Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-01 Room:302 Time:May 27 14:15-14:30

A model of seismogenic layer inferred from the number-magnitude distribution of earthquakes

harumi aoki[1*]

[1]TRIES

The number-magnitude distribution of earthquakes suggests an irregular structure of the crust. The model presented here supposes a layer made up of broken blocks in the crust, where size of earthquake depends on block size. In order to simulate such a structure, the original layer is divided into two blocks with arbitrary ratio. Next, each block is similarly divided into two. The k-th division makes 2**k blocks. We call it k-th division of basic process. The number-size distribution of basic process is obtained with the use of random function. At a point in time, however, the order of division is different from place to place. Such a block distribution is interpreted as a weighted sum of basic processes. It is found that the equal weight gives rise to a b value close to 1 and lower weight in higher order of division, less than 1, respectively. The constancy of b value is held for a wide range of magnitude.

Keywords: b value, magnitude, simulation, fault, seismogenic layer

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-02 Room:302 Time:May 27 14:30-14:45

Early aftershocks following the 2007 Noto Hanto, Japan, earthquake

Aitaro Kato[1*]

[1]ERI University of Tokyo

A shallow Mw = 6.7 inland earthquake occurred on the west coast of the Noto Peninsula in Japan on March 25, 2007. A fine local tomography and a magnetotelluric (MT) survey conducted after the mainshock [Kato et al., 2008; Yoshimura et al., 2008] found out a low-Vp and high-conductivity anomaly beneath the mainshock hypocenter. In addition, an anomalous depth dependency of the stress field associated with the mainshock was revealed [Kato et al., 2011]. These results suggest a potential involvement of a deep fluid reservoir with the earthquake generation. To access the dynamic interaction of fluids with the aftershock generation, I focus on the early aftershocks just following the mainshock. Recovery of the missing early aftershocks is quite important to state aftershock activity induced by fluid migrations. Thus, I used the waveforms of aftershocks as templates to detect the missing events within one-day after the mainshock, applying the matched filter technique [Shelly et al., 2007, Peng and Zhao, 2009]. We have a total of several hundreds of thousands positive detections.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-03 Room:302 Time:May 27 14:45-15:00

Medium-scale characteristic earthquakes around Japan

Noriko Kamaya[1*], Masami Okada[2], Akio Katsumata[2]

[1]Meteorological College, [2]Meteorological Research Institute, JMA

Medium-scale characteristic earthquakes around Japan have been detected on the basis of regularity, geographical proximity, magnitude, correlation coefficient and coherence. Among 30 detected groups, 16 groups had digital wave data of 87-type strong motion seismometer and 95-type seismic intensity meter of JMA. Among them, 11 groups showed high correlation coefficients and coherences. They are Off Akkeshi M4.8, Off Hidaka M4.8, Off Urakawa M5.4, Off Taneichi M5.9, Off Kamaishi M4.7, Off Iwaki M5.6, Hitachi M5.2, Tsukuba M5.3, Off Choshi M5.0, Group A of West of the Okinoerabu Island M5.1 and South of the Miyakojima Island M6.5.

Keywords: Characteristic earthquake, Recurrent earthquake, Correlation coefficient, Coherence, Off Hidaka, Hitachi

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-04 Room:302 Time:May 27 15:00-15:15

Detection of M5 level recurrent earthquakes associated with the Boso slow slip events

Yoshiomi Hasegawa[1*], Akio Katsumata[2], Masami Okada[2], Noriko Kamaya[1]

