

SCG063-01

Room:201B

Time:May 26 14:15-14:30

## Reanalysis of motion of forearc sliver along the southern Kuril arc using the F3 solution of site coordinates of GEONET

Tamao Sato<sup>1\*</sup>, Shinya Hiratsuka<sup>1</sup>

<sup>1</sup>Hirosaki University

Previously, we investigated the motion of forearc sliver along the southern Kuril trench, using the F2 solution of GPS site coordinates of GEONET in Hokkaido. Thereafter, newly determined site coordinates called F3 solution have been provided by GSI. Since the errors of F3 solution are considered to be smaller than those of F2 solution, we reanalyze the motion of forearc sliver using the F3 solution.

We employ a kinematic model which is basically similar to the previous one. It assumes that the observed site velocities in Hokkaido are affected by the motion of forearc sliver as well as by the slip deficit on the interface of the subducted Pacific plate. Thus the model parameters are the slip deficits on the megathrust plate boundary, the rate of rigid motion of the forearc sliver, and the slip deficits on the boundary of forearc sliver. The slip direction on the megathrust plate boundary at the base of forearc sliver is assumed to be different from that in the surrounding region. In contrast to the previous case in which we dealt with the site velocities relative to Sarufutsu (950101), a site located at the northern tip of Hokkaido, we deal with the velocities in the reference frame of ITRF2005. Presuming that the GPS sites are placed on an unknown microplate, perhaps Okhotsk plate, we determine the Euler vector of the microplate such that the GPS site velocities represented in the reference frame of the microplate can best be fit by the slip deficit on the megathrust plate boundary between the microplate and Pacific plate. This is done simultaneously with the inversion for the other model parameters. Thus we can deal with the problem without assuming the plate on which the GPS sites are placed. Moreover, a correction is made for the effect of the slip deficit on the convergent plate boundary along the eastern margin of the Japan Sea before the inversion, since it became clear in the previous study that the effect is significant. As a result, the standard deviation of residuals reduced greatly in comparison with the previous case.

As in the previous study, the results show that it is difficult to determine the motion of forearc sliver and the slip direction of the subducted Pacific plate relative to the forearc sliver independently, though the standard deviation of residuals is reduced appreciably by allowing for the discrepancy between the slip direction of the subducted Pacific plate relative to the forearc sliver and slip direction on the megathrust plate boundary in the surrounding region. The model of partitioning of oblique plate convergence cannot explain the inverted correlation between the motion of forearc sliver and slip direction of the subducted Pacific plate relative to the forearc sliver. It is suggested that the slip direction on a severely deformed megathrust boundary may not simply be represented by the rigid rotation of horizontal plate convergence vector about the local strike of subducted slab.

Keywords: motion of forearc sliver along the southern Kuril arc, F3 solution of GPS site coordinates of GEONET, plate tectonics in far-east Asia region, oblique plate convergence boundary, crustal deformation in Hokkaido, slip deficit on the subducted Pacific plate

SCG063-02

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## Precise seismic velocity structure beneath the Hokkaido corner: Arc-arc collision and the 1982 Urakawa-oki earthquake

Saeko Kita<sup>1\*</sup>, Akira Hasegawa<sup>1</sup>, Junichi Nakajima<sup>1</sup>, Tomomi Okada<sup>1</sup>, Toru Matsuzawa<sup>1</sup>, Kei Katsumata<sup>2</sup>

<sup>1</sup>RCPEV, Tohoku University, <sup>2</sup>Hokkaido University

Using data both from the nationwide Kiban seismic network and from a dense temporary seismic network covering the area of the Hokkaido corner [Katsumata et al., 2002], we precisely determined three-dimensional seismic velocity structure beneath this area to understand the collision process between the Kuril and NE Japan forearcs. Tomographic inversions were performed with smaller grid spacing than our previous study [Kita et al., 2010]. Inhomogeneous seismic velocity structure was more clearly imaged in the Hokkaido corner at depths of 0-120 km than the previous result. A northeastward-dipping high-velocity zone with a volume of 20 km x 90 km x 35km was detected at depths of 0-35 km. This high-velocity zone reaches near the surface at the Hidaka metamorphic belt. The highest velocity value in the high-V zone corresponds to those of the upper mantle material. The southern edge of the high-V zone is located just beneath the Horoman-peridotite. On the other hand, a broad low-velocity zone of P- and S- waves with a total volume of 80 km x 100 km x 50 km is distributed to the west of the Hidaka metamorphic belt at depths of 30-90km, having velocities of crust materials. This low-V zone consists of several layers of high and low velocities forming alternate layers, and is inclined toward the northeast at an angle of 40-60 degrees. One of the layer boundaries within the low-V zone corresponds to the main fault plane of the 1982 M7.1 Urakawa-oki earthquake. The hanging wall of the fault plane has anomalously high velocities, while the foot wall low velocities. A considerable number of earthquakes, including aftershocks of the 1982 Urakawa-oki earthquake, occur in this low-V zone at depths of 0-80 km (even at depths of the mantle wedge), whereas seismicity is very low in other areas. The present observation provides important information to deepen our understanding of the ongoing arc-arc collision process and earthquake generation mechanism in the Hokkaido corner.

