T52B-0273 1330h POSTER

Controls on the Morphological Variability of the Decollement in the Nankai Trough Subduction Zone

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Decollements form plate boundaries at subduction zones, hence the details of their initiation are of fundamental importance in the development of large fault systems. A key question at Nankai is does the decollement initiate and remain in a singular layer or jump around and if so why? To investigate this issue, we analyzed 3-D seismic reflection data collected off the Muroto Peninsula by a US-Japanese consortium in 1999. We examined seismic profiles and correlated our interpretations to core and log data from ODP sites 1173, 1174, and 808 to determine the physical properties of the decollement from the undeformed incoming sediment to the deformation front. These seismic profiles indicate that substantial along-strike variability characterizes the decollement in the Nankai Trough subduction zone. The decollement forms a series of overlapping splays above an elongate basement high that is approximately 1 km wide, rises 100-150 m above the adjacent low areas, and trends northwest across the survey area. Seismic profiles show the amount of overlap along the decollement above the basement high ranges from 80 m seaward of the deformation front to 40 m at the frontal thrust. These initial observations suggest the basement relief significantly influences the undulating character of the decollement, becoming less of a factor with increased subduction. Other possible influences on the decollement morphology include the variation in stress orientation caused by the basement high and differences in overpressure resulting from along-strike differences in sediment loading. Determination of these factors will provide a better understanding of the controls of decollement formation.

T52B-0274 1330h POSTER

Diagenetic Phase Boundary at the Nankai Trough, SW Japan: Relationship to the Decollement/ Proto-Decollement

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In the subduction environment, phase changes within sediments may affect their subsequent deformation during the accretion process. At the Nankai trough, off Cape Muroto, southwest Japan, a phase change from cristobalite to quartz occurs near the depth of the decollement zone, with a prominent seismic reflector marking this diagenetic boundary between the upper and lower Shikoku Basin facies. Outboard of the trench this reflector is initially at greater depth than the projected proto-decollement but migrates upward to transgress it before reaching Ocean Drilling Program Site 1173 in the landward direction. This effectively encases the entirety of the decollement in a lithology depleted in cristobalite and enriched in quartz. Creation of a depth section within a three-dimensional seismic reflection volume enabled this diagenetic reflector to be mapped relative to the oceanic basement reflector, the seafloor reflector, and intervening stratigraphic reflectors. Within areas of recent sedimentation in the trench the diagenetic reflector diverges from the basement reflector and rises vertically in the section. This upward migration of the diagenetic reflector follows a similar upward migration of the isotherms. Thermal gradients in the Muroto region are increased by proximity to the Shikoku Basin paleospreading center axis. At subduction regions with lower thermal gradients the cristobalite zone could be expanded to greater depths, allowing sediments untransformed by this diagenetic process to be incorporated into the toe of the prism and potentially altering initial accretionary structures.

T52C MCC: Level 1 Friday 1330h

At the Seismogenic Front: Dynamic Processes at Convergent Margins V Posters *(joint with G, S)*

Presiding: **H DeShon,** University of California, Santa Cruz**; T Ike,** University of Hawaii

T52C-0275 1330h POSTER

Numerical Modeling of Dewatering of Underthrust Sediments, Costa Rica Subduction Zone

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Drilling-related investigations at the Costa Rica subduction zone have provided constraints on dewatering processes and overpressure generation during initial subduction. The 380 m thick incoming sediment section, which is composed of 160 m of hemipelagic mudstones overlying 220 m of pelagic carbonates, is nearly completely underthrust beneath the margin wedge. Within the first 1.6 km of subduction, drilling results indicated that the upper, hemipelagic unit and the lower, pelagic carbonate unit thin to 67% and 80%, respectively, of their original thickness, presumably due to dewatering. Despite the observed thinning, laboratory consolidation tests suggested that the underthrust sediments are only partly drained in response to rapid loading beneath the margin wedge. In this investigation, we simulated the progressive loading, fluid migration, and compaction of sediments during their initial subduction by combining a loading model with a transient fluid flow model. Results of the modeling indicate that previously measured permeabilities of the hemipelagic sediments are sufficiently high to allow the observed dewatering while being low enough to maintain elevated pore pressures. In contrast, the modeling suggests that the laboratory-determined permeabilities of the pelagic carbonates are too high to be representative of large-scale in situ permeabilities, because the laboratory-derived permeabilities would allow much greater dewatering and compaction than observed.

T52C-0276 1330h POSTER

Development of Overpressures at Nankai Accretionary Prism, Ocean Drilling Program Sites 1173 and 1174

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In this study, we used a one-dimensional model of sedimentation, initial prism loading, and fluid flow to examine the development of overpressures at the toe of the Nankai accretionary complex. A permeability-porosity relationship was established for hemipelagic sediments from laboratory measured permeabilities as an input to the model. Vertical permeabilities were measured for 10 core samples from the Ocean Drilling Program (ODP) Leg 190, Sites 1173 and 1174, from the upper and lower Shikoku Basin facies. Both sites were drilled along the Muroto Transect through the dècollement zone or its equivalent. Site 1173 is located 11 km seaward of the deformation front and it represents the undeformed incoming sediments, where as Site 1174 represents sediments within the proto-thrust zone. Although turbidite-rich sediments dominate the Nankai accretionary prism, the dècollement and underthrust sediments are primarily composed of hemipelagic muds. Using the permeability-porosity relationship, our modeling results indicate excess pore pressures that are greater than 30% of lithostatic pressure at the toe of the prism at a convergence rate of 4cm/yr. These values are slightly lower than previously inferred excess pore pressures estimated from porosity data. Additional runs were conducted to simulate a 10-m thick low permeability barrier at the dècollement where vertical fluid flow is restricted. The low permeability barrier required a permeability less than 1 x 10^{-19} m^2 to generate excess pore pressures greater than 50% of lithostatic pressure. Modeling was further extended to test the significance of variable prism loading rates due to uncertainties in the convergence rate and affects of lateral stress above the dècollement.

T52C-0277 1330h POSTER

Permeability and strength structure around an ancient exhumed subduction-zone fault

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Investigating the transporting properties of subduction zone faults is crucial for understanding shear strength and slip-stability, or instability, of subduction zone faults. Despite the influence of pore pressure on a wide range of subduction-zone fault processes, few previous studies have evaluated the permeability structure around the fault placed in a well-defined structural context. In this study, the aim is to gain the entire permeability and the shear strength structure around the ancient subduction zone fault. We have conducted a series of permeability measurements and shear failure experiments in seismogenic environments using intact rocks sampled at the outcrop of an exhumed fault zone in the Cretaceous Shimanto accretionary complex, in Shikoku, SW Japan, where a typical evidence for seismic fault rock of pseudotachylyte has been demonstrated [Ikesawa et al., 2003]. This fault zone is located at boundary between the sandstone-dominant coherent unit of the Nonokawa Formation and the Okitsu mélange. The porosity of each rock sample is less than 1 %, except for the shear zone. Cylindrical test specimens (length = 40 mm, diameter = 20 mm) were cored to an accuracy of within 0.02 mm.