[1]Meteorological College, [2]Meteorological Research Institute, JMA

M5 level recurrent earthquakes on the plate boundary between the North American plate and the Phillipine Sea plate around the Boso peninsula have been detected by waveform correlation. The similarity of the waveforms among six M5 level earthquakes on October 20, 1955, 2 events on July 14, 1966, December 30, 1990 and 2 events on August 18, 2007 at Tokyo station has been confirmed by relatively high correlation coefficient. In particular, three of them which occurred on December 30, 1990 and August 18, 2007 have had similar waveforms at Yokohama station and Tateyama station. The epicenters of three recent M5 level earthquakes on December 30, 1990 and August 18, 2007 have been located within a radius of 2.5 km and the depth range is 20 - 37 km. This means that these M5 level earthquakes are recurrent earthquakes which result from repeated slip of the same asperity patch on the plate boundary. In addition, it has become clear that the waveforms of these M5 level earthquakes and M4.5 earthquake on May 22, 1983 look similar. Taking this and two cases of two repeating earthquakes occurred on same day into account, this asperity patch may be ruptured at once or at least twice which are divided into main-event and sub-event. Main-events have about 17-year recurrence time, and this suggests that the stick ratio of this asperity is estimated about 90%. Four recent recurrent earthquakes had occurred in the earthquake swarm activities with the Boso slow slip event(SSE). This means that the earthquake swarm activities with the Boso SSE might also occur in October, 1955 and July, 1966. Main-events of M5 level recurrent earthquakes may occur in every third the earthquake swarm activities with the Boso SSE. The event probability of the next main-event of M5 level recurrent earthquake within 20 years is estimated to be 73 - 77% by small sampling theory and the renewal model with lognormal distribution.

Keywords: Boso slow slip event, Earthquake swarm, Recurrent earthquake, Waveform correlation, Asperity, Probabilistic prediction

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-05 Room:302 Time:May 27 15:15-15:30

Stress drops of interplate earthquakes along the Japan trench by coda spectrum ratio analysis

Naoki Uchida[1*], Toru Matsuzawa[1]

[1]RCPEV, Tohoku Univ.

The use of S-wave coda spectrum-ratio in estimating corner frequencies is thought to have advantages that it can reduce the effect of site, path and radiation pattern differences significantly (e.g., Mayeda et al., 2007; Somei, 2010; Wada et al. 2010; Moyer et al., 2010). First of all in this study, we applied the method to the off-Kamaishi M˜4.9 repeating earthquake sequence (Matsuzawa et al., 2001) to check its validity for relatively separated event pairs. The results show that the corner frequencies are estimated precisely even for earthquake pairs with hypocentral separations of 40-50km. Here, we used multiple time windows of 5 s by repeatedly shifting by 1 s in the time range of 20-50s after the S wave arrival. Next we applied this method to three categories of interplate earthquakes along the Japan trench: 1) small repeating earthquakes (M3.0-4.4, Uchida et al. 2006, 2009), 2) moderate sized repeating earthquakes (M4.5-5.9, Uchida et al., 2010), 3) low-angle thrust type earthquakes (M3.6-5.9, NIED, 2011). For these offshore earthquakes, the hypocenter errors sometimes exceed 20km and it is difficult to select closely located earthquakes. Thus, the coda spectrum ratio can contribute to the precise estimation of corner frequencies and stress drops for these earthquakes. The estimation show that the stress drops for the earthquakes in these three categories increase with their depths. This probably reflects the increase of confining stress with depth.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-06 Room:302 Time:May 27 15:30-15:45

Complex seismic source inversion method with the data covariance matrix: Application to the 2010 Haiti earthquake

Amato Kasahara[1*], Yuji Yagi[1]

[1]Life and Env. Sci., Univ. Tsukuba

In general, it is difficult to approximate seismic source fault zone by a simple fault plane because of its complex geometry. Most of pervious study, however, applied the planar fault approximation for estimating the seismic source process of large earthquakes. Since the planar fault approximation should lead to a biased result in the seismic waveform analysis, it is important to formulate observed equation so as to mitigate modeling errors originated from complexity of fault geometry. Modeling errors of fault geometry can be divided into two parts: error of strike and dip of the fault, and error of location of the seismic source. Modeling error originated from a restriction on focal mechanism especially in strike and dip may be predominant in the analysis of teleseismic body wave, considering that travel time is insensitive to relative location of the seismic source. This modeling error can be mitigated by increasing freedom of mechanism solutions in assumed seismic source area.

We developed a waveform inversion method to estimate a spatio-temporal moment tensor distribution from teleseismic body wave (P-wave), which is able to describe a complex seismic source model that reflects complexity of geometry of real seismic source fault. We constructed mathematical formulation expanded from Yagi and Fukahata (2010), which considers data covariance components of observation and Green's function error, to stably obtain a solution through the model with high degree of freedom.

