geographically-restricted southeastern portion of Namche Barwa or other remote sites on Earth, a critical first step in forming topographic descriptions that can determine where and how the landscape is responding to underlying geodynamic processes. Globally, unprecedented opportunities for remote studies of topography will arise as more 90-m SRTM and data of similar resolution are released, and it is timely to further characterize their uses and limits.

URL: http://ees.lehigh.edu

T42B-0302 1330h POSTER

Wavelet-based Fusion Of Panchromatic ETM+ And Multispectral ASTER Images Covering The Neoproterozoic Allaqi-Heiani Suture,Southeastern Egypt

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The Allaqi-Heiani Suture is a WNW-ESE trending deformation zone defined by a S-verging fold and thrust belt and is dominated by volcano-sedimentary rocks, dismembered ophiolites, and syn- and post-tectonic granitoids. The Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) data covering this area is processed by performing the Optimum Index Factor (OIF) analysis for the purpose of selecting the optimum Red-Green-Blue (RGB) color cpombinations. ASTER data have fourteen bands; 3 in Visible and near infrared (VNIR) with 15 m spatial resolution; 6 Short wave infrared (SWIR) with 30 m spatial resolution, and 5 in the Thermal infrared (TIR) with 90 m spatial resolution. Therefore, the selected RGB color combinations from ASTER data are sometimes have poor spatial resolution. The Enhanced Thematic Mapper Plus (ETM+) panchromatic band with 15 m spatial resolution covering the same area is used to enhance the spatial resolution of ASTER images. The ETM+ panchromatic bands and the multispectral RGB color combinations from ASTER data are fused together to incorporate the higher spatial resolution of the ETM+ panchromatic band (high frequency information) and the better spectral characteristics (low frequency) of the ASTER bands. Two- and multi-band wavelet transformations are performed for three newly generated ETM+ panchromatic bands based on three histograms that corresponds to those of the three ASTER bands used in the fusion. Three approximation, low frequency images and numerous exact, high frequency images are obtained each time from the ETM+ panchromatic bands. The low frequency information in the ASTER bands (better spectral information) and the high frequency information in the ETM+ panchromatic band (better spatial resolution) are fused together. Hence, the 3 approximation (low frequency) images obtained from the two-band wavelet or multi-band wavelet for the ETM+ panchromatic band are replaced by the three selected ASTER bands, respectively. Three new bands are generated by performing the inversed wavelet transformation for the approximation images from ASTER bands and the corresponding detailed bands from the ETM+ band are used to generate new RGB color combination images. The results from the two-band wavelet and multi-band wavelet are compared with each other and also with other fusion techniques such as RGB-Hue-Saturation-Intensity (HSI-RGB and Color Normalization Transformation (CNT). Wavelet-based fusion proved to be advantageous in retaining better spectral characteristics of multi-spectral ASTER data and incorporating the better spatial resolution of the panchromatic ETM+ data. geological features which were not obvious in either images or images produced by RGB-HSI-RGB and CNT fusion techniques were revealed more clearly in images generated by wavelet-based fusion.

T42C MCC: 2002-2004 Thursday 1340h

At the Seismogenic Front: Dynamic Processes at Convergent Margins III

(joint with G, S)

Presiding: **D Saffer,** University of Wyoming**; D Cardace,** Washington University

T42C-01 1340h INVITED

Geodetic and Seismic Constraints on some Seismogenic Zone Processes in Costa Rica

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E. Norabuena (UM/RSMAS), S. Schwartz and H. DeShon (UCSC) L. Dorman (SIO), E. Flueh (GEOMAR), P. Lundgren (JPL), A. Newman, F. Pollitz (USGS), M. Protti (OVSICORI). We report results from joint seismic (on-land PASCAL and offshore OBS) and geodetic (GPS) observations in Costa Rica designed to elucidate seismogenic zone processes related to subduction of the Cocos plate beneath the western edge of the Caribbean plate. For the Nicoya peninsula, where our seismic deployment was longer, the seismic data are used to constrain the geometry of the plate interface for purposes of modeling the geodetic data. Seismogenic zone events here show significant updip variability, corresponding to changes in subducted oceanic crust origin and heat flow. Inversion of the GPS data here suggests a patchy distribution of locked zones, with two relatively small, elliptically shaped locked zones elongated parallel to the trench (centered on 14 and 38 km depth) within a larger region of low locking (or possibly freely slipping), as well as northeast motion of a coastal "sliver block" at 8 plus/minus 3 mm/yr associated with oblique convergence. In contrast, for the Osa peninsula, there is no evidence of trench-parallel motion (convergence here is orthogonal) and the entire plate interface to a depth of about 50 km appears to be fully locked. In addition, the southwest-dipping block boundary on the Caribbean coast separating the Panama block and Caribbean plate also appears to be fully locked and accumulating strain, with shortening rates of about 1-2 cm/yr. The large zone of locked slip on the main plate interface beneath the Osa Peninsula, as well as the associated "back-arc" deformation, is presumably related to subduction of the shallow Cocos Ridge and consequent high compressive stress in the direction of plate convergence. Over geologic time, this may promote crustal shortening in the region, and uplift of the Cordillera Talamanca in southern Costa Rica.