Keywords: Hidaka collision zone (the arc-arc type collision zone), Seismic velocity structure, Seismicity, the 1982 Mj 7.1 Urakawa-Oki earthquake, Horiman Peridotite

SCG063-03

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## Seismic Deformation at the Northern Tip of the Subducting African Plate in SW Turkey

Ali Pinar<sup>1\*</sup>, Semir Over<sup>2</sup>, Suha Ozden<sup>3</sup>, Zuheyr Kamaci<sup>4</sup>, Huseyin Yilmaz<sup>5</sup>, Ulvi Can Unlugenc<sup>6</sup>, Keiko Kuge<sup>7</sup>

<sup>1</sup>Istanbul University, Geophysics, Turkey, <sup>2</sup>Mustafa Kemal University, Geophysics, TR, <sup>3</sup>Canakkale Onsekiz Mart Univ, Geology, TR, <sup>4</sup>Suleyman Demirel Univ, Geophysics, TR, <sup>5</sup>Cumhuriyet University, Geophysics, TR, <sup>6</sup>Cukurova University, Geology, TR, <sup>7</sup>Kyoto University, Geophysics, Japan

We investigate the seismotectonic features resulting directly and indirectly from the interaction between the northeast moving African plate and the westward moving Anatolian block focusing mainly offshore and onshore of the region between the Fethiye Bay and the Gulf of Antalya. Our data is the broadband waveforms recorded at the seismic stations run by Kandilli Observatory and Earthquake Research Institute. In addition to these stations we deployed three broadband stations along the Mediterranean seaside to improve the network coverage so as to constrain better the source parameters of the smaller events taking place offshore. The recorded 3-component waveforms of the small to moderate size earthquakes were analyzed to determine a seismic moment tensor for each event. The tectonic implications of the spatial distribution of the events and their focal mechanism solutions shed light onto the present geodynamic processes taking place along the Anatolia-Africa boundary zone.

These results points out three distinct patterns of deformation undergoing in the western, central and eastern part of the project region. The tectonics in the western part is mainly influenced from the interaction of the motion along the eastern flank of the Hellenic arc and the southwestward extrusion of Anatolia. The intermediate depth seismic activity along the eastern flank of the Hellenic arc where predominantly left-lateral strike-slip faulting occurs extends well below the Fethiye Bay and even further northeast. The piece of knowledge that gives sign for the propagation of the left-lateral motion further beneath the mainland is based on quite recent data acquired from the Cameli Basin which comes both from the field and seismology. The analysis of the data reveals conjugate extensional directions from NW-SE in Mio-Pliocene and NE-SW to N-S in Quaternary up to present. In the western part although the intermediate depth seismic activity exhibits strike-slip faulting the shallow seismicity shows predominantly normal faulting mechanisms. The central part of the project area undergoes different pattern of deformation where most of the seismic activity is confined within the crust and the dominant focal mechanisms are strike-slip and reverse faulting resulting from north to northeast compression and south- to southeast extension. No normal faulting mechanism events are inferred from the seismological data in the central part though the field data points out several recent normal faulting events. The tectonics of the eastern part of the project area is influenced mainly from the subduction process along the western flank of the Cyprus arc. The intermediate depth seismic activity beneath the Gulf of Antalya exhibits mostly reverse and strike slip faulting resulting from NE compression while the shallow seismic activity show predominantly normal faulting.

Considering the three pattern of deformation we suggest that the western part of the study region is influenced from the north-eastward propagation of the eastern flank of the Hellenic arc. Subduction process along the western flank of the Cyprean arc is active and effective beneath the Gulf of Antalya. The central part is a transition between the two where no evidence of subduction is observed and this part is probably the most northern tip of the African plate that touch Anatolian block supporting the highly elevated mountains.

Keywords: Small earthquakes, Seismic moment tensors, Subduction, African plate, Seismic deformation, Turkey

SCG063-04

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## Crustal deformation in the Andaman Islands suggested from paleoseismological data

Masanobu Shishikura<sup>1\*</sup>, Yasutaka Ikeda<sup>2</sup>, Tomoo Echigo<sup>3</sup>, Javed Malik<sup>4</sup>, Hajime Kayanne<sup>2</sup>, Kenji Satake<sup>2</sup>

<sup>1</sup>Active Fault Earthq. Res. Ctr., AIST/GSJ, <sup>2</sup>University of Tokyo, <sup>3</sup>Geo-Research Institute, <sup>4</sup>Indian Inst. Tech. Kanpur

The Andaman Islands were located in the northern part of the rupture area of the 2004 Sumatra-Andaman earthquake, and accompanied with coseismic crustal movement which was southeastward tilting based on the height of uplifted corals and tide gauge data. After the 2004 earthquake, we carried out paleoseismological survey all through the islands.