We applied the present method to the 2010 Haiti earthquake, whose seismic source process should be complex. P-axes distribution consistent with stress field of the region was obtained only with smoothness constraint in space and time. Moment tensor distribution suggests three faulting zones having different mechanism solution: near hypocenter, east and west of the hypocenter, were activated in the 2010 Haiti earthquake. Estimated Strikes for east-westward nodal planes of each faulting zone are consistent with hinge line of eastward displacement distribution obtained from InSAR data by Hayes et al. (2010). This consistency suggests that the 2010 Haiti earthquake occurred on unmapped fault whose strike is oblique to surface trace of the Enriquillo fault.

Focusing on the time variation, we found that the rupture propagation through shallow part of crust, which is weaker than deeper part and east fault zone were ruptured earlier than west one. Similarity of fault geometry between east and hypocenter are higher than that of west and hypocenter. Our result shows that the complex fault geometries controls rupture propagation manner. Aftershocks, whose mechanism solutions were different from that of the west fault, were triggered at west of the west fault. Westward rupture seems terminated at the focal mechanism transition zone.

Keywords: teleseismic body wave, the 2010 Haiti earthquake, complex fault geometry, seismic source inversion

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-07 Room:302 Time:May 27 15:45-16:00

Anomalies of rupture velocity in deep earthquakes

Mitsuru Suzuki[1], Yuji Yagi[1*]

[1]Life and Env. Sci., Univ. Tsukuba

Explaining rupture mechanics and seismicity of deep earthquake is a long-standing challenge in earth science. Previous researchers had estimated seismic rupture process of deep earthquake on the basis of the seismic wavefrom modeling. From previous source studies, however, it had been difficult to find clear characteristic in rupture process of deep earthquake, since seismic source models for same deep earthquake are often quite different from one another. To estimate stable and detailed rupture model of deep large earthquakes, we applied the back projection method to tele-seismic body waveforms (P-wave) recorded Global Seismograph Network (GSN) and Federation of Digital Broad-Band Seismograph (FDSN). Using this method, we can obtain an image of the seismic source process from the observed data without a priori constraints or discarding parameters. We further applied 4th-root stacking technique which significantly improved resolution of rupture image compared to standard linear stacking. By imaging the seismic rupture process for a set of recent deep earthquakes using the back projection of teleseismic P-waves, we found that the rupture velocities are less than 60% of the shear wave velocity except in the depth range of 530 to 610 km. In this exceptional depth range, about eighty percent of earthquakes have fast rupture velocity ($Vr > 0.6Vs$) and seismicity reaches local maximum. We propose that large fracture surface energy (Gc) values for deep earthquakes generally prevent the acceleration of dynamic rupture propagation and generation of earthquakes between 300 and 700 km depth, whereas small Gc value in the exceptional depth range promote dynamic rupture propagation and explain the seismicity peak near 600 km.

Keywords: deep earthquake, back projection method, rupture process, rupture velocity

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-08 Room:302 Time:May 27 16:00-16:15

Scaling Model of Intraslab Earthquakes

Junji Koyama[1*], Takahiro Maeda[2]

[1]Natural History Sci., Hokkaido Univ., [2]NIED

Intraslab earthquakes are particularly interested on their mechanism generating short-period seismic waves not only in the seismological field but also in the earthquake engineering aspect. We have studied the relation between short-period acceleration level A and seismic moment M_0 by large intraslab earthquakes evaluated independently. The relation has been tested against the theory of complex faulting process by Koyama(1997) and the standard omega-square model. The observation favors the former predicted by a relation of M_0 proportional to A-square. The physical background of this result will be presented.