T42C-02 1355h

Inter-plate coupling in Nicoya Peninsula, Costa Rica, as deduced from trans-peninsula GPS experiment

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We investigate state of plate coupling at the subduction zone beneath Nicoya Peninsula, northwestern Costa Rica, from 1.5-years of trans-peninsula GPS campaign measurement. Inter-plate coupling zone beneath Nicoya Peninsula is recognized as a clear seismic gap named "Nicoya seismic gap". In this area, Cocos plate is subducting beneath the Caribbean plate from the Mid American Trench with large convergence rate about 90mm/yr, and because of this, large earthquakes have occurred in 1853, 1900, and 1950 at this segment, and two large earthquakes occurred around Nicoya peninsula (M_W 7.0 in 1990 to the SE and the 1992 M_W 7.6 off Nicaragua to the NW). In the Nicoya seismic gap, a strong coupling of the two plates is manifested by low background seismicity, the sharp edge of aftershock zone of the 1990 and 1992 earthquakes, and the northeastward movement of the Nicoya peninsula recorded with GPS observations.

We started a new GPS survey program in Nicoya peninsula in 2001 to obtain new knowledge about the seismic coupling and the potential earthquake. 7 new benchmarks for GPS campaign observation were installed completing a 10-sites transect across Nicoya peninsula. We have done 3 times of GPS campaign observation on this array.

Crustal deformation on inter-seismic period above Nicoya seismic gap is estimated from 1.5 years of GPS observations. Obtained velocity field suggests that the forarc sliver motion along the pacific coast of Nicoya peninsula produces 8.5mm/yr of northwestward motion parallel to the Mid American Trench.

We performed an inversion analysis to infer inter-plate coupling at Nicoya seismic gap. The result of the inversion shows that upper and lower limits of coupling zone are corresponding with ones of seismogenic zone, which was investigated by Newman *et al.* (2002) with seismological methods. Accumulated strain in the Nicoya seismic gap is able to bring earthquake whose moment magnitude is larger than 7.5.

T42C-03 1410h

Aseismic Slip and Stress Transfer in Guerrero, Southern Mexico

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Geodetic measurements from Guerrero, southern Mexico, show evidence for at least four large transient slip events in 1995, 1998, 2002 and 2003. Inverse modeling of the data suggests that the steady-state slip on the plate-boundary thrust includes partial frictional coupling at depths greater than 25 km, producing a slip deficit which is partially or completely relieved during aseismic slip events, and strong frictional coupling on the shallow thrust which is not relieved aseismically. Slip events have been observed down-dip of the seismogenic zone at several other subduction zones including New Zealand, Japan, Alaska and Cascadia. In many cases, these are interpreted as repeating events that activate a similar area on the thrust at regular intervals. In Guerrero, however, the behavior is more complex: Quiescent intervals range from one to four years, and moment release in these four events varies by up to an order of magnitude. Spatial distributions also vary substantially between events. Perhaps the most consistent feature of the events is the timescale: Significant anomalous slip lasted about three to four months during all three events observed by continuous GPS. The events are also characterized by widespread activation of slip. The current network of continuous GPS sites covers an area of about 480 km strike-parallel by 270 km strike-perpendicular, but in all events there remains the possibility that slip extended well beyond the instrumental coverage. In this presentation, we will examine the potential role of these slip events as agents for stress transfer, and assess the possibility that they are initiated by stress changes during seismic events of magnitude 6 and higher on or near the thrust.

