", observed in mid-IR satellite images. Large blocks of granite and labradorite (45 x 30 x 7 cm3) were loaded in their center between two vertically oriented pistons (11.25 cm diameter). Smaller blocks of the same rocks plus gabbro (about 10 x 10 x 7 cm3) were loaded uniformly over their entire cross sections. We used a SATEC press (250 tons) and a BOMEN FT-IR spectrometer (3.3-14 micron), equipped with two black body sources (one at ambient temperature and another controlled at a higher temperature) for calibration. At 1 m from the samples, the spot size on the surface analyzed was about 5 cm in diameter. The blocks were loaded at a constant rate until failure. Typical runs lasted for 10-15 min. We monitored the IR emission from the front faces, which were either rough saw-cut or irregular broken. In the case of the large blocks the emitting surfaces were 20-25 cm from where the rocks were loaded. In the case of the smaller blocks the emitting surfaces were part of the rock volume that experienced increasing levels of stress and, at higher loads, underwent cracking and occasional spallation. We observed distinct changes in the IR emission spectra during press. The changes were specific of the rock and the loading geometry. They include a band at 11.7 micron, the position of which agrees with that of vibrationally excited O-O bonds, predicted to form when positive hole charge carriers, activated in the inner rock volume under stress, recombine at the rock surface.

T51E-0201 0830h POSTER

Charge Releasing of Charge Trapping Centers on Milled Quartz Grains

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Milling treatment makes quartz grains with amorphous and/or disturbed surface layers that acquires many E' centers and is often called the surface disordered layer. We measured thermoluminescence (TL) from milled quartz grains of different sizes with and without surface disordered layers. Here, TL phenomenon from quartz is caused by recombination of thermally stimulated electrons and Al-hole centers. The TL intensities per unit mass of both grains with and without the surface disordered layers decreased with decreasing grain diameter. It is due to loss of photons through reflection on grain surfaces. In addition, the TL intensity of grains with the layers decreased more rapidly than that without the layers. This indicates deformation and/or breakage of Al-hole centers in the surface disordered layers. Broken Al-hole centers release holes, while newly formed E' centers release electrons. These holes and electrons are disturbed in surface disordered layers during the milling procedure. These charges form surface electrification on grains and generate even TL. Faulting similarly forms the surface disordered layers along fault surfaces and in the gouge. Therefore, the charge releasing of charge trapping centers may be widely related to generation of electromagnetic phenomena accompanied with earthquakes.

T51E-0202 0830h POSTER

An Electrochemical Model for the Inception and Prediction of Earthquakes

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Much has been said and written about increased pore pressures prior to earthquake events. I will present a model that shows how the pore pressure in rocks increases catastrophically due to simple electrochemical principles. The model is applicable to all rocks under stress in contact with aqueous pore fluids. Its simplicity probably means that the mechanism is ubiquitous in the crust. Additionally, this new model of the earthquake source suggests that significant electrical signals will be created in the hypocenter region.

T51E-0203 0830h POSTER

In Search of Correlations between Geoelectrical Signals and Earthquakes in a Seismic Active Area of Southern Italy

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The aim of this work is to investigate the possible correlation between electrical anomalous patterns and incoming earthquakes in a seismic active area of Southern Apennine chain (Italy). In this research field, the greatest problem is the sporadically monitoring activities in time and space. A very weak point is also the current approach to time series analysis that makes no use of robust statistical methods to discriminate extreme events from random noise. Further, the lack of objective criteria to assess the precursory character of the geophysical anomalous signals makes the short-term predictions based on them poorly reliable. Altogether these shortages concur to explain the low scientific consensus placed so far on the claimed correlation between the observed geophysical anomalies and the occurrence of earthquakes. Taking into account these considerations, in this paper we analyse the self-potential time series coming from a new geophysical monitoring network installed in a seismic active area of the Southern Apennine chain (Southern Italy). All the remote stations (Tramutola, Tito, Giuliano, Marsico Nuovo and Laterza) are equipped with multi-electrode array able to detect the time fluctuations of self-potential along two directions, N-S and E-W. The monitoring strategy combines new technologies for data acquisition with advanced statistical packages for the identification of the extreme events in geophysical time series. During the last years a very large data-base of self-potential time series has been organized and it is actually available to assess robust statistical methodologies to identify extreme events. Firstly, we have investigated the inner dynamical structure the self-potential time series and we have filtered the effects induced by climatological parameters (temperature, rainfall, etc.). In a second step, we propose robust statistical methods to pick out extreme events from background electrical noise. Finally, we compare the extreme events identified in the self-potential time series and the earthquakes sequences recorded during the past 5 years (1997-2002) in the investigated area. The results allow us to obtain only in few cases a significant correlation between sequence of extreme events in electrical signals and incoming earthquakes, the measuring period is not sufficient to perform an high number of statistical checks. However the time dynamics of self-potential signals seem to be correlate with the fluctuations of seismic cycle over long time periods.

T51E-0204 0830h POSTER

Observations of Seismoeletric Signals Induced by a Hydro-fracturing Experiment in a Deep Geothermal Reservoir

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During a hydro-fracturing experiment at the Soultz-sous-Forêts Hot Dry Rock site, more than 100,000 microseismic events of magnitude greater than -2.0 were induced by the continuous injection of 30,000 m^3 of fresh water at 5 km depth. At the same time, we carried out monitoring of surface electric fields at a sampling rate of 2 kHz with two pairs of unpolarizable electrodes. After removal of the man-made noise, we observed strong electric field perturbations associated to the 48 microseismic events of magnitude greater than 1.8. Their maximum amplitude is 20 mV for the largest event (M = 2.7) while the background electrical noise is roughly 70 mV. The start of these electric perturbations coincides with the P-arrival time of the seismic waves at a depth of 1.5 km i.e. roughly half a second before the surface arrival time and their duration is about one second. As the sediments - granite interface is located at the same depth, the source of these electromagnetic signals could be an electroseismic conversion at this high acoustic impedance contrast. Moreover, a detailed analysis of the electric waveform reveals that several electric phases are arriving on the surface after the first pulse which may be caused by electroseismic conversions within the sediment layers. We did not however observe any electric field perturbations prior to rupture and the alleged first pulse associated with piezoelectric effect. It seems therefore that the prevailing effect when monitoring high-frequency ($\geq$ 1 Hz) synearthquake EM phenomena is seismoelectric.

T51E-0205 0830h POSTER

Pre-earthquake Electromagnetic Waves Propagation from the Underground Seismic Source to the Earth's Surface

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