Keywords: Intraslab earthquakes, scaling law

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-09 Room:302 Time:May 27 16:30-16:45

Dynamic Fault Rupture Propagation in Agarose-gel

Osamu Kuwano[1*], Shiro Hirano[1], Satoshi Fujita[1], Tetsuya Kusakabe[1], Yuuki Kodera[1], Nobuki Kame[1], Masao Nakatani[1], Ryosuke Ando[2]

[1]ERI, Univ. of Tokyo, [2]Geological Survey of Japan AIST

We report on the experimental observation of mode-II crack propagation along a weak plane in agarose-gel. Agarose gels of three different concentration(1, 2,and 3 wt%) are prepared and their rheological properties are measured. In the experiment, transparent agarose-gel which contains straight weak plane is applied constant load. The position of crack tip is tracked by means of photoelastic visualization. We observed evolution of rupture front from slow nucleation to fast, unstable propagation. Observed terminal velocity of rupture propagation for 1wt%-gel is typically about 4m/s, which is corresponding to shear wave velocity of the gel. Terminal velocity and critical crack size are compared with theoretical expectations.

We also discuss the capability of the experiment to investigate the earthquake rupture process.

Keywords: fracture experiment, fault dynamics, fault nucleation, laboratory experiment, photoelasticity, gel

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-10 Room:302 Time:May 27 16:45-17:00

Understanding of diversity of the secondary fracture based on energy change due to damage evolution

Takehito Suzuki[1*]

[1]EPS, Univ. Tokyo

We consider damage effect to investigate how the secondary fracture evolves with dynamic crack extension. The secondary fracture, defined as the fracture created near and around the main fault plane by the fault motion, shows many aspects. Some experimental studies show many microcracks distributed in a medium around the fault plane after the main fault slip. In addition, the region where the rocks are pulverized sometimes appears around the fault plane. For example, Dor et al. (2006) investigated San Andreas Fault zone and found homogeneous pulverization and selective pulverization zones. The former is defined as the zone where the crystals yield a rock-flour texture, while the latter is defined as the zone where only some of the crystals yield powdery texture. Though these various behaviors about the secondary fracture are known to exist, the unified model explaining all of them has not been established. We will construct the model based on the framework of Murakami and Kamiya (1997). We assume damage tensor D and energy release tensor Y here. The damage tensor describes the damage state of the medium and the energy release tensor denotes the strain energy released by unit damage evolution.

We consider a 2-D crack embedded in a medium causing damage. The fracture criterion is introduced for the energy release tensor as follows. First, the tensors Y and D are rotated with the principal axes for Y, which makes Y diagonal. If 1-1 (2-2) component of the diagonalized Y exceeds the criterion Yc, the 1-1 (2-2) component of the rotated D is set to be unity artificially. If all the eigenvalues of the tensor D become unity, we can regard the region as homogeneously pulverized. On the other hand, if not all of the eigenvalues become unity, the region is regarded as selectively pulverized. We have here Yc and other two parameters, eta2 and eta4, and diversity observed for the secondary fracture can be understood in terms of those parameters. The homogeneous pulverization is represented by the situation where eta2 has a finite value, eta4 equals to zero and Yc is sufficiently so small that the fracture criterion is satisfied. The tensors D and Y are proportional to the unit tensor in this case and pulverization occurs in an isotropic way. On the other hand, the selective pulverization is represented by the condition where eta4 has a finite value and Yc is sufficiently small. The nondiagonal components of D and Y appear in this case and they generate the anisotropic pulverization. If Yc is sufficiently high, pulverization does not occur and microcracks distribute around the fault plane. Both the open and shear microcracks can be understood in our framework because we can consider both maximum extension direction and normal directions of microcracks in the medium. Their parallel components describe the open mode, while perpendicular components stand for the shear mode. The results obtained here suggest that the damage effect should be treated by the tensor, not by scalar parameters.

Keywords: damage tensor, energy release tensor, secondary fracture, microcrack, pulverization

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-11 Room:302 Time:May 27 17:00-17:15

2-D simulation of shear faulting: the slip- and time-dependent fault constitutive law and a diversity of slip behaviour

Yuki Nomura[1*], Chihiro Hashimoto[1]

[1]Graduate School of Nagoya University

The occurrence of interplate earthquakes can be regarded as the process of tectonic stress accumulation and release in source regions, driven by relative plate motion. Stress accumulation between earthquakes results from slip deficit relative to steady plate motion. Recently, on the basis of detailed analysis of geodetic and seismic data, it have been revealed that many slow earthquakes that have extraordinary low slip-velocity occur at plate interfaces. This indicates a diversity of slip behaviour to release the accumulated stress at plate interfaces. The mode of fault slip is prescribed by constitutive properties there. Thus, to understand the process of tectonic stress accumulation and release in plate subduction zones, it is crucial to make clear the dependence of slip behaviour on the constitutive properties.