T42C-04 1425h

Episodic Forearc Uplift Related to Subduction of the Woodlark Basin, Western Solomons Arc: Intermittent Aseismic Slip or Multi-Century Earthquake Recurrence Intervals?

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Aseismic subduction of very young lithosphere may occur if the downgoing plate is too young and hot to support stick-slip cycles of interplate elastic strain accumulation and rupture. However, we have found a series of discrete episodic uplift events of 1-2 m each in the Western Solomons forearc where ∼1-2 Ma Woodlark Basin lithosphere is subducting at rates on the order of 80-100 mm/yr. These uplift events produce average forearc Holocene uplift rates ranging up to 5-8 mm/yr on southern Rendova and Tetepare Islands about 25 km from the plate boundary in a forearc area lacking historical evidence for large forearc thrust events. The best evidence of paleouplifts is in central eastern Rendova where the Holocene uplift rate is ∼3 mm/yr. Here we find morphologically pristine emerged corals at ∼2 m elevation that give a cluster of radiocarbon ages (783±38, 799±28, 800±34 yr BP) (calib. age: 279 - 463 yr BP) that match a local solution notch at ∼2 m elevation. Additional distinct notches occur immediately above at ∼3.5 and 5 m elevation. Corals at ∼3.3 m give ages of 1286±43 yr BP(calib. age: 663 -787 yr BP) and at ∼ 4.75 m the age is 1436±39 yr BP (calib. age: 762 - 932 yr BP). Additional notches cut the lower 10 m of emerged Holocene reef that rises to 20 m maximum elevation in this area. Thus, late Holocene uplift appears to occur by discrete events on the order of 1-2 m that affect a large area of the outer forearc. Maximum uplift rates located in a zone only ∼25 km from the convergent plate boundary are best explained by subducting rugged seafloor topography causing full or at least partial locking of the interplate thrust zone from near the sea floor to ∼10-20 km depth on the interplate thrust zone. A recurrence interval of several hundred years between ruptures on a locked thrust zone could explain why seismicity in this area is depressed. However, if the interplate thrust zone is aseismic, then perhaps these uplift events are generated by episodic non-seismic interplate slip. Another possibility is that locking at the shallow end of the interplate thrust zone is sufficient to delay slip at greater depths so that it occurs episodically rather than continuously.

T42C-05 1440h INVITED

Earthquake Recurrence along the Kuril Trench: A New View from Paleoseismology

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Paleoseismological data along the Pacific coast of eastern Hokkaido indicate that unusual earthquakes have repeated at about 500 year interval with the most recent event in the 17th century. Along the Kuril trench, interplate earthquakes with rupture length of 100-200 km occurred in 1952 (Mw 8.1) and 1973 (Mw 7.8), as well as 1843 (M 8.0) and 1894 (M 7.9), which have been considered characteristics of this subduction zone. We review paleoseismological data, examine coastal deformation and tsunami inundation from fault models, and propose a model of earthquake recurrence in the Kuril subduction zone. Pleistocene marine terraces on the Pacific coast show slight net uplift, at an average of 0.1-0.4 mm/yr in the past several hundred thousand years, whereas tide-gauge data show gradual subsidence of 8-9 mm/yr since 1900. Infrequent unusual event (Armageddon) has been inferred (Ikeda, 1996) to resolve this conflict. Holocene stratigraphic and microfossil studies have indicated sea-level changes in the last 3 ka (e.g., Sawai, 2001). Each event is marked by an abrupt upward change from brackish bay deposits to freshwater peat. The youngest change has been dated in the 17th century with an estimated uplift amount of 0.5-1m (Atwater et al., 2003). Such evidence has been found along the 100 km long coast and recurred up to seven times in the last 2.5 ka (Kelsey et al., 2002). Extensive tsunami deposits indicate large prehistoric tsunamis (Nanayama et al., 2003). At Kiritappu, for instance, sand sheets extend 3 km inland, much further than historic tsunamis. Ten sheets of tsunami deposits indicate recurrence of such unusual tsunami with an average recurrence interval of about 500 years. The most recent event occurred in the 17th century. Historic documents in Honshu rules out unusual tsunamis that would cause damage along the Sanriku coast. Tsunami damage from the 1611 and 1677 earthquakes, both along the Japan trench, have been documented along the Sanriku coast. We modeled and examined three types of earthquakes: Armageddon, interplate events, and tsunami earthquakes. The fault extends down to 85 km depth in the Armageddon model, and would cause the coastal uplift. Interplate earthquake fault, down to 50 km depth, would cause slight subsidence of coast. The ocean bottom deformation from the tsunami earthquakes is limited near the trench axis. We also varied fault length along the trench axis as 200 km (single segment) and 300 km (multi-segment). Tsunami numerical modeling from these fault models calculates coastal tsunami heights for the Hokkaido and Honshu coasts and inundation for selected sites where the tsunami deposits were mapped. Only multi-segment fault can explain the tsunami deposits and lack of documented damage on Sanriku coast. The coastal uplift seems to be caused by postseismic deformation along the deeper extent of such infrequent multi-segment interplate earthquakes. To explain the observed uplift, however, postseismic slip larger than the coseismic slip in seismogenic zone is needed.

