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

geosynchronous satellites also reduces the potential for miscalculation of trends due to weather front movement or local cloud/fog formation. The polar orbiting satellites have better resolution (1km vs 5km) and better signal-to-noise, but only acquire images twice during an evening, thereby making trend analysis difficult. Case studies investigated to date include the Hector Mine California and Ikrit Turkey earthquakes of 1999, and the Bhuj India quake of 2001. The result of the new analytic procedures has been the observance of apparent heating trends close to epicenters in satellite data acquisitions a few hours prior to an earthquake. When observations along known fault-lines showed a much-reduced temperature decline through the evening, or in some cases an actual temperature increase, an earthquake occurred. This result may indicate mid-infrared luminescence associated with crustal deformation(Freund, 2002), rather than heat emission. Other events are currently under investigation using the methods developed.

S71C-1107 0830h POSTER

Constraints On The Rupture Mechanism Of The 2001 Bhuj Earthquake From Satellite Imagery

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We use satellite imagery collected by Landsat, ASTER, and IRS-1D in the years before and after the January 26, 2001 Bhuj earthquake, India, to identify coseismic changes in the topography. In this approach, we search for changes in the distribution of submergence during the seasonal monsoon flooding that covers the low lying portions of the region in the southernmost Rann of Kachchh. It appears that about 15 km WNW of the reported USGS epicenter, ponding in an area of about 80 km^2 occurred in the ensuing monsoon period whereas prior to 2001, namely in 1999 and 2000, the submergence occurred further north of this region. The observed changes in the distribution of submerged areas during the monsoon are consistent with a zone of uplift near approximately 23.45° latitude. It appears that this uplift also shifted the southern limit of the adjacent salt region to the north. We suggest that the inferred uplift puts additional constraints on the location of the rupture. A rupture model with slip on a 40x20km^2 rupture, extending from a depth of about 37 km to 10 km is consistent with the models suggested previously from teleseismic waveform inversions and the aftershock distribution. The dislocation model predicts subsidence in the north which coincides with the low lying salt flat region between the Pachham and Khadir islands. This apparent corelation between the earthquake induced subsidence and the low lying area suggests that similar large earthquakes in this region occurred in the past.

S71C-1108 0830h POSTER

Investigation for Anomalous Focal Mechanisms: Bárdarbunga Volcano, Iceland Events

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Using the complete moment tensor inversion method as described in Dreger at al. (2000), we investigate the September 29, 1996 Mw=5.6 volcanic event beneath Bárdarbunga caldera in Iceland. Green's were calculated using a suite of crustal models determined by combining teleseismic receiver functions and surface wave dispersion curves (Du and Foulger, 2001) to account for lateral heterogeneity. Long-period (20 to 50 sec) three-component waveform data from 6 Iceland Hotspot Project stations were inverted yielding a solution that is characterized by a 67% vertically-oriented CLVD. This solution is similar to that previously reported in the Harvard centroid moment tensor (CMT) catalog, and later confirmed by analysis of long-period and intermediate surface wave data (e.g. Nettles and Ekstrom, 1998). The full moment tensor inversion yielded the same CLVD (66%) with an insignificant amount of volumetric contraction. Sensitivity tests investigating the stability of the CLVD and isotropic components as a function of the numbers of stations used indicate that the CLVD component is very robust. The isotropic component is seen to decrease to a nominal level as more stations are used in the inversion. In addition, we investigated the level of fit afforded by pure double-couple, pure isotropic, and combined double-couple plus isotropic models. None of these provided a better fit than the vertically oriented CLVD. It is unlikely that smaller events in the sequence would resemble the NDC nature of the main event, and that the same physical mechanism would be responsible for them (e.g. faulting on an outward dipping cone-shaped ring fault beneath the caldera, as proposed by Nettles and Ekstrom (1998)). Unfortunately, due to poor signal to noise ratios the same waveform method cannot be applied to the smaller events. For these events the linear-programming method developed by Julian and Foulger (1996) to invert simultaneously polarities and amplitude ratios was used. Our analysis shows that there exist at least several events that have NDC solutions that are similar to the main event. Although our results cannot rule out the hypothesis of faulting on an outward dipping cone-shaped ring fault beneath the caldera, similar FM solutions found for the smaller events suggest that a different type of physical mechanism is responsible for Bárdarbunga, September 29, 1996 earthquake sequence.