In the present study, we developed a simple two-dimensional simulation model of shear faulting to examine in detail the dependence of slip behaviour on fault constitutive properties through the entire process of earthquake generation cycles. The coupled non-linear system prescribing the process of stress accumulation and release in a strength asperity consists of the equation of equilibrium for two-dimensional shear faulting, fault constitutive relation, and steady slip motion as a driving force. First, we used a simple slip-weakening fault constitutive law. In this system, slip behaviour in the strength asperity is controlled by a single non-dimensional parameter defined by (rigidity$*$critical weakening displacement)/(peak strength$*$characteristic length indicating the size of the strength asperity). In the case that the non-dimensional parameter is small, accumulated stress is released by unstable slip, while in the case that the non-dimensional parameter is very large, accumulated stress is released by stable slip. Only in the case that the non-dimensional parameter is moderately large, a slow slip event can be realized. Second, we used the slip- and time-dependent constitutive law by Aochi & Matsu'ura (2002), which has been derived from theoretical consideration on the fault-surface abrasion with slip and adhesion with contact. Through numerical simulation, we reproduced recurrent stable/unstable fault slip in the strength asperity. In this case, the dependence of slip behaviour on the constitutive parameters is not so simple. The essential parameters controlling the slip-and time-dependent fault constitutive law are the abrasion rate and the adhesion rate. Given the values of the abrasion rate and the adhesion rate, and the past history of the fault slip, the values of fault constitutive parameters, the breakdown strength drop and the critical weakening displacement, can be defined at each moment. Such a process dependence of the fault constitutive parameters causes complicated fault slip behaviour.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-12 Room:302 Time:May 27 17:15-17:30

Dependence of earthquake stress drop on critical slip-weakening distance

Naoyuki Kato[1]*

[1]ERI, Univ. Tokyo

Earthquake stress drop is one of the most fundamental parameters that characterize earthquake sources. It is known that there is a large variation of estimated stress drop, and its origin is unknown. Numerical simulations are carried out in order to examine factors that control stress drop of earthquakes. A straight fault, on which friction obeys a rate- and state-dependent friction law, is embedded in a 2D uniform elastic medium, and the fault is shear loaded at a constant rate. Velocity-weakening friction is assumed on the central part of the fault, which is sandwiched between regions of velocity-strengthening friction. Stable sliding at the velocity-strengthening regions generates stress concentration at the edges of the velocity-weakening region, which results in earthquake occurrence. Stress drop is measured by the ratio of average slip on the fault to the fault rupture length, using a plane-strain shear crack model. Many simulations are done for various values of applied normal stress to the fault and characteristic slip distance L. Simulation results indicate that the average stress drop increases with the normal stress and L. By definition, the stress drop is proportional to the average seismic slip at the velocity-weakening region of the model fault, and therefore to accumulated slip deficit during an interseismic period approximately. Rupture occurs when the stress concentration at an edge of the locked zone becomes large enough to overcome fracture energy Gc, which is approximately proportional to the normal stress and L. Critical slip-weakening distance Dc and Gc are estimated from relations between shear stress and slip obtained for simulated data, and it is found that stress drop increases with Gc and Dc. Stress drop does not linearly increase with normal stress, which may be related to relatively small depth dependence of observed stress drop. Note that the above results hold when seismic coupling is high and rupture starts near an edge of the locked region of the fault. When seismic coupling is low because of low normal stress or large L, stress drop is simply proportional to the normal stress and is not dependent on L or Dc. It is known that stress drop is little dependent on L and is proportional to normal stress for a single-degree-of-freedom spring-block model. This is because stress concentration at an edge of a locked zone cannot be realized in the spring-block model.