In the Interview Island situated in the 2004 uplifted area, northwestern part of the Andaman Islands, we found older uplifted corals divided into at least four levels. Radiocarbon ages suggest that uplift events have repeatedly occurred at every 250-350 years during 6600-5700 years ago. However, their heights reached to 0.6-1.3 m above present mean sea level are unexpectedly low in spite of repeating uplift. And curiously, no visible evidence of uplift in the period until the 2004 since 5700 years ago was found. This phenomena can be explained by influence of eustatic sea level change, but also it suggests that residual uplift per event is little (0.1-0.5 m).

In the southeastern part, the 2004 subsided area, we found the evidence of past subsidence as well as the 2004 event from the stratigraphy observed by trenching and coring survey. Radiocarbon ages indicate that the timing of event is after 400 years ago which is probably correlated with the historical earthquake of the 1679 in Eastern Bengal. Although this area has repeatedly subsided, we also found in-situ fossil coral of 5000 years ago at almost present sea level, which suggests residual subsidence is very little.

In the Neil Island located at back arc side, further east of the 2004 rupture area, five steps of distinct marine terraces have been developed, though this island was coseismically stable during the 2004 earthquake. Height distributions and radiocarbon ages obtained from each step suggest that coseismic event accompanied with net uplift of 1-2 m have occurred at every 700 years during 6000-3000 years ago.

Summarizing above results, cumulative amount of coseismic crustal movement in the 2004 rupture area of the Andaman Islands is little through Holocene. Recurrence interval revealed by paleoseismology is consistent with geodetical estimations in and around the islands (230-600 years; Subarya et al., 2006, *nature*. ave. 400 years; Gahalaut et al., 2008, *JGR*.). This suggests that the most of crustal strain associated with plate subduction has been released by great earthquake such as the 2004 event. On the other hand, back arc side of the islands has been actively uplifted by another type event probably related to intra-plate fault.

Keywords: giant earthquake, crustal deformation, Holocene, uplifted coral, marine terrace, Andaman Islands

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## Complementary distribution of various slip events on the plate boundary around Shikoku, southwest Japan

Hirokazu Okazaki<sup>1</sup>, Takeshi Sagiya<sup>1\*</sup>

<sup>1</sup>Environmental Studies, Nagoya Univ.

A wide variety of interplate faulting phenomena have been found in the western Nankai Trough subduction zone around Shikoku, southwest Japan. The Nankai megathrust earthquake occurred in 1946, followed by the significant afterslip. Long-term slow slip events repeated beneath the Bungo Channel in 1997, 2003, and 2009-2010. In addition, short-term slow slip events accompanying deep low frequency tremors occur almost every 6 months. Such a diversity of faulting phenomena may be attributed to the heterogeneous distribution of frictional properties on the plate interface. Then we infer that those different types of faulting behaviors should have complementary distribution one another. There have been several studies demonstrating complementarity of the coseismic slip and the following afterslip. On the other hand, spatial relationship between the afterslip and slow slip events has not been investigated so far. Thus we analyze leveling, tidal, and GPS records to examine complementarity of various faulting phenomena on the plate interface after the 1946 Nankai earthquake.

For this purpose, we conduct inversion analyzes of geodetic data to estimate slip distribution during the coseismic (1929-1947), the postseismic (1947-1964), and the slow-slip periods (1997, 2003, 2009-2010). We apply the same geodetic inversion code with the same three prior constraints: 1) the slip distribution is smooth, 2) the slip direction is in accordance with the plate motion, 3) the low frequency tremor distribution delineates the deeper limit of the fault slip. Relative weights of prior constraints are determined by the ABIC minimum criterion.

As a result, the coseismic slip of the 1946 Nankai earthquake occurred shallower than 20km depth. The afterslip occurred at the deeper extension, in the depth range of 20-30km, beneath the central as well as the eastern Shikoku. On the other hand, the slow slip events occur at the depth of 20-40km to the west, and the slow slip area does not overlap with the afterslip distribution. Based on this analysis, we conclude that the slow slip and the afterslip are spatially separated. Since the 1946 afterslip and the Bungo Channel slow slip events occur in the same depth range, the variability in slip behavior and thus the frictional properties may be ascribed to the dip angle or some other structural features such as the amount of oceanic sediments, rather than the temperature.