S71C-1109 0830h POSTER

Constant b-value to M -1 From Aftershocks of the Little Skull Mountain Earthquake

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Laboratory and theoretical studies suggest that there is a minimum patch size for earthquakes, thus limiting earthquakes to above some moment or magnitude corresponding to this patch size. This limit, being generally at a much lower magnitude (-2 or below) than that which can be observed due to background noise of the earth and to attenuation, is difficult to verify for real earthquakes. We have recorded earthquakes to as small as M -2 (Richter local magnitude) in the aftershock zone of the M 5.6 Little Skull Mountain earthquake of 29 June 1992. The network threshold for location is slightly below M 0. However, by considering all the triggered earthquakes at the station LSC, which is just above the aftershock zone, and combining these with the located events, the recurrence curve is extended well below the network threshold. We do this by forming a relation between the trace amplitudes of the LSC recordings and the network magnitudes for larger events and then assigning an estimated M to the smaller triggered events. The recurrence curve plotted for the combined data shows a constant b value of 0.85 down to roughly M -1.2. The smallest recorded events are similar in appearance to events larger by as much as three magnitude units in the aftershock zone, partly due to the band limitation of the 100 sps data and local attenuation. S-to-P ratios greater than one and broadband signals for these small events are indicative of normal tectonic earthquakes. The seismic moments of the very smallest events near M 2 are approximately 1.5*10**9 N-m, larger than observations in deep mines by an order of magnitude. Because the source corner frequency is too high to be seen in the spectrum of the smallest earthquakes, we cannot estimate a source radius directly and so are left with a tradeoff between slip amplitude and rupture area.

S71C-1110 0830h POSTER

The Effects of 3-D Velocity Structure on a Finite Fault Inversion of the 1989 M 7.1 Loma Prieta Earthquake

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Several excellent studies on finite fault source of the 1989 M 7.1 Loma Prieta earthquake have been completed using different data sets and approaches (Beroza, 1991; Hartzell et al., 1991; Steidl et al., 1991; Wald, et al., 1991). Most of these studies find low slip in the hypocentral region and a bimodal distribution of slip with respect to the hypocenter. The seismic moment ranges from 2.3x1019 to 3.5x1019 N-m, spanning approximately the same range determined teleseismically at longer periods. In addition to the similarities, the differences in these models were also indicated by Beroza (1995). The location of the high-slip areas and, specially, the rake differs among these models. The lateral variations in velocity structure may be one important effect causing the differences among the source models. To address this problem, we determine a finite fault source model for the Loma Prieta earthquake through the inversion of ground motion using 3D Greens functions. We used the 3D crustal model recently developed by the U.S. Geological Survey (Brocher et al., 1997) and a 3D viscoelastic finite-difference method (Liu and Archuleta, 1999) to compute the Greens functions. The data from 16 three-component stations and Greens functions are bandpassed between 0.051.0 Hz. A global inversion algorithm (Liu and Archuleta, 2001) is employed to solve for the two components of fault slip, rise time, rupture time and the shape of source function for each subfault. In the inversion process we limit the time window to the direct P and S waves to mitigate the influence of the uncertainties in the 3D-velocity structure on later arrivals. We also perform another inversion using 1-D synthetic Green's functions. To insure that the inversion results are comparable, both inversions will use exactly same procedure, data, source parameterization and constraint conditions. By quantitatively comparing spatial distributions of source parameters and the fit between the data and the synthetics, we can estimate the bias for the finite fault inversion due to 3D propagation effects.

S71C-1111 0830h POSTER

Complex Source Process of the February 3, 2002 Afyon Turkey Earthquake

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Three earthquakes occurred on Dec. 15, 2000 (Mw=6.0) and Feb. 3, 2002 (Mw=6.5 And Mw=6.0) in the Afyon province in Western Turkey, a tectonic complex with intersecting faults. By comparing their waveforms, the source process of Feb. 3, 2002 Afyou, Turkey Mw=6.5 earthquake appeared to be complex and composed at least two rupture processes. Incorporating with geological information and the aftershock distribution, an initial model of complex rupture process is constructed. With this a priori model, a multiple-point source representation is determined by inverting the broadband teleseismic P-wave data at epicentral distances of 30 $\sim$ 90^o. The results suggest that the rupture process can be divided into two steps. In the first step, rupture initiated from the hypocenter and extended about 15 Km in North-West direction along a NW-SE striking fault with oblique left-lateral normal motion. This step lasted about 10 seconds, releasing a total moment of 2.3 $\times$ 10^{17} Nt-m. Then, a westward propagating rupture was triggered along an EW striking fault with also oblique left-lateral normal motion. It lasted more than 12 Sec and had a moment of 1.1 $\times$ 10^{18} Nt-m, predominant part of whole source process. This may be the reason why other research groups, such as Harvard, USGS and Tokoyo University gave the focal mechanism solution as an almost pure EW striking fault. The maximum slip is about 0.2 meters, and happened at relative shallow area, close to eastern edge of the E-W rupture. This is consistent with the intensity map given by KOERI.