Most of values of permeability were evaluated at confining pressure P_c of 140 MPa and pore pressure P_p of 115 MPa simulating the depth of 5 km (suprahydrostatic pore pressure). It is found that the permeability at room temperature shows the heterogeneous structure across the fault zone. The permeability of sandstone-dominant coherent unit is the lowest (10^{-19} m^2) across the fault zone. In contrast, high shear zone has the highest permeability (10^{-16} m^2). Following the increase in temperature, permeability evolution has been investigated. The permeability at 250°C continuously decreases with hold time for all types of rock specimens, and the reduction rate of permeability against hold time seems to become small with hold time. It seems that the reduction rate does not significantly depend on the rock types.

The specimen was loaded at a strain rate of 2×10^{-6} /s under the conditions (P_c, P_p, T) = (140 MPa, 105 MPa, 250°C) to conduct the shear fracture experiments. High shear zone has a minimum value in strength profile. In contrast, the largest shear strength is observed at sandstone in coherent unit.

From the seismic reflection surveys in the Nankai Trough, Park et al. [2002] delineated reflections with negative polarities beneath the Nankai accretionary prism 20-60 km landward of the frontal thrust, which are located deeper than the negative polarity décollement near the frontal thrust. They interpreted that the DSRs indicate the elevated fluid pressures. The fault zone studied in this paper is consistent with the duplex-model, and corresponds to the area where the décollement near the frontal thrust stepped down. Present results show the possibility that the coherent sandstone acts as a cap rock for fluid flow, and shear zone as a conduit for the flow, which leads to the elevated pore pressures along the roof thrust.

T52C-0278 1330h POSTER

Spatial and Temporal Variations of Sediment Input to the Cascadia Subduction Zone

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The abundance of expandable clay (smectite) in subducting sediments is an important parameter to consider during studies of plate-boundary seismogenic zones because the mineral has an unusually low coefficient of internal friction. Furthermore, interlayer

water is released during smectite-to-illite diagenesis, which increases the likelihood of excess pore pressure and low effective stress. In theory, the up-dip limit of a seismogenic zones might coincide with the down-dip dissipation of excess pore pressure. In the specific case of Cascadia Basin, the amount and types of clay on the abyssal floor change considerably in both time and space. Those variations probably influence the strength of the plate-boundary fault, the vergence of imbricate thrusts within the frontal accretionary prism, and the fluid budget in 3-D. New data from more than 200 gravity-piston cores show that distal parts of Cascadia Basin contain 4% to 70% smectite in the clay fraction (Biscaye weighting factors). Smectite is more abundant within a plume of discharge that emanates from the Columbia River, but spatial variations are not clear-cut, even within the upper meter of Holocene mud. This complexity is a product of interplay among autocyclic factors (e.g., channel switching, migration of surface currents), allocyclic variables (e.g., continental glaciation, volcanism, balance of chemical to mechanical weathering, earthquake trigger of turbidity currents), and eustatic forcing (e.g., attachment-detachment of river-canyon connections). In addition, new data from ODP Site 888 (Nitinat Fan) and DSDP Site 174 (Astoria Fan) show substantial changes in clay composition with depth. Smectite at Site 888 varies erratically from 13% to 55%. Smectite content is 11% to 64% at Site 174, with a marked increase from the younger submarine-fan facies (average 22%) to the underlying abyssal-plain facies (average 42%). Models of fault-zone mechanics and accretionary-prism hydrogeology should take this compositional variability into account.

T52C-0279 1330h POSTER

A subducted oceanic ridge imaged at the eastern Nankai subduction zone

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Megathrust earthquake rupture is highly influenced by seafloor bathymetric features such as oceanic fracture zones, seamounts, and ridges in convergent plate margins where these features subduct. Recent seismic reflection and refraction data reveal a trough-parallel subducted oceanic ridge that is attached to the descending Philippine Sea Plate beneath the accretionary wedge of the overriding Eurasian Plate in the eastern Nankai Trough subduction zone consisting of the Tonankai and Tokai segments. The seismic survey data confirms the existence of subducted paleo-Zenisu ridge that was suggested by just magnetic data, and as a result, expands its distribution to the west. The newly constrained subducted ridge that spans the two segments is estimated to be a maximum of 2.5 km high, 20-30 km wide, and 200 km long. Spatial mapping of the ridge shows that it is located roughly at the seaward edge of the coseismic rupture zone of the 1944 Tonankai earthquake (M = 8.1). This ridge appears to be in close contact with the seaward end of the rigid backstop in the Tonankai segment. Both the spatial correlation and the ridge-backstop collision geometry suggest that the subducted ridge might be strongly mechanically coupled and may thus play a significant role as a seaward barrier inhibiting the 1944 earthquake rupture from propagating farther seaward.

T52C-0280 1330h POSTER

Seismic Investigation of the Décollement Offshore Costa Rica

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The convergent margin offshore Costa Rica is the focus of the investigations within the SFB 574 "Volatiles and Fluids in Subduction Zones: Climate Feedback and Trigger Mechanisms for Natural Disasters." Within the subproject A2, the main objectives are the coupling and the mass transfer between overlying and downgoing plate. We present a detailed seismic study of the near trench plate boundary, just 3 km landward of the Middle American Trench, located between the Quepos Plateau and the Cocos Ridge. In this area, previously recorded dip-profiles showed a very bright décollement reflection of negative polarity within the first five kilometres landward of the trench. Along strike, the zero-offset reflection strength of the décollement shows a high lateral variability. To further investigate these lateral variations, we deployed ten ocean-bottom-stations on a profile of 1.5 km length during the cruise 173 of RV Sonne in July 2003. Due to the shallow depth of the décollement (around 700 m below seafloor), we are able to observe reflected waves at angles up to 50 degrees. This will enable us to describe the amplitude-variations with angle in detail and will allow us to further investigate the lithologic parameters causing this variations.

T52C-0281 1330h POSTER

Microstructural analysis and fluid flow of the shallow part of the paleo-seismogenic out-of-sequence thrust: An example from the Cretaceous Shimanto accretionary complex, Southwest Japan

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Out-of-sequence thrust (OST) plays a great role in thickening of an accretionary prism, formation of a forearc basin and tsunami generation. It is pointed out that the sharp discontinuity of the thermal structure in the east Shikoku was caused by an activity of the OST (Ohmori et al., 1997). However the textural analysis and interaction with seismo-genesis have still been uncertain. The purpose of this study is to investigate the lithology, texture and evolution of OST in order to know the role in the seismo-genesis. I had mainly a feild observation in the subduction zone, Kure merange unit of the cretaceous Shimanto accretionary complex, southwest Japan, and revealed the thermal structure based on the vitrinite reflectance, microstructure and fluid inclusion analyses. More than ten small echelon OSTs was found by detaild geologic and thermal structural analysis. Because the maximum temperature of 150 (+-30)C was estimated at the hanging wall of this faults based on the vitrinite reflectance, shallow portion of the OST would have been exposed in this outcrop. The echelon fault system has large total offset of thermal difference of 100C in temperature, and they cut previous geologic structure. Although small thermal difference was found in some thrusts, any specific thrust to make large offset was not developed within the faults system. The fault rock is composed of cataclacite and pseudotachylytes, and some of coexistent fluid inclusions of CH4 and H2O were found within the vein mineral of quartz and calcites along the faults. The fluid density of the inclusions tend to decrease toward the main shear zone. This fault system would happen rapid slip with formation of pseudotachylyte repeatedly to make large total offset of the thermal structure. The decrease of the fluid density of the fluid inclusions indicates the drop of the pore-fluid pressure around the fault due to the rupture propagation along this fault. Thus dewatering with rupture propagation would have been able to make the OST strength after faulting.