Keywords: Shikoku, Nankai Trough, Nankai earthquake, afterslip, slow slip event

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SCG063-06

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## Split Philippine Sea Plate beneath Western Japan

Satoshi Ide<sup>1\*</sup>, Katsuhiko Shiomi<sup>2</sup>, Kimihiro Mochizuki<sup>3</sup>, Takashi Tonegawa<sup>3</sup>, Gaku Kimura<sup>1</sup>

<sup>1</sup>Dept. EPS, Univ. Tokyo, <sup>2</sup>NIED, <sup>3</sup>ERI, Univ. Tokyo

The shape of the Philippine Sea Plate subducting beneath western Japan is a crucial factor in understanding earthquakes and volcanic activity. We propose that the subducted plate was split along an extinct ridge due to an abrupt change of subduction direction, followed by elastic deformation of the plate and an accumulation of stress near the ridge. This shape is consistent with receiver function images, the distribution of deep tremor sources, the seismicity and focal mechanisms of intraplate earthquakes, and the distribution of anomalous ratios of helium isotopes in ground water. The movement history of the plate can explain active tectonics in western Japan in the last 2?4 Ma. The location history of the volcanic front and the tear control where fluids ascend in the crust, and these fluids are responsible for the generation of large earthquakes and volcanoes.

Keywords: Philippine Sea Plate, Plate motion, Receiver function

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SCG063-07

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## Deformation of the Philippine Sea slab and its implication for tectonics of central and western Japan

Yukitoshi Fukahata<sup>1\*</sup>

<sup>1</sup>DPRI, Kyoto University

The contraction rate in central and western Japan was estimated from the deformation of the Philippine sea slab. Usually a slab subducts with little deformation as indicated by the slab contour lines which are nearly parallel to the trench. Little deformation of slabs is also reasonable from the point of view of elastic energy.

However, large deformation of the Philippine Sea slab under central Japan has been estimated from hypocenter distributions, receiver function analyses, and tomography. Such large deformation is considered to be caused by east-west contraction, which prevails in the most area of Japan.

Observed characteristics of the deformation in the Philippine Sea slab are as follows: (1) little deformation in the west of the Kii strait; in the east of the Kii strait, (2) little deformation in the region between the Nankai trough and the coast line, (3) progressively accumulated deformation to the north of the coast line. Little deformation in the west of the Kii strait is consistent with less number of active faults and their commonly slow displacement rates.

The deformation rate of the Philippine Sea slab related to the characteristic (3) was estimated to be about 5 - 10 km/Ma. This estimate would give the minimum contraction rate in the crust of the Chubu and Kinki district, Japan.

Keywords: slab, deformation, Philippine Sea Plate, Kinki triangle, central Japan

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SCG063-08

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## Review and new perspectives on Quaternary tectonics from Kanto to southwest Japan

Tatsuya Ishiyama<sup>1\*</sup>, Hiroshi Sato<sup>1</sup>

<sup>1</sup>ERI, University of Tokyo

We show review and new perspectives on Quaternary Tectonics from Kanto to southwest Japan subducted by Philippine Sea and Pacific plates.



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## Spatial distribution of random inhomogeneities and intrinsic attenuation in the crust and uppermost mantle

Tsutomu Takahashi<sup>1\*</sup>

<sup>1</sup>JAMSTEC

High frequency seismic waves ( $>1\text{Hz}$ ) that are impulsively radiated from a point source are collapsed and broadened as travel distance increases. This broadening process can be described by the multiple forward scattering due to random velocity inhomogeneities and intrinsic attenuation. Recent progresses of the theoretical studies on the wave propagation in random media clarified mutual relations between the seismic wave envelopes and statistical properties of random velocity inhomogeneities [e.g., Saito et al. 2002 JGR]. On the basis of these studies, inversion approaches have been proposed to estimate the 3D distribution of random inhomogeneities and intrinsic attenuation [Takahashi et al. 2009, GJI; Takahashi et al. 2010, JPGU SCG004-01]. For example, inversion analysis in the northeastern Japan imaged the strongly inhomogeneous regions at small spatial wavelength range ( $\sim$  a few hundred meters) beneath the Quaternary volcanoes and at the high-seismicity region [Takahashi et al. 2009, GJI]. Random inhomogeneities beneath the Quaternary volcanoes are characterized by weak spectral gradient. Meanwhile, those in the high-seismicity region has steep spectral gradient. Intrinsic attenuation structure in the northeastern Japan shows strong attenuation beneath the Quaternary volcanoes ( $1/Q \sim 1/300$  at 4-8Hz) and high- $V_p/V_s$  region in the fore-arc side of the volcanic front ( $1/Q \sim 1/500$  at 4-8Hz). Dimension reduction for random inhomogeneities, intrinsic attenuation and seismic velocity [Matsubara et al. 2008] shows components that are related to volcano distribution and seismic activity. This reduction result implies that random inhomogeneities and attenuation are important to characterize medium properties in the crust and uppermost mantle.