S71C-1112 0830h POSTER

Shallow Seismicity Around the Arica Bend in the Western Altiplano Piedmont

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The Arica bend region corresponds to the main along strike geometrical change observed in the western South America subduction zone. The geometry of the underlying subduction plate presents a remarkable symmetry relative to an axis oriented along the direction of convergence between the Nazca and South American plates and passing through the Arica bend. The fact that the topography of the Altiplano and the geometry of the subduction exhibit the same symmetry suggests that the tectonic of the Central Andes depends strongly on the subduction process. Following the 23 June, 2001 southern Peru, Mw=8.4 thrust earthquake, a portable seismic network was installed in southern Peru in order to follow the aftershock sequence.This network, together with the permanent seismic network operating in northern Chile since 1994, allowed to monitor the seismicity located north and south of the Arica bend from 16.5° to 20.5°S, and from 68.5°-72.5°W between June and August, 2001. Both networks recorded a notable increase of shallow crustal seismicity located in the fore-arc region, close to the Altiplano western piedmont. This activity culminated with the 24 July, 2001 Mw=6.3 Aroma (northern Chile) crustal earthquake followed by numerous aftershocks distributed between the surface and about 25 km depth.This last event occured along a major accident already evidenced by a previous tomographic study in the region. At the northern extremity of this superficial seismicity arc, in southern Peru, a dense swarm of activity, without major event, is observed for the first time.

S71C-1113 0830h POSTER

Slip Directions and Moment Magnitudes for Earthquakes off Canada's West Coast

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Moment tensor analysis of regional seismic data (∼ 1000 km or less) in western Canada and southeast Alaska, primarily the coastal and offshore region of British Columbia, has recently become possible due to the installation of more than 35 three-component broadband stations in western Canada, the U.S. Pacific northwest, and southeast Alaska. Regional moment tensor analysis using robust waveform fitting techniques are employed to determine the source parameters (strike, dip, rake), moments, and depths of earthquakes with magnitudes greater than ∼ 3.5-4.0 in western Canada and southeast Alaska. More than 140 new focal mechanisms for earthquakes with magnitudes greater than ∼ 3.5-4.0 have been calculated in the Explorer region in this research. These solutions, along with 84 moment tensor solutions calculated by Oregon State University from 1994-1998 and 26 Harvard solutions for earlier, larger events from 1976-1993, gives a large data set of moment tensor solutions for the Explorer region.

The coastal and offshore region of British Columbia is a tectonically active area consisting of the Pacific, North America, Juan de Fuca, and Explorer plates. The Explorer plate and the Winona block are two microplates bounded by four active fault regions - the Nootka fault zone, the Sovanco fracture zone, the Explorer ridge, and the Revere-Dellwood-Wilson fault. Slip directions calculated from the moment tensor solutions can also be used to constrain the motions of the Explorer plate, refine the location of the Pacific-Explorer rotation pole, and calculate a North America-Explorer rotation pole Local magnitude (ML) values of earthquakes in the offshore region are known to be underestimated by as much as 0.5 magnitude units. Seismic moments (Mo) (and from them, moment magnitude (Mw)) calculated by moment tensor analysis provide a more reliable estimate of the magnitude of events in the offshore region of British Columbia. A relationship between Mw and ML can provide a correction factor for ML's in the offshore region of British Columbia and give more reliable magnitudes for earthquakes where Mw is not calculated.

S71C-1114 0830h POSTER

Surface-Wave Focal Mechanism of the 23 July 2002 Yellow-Sea Earthquake Event

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The Yellow-Sea earthquake event of 23 July 2002 was reported by the USGS as follows: mb=4.7, Origin Time=12:48:08.23, Latitude = 35.563N, Longitude = 122.183E. In this study, we will present the focal mechanism of this event. Corrected Love-wave and Rayleigh-wave amplitude data from six CDSN stations and INCN station were used in the search for focal mechanism employing the technique of Nguyen and Herrmann (1992, SRL). Eigenfunctions were computed from the average crustal model that was obtained by inversion from surface-wave group velocities of these stations. Surface-wave attenuation coefficients were obtained using the technique of Tsai and Aki (1969). The result for surface-wave focal mechanism is much less as a strike-slip source than a more strike-slip one of the 4.8-mb Yellow-Sea 03 November 1992, as reported by Nguyen (1994 AGU Spring Meeting). The focal mechanism of this event has a nodal plane with dip= 65 deg., slip = 140 deg., and rake = 10 deg. The seismic moment obtained is 1.9E+23 dyne-cm. The source depth is 9 km.

S71C-1115 0830h POSTER

The Initial Rupture of the 2000 Western Tottori Earthquake

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Two clear P phases were identified on the seismograms for the 2000 Western Tottori earthquake(M7.3). Following the initial P phase (P1), a larger arrival (P2) several seconds later indicates that the rupture did not grow smoothly, but has at least 2 subevents. Hypocenters corresponding to these two P arrivals were determined using 14 stations within hypocentral distances of 60 km. The initial rupture started from the edge of a region that has had swarm activity, including M5 events, since 1989. The source of the second larger P phase was located 1km deeper and 5km southeast from the initial rupture. The hypocenter of the second rupture was off the fault plane estimated from the mechanism solution of the initial rupture using the P1 phase first motions. The average time interval between the two phases was 2.5 second, which is consistent with an empirical relation between the magnitude and duration time for initial ruptures.