T52C-0282 1330h POSTER

Characterization of Decollement in the Nankai Trough Using Seismic Attributes Analysis

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At plate convergent margins, the physical properties along the plate boundary fault (Decollement; a detachment that separates a deformed accretionary prism from undeformed underthrust sediments) are very important, considering the nature of the deformation features and of the earthquake mechanisms. The decollement and its seaward stratigraphic projection (Proto-decollement) are identified as a prominent reversed-polarity reflector on the seismic profile. In order to delineate the physical properties along the decollement/proto-decollement at the Nankai Trough off Muroto peninsula, we have applied seismic attributes analysis via a neural network to a 3-D seismic reflection data. This approach has been applied to characterize physical properties of hydrocarbon reservoirs in the oilfields. First of all, seismic attributes were computed from 3-D seismic reflection data. Then, seismic attributes form the input to a particular type of neural network called a Kohonen Self-Organizing Map (K-SOM), and the output of which divides the seismic profile into several regions with geologically similar features. In this study, Envelope, Instantaneous frequency, Instantaneous Q and Similarity are selected as input attributes. The result of classification along the decollement/proto-decollement shows a drastic change in the physical properties around the sole of the proto-thrust. Integrating with ODP data, the classification result may help understand the development of the decollement. The decollement develops at the sole of the proto-thrust. We infer that this localization relates to the release of the shear stress accompanied with the plate subducting process, because the proto-thrust is the most seaward thrust where the shear stress can be released to the seafloor. The release of shear stress can easily be responsible for plate boundary slip landward of the proto-thrust. Furthermore, we found the geometry of the proto-decollement/decollement supports above interpretation. The geometry of the proto-decollement/decollement seaward of the proto-thrust is not a continuous single plain, but two separated surfaces with an offset of ∼100m height. These two horizons converge and form a single detachment surface immediately landward of the proto-thrust. The plate boundary slip initiates from these two horizons of high fluid pressure layer, presumably due to the increase in overburden by the turbidite sedimentation and lateral tectonic loading. As a result of the plate boundary slip, these two horizons may connect to one horizon in order to become more stable condition (less frictional condition).

T52C-0283 1330h POSTER

The Dynamics of Deformation across the Southern Hikurangi Margin

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New Zealand lies on the plate boundary between the obliquely converging Australian and Pacific Plates. Off the east coast of the North Island, this motion is accommodated by subduction of the Pacific Plate along the Hikurangi Margin. This system terminates northeast of the South Island, where the motion is transferred onto the transpressive Marlborough Fault System. At this transition between subduction and continental collision, a portion of the convergent component of relative plate motion is accommodated across a fold-and-thrust belt, which lies above the plate interface with the subducted slab. Regional structural and geomorphic data indicates that the deformation, both in this fold-and-thrust belt and further north along the margin, has accelerated within the last 1–2 Myr. This cannot be explained by changes in the relative plate motion and, as little is understood about the dynamics of this system, there are currently no constraints on why it has begun to deform more actively. In this study critical wedge modelling, topographic buoyancy stress calculations and heat flow data are used to better constrain the dynamic properties of the fold-and-thrust system. Of the three different rheological critical wedge models tested, a bulk plastic rheology best describes the surface topography and strain partitioning observed. The models also show that the relative strength of the underlying plate interface compared to the wedge is rather higher than in other subduction systems, in agreement with published seismic and geodetic data. The wedge modelling results, combined with buoyancy stress contrast calculations along the length of the Hikurangi Margin, give a estimate for the shear stress on the underlying plate interface of between 12–18 MPa. The dynamic framework of these models is used to provide plausible explanations for the recent acceleration in deformation. These include increased rates of erosion and sediment accretion in association with climate change over the last ∼ 0.8 Myr, or a change in the buoyancy of the subducted slab.

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T52C-0284 1330h POSTER

Control Factor Of K_0-value, Which Indicates Initial Stress Conditions and Physical Properties Of Sediments

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Experimental study had been done to confirm fundamental difference of physical properties between sand and mud, and to grasp influence of physical property on K $_0$-values. One series of compaction experiment had been done to vary their clay content and another series had been done under abnormal stress ratio. The results of experiments during compaction showed that (1) clear relationship between K $_0$-values and porosity and (2) rather indistinct relationship between K $_0$-values and clay contents. The results of abnormal stress ratio, they were no longer K0-compaction. K $_0$-value that is known as stress ratio under K0-condition connotes information of ductility. When sediments exhibit deviator stress, stress condition of each sediment can be expressed by a stress circle that center is placed on stress axis. On this condition, half of central angle, which is set between stress axis and tangent line of stress circle, indicate the limit angle to keep K $_0$-value fixing. It is known that K $_0$-values for sandy sediments are 0.3-0.4, though those for muddy sediments are higher than 0.7, i.e., diameter of stress circle for sandy sediments are almost twice larger than those for muddy sediments, even if they are under same compressive stress (maximum stress). It means that difference of limit angles between muddy sediments and sandy sediments could be a reason of K $_0$-value difference. Both of lithological effects and porosity effects on K $_0$-value can be explained by introducing theory of granular material for estimating contact area among grain boundaries. Equation for function of K $_0$-value can be described by number of grain contact, friction among grains and porosity. The function implies that magnitude of K $_0$-value difference between sandy sediments and muddy sediments should become smaller when they are compacted, because elements are controlled not only by lithology of each layers but also by compressive stress. Thus, when sediments undergo lateral compaction, permissible stresses are seriously different especially in case of soft sediments. Such difference may be quite important for decollement propagation.

T52C-0285 1330h POSTER

Finite Element Modeling of Subduction Zone Stresses in the Wake of Bathymetric Feature Subduction Offshore Costa Rica

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There are several cases of interaction between subducting bathymetric features and large subduction zone earthquakes. For large earthquakes in the Nankai subduction zone, it appears that subducted features have acted as barriers to rupture along the plate boundary. In other regions, such as Costa Rica and Java, subducted seamounts appear to be in regions of high slip during large plate boundary earthquakes. Subducting seamounts and ridges also impact upper plate structure and seismicity. Margin wedge slumps and landslides have been imaged along several margins where seamounts enter the subduction zone. Subducting seamounts also lead to uplifted coastal marine terraces, noted in several upper plate regions. Heterogeneous plate coupling in areas of seamount subduction has been shown to influence seismicity patterns in the upper plate. In order to explore the role of subducting features on the stresses and seismicity along the Costa Rica margin, we have developed a 3D finite element model for this region. In the simplest case, we use the geometry consistent with the Costa Rica subduction zone, but prescribe a smooth subducting Cocos plate to verify that the stresses predicted for the plate interface and upper plate environments are reasonable. To simulate conditions for the 1990 and 1999 large underthrusting earthquakes, we then allow for spatially variable slip along the plate interface, with greater slip at prescribed subducted "asperities" representing the Fisher seamount and Quepos Plateau. We model the effects of this variable slip on stress changes in the upper plate and along the plate interface. Modeled stress changes will then be compared to patterns of local seismicity and focal mechanism solutions.