Keywords: random inhomogeneities, intrinsic attenuation, dimension reduction

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SCG063-10

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## Characteristics of crustal deformation style of inland Japan deduced from dense GPS observation

Takeshi Sagiya<sup>1\*</sup>

<sup>1</sup>Nagoya University

We have been investigating detailed crustal deformation around active fault zones in central Japan to understand the tectonic loading and inland deformation processes. Based on these GPS observation data, the short-term geodetic deformation rate is equal to the long-term geologic deformation rate in some cases, but in most cases, a few times as large as the long-term rate. The difference in deformation rates depends on how we obtain those estimates. Geodetic estimates are based on the measurement of crustal movement over a wide area. On the other hand, geologic estimate is usually based on on-site measurement at the fault trace. So we also have to take the earthquake cycle deformation of the surrounding crustal blocks into account. That is, if all the distributed interseismic strain concentrates on the fault at the time of an earthquake, both data should be consistent each other. Contribution of inelastic deformation becomes negligible in this case. The situation around the Gofukuji Fault and plate boundaries where there is distinct strength difference between the fault plane and the surrounding media. On the other hand, it is highly possible that a significant portion of inland deformation is inelastic and earthquakes at active faults release only a part of accumulated strain. It is suggested based on such discussion that contribution of off-fault inelastic deformation to the inland earthquake cycle needs to be quantitatively discussed for evaluating long-term seismic activity in the inland area. Inconsistency between geodetic and geologic deformation rate provides a clue to quantitative estimate for that.

Keywords: crustal deformation, GPS, slip rate, active faults, stress accumulation, inelastic deformation

SCG063-11

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## Stress fields in inland areas of the Japanese Islands reproduced by plate subduction and compression

Ikuo Cho<sup>1\*</sup>, Yasuto Kuwahara<sup>1</sup>, Taku Tada<sup>1</sup>

<sup>1</sup>National Institute of Advanced Industrial Science and Technology

We calculated theoretically the stress accumulation rates generated by the subduction of plates surrounding Japan and by crustal compression, with a view to elucidating the origins of the overall stress distribution patterns in the Japanese Islands.

As in Hashimoto and Matsu'ura (2006), the stress accumulation rates were calculated by superposing analytic solutions for viscoelastic responses to dislocations along plate boundaries (Sato and Matsu'ura, 1991). Rates of relative motion between the Eurasian, North American, Pacific and Philippine Sea plates were derived from the NUVEL-1A model (DeMets et al., 1994). No relative motion was assigned to the Izu collision zone. We adopted the NIED's J-SHIS model for the geometry of the subducting Pacific plate and Nakajima et al.'s (2009) model for the geometry of the subducting Philippine Sea plate. Viscoelastic responses were calculated by using the analytic solution of Fukahata and Matsu'ura (2006) for an assumed elastic/viscoelastic two-layered structure (elastic layer thickness 40 km).

Calculations for individual plate subduction-zone segments produced stresses that tended to be of the normal-fault type inland in front of a subduction zone, of the reverse-fault type on both its sides, and of the strike-slip type diagonally to its front. The normal-fault type stresses in front of a subduction zone were also present in the results of Sato and Matsu'ura (1991), who pointed out the effects of plate bending.

Summing up the effects of all subduction zones resulted in the accumulation of strike-slip type stresses in the Izu area and to its front, whereas accumulation of normal-fault type stresses was seen nearly everywhere else in the Japanese Islands. In reality, by contrast, active fault surveys and seismic source mechanism analyses have revealed the following characteristics in the Japan area:

- (i) Compressional stresses, tending roughly E-W, from eastern Hokkaido to northern Kyushu
- (ii) Reverse-fault type stresses over broad areas in NE Japan, and strike-slip type stresses over broad areas in SW Japan
- (iii) An island of reverse-fault type stresses in the Kinki triangular zone in SW Japan.

The above calculations have therefore not been able to reproduce the real stress fields.

On top of the calculation results described above, we added a homogeneous compressional stress rate of 3 kPa/y oriented N110E, which is the direction of motion of the Pacific plate. This changed the normal-fault type stresses into the strike-slip type. However, the reverse-fault type stresses in the Tohoku district could still not be reproduced.

Finally, we assumed crustal shortening localized in the Tohoku district and, instead of adding homogeneous E-W compression, we imposed normal, compressional stresses along the plate boundary off Tohoku. We then redid the calculations by slicing 25% off the plate subduction rates off Tohoku. This relies on the hypothesis of Takahashi (2006), who argued that the westward motion of the Philippine Sea plate necessitates westward motion of the Izu-Bonin trench, whereby the Japan trench also travels westward at a speed of 2-3 cm/y. The Tohoku district is thereby subject to horizontal compression from the east and, out of the approximately 10 cm/y in the relative plate motion rate, net subduction accounts for only 7-8 cm/y. These recalculations changed the stresses in Tohoku into the reverse-fault type, overall satisfying the characteristics (i)-(iii). It thus became evident that the overall patterns of the stress fields in Japan can be explained by considering the combination of two factors, namely (1) subduction of the neighboring plates and (2) compression/shortening in the Tohoku district.