According to rupture model of this earthquake determined by Sekiguchi and Iwata, little slip occurred near the starting point, and 3 seconds after, larger slip occurred 5km southeast of the starting point, corresponding to our location of the source of second rupture. In this study, we tried deriving the rupture process for the spatiotemporal slip distribution of the first few seconds of the rupture of this earthquake by using a waveform inversion. We divided the area near the initial hypocenter into 10 x 6 subfaults with dimensions of 250 x 250 m2. For the inversion, we used 3-component data from 12 KiK-net and K-net stations data integrated from acceleration to velocity and bandpassed filtered from 0.1 to 3.0 Hz. Greenfs functions were calculated using a 1-dimensional velocity structure that was determined from the temporary aftershock observations. We used 12 time windows spaced at 0.05 sec intervals Our results show that the area of the initial rupture area was about 0.5 km2 and extended toward the southeast from the initial hypocenter. There does not appear to be much slip in the area between the location of the initial rupture and the location of the sudden increase in slip 2.5 seconds later.

S71C-1116 0830h POSTER

Frequency-dependent source processes for the 1989 Loma Prieta earthquake by complex spectral inversion

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Low- and high-frequency wave radiations contain significant information for interpretation of earthquake source physics and it is important to try to clarify the frequency-dependence of the generation of seismic waves over as wide a frequency range as possible. Based on complex spectral inversions proposed by Olson and Anderson (1993) and Cotton and Campillo (1995), we have developed an approach of fitting the complex source spectra with frequency-dependent phase weighting that models both the coherent and stochastic summation of waveforms using empirical Green's functions. We apply this technique to estimate the distribution of slip-velocity intensity for the 1989 Loma Prieta earthquake in the frequency range of 0.4-1Hz (λ=1.0), 1-2Hz (λ=0.5), and 2-4Hz (λ=0.0), where λ is the relative weight of phase and amplitude source spectra in the matrix for the complex spectral inversion. The lower-limit of the available frequency range depends on the noise level of the aftershock records. Ground velocity records for the mainshock and aftershocks as empirical Green's functions were selected at 6 stations. We assumed 36km length by 16km width fault plane and a single time window for rupture, propagating 2.5km/s from the hypocenter. The subfault size was calibrated by strong ground motion simulation using the empirical Green's function method formulated by Irikura (1986). We obtained low-frequency (0.4-1Hz) wave radiations corresponding to two asperities seen in previous time-domain waveform inversions (e.g., Beroza, 1991; Wald et al., 1991), and high-frequency (2-4Hz) wave radiations mainly generated at the breaking points of the asperities. The distributions of slip-velocity intensity indicated a progression of wave generation from the center to edge of each asperity with increasing frequency.

S71C-1117 0830h POSTER

Estimating the similarity of earthquake focal mechanisms from waveform cross-correlation in regions of minimal local azimuthal station coverage

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In the Xinjiang province of China, 2000 earthquakes were recorded by the Tien Shan network during 1997-1999 that exhibit a clear spatial progression of seismicity. This progression, which is confined to a 50 km diameter region, is undetectable in other data catalogs, both global (e.g., REB, PDE, CMT) and local (KIS). The two largest earthquakes in this sequence were the M6.1 August 2, 1998, and the M6.2 August 27, 1998, earthquakes. According to the Harvard moment tensor solutions, both events ruptured faults that trend parallel to the geologic structures in the region (N55W). However, the August 27 event was a vertical strike slip event while the August 2 event ruptured a dipping fault and had a normal component of slip. These slip directions are counter to what we expect for this fold-and-thrust-belt, which typically has earthquakes with thrust mechanisms.

Often seismological researchers make the assumption that aftershocks have the same focal mechanism as their associated mainshocks and/or assume all aftershock fault planes are similarly oriented. We test this assumption by examining the similarity of aftershock mechanisms from the August 2nd and 27th mainshocks. It is difficult to determine focal mechanisms from inversions of full seismic waveforms because the velocity model in the Tien Shan region is so complicated a 3D velocity model would be required. Also, the azimuthal station coverage is poor. Alternative, it impossible to determine accurate focal mechanisms from first motion data because the closest seismic stations have weak and complicated first arrivals.

Our approach more easily determines the similarity of earthquake focal mechanisms using waveform cross-correlation. In this way information from the full waveform is utilized, and there is no need to make estimates of the complicated velocity structure. In general, we find there is minimal correlation between pairs of event waveforms (filter 1-8 Hz) within each aftershock sequence. For example, at station KAZ, we find only 20 percent of the 11,000 earthquake pairs have correlation values over 0.6. We infer from this that the majority of focal mechanisms are not alike. Therefore the assumption that all aftershock mechanisms are the same and that they always mimic their mainshocks should be avoided in future studies, especially when the results are sensitive to errors in focal mechanisms.