T52C-0286 1330h POSTER

3D Pre-stack depth imaging of the Nankai Trough accretionary prism off Shikoku Island, Japan

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During 1999 we acquired an 8x90 km 3D seismic dataset across the toe of the Nankai Through accretionary prism south of Shikoku. Previous processing steps have focused on 3D pre-stack time migration of the entire survey and 2D pre-stack depth migration (PSDM) of two in-lines that cross the Leg 190/196 drill sites. In this study, we conducted 3D PSDM of the seaward half of the data set to improve structural images and to derive the velocity structure of the underthrust sedimentary section in order to better understand its 3D compaction and dewatering history. Velocities derived from pre-stack depth migration are considered to most accurately reflect actual in-situ formation velocities. Our processing procedure started with pre-stack time migration in the cross-line direction to image the data into 2D inlines, allowing us to use 2D migration velocity analysis (MVA) techniques to update the velocity field. 3D imaging of target volumes of data around the leg 190/196 drill holes using several distinctive reflections as depth marker horizons provided constraints for the migration input velocity model. We then 2D MVA on every 5th inline (total of 32 lines), using a top-down, layer stripping technique with Residual Move Out picking to iteratively update the velocity model and flatten the Common Reflection Point (CRP) gathers. We also compared CRP gathers with image gathers in order to detect dipping events and velocity anisotropy. We then used the resulting 3D velocity field as input to a full 3D PSDM of the entire data set. The depth image clarified the accretionary prism's structure, including the numerous thrust faults, the basal décollement, and the underthrusting Shikoku Basin sedimentary unit. The thickness of the underthrust section decreases landward because of compaction. The velocity model shows that the underthrust section's velocity increases about 20% over the first 15 km landward. Along strike variations in velocity are generally less than about 5-10%.

T52C-0287 1330h POSTER

Pre-stack Depth Imaging of NanTroSEIZE Drill Targets in the Eastern Nankai Accretionary prism, Kumano Basin

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In support of the NanTroSEIZE proposal for IODP deep riser drilling into the seimogenic zone of the eastern Nankai Trough, CDEX contracted a commercial seismic reflection survey in spring, 2003. This new survey supplements a 2002 regional seismic survey by IFREE. We report the results of pre-stack depth migration (PSDM) of two dip lines from each survey that clarify the structure and velocity distribution around the proposed IODP drill targets. The seaward 25 km of the accretionary prism is characterized by imbricate thrust faults that sole into a well-imaged decollement. The width of the frontal thrust shear is variable along strike due to interaction with a small subducting seamount. There is a small, laterally discontinuous proto-thrust zone seaward (and in some places beneath), the frontal thrust. The subducting Shikoku Basin sediment secquence is about 500 m thick under the seaward part of the prism. At about 28 km from the deformation front (DF), the decollement steps down to near the top of oceanic crust. A splay fault rises from the plate boundary fault near the top of oceanic crust about 50 km from the DF at a depth of about 10 km. Its dip becomes steeper above the decollement step-down at 28 km and it cuts through the prism to near the sea floor at about 24 km from DF. The overlying sedimentary sequence in the Kumano forearc basin is progressively tilted landward with depth, reflecting uplift caused by motion along the splay fault.

T52C-0288 1330h POSTER

Origin of Low Salinity Pore Fluids: Kumano Forearc Mud Volcanoes, Nankai Trough

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Several seafloor mud volcanoes have been found in the Kumano forearc basin located in the northern part of the Middle Nankai Trough (Kuramoto, 1998 etc.). From 2000 to 2002, we took five piston core samples (length 1 3.9 m) were retrieved from four of the mud volcanoes. In this study, we report the origin of pore fluids of the Kumano mud volcanoes based on the results of chemical analyses of the pore waters squeezed from these core samples. We found that the pore waters in the Kumano mud volcanoes can be characterized by slight Cl^- depletion relative to seawater. The maximum anomaly is ca. 5%. Besides, the isotopic ratio ratios of the pore fluids become enriched in 18-O and depleted in D with the decrease of Cl^- concentration. Assuming that the isotopic compositions of pore water have been decided by the simple mixing of seawater and freshwater (Cl^-=0), the $\delta^{18}O$ and δ D values of fresh water can be estimated to be approximately +14 ($^o/_{oo}$ SMOW) and -41 ($^o/_{oo}$ SMOW). These values correspond to those of the clay minerals. On the other hand, the ratio of methane to ethane in pore water and stable carbon isotope ratios of methane (C1/C2: <100, $\delta^{13}C$: ca. -60 -30$^o/_{oo}$ suggest that the thermogenic-originated hydrocarbons mixed in biogenic-originated methane.

T52C-0289 1330h POSTER

Tectonic Structure of the Middle America Pacific Margin and Incoming Cocos Plate From Costa Rica to Guatemala

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A new multibeam bathymetry and magnetic survey with R/V SONNE in summer 2003 has mapped the continental margin and incoming plate of NW Nicaragua, El Salvador and Guatemala, extending existing coverage from offshore Costa Rica and part of Nicaragua to a full coverage map of about 1200 km long by 100 km wide area along the plate boundary. The incoming plate along Nicaragua, El Salvador and Guatemala is of similar age and was formed at superfast spreading rates; however, its morphology changes drastically along strike. The seafloor-spreading inherited morphology is very smooth along Nicaragua, but with ridges up to 800 m high in Guatemala, with a transition across El Salvador. The development and dimensions of the dominant inherited fabric seems to be related to discontinuities at the paleospreading center. A series of

troughs oblique to the main fabric may indicate the location of pseudofaults and correspond to areas where the seafloor fabric is most prominent. Bending of the oceanic plate into the trench reactivates the inherited fabric forming a well pervasive faulting system along the oceanic trench slope. The continental slope displays three morphotectonic units that roughly correspond to the upper, middle and lower slope, although the across slope width of each unit is fairly variable. Small canyons and gullies that form at the sudden dip change across the shelf break carve the upper slope. The canyons coalesce and become shallower as the dip decreases downslope. Locally some large canyons continue into the slope toe. The middle slope is a rough terrain variable in width and dip sculptured by pervasive normal faulting and locally by mass wasting processes. The lower slope is formed by en echelon terraces striking similar to the rough terrain of the incoming plate and mimicking the half graben morphology of the underthusting plate. The three morphotectonic slope domains represent differences in tectonic activity, with more stable upper slope, a middle slope dominated by tectonic extension and the thin, highly fractured upper plate of the lower slope riffling over the incoming plate topography. The trench axis is largely empty, with local turbidite ponds at the mouth of a few large canyons transecting the entire slope.