Keywords: earthquake mechanics, earthquake parameters, friction, numerical simulation

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-13 Room:302 Time:May 27 17:30-17:45

Shear fracture strength of faults (V): The orientation of in-situ stress and the direction of GPS velocity

Kiyohiko Yamamoto[1*], Yasuo Yabe[2], Namiko Sato[3]

[1]none, [2]Graduate School of Sci., Tohoku Univ., [3]none

1. Introduction: The in-situ stress measurements by DRA have revealed as follows; 1) The smallest horizontal stress in the Kitakami Mountains lies almost parallel to the GPS velocity. 2) The direction of the smallest horizontal stress in ODP Hole 794C is close to that of the largest P-wave velocity of the upper mantle beneath the Sea of Japan. 3) The largest horizontal stress is almost perpendicular to the fault strike in the vicinity of the Nojima fault. The results (1) and (2) suggest that the crust is driven by the motion of the upper mantle and the result (3) suggests that the strength of the fault is small or the fault is weak.

A fault zone model has been proposed to explain the weak faults by Yamamoto (in preparation). The result (1) suggests that the direction of GPS velocity can be employed in place of the principal direction of in-situ stress. In order to show that the model is universal for every fault, Yamamoto and Yabe (2007) have investigated the relationship of the direction of a fault strike to that of GPS velocity for the recent large earthquakes. They have found that the directions are parallel or perpendicular to each other within an error less than about 15 degree. In-situ stress data by DRA are newly obtained for 6 sites in the Tohoku district (Yabe, 2005). The relationship between the in-situ stress and the GPS velocity will be reexamined in this study.

2. Results: The in-situ stress measured by DRA is thought to be the average in-situ stress, to which a rock has been subjected at a depth for a time longer than a few years at least (Yamamoto, 2009). Therefore, the GPS velocities to be used for the comparison should be their averages over a time longer than a few years. In this study, the GPS velocity means the shift rate of the coordinate of a GPS station from 1997/4 to 2007/5. The direction of the largest or the smallest horizontal stress is compared with the directions of GPS velocity at the stations located at a distance within 20 km from the site of stress measurement. When a site (GNB) in the back born mountain range is neglected, the average difference in the direction between the largest or the smallest stress and the GPS velocity is about 10 degree. The largest is about 23 degree at a site FDI on the northern coast of the Pacific Ocean. It has been already shown that the largest horizontal stresses in the vicinity of the Nojima Fault lie nearly parallel to the GPS velocity.

The precision of the direction determined by DRA is about 5 degree. Referring to the data at the sites near the Nojima Fault by Sato et al. (2003), the direction of the largest horizontal stress varies by 25 degree at largest with depth in a hole. This suggests that the direction of the principal direction of stress has an ambiguity of about +/-13 degree at largest. The direction of GPS velocity shows the changes due to an earthquake occurrence. We divide the period from '97 to '07 into two periods, '97 to '02 and '02 to '07, to know the fluctuation of the direction with the period. The large difference between the two periods is seen for the stations around ENS and SND in the southeastern part of the Tohoku district. The difference amounts to +/- 25 degree. This may be caused mainly by the earthquakes that have occurred in and around the district during the period after 2003.

3. Conclusion: Although the direction of GPS velocity changes with an earthquake near a region, it is confirmed that the direction of GPS velocity in a long term approximates the principal direction of stress with an error smaller than about 10 degree. Yamamoto and Yabe (2007) have shown that the fault strikes are perpendicular or parallel to the GPS velocity with an error smaller than about 15 degree for the relatively large earthquakes that have recently occurred. The present results support thus that the fault surface is nearly equal to one of the principal plane of stress, or, the faults are weak.