Acknowledgment: Viscoelastic responses were calculated using a modification of codes provided by Dr. Yukitoshi Fukahata.

Keywords: Stress field, Stress accumulation, Plate tectonics, Viscosity, Collision, Subduction

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## Back-arc rifting favoured by a hot and wet continental lithosphere

Tadashi Yamasaki<sup>1\*</sup>, Randell A. Stephenson<sup>2</sup>

<sup>1</sup>University of Leeds, <sup>2</sup>University of Aberdeen

Understand how rifting is initiated promotes a better understanding of the subsequent rifting process. Many quantitative modelling studies have shown how rifting evolves with time for given boundary and other conditions (e.g., Braun & Beaumont, *Can. Soc. Petr. Geol., Mem.*, 12, 241, 1987; Takeshita & Yamaji, *Tectonophysics* 181, 307, 1990; Buck, *JGR*, 96, 20,161 1991; Huismans & Beaumont, *Geology*, 30, 211, 2002; Yamasaki & Stephenson, *J.Geod.*, 47, 47, 2009), but how rifting was initiated has usually been ignored. This is mainly because of poor constraints on the pre-rift structure of the lithosphere and the origin and magnitude of the responsible driving forces.

In this study, using a simple one-dimensional pure shear stretching model, tectonic subsidence data observed in several back-arc basins in the Tethyan belt of Europe and in the western Pacific are examined to infer something about the initiation of rifting and its subsequent evolution in back-arc settings. The origin of the force driving back-arc rifting is relatively better known than for rifting in other tectonic settings: the negative buoyancy force of subducted oceanic lithosphere (e.g., Uyeda & Kanamori, *JGR*, 84, 1049, 1979; Uyeda, *Tectonophysics*, 81, 133, 1982), which allows an examination of rifting initiation in relation to the behaviour of the subducting oceanic lithosphere.

The results show that back-arc rifting is initiated only after a certain magnitude of tensional force has been reached. Thus, the timing of back-arc rifting initiation can be explained in terms of the behaviour of the subducting oceanic lithosphere, assuming a balance between continental and oceanic lithospheric deformation. Back-arc rifting is initiated after subduction has already progressed to a point such that the negative buoyancy force of the oceanic lithosphere becomes large enough to deform oceanic lithosphere that has more strength than the overriding continental lithosphere.

The tectonic subsidence data require the magnitude of the tensional tectonic force to abate with time once rifting has started. This indicates that the rifting process is rapid enough that weakening due to an increasing geothermal gradient exceeds strengthening due to crustal thinning and thermal diffusion. This is achieved, given the currently accepted magnitude of slab subduction force, only if the thickness of the thermal lithosphere of the overriding continent is significantly less than 125 km and it has a wet rheology.

Sedimentary basin formation has often been discussed according to tectonic setting, but any aspect of rifting dynamics, such as the magnitude of driving force and the rheology of the lithosphere, has been poorly examined in such discussions. This study describes how the dynamics of back-arc rifting can be characterised in a general way as a first-order approximation. Although the focus was only on back-arc rifting, the results provide a reference for further discussion about the processes controlling rifting in other tectonic settings.

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## Inelastic Deformation of Island-Arc Crust and Generation of Intraplate Earthquakes: Basic Ideas

Mitsuhiro Matsu'ura<sup>1\*</sup>, Akemi Noda<sup>2</sup>, Toshiko Terakawa<sup>3</sup>, Yoshihiko Ogata<sup>1</sup>

<sup>1</sup>Institute of Statistical Mathematics, <sup>2</sup>Kozo Keikaku Engineering Inc., <sup>3</sup>Nagoya University

The occurrence of earthquakes is the sudden release of tectonically accumulated stress by faulting. On this point, there is no difference between interplate earthquakes and intraplate earthquakes. However, on the mechanism of stress accumulation in source regions, there is an essential difference between them. In the case of interplate earthquakes, the stress accumulation results from slip deficit at a stronger portion (asperity) of plate interface (Hashimoto & Matsu'ura, PAGEOPH, 2002; Hashimoto, Fukuyama & Matsu'ura, GJI, 2011). The accumulated stress is almost completely released by sudden fault slip that cancels the slip deficit. On the other hand, in the case of intraplate earthquakes, aseismic pre-slip in a weak portion (nucleation zone) of fault causes stress concentration at its margins, and dynamic rupture starts if the stress concentration goes critical (Matsu'ura, Kataoka & Shibasaki, Tectonophysics, 1992). Tectonic stress field in the source region governs the development of dynamic rupture, and so the problem to be solved is how the local tectonic stress field is formed. The essence of this problem is in the inelastic deformation of island-arc crust and the associated stress redistribution process. From the inversion analysis of CMT data of seismic events in and around Japan (Terakawa & Matsu'ura, Tectonics, 2010), we can understand that the regional tectonic stress field of the island-arc crust has been formed as a result of long-term mechanical interaction at plate boundaries and intraplate tectonic boundaries. On the other hand, from the physics-based strain analysis of GPS data, we can estimate continuous inelastic deformation in the crust (Noda & Matsu'ura, GJI, 2010). If the stress change produced by the inelastic deformation is the same as the regional stress field in sense, seismic activity will increase there. If the sense of stress change is opposite to the regional stress field, seismic activity will decrease there. The validity of earthquake generation models based on such ideas can be tested through the statistical analysis of seismic events with a space-time point process model (Ogata, JGR, 2004).