S71C-1118 0830h POSTER

Preliminary Results of Double Difference Relocations in the Anchorage Region

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Patterns of recent seismicity in the Anchorage region (about 100 km around the city of Anchorage, Alaska) indicate there could be shallow seismogenic structures possibly related to recognized surface geologic features. Recent studies show there is a potential seismic hazard in the region from faults concealed within folds and other structures. Shallow earthquakes in this region have been relocated using Joint Hypocenter Determination JHD and have revealed clues to the stress regime and the complexity of the crust. We attempt to relocate these same events using the Double Difference Algorithm to find if this relocation technique will give still more insights to the near surface structure of the Anchorage region. Preliminary results show promise in finding and understanding subsurface structures. In combination with these relocation techniques we incorporate historical seismic data to understand the seismic processes in the Anchorage region.

S71C-1119 0830h POSTER

Event Clustering: Accuracy and Precision of Multiple Event Locations with Sparse Networks

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In the last 15 years passive PASSCAL experiments have been fielded on every continent. Most of these deployments were designed to record teleseismic or large local seismic events to infer crustal and mantle structure. However, the deployments inevitably record small, local seismicity. Unfortunately, the configuration of the experiments are not optimal for location (typically the stations are arranged in linear arrays), and the seismicity is recorded at a very limited number of stations. The standard location procedure (Geigers method) is severely limited without a detailed crustal model. A number of methods have been developed to improve relative location precision, including Joint Hypocenter Determination (JHD) and Progressive Multiple Event Location (PMEL). In this study we investigate the performance of PMEL for a very sparse network where there appears to be strong event clustering.

CHARGE is a passive deployment of broadband seismometers in Chile and Argentina, with a primary focus of investigating the changes in dip along the descending Nazca Plate. The CHARGE stations recorded a large number of small, local events in 2000-2002. For this study events were selected from the northern profile (approximately along 30o S) in Chile. The events look similar, and appear to be clustered southeast of the city of La Serena. We performed three sets of experiments to investigate precision: (1) iterative Master Event Corrections to measure the scale length of clusters, (2) PMEL locations, and (3) PMEL locations using a cross-correlation to determine accurate relative phase timing. The analysis shows that for the PMEL experiment clusters must occupy an area of 600 km2 for the results to be consistent. We will present a method to estimate the precision errors based on bootstrapping.

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S71C-1120 0830h POSTER

New MAXimum Intersection Method (MAXIM) Applied to the Determination of Earthquake Hypocenters in a Structurally Complex Area, Offshore Eastern Taiwan

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The Maximum Intersection Method (MAXIM) determines independently earthquake hypocenters based on seismic arrival time measurements within a 3D velocity model. The MAXIM originates from the Master Station Method (Zhou, 1994). First, the hypocenter is predetermined (PRED solution) by intersecting all possible combination of Equal Differential Time (EDT) surfaces available from the set of arrivals. An EDT surface is the deformed hyperbola defined by the collection of spatial points that satisfy the time difference between the arrivals recorded at 2 stations. Second, a statistical minimization (residual rms and origin time error) is conducted in a small domain around PRED and results in a unique final solution. MAXIM benefits from the following properties:

(1) Is fast because precomputed travel times are stored in reference files,

(2) Does not depend on the origin time assumption and residual minimization during the PRED determination,

(3) Automatically detects and filters spurious data within the set of arrivals (outlier residues),

(4) Establish a new quality factor (Qedt), referring to the percentage of EDT surfaces crossing though PRED with respect to the total number of EDT surfaces involved in the process. Qedt is independent of travel time residual and shows a good correlation with residual rms,

(5) Correct seismic stations from site effects.

MAXIM is applied at the southernmost extremity of the Ryukyu subduction zone, where several dense seismic clusters occur near the seismogenic plate interface. The location of the earthquakes, recorded at both the Taiwanese and Japanese networks, is achieved for about a thousand events (between 1992 and 1997). The process uses a detailed 3D velocity model based on multiple geophysical data sources obtained in the junction area between subduction and collision (east of Taiwan). The earthquake clusterization and the significant drop in residual statistics (1.23, 0.79 and 0.35 s, for Taiwanese catalog, MSM and MAXIM solutions, respectively) attest for the accuracy of the method.

S71C-1121 0830h POSTER

Hydro-Acoustic Location of an Oceanic Earthquake Origin Area

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A joint analysis of the local Kamchatka earthquake catalogue data and hydro-acoustic measurements obtained during the Acoustic Thermometry of Ocean Climate (ATOC) experiment was carried out. The time series of acoustic records coincident with the earthquakes or measured immediately before the beginning of earthquakes were analyzed. Two types of signals were distinguished from the hydro acoustic records (HAR): the micro-earthquakes (MEQ) whose focuses were located in the same area as the seismic focus of the main EQ and a seismic noise, which starts before the main shock. The duration of a MEQ was about 3-4 seconds. The new method of the HAR data processing demonstrates the possibility of an oceanic earthquake origin location for a few minutes before the main shock hit.