Keywords: weak faults, GPS velocity, in-situ stress, deformation rate analysis (DRA), strike of a fault, ODP Hole 794C

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-14 Room:302 Time:May 27 17:45-18:00

A primary model of earthquake cycle almost controlled by pore pressure evolution

Yuta Mitsui[1*], Kazuro Hirahara[2], Massimo Cocco[3]

[1]Sci., Hokkaido Univ., [2]Sci., Kyoto Univ., [3]INGV

In a recent Ph.D thesis by the first author (and related papers), certain effects of pore pressure evolution are introduced to simple numerical models for earthquake cycles. One is the pore pressure increase by shear heating, and the others are the pore pressure alteration by porosity changes. Since evolution of pore pressure within fault zones directly affect friction as well as frictional coefficient, earth cycles in fluid-saturated fault zones are related to pore pressure evolution by necessity. This introduction of the pore pressure evolution was an essential step toward constructing realistic mechanical models for natural faults.

On that basis, here, we make a model of earthquake cycle, almost controlled by continuous evolution of pore pressure. It would be an alternative model to that just controlled by evolution of frictional coefficient. By unifying our previous models of one-degree-of-freedom (*Mitsui and Hirahara* [2009, JGR], *Mitsui and Hirahara* [2009, GRL], *Mitsui and Cocco* [2010, GRL]), we can implement the continuous effects of pore pressure evolution by shear heating (including heat diffusion), porosity changes (pore dilatancy and compaction) and fluid diffusion in a traditional model for earthquake cycles only controlled by a rate- and state-dependent friction law.

Since the shear heating and porosity changes are assumed to occur homogeneously within a certain thickness in our simplified model, the fault behavior strongly depends on the value of the fault thickness. This fault thickness almost represents the thickness of fault gouge. We show examples that the fault behavior changes from stick-slip behavior, recurrence of moderate (slow) slip and completely aseismic slip, depending on the thickness value. Although the assumptions in our present model are too rough to represent the structures of natural faults, this is another fundamental step for realistic fault models.

Keywords: Earthquake cycle, pore pressure fluctuation, thermal pressurization, porosity change, fluid diffusion, fault thickness

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-15 Room:302 Time:May 27 18:00-18:15

Heterogeneous pre-stress field in source region

Takashi Miyatake[1*]

[1]Earthquake Res. Inst. Univ. of Tokyo

In the previous SSJ fall meeting, we found that the heterogeneous 3D structure model of the 2004 Chuetsu earthquake generate the stress field which could cause a high stress drop in asperity of the event and also minimum strength excess around the hypocenter. In order to interpret the above, we study the relationship between the heterogeneity of the crustal structure and the resultant stress field by using simple crustal model.

Keywords: Earthquake source process, stress field

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS025-16 Room:302 Time:May 27 18:15-18:30

Precise estimation of AE behavior prior to rock failure with continuous broadband recording

Nana Yoshimitsu[1*], Hironori Kawakata[1], Takashi Yanagidani[2]

[1]Ritsumeikan Univ., [2]DPRI, Kyoto Univ.

A laboratory rock fracture experiment enables us to observe elastic waves radiated from micro fractures (Acoustic Emission; AE) at the proximity to the rupture plane. Previous experiments indicated that AEs are activated and concentrate on and around a future rupture plane prior to the rock failure (e.g., Yanagidani et al., 1985; Lockner et al., 1991). However, waves arrive within a mask time of the last trigger were missed in a trigger mode recording. Furthermore, they used narrowband recordings, so that information about source process could not be obtained. To apply the knowledge obtained from AE analysis, it is necessary that AE source parameters are estimated in a similar manner as natural earthquake parameters. Broadband records enable us to precisely estimate source parameters, such as rupture duration, seismic moment, and seismic energy. In this study, we conducted continuous and broadband recording through a uni-axial rock fracture experiment under a dry condition at an ambient temperature.

First, as a preliminary experiment, we prepared a cylindrical Oshima granite sample, 110 mm in height and 45 mm in diameter. A P wave type broadband transducer and a PZT (narrowband transducer) were attached on the both side surfaces of the sample. Recording was continued with 33MS/s even after the sample fractured.

Spectrum of waveforms showed clear variability of corner frequency, corresponding to their amplitude level. We will conduct further experiments with several broadband sensors, and discuss source characteristics of AEs, from the determination of source parameters of them.

Keywords: AE (Acoustic Emission), laboratory experiment, broadband, continuous recording, source process