T52C-0290 1330h POSTER

Implications of Smectite Subduction at the Costa Rican Convergent Margin

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Legs 205/170 of the Ocean Drilling Program (ODP) drilled a reference section on the incoming plate and sites at the toe of the sedimentary prism at the Costa Rican convergent margin. Complete sediment subduction has been documented, with the prism described by Leg 205/170 shipboard scientists as a paleoslump prism. Despite sediment subduction, Costa Rican arc lava geochemistry shows little sediment signal. Though subduction erosion has been posited as a mechanism for damping the geochemical sediment signal, this abstract addresses whether the clay content and distribution in the subducting pile can (a) play a role in localizing the decollement and (b) impact subduction of sediment to depth. X-ray diffraction (XRD) analyses of bulk sediment, with biogenic silica determinations, have been carried out for samples from the prism, through the decollement, to the underthrust sediments. Clay fractions have been isolated and silica studied for a subset of these samples. XRD peak areas of bulk samples were transformed into relative abundances via matrix singular value decomposition (Fisher and Underwood, 1995, Proc. ODP, Init. Repts., 156: 29-37), and adjusted following silica determination; volcanic ash has been neglected as a sedimentary component. Average relative weight percents of dominant minerals and biogenic silica (bSiO2) for prism toe units (Site 1040) are: P1A (silty clay, 74.8 m thick) 82 wt% clay, 5 wt% quartz, 13 wt% plagioclase, 0 wt% calcite; P1B (silty clay, 296.4 m thick) 82.1 wt% clay, 6.0 wt% quartz, 10.4 wt% plagioclase, 0 wt% calcite, 1.4 wt% bSiO2. Below the decollement, underthrust abundances are: U1A (clayey diatomite, 13.2 m thick) 82.7 wt% clay, 5.2 wt% quartz, 8.9 wt% plagioclase, 0 wt% calcite, 3.2 wt% bSiO2; U1B (clayey diatomite, 38.2 m thick) 80.7 wt% clay, 4.4 wt% quartz, 6.6 wt% plagioclase, 0 wt% calcite, 8.2 wt% bSiO2; U2 (silty claystone, 57.1 m thick) 84.8 wt% clay, 4.5 wt% quartz, 6.8 wt% plagioclase, 0 wt% calcite, 3.9 wt% bSiO2; U3A (siliceous nannofossil chalk, 18.1 m thick) 44.1 wt% clay, 2.0 wt% quartz, 5.6 wt% plagioclase, 31.8 wt% calcite, 16.5 wt% bSiO2; U3B (siliceous nannofossil chalk, 75.55 m thick) 1.9 wt% clay, 0 wt% quartz, 1.1 wt% plagioclase, 92.4 wt% calcite, 4.7 wt% bSiO2; and U3C (siliceous nannofossil chalk, 80.18 m thick) 6.6 wt% clay, 6.1 wt% quartz, 4.6 wt% plagioclase, 74.1 wt% calcite, 8.7 wt% bSiO2. XRD peak areas for clay fractions of prism samples above and in the decollement (Site 1254∼Site 1040, 300-370 mbsf) were transformed into relative weight percent data with Biscaye weighting factors. Smectites ranged from 77-93 wt%, illites ranged from 0-4 wt%, and kaolinites/chlorites ranged from 5-20 wt%. The maximum smectite value was obtained in the lower decollement. Bulk mineralogy data for sediments subducting at Costa Rica show that the prism and uppermost underthrust sediments are 80-93 wt% clay sized minerals. Clay mineralogy suggests that the smectite maximum occurs in the lower decollement and decreases dramatically below. Low biogenic silica abundances persist down core, emphasizing the importance of clays to the subducting section at Costa Rica.

T52C-0291 1330h POSTER

Detailed Structure of the Large Thrust Slice Zone in the Nankai Trough off Muroto

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A 3D seismic reflection data set were collected in the Nankai trough off cape Muroto in 1999. Pre-stack time migration has been perfomed on the 3D data. We will present on the detailed structure of the large thrust slice zone revealed from the 3D seismic reflection volume. The Large Thrust Slize Zone (LTSZ) with ∼25km length is located ∼40km landward from the deformation front, where the water depth shallows to 3000m from 4000m. The LTSZ is characterized by the imbricate structure which is also recognized in the frontal thrust zone, and thrust faults developed in the accretionary prism, which suggests that old accretionary prism in the LTSZ has been uplifted by the underplating and thrust faulting. Several faults can be traced in the LTSZ. These faults cut the well stratified imbricate thrust packages. Imbricate package beneath the upper slope area is thicker than that beneath the lower slope area. Strong flat reflectors were imaged beneath the base of the slope. These reflectors are terminated by a low angle fault landward. This setting of flat reflectors and a low angle fault is similar with that at the deformation front off Kumano area. The low angle fault might be a remnant decollement. The flat reflectors are clearly imaged in the southwest half of the 3D box, but not clear in the northeastern part. Low angle landward dipping reflectors (LA-LDRs) are imaged at the depth of 6.5-6.7s beneath the upper slope of whole 3D box. The LA-LDRs accompany with sigmoidal reflection events, which may represent a duplex structure. Some of the thrust faults take off from the landward end of LA-LDRs.

T52C-0292 1330h POSTER

The heterogeneity of the seismogenic fault rock fault along the strike in Shimanto accretionary complex.

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The typical evidence for the rapid slip of the pseudotachylyte is found in the Shimanto accretionary complex where is inshore extension of the Nankai seismogenic zone. The Latest Cretaceous Okitsu Melange, 0.8 km in thickness, is composed of at least fifth sheets of the imbricate oceanic stratigraphy with the duplex structure. The seismogenic fault where is replaced at the roof thrust of the duplex structure, is characterized by the concentration of the vein mineral layers. The fault rock suffered deformation of the pressure solution creep with S-C fabric and the rapid slip with pseudotachylyte formations repeatedly. The thermal analysis indicates that the Okitsu Melange suffered much higher temperature than the surrounding strata, and the seismogenic fault was affected extra higher temperature among the melange zone. Such a higher temperature of the melange than the hanging wall must be caused by the hydro-thermal fluid flow along the horizontal decollemant zone of the roof thrust of the duplex structure in the Okitsu Melange. The two types of deformations of the creep and rapid slips may related with the flux of the fluid flow. This characteristic feature, however, is discontinuous along the strike. The western extension of this outcrop approximately 1 km in distance, the faultrock has cataclacite with random fabric without vein mineral. The precipitation of the vein minerals with fluid flow would cause the cementation of the fault breccia and reduce of the pressure solution creep to release the elastic strains. Thus cementation is able to make the faultrock strength with time. In the friction theory, time depend strengthen is required for velocity weakening behavior of the seismogenic fault, and strain is concentrated at the local contact area of the asperity. The vein mineral concentration area with S-C fabric of pressure solution deformation is probably comparable with the asperity. The another outcrop along the strike of the fault looks the cementation of the fault and interseismic strain localizations were ineffective, because of lack of vein mineral and deformation fabrics within the fault zone. The vein mineral concentration and pressure solution deformation are probable feature of the fault rock of asperity in accretionary prism.