S71C-1122 0830h POSTER

Seismicity of the Woodlark-D'Entrecasteaux Rift System in Eastern Papua New Guinea

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The Woodlark-D'Entrecasteaux rift system may be the fastest opening continental rift on the planet, accommodating 25-40 mm/yr extension in continental crust. Along strike, extension rates increase and rifting has progressed to full sea floor spreading. We report on the results from the first local earthquake survey in the region, across the transition from oceanic rifting to distributed continental extension. From June 1999 - June 2000 a network of 19 PASSCAL broadband seismometers were deployed along the D'Entrecasteaux metamorphic core complexes (MCCs) and on islands in the western Woodlark Basin. The land stations complement 14 OBS/OBH instruments deployed near the active oceanic rift tip; the OBS/OBHs operated from September 1999-February 2000. We have merged the land and marine arrival time datasets to create a high quality, regional seismicity catalog and construct a 3D crustal velocity model.

Initially the land and marine datasets were processed separately. Merging the two produces a catalog of ∼1800 local earthquakes of which ∼200 could be located by both networks. Most earthquakes are between ML 1.0-3.0 with the largest 5-10 approaching ML 4.0. Four earthquakes are large enough to appear in the ISC catalog within a 300 by 300 km region covered by the networks. The hypocenters delineate several zones of earthquakes within the rift system, likely representing individual faults or fault zones. The most prominent is a WNW-trending zone from the rift tip to the area south of the Amphlett Islands and north of the easternmost MCCs on Fergusson Island. This zone follows a graben identified on high resolution bathymetry and probably represents the primary normal fault system accommodating extension, as most of the events previously located teleseismically lie along it. Large earthquakes along this belt have focal mechanisms showing low-angle normal faulting, including the largest such event recorded (Mw=6.8). A narrow band of seismicity runs perpendicular to this trend along the east flank of Normanby Island. Earthquakes in this region had not been previously observed and indicate a major fault parallel to the coast. This structure appears to transfer some extension away from the primary belt south to faults on the Papuan Peninsula. Thus, in the transition from localized sea floor spreading to distributed continental rifting most continental seismicity continues along the trend of the rift tip but some deformation occurs on parallel structures offset by 50-100 km by transfer structures.

S71C-1123 0830h POSTER

Tectonics and Earthquake Source Parameters in the Isthmus of Tehuantepec, Mexico: A Microseismic Study

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Tectonics and earthquake source parameters in the Isthmus of Tehuantepec, Mexico- A microseismic study

The Isthmus of Tehuantepec (IT) is located in southeastern Mexico where the Cocos, the Caribbean and the North American plates converge. The seismicity of the region has been recently studied, based on the recordings obtained during a microearthquake campaign carried out during the fall of 1995, preliminary results were presented previously (Chavez et al. EOS, 78, 46, 1997; EOS, 80, 46, 1999; EOS, 81, 48, 2000). Herewith, we present the latest results obtained from the processing, with the code SEISAN (Havskov, 1995, 1997), of about 200 events (out of more than 900) located with an RMS $\leq$ 0.5 s. The source parameters of 44 of them were estimated. Among other results, the following can be mentioned: 1) 30 percent of the located events are shallow (H$\leq$50 Km), 30% with depths between 50 and 100 Km, and the rest with H^3 100 Km; 2) The errors in their Latitudes, Longitudes and Depths best fitted the lognormal and inverse Gaussian distributions with standard deviations of about 5 Km; 3) The shallow seismic activity occurs mainly in the Tehuantepec Gulf, parallel to the Middle American Trench , as well as in the Central and Northern parts of the IT. Under the latter shallow events, we confirmed the existance of the so-called Central Seismic Cluster of the IT (Ponce et al., 1992) at a depth of about 120 Km and found another one south of Cuauthemoc (17° N, -95° W) at a depth of 100 Km; 4) The intense deformation undergoing in the Cocos plate in the IT region was also confirmed by the its gradual, but sustancial, inclination angle from west to east and south to north in the NE 45° direction (Burbach et al., 1984, Ponce et al. 1992); 5) From the 44 fault plane solutions (fps) found, about 46% were normal and the rest had a thrust fps. The events with a normal fps are located in the central and southern parts of the IT; 6) The T axis directions of the former are E-W, N-S, and NE-SW and are generally subhorizontal, the T axis directions of the latter generally coincides with the one shown by the Cocos plate in the IT region (this result agrees with the one found for the normal mechanism earthquake ocurred in

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the IT region the 21/10/1995, Mw 7.1, H 165 Km, Rebollar et al., 1999); 7) The events with a thrust fps are aligned in a NNE-SSW and a NW-SE bands, these two bands intersect each other at Cuauthemoc, the P axis of the events with H< 40 Km have the same direction than the Cocos plate, the P axis of the events with H between 40 and 100 Km are subhorizontal, and for the events with H> 100 Km their P axis increase their inclination angle; 8) Several shallow events H< 30 Km with normal and thrust fps were also detected, these events were associated to surficial intraplate activity in the region (Ramirez, 2000); 9) We consider that the N-S and NE-SW stress directions mentioned above are due to the Cocos plate subduction in the IT region, and that the NW-SE stress direction is probably associated to the interaction of the Chiapas Batholit and the left lateral fault system of southeast Mexico with the Cocos plate, we also think that the compresive stresses in the N-S and NW-SE directions acting in the same IT zone where the E-W tension stresses are also present, bring the equilibrium in this part of the IT; 10) The source parameters of the 44 events are: $1.2 \leq$ Mw ≤ 2.8, $10.3 \leq \log_{10}$Mo ≤ 12.7, $5.6 \leq fc \leq 13.2$ Hz, $0.1 \leq \Delta\sigma \leq 4.6$ bars, $0.1 \leq r \leq 0.3$ Km.