T42C-06 1455h

Heat flow distribution and thermal regime across the Nankai accretionary complex

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The seismogenic feature along subducting plate boundaries is largely controlled by the thermal structure, as well as material difference and hydrological parameters. By April, 2003, the NanTroSEIZE (Nankai Trough Seismigenic Zone Experiment) working group submitted a CDP (Complex Drilling Project) proposal to IODP, consisting of an umbrella proposal and two proposals. The foremost goal of this CDP proposal is to understand the state and behaviour of seismigenic fault zone. The Nankai accretionary complex is one of the well-known field of accretionary-dominant tectonics; many heat flow data exist, either measured using probes or estimated from gas hydrate BSR depths. Heat flow profile across the Nankai forearc region was obtained off Muroto, and was shown that; 1) heat flow is almost twice as high On the trough axis as that predicted from the age of Shikoku Basin, 2) heat flow gradually decreases landward on the forearc slope, and 3) there are local high heat flow anomalies near the toe of accretionary complex, probably related to the cold seep activities. Gradual decrease in heat flow can be explained be a conductive cooling of the overlying accretionary prism, and a thermal regime of the subducting plate plays a significant role on the overall thermal structure of the accretionary prism. The forearc structure off Kumano;, where we submitted the drilling proposal, is basically similar to that off Muroto. Recent intensive heat flow measurements revealed a heat flow profile off Kumano. On the trough floor heat flow mostly uniform around 100 mW/m2. This is basically consistent with theoretical estimates, if corrected for a sedimentation effect. Heat flow on the forearc slope decreases gradually landward, which can be explained similarly to Muroto. The conductive regime beneath the slope would be supported by the fact that heat flow obtained by the probes is consistent with those estimated from BSR. In the Kumano Basin heat flow is 60-80 mW/m2, with some anomalies on the mud volcanoes. We found, however, that there is significant variation in the bottom water temperatures down to 3000 m water depth. This raises a serious problem when we measure and interpret heat flow in the shallow part of forearc slope, where we expect active faulting causing a surface offset and associated cold seep activities.

T42C-07 1510h

3-D Numerical Modeling of Rupture Sequences of Large Shallow Subduction Earthquakes

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We study the rupture behavior of large earthquakes on a 3-D shallow subduction fault governed by a rate and state friction law, and loaded by imposed slip at rate V_{pl} far downdip along the thrust interface. Friction properties are temperature, and hence depth, dependent, so that sliding is stable $(a - b > 0)$ at depths below about 30 km. To perturb the system into a nonuniform slip mode, if such a solution exists, we introduce small along-strike variations in either the constitutive parameters a and $(a - b)$, or the effective normal stress, or the initial conditions. Our results do show complex, nonuniform slip behavior over the thousands of simulation years. Large events of multiple magnitudes occur at various along-strike locations, with different recurrence intervals, like those of natural interplate earthquakes. In the model, a large event usually nucleates in a less well locked gap region (slipping at order of 0.1 to 1 times the plate convergence rate V_{pl}) between more firmly locked regions (slipping at 10^{-4} to 10^{-2} V_{pl}) which coincide with the rupture zones of previous large events. It then propagates in both the dip and strike directions. Along-strike propagation slows down as the rupture front encounters neighboring locked zones, whose sizes and locking extents affect further propagation. Different propagation speeds at two fronts results in an asymmetric coseismic slip distribution, as is consistent with the slip inversion results of some large subduction earthquakes [e.g., Chlieh et al., 2003]. Current grid resolution is dictated by limitations of available computers and algorithms, and forces us to use constitutive length scales that are much larger than realistic lab values; that causes nucleation sizes to be in the several kilometers (rather than several meters) range. Thus there is a tentativeness to present conclusions. But with current resolution, we observe that the heterogeneous slip at seismogenic depths (i.e., where $a - b < 0$) is sometimes accompanied by events that have clearly aseismic slip rates (10^2 to 10^3 V_{pl}), and seem to migrate in the strike direction at depths slightly downdip from the seismogenic zone. Sometimes they reach a gap like described above in the shallow locking region and rupture the updip seismogenic zone. The frequency-size distribution of simulated large events on the thrust interface shows an increase in slope around $M_w = 7.5$, like has been found for actual earthquakes [Pacheco and Sykes, 1992]. We are also investigating the relation of hydrolytic reactions to the hydrologic state of the thrust interface, and their possible relation to observed non-volcanic tremors and aseismic transients downdip of the seismogenic zone [Obara, 2002; Dragert et al., 2001], by coupling the fluid motion induced pore pressure changes into the system.

T42C-08 1525h

Stress interaction between subduction earthquakes and forearc strike-slip faults: Modeling and observations

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We explore the interaction between thrust events on the subduction interface and strike-slip faults within the forearc using 3-D models of static coulomb stress change. Strike-slip faults in the forearc often present significant seismic hazard because of their proximity to population centers. Static stress change models show a relationship between slip vector azimuth and the locations of induced stress on strike slip faults in the forearc. Stress is enhanced on faults that are located closer to the trench and is reduced on faults farther inland for increasing slip obliquity, which is defined as the angle between the actual slip vector of a subduction zone and the vector normal to the overall trend of the subduction trench. Significant contribution to the stress change on strike slip faults in the forearc comes from “unclamping” of the fault (reduction in normal stress) due to thrust motion on the subduction interface. We use these models to explain the contrasting deformation pattern between two adjacent segments of oblique subduction of the North American (NOAM) plate under the northern Caribbean. The abnormally-thick crust of the Bahamas subducts under the Hispaniola trench, whereas normal oceanic crust subducts under the Puerto Rico trench to the east. GPS measurements indicate that oblique convergence under Hispaniola is partitioned between dip-slip reverse motion on the subduction interface and left-lateral strike-slip on known faults in the forearc at a distance of 60 km or more from the trench. Slip of large earthquakes under Hispaniola is dominantly dip-slip reverse motion. In contrast, GPS measurements in the Puerto Rico segment indicate that oblique convergence is not partitioned. The velocity vector of Puerto Rico relative to NOAM is similar (within error) to that of the Caribbean plate relative to NOAM, and there is no internal deformation within Puerto Rico itself. Focal mechanisms of moderate earthquakes in the past 25 years show a slip direction which is subparallel to the highly oblique plate motion vector. The major left-lateral strike-slip fault in this segment is located at a distance of 10-15 km from the trench, cuts through the accretionary prism, and extends to the subduction interface at a depth of only 5 km. The fault curves inland as it approaches the Hispaniola segment, but does not connect with strike-slip faults on Hispaniola. The jump from a strike-slip fault near the trench in the Puerto Rico segment to an inland fault in Hispaniola is explained by different stress distributions in the forearc of the two segments due to the change from oblique slip on the subduction interface in Puerto Rico to dip slip in Hispaniola. The observations and modeling suggest that seismic hazard to Puerto Rico from oblique subduction and from subduction-induced forearc strike-slip earthquakes is much smaller than previously assumed, but hazard to Hispaniola remains high.

T42D MCC: 3007 Thursday 1340h

Deformation Mechanisms: From the Lab to the Lithosphere II *(joint with V, MR)*

Presiding: **I Katayama,** Yale University**; D L Goldsby,** Brown University

T42D-01 1340h

Viscosity of a molten mantle: experimental data for liquid peridotite.

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The debate surrounding Earth evolution accompanied by a largely molten magma is increasingly reliant on the results of models for physico-chemical processes in such a scenario. To date, the primary emphasis in the physical characterisation of molten peridotite has been the determination of a PVT equation of state with contributions from shock-wave and buoyancy studies. Determinations or other melt properties are largely lacking. The viscosity, in particular, has received too little attention. Here, the Newtonian viscosity of molten peridotite has been determined experimentally at superliquidus and supercooled conditions. The high temperature determinations were obtained using a concentric cylinder technique employing constant high-speed deformation. The low temperature determinations have been obtained from the analysis of the glass transition in scanning calorimetric traces and conversion via published shift factors into viscosity data. These latter measurements were made possible by the experimental synthesis of peridotite glass using a splat-quenching device. Taken together the superliquidus and supercooled data provide the first quantitative description of the viscosity of molten peridotite. The temperature-dependence of the viscosity of molten peridotite is extremely non-Arrhenian. As a result, molten peridotite, despite having an extremely low viscosity near its liquidus temperature, exhibits a very high glass transition temperature. The extrapolation of viscosity in terms of temperature is of central importance to the application of these data to nature. The viscosity data presented here cover over 12 log units of viscosity and 800K. As a result, this data set provides a robust basis for the extrapolation of melt viscosity to the even higher temperatures expected to exist where molten peridotite is or was present in the mantle. Further influences on the viscosity of peridotite, such as volatiles and pressure, are expected to play a relatively minor role. Extrapolated values of these peridotite viscosity data are compared with those estimated for non-silicate liquids at pressure-temperature conditions for a molten mantle in the Earth.

T42D-02 1355h

Effects of Temperature and Water on Deformation Microstructures of Olivine

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Recent studies in our laboratory have shown that water and stress have important effects on deformation microstructures of olivine including lattice preferred orientation and recrystallized grain-size (Jung and Karato, 2001a,b). These findings provide us with different interpretations of the geodynamic significance of seismic anisotropy, particularly in subduction zones. However, these initial studies were limited to a narrow temperature range (~1500-1600K). Theoretical considerations suggest that in addition to water content and stress, temperature is likely to modify these microstructures. Temperatures in some parts of subduction zone upper mantle are likely significantly lower than ~1500 K. Consequently, it is crucial to extend these previous studies to lower temperatures and compare these results with microstructures of naturally deformed peridotites from collision zones which were likely deformed at low temperature conditions. We conduct deformation experiments in simple shear at lower-temperature (to 1273 K). An olivine single crystal was sandwiched between alumina pistons cut at 45^o from the compression direction, and surrounded by a mixture of talc and brucite that acts as a water source. Shear strain was measured by the rotation of a strain marker, and the microstructures of olivine samples were investigated by a scanning electron microscope with an electron backscatter diffraction (EBSD) technique. Even at a temperature as low as ~1273 K, samples were totally recrystallized at small strain (~0.8). The recrystallized olivine grains show a fabric which is different from any of the known fabrics. We tentatively interpret this as caused by the combination of inherited fabric and deformation- (+ recrystalllization-) induced fabric involving the activity of the b=[001]. The details of fabrics and its variation with temperature, stress and water content will be reported together with a comparison with the fabrics in naturally deformed peridotites under low temperature (and "wet" ?) conditions.

T42D-03 1410h

Dislocation Microstructures in Deformed Olivine Displaying the C-type and B-type Fabrics

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Because seismic anisotropy in the upper mantle is commonly a result of lattice preferred orientations (LPOs) of minerals as a result of mantle flow, seismic anisotropy is used to probe fabrics and therefore flow directions in the mantle. Jung and Karato, (2001) have shown that the fabrics developed in experimentally deformed olivine are dependent on H2O fugacity and stress, suggesting that olivine fabric in the upper mantle can provide a means of probing H2O content and stress. Olivine fabrics, known as B-type and C-type, occur in olivine deformed under high H2O fugacity and high stress. In order to extrapolate these experimental deformation fabrics to the mantle, one must understand how H2O changes the mechanisms of plastic deformation in olivine. Experimentally deformed olivine samples with C-type and B-type fabrics have been examined by TEM to determine dislocation microstructures, core structures and active slip systems. In the C-type sample, we examined a relatively large olivine grain with its b axis normal to the TEM foil and the a and b axes approximately 45^o from the slip direction. Tilt boundaries along (100) and (001), consisting of edge dislocations with b = [100] and b = [001], respectively, indicate that the dominant slip systems are (001)[100] and (100)[001]. HRTEM imaging of the b = [100] and b = [001] edge dislocations along [010] shows no dissociation for b = [100], whereas the b = [001] dislocations are dissociated into 1/2[-101] and 1/2 [101] partial dislocations separated by 3 nm along the (-101) plane. The C-type fabric, which occurs in wet olivine deformed at low stress, results from the domination of the (100)[001] slip system over the (010)[100] slip system that produces the A-type fabric. Based on the abundance of b = [001] edge dislocations, we infer that the presence of hydrogen in olivine reduces Peierls stresses for glide of b = [001] screw dislocations in (100). The more complicated microstructures in the B-type sample will be presented at the meeting.

T42D-04 1425h

Effect of Mineral Reaction on the Deformation of Plagioclase-Olivine Aggregates

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There have been many studies that have described the relative timing of deformation and metamorphism in natural rocks, but there are few studies that have analysed the interrelationship of the processes that produce simultaneous deformation and chemical reactions. We studied the physical and microstructural relationships between the processes of deformation and chemical reaction by performing simple shear deformation experiments on plagioclase-olivine aggregates. Our study shows that deformation and reaction processes are strongly related by a mutual positive feedback, and point out possible mechanisms for shear localization in the upper mantle lithosphere during subduction and extension. Shear deformation experiments were carried out on dry plagioclase-olivine mixtures (4-10 μm grain sizes, ±50-50 vol.% olivine-plagioclase ratio) in a Griggs apparatus under a constant applied shear strain rate of $\sim 5*10^{-5}s^{-1}$ at 900°C and 1.0-1.6 GPa confining pressures. We have studied the plagioclase-olivine deformation in presence and absence of reaction by choosing plagioclase to be of labradorite (An60) and anorthite (An92) composition. At 1.0-1.6 GPa confining pressures, the anorthite-olivine samples react to spinel-pyroxene bearing assemblages, whereas the labradorite-olivine samples do not. Labradorite and anorthite are expected to have fairly similar deformation behaviour. *Effect of reaction on deformation:*
In the absence of reaction, labradorite-olivine mixtures are so strong at the chosen experimental conditions that they hardly deform plastically. In contrast, anorthite-olivine mixtures deformed at the same temperature and strain rate react during deformation, producing a stress maximum (~375 MPa) followed by a significant stress decrease. Regardless of the chosen confining pressure, reacting samples commonly weaken towards a shear stress of ~275 MPa. The plagioclase-olivine reaction strongly reduces the grain size of the samples (down to 0.1 μm), and causes a transition from grain size insensitive (dislocation) creep of plagioclase and olivine to diffusion accommodated grain boundary sliding of the reaction products, even though the newly formed minerals (e.g. pyroxene, spinel) are mechanically stronger than the original minerals. *Effect of deformation on reaction:*
The plagioclase-olivine reaction progress is greatly enhanced by differential stress and/or crystal plastic strain. At 1.5 GPa, hydrostatic experiments of 168 hours show less than 30% reaction progress, whereas in the deformation experiments (~58 hours) the reaction goes to completion.

T42D-05 1440h

DEFORMATION OF SERPENTINITE AND ITS IMPLICATIONS FOR THE ASEISMICITY AND SEISMIC LOW VELOCITY ANOMALY IN SUBDUCTION ZONES

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Recent seismic data suggest that a low velocity layer up to ~ 7 km thick exists at the top of the subducting slab in many subduction zones (Abers, 2000). Both P and S-wave velocities are consistently 5-7 % lower than the surroundings. There are also observations of a distinct low seismicity zone in the Japan Trench (Fujie et al., 2002) and even an aseismic zone in central Oregon (Brocher et al., 2003). We have investigated a possible cause of these observations by deforming a natural serpentinite at the pressures of 1.0 - 3.4 GPa and the temperatures of 923 - 1023 K. We conducted triaxial deformation experiments at a constant strain rate using a Griggs-type apparatus. Oxygen fugacity was buffered by Ni/NiO. We find that under conditions where serpentine is dehydrating during deformation, Mode-I cracks are commonly observed in serpentine as well as in relict olivine. A similar phenomenon (Mode-I cracks) may occur at the top of the subducting slab due to the deformation of a hydrated mantle wedge above a dehydrating subducting slab. We propose that such aligned Mode-I cracks, which fill with water as they open, may result in the low seismic velocity in subduction zones (i.e. Alaska, the Aleutians, Kuriles, Honshu, the Marianas, and Nicaragua). We also find that deformation of the serpentinite under a differential stress display faults and localized shear zones, delineated by ultra fine-grained solid reaction products, formed as byproducts of antigorite dehydration. We observe this phenomenon under all conditions tested. A distinct low seismicity zone in the Japan Trench region, aseismicity beneath central Oregon, and other aseismic

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