T52C-0293 1330h POSTER

Halogen Concentrations and Stable Isotopes (O, Sr, and Cl) in the Nankai Muroto Transect and Their Implication for Fluid-Sediment Interactions and Fluid Flow

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The halogen concentrations and stable isotopic abundances of Sr, O, and Cl in the pore fluids at ODP sites 808, 1174 and 1173, provide new insights on the geochemical reactions and fluid flow at Nankai Trough. The sharp reversal in the Cl concentration gradient and oxygen isotope data (-3.4 $^{o}/_{oo}$SMOW at Site 808, and -2.0 $^{o}/_{oo}$SMOW at Site 1174) at the boundary between the trench-wedge and upper Shikoku Basin sediments is likely maintained by flow of a slightly more saline fluid than seawater or by in situ hydration reactions that outpace diffusion. The curvature of the ^{18}O profile and the depth of the glacial maximum Cl concentration suggest vertical advection in the upper part of turbidite section. F concentration of the pore fluids remains about seawater value throughout the turbidite facies at Sites 808 and 1174, then increases dramatically at the volcanic ash-rich versus ash-poor lithological boundary (90 ppm at Site 808 and 60 ppm at Site 1174). The maximum F concentrations observed are significantly higher than previously reported values from all other ODP sites. A lithological control on F concentration profiles is suggested by the preliminary data of F concentration in the solids at Site 808, indicating F concentration may be related with volcanic ash abundance. Br is associated with organic matter diagenesis in the turbidite section, thus Br concentration reaches a maximum value at a rather shallow burial depth where organic matter is more abundant. At all three sites, Br concentrations decrease with depth but Br/Cl ratios do not return to, and remain higher than, the seawater value of 1.5, implying fractionation between Br and Cl. The Sr isotopic ratio exhibit similar depth profiles at the three sites, controlled by the same lithology. ^{87}Sr/^{86}Sr reaches the most non-radiogenic value of about 0.7071 at Site 808 at the same lithological boundary of minimum F concentration. The more radiogenic maxima, below the dcollement at Site 808 and 1174, which coincide with the Cl minima depths, most likely reflect transformation reactions of predominantly detrital minerals having radiogenic-continental-Sr composition. These Sr and oxygen isotope data together with F and Cl concentration profiles could be explained by either 1) in situ clay dehydration and transformation controlled by lithology, temperature, and pressure; 2) transport of a deep-sourced fluid enriched in F, radiogenic Sr and ^{18}O, but depleted in Cl which is uptaken by hydrous silicate reactions; for example, serpentine, chlorite, or talc incorporate considerable amounts of Cl in their structure, forming at temperatures of 250 to 450°C; 3) a combination of both. The Cl isotope data help to differentiate between the two possible options. The highly negative Cl isotopic values observed at all three sites could not be explained by smectite dehydration alone, which would produce ^{37}Cl enriched pore fluids. In contrast, hydrous mineral transformation would result in ^{37}Cl depleted pore fluids, as observed. The chemical and isotopic signatures observed in the pore fluids most likely reflect a mixed signal of in situ reactions and fluid flow from depth, probably from the seismogenic zone. The extent of mixing between the two fluids is being modeled.

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T52C-0294 1330h POSTER

Seafloor gamma ray measurements around active faults in the central Nankai accretionary prism

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A large number of sea bottom gamma ray data have been obtained using JAMSTEC submersibles and ROVs, and have been discussed about relations to geological background. However, γ-ray spectrometers attached with the submersible or vehicle are affected by relatively short measurement time and seafloor disturbance during landing and taking-off. We developed a stand-alone system of gamma ray measurement, named GRAMS (Gamma Ray Monitoring System) and tested it in the Sagami Bay. Total intensity of gamma ray and radionuclide contents monitored for about two days are relatively constant and show no periodic variation. We carried out GRAMS to know spatial distribution of gamma ray along the out-of-sequence thrust in the central Nankai accretionary prism. It is evident that total intensity of gamma ray and radionuclide contents of Th-series and U-series at cold seep sites are higher than those at normal seafloor. Twenty-two day's records of gamma ray monitoring by GRAMS show very high intensity and high anomaly of U-series radionuclide at the seep site. However, all values show no fluctuation with time. This suggests that gamma ray is not sensitive to seep itself but attributed to accumulation of radionuclide, probably derived from damaged rock of the fault zone, within surface sediments.

T52C-0295 1330h POSTER

Systematic variation in shear-induced physical properties and fabric in shallow part of accretionary prism

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Middle Miocene to early Pliocene on-land example of shallow part of an accretionary prism consisting of non-metamorphosed and high-porous sediments is well represented in the southern Miura and Boso Peninsulas, central Japan. Neogene deep marine volcaniclastic sedimentary sequences are accreted from the Izu forearc side to the Honshu forearc during the Izu arc collision. Based on the mode of deformation, this off-scraped body could be divided into three parts ascendingly; gouge zone of the basal detachment fault, thrust fault-dominated unit just above the gouge zone in the lower part of the off-scraped body, upper coherent unit in the upper part of the off-scraped body. Sediment-fabrics obtained from measurement of anisotropy of magnetic susceptibility (AMS) and physical properties such as porosities and pore size distributions are quite variable in the respective three parts. Sediments in the upper coherent unit show layer-parallel flattening fabrics. Comparing with this, sediments in the thrust fault-dominated zone show constriction field of less magnetic foliation, and those in the gouge zone flattening fabrics parallel to the detachment fault plane, with stronger magnetic foliation and lineation. Sudden 7 to 9 % down drop of porosity is recognized at the boundary between the coherent upper unit and the thrust faults dominated lower unit. Similar down drop was also recognized in the contact between the thrust fault-dominated zone and gouge zone. Mercury porosimetries indicate that pore size distribution in the thrust fault-dominated zone is characterized by a small amount of large pores, whereas that in the coherent unit by a large amount of large pores. These analyses indicate the strain history during accretionary prism process in its shallow part. At the first stage, sediments suffer vertical compaction before accretion in general. When horizontal compressional stress is exerted during accretionary prism formation, the previous compaction fabric is disturbed accompanied with porosity decrease in several tens meters thick, before the displacement occurs. This porosity decrease is caused by large pore collapse and associated dewatering induced by the tectonic stress. At the last stage, displacement of thrusting occurs in a restricted zone where strain is localized. Flattening fabric parallel to the thrust fault and further porosity reduction occur associated with this thrusting only in the gouge zone.