S71D MCC: 133 Sunday 0830h

Plumes, Hot Spots, and Calderas I

(joint with G, GP, OS, T, V, DI)

Presiding: **R B Smith,** University of Utah**; M Wilson,** Leeds University

S71D-01 0830h INVITED

Hotspot Motion and Shape of Plume Conduits as Inferred From Global Mantle Flow Models

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Mantle plumes are frequently inferred as cause of hotspots, however alternative explanations exist as well. Different models of hotspot origin can be tested by comparing how well they are able to explain existing observations, or predict expected observations associated with hotspots. As a contribution to such a comparison, we use here a model of plumes distorted by global mantle flow to compute hotspot motion and conduit shape. Both can be compared to observations: For the hotspot motion, paleomagnetic results may indicate hotspot latitude in the past. For both Hawaii and Kerguelen hotspot, suitable results exist, and indicate a more northerly location in the past. A southward motion of roughly the right magnitude is also a robust feature of our model results. In combination with plate motion models, it is also possible to compute geometry and age progression of hotspot tracks and compare these to observations. In this context, our models yield a motion of the Easter hotspot towards Hawaii and Louisville hotspots at a speed of several cm per yr, hence a predicted age progression along the Easter hotspot track on the Nazca plate that is measurably faster than for assuming fixed hotspots. For the Yellowstone hotspot, our models tend to yield westward motion, beginning with several cm per year and slowing down with time, hence an age progression on the North American plate measurably faster than for a fixed hotspot. Conduit shapes can be compared to seismological results (areas of transition zone thinning, tomography). For Iceland, a robust prediction of our model is a conduit coming up from the south; this prediction has been confirmed by seismological results that indicate thinner transition zone to the south of Iceland. For a Yellowstone plume, a conduit coming up from the west is predicted. Not all hotspots may be underlain by deep mantle plumes, and the comparison of our predictions with observations may help to assess which hotspots are more likely candidates for a deep mantle origin.

S71D-02 0850h INVITED

The General Theory of Plate Tectonics; No Role for Lower Mantle Components, Thermals or Other ad hoc Adjustments

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Plate tectonics introduces chemical,thermal,viscosity,melting and density inhomogeneities into the mantle and stress inhomogeneity into the plates.Idealized models often assume uniform mantle, rigid homogeneous plates ,non-passive mantle, and ad hoc explanations for island chains, melting anomalies and continental breakup. Plates, however, drive and break themselves and organize the underlying mantle, in common with other cooled-from-above systems.Pressure, often ignored in simulations, suppresses thermal expansion and the Rayleigh number making the deep mantle a sluggish system with gigantic features, consistent with tomography,and isolating it from the upper mantle and plate tectonics (except by conduction and gravity).Large scale chemical stratification is therefore likely. Plate tectonics, with adjectives such as rigid, homogeneous, isothermal, fixed, subsolidus, reservoir, steady-state etc. dropped, is a much more powerful concept than generally believed. Cracks, rifts, dikes, incipient plate boundaries, melting anomalies and variations in melt volume and chemistry are natural parts of the general theory of plate tectonics. The long-sought alternative theory to deep mantle plumes may just be a less restricted view of plate tectonics. It appears to be the adjectives, assumptions and other baggage that are the problem. Many of the geochemical paradoxes associated with deep plumes and primordial views of the mantle can be traced to the reservoir concept where deep seismic boundaries are assumed to delineate reservoirs. The mantle is heterogeneous, as it should be from plate tectonic considerations (recycling, inefficient melt and gas extraction, history).This suggests that sampling theory and dispersed components may explain the diversity of basalts. The central limit theorem (CLT) predicts that large scale averagers, such as ridges, should have less variance and less extreme values than xenoliths,inclusions,seamounts or OIB, as observed. Homogeneity is achieved by partial melting, averaging and magma chamber processes, not by large scale convection. This idea is tested with Os and He isotopes, which are as different from each other and from the standard isotopes as possible. The conclusion is that both MORB and OIB are products of a heterogeneous upper mantle, sampled in different ways (volume of mantle averaged, degree of melting, magma chamber processes). The CLT plus mass balance calculations obviate the need for an undegassed reservoir or lower mantle components . High 3He/4He components can be ubiquitous in the shallow mantle but only expressed in OIB, off-axis seamounts and other volcanic systems sampling small mantle volumes, or at the onset of volcanism.