Keywords: island-arc crust, inelastic deformation, stress redistribution, intraplate earthquake, seismicity

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## Deformation in Niigataken-Chuetsu region by using an InSAR time-series analysis

Yo Fukushima<sup>1\*</sup>, Andrew Hooper<sup>2</sup>

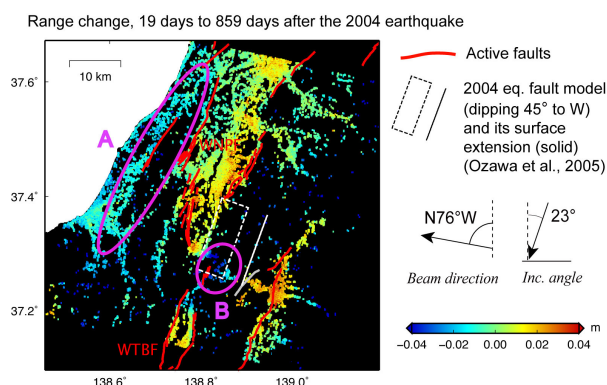
<sup>1</sup>DPRI, Kyoto Univ., <sup>2</sup>DEOS, Delft University of Technology

Plate convergence zones exhibit deformation of various scales in both time and space. It is fundamentally important to know the spatio-temporal pattern of such deformation in detail to understand the physics of plate interactions. InSAR time-series analyses, which can track the temporal evolution of detailed deformation patterns, are suitable for such a purpose. In this presentation, we report the result of an InSAR time-series analysis applied on data acquired over Niigataken Chuetsu area, central Japan.

We used 13 ENVISAT SAR images acquired between the occurrences of 2004 Niigataken-Chuetsu and 2007 Niigataken-Chuetsuoki earthquakes. We first performed a persistent scatterer SAR interferometry analysis using the StaMPS algorithm (Hooper et al., 2007, JGR). We then corrected for artifacts due to orbit inaccuracies and atmospheric phase delay using GPS displacements. This post-processing revealed that the dominant component of the displacements is a seasonal pattern caused by water extraction during winter. Precise estimation of the tectonic component of the displacements was further obtained by separating out the seasonal component using a principal component analysis.

We identified quasi-steady signals in two different locations. An area close to the coast (A in the figure) moved in the direction toward the satellite (upward and eastward) with an approximate rate of 1 cm/yr. This signal is consistent with the motion of the Amurian plate with respect to the North American plate, supporting the idea that the NKTZ can be considered as the plate boundary. The signal around the southern end of the source fault of the 2004 earthquake (B; west of Suwa-toge flexure (gray curve)) exhibits a higher rate of 2 cm/yr. This signal is consistent with leveling surveys conducted by the Geospatial Authority of Japan, and is best interpreted by an afterslip of the 2004 earthquake.

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**Keywords:** InSAR time-series analysis, Niigataken Chuetsu region, Niigata-Kobe Tectonic Zone, Crustal Deformation

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## Crustal structure and active tectonics in the southeastern border of Chubu, Central Japan

Tanio Ito<sup>1\*</sup>, Ken-ichi Kano<sup>2</sup>, Satoru Kojima<sup>3</sup>, Satoshi Yamakita<sup>13</sup>, Takaya Iwasaki<sup>4</sup>, Yasutaka Ikeda<sup>4</sup>, Hiroshi Sato<sup>4</sup>, Yannis Panayotopoulos<sup>4</sup>, Tetsuya Takeda<sup>8</sup>, Yukitoshi Fukahata<sup>5</sup>, Shigeharu Mizohata<sup>10</sup>, Susumu Abe<sup>10</sup>, Shinsuke Kikuchi<sup>10</sup>, Akira Fujiwara<sup>11</sup>, Takeshi Muramatsu<sup>6</sup>, Nobuyuki Matsushima<sup>6</sup>, Kazuro Kawamoto<sup>7</sup>, Kazunori Murata<sup>12</sup>, Noriko Tsumura<sup>1</sup>, Makoto Hayakawa<sup>1</sup>, Hiroshi Furuya<sup>1</sup>, Toshinori Sato<sup>1</sup>, Heitaro Kaneda<sup>1</sup>, Yasuharu Shuri<sup>1</sup>, Taku Kawanaka<sup>10</sup>, Akinori Hashima<sup>1</sup>, Takahiro Miyauchi<sup>1</sup>, Akihisa Takahashi<sup>10</sup>

<sup>1</sup>chiba University, <sup>2</sup>Shizuoka University, <sup>3</sup>Gifu University, <sup>4</sup>University of Tokyo, <sup>5</sup>Kyoto University, <sup>6</sup>Iida City Museum, <sup>7</sup>Oshika Median Tectonic Line Museum, <sup>8</sup>NIED, <sup>9</sup>ADEP, <sup>10</sup>JGI, <sup>11</sup>GEOSYS, <sup>12</sup>Suncoh Consultants, <sup>13</sup>Miyazaki University

New powerful technique, MDRS (Multi-Dip Reflection Surface) Method (Aoki et al., 2010), has improved successfully seismic imaging of SCAT (2008 Southern and Central Alps Transect). This makes it possible to reveal the crustal framework in the southeastern border of structurally active Chubu region adjoining the Izu collision zone, as follows.

1.The frontal active fault group of the Itoigawa-Shizuoka Tectonic Line and its deeper extension (Active ISTL) is traceable down to 20 km deep at about 20 degrees. It cuts the deeper parts of both the Itoigawa-Shizuoka Tectonic Line (ISTL) and the Outer zone. Beneath it, the subducting Izu arc materials extends in 40 km thick. A-ISTL has been keeping its original form at the beginning of the subduction of the Philippine Sea plate, and still active associated with the present subduction at depth.

2.The present Median Tectonic Line (MTL) running along the western margin of the Southern Alps is not the original one, but corresponds to the northern extension of the vertical Akaishi Tectonic Line (ATL)(Kano,1990). The ATL played the important role on the Middle Miocene bending of the Japanese Island Arc as a huge left-lateral fault, together with the ISTL. Although both the ATL and the MTL do not show superficially the manner of an active fault, their deeper parts are surely active at depth with left-lateral-type-dominant microseismicities.

Keywords: Itoigawa-Shizuoka Tectonic Line, seismic reflection survey, Izu collision zone, bending of the Japanese island arc, Median Tectonic Line, Akaishi Tectonic Line



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## Significance of the Tanna Fault in the convergence tectonics around the northeastern Izu Peninsula

Akio Yoshida<sup>1\*</sup>, Masatake Harada<sup>1</sup>, Kei Odawara<sup>1</sup>

<sup>1</sup>Hot Springs Research Institute

The Tanna fault is one of the most active faults in Japan with a left-lateral slip of 2m/1000 year over 500 hundred thousand years (Kuno, 1936). On the other side of the Ashigara plain, parallel to the Tanna fault, there exists the Kozu-Matsuda fault whose vertical slip rate is 2-3m/1000 year. In this report, we present new evidence that shows the Tanna fault has a dip slip component where the eastern side subsides against the western side, and propose an idea that the area enclosed by the Tanna and Kozu-Matsuda faults has been undergoing buoyant subduction.

Having shown that the inclination angle of the eastern flank of Hakone Volcano is steeper than the western flank, Suzuki (1971) suggested it indicates an inclining of the edifice of Hakone Volcano to the east. Using 50m-mesh digital altitude data around Hakone volcano, we calculated average inclination angle at each of the mesh and found that the difference in the inclination angle between the eastern and western parts is seen not only in Hakone volcano, but in the regions to the north and south of the volcano, and the boundary in the difference corresponds to the Tanna fault.

It was already pointed out by Kuno (1936) that motions of the Tanna fault had dip slip components besides left lateral components, but no one has ever noted significance of the fact. We suggest that the vertical slip on the Tanna fault as well as the thrust movement of the Kozu-Matsuda fault can be understood by supposing that the area between the two faults has been subsiding (we call the area the Manaduru block here), and consider that the subsidence manifests buoyant subduction of the Manaduru block associated with the motion of the Philippine Sea plate. Tsuboi (1932), who analyzed crustal deformation caused by the 1930 Northern Izu Earthquake, estimated that the land on the western side of the Tanna Fault displaced at the earthquake. This estimate is concordant with the idea that the Manaduru block constituting the eastern side of the fault has been moving stationary towards north and the western block that has been usually dragged by the motion rebounds at the occurrence of the earthquake. However, since the slip rates on the Tanna and Kozu-Matsuda faults are about one tenth of the relative plate velocity of the Philippine Sea plate, it cannot be considered that the Manduru block moves with the Philippine Sea plate riding on the plate. We speculate that the difference in the motions may provide a clue to elucidate fault model of the so-called Odawara earthquake.

Keywords: Izu Peninsula, Tanna fault, Koju-Matsuda fault, Hakone volcano, Inclination, Buoyant subduction