T52C-0296 1330h POSTER

Along strike variations in temperature, sediment diagenesis and dewatering in the Costa Rica subduction zone

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For the subduction zone off the Nicoya Peninsula, Costa Rica, we have estimated the thermal structure, determined the nature of the sediment entering the subduction zone, and estimated the location of diagenetic fluid sources. A previously documented along-strike offset in the updip limit of seismicity appears to coincide with a transition between subduction of relatively warm crust (seafloor heatflow of $\sim$100 mW/m^2) south of a triple-junction trace and cool crust (seafloor heatflow of $\sim$20 mW/m^2) to the north. The lower heat flow north of the triple junction trace is generally attributed to vigorous fluid circulation within the uppermost (1-2 km) ocean crust. The observed along strike variation in crustal heat flow leads to different temperature histories for subducted sediments. We calculated temperatures in the subducted sediments and the overlying margin wedge using a transient 1-D conductive model that accounts for advection and conduction of heat during progressive burial of subducted sediments beneath the wedge as well as frictional heating along the plate interface. Temperature profiles through the subduction zone were calculated for cases with warm crust (no hydrothermal cooling of the crust) and cool crust (with varying depths of hydrothermal cooling in the crust). The hemipelagic sediment on the incoming plate is approximately 10% opal and 60% smectite by weight, with no significant variations along strike. We then use previously published kinetic expressions for opal and smectite dehydration to estimate the reaction progress and distribution of fluid production within the subducting sediments. Overlying the warm crust (in the south), most of the opal-to-quartz and smectite-to-illite reaction progress (and associated release of fluid) occurs $\sim$25-45 km landward of the trench. Overlying the hydrothermally cooled crust, most of the sediment dewatering reaction progress occurs $\sim$35-55 km landward of the trench. At the peak of the reactions, the combined volume of fluid released from opal and smectite is comparable to the volume of fluid expelled from the sediment by compaction at the same locations. Our results indicate that the spatial distribution of fluid released from kinetically controlled sediment dewatering reactions (i.e. opal $\rightarrow$ quartz, and smectite $\rightarrow$ illite) mimics the pattern of the updip limit of seismicity, which occurs $\sim$10-20 km landward of the modeled release of most of the fluid from the smectite-to-illite transition. The release of fluid from diagenetic reactions probably causes fluid overpressures and affects the pattern of fluid flow along the plate interface. The location of the updip limit of seismicity may be influenced by the dissipation of fluid overpressures landward of the smecitite-to-illite dehydration front.

T52C-0297 1330h POSTER

Fluid origin and its over-pressure ratio estimated from mineral veins in an ancient accretionary complexe: Constraints from fluid inclusion analysis

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In IODP, we target to drill the fault rocks at the seismic front in the subduction plate interface. Fault and fluid system is one of the most interests of the project to understand rock and fault mechanics associated with fluid, heat and material transfer along subduction interface, and formation of biological environment. P-T conditions of fluids have been estimated fluid inclusions in mineral veins observed in ancient accretionary complexes on land. The P-T condition, however, is just of fluid at the time of precipitation of minerals. We have no information about the equality in temperature between fluid and host rocks (in-situ or exotic origin) and over-pressure ratio of fluid. This study suggests a way to estimate the fluid origin (in-situ or exotic) and its overpressure ratio from mineral veins in ancient accretionary complex on-land on the basis of fluid inclusion analysis. The study area is the Miyama assemblage which is the Cretaceous Shimanto complex, Kii Peninsula, SW Japan. The Miyama assemblage is consisted of mainly sandstone and shale-tectonic melange, and minor basalt and chert. Map-scale geologic structure shows the duplex structure. The existence of tectonic mélange and duplex structure indicates that the study area records the deformation along subduction interface from underthrusting and underplating. P-T conditions of fluids were estimated by microthermometry of fluid inclusion. The coexistence of the two types of inclusions (methane-rich and water-rich) are observed and suggests that the fluid was a mixture of methane and water, which let an assumption that the water is saturated by methane at the time of fluid trapping. Under the assumption, pressure and temperature of trapping is estimated from one sample. Estimated temperature ranges from ca. 150 degree C to 270 degree C, and pressure ranges from ca. 80MPa to 300MPa. The P-T range corresponds to the seismogenic zone suggested by thermal model. The methane ratio to water is estimated from simply the ratio between numbers of methane inclusion and all inclusion in each sample. A considerable linear-trend is found, that is, methane ratio to water increases with temperature. This trend suggests that the temperature of fluid was equaled to that of host rocks (may be in-situ origin) because the all P-T data from fluid inclusion analysis may represent instantaneous condition. In other words, the methane ratio is an indicator of relative depth. Only one datum is not on the line, which may have exotic origin. In in-situ data, the fluid pressure range between lithostatic pressure and hydrostatic pressure should be shown in fluid pressure vs. the methane ratio space. We can constrain the lithostatic line (an upper limit line may be close to lithostatic line) in the space, and then hydrostatic line (about 1/3 of the slope of the lithostatic line). All data are within the space between the two lines in the fluid pressure vs. the methane ratio space. Therefore, we can estimate overpressure ratio from the lines and pressure data. The on-land observation of accretionary complexes, although the complexes is fossil rocks of seismogenic plate interface, may become more significant after drilling rather than before drilling because the drilling core has much new information but almost one-dimensional information. Other hand, on-land complexes have much wide two or three-dimensional outcrops. In the case of this study, no time-spacio relations between fluid origin, overpressure ratio, and deformation structure is represented. We need more detailed observations and much more fluid inclusion data.

T52C-0298 1330h POSTER

Sources of Low-Chloride Fluids in Sediments beneath Biological Communities on the Nankai Accretionary Wedge off Kumano

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We report chemical and isotopic compositions of interstitial waters extracted from surface sediments inside and outside of dense biological communities on the seafloor of the Nankai accretionary prism off Kumano. Particularly those taken within bacterial mat at the Oomine Ridge site show the following characteristics: (1) CH_4 enrichment (more than 600 μ mol/kg), (2) chloride depletion (up to 10% depletion from bottom seawater), and (3) δ D$_{H2O}$ and $\delta^{18}O_{H2O}$ depletion (more than $4^o/_{oo}$ and $0.7^o/_{oo}$ depletion, respectively), compared with bottom seawater. The highest CH_4 value observed at the Oomine Ridge samples is compatible with that previously reported at one of the most active seep areas within Nankai Trough, suggesting that also this site should be one of the most active seep sites in Nankai Trough. The fluid chemistries of these samples show that the fluids of CH_4 enrichment, chloride depletion, and low δ D$_{H2O}$ and $\delta^{18}O_{H2O}$ value relative to bottom seawater are ascending from deeper zone to sediments beneath the Oomine Ridge site. Assuming simple two-component mixing of ambient seawater with fresh water of $Cl^- = 0$ mmol/kg, the estimated end-member δ D$_{H2O}$ and $\delta^{18}O_{H2O}$ values were -46$\pm 7^o/_{oo}$ SMOW and -6.3$\pm 0.7^o/_{oo}$ SMOW, respectively. The δ D$_{H2O}$ and $\delta^{18}O_{H2O}$ values coincide with those of groundwater at nearby land area. Land-derived groundwater could be one of the possible sources for the low chloride fluids, while we donOt

have any idea for such underground lateral flow system of groundwater to the depth of ca. 2,500 m and ca. 100 km off the Japan Islands. Alternative possible source to produce the fluid of low Cl^-, $\delta\ D_{H2O}$ and $\delta^{18}O_{H2O}$ is phase separation of seawater. Phase separation would lower Cl^-, $\delta\ D_{H2O}$ and $\delta^{18}O_{H2O}$ of vapor phase by a fractionation process during boiling, while we have no idea for a heat source to induce phase separation at the area. Fault slips during large earthquake could possibly be result in such source of heat.

T52C-0299 1330h POSTER

A Normal-faulting Paleostress in the Vicinity of Up-dip Limit of Seismogenic Zone Detected by Meso-scale Fault Analysis in a Tectonic Mélange

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The Mugi mélange in the Shimanto Belt, SW Japan, is a mixture of terrigenous and oceanic materials of late Cretaceous to Paleocene. Intermittent bedding planes trend ENE-WSW to E-W (subparallel to the Nankai trough axis) and dip steeply northward. The Mugi mélange consists of several duplex units accompanied by shear zones of basalt layers at their boundaries. Systematic shear fabrics and P-T conditions estimated from analyses of vitrinite reflectance and fluid inclusions indicate that the Mugi mélange had once been subducted to a significant depth (6-7 km below sea floor, which appears to coincide with the up-dip limit of the seismogenic zone), then underplated to the Shimanto accretionary prism, and is now exhumed on ground surface. In this study, for the purpose of determining paleostress fields related to the processes in which subducted materials were deformed, underplated and uplifted to surface, orientations of meso-scale faults and striations were analyzed. Stress inversion techniques including Angelier's Inversion, Multiple Inversion and Ginkgo Method were applied to fault-slip data obtained in each duplex unit of the Mugi mélange, and the results were almost consistent with each other. Most of the resultant $\sigma 1$ axes trend N-S horizontally, and are parallel to poles of shale cleavages, which are roughly parallel to bedding planes. Although the cleavages slightly vary their orientations according to later rotation, $\sigma 1$ axis changes together with them. This cleavage-controlled paleostress has a low Bishop's stress ratio (i.e. low magnitude of $\sigma 2$), therefore is an axial compressional stress normal to cleavages. The restored paleostress was probably exerted just before or at the same time of the formation of duplex structure and the rotation of bedding planes. The meso-scale faults appear to have been formed as normal ones due to overburden. P-T conditions estimated by analysis of fluid inclusions, which occur in the mineral veins sealing measured faults, and cross-cutting relationships between the faults and unit boundary shear zones indicate the simultaneity of these faulting and duplexing. The duplex structure is thought to be formed at the moment of underplating and be caused by stepdown of the décollement. A great variety of drastic changes in properties of material and circumstance such as stress field may occur at the very point of the stepdown, underplating of subducted material, and the up-dip limit of the seismogenic zone.

T52C-0300 1330h POSTER

Mélange as a Plate Boundary Rock and its Seismogenic Roof Thrust - An Example From the Shimanto Belt, Japan

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A tectonic mélange of the ancient accretionary prism of the Shimanto Belt, Japan is investigated to understand a plate boundary process, especially of seismogenic zone in subduction zone. We analyzed deformation fabric, magnetic fabrics, deformation mechanisms and their thermal condition by using vitrinite reflectance. The investigated Mugi mélange is located in western Shikoku. In the Mugi mélange, systematic fabrics such as Y-P-R fabric formed by micro shear and pressure solution mechanisms are penetrated throughout the mélange pile. Magnetic ellipsoids obtained from the anisotropy of magnetic susceptibility (AMS) are highly oblate. Maximum and minimum axes of the ellipsoids are in accordance with shear orientation of mélange and mean pole of foliation, respectively. These facts suggest that the Mugi mélange was formed as a result of underthrusting of trench filling sediments. Vitrinite reflectance ranges from 2.52% to 3.08%, which correlates to the maximum paleo-temperature of ca. 240 ^{o}C to 260 ^{o}C. Pseudotachylite of the most reliable seismogenic rock was found from the upper boundary roof fault of the Mugi mélange. The fault is composed of about 1 m thick cataclastic zone injected by many veins. The overlying Hiwasa formation is sandstone-dominated and folded coherent piles. The finding of the pseudotachylite in this study area is another example from the ancient accretionary complex after the first one from the Okitsu mélange in western Shikoku Island. The setting of the pseudotachylite from the boundary fault between tectonic mélange and overlying folded coherent pile is quite similar to that of the first one. There is no thermal gap between the mélange and coherent piles but temperature obtained from vitrinite reflectance gradually rises in descending from the coherent piles to the mélange beyond the boundary fault. Such setting suggests that paleo-isotherm was parallel to the orientation of the boundary fault. The isotherm in the seismogenic zone is estimated almost in parallel to the plate boundary decollement, therefore the setting of the cataclastic boundary fault including pseudotachylite appears to be a major plate boundary thrust. Consistency of the sense of shear from the Mugi mélange and the seismogenic roof fault suggests that a slip along the plate boundary fault was partitioned in space and time: interseismic slip in the mélange and seismic slip along the roof fault.

T52C-0301 1330h POSTER

On Physical Properties Acquired in ODP Logging and Possible Future Extensions in Log Interpretation -Leg 196 Nankai Seismogenic Zone Drilling-

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Leg-196 was conducted in May through June 2001 and continuous logging was performed using LWD. After the leg, post cruise studies are on-going and various results are now being published by the on-board researchers. The subjects of these studies include fluid flow, formation of decollement, stress fields, overpressures, etc. Although there are number of issues to be investigated using logging tools available commercially, there exist the limitations in the current ODP in the utilization of tools, such as nuclear magnetoresonance tools, ultrasonic tools, core samplers, dynamic testers, microscanners with doubled number of electrodes, multi-level borehole seismic sensors, etc. In the course of the hardware development in the science community, we expect to use these logging tools and to think what will be achieved in science with increased acquirable number of physical properties. We now focus the issue in terms of the following concepts: logged physical properties as an interface between core and seismic data, and how seismolithological methods to be applied to seismogenic studies. Additional properties which may be obtained in the future include multilateral resistivity profile for plural depths of investigations, both free and bound porosities, effective permeability, borehole electrical images in 5 mm resolution with doubled coverage, seismic anisotropy, etc. Cluster analyses would also become possible and be stably applied to data. We believe these physical properties would surely extend what we do with data to certain possible directions: fracture analyses, underground fluid circulations, stress orientations and possibly quantitative stress analyses, etc. We would like to discuss what could have been obtained if there were other physical properties available using examples from the leg-196.

T52C-0302 1330h POSTER

A Perturbation Expansion Approach to Solving the Electromagnetic Induction Problem in Three Dimensions

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We address the electromagnetic induction problem for fully 3D geologic media and present a solution to the governing Maxwell equations based on a power series expansion. The coefficients in the series are computed using the adjoint method assuming an underlying homogeneous reference model. These solutions are available analytically for point dipole source terms and lead to rapid calculation of the expansion coefficients. First order solutions are presented for a model study in petroleum geophysics composed of a multi-component induction sonde proximal to fault within a compartmentalized hydrocarbon reservoir.

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