S71D-03 0910h INVITED

Tomographic Constraints on Plume Imaging

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Recently emotions are running high in the earth science community on the debate whether or not plumes/plume-like structures are existing.
Much of the seismological evidence for the existence of plumes stems from the tomographic imaging of structures interpreted to be hot spot related or plume-like. In this paper we shall review some of the recent results of tomographic imaging of plumes of different scales as well as discuss some tomographic constraints on plume imaging, such as
the general limitations of tomographic imaging of deep structures,
the issue of resolution and
the influence of different methodologies and/or colour-coding on the images and their interpretation.

S71D-04 0930h

Detection of Mantle Plumes Under Hotspots

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The mantle plume hypothesis is now widely accepted to explain hotspot volcanoes, but direct evidence for actual plumes is weak, and seismic images are available for only a few hotspots. In this work, whole-mantle tomographic images under 45 major hotspots on Earth are presented. Slow anomalies are revealed in the mantle under almost all the hotspots. Plume-like, continuous slow anomalies in the entire mantle are clearly visible under Hawaii, Iceland, Jan Mayen, Cobb, Eifel, Louisville, Canary, Cape Verde, Kerguelen, Tibesti, Tahiti and other five hotspots in the South Pacific, suggesting that mantle plumes under those hotspots originate from the core-mantle boundary. The slow anomalies under those hotspots usually do not show a vertical pillar shape, which suggests that plumes are not fixed in the mantle but can be deflected by the mantle flow. As a consequence, hotspots are not fixed but can wander on the Earth's surface, as evidenced by recent paleomagnetic and numeric modeling studies. In many cases, slow anomalies under the hotspots are complex around the transition zone. A thin low-velocity layer is visible right beneath the 660 km discontinuity under some hotspots, which reflects ponding of plume material in the top part of the lower mantle. Under a few other hotspots, slow anomalies spread laterally just above the 660 km discontinuity. The variety of behaviors of the slow anomalies under hotspots reflects strong lateral variations in temperature and viscosity of the mantle, which controls the generation and ascending of mantle plumes as well as the flow pattern of mantle convection.

S71D-05 1005h INVITED

Proof of plumes, or richness of plate tectonics?

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Large volcanic provinces are traditionally attributed to plumes of hot material rising from the core-mantle boundary. However, with ever-improving quantity and quality of data, there is growing awareness that the most fundamental predictions of the plume model are often not confirmed by observation. At well-studied areas such as Iceland and Yellowstone, multiple predictions of plume theory may be tested. Evidence for high, plume-like temperatures is absent in petrology and heat flow. At Iceland, and most other hotspots, there is no hotspot track. Volcanism there has always coincided with the mid-Atlantic ridge, and has not migrated as predicted by models of relative hotspot fixity. The mantle low-velocity anomaly extends no deeper than the mantle transition zone. At Yellowstone, superimposed on widespread basaltic volcanism, there is a time-progressive track of silicic volcanism that has an orientation consistent with the fixed-hotspot reference frame. However, there, the mantle seismic low-velocity anomaly clearly does not extend deeper than 200 km, arguing against a downward-continuous plume. In both regions, high maximum values of helium isotope ratios are observed, generally assumed to indicate plume-transported, lower-mantle material. Other observations, however, are incompatible with either Iceland or Yellowstone being the products of deep mantle plumes, suggesting that voluminous melt, time-progressive volcanic tracks, high helium isotope ratios and OIB geochemistry may result from shallow processes. Such observations may thus not be used as conclusive evidence for plumes elsewhere. Alternative theories can explain the holistic observations at volcanic provinces with less special pleading and fewer coincidences than the plume model. Excess melt may be produced by variations in fertility, e.g., remelting recycled oceanic crust in old subduction zones and sutures. This is predicted to generate much greater volumes of melt than passive upwelling, and can also explain OIB geochemistry. Local EDGE convection, and melt focusing at the juxtaposition of thick cratons and thin, young crust, also predict anomalous melt volumes and can explain volcanic margins. High helium-isotope ratios may be preserved by storage of ancient helium in low U, Th rocks, e.g., the mantle lithosphere, and time progressive magmatism may result from the propagation of cracks where intraplate extensional strain gradients exist. Large volcanic provinces clearly have various genesis mechanisms, and cannot all be attributed to one cause. Alternative theories must be critically discussed as part of the work of data interpretation and should take precedence over plume models where they are more consistent with the observations as a whole.

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Effects of Variable Melt Productivity and Active Mantle Upwelling on Trace-Element and Isotopic Composition of Hotspot Magmas

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We examine the effects of variable melt productivity and upwelling rate on the composition of magmas generated by mantle plumes. Melting of peridotite with relatively high concentrations of highly incompatible elements and volatiles is expected to begin at greater depths than for more depleted peridotite. The deepest melting is expected to occur at a minimal rate of melt production per increment of decompression (i